UNITED STATES NAVAL

POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

★

CATALOGUE FOR 1966-1967

UNITED STATES NAVAL
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CATALOGUE FOR 1966-1967

Paul Henry Nietze
Secretary of the Navy

MISSION

The Secretary of the Navy has defined the mission of the Naval Postgraduate School as follows:

"To conduct and direct the Advanced Education of commissioned officers, to broaden the professional knowledge of general line officers, and to provide such other indoctrination, technical and professional instruction as may be prescribed to meet the needs of the Naval Service; and in support of the foregoing, to foster and encourage a program of research in order to sustain academic excellence."

Superintendent
EDWARD JOSEPH O'DONNELL
Rear Admiral, U. S. Navy
B.S., U. S. Naval Academy, 1929; U. S. Naval Postgraduate School, 1939

Senior Professor
Chief Administrative Officer of Faculty

ROBERT FROSS RINEHART

B.A., Wittenberg College, 1930;
M.A., Ohio State Univ., 1932;
Ph.D., 1934; D.Sc., Wittenberg Univ., 1960

Entrance to Quarterdeck, Herrmann Hall

U. S. NAVAL POSTGRADUATE SCHOOL

Deputy Superintendent
Henry Filledes Lloyd
Captain, U.S. Navy
B.S., U.S. Naval Academy, 1939; U.S. Naval Postgraduate School, 1945;
M.S., Massachusetts Institute of Technology, 1946;
Industrial College of the Armed Forces, 1956

Director of Programs
John William Murph
Captain, U.S. Navy
B.A., Wofford College, 1939;
Naval War College, 1958

Dean of Programs
Wilbert Frederick Koehler
B.S., Allegheny College, 1933; M.A.,
Cornell Univ., 1934; Ph.D., Johns Hopkins Univ., 1948

Executive Assistant to the Director of Programs
Thomas Andrew Melusky
Captain, U.S. Navy
B.S., Univ. of Washington, 1941;
M.S., George Washington Univ., 1963

Dean of Curricula
Brooks Javins Lockhart
B.A., Marshall Univ., 1937; M.S., West
Virginia Univ., 1940; Ph.D., Univ. of Illinois, 1943

Dean of Research Administration
Carl Ernest Menneken
B.S., Univ. of Florida, 1932;
M.S., Univ. of Michigan, 1936

Head of Computer Facility
Douglas George Williams
M.A. (honors), Univ. of Edinburgh, 1954

Superintendent's Staff Assistants

Aide to the Superintedent........................Lt Matthew A. McCarthy, usn

Plans Officer..Cdr Loren I. Moore, usn

Comptroller.......................................Capt Edward A. Sanford, Jr., sc, usn

Staff Secretary..Ltjg Donald Edwin Towne, usn

Industrial Relations Officer..Mr. John J. Coyle

Aviation Officer (CO, NALF)................Capt Mark Twain Whittier, usn

Senior Medical Officer (NALF)..........Lcdr Theodore J. Trimble, mc, usn

Marine Corps Representative......................LtCol Edwin M. Rudzis, usmc

Submarine Liaison Officer....................................Cdr Boone C. Taylor, usn

Senior Chaplain.............................Capt Samuel D. Chambers, ChC, usnr

Programs Administrative Staff

Registrar..Mrs. Bessie Wilk

Class Scheduler...Mrs. Jacqueline M. Olson

Cataloguer...Mrs. Mary Klotz Burton

Foreign Officer Coordinator........................Cdr George W. Fairbanks, usn

Flight Officer..Cdr Edward D. Jackson, usn

Administrative Officer for
Curricular Programs....................................Lcdr Nancy L. Denton, usn

Program Allotment and
Material Control Officer................................Lcdr Deroy L. Hanson, usn

Administrative and Logistic Services

Director of Logistics.................................Capt William A. Pitcher, usn

Head, Administration Dept.......................Cdr Phillip W. Nicholas, usn

Head, Supply Dept..Cdr Mary J. Aplin, SC, usn

Head, Public Works Dept........................Cdr Wayne S. Mitter, CEC, usn

Head, Dental Dept.................................Capt Edmund H. Frizzell, DC, usn

Catholic Chaplain...........................Cdr Francis J. Fitzpatrick, ChC, usn

Protestant Chaplain.......................Capt Samuel D. Chambers, ChC, usnr

Public Affairs & Visit Liaison......................Lcdr John A. Widder, Jr., usn

Legal Officer..Lt M. J. Gormley, III

Communications Officer..Lt Ronald J. McAfee, usn

POSTGRADUATE SCHOOL CALENDAR

Academic Year 1966-1967

1966

Fourth of July (holiday)........Monday, 4 July
Eight Week Summer Term Ends........Friday, 15 July
Registration for all Curricular Areas........Monday, 25 July
Fifth Term Ends (1965-1966)........Thursday, 28 July
First Term Begins (1966-1967)........Monday, 1 August
Graduation ....Wednesday, 3 August
Labor Day (holiday)........Monday, 5 September
First Term Ends........Thursday, 6 October
Second Term Begins........Monday, 10 October
Graduation ....Wednesday, 12 October
Veterans' Day (holiday)........Friday, 11 November
Thanksgiving Day (holiday)........Thursday, 24 November
Second Term Ends, Christmas Holiday Begins........Friday, 16 December
Graduation ....Wednesday, 21 December
Registration for all Curricula except Navy Management, Management/Data Processing, Nuclear (Effects), and Engineering Electronics........Tuesday, 27 December

CALENDAR FOR 1966

JANUARY

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DECEMBER

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CALENDAR FOR 1967

JANUARY

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FEBRUARY

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MARCH

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APRIL

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MAY

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JUNE

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JULY

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AUGUST

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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1967

Third Term Begins........Tuesday, 3 January
Washington's Birthday (holiday)........Wednesday, 22 February
Third Term Ends........Thursday, 9 March
Fourth Term Begins........Monday, 13 March
Graduation ....Wednesday, 15 March
Fourth Term Ends........Thursday, 18 May
Fifth Term Begins........Monday, 22 May
Graduation ....Friday, 26 May
Memorial Day (holiday)........Tuesday, 30 May
Six Week Summer Term Ends........Friday, 30 June
Fourth of July (holiday)........Tuesday, 4 July
Fifth Term (1966-1967) Ends........Friday, 14 July
Registration for All Curricula........Monday, 24 July
First Term (1967-1968) Begins........Monday, 31 July
Graduation ....Wednesday, 2 August

Entrance to Officers' Club, Herrmann Hall

DISTINGUISHED ALUMNI

Among those who have completed a postgraduate curriculum who attained flag (USN) or general (USMC) rank on the active list are the following: (The asterisk (*) indicates those on active list as of 1 January 1966.)

Admiral Walter F. Boone
Admiral Arleigh A. Burke
General Clifton B. Cates
Admiral Maurice E. Curts
Admiral Arthur C. Davis
Admiral Robert L. Dennison
Admiral Donald B. Duncan
Admiral Frank G. Fahrion
Admiral Cato D. Glover, Jr.
Admiral Roscoe F. Good
Admiral Charles D. Griffin*
Admiral Byron H. Hanlon
Admiral Royal E. Ingersoll
Admiral Albert G. Noble
Admiral Alfred M. Pride
Admiral James O. Richardson
Admiral Horacio Rivero, Jr.*
Admiral Samuel M. Robinson
Admiral James S. Russell
Admiral Ulysses S. G. Sharp, Jr.*
Admiral John H. Sides
General Holland M. Smith
Admiral Felix B. Stump
General Merrill B. Twining
Admiral Alfred G. Ward*
Admiral John M. Will
Vice Admiral Walter S. Anderson
Vice Admiral Harold D. Baker
Vice Admiral Wallace M. Beakley
Vice Admiral George F. Beardsley
Vice Admiral Donald B. Beary
Vice Admiral Frank E. Beatty
Vice Admiral Robert E. Blick, Jr.
Vice Admiral Charles T. Booth, II*
Vice Admiral Harold G. Bowen
Vice Admiral Roland M. Brainard
Vice Admiral Carleton F. Bryant
Vice Admiral Edmund W. Burrough
Vice Admiral William M. Callaghan
Vice Admiral John H. Carson
Vice Admiral Ralph W. Christie
Vice Admiral Edward W. Clexton
Vice Admiral Oswald S. Colclough
Vice Admiral John B. Colwell*
Vice Admiral Thomas S. Combs
Vice Admiral Thomas F. Connolly*
Vice Admiral George R. Cooper
Vice Admiral William G. Cooper
Vice Admiral John C. Daniel
Vice Admiral Glenn B. Davis
Vice Admiral Harold T. Deutermann
Vice Admiral Glynn R. Donaho*
Vice Admiral James H. Doyle
Vice Admiral Irving T. Duke
Vice Admiral Calvin T. Durgin
Vice Admiral Ralph Earle, Jr.
Vice Admiral Clarence E. Ekstrom
Vice Admiral Emmet P. Forrestel
Vice Admiral Roy A. Gano
Vice Admiral William E. Gentner, Jr.*
Vice Admiral Elton W. Grenfell
Lieutenant General Field Harris
Vice Admiral Truman J. Hedding
Lieutenant General Geo. D. Hermle
Vice Admiral Ira E. Hobbs
Vice Admiral Ephraim P. Holmes*
Vice Admiral George F. Hussey, Jr.
Vice Admiral Olaf M. Hustvedt
Vice Admiral Thomas B. Inglis
Vice Admiral Robert W. Hayler
Vice Admiral Andrew M. Jackson, Jr.*
Vice Admiral Albert E. Jarrell
Vice Admiral Harry B. Jarrett
Lieutenant General Clayton C. Jerome
Vice Admiral Robert T. S. Keith
Vice Admiral Ingolf N. Kiland
Vice Admiral Fred P. Kirtland
Vice Admiral Willard A. Kitts
Vice Admiral Harold O. Larson
Vice Admiral Ruthven E. Libby
Vice Admiral Frank L. Lowe
Vice Admiral Vernon L. Lowrance*
Vice Admiral James E. Maher
Vice Admiral William J. Marshall
Vice Admiral Charles B. Martell*
Vice Admiral Kleber S. Masterson*
Vice Admiral John L. McCrea
Vice Admiral Ralph E. McShane
Vice Admiral Charles L. Melson*
Vice Admiral Arthur C. Miles
Vice Admiral Milton E. Miles
Vice Admiral Earle W. Mills
Vice Admiral Marion E. Murphy
Vice Admiral Lloyd M. Mustin*
Vice Admiral Frank O'Beirne
Vice Admiral Francis P. Old
Vice Admiral Howard E. Orem
Vice Admiral Harvey E. Overesch
Vice Admiral Edward N. Parker
Vice Admiral Frederick W. Pennoyer, Jr.
Vice Admiral Charles A. Pownall
Vice Admiral Thomas C. Ragan
Vice Admiral Lawson P. Ramage*
Vice Admiral William L. Rees
Vice Admiral Robert H. Rice
Vice Admiral Hyman G. Rickover*
Vice Admiral Rufus E. Rose
Vice Admiral Richard W. Ruble
Vice Admiral Theodore D. Ruddock, Jr.
Vice Admiral Lorenzo S. Sabin, Jr.
Vice Admiral Harry Sanders
Vice Admiral Walter G. Schindler
Vice Admiral William A. Schoech
Vice Admiral Harry E. Sears
Vice Admiral Thomas G. W. Settle
Vice Admiral William B. Smedberg, III
Vice Admiral Allan E. Smith
Vice Admiral Chester C. Smith
Vice Admiral Roland N. Smoot
Lieutenant General Edward W. Snedeker
Vice Admiral Selden B. Spangler
Vice Admiral Thomas M. Stokes
Vice Admiral Paul D. Stroop
Lieutenant General James A. Stuart
Vice Admiral Wendell G. Switzer
Vice Admiral John Sylvester
Vice Admiral Aurelius B. Voseller
Vice Admiral Homer N. Wallin
Vice Admiral James H. Ward
Vice Admiral Charles E. Weakley*
Vice Admiral Charles Wellborn, Jr.
Vice Admiral George L. Weyler
Vice Admiral Charles W. Wilkins
Vice Admiral Ralph E. Wilson
Vice Admiral Chester C. Wood
Vice Admiral George C. Wright
Rear Admiral John W. Ailes, III
Rear Admiral Frank Akers
Rear Admiral Jackson D. Arnold*
Rear Admiral Frederick L. Ashworth*
Rear Admiral Edgar H. Batcheller*
Rear Admiral Richard W. Bates
Rear Admiral Frederick J. Becton*
Rear Admiral David B. Bell*
Rear Admiral Fred G. Bennett*
Rear Admiral Rawson Bennett, II
Rear Admiral Philip A. Beshany*
Rear Admiral Abel T. Bidwell
Major General Arthur F. Binney
Rear Admiral Calvin M. Bolster
Rear Admiral Harold G. Bowen, Jr.*
Rear Admiral Frank A. Braisted
Rear Admiral Harold M. Briggs
Rear Admiral WilliamA. Brockett*
Rear Admiral Charles B. Brooks, Jr.
Rear Admiral James A. Brown*
Rear Admiral Henry C. Bruton
Rear Admiral Louis A. Bryan*
Rear Admiral Charles A. Buchanan
Rear Admiral Thomas Burrowes
Rear Admiral Robert L. Campbell
Rear Admiral Milton O. Carlson
Rear Admiral Worrall R. Carter
Rear Admiral Robert W. Cavenagh*
Rear Admiral Lester S. Chambers*
Rear Admiral John L. Chew*
Rear Admiral Ernest E. Christensen*
Rear Admiral David H. Clark
Rear Admiral Henry G. Clark, CEC
Rear Admiral Sherman R. Clark
Rear Admiral Leonidas D. Coates, Jr.
Rear Admiral Howard L. Collins
Rear Admiral Joshua W. Cooper
Rear Admiral Roy T. Cowdrey
Rear Admiral Ormond L. Cox
Rear Admiral Richard S. Craighill*
Rear Admiral Frederick G. Crisp
Rear Admiral Robert E. Cronin
Rear Admiral Charles A. Curtze
Rear Admiral John E. Dacey*
Rear Admiral Lawrence R. Daspit*
Rear Admiral James R. Davis, CEC*
Rear Admiral James W. Davis
Rear Admiral James C. Dempsey*
Rear Admiral Vincent P. de Poix*
Rear Admiral Joseph E. Dodson

Rear Admiral William A. Dolan, Jr.
Rear Admiral Marshall E. Dornin*
Rear Admiral Jack S. Dorsey*
Rear Admiral Jennings B. Dow
Rear Admiral Wallace R. Dowd
Rear Admiral Louis Dreller
Rear Admiral Norman J. Drustrup, CEC*
Rear Admiral Clifford H. Duerfeldt
Rear Admiral Charles A. Dunn
Rear Admiral Donald T. Eller
Rear Admiral Robert B. Ellis
Rear Admiral Edward J. Fahy*
Rear Admiral James M. Farrin, Jr.
Rear Admiral Emerson E. Fawkes*
Rear Admiral John J. Fee*
Rear Admiral William E. Ferrall
Rear Admiral Charles W. Fisher
Rear Admiral Henry C. Flanagan
Rear Admiral Eugene B. Fluckey*
Rear Admiral Mason B. Freeman*
Rear Admiral Laurence H. Frost
Rear Admiral Robert B. Fulton, II*
Rear Admiral Julius A. Furer
Rear Admiral Daniel V. Gallery
Rear Admiral Fillmore B. Gilkeson*
Rear Admiral Robert O. Glover
Rear Admiral Willard K. Goodney
Rear Admiral Arthur R. Gralla*
Rear Admiral Lucien McK. Grant
Rear Admiral Edward E. Grimm*
Rear Admiral Peter W. Haas, Jr.
Rear Admiral Ira F. Haddock, SC*
Rear Admiral Frederick E. Haeberle
Rear Admiral Wesley M. Hague
Rear Admiral Grover B. H. Hall
Rear Admiral Lloyd Harrison
Rear Admiral Hugh E. Haven
Rear Admiral Frederick V. H. Hilles
Rear Admiral Wellington T. Hines
Rear Admiral Morris A. Hirsch*
Rear Admiral George A. Holderness, Jr.
Rear Admiral Paul A. Holmberg*
Rear Admiral Ralston S. Holmes
Rear Admiral Ernest C. Holtzworth
Rear Admiral Leroy V. Honsinger
Rear Admiral Edwin B. Hooper*
Rear Admiral Harold A. Houser
Rear Admiral Herbert S. Howard
Rear Admiral Miles H. Hubbard
Rear Admiral Harry Hull*
Rear Admiral James McC. Irish
Rear Admiral William D. Irvin*
Rear Admiral Joseph A. Jaap*
Major General Samuel S. Jack
Major General Arnold W. Jacobsen
Rear Admiral Ralph K. James
Rear Admiral Frank L. Johnson*
Rear Admiral Horace B. Jones, CEC
Rear Admiral Timothy J. Keleher
Rear Admiral Sherman S. Kennedy
Rear Admiral Husband E. Kimmel
Rear Admiral Grover C. Klein
Rear Admiral Denys W. Knoll*
Rear Admiral Sydney M. Kraus
Rear Admiral Thomas R. Kurtz, Jr.
Rear Admiral David Lambert*
Major General Frank H. Lamson-Scribner
Rear Admiral Martin J. Lawrence
Rear Admiral William H. Leahy
Rear Admiral Joseph W. Leverton, Jr.
Rear Admiral John K. Leydon*
Rear Admiral Theodore C. Lonnquest
Rear Admiral Almon E. Loomis
Rear Admiral Wayne R. Loud
Rear Admiral Charles H. Lyman, III
Major General William G. Manley
Rear Admiral Charles F. Martin
Rear Admiral John B. McGovern
Rear Admiral Eugene B. McKinney
Rear Admiral Kenmore M. McManes
Rear Admiral Robert W. McNitt*
Rear Admiral John H. McQuilken*
Rear Admiral Wm. K. Mendenhall, Jr.
Major General Lewie G. Merritt
Rear Admiral William Miller
Rear Admiral Benjamin E. Moore*
Rear Admiral Robert L. Moore, Jr.
Rear Admiral Armand M. Morgan
Rear Admiral Thomas H. Morton
Rear Admiral Albert G. Mumma
Rear Admiral Joseph N. Murphy
Rear Admiral William T. Nelson
Rear Admiral Charles A. Nicholson, II
Rear Admiral Robert H. Northwood, SC*
Rear Admiral Ira H. Nunn
Rear Admiral Emmet O'Beirne
Rear Admiral Edward J. O'Donnell*
Rear Admiral Clarence E. Olsen
Rear Admiral Ernest M. Pace
Rear Admiral Charles J. Palmer
Rear Admiral Lewis S. Parks
Rear Admiral Goldsborough S. Patrick
Rear Admiral John B. Pearson, Jr.
Rear Admiral Henry S. Persons*
Rear Admiral William F. Petrovic*
Rear Admiral Carl J. Pfingstag
Rear Admiral Richard H. Phillips
Rear Admiral Ben B. Pickett*
Rear Admiral Paul E. Pihl
Rear Admiral Frank L. Pinney, Jr.*
Rear Admiral Walter H. Price
Rear Admiral Schuyler N. Pyne
Rear Admiral John Quinn
Rear Admiral Joseph R. Redman
Rear Admiral Harry L. Reiter, Jr.*
Rear Admiral Henry A. Renken*
Rear Admiral Joseph E. Rice*
Rear Admiral Lawrence B. Richardson
Rear Admiral Basil N. Rittenhouse, Jr.
Rear Admiral Walter F. Rodee
Rear Admiral William K. Romoser
Rear Admiral Gordon Rowe
Rear Admiral Donald Royce
Rear Admiral Edward A. Ruckner*
Rear Admiral Thomas J. Rudden, Jr.*
Rear Admiral George L. Russell
Rear Admiral Dennis L. Ryan
Rear Admiral Ben W. Sarver*
Rear Admiral Malcolm F. Schoeffel
Rear Admiral Floyd B. Schultz*
Rear Admiral John N. Shaffer*
Rear Admiral William B. Sieglaff*
Rear Admiral Harry Smith
Rear Admiral John V. Smith*
Rear Admiral Levering Smith*
Rear Admiral John A. Snackenberg
Rear Admiral Philip W. Snyder
Rear Admiral Thorvald A. Solberg
Rear Admiral Edward A. Solomons
Rear Admiral Robert H. Speck*
Rear Admiral Frederick C. Stelter, Jr.
Rear Admiral Edward C. Stephan
Rear Admiral Earl E. Stone
Rear Admiral Charles W. Styer
Rear Admiral Robert L. Swart
Rear Admiral William E. Sweeney*
Rear Admiral Evander W. Sylvester
Rear Admiral Frank R. Talbot
Rear Admiral Raymond D. Tarbuck
Rear Admiral Arthur H. Taylor
Rear Admiral John McN. Taylor*
Rear Admiral Theodore A. Torgerson*
Rear Admiral George C. Towner
Rear Admiral Robert L. Townsend*
Rear Admiral David M. Tyree
Rear Admiral Alexander H. Van Keuren
Rear Admiral Frank Virden
Rear Admiral John R. Wadleigh*
Rear Admiral George H. Wales
Rear Admiral Thomas J. Walker, III*
Rear Admiral Frederick B. Warder
Rear Admiral William W. Warlick
Rear Admiral Odale D. Waters, Jr.*
Rear Admiral Hazlett P. Weatherwax
Rear Admiral Ralph Weymouth*
Rear Admiral Charles D. Wheelock
Rear Admiral Francis T. Williamson
Rear Admiral Frederick S. Withington
Rear Admiral Edward A. Wright
Rear Admiral Howard A. Yeager*
Rear Admiral Elmer E. Yeomans
Major General Keith B. McCutcheon*
Commodore Harry A. Badt
Commodore Harold Dodd
Brigadier General Edward C. Dyer
Commodore Stanley D. Jupp
Commodore John H. Magruder, Jr.
Brigadier General Ivan W. Miller
Commodore Robert E. Robinson, Jr.
Commodore Henry A. Schade
Commodore Oscar Smith
Commodore Ralph S. Wentworth

Rear Admiral Selectees:

CAPT Roy G. Anderson*
CAPT Ernest W. Dobie, Jr.*
CAPT Alexander S. Goodfellow, Jr.*
CAPT William E. Lemos*
CAPT Frederick H. Michaelis*
CAPT Thomas R. Weschler*

HISTORY

The U. S. Naval Postgraduate School had a modest beginning at the Naval Academy at Annapolis in 1909, at which time the first class of ten officers enrolled in a Marine Engineering curriculum. The need for technically educated officers became evident at the turn of the century. The idea of a naval graduate school had its inception in a course of instruction in Marine Engineering which the Bureau of Engineering instituted in 1904. The results of this course were so encouraging that in 1909 the Secretary of the Navy established a School of Marine Engineering at the Naval Academy in Annapolis. In 1912 the School was designated the Postgraduate Department of the U. S. Naval Academy.

The operation of the school was temporarily suspended during World War I, but in 1919 classes were resumed in converted Marine Barracks on the Naval Academy grounds. At this time curricula in Mechanical Engineering and Electrical Engineering were added. With the passing years other curricula — Ordnance Engineering, Radio Engineering, Aerological Engineering and Aeronautical Engineerin — were added as the Navy's need for officers with technical knowledge in these fields became evident.

In 1927 the General Line Curriculum was established within the Postgraduate School to provide courses of instruction to acquaint junior line officers returning from sea duty with modern developments taking place in the Navy. The courses dealt with naval and military subjects for the most part. The General Line Curriculum remained as an integral part of the Postgraduate Department until the declaration of the emergency prior to the outbreak of World War II, at which time it was discontinued because of the need for officers in the growing fleet.

The enrollment in the Postgraduate School increased rapidly in the war years both in the several engineering curricula and in the communications curriculum which was added to meet the need for trained communication officers in the naval establishment. The School outgrew its quarters necessitating the building of an annex to house the additional classrooms and laboratories required, but even with this addition, the space requirements of the expanded school were not met.

The post-war program called for still further expansion and the re-establishment of the General Line Curriculum with a greatly increased enrollment. In 1946 the General Line School was established at Newport, Rhode Island, as an outlying element of the Postgraduate School and continued until disestablished in 1952; in 1948 an additional General Line School was established at Monterey, California. The objective of the General Line School program — that of providing an integrated course in naval science to broaden the professional knowledge of unrestricted line officers of the Regular Navy — continued in effect as it had since the inception of this program. From 1946 until 1955 a curriculum varying in length from six months to one year provided such a course for Reserve and ex-Temporary officers who had transferred to Regular status. From 1955 to 1962, the curriculum was of nine and one-half months duration.

The physical growth of the School and its increase in scope and importance were recognized in Congressional action which resulted in legislation during the years of 1945 to 1951 emphasizing the academic stature of the School, and providing for continued growth in a new location with modern buildings and equipment. This legislation authorized the Superintendent to confer Bachelor's, Master's, and Doctor's degrees in engineering and related subjects; created the position of Academic Dean to insure continuity in academic policy; established the School as a separate naval activity to be known as the United States Naval Postgraduate School; authorized the establishment of the School at Monterey, California; provided funds to initiate the construction of buildings to house modern laboratories and classrooms at that location.

On 22 December 1951, by order of the Secretary of the Navy, the United States Naval Postgraduate School was officially disestablished at Annapolis, Maryland, and established at Monterey, California. This completed the transfer of the School from the East to the West Coast, which had begun in 1948 when Aerology Department and Curricular office were moved to the new location. Concurrently with this relocation the U. S. Naval School (General Line) at Monterey was disestablished as a separate military command and its functions and facilities were assumed by the U. S. Naval Postgraduate School. At the same time, there was established the U. S. Naval Administrative Command, U. S. Naval Postgraduate School, Monterey, to provide logistic support, including supply, public works, medical and dental functions, for the Naval Postgraduate School and its components.

In June 1956, by direction of the Chief of Naval Personnel, the Navy Management School was established as an additional component of the Postgraduate School. Its mission was to provide an educational program for officers in the application of sound scientific management practice to the complex organizational structure and operation of the Navy with a view to increasing efficiency and economy of operation. The first class included only Supply and Civil Engineering Corps officers and emphasis was placed on general management theory, financial management, and inventory management. In August 1957 this school was expanded to include input from both Line and Staff Corps officers. Since that time the curriculum has been under constant revision to include new areas of import to, and changes of concept in, the field of management. In August 1960, the school curriculum was lengthened from a five to a ten month course leading to a master's degree for those who can meet the requirements for such a degree. Commencing in August 1964 the Management Curriculum was lengthened from a four to a five term course, thus requiring 12 months for completion.

Discussions commenced in mid-1957 resulted in the establishment in August 1958 of a Bachelor of Science curriculum in the General Line School and a change in the name of that school, effective 1 July 1958, to the General Line and Naval Science School. The new curriculum, with planned semi-annual input of 50 officers, was to become a part of the Navy's Five-Term Program, with the long range prospect of having the entire program carried out at Monterey.

The curriculum was to include subjects taught in the General Line curriculum plus new courses adequate in number, level, and scope to support a degree of bachelor of science, no major designated. The success of the program through the early classes led to the addition of an Arts program in August 1961 to provide for those officers whose previous education emphasized the humanities rather than science and mathematics.

The continuing growth and projected expansion of the School led the Superintendent to establish, in the fall of 1961, a special group of staff and faculty members to study internal organization. The outgrowth of this study coupled with further deliberations of the Superintendent and other staff and faculty members was the decision to undergo major reorganization. In June 1962, the Administrative Command was disestablished as a separate command, its functions continuing to be performed by personnel reporting to a new Director of Administrative and Logistic Services. In August 1962, the three component schools were disestablished and a completely new organization became effective. There is now but one School — the U. S. Naval Postgraduate School — with unified policy, procedure, and purpose. The position of Chief of Staff was replaced by Deputy Superintendent and responsibility for the operation of the academic programs was placed under the dual control of a naval officer Director of Programs and a civilian Dean of Programs.

ORGANIZATION AND FUNCTIONS

The Superintendent of the Postgraduate School is a rear admiral of the line of the Navy. His principal assistants are a Deputy Superintendent who is a captain of the line, and an Academic Dean who is the senior member of the civilian faculty.

The academic programs and direct supporting functions are administered and operated through a unique organization composed of Curricular Offices and Academic Departments. The former are staffed by naval officers whose primary fuctions are threefold: (1) academic and military supervision and direction of officer students; (2) coordinating, in conjunction with Academic Associates, the elements of each curriculum within their program areas; and (3) conducting liaison with curricula sponsor representatives. Officer students are grouped into the following curricular programs areas:

Aeronautical Engineering
Electronics and Communications Engineering
Ordnance Engineering
Naval Engineering
Environmental Sciences
Naval Management and Operations Analysis
Engineering Science
General Line and Baccalaureate

Officer students in each curricula group pursue similar or closely related curricula. With most of these areas a common core program of study is followed for at least half the period of residency.

Objectives and details of curricula are contained elsewhere in this catalogue.

The teaching functions of classroom and laboratory instruction and thesis supervision are accomplished by a faculty which is organized into eleven academic departments:

- Aeronautics
- Business Administration and Economics
- Electrical Engineering
- Government and Humanities
- Material Science and Chemistry
- Mathematics
- Mechanical Engineering
- Meteorology and Oceanography
- Naval Warfare
- Operations Analysis
- Physics

Approximately two-thirds of the teaching staff are civilians of varying professorial rank and the remainder naval officers. The latter are spread amongst most of the departments with the majority being in the Department of Naval Warfare which offers courses only in the naval professional area.

Detailed listings of faculty members and course offerings are contained in later sections of the catalogue.

The Academic Program organization just described is tied together at the top by a naval officer Director of Programs and a civilian Dean of Programs who collaborate to share jointly the responsibilities for planning, conduct and administration of the several educational programs. An Executive Assistant to the Director of Programs similarly shares curricular responsibilities with a Dean of Curricula in a position just above the Curricular Officers.

The close tie between elements of this dual organization is further typified by the Academic Associates. These are individual civilian faculty members appointed by the Academic Dean to work closely with the Curricular Officers in the development and continuing monitoring of curricula — the Navy's needs being the responsibility of the Curricular Officer and academic soundness being the responsibility of the Academic Associate.

The educational programs conducted at Monterey fall into several general categories:

a. Engineering and scientific education leading to designated baccalaureate and/or advanced degrees.

b. Management education to the Master's level.

c. Undergraduate education leading to a first baccalaureate degree, either B.S. or B.A.

d. Navy professional type education designed to build upon and/or broaden the base of professional experience.

Supplementing category a. above is a program entitled Engineering Science. The major portion of the officers selected for this program undergo two terms of refresher and prerequisite study. Those who are so motivated and available for the requisite time may be selected by the Superintendent for a two or three year engineering or science curriculum. Those not selected continue in a non-degree program with the primary objective of basic scientific education which will better prepare them for advanced functional training and/or general updating in technical areas.

Logistic service support is rendered by conventional departments such as Supply and Disbursing, Public Works, Dental, Public Affairs and Visit Liaison, etc., grouped organizationally under a Director of Administrative and Logistic Services. Certain other offices such as those of the Comptroller and Plans are directly responsible to the Deputy Superintendent in a slightly modified but typical naval staff organization.

FACILITIES

The School is located about one mile east of downtown Monterey on the site of the former Del Monte Hotel. Modern classroom and laboratory buildings have been constructed and are situated on a beautifully landscaped campus. A group of buildings comprising new Aeronautical Propulsion Laboratories has recently been completed.

The Superintendent and central administrative officers are located in the main building of the former hotel, now called Herrmann Hall. The East wing of the main building complex has been converted into classroom and administrative spaces and a portion of the ground floor of the West wing has been similarly converted.

Spanagel, Bullard, Halligan, and Root Halls are modern buildings which are devoted to classroom, laboratory and faculty office spaces. About one-third of Root Hall houses the Library and Reference Center. A fifth new building of matching architectural style is King Hall — the main auditorium.

Additional smaller buildings spread throughout the campus house specialized laboratory facilities as well as various support activities.

STUDENT AND DEPENDENT INFORMATION

Monterey Peninsula and the cities of Monterey, Carmel, Pacific Grove, and Seaside, all within 5 miles of the School, provide community support for the officers of the Postgraduate School.

La Mesa Village, located 3 miles from the School, consisting of former Wherry Housing and new Capehart Housing, contains 608 units of public quarters for naval personnel. An elementary school is located within the housing area.

The Naval Auxiliary Landing Field is located about one mile from the School. Aircraft are available for maintaining flight proficiency. Cross-country flights up to 1200 miles are now permitted. One half-day each week is scheduled for flying as part of the student work-week.

On the main School grounds are 149 BOQ rooms, an Open Mess, a Navy Exchange, 4 tennis courts, a large swimming pool and 6 lane bowling alley. An eighteen-tee nine-hole golf course has been built and opened on 1 April 1963. It is located in the old polo ground area across the street from the main campus.

Medical facilities include a Dispensary at the Naval Auxiliary Landing Field, Monterey, supported by the U. S. Army Hospital, Ford Ord (7 miles away) and the U. S. Navy Hospital at Oakland (120 miles away). A Dental Clinic is located in Herrmann Hall.

ADMISSIONS PROCEDURES

U. S. Navy officers interested in admission to one of the curricula offered at the Postgraduate School are referred to BuPers Notice 1520, Subject: Postgraduate and Undergraduate Education Programs, which is published annually by the Chief of Naval Personnel. This directive outlines the various educational programs available and indicates the method of submitting requests for consideration for each program.

A selection board is convened annually by the Chief of Naval Personnel to select officers, based upon professional performance, academic background, and ability, within quotas which reflect the Navy's requirements in the various fields of study available. Officers will be notified of selection by a BuPers Notice at the earliest feasible date after the meeting of the selection board, or by official correspondence.

The curriculum numbers as assigned in the annual BuPers Notice 1520 are repeated in the title of each curriculum and are also included in the list of curricula at the Postgraduate School on page 26 and the list of curricula conducted at civilian institutions on page 64.

Officers on duty with other branches of service are eligible to attend the Postgraduate School. They should apply in accordance with the directives promulgated by the Department of the Army, Department of the Air Force, Commandant U. S. Marine Corps, or the Commandant U. S. Coast Guard, as appropriate.

DEGREES, ACCREDITATIONS, AND ACADEMIC STANDARDS

The Superintendent is authorized to confer Bachelor's, Master's or Doctor's degrees in engineering or related fields upon qualified graduates of the School. This authority is subject to such regulations as the Secretary of the Navy may prescribe, contingent upon due accreditation from time to time by the appropriate professional authority of the applicable curricula. Recipients of such degrees must be found qualified by the Academic Council in accordance with prescribed academic standards.

The Naval Postgraduate School was accredited in 1962 as a full member of the Western College Association (WCA). Initial accreditation as an associate member was given in 1955 and was renewed in 1959 and 1964. Specific engineering curricula have been accredited by the Engineer's Council for Professional Development (ECPD), originally in 1949, renewed in 1955 and again in 1959.

The term length at the School is 10 weeks. The School's term credit hours are equivalent to two-thirds semester hours, as compared with schools using semesters of 15-16 weeks.

Students' performance is evaluated on the basis of a quality point number assigned to the letter grade achieved in a course as follows:

Performance	*Grade*	*Quality Point Number*
Excellent	A	3.0
Good	B	2.0
Fair	C	1.0
Barely Passing	D	0.0
Failure	X	—1.0

When the term hours value of a course is multiplied by the quality point number of the student's grade, a quality point value for the student's work in that course is obtained. The sum of the quality points for all courses divided by the sum of the term hour value of all courses gives a weighted numerical evaluation of the student's performance termed the Quality Point Rating (QPR). A student achieving a QPR of 2.0 has maintained a B average in all courses undertaken with a proper weight assigned for course hours. Satisfactory academic proficiency at the Naval Postgraduate School has been established at a QPR of 1.0 for all courses of a curriculum.

Officer students have no major duties beyond applying themselves diligently to their studies. It is expected that students will maintain a high level of scholarship and develop attributes which are associated with a scholar seeking knowledge and understanding. Program schedules are such that the student should anticipate spending several hours in evening study each weekday to supplement time available for this purpose between classes.

Courses listed in this catalogue carry a letter designator following the course number to indicate the kind of credit received for the successful completion of that course as follows:

A Graduate Credit
B Graduate or Undergraduate Credit
C Upper Division Credit
D Lower Division Credit
E No credit.

The two numbers in parenthesis (separated by hyphens) following the course title indicate the hours of instruction per week in classroom and laboratory respectively. Laboratory hours are assigned half the value shown in calculating term hours for the credit value of the course. Thus a (3-2) course (having three hours recitation and two hours laboratory) will be assigned a credit value of 4 term hours.

DIPLOMAS OF COMPLETION

Diplomas of Completion are issued to students completing programs which do not offer a degree. To establish eligibility for a Diploma of Completion, a student must obtain an over-all QPR of 1.0 or better. Where applicable, students obtaining a QPR of 2.75 or better will receive Diplomas of Completion "With Distinction."

REQUIREMENTS FOR THE BACCALAUREATE DEGREE

1. A Bachelor's degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well defined major.

2. Admission with suitable advanced standing and a minimum of two academic years of residence at the Naval Postgraduate School are normally required. With the approval of the Academic Council, this residence requirement may be reduced to not less than one academic year in the case of particular students who have had sufficient prior preparation at other institutions.

3. The general requirements for the Bachelor of Science Degree are as follows:

a. 200 term hours of which at least 80 term hours must be at an upper division level.
b. Mathematics through Calculus.
c. 16 term hours of general physics.
d. 10 term hours of general chemistry.
e. 25 term hours of upper division engineering and/or physics.
f. 35 term hours of upper division work in a major field of study.
g. 36 term hours in Humanities and the Social Sciences.

4. The general requirements for the Bachelor of Science Degree in a specified field are as follows:

a. 216 term hours.
b. 36 term hours in Mathematics and the Physical Sciences.
c. 36 term hours in Humanities and the Social Sciences.
d. Departmental requirements for award of degree in the specified field.

5. The general requirements for the Bachelor of Arts Degree are as follows:

a. 200 term hours of which at least 80 term hours must be at an upper division level.
b. 36 term hours in Mathematics and the Physical Sciences.
c. 36 term hours in Humanities and the Social Sciences.
d. 35 term hours of upper division work in a major field of study.

6. To be elegible for the degree, the student must attain a minimum average quality point rating of 1.0 in all courses of his curriculum. In very exceptional cases, small deficiences from this figure may be waived at the discretion of the Academic Council.

7. With due regard for the above requirement, the Academic Council will decide whether or not to recommend the candidate to the Superintendent of the Naval Postgraduate School for the award of the Bachelor's Degree.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

1. The Master's Degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree. Such curricula shall conform to current practice in accredited institutions and shall contain a well defined major.

2. General Postgraduate School minimum requirements for the Master of Science Degree are as follows:

a. 48 term hours of graduate (A and B) level courses.
b. A thesis or its equivalent is required.
c. One academic year in residence.
d. Departmental requirements for the degree in a specified subject.

3. Admission to a program leading to the Master of Science degree requires a baccalaureate degree with appropriate undergraduate preparation for the curriculum to be pursued. If a student enters the Postgraduate School with inadequate undergraduate preparation, he will be required to complete the undergraduate prerequisites in addition to the degree requirements.

4. To be eligible for the Master's Degree, the student must attain a minimum average quality point rating of 2.00 in all the A and B level courses in his curriculum and either 1.50 in the remaining courses or 1.75 in all courses of the curriculum. In very exceptional cases, small deficiences from these grade averages may be waived at the discretion of the Academic Council.

REQUIREMENTS FOR THE DOCTOR'S DEGREE

1. The Doctor's Degree in engineering and related fields is awarded as a result of very meritorious and scholarly achievement in a particular field of study which has been approved by the Academic Council as within the purview of the Naval Postgraduate School. A candidate must exhibit faithful and scholarly application to all prescribed courses of study, achieve a high level of scientific advancement and establish his ability for original investigation. He shall further meet the requirements described in the following paragraphs.

2. Any program leading to the Doctor's degree shall require the equivalent of at least three academic years of study beyond the undergraduate level with at least one academic year being spent at the Naval Postgraduate School.

3. A student seeking to become a candidate for the Doctorate shall hold a Bachelor's degree from a college or university, based on a curriculum that included the prerequisite for full graduate status in the department of his major study, or he shall have pursued successfully an equivalent course of study. The student shall submit his previous record to the Chairman of the Department of his proposed major subject for determination of his acceptability as a Doctoral student.

4. This Chairman will select two or more additional departments and in consultation with the Chairman of these

departments will nominate a Doctoral Committee for the student. The Committee shall consist of five or more members with at least one representative from each of the selected departments. The Chairman of the Department of the major will submit the proposed Committee to the Academic Council for its approval.

5. The Doctoral Committee has full responsibility for prescribing a program of study, which shall include one or more minor fields, suitable to the needs of the student and the requirements for award of the Doctorate.

6. When the program of study in his major and minor fields is essentially complete, the student shall be given qualifying examinations, including tests of his reading knowledge of foreign languages. The selection of these languages depends on the field of study. The minimum is a reading knowledge of German or Russian and a second language selected by his Committee. The language examinations will be conducted by a committee especially appointed by the Academic Council. The other qualifying examinations will cover the major and minor fields of study; they will be both written and oral and will be conducted by the Doctoral Committee. The members of the Academic Council or their delegates will be invited to attend the oral examinations.

7. If the Doctoral Committee decides that the student has successfully completed the qualifying examination, it will report this fact to the Academic Council; the student will then be considered to be a candidate for the Doctorate.

8. The distinct requirement of the Doctorate is successful completion of a scholarly investigation leading to an original and significant contribution to knowledge in the candidate's major area of study. The subject of the investigation must be approved, in advance, by the Doctoral Committee. When the results of the investigation, in the form of a dissertation, are submitted, the Committee will appoint two or more referees who will make individual written reports on the dissertation. The Committee will make the final decision on the acceptance of the dissertation.

9. After the approval of the dissertation, and not later than two weeks prior to the award of the degree, the Committee will conduct a final oral examinaiton of the candidate. The members of the Academic Council or their delegates will be invited to attend the examination. In this final examination, the candidate will be asked to defend his Dissertation and in addition shall be questioned on any subject deemed important to the Committee. Upon completion of the final examination the Committee will nominate the successful candidate to the Academic Council for the award of the Doctor's Degree. The Committee will supply to the Council such information concerning the candidate as may be requested by the Council Secretary.

10. With due regard for all the requirements for awarding the Doctorate and the recommendations of the Doctoral Committee, the Academic Council will make the final decision to recommend the candidate to the Superintendent of the Naval Postgraduate School for the award of the degree.

THE LIBRARIES

DESCRIPTION

The Library system serves the research and instructional needs of the community comprising students, faculty, and staff of all departments of the School. It embraces an active collection of 114,500 books, 180,000 technical documents, over 2400 periodical works currently received, and 140,000 abstract cards and microcards. These materials parallel the School's curricular fields of engineering, physical sciences, industrial engineering, management, naval sciences, government and the humanities.

The Reference Library, located at the southeast end of Root Hall, provides the open literature sources such as books, periodicals and journals, indexes and abstracting services, pamphlet materials and newspapers. It also furnishes facilities for microfilming and microfilm reading, for photographic and contact reproduction of printed matter, and for borrowing, from other libraries, publications not held in its collections.

The Technical Reports and Classified Materials Section is the principal repository for technical research documents received by the School. It houses 180,000 documents, 65,000 of which are classified, and exercises control over the microcard collection. A machine information storage and retrieval system that utilizes the School's computer facilities is now available for literature searches of documents received since November, 1960.

The Christopher Buckley, Jr., Library is a branch of the Reference Library and is located on the first floor adjacent to the lobby. It is a collection of some 8,000 volumes pertaining principally to naval history and the sea. The establishment of this collection was made possible by the interest and generosity of Mr. Christopher Buckley, Pebble Beach, California, who has been donating books to the School for this Library since 1949.

Library Facilities

STAFF

George R. Luckett, Professor and Librarian (1950); B.S., Johns Hopkins University, 1949; M.S., Catholic University, 1951.

Paul Spinks, Associate Professor and Associate Librarian (1959); B.A., University of Oklahoma, 1958; M.S., University of Oklahoma, 1959.

Edgar R. Larson, Assistant Professor and Reader Services Librarian (1959); B.A., University of Washington, 1939; B.S., University of Washington, 1950.

Janusz I. Kodrebski, Assistant Professor and Head Cataloger (1956); Officer's Diploma, National War College, Warsaw, Poland, 1938; M.S., University of Southern California, 1955.

Janusz Tyskziewicz-Lacki, Assistant Professor and Technical Reports Librarian (1961); Absolutorium, University of Poznan, Poland. 1924; M.S., University of California, Berkeley, 1958.

Georgia P. Lyke, Reference Librarian (1952); A.A., Hartnell College, 1940.

Mabel Van Vorhis, Librarian, Physical Sciences and Engineering (1955): B.A., University of California. Berkeley, 1926.

Robert Moran Tierney, Acquisitions Librarian (1957): B.A., Columbia University, 1937: M.A., San Jose State College, 1962.

Alice M. Stude, Cataloger (1957); B.S., University of Minnesota, 1930; M.S., University of California, Berkeley, 1961.

Elsa M. Kuswalt, Cataloger (1958); B.A., University of California, Berkeley, 1957.

Doris Baron, Librarian, Physical Sciences and Engineering (1961); B.A., University of California, Berkeley, 1946; M.S., University of Southern California, Los Angeles, 1960.

Arline Hall Hayden, Librarian (General) (1965); B.A., University of California, Berkeley, 1963; M.L.S., University of California, Berkeley, 1964.

Mary T. Britt, Librarian (1966); B.S., College of St. Catherine, 1947.

Beth Peterson, Cataloger (1958); A.A., Red Oak College, 1938.

Spanagel Hall

LABORATORY FACILITIES

Extensive laboratory experimentation is carried on in connection with the instructional and research programs of the various departments. The experimental facilities have been greatly improved and expanded in recent years, and further improvement is planned for the future.

The AERONAUTICAL LABORATORIES contain facilities for experimentation and research in aerodynamics, structural and stress analysis, aerothermodynamics, rocket and jet propulsion, and turbomachinery.

The Subsonic Aerodynamics Laboratory consists of two subsonic wind tunnels, one with a 32x45 inch test section and a speed range up to 185 knots, and the other with a 42x60 inch test section and a speed range up to 200 knots. Force and moment beam balances measure aerodynamic reactions. A small classroom wind tunnel, 7x10 inches in cross-section, and a small two-dimensional smoke tunnel are also in use. Equipment for operating powered propeller aircraft models is available. Experiments in boundary layers, pressure distribution, component aerodynamics, performance and dynamics can be performed.

The Structural Test Laboratory contains testing machines with varying capacities up to 600,000 pounds for demonstration and analysis of relatively small structures. Large aircraft components such as a P2V wing, a F8U-3 wing, and an A3D tail are accommodated on the loading floor of the laboratory where static vibration tests are carried out.

The Dynamics Test Laboratory uses a 20 amplifier analog computer, two electromagnetic shakers, and associated electronic instrumentation for demonstrations of the principles of structural dynamics.

The facilities of the Compressibility Laboratory include a transonic wind tunnel having a 4″x16″ test section and operating in the Mach number range from 0.4 to 1.4; a supersonic wind tunnel having a 4″x4″ test section and a vertical free-jet of 1″x1″ cross-section, both operating in the Mach number range from 1.4 to 4; and a 4″x16″ shock tube. Instruments associated with these facilities include a 9″ and 6″ Mach-Zehnder interferometers and 9″ and 5″ Schlieren systems for flow observations.

The Rocket and Jet Engine Laboratory facilities provide for full scale operation of current and future Naval aircraft jet engines, and for small rocket engines of 2,000 pounds thrust or less. Two separate and complete test cells are provided in one building for the operations of a J57 engine with afterburner and for the future installation of a T56 turboprop engine. A separate engine maintenance shop is located adjacent to these test cells. A separately located external pad and control house are also in use for the operation of a J34 jet engine and a Boeing XT-50 turboprop engine. Rocket engine tests can be run from a common control room in three test cells housed in the rocket engine building, which also contains a propellant chemistry laboratory. The three test cells provide for operation of solid rocket engines, liquid rocket engines, and hybrid or experimental engines.

The advanced facilities of the Cascade and Turbomachinery Laboratories are distributed in three buildings, one of which provides low speed tests with rectilinear, cylindrical and rotating cascades of large dimensions. The source of air is a 700 HP fan, used either to draw or to blow air through the test items. The fan delivers about 100,000 cfm of air at a pressure difference of about 40 inches of water. The fan can be run at speeds of 50% and 75% of the design speed. This source can be used also to perform model tests with flow channels, inlet and discharge casings, scrolls and diffusors. The special rectilinear cascade test rig is equipped with semi-automatic instrumentation; data are obtained with an electronic logging system for data reduction on digital computers. A second building houses a centrifugal compressor test rig, instrumented for conventional performance measurements and for special investigations of three-dimensional flows about both the stationary and the rotating vanes. The third building is devoted to high speed tests, in three tests cells, monitored from a central control room. A 1250 HP variable-speed axial-flow compressor, which is instrumented also for interstage measurements, produces high pressure air either for turbine testing, or to drive test compressors, pumps, and other test items. The compressor is capable of delivering 10,000 cfm of air at sea-level conditions. The design pressure ratio is three, and speed control is possible between 40% and 100% of design speed by means of a hydraulic drive. A surge-suppressing device makes it possible to operate test items with greatly varying flow rates. Data acquisition is carried out with an electronic logging system as well as with conventional instrumentation. Adjacent to the third building is a hotspin test unit, where disks and propellers can be rotated at speeds up to 50,000 rpm. Heating and cooling elements make it possible to impose radial temperature gradients. Instrumentation is provided to conduct stress work, with strain gauges, up to 27,000 rpm and at maximum temperatures of 1800°F.

The CHEMICAL LABORATORIES provide facilities for undergraduate and graduate study and research in chemistry and chemical engineering. Included for these purposes are: a radio-chemistry ("hot") laboratory with Geiger and scintillation counters and special apparatus for handling and testing radio-active materials; a molecular spectroscopy laboratory, including high resolution infra-red and ultra-violet spectrophotometers, an electron paramagnetic resonance spectrometer, and associated high vacuum manifolds; a chemical instruments laboratory for instruction in the use and theory behind obtaining data with infra-red and ultraviolet spectrophotometers, vapor fractometers, refractometers, vapor pressure osmometers, polarographs, and other instruments commonly used for chemical determinations. A plastics laboratory is available where plastics are synthesized, molded in compression or injection presses, and their mechanical, physical, and chemical properties are determined. The department has a well-equipped fuel and lubricant laboratory, and an explosives laboratory with impact tester, ballistics mortar, chronograph and other apparatus for evaluating explosives. In the rocket propellent laboratory, small batches of solid propellents can be produced and many of the ballistic parameters and mechanical properties measured. Facilities are available for burning rate studies. Thrust stands in the adjoining facility provide for static firing of solid and liquid propellent motors.

The COMPUTER FACILITY provides a variety of services to the school. Its primary function is to support the academic programs, serving as a laboratory adjunct to courses on computer programming, logical design and the use of computers in solving scientific and engineering problems as well as those of interest specifically to the Navy. The Facility has a small permanent staff of programmer/mathematicians who provide a consulting service to students and faculty in programming and problem formulation. In addition, their efforts are concentrated toward developing and maintaining a good library of programs and subroutines, improving programming systems and, generally, creating a suitable environment for class and research use of computers. Current Facility activity includes work in the areas of scientific and engineering computing systems programming, information retrieval, simulation and student administration.

The School owns the following digital computers: a Control Data Corporation (CDC) 1604, 2 CDC 160's and an IBM 1401. Both CDC 160 Computers are connected to the CDC 1604 in a satellite mode, thus providing a moderately complex computer system with which to study and develop experience in machine-machine interactions such as those encountered in operational units in the Navy.

During FY '67, the School plans to replace some or all of the above equipment with a large multi-processor system accessible simultaneously to users at remote terminals on the campus. The configuration will provide a general-purpose time-sharing service of an advanced nature for direct on-line programming and control of laboratory experiments. The equipment in the remote stations will range from typewriters in academic departments to a small independent computer in the Digital Control Laboratory.

The ELECTRICAL ENGINEERING LABORATORIES have ample facilities for comprehensive instructional and research programs in all phases of present-day electrical engineering, including electrical circuits, machinery and measurements, electronic devices, circuits and systems, feedback control mechanisms and systems, and computer technology.

The extensive conventional facilities in the Electrical Circuits and Machinery Laboratories are supplemented by special bridges and other measuring equipment, data-recording devices and generalized machine sets. Analog computers are available for simulation and analysis of circuits and machines.

In the Electronics Laboratories, facilities are provided for investigating the characteristics of modern electronic devices, circuits and equipments at frequencies ranging from d-c to the optical region. Available systems include representative communications, radar, telemetry, sonar and countermeasures systems, and navigational aids. Special facilities are available for intensive study of transmission and radiation properties of electromagnetic energy, including a micro-wave anechoic chamber and an antenna model range.

The Digital Control Laboratory provides special computational facilities, including a satellite digital processor, a hybrid linkage system and versatile computer accessing displays. These facilities support studies in signal processing, digital communications, surveillance and tracking, control theory, computer programming, time-sharing systems, tactical simulation and war gaming.

The Servomechanisms Laboratory is equipped with analyzers, recorders and the basic units required to synthesize and test a wide variety of systems. Analog computers serve an important role in the synthesis and analysis of control systems.

A Standards and Calibration Laboratory is used for precision measurements and to calibrate the laboratory instruments. Excellent standard frequency sources and standardizing equipment are available.

The *MATERIALS LABORATORIES* are well equipped for both materials science and materials engineering studies and research. For these purposes standard universal testing machines, hardness testers, etc. are available for mechanical property determinations. For metallurgical studies the laboratory is equipped with heat-treating furnaces, metallographs, and microscopes. A plastics laboratory is available for evaluation of the mechanical, physical and chemical properties of plastics. Facilities for basic materials science studies include: several x-ray diffraction units; precision heating and powder cameras; Weissenberg x-ray unit; precision goniometers; recording photo-densitometer, etc. Metal fabricating equipment includes welding facilities, a swaging machine, rolling mill, induction and vacuum melting furnaces and a die-casting machine, and provides facilities for materials processing studies. A laboratory for high and low temperature studies of materials, including creep testing machines, afford additional modern equipment for materials research.

Laboratory equipment for MATHEMATICS now available includes an electronic and analogue computer and a digital differential analyzer both of which are used to find the solutions of differential equations; a specially modified accounting machine used in fine differences computations, a variety of planimeter type instruments including a large precision moment integrator, a Stieltjes integrator and a harmonic analyzer. A large number of modern electric desk calculators are available in the laboratory for numerical methods and statistics. Many special models and demonstrators, including the only two automatic relay controlled Wald Sequential Sampling Machines ever made, and other devices and visual aids in mathematics, probability and mechanics are used in support of courses in these subjects. An 85 foot Foucault Pendulum with an 184 lb. bob is kept in constant operation and display.

The MECHANICAL ENGINEERING LABORATORIES provide facilities for instruction and research in heat-power, heat transfer, fluids mechanics, deformable body mechanics, and dynamics. Noteworthy equipment in the heat-power laboratories includes a gas fired boiler, 200 psi, and 8000 lb/hr, full automatic controls; a 175 HP gas turbine installation, dynamometer loaded; a two dimensional supersonic air nozzle with Schlieren equipment for analysis of shock-wise flows; a two-stage axial flow test compressor; an experimental single cylinder diesel engine; a multistage centrifugal blower; an air flow metering bench; hydraulic test equipment including a two-stage centrifugal pump, a deep well pump, an impulse turbine and a torque converter, a single-blow transient testing facility for compact heat exchanger surfaces; a steam to air facility for testing heat exchangers; and a small cryogenic facility for evaluating cryopumping surfaces.

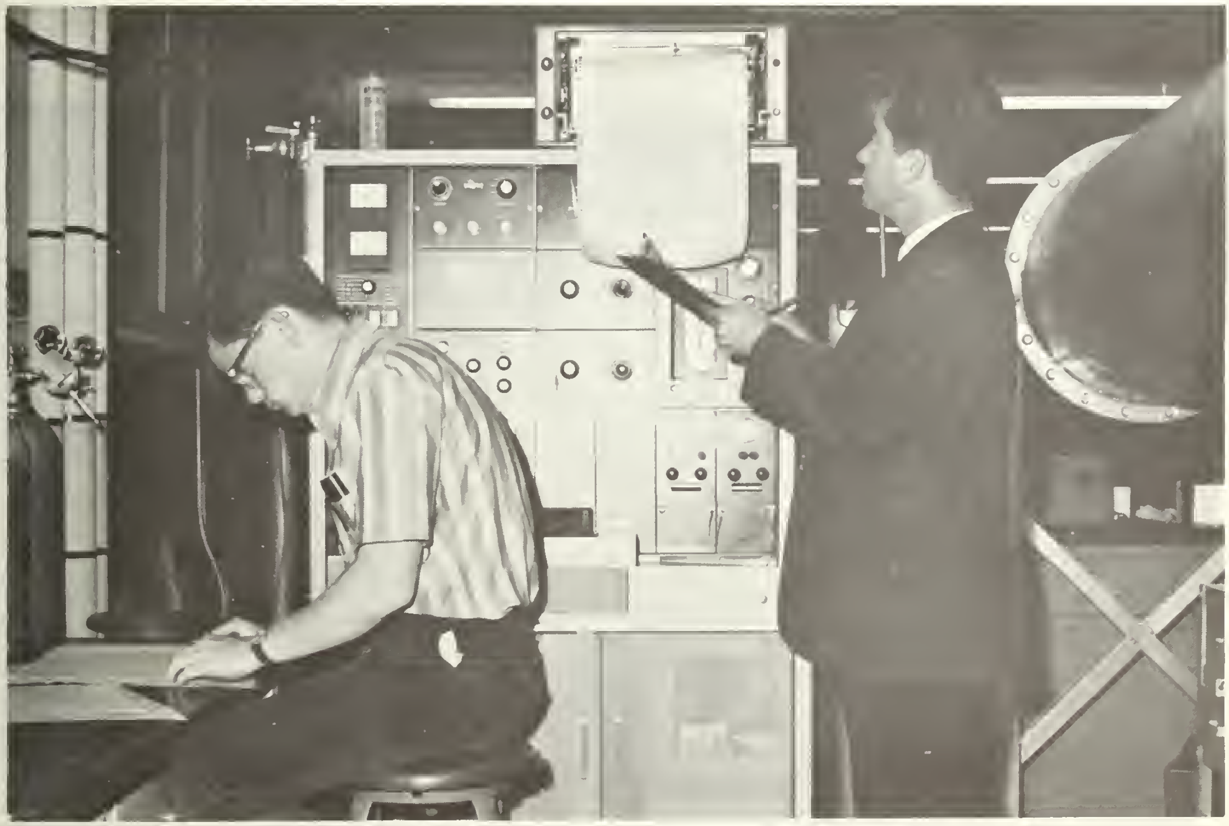
Facilities in the mechanics laboratory include equipment for static, fatigue, and impact testing. Stress analysis equipment includes instrumentation for multi-channel recording of static and dynamic strains, a photoelastic laboratory, and facilities for brittle lacquer studies. Dynamics equipment includes electrodynamic exciters, force and motion transducers and associated instrumentation. An analog computer laboratory provides for electronic simulation of linear and nonlinear engineering systems.

METEOROLOGY AND OCEANOGRAPHY FACILITIES include all instruments in present-day use for measuring the physical and dynamic state of the atmosphere, as well as teletype and facsimile communications equipment for the rapid reception and dissemination of weather data in coded and analyzed form for the entire northern hemisphere.

The instruments for gathering weather data include rawinsonde equipment, which provides a continuous recording of temperature, pressure, humidity and wind direction and velocities at designated levels above the surface; radiosonde equipment whereby pressure, temperature and humidity information is transmitted to ground via radio signals from heights that may extend above 100,000 feet; a wiresonde that measures air temperature and humidity conditions in the lower strata of the atmosphere, and inversion meter designed for remote recordings of free air temperature at designated heights in the boundary layer.

The school has recently installed an automatic picture transmission (APT) receiving apparatus for the reception of pictures from the NIMBUS and TOS weather satellites. Rectification grid templates are used in the laboratories for direct correlation of current satellite pictures with conventional synoptic analyses and nephanalyses.

The proximity of the Fleet Numerical Weather Facility on the school grounds provides introduction to the latest environmental computer products and the high speed data links utilized to provide transmission and automatic reproduction through a world-wide network.



Chemical Fuel Analysis by Gas Chromatography

The school operates a 63-foot boat converted for use in oceanographic instruction and research. It is utilized for actual field oceanographic studies by Environmental Sciences students. Included in its installed equipment are deep and shallow echo sounders, a bathythermograph winch, and a deep sea hydrographic winch using 20,000 feet of wire.

Oceanographic equipment installed in the area near the school include a wave gauge and a tide gauge for recording nearshore wave action and local tide fluctuations.

The PHYSICS LABORATORIES are equipped to carry on instructional and research work in nuclear physics, low temperature and solid state physics, plasma physics, spectroscopy, and acoustics.

The laboratory facilities include a nuclear physics laboratory centering around a two million volt Van de Graaff accelerator, an Aerojet Nucleonics nuclear reactor operating at power levels up to 1000 watts, and an electron linear accelerator with a maximum energy of 100 million electron volts, and 20 micro ampere beam intensity.

In low temperature and solid state physics the equipment includes nitrogen liquifiers, a Collins helium liquifier, He^3 refrigeration equipment to reach temperatures below 1° K, a 12 inch uniform field electromagnet, microwave gear for spin resonance and maser studies, and high frefrequency pulse acoustic equipment for phonon studies.

The plasma physics equipment includes a number of small vacuum systems, a large plasma system, and diagnostic equipment for studies of plasma dynamics. A steady state plasma source with magnetic fields up to 10,000 gauss will soon be available for plasma research. The spectroscopy equipment includes a large grating spectrograph, a large prism spectrograph, and an infrared spectrophotometer.

The acoustics laboratory equipment includes a large anechoic chamber, a small reverberation chamber, and a multiple-unit acoustics laboratory for student experimentation in airborne acoustics. Sonar equipment, test tanks, and instrumentation for investigation in underwater sound comprise the sonar laboratory.

The REACTOR LABORATORY features an AGN-201 reactor which has been recently modified to operate at powers up to 1000 watts. The Laboratory provides facilities and equipment for teaching and research in nuclear physics, radio-chemistry, and reactor physics.

SUPERINTENDENT'S GUEST LECTURE SERIES

During the third and fourth terms, the eighth period on Wednesdays is scheduled for presentation of a lecture series in King Hall for all students, administered by the Director of Programs.

It is the purpose of this series to present eminently qualified speakers to talk on international affairs and naval professional and technical subjects, to inform as well as to challenge the thinking of the officer students in areas outside of their immediate academic pursuits.

Computer Facility

CURRICULAR OFFICES and PROGRAMS

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CURRICULA AT THE POSTGRADUATE SCHOOL

Curriculum	*Curriculum Number*	*Length*	*Convening Dates*
Advanced Science	380	3 yrs.	January, August
Chemistry	380	3 yrs.	January, August
Hydrodynamics	380	3 yrs.	January, August
Mathematics (Applied)	380	3 yrs.	January, August
Material Science	380	3 yrs.	January, August
Physics (General)	380	3 yrs.	January, August
Physics (Nuclear)			
Aeronautical Engineering	610	2 yrs.	January, August
General	610	3 yrs.	January, August
Advanced*			
Electronics and Communications Engineering			
Communications Engineering	600	2 yrs.	January, August
Basic	600	3 yrs.	January, August
Advanced			
Engineering Electronics	590	2 yrs.	January, August
Basic	590	3 yrs.	January, August
Advanced	590	3 yrs.	January, August
Information and Control	472	12-18 mos.	January, August
Special (CEC)	620	1 yr.	August
Staff Communications	460	1 yr.	January, August
Engineering Science			
Environmental Sciences			
Advanced Meteorology	372	2 yrs.	January, August
General Meteorology	372	2 yrs.	January, August
Oceanography	440	2 yrs.	August
General Line and Baccalaureate			
General Line		1 yr.	August
Bachelor of Science	461	2 yrs.	January, August
Bachelor of Arts	461	2 yrs.	January, August
Naval Engineering			
Naval Engineering (Mechanical)	570	2 yrs.	August
Naval Engineering (Electrical)	570	2 yrs.	August
Mechanical Engineering (Advanced)	570	3 yrs.	August
Electrical Engineering (Advanced)	570	3 yrs.	August
Navy Management and Operations Analysis			
Naval Management	817	1 yr.	January, August
Management (Data Processing)	367	1 yr.	January, August
Operations Research/Systems Analysis	360	2 yrs.	January, August
Ordnance Engineering			
Nuclear Engineering (Effects)	521	2 yrs.	August
Underwater Physics Systems			
Basic	535	2 yrs.	August
Advanced	535	3 yrs.	August
Weapons Systems Engineering			
General	530	2 yrs.	January, August
Special	530	2 yrs.	January, August
Advanced			
Air/Space Physics	530	3 yrs.	January, August
Chemistry	530	3 yrs.	January, August
Electronics	530	3 yrs.	January, August

*Usually the third year is taken at a civilian university.

ADVANCED SCIENCE PROGRAMS CURRICULUM NUMBER 380

Chemistry
Hydrodynamics
Material Science
General Physics
Nuclear Physics
Applied Mathematics

Objective—To prepare selected officer personnel to deal with the problem of fundamental and applied research in the fields of general physics, nuclear physics, hydrodynamics, chemistry, material science, and applied mathematics.

Description — Officers nominated for Advanced Science Curricula are selected from among those first-year students enrolled in technical curricula at the Postgraduate School who apply for the Advanced Science Program. Applicants are carefully screened and only those having a very good academic background and who appear to have an excellent chance of succeeding in their chosen field are nominated to the Chief of Naval Personnel.

Officers selected for Advanced Science Curricula complete their first year at the U. S. Naval Postgraduate School, and may spend their second and third years of study at a selected civilian university. The curriculum at the civilian university for each officer is arranged from courses selected to suit the needs of the Navy, to develop the capabilities of the individual student, and to meet the ultimate objective of his specialty.

The Advanced Science Curricula normally lead to the Master of Science degree for those officers meeting the requirements for that degree.

AERONAUTICAL ENGINEERING PROGRAM CURRICULUM NUMBER 610

Robert Stanley Hutches, Commander, U. S. Navy; Curricular Officer; B.S., U. S. Naval Academy, 1945; B.S., Aeronautical Engineering, U. S. Naval Postgraduate School, 1953; M.S., Univ. of Minnesota, 1954; Naval War College, 1962.

Charles Horace Kahr, Jr., Academic Associate (1947); B.S., Univ. of Michigan, 1944; M.S., 1945.

Lawrence Cleveland Chambers, Lieutenant Commander, U. S. Navy; Assistant Curricular Officer; B.S., U. S. Naval Academy, 1952; B.S. Aeronautical Engineering, U. S. Naval Postgraduate School, 1959; M.S. Aeronautical Engineering, Stanford Univ., 1960.

Objective — To provide officers with advanced aeronautical education to meet Navy technical requirements in flight vehicles and their environmental fields. Curricula are edited to suit the field of the major, choosing fundamental or advanced material from mathematics, mechanics, physics, chemistry, metallurgy, structural analysis, aerodynamics, propulsion, electricity, electronics, environmental and vehicle dynamics; also the application of these sciences to flight vehicles and to space technology.

Description — The entrance requirement to the Aeronautical Engineering curricula, General and Graduate, is a Bachelor of Science degree, Naval Academy or its equivalent. The Naval Academy coverage in the basic prerequisite sciences in semester hours in Mathematics (20), Basic Engineering (30), Electrical Engineering (14), Physics (10) and Chemistry (8).

First year courses of study are listed below in a sequence of academic terms following entrance, and include the refresher material usually required, commensurate with the time elapsed from previous academic experience for the majority of officer students. Since students may enter school either in August or in January, the same course sequences are usually offered beginning twice a year and running two calendar terms apart. Considerable flexibility in curricular programming is thereby provided, since one or more of the several course sequences can be delayed or accelerated to four terms according to the needs or the validated advanced standing of each student.

When the first-year curriculum has been essentially completed, students may be nominated for candidacy in one of the graduate curricular options: aerospace dynamics, flight structures, propulsion, or avionics. Courses to suit the option are tabulated below. Students who continue high scholastic achievement may be admitted to a third year either at this School or at one of the civilian institutions listed. Either the Master or the Engineering Degree may be earned in these curricula.

Students who do not enter candidacy for a graduate curriculum may continue in one of the second-year options listed, including the flight performance option, leading to the B.S. (A.E.) Degree.

FIRST YEAR
August Input

First five terms are common to all curricula.

First Term

Ae 101C	Aero-Statics	3- 2
Ae 102C	Aeromechanics	3- 2
Ma 120C	Vectors and Matrices with Geometric Applications	3- 1
Ma 230D	Calculus of Several Variables	4- 0
		13- 5

Second Term

Ae 211C	Solid Mechanics	3- 2
Ae 301C	Technical Aerodynamics	3- 2
Ae 381C	Subsonic Laboratory	0- 3
Ae 401C	Aerothermodynamic Fundamentals	3- 2
Ma 073C	Differential Equations	5- 0
		14- 9

Third Term

Ae 212C	Structural Analysis	3- 2
Ae 302C	Airfoil and Wing Theory	3- 2
Ae 501B	Thermodynamics of Compressible Flow	3- 2
Ae 581B	Gas Dynamics Laboratory	0- 3
Ma 262B	Vector Mechanics	4- 0
		13- 9

Fourth Term

Ae 213B	Structural Components I	3- 2
Ae 303C	Flight Vehicle Performance	3- 3
Ae 402B	Aircraft Propulsion	3- 2
Ae 481B	Propulsion Laboratory	0- 3
EE 105C	Basic Electrical Phenomena	3- 2
		12-12

Fifth Term

Ae 281B	Structures Laboratory	0- 3
EE 106C	Basic Circuit Analysis I	3- 2
Ma 416C	Numerical Methods and FORTRAN Programming	4- 1
MS 208B	Properties of Materials	3- 2
		10- 8

FIRST YEAR
January Input
COMMON CURRICULA

First Term (Term III)

Ae 101C	Aero-Statics	3- 2
Ae 102C	Aeromechanics	3- 2
Ma 120C	Vectors and Matrices with Geometric Applications	3- 1
Ma 230D	Calculus of Several Variables	4- 0
		13- 5

Second Term (Term IV)

Ae 211C	Solid Mechanics	3- 2
Ae 301C	Technical Aerodynamics	3- 2
Ae 381C	Subsonic Laboratory	0- 3
Ae 401C	Aerothermodynamic Fundamentals	3- 2
Ma 073C	Differential Equations	5- 0
		14- 9

Third Term (Term V)

Ae 501B	Thermodynamics of Compressible Flow	3- 2
Ae 581B	Gas Dynamics Laboratory	0- 3
EE 105C	Basic Electrical Phenomena	3- 2
Ma 416C	Numerical Methods and FORTRAN Programming	4- 1
		10- 8

Fourth Term (Term I)

Ae 212C	Structural Analysis	3- 2
Ae 302C	Airfoil and Wing Theory	3- 2
Ae 402B	Aircraft Propulsion	3- 2
Ae 481B	Propulsion Laboratory	0- 3
EE 106C	Basic Circuit Analysis I	3- 2
		12-11

Fifth Term (Term II)

Ae 213B	Structural Components I	3- 2
Ae 281B	Structures Laboratory	0- 3
Ae 303C	Flight Vehicle Performance	3- 3
Ma 262B	Vector Mechanics	4- 0
MS 208B	Properties of Materials	3- 2
		13-10

SECOND YEAR
August Input
AERODYNAMICS (GENERAL)—2 Year B.S. (A.E.)
(Group AG)

First Term

Ae 111B	Fundamentals of Dynamics	3- 2
Ae 181B	Fundamental Dynamics Laboratory	0- 3
Ae 321C	Flight Stability and Control I	3- 3
Ae 420B	Elements of Combustion and Heat Transfer	3- 2
PS 351B	Probability and Statistics	4- 2
		13-12

Second Term

Ae 241B	Elements of Aeroelasticity	3- 2
Ae 322C	Flight Stability and Control II	3- 3
Ae 414B	Fundamentals of Rockets	3- 2
Ae 482B	Thermodynamics Laboratory	0- 3
MN 310C	Engineering Economics	4- 0
		13-10

Third Term

Ae 314B	Adanced Flight Vehicle Performance	3- 2
Ae 502B	Flow Dynamics	4- 0
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
Ae 214B	Structural Components II	3- 2
Ae 283B	Structural Performance	1- 2
		15- 6

Fourth Term

Ae 271B	Fundamentals of Flight Vehicle Design	3- 3
Ae 340B	Fundamentals of Automatic Control	3- 2
Ae 503B	Boundary Layers	4- 0
OA 510B	Systems Analysis	4- 0
		14- 5

SECOND YEAR
August Input
FLIGHT PERFORMANCE—2 Year B.S. (A.E.)
(Group AF)

First Term

Ae 111B	Fundamentals of Dynamics	3- 2
Ae 181B	Fundamental Dynamics Laboratory	0- 3
Ae 321C	Flight Stability and Control I	3- 3
Ae 420B	Elements of Combustion and Heat Transfer	3- 2
PS 351B	Probability and Statistics	4- 2
		13-12

Second Term

Ae 241B	Elements of Aeroelasticity	3- 2
Ae 322C	Flight Stability and Control II	3- 3
Ae 414B	Fundamentals of Rockets	3- 2
Ae 482B	Thermodynamics Laboratory	0- 3
MN 310C	Engineering Economics	4- 0
		13-10

Third Term

Ae 214B	Structural Components II	3- 2
Ae 283B	Structural Performance	1- 2
Ae 314B	Advanced Flight Vehicle Performance	3- 2
Ae 332C	Flight Test Evaluation I	2- 0
Ae 382C	Flight Test Evaluation Laboratory I	0- 4
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		13-10

Fourth Term

Ae 271B	Fundamentals of Flight Vehicle Design	3- 3
Ae 333B	Flight Test Evaluation II	2- 0
Ae 383B	Flight Test Evaluation Laboratory II	0- 4
Ae 340B	Fundamentals of Automatic Control	3- 2
OA 510B	Systems Analysis	4- 0
		12- 9

SECOND YEAR
January Input
AERODYNAMICS (GENERAL)—2 Year B.S. (A.E.)
(Group AG)

First Term (Term III)

Ae 111B	Fundamentals of Dynamics	3- 2
Ae 181B	Fundamental Dynamics Laboratory	0- 3
Ae 321C	Flight Stability and Control I	3- 3
Ae 420B	Elements of Combustion and Heat Transfer	3- 2
PS 351B	Probability and Statistics	4- 2
		13-12

Second Term (Term IV)

Ae 241B	Elements of Aeroelasticity	3- 2
Ae 322C	Flight Stability and Control II	3- 3
Ae 414B	Fundamentals of Rockets	3- 2
Ae 482B	Thermodynamics Laboratory	0- 3
MN 310C	Engineering Economics	4- 0
		13-10

Third Term (Term V)

Ae 214B	Structural Components II	3- 2
Ae 283B	Structural Performance	1- 2
Ae 314B	Advanced Flight Vehicle Performance	3- 2
Ae 502B	Flow Dynamics	4- 0
		11- 6

Fourth Term (Term I)

Ae 271B	Fundamentals of Flight Vehicle Design	3- 3
Ae 340B	Fundamentals of Automatic Control	3- 2
Ae 503B	Boundary Layers	4- 0
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		14- 5

SECOND YEAR
January Input
FLIGHT PERFORMANCE—2 Year B.S. (A.E.)
(Group AF)

First Term (Term III)

Ae 111B	Fundamentals of Dynamics	3- 2
Ae 181B	Fundamental Dynamics Laboratory	0- 3
Ae 321C	Flight Stability and Control I	3- 3
Ae 420B	Elements of Combustion and Heat Transfer	3- 2
PS 351B	Probability and Statistics	4- 2
		13-12

Second Term (Term IV)

Ae 241B	Elements of Aeroelasticity	3- 2
Ae 322C	Flight Stability and Control II	3- 3
Ae 414B	Fundamentals of Rockets	3- 2
Ae 482B	Thermodynamics Laboratory	0- 3
MN 310C	Engineering Economics	4- 0
		13-10

Third Term (Term V)

Ae 214B	Structural Components II	3- 2
Ae 283B	Structural Performance	1- 2
Ae 314B	Advanced Flight Vehicle Performance	3- 2
Ae 332C	Flight Test Evaluation I	2- 0
Ae 382C	Flight Test Evaluation Laboratory I	0- 4
		9-10

Fourth Term (Term I)

Ae 271B	Fundamentals of Flight Vehicle Design	3- 3
Ae 333B	Flight Test Evaluation II	2- 0
Ae 383B	Flight Test Evaluation Laboratory II	0- 4
Ae 340B	Fundamentals of Automatic Control	3- 2
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		12- 9

SECOND YEAR
FLIGHT DYNAMICS—3 Year M.S. (A.E.) or Ae.E.
(Group AA)

First Term (August Input, Term I; January Input, Term III)

Ae 325B	Flight Dynamics I	3- 3
Ae 521A	Fundamentals of Flow Dynamics	4- 0
Ma 272C	Complex Variables	4- 0
Ma 246B	Partial Differential Equations	4- 0
		15- 3

Second Term (August Input, Term II; January Input, Term IV)

Ae 121B	Potential Flows and Boundary Value Problems	3- 2
Ae 326B	Flight Dynamics II	3- 3
Ae 522A	Boundary Layer Flows	4- 0
Ma 248B	Differential Equations for Optimum Control	3- 0
		13- 5

Third Term (August Input, Term III; January Input, Term I)

Ae 327B	Space Vehicle Dynamics	3- 2
Ae 431A	Principles of Turbomachines	4- 0
Ae 483A	Turbomachinery Laboratory	0- 3
Ae 523A	Fundamentals of Compressible Flow	4- 0
Ae	Elective	4- 0
		15- 5

Fourth Term (August Input, Term IV; January Input, Term II)

Ae 341A	Automatic Control I	3- 2
Ae 432A	Advanced Theory of Turbomachines	4- 0
Ae 524A	Supersonic Aerodynamics	3- 2
Ae 583A	Gas Dynamics Laboratory	0- 3
Ae	Elective	4- 0
		14- 7

Term V (Summer) both August and January Inputs
Industrial Tour at assigned aerospace industry.

SECOND YEAR
GAS DYNAMICS—3 Year M.S. (A.E.) or Ae.E. (Group AD)

First Term (August Input, Term I; January Input, Term III)

Ae 115A	Engineering Dynamics I	4- 0
Ae 521A	Fundamentals of Flow Dynamics	4- 0
Ma 272C	Complex Variables	4- 0
Ma 246B	Partial Differential Equations	4- 0
		16- 0

Second Term (August Input, Term II; January Input, Term IV)

Ae 116A	Engineering Dynamics II	4- 0
Ae 121B	Potential Flows and Boundary Value Problems	3- 2
Ae 182A	Engineering Dynamics Laboratory	0- 3
Ae 522A	Boundary Layer Flows	4- 0
Ma 248B	Differential Equations for Optimum Control	3- 0
		14- 5

Third Term (August Input, Term III; January Input, Term I)

Ae 244A	Matrix Structural Analysis	3- 2
Ae 431A	Principles of Turbomachines	4- 0
Ae 483A	Turbomachinery Laboratory	0- 3
Ae 523A	Fundamentals of Compressible Flow	4- 0
Ae	Elective	4- 0
		15- 5

Fourth Term (August Input, Term IV; January Input, Term II)

Ae 245A	Plates and Shells	4- 0
Ae 432A	Advanced Theory of Turbomachines	4- 0
Ae 583A	Gas Dynamics Laboratory	0- 3
Ae 524A	Supersonic Aerodynamics	3- 2
Ae	Elective	4- 0
		15- 5

Term V (Summer) both August and January Inputs
Industrial Tour at assigned aerospace industry.

SECOND YEAR
FLIGHT STRUCTURES—3 Year M.S. (A.E.) or Ae.E. (Group AS)

First Term (August Input, Term I; January Input, Term III)

Ae 115A	Engineering Dynamics I	4- 0
Ae 131A	Continuum Mechanics I	4- 0
Ae 214B	Structural Components II	3- 2
Ae 283B	Structural Performance	1- 2
Ae 325B	Flight Dynamics I	3- 3
		15- 7

Second Term (August Input, Term II; January Input, Term IV)

Ae 116A	Engineering Dynamics II	4- 0
Ae 132A	Continuum Mechanics II	4- 0
Ae 182A	Engineering Dynamics Laboratory	0- 3
Ae 326B	Flight Dynamics II	3- 3
Ma 245B	Partial Differential Equations	3- 0
		14- 6

Third Term (August Input, Term III; January Input, Term I)

Ae 133A	Solid Mechanics I	4- 0
Ae 244A	Matrix Structural Analysis	3- 2
Ae 327B	Space Vehicle Dynamics	3- 2
Ae 521A	Fundamentals of Flow Dynamics	4- 0
		14- 4

Fourth Term (August Input, Term IV; January Input, Term II)

Ae 134A	Solid Mechanics II	4- 0
Ae 245A	Plates and Shells	4- 0
Ae 275A	Flight Vehicle Design	3- 3
Ae 522A	Boundary Layer Flows	4- 0
		15- 3

Term V (Summer) both August and January Inputs
Industrial Tour at assigned aerospace activity.

SECOND YEAR
FLIGHT PROPULSION (ROTATING MACHINERY) 3 Year M.S. (A.E.) or Ae.E. (Group AT)

First Term (August Input, Term I; January Input, Term III)

Ae 115A	Engineering Dynamics I	4- 0
Ae 131A	Continuum Mechanics I	4- 0
Ae 521A	Fundamentals of Flow Dynamics	4- 0
Ma 272C	Complex Variables	4- 0
		16- 0

Second Term (August Input, Term II; January Input, Term IV)

Ae 116A	Engineering Dynamics II	4- 0
Ae 121B	Potential Flows and Boundary Value Problems	3- 2
Ae 182A	Engineering Dynamics Laboratory	0- 3
Ae 132A	Continuum Mechanics II	4- 0
Ae 522A	Boundary Layer Flows	4- 0
		15- 5

Third Term (August Input, Term III; January Input, Term I)

Ae 133A	Solid Mechanics I	4- 0
Ae 431A	Principles of Turbomachines	4- 0
Ae 483A	Turbomachinery Laboratory	0- 3
Ae 523A	Fundamentals of Compressible Flow	4- 0
Ma 246B	Partial Differential Equations	4- 0
		16- 3

Fourth Term (August Input, Term IV; January Input, Term II)

Ae 134A	Solid Mechanics II	4- 0
Ae 432A	Advanced Theory of Turbomachines	4- 0
Ae 583A	Gas Dynamics Laboratory	0- 3
Ae 524A	Supersonic Aerodynamics	3- 2
Ma 248B	Differential Equations for Optimum Control	3- 0
		14- 5

Term V (Summer) both August and January Inputs
Industrial Tour at assigned aerospace industry.

SECOND YEAR
FLIGHT PROPULSION (ROCKETS)
3 Year M.S. (A.E.) or Ae.E.
(Group AR)

First Term (August Input, Term I; January Input, Term III)

Ae 115A	Engineering Dynamics I	4- 0
Ae 410A	Statistical Thermodynamics	3- 2
Ae 521A	Fundamentals of Flow Dynamics	4- 0
Ma 246B	Partial Differential Equations	4- 0
		15- 2

Second Term (August Input, Term II; January Input, Term IV)

Ae 116A	Engineering Dynamics II	4- 0
Ae 182A	Engineering Dynamics Laboratory	0- 3
Ae 465A	Advanced Engineering Thermodynamics	4- 0
Ae 522A	Boundary Layer Flows	4- 0
Ma 248B	Differential Equations for Optimum Control	3- 0
		15- 3

Third Term (August Input, Term III; January Input, Term I)

Ae 421A	Heat Transfer I	4- 0
Ae 461A	Combustion Thermodynamics	3- 2
Ae 523A	Fundamentals of Compressible Flow	4- 0
Ae	Elective	4- 0
		15- 2

Fourth Term (August Input, Term IV; January Input, Term II)

Ae 422A	Heat Transfer II	4- 0
Ae 462A	Aerothermochemistry	3- 2
Ae 524A	Supersonic Aerodynamics	3- 2
Ae 583A	Gas Dynamics Laboratory	0- 3
Ae	Elective	4- 0
		14- 7

Term V (Summer) both August and January Inputs
Industrial Tour at assigned aerospace industry.

SECOND YEAR
AEROELECTRONICS—3 Year M.S.
(Group AX)

First Term (August Input, Term I; January Input, Term III)

Ae 325B	Flight Dynamics I	3- 3
EE 107C	Basic Circuit Analysis II	3- 2
EE 231C	Electronics I	4- 3
Ma 272C	Complex Variables	4- 0
		14- 8

Second Term (August Input, Term II; January Input, Term IV)

Ae 115A	Engineering Dynamics I	4- 0
Ae 326B	Flight Dynamics II	3- 3
EE 113B	Linear Systems Analysis	4- 3
EE 232C	Electronics II	4- 3
		15- 9

Third Term (August Input, Term III; January Input, Term I)

Ae 327B	Space Vehicle Dynamics	3- 2
EE 321C	Electromechanical Devices	3- 4
EE 621B	Electromagnetics I	3- 2
Ma 245B	Partial Differential Equations	3- 0
		12- 8

Fourth Term (August Input, Term IV; January Input, Term II)

Ae 341A	Automatic Control I	3- 2
EE 411B	Feedback Control Systems I	3- 3
EE 622B	Electromagnetics II	4- 0
PS 351B	Probability and Statistics	4- 2
		14- 7

Term V (Summer) both August and January Inputs
Industrial Tour at assigned aerospace activity.

THIRD YEAR
FLIGHT DYNAMICS—3 Year M.S. (A.E.) or Ae.E.
(Group AA)

First Term (August Input, Term I; January Input, Term III)

Ae 115A	Engineering Dynamics I	4- 0
Ae 131A	Continuum Mechanics I	4- 0
Ae 484A	Turbomachinery Laboratory II	0- 3
PS 351B	Probability and Statistics	4- 2
		12- 5

Second Term (August Input, Term II; January Input, Term IV)

Ae 116A	Engineering Dynamics II	4- 0
Ae 132A	Continuum Mechanics II	4- 0
Ae 182A	Engineering Dynamics Laboratory	0- 3
MN 310C	Engineering Economics	4- 0
		12- 3

Third Term (August Input, Term III; January Input, Term V)

Ae 244A	Matrix Structural Analysis	3- 2
Ae 251A	Structural Dynamics	4- 0
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		11- 2

Fourth Term (August Input, Term IV; January Input, Term I)

Ae 245A	Plates and Shells	4- 0
Ae 242A	Principles of Aeroelasticity	3- 2
OA 510B	Systems Analysis	4- 0
		11- 2

THIRD YEAR
GAS DYNAMICS—3 Year M.S. (A.E.) or Ae.E.
(Group AD)

First Term (August Input, Term I; January Input, Term III)

Ae 131A	Continuum Mechanics I	4- 0
Ae 484A	Turbomachinery Laboratory	0- 3
Ae 525A	Hypersonic Aerodynamics	3- 2
PS 351B	Probability and Statistics	4- 2
		11- 7

Second Term (August Input, Term II; January Input, Term IV)

Ae 132A	Continuum Mechanics II	4- 0
Ae 541A	Viscous Hypersonic Flow	4- 0
MN 310C	Engineering Economics	4- 0
		12- 0

Third Term (August Input, Term III; January Input, Term V)

Ae 133A	Solid Mechanics I	4- 0
Ae 542A	Hypersonic Techniques	3- 2
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		11- 2

Fourth Term (August Input, Term IV; January Input, Term I)

Ae 134A	Solid Mechanics II	4- 0
Ae 543A	Magnetohydrodynamics	4- 0
OA 510B	Systems Analysis	4- 0
		12- 0

THIRD YEAR
FLIGHT STRUCTURES—3 Year M.S. (A.E.) or Ae.E.
(Group AS)

First Term (August Input, Term I; January Input, Term III)

Ae 410A	Statistical Thermodynamics	3- 2
Ma 272C	Complex Variables	4- 0
PS 351B	Probability and Statistics	4- 2
		11- 4

Second Term (August Input, Term II; January Input, Term IV)

Ae 121B	Potential Flows and Boundary Value Problems	3- 2
Ae 465A	Advanced Engineering Thermodynamics	4- 0
MN 310C	Engineering Economics	4- 0
		11- 2

Third Term (August Input, Term III; January Input, Term V)

Ae 251A	Structural Dynamics	4- 0
Ae 243A	Thermo-Structural Analysis	3- 2
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		11- 2

Fourth Term (August Input, Term IV; January Input, Term I)

Ae 242A	Principles of Aeroelasticity	3- 2
Ae 252A	Plasticity, Visco-Elasticity and Fatigue	4- 0
OA 510B	Systems Analysis	4- 0
		11- 2

THIRD YEAR
FLIGHT PROPULSION (ROTATING MACHINERY)
3 Year M.S. (A.E.) or Ae.E.
(Group AT)

First Term (August Input, Term I; January Input, Term III)

Ae 433A	Advanced Propulsion Systems	4- 0
Ae 484A	Propulsion Laboratory	0- 3
Ae	Elective	4- 0
PS 351B	Probability and Statistics	4- 2
		12- 5

Second Term (August Input, Term II; January Input, Term IV)

Ae 475A	Turbopropulsion Design	4- 2
Ae 485A	Advanced Propulsion Laboratory	0- 3
Ae	Elective	4- 0
MN 310C	Engineering Economics	4- 0
		12- 5

Third Term (August Input, Term III; January Input, Term V)

Ae 260A	Structural Problems in Propulsion	2- 3
Ae 434A	Space Power Plants	3- 0
Ae 492A	Power Plants Seminar	1- 4
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		10- 7

Fourth Term (August Input, Term IV; January Input, Term I)

Ae 491A	Selected Problems in Turbopropulsion	3- 3
Ae 496A	Advanced Power Generation	0- 4
OA 510B	Systems Analysis	4- 0
		7- 7

THIRD YEAR
FLIGHT PROPULSION (ROCKETS)
3 Year M.S. (A.E.) or Ae.E.
(Group AR)

First Term (August Input, Term I; January Input, Term III)

Ae 131A	Continuum Mechanics I	4- 0
Ae 493A	Advanced Problems in Combustion and Aerophysics I	3- 2
PS 351B	Probability and Statistics	4- 2
		11- 4

Second Term (August Input, Term II; January Input, Term IV)

Ae 132A	Continuum Mechanics II	4- 0
Ae 494A	Advanced Problems in Combustion and Aerophysics II	3- 2
MN 310C	Engineering Economics	4- 0
		11- 2

Third Term (August Input, Term III; January Input, Term V)

Ae 133A	Solid Mechanics I	4- 0
Ae 434A	Space Power Plants	3- 0
Ae 492A	Power Plants Seminar	1- 4
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		12- 4

Fourth Term (August Input, Term IV; January Input, Term I)

Ae 134A	Solid Mechanics II	4- 0
Ae 496A	Advanced Power Generation	0- 4
OA 510B	Systems Analysis	4- 0
		8- 4

THIRD YEAR AEROELECTRONICS 3 Year M.S. (Group AX)

First Term (August Input, Term I; January Input, Term III)

EE 234C	Pulse Techniques and High Frequency Tubes	3- 3
EE 433A	Radar Systems	4- 2
MN 310C	Engineering Economics	4- 0
		11- 5

Second Term (August Input, Term II; January Input, Term IV)

Ae 551A	Fundamental Concepts of Fluid Mechanics	4- 2
EE 114B	Communication Theory I	4- 0
EE 419B	Non-linear and Sampled Systems	3- 4
		11- 6

Third Term (August Input, Term III; January Input, Term V)

Ae 552A	Flow of Compressible Fluids	4- 0
EE 233B	Communications Circuits and Systems	4- 3
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
		12- 3

Fourth Term (August Input, Term IV; January Input, Term I)

Ae 553A	Viscosity, Turbulence and Boundary Layer Effects in Fluid Flow	3- 0
EE 571A	Statistical Communication Theory	4- 0
OA 510B	Systems Analysis	4- 0
		10- 2

Civilian universities currently used in third year work and the fields in which they provide the strongest competence for advanced study are as follows:

CALIFORNIA INST. OF TECHNOLOGY, PASADENA, CALIF.
- Aerodynamics
- Structures
- Jet Propulsion

MASSACHUSETTS INST. OF TECHNOLOGY, CAMBRIDGE, MASS.
- Astronautics
- Airborne Weapons Systems

UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN
- Aerodynamics
- Aero-instrumentation
- Propulsion
- Structures
- Nuclear Engineering

PRINCETON UNIVERSITY, PRINCETON, N.J.
- Aerodynamics (flight mechanics)
- Propulsion

COLLEGE OF AERONAUTICS, CRANFIELD, ENGLAND
- Aerodynamics
- Aircraft Design
- Propulsion
- Aircraft Electronics

STANFORD UNIVERSITY, PALO ALTO, CALIF.
- Aero- and Gasdynamics
- Structures
- Guidance and Control

ELECTRONICS AND COMMUNICATIONS ENGINEERING PROGRAMS CURRICULA NUMBERS 590, 600, 472, and 620

Robert Edward Sheldon, Commander, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1952; B.S., Engineering Electronics, U.S. Naval Postgraduate School, 1959.

John Robert Ward, Academic Associate; B.Sc., Univ. of Sydney, 1949; B.E., 1952; Ph.D., 1958.

John Richard King, Lieutenant, U. S. Navy; Assistant Curricular Officer; B.S., Communications Engineering, U. S. Naval Postgraduate School, 1965.

Roy Elwood Lawton, Lieutenant, U. S., Navy; Assistant Curricular Officer; BSEE, Univ. of Washington, 1961.

ENGINEERING ELECTRONICS (590) and COMMUNICATIONS ENGINEERING (600)

Objective — The objective of the Bachelor of Science program is to educate officers in the basic scientific and engineering fields related to electronics and communications and their application to the art of naval warfare.

The objective of the Master of Science program is to educate a selected group of academically qualified officers to develop a particular competence and ability in directing the development, evaluation and operation of electronic and communications systems, as required by the Navy.

DESCRIPTION — Officers ordered for instruction in Electronics or Communications Engineering normally enter a basic core curriculum for the first four terms. However, officers with recent and appropriate academic backgrounds may be placed in a correspondingly advanced program. At the end of the first four terms, officers will be selected either for an advanced 3-year curriculum or for a 2-year curriculum. This selection is based upon the Superintendent's appraisal of the individual's academic ability and is subject to final approval by the Chief of Naval Personnel. For properly qualified entering students, successful completion of one of the two 2-year curricula leads to the award of a Bachelor of Science degree in either Engineering Electronics or Communications Engineering, while successful completion of one of the 3-year curricula leads to the award of a Master of Science degree in one of these same two fields.

First Year Curriculum (for BS and MS Programs)

First Term

EE 111C	Fields and Circuits	4- 4
Ma 150C	Vectors and Matrices with Geometric Appl.	4- 1
Ma 230D	Calculus of Several Variables	4- 0
Ph 105D	Mechanics and Thermodynamics	4- 0
		16- 5

Second Term

EE 112C	Circuit Analysis	4- 3
EE 211C	Electron Devices and Circuits	4- 2
Ma 241C	Elementary Differential Equations	3- 0
Ma 251C	Elementary Infinite Series	3- 0
		14- 5

Third Term

EE 113B	Linear Systems Analysis	4- 3
EE 212C	Electronic Circuits I	4- 3
Ma 271C	Complex Variables	4- 0
PH 205C	Waves and Particles	4- 0
		16- 6

Fourth Term

EE 114B	Communication Theory I	4- 0
EE 213C	Electronic Circuits II	4- 3
EE 731C	Electronic Measurements	3- 4
MN 301C	Basic Management I	4- 0
		15- 7

Fifth Term (includes leave period)

EE 811C	Introduction to Digital Computers	3- 3
†EE 321C	Electromechanical Devices	3- 4
‡Ma 245B	Partial Differential Equations	3- 0
‡Ma 260C	Vector Analysis	3- 0
	(BS)	6- 7
	(MS)	9- 3

†Required course for BS program

‡Required course for MS program

Second Year Common Curriculum (for BS Programs)

First Term

EE 214C	Electronic Communication Circuits	4- 3
EE 215C	Pulse and Waveforming Circuits	4- 3
EE 611C	Electromagnetic Fields	4- 0
PH 604C	Structure of Atoms and Solids	4- 0
		16- 6

Second Term

EE 116B	Communications Theory II	3- 2
EE 216C	Special Electronic Devices	4- 2
EE 612C	Transmission of Electromagnetic Energy	3- 2
PS 311C	Introduction to Probability & Statistics	4- 1
		14- 7

Second Year Common Curriculum (for MS Programs)

First Term

EE 214C	Electronic Communication Circuits	4- 3
EE 621B	Electromagnetics I	3- 2
PS 321B	Probability	4- 2
PH 605B	Atomic Physics	4- 0
		15- 7

Second Term

EE 215C	Pulse and Waveforming Circuits	4- 3
EE 571A	Statistical Communication Theory	3- 2
EE 622B	Electromagnetics II	4- 0
PH 705B	Electronic Processes in Materials	4- 2
		15- 7

Third Term

EE 217B	Advanced Electron Devices	4- 2
EE 321C	Electromechanical Devices	3- 4
PS 322A	Decision Theory and Classical Statistics	3- 2
*EE 433A	Radar Systems	4- 2
		14-10

*Communications Engineering students will substitute EE 631B Antenna Engineering (3-3)

ENGINEERING ELECTRONICS CURRICULUM NUMBER 590 BS PROGRAM

For the last two terms of the second year, students in the 2-year BS program are permitted to elect a number of courses to further their individual interests and Naval experience. Four courses not exceeding 24 total hours or 3 labs per week are required for each term. The choice of elective courses is subject to the approval of the Curricular Officer and Academic Associate.

Third Term

*EE 254B	Transistor and Solid State Devices and Circuits	3- 3
EE 411B	Feedback Control Systems I	3- 3
MN 302C	Basic Management II	4- 0
PH 450C	Underwater Acoustics	3- 2
		13- 8

Fourth Term

*EE 419B	Non-Linear and Sampled Systems	3- 4
EE 432B	Pulse Radar	3- 3
*EE 455B	Sonar Systems	3- 3
OA 101C	Elements of Operations Research/ Systems Anal.	4- 1
		13-11

*Typical Electives.

MS PROGRAM

Students selected for an MS program in Engineering Electronics will continue their studies in one of two options listed below. These options are designated to develop a particular competence in Advanced Electronics or Information and Control Systems. The final six terms of these programs are a combination of required and elective courses.

Where elective courses are permitted, the selection must meet the approval of the Curricular Officer and Academic Associate as being consistent with the option major.

The third term of the third year may be spent in an industrial electronics laboratory. During this period, the student works as a junior engineer on a selected project.

OPTION I—ADVANCED ELECTRONICS (Group EA)

Second Year

Fourth Term

EE 411B	Feedback Control Systems I	3- 3
EE 541A	Signal Processing	4- 0
EE 652A	Microwave Circuits and Measurements	3- 2
PH 152B	Mechanics II	4- 0
		14- 5

Fifth Term (includes leave period)

Field trip, and/or supervised project work, and/or appropriate elective courses.

Third Year

First Term

*EE 256B	Theory of Semiconductor Devices	4- 0
EE 419B	Non-Linear and Sampled Systems	3- 4
OA 121A	Principles of Operations Analysis	4- 1
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		11- 9

Second Term

*EE 473A	Missile Guidance Systems	3- 0
*EE 623A	Advanced Electromagnetic Theory	3- 0
MN 302C	Basic Management II	4- 0
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		10- 4

Third Term

Industrial tour or supervised project work.

Fourth Term

EE 122A	Network Synthesis I	4- 0
*EE 481B	Electronic Countermeasures	3- 3
OA 151B	Reliability Engineering and Systems Analysis	3- 0
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		10- 7

*Typical Electives.

OPTION II—INFORMATION AND CONTROL (Group EI)

Second Year

Fourth Term

EE 411B	Feedback Control Systems I	3- 3
EE 541A	Signal Processing	4- 0
EE 812B	Logical Design and Circuitry	4- 0
Ma 423B	Advanced Digital Computer Programming	4- 0
		15- 3

Fifth Term (includes leave period)

Field trip and/or supervised project work, and/or appropriate courses.

Third Year

First Term

EE 419B	Non-Linear and Sampled Systems	3- 4
EE 551A	Information Networks	3- 2
OA 121A	Principles of Operations Analysis	4- 1
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		10-11

Second Term

*EE 417A	Modern Control Theory	3- 1
EE 462A	Automation and System Control	3- 3
MN 302C	Basic Management II	4- 0
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		10- 8

Third Term

Industrial tour or supervised project work.

Fourth Term

EE 122A	Network Synthesis I	4- 0
Ma 116B	Matrices and Numerical Methods	3- 2
*OA 151B	Reliability Engineering and Systems Analysis	3- 0
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		10- 6

*Typical Electives.

COMMUNICATIONS ENGINEERING CURRICULUM NUMBER 600 (Group CE) BS PROGRAM

For the last two terms of the second year, students in the 2-year BS program are permitted to elect a number of courses. Four courses not exceeding 24 total hours or 3 labs per week are required for each term. The choice of elective courses is subject to the approval of the Curricular Officer and Academic Associate.

Third Term

*EE 254B	Transistor and Solid State Devices and Circuits	3- 3
EE 411B	Feedback Control Systems I	3- 3
EE 631B	Antenna Engineering	3- 3
MN 302C	Basic Management II	4- 0
		13- 9

Fourth Term

EE 422B	Modern Communications	3- 3
EE 671B	Theory of Propagation	4- 0
*EE 821B	Computer Systems Technology	3- 3
OA 101C	Elements of Operations Research/ Systems Analysis	4- 1
		14- 7

*Typical Electives.

MS PROGRAM

Communications Engineering students selected for an MS program will follow the curriculum outlined below.

Where elective courses are permitted, the selection must meet the approval of the Curricular Officer and Academic Associate as being consistent with the major field of study.

The third term of the third year may be spent in an industrial laboratory. During this period, the student works as a junior engineer on a selected project.

Second Year

Fourth Term

EE 411B	Feedback Control Systems I	3- 3
EE 422B	Modern Communications	3- 3
EE 541A	Signal Processing	4- 0
EE 671B	Theory of Propagation	4- 0
		14- 6

Fifth Term (includes leave period)

Field trip and/or supervised project work, and/or appropriate elective courses.

Third Year

First Term

*EE 256B	Theory of Semiconductor Devices	4- 0
*EE 581A	Information Theory	4- 0
OA 111B	Principles of Operations Research/ Systems Analysis	4- 2
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		12- 6

Second Term

*EE 542A	Advanced Signal Processing	3- 0
MN 302C	Basic Management II	4- 0
OA 112A	Advanced Methods in Operations Analysis	4- 0
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		11- 4

Third Term

Industrial tour or supervised project work.

Fourth Term

EE 122A	Network Synthesis I	4- 0
*EE 821B	Computer Systems Technology	3- 3
OA 151B	Reliability Engineering & Systems Analysis	3- 0
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		10- 7

*Typical Electives.

SPECIAL ELECTRONICS CURRICULUM FOR SELECTED CEC OFFICERS CURRICULUM NUMBER 472 (Group EY)

Objective — To prepare selected CEC officers for special duties requiring a technical capability for planning electronic facilities and accomplishing the engineering studies required in the development of plans and specifications for their construction.

Prerequisite — Recent BSEE degree from an accredited institution with an overall grade average of at least B.

Description — For properly qualified entering students, successful completion of this curriculum affords the opportunity to earn a Master of Science degree in Engineering Electronics. The curriculum can be modified both as to length and content depending upon the individual student's background. A typical curriculum is outlined below:

First Year

First Term

EE 113B	Linear Systems Analysis	4- 3
EE 621B	Electromagnetics I	3- 2
PH 205C	Waves and Particles	4- 0
		11- 5

Math review course to suit student's needs.

Second Term

EE 114B	Communication Theory I	4- 0
EE 213C	Electronic Circuits II	4- 3
EE 622B	Electromagnetics II	4- 0
EE 811C	Introduction to Digital Computers	3- 3
		15- 6

Third Term

EE 214C	Electronic Communication Circuits	4- 3
MN 302C	Basic Management II	4- 0
PH 604C	Structure of Atoms and Solids	4- 0
PS 321B	Probability	4- 2
		16- 5

Fourth Term

EE 411B	Feedback Control Systems I	3- 3
EE 422B	Modern Communications	3- 3
EE 571A	Statistical Communication Theory	3- 2
MN 301C	Basic Management I	4- 0
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 2
		13-11

Fifth Term (includes leave period)

Student will work on thesis and participate in CEC workshop seminar.

Second Year

First Term

EE 122A	Network Synthesis I	4- 0
EE 217B	Advanced Electron Devices	4- 2
EE 433A	Radar Systems	4- 2
PS 322A	Decision Theory & Classical Statistics	3- 2
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 2
		15- 9

Second Term

EE 541A	Signal Processing	4- 0
EE 631B	Antenna Engineering	3- 3
OA 121A	Principles of Operations Analysis	4- 1
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 3
		11- 8

STAFF COMMUNICATIONS PROGRAM CURRICULUM NUMBER 620 (Group CO)

OBJECTIVE — To prepare officers to become qualified for major staff and operational afloat and ashore communications billets with a firm knowledge of U. S. Department of Defense and Naval Communications organization and policies, operational communications planning and direction. communication equipment and procedures, and an understanding of basic electronics, computer techniques and military material management.

DESCRIPTION — Officers ordered for instruction in the and non-technical courses. Officers successfully completing the curriculum will be awarded a Diploma of Completion. Staff Communications Program will matriculate in a four-term curriculum consisting of a combination of technical

First Term

EE 101D	Electrical Fundamentals	3- 2
Ma 232D	Calculus Review	5- 0
MN 163C	Material Management	4- 0
NW 162C	Communications Organization	5- 0
		17- 2

Second Term

EE 241C	Electronic Fundamentals	3- 2
NW 163C	Operational & Communication Planning	4- 0
NW 164C	Communications Administration & Procedures I	5- 0
PS 315C	Introduction to Probability & Statistics	4- 2
		16- 4

Third Term

EE 242C	Communication Electronics I	4- 3
EE 811C	Introduction to Digital Computers	3- 3
NW 165C	Communications Administration & Procedures II	3- 0
NW 166C	Communication Equipment & System Application I	4- 0
		14- 6

Fourth Term

EE 243C	Communication Electronics II	4- 3
EE 821B	Computer Systems Technology	3- 3
NW 167C	Communication Equip. & Syst. Application II	3- 2
NW 168C	Special Communications Topics (Classified)	5- 0
		15- 8

ENGINEERING SCIENCE PROGRAMS CURRICULUM NUMBER 460

MARTIN FULLER COMBS, Lieutenant Commander, U.S. Navy; Curricular Officer; B.S., Vanderbilt Univ., 1950; M.S., Physics, U.S. Naval Postgraduate School, 1965.

LEONARD OLIVER OLSEN, Academic Associate; B.A., Iowa State Teachers College, 1932; M.S., State Univ. of Iowa, 1934; Ph.D., 1937.

OBJECTIVE — To provide post-commissioning education in the fields of Mathematics, Physics and Engineering, designed to update and build on undergraduate education and to prepare students for advanced functional training such as Naval Tactical Data Systems; Polaris and other missiles; instructor duty on school staffs; test pilot schools.

The High and Average Academic Background Curricula may serve as a review to qualify selected officer-students for transfer to other technical curricula. Such transfers normally will be made upon completion of the second term of these curricula and will be based upon length of availability of student for duty under instruction, academic performance and quota limitations in the technical curricula.

HIGH ACADEMIC BACKGROUND (Group SA)

First Term

Ma 071D	Calculus I	5- 0
PH 021D	Mechanics	4- 0
CH 106C	Principles of Chemistry I	3- 2
OC 110C	Introduction to Oceanography	3- 0
		15- 2

Second Term

Ma 072D	Calculus II	5- 0
PH 022D	Fluid Mechanics, Wave Motion and Thermodynamics	4- 0
PH 023D	Electricity and Magnetism	4- 0
CH 107C	Principles of Chemistry II	3- 2
		16- 2

Third Term

Ma 073C	Differential Equations	5- 0
PS 315C	Introduction to Probability and Statistics	4- 2
PH 024D	Electromagnetic Radiation and Optics	4- 0
EE 271C	Electronic Devices and Circuits I	4- 2
		17- 4

Fourth Term

Ma 416C	Numerical Methods and Fortran Programming	4- 1
PH 025C	Modern Physics	4- 0
OA 141B	Fundamentals of Operations Research/ Systems Analysis	4- 1
EE 272C	Electronic Devices and Circuits II	4- 2
		16- 4

AVERAGE ACADEMIC BACKGROUND (Group SB)

First Term

Ma 051D	Calculus and Analytic Geometry I	5- 0
PH 016D	General Physics — Mechanics	4- 0
CH 106C	Principles of Chemistry I	3- 2
OC 110C	Introduction to Oceanography	3- 0
		15- 2

Second Term

Ma 052D	Calculus and Analytic Geometry II	5- 0
PH 017D	General Physics — Thermodynamics, Sound and Light	4- 0
PH 018D	General Physics — Electricity and Magnetism	4- 0
CH 107C	Principles of Chemistry II	3- 2
		16- 2

Third Term

Ma 053D	Calculus and Analytic Geometry III	5- 0
PS 315C	Introduction to Probability and Statistics	4- 2
PH 019C	Modern Physics	4- 0
EE 271C	Electronic Devices and Circuits I	4- 2
		17- 4

Fourth Term

Ma 073C	Differential Equations	5- 0
Ma 416C	Numerical Methods and Fortran Programming	4- 1
OA 141B	Fundamentals of Operations Research/ Systems Analysis	4- 1
EE 272C	Electronic Devices and Circuits II	4- 2
		17- 4

FAIR ACADEMIC BACKGROUND (UPPER) (Group SC)

First Term

Ma 031D	College Algebra and Trigonometry	5- 0
PH 001D	General Physics I — Mechanics	4- 0
CH 001D	Introductory General Chemistry I	4- 3
OC 110C	Introduction to Oceanography	3- 0
		16- 3

Second Term

Ma 051D	Calculus and Analytic Geometry I	5- 0
PS 311C	Introduction to Probability and Statistics	4- 1
PH 003D	General Physics III — Electricity and Magnetism	4- 0
CH 002D	Introductory General Chemistry II	3- 3
		16- 4

Third Term

Ma 052D	Calculus and Analytic Geometry II	5- 0
PH 002D	General Physics II — Harmonic Motion, Sound and Heat	4- 0
OA 101C	Elements of Operations Research/ Systems Analysis	4- 1
EE 271C	Electronic Devices and Circuits I	4- 2
		17- 3

Fourth Term

Ma 053D	Calculus and Analytic Geometry III	5- 0
Ma 411C	Digital Computers and Military Applications	4- 0
PH 004D	General Physics IV — Light and Modern Physics	4- 0
EE 272C	Electronics Devices and Circuits II	4- 2
		17- 2

FAIR ACADEMIC BACKGROUND (LOWER) (Group SD)

First Term

Ma 025D	Elementary Sets with Applications	3- 0
Ma 030D	Intermediate Algebra	5- 0
PH 001D	General Physics I — Mechanics	4- 0
CH 001D	Introductory General Chemistry I	4- 3
		16- 3

Second Term

Ma 031D	College Algebra and Trigonometry	5- 0
PH 003D	General Physics III — Electricity and Magnetism	4- 0
CH 002D	Introductory General Chemistry II	3- 3
OC 110C	Introduction to Oceanography	3- 0
		15- 3

Third Term

Ma 051D	Calculus and Analytic Geometry I	5- 0
PS 311C	Introduction to Probability and Statistics	4- 1
PH 002D	General Physics II — Harmonic Motion, Sound and Heat	4- 0
EE 271C	Electronic Devices and Circuits I	4- 2
		17- 3

Fourth Term

Ma 052D	Calculus and Analytic Geometry II	5- 0
Ma 411C	Digital Computers and Military Applications	4- 0
OA 101C	Elements of Operations Research/ Systems Analysis	4 1
EE 272C	Electronic Devices and Circuits II	4- 2
		17- 3

Meteorology Studies

ENVIRONMENTAL SCIENCES PROGRAMS
CURRICULA NUMBERS 372 and 440

Richard Sherry Downey, Commander, U. S. Navy; Curricular Officer; B.S., Meteorology, U. S. Naval Postgraduate School.

Charles Luther Taylor, Academic Associate; B.S., Pennsylvania State Univ., 1942; M.S., 1947.

John David Ploetz, Commander, U. S. Navy; Assistant Curricular Officer; B.A.S., Univ. of California at Los Angeles, 1946.

ADVANCED METEOROLOGY CURRICULUM
CURRICULUM NUMBER 372 (MM)
(Group MMZ)
(Entering in August)

Objective — To provide advanced education in meteorology, to prepare officers to become qualified operational meteorologists with a working knowledge of oceanography, and to enable them to conduct independent research. Naval applications of this curriculum include forecasting weather and oceanographic conditions for air, surface, and submarine operations.

First Year

First Term

Ma 120C	Vectors and Matrices	3- 1
Ma 230D	Calculus of Several Variables	4- 0
Mr 200C	Introduction to Meteorology	3- 0
Oc 110C	Introduction to Oceanography	3- 0
Ph 196D	Review of General Physics	4- 2
Mr 001D	Weather Codes and Elementary Analysis	0- 3
		17- 6

Second Term

Ma 073C	Differential Equations	5- 0
Mr 201C	Elementary Weather-Map Analysis	0- 9
Mr 211C	Elementary Weather-Map Analysis	3- 0
Mr 410C	Meteorological Instruments	2- 2
Mr 413B	Thermodynamics of Meteorology	3- 2
		13-13

Third Term

Ma 261B	Vector Mechanics	5- 0
PS 332B	Statistics I	3- 0
Mr 202C	Weather-Map Analysis	0- 6
Mr 212C	Introduction to Weather Elements	3- 0
Mr 321A	Dynamic Meteorology I	3- 0
Oc 220B	Descriptive Oceanography	3- 0
LP 101E	Lecture Program I	0- 1
		17- 7

Fourth Term

Ma 125B	Numerical Methods for Digital Computers	2- 2
PS 333B	Statistics II	2- 2
Mr 203C	Analysis and Forecasting of Operational Weather Elements	0- 6
Mr 213B	Analysis and Forecasting of Operational Weather Elements	3- 0
Mr 322A	Dynamic Meteorology II	3- 0
Oc 260B	Sound in the Ocean	3- 0
LP 102E	Lecture Program II	0- 1
		13-11

Fifth Term

Ma 421C	Introduction to Digital Computers	4- 1
Oc 201B	Ocean Waves and Tides	3- 1
Oc 601B	Ocean Wave Forecasting	3- 6
		10- 8

Second Year

First Term

Ma 128B	Numerical Methods in Partial Differential Equations	3- 1
Mr 204B	The Middle Atmosphere	0- 6
Mr 214B	The Middle Atmosphere	3- 0
Mr 323A	Dynamic Meteorology III	3- 0
Mr 412A	Physical Meteorology	3- 0
Mr 521B	Synoptic Climatology	2- 2
		14- 9

Second Term

Mr 205B	Upper-Air and Surface Prognosis	0- 6
Mr 215B	Upper-Air and Surface Prognosis	4- 0
Mr 228B	Tropical and Southern Hemisphere Meteorology	3- 0
Mr 324A	Dynamical Prediction	3- 3
Mr 325A	Energetics of General Circulation	2- 0
		12- 9

Third Term

Mr 208B	Tropical and Southern Hemisphere Meteorology	1- 5
Mr 422A	The Upper Atmosphere	4- 0
Oc 619B	Oceanographic Forecasting	3- 4
LP 101E	Lecture Program I	0- 1
	Thesis I	0- 8
		8-18

Fourth Term

Mr 206C	Naval Weather Service Operational Procedures	1-12
Mr 810B	Seminar in Meteorology and Oceanography	2- 0
LP 102E	Lecture Program II	0- 1
	Thesis II	0- 8
		3-21

(Group MMA)
(Entering in January)
First Year

First Term

Ma 120C	Vectors and Matrices	3- 1
Ma 230D	Calculus of Several Variables	4- 0
Mr 200C	Introduction to Meteorology	3- 0
Oc 110C	Introduction to Oceanography	3- 0
Ph 196D	Review of General Physics	4- 2
Mr 001D	Weather Codes and Elementary Analysis	0- 3
LP 101E	Lecture Program I	0- 1
		17- 7

Second Term

Ma 073C	Differential Equations	5- 0
Mr 201C	Elementary Weather-Map Analysis	0- 9
Mr 211C	Elementary Weather-Map Analysis	3- 0
Mr 410C	Meteorological Instruments	2- 2
Mr 413B	Thermodynamics of Meteorology	3- 2
LP 102E	Lecture Program II	0- 1
		13-14

Third Term

Ma 421C	Introduction to Digital Computers	4- 1
Oc 201B	Ocean Waves and Tides	3- 1
Oc 601B	Ocean Wave Forecasting	3- 6
		10- 8

Fourth Term

Ma 261B	Vector Mechanics	5- 0
PS 332B	Statistics I	3- 0
Mr 202C	Weather-Map Analysis	0- 6
Mr 212C	Introduction to Weather Elements	3- 0
Mr 321A	Dynamic Meteorology I	3- 0
Oc 220B	Descriptive Oceanography	3- 0
		17- 6

Fifth Term

Ma 125B	Numerical Methods for Digital Computers	2- 2
PS 333B	Statistics II	2- 2
Mr 203C	Analysis and Forecasting of Operational Weather Elements	0- 6
Mr 213B	Analysis and Forecasting of Operational Weather Elements	3- 0
Mr 322A	Dynamic Meteorology II	3- 0
Oc 260B	Sound in the Ocean	3- 0
		13-10

Second Year

First Term

Ma 128B	Numerical Methods in Partial Differential Equations	3- 1
Mr 204B	The Middle Atmosphere	0- 6
Mr 214B	The Middle Atmosphere	3- 0
Mr 323A	Dynamic Meteorology III	3- 0
Mr 412A	Physical Meteorology	3- 0
Mr 521B	Synoptic Climatology	2- 2
LP 101E	Lecture Program I	0- 1
		14-10

Second Term

Mr 205B	Upper-Air and Surface Prognosis	0- 6
Mr 215B	Upper-Air and Surface Prognosis	4- 0
Mr 228B	Tropical and Southern Hemisphere Meteorology	3- 0
Mr 324A	Dynamical Prediction	3- 3
Mr 325A	Energetics of General Circulation	2- 0
LP 102E	Lecture Program II	0- 1
		12-10

Third Term

Mr 208B	Tropical and Southern Hemisphere Meteorology	1- 5
Oc 619B	Oceanographic Forecasting	3- 4
	Thesis I	0- 8
		4-17

Fourth Term

Mr 206C	Naval Weather Service Operational Procedures	1-12
Mr 422A	The Upper Atmosphere	4- 0
Mr 810B	Seminar in Meteorology and Oceanography	2- 0
	Thesis II	0- 8
		7-20

For properly qualified entering students, this curriculum affords the opportunity to qualify for the Master of Science degree in Meteorology.

GENERAL METEOROLOGY CURRICULUM

CURRICULUM NUMBER 372 (MA)
(Group MAZ)
(Entering in August)

OBJECTIVE — To provide general education in meteorology and to prepare officers to become qualified operational meteorologists with a working knowledge of oceanography. Naval applications of this curriculum include forecasting weather and oceanographic conditions for air, surface, and submarine operations.

First Year

First Term

Ma 051D	Calculus and Analytic Geometry I	5- 0
Mr 200C	Introduction to Meteorology	3- 0
Oc 110C	Introduction to Oceanography	3- 0
Ph 001D	General Physics I	4- 0
Mr 001D	Weather Codes and Elementary Analysis	0- 3
		15- 3

Second Term

Ma 052D	Calculus and Analytic Geometry II	5- 0
Mr 201C	Elementary Weather-Map Analysis	0- 9
Mr 211C	Elementary Weather-Map Analysis	3- 0
Mr 410C	Meteorological Instruments	2- 2
Ph 002D	General Physics II	4- 0
		14-11

Third Term

Ma 053D	Calculus and Analytic Geometry III	5- 0
Mr 202C	Weather-Map Analysis	0- 6
Mr 212C	Introduction to Weather Elements	3- 0
Mr 402C	Introduction to Meteorological Thermodynamics	3- 2
Oc 220B	Descriptive Oceanography	3- 0
LP 101E	Lecture Program I	0- 1
		14- 9

Fourth Term

PS 381C	Elementary Probability and Statistics	4- 2
Mr 203C	Analysis and Forecasting of Operational Weather Elements	0- 6
Mr 213B	Analysis and Forecasting of Operational Weather Elements	3- 0
Mr 301B	Elementary Dynamic Meteorology I	4- 0
Oc 700B	Oceanographic Instruments and Observations	2- 2
LP 102E	Lecture Program II	0- 1
		13-11

Fifth Term

Ma 421C	Introduction to Digital Computers	4- 1
Oc 201B	Ocean Waves and Tides	3- 1
Oc 601B	Ocean Wave Forecasting	3- 6
		10- 8

Second Year

First Term

Mr 204B	The Middle Atmosphere	0- 6
Mr 214B	The Middle Atmosphere	3- 0
Mr 302B	Elementary Dynamic Meteorology II	4- 0
Mr 521B	Synoptic Climatology	2- 2
Oc 720B	Field Experience in Oceanography	0- 4
		9-12

Second Term

Mr 205B	Upper-Air and Surface Prognosis	0- 6
Mr 215B	Upper-Air and Surface Prognosis	4- 0
Mr 228B	Tropical and Southern Hemisphere Meteorology	3- 0
Mr 403B	Introduction to Micrometeorology	4- 0
Oc 260B	Sound in the Ocean	3- 0
		14- 6

Third Term

Mr 208B	Tropical and Southern Hemisphere Meteorology	1- 5
Oc 241B	Elementary Dynamic Oceanography	3- 0
Oc 615B	Oceanographic Forecasting I	3- 4
LP 101E	Lecture Program I	0- 1
	Research Problem	0- 6
		7-16

Fourth Term

Mr 206C	Naval Weather Service Operational Procedures	1-12
Mr 810B	Seminar in Meteorology and Oceanography	2- 0
Oc 612B	Arctic Oceanography	3- 0
Oc 617B	Oceanographic Forecasting II	3- 4
LP 102E	Lecture Program II	0- 1
		9-17

(Group MAA)
(Entering in January)
First Year

First Term

Ma 051D	Calculus and Analytic Geometry I	5- 0
Mr 200C	Introduction to Meteorology	3- 0
Oc 110C	Introduction to Oceanography	3- 0
Ph 001D	General Physics I	4- 0
Mr 001D	Weather Codes and Elementary Analysis	0- 3
LP 101E	Lecture Program I	0- 1
		15- 4

Second Term

Ma 052D	Calculus and Analytic Geometry II	5- 0
Mr 201C	Elementary Weather-Map Analysis	0- 9
Mr 211C	Elementary Weather-Map Analysis	3- 0
Mr 410C	Meteorological Instruments	2- 2
Ph 002D	General Physics II	4- 0
LP 102E	Lecture Program II	0- 1
		14-12

Third Term

Ma 053D	Calculus and Analytic Geometry III	5- 0
Oc 201B	Ocean Waves and Tides	3- 1
Oc 601B	Ocean Wave Forecasting	3- 6
		11- 7

Fourth Term

PS 381C	Elementary Probability and Statistics	4- 2
Mr 202C	Weather-Map Analysis	0- 6
Mr 212C	Introduction to Weather Elements	3- 0
Mr 402C	Introduction to Meteorological Thermodynamics	3- 2
Oc 220B	Descriptive Oceanography	3- 0
		13-10

Fifth Term

Ma 421C	Introduction to Digital Computers	4- 1
Mr 203C	Analysis and Forecasting of Operational Weather Elements	0- 6
Mr 213B	Analysis and Forecasting of Operational Weather Elements	3- 0
Mr 301B	Elementary Dynamic Meteorology I	4- 0
Oc 260B	Sound in the Ocean	3- 0
		14- 7

Second Year

First Term

Mr 204B	The Middle Atmosphere	0- 6
Mr 214B	The Middle Atmosphere	3- 0
Mr 302B	Elementary Dynamic Meteorology II	4- 0
Mr 521B	Synoptic Climatology	2- 2
Oc 615B	Oceanographic Forecasting I	3- 4
LP 101E	Lecture Program I	0- 1
		12-13

Second Term

Mr 205B	Upper-Air and Surface Prognosis	0- 6
Mr 215B	Upper-Air and Surface Prognosis	4- 0
Mr 228B	Tropical and Southern Hemisphere Meteorology	3- 0
Mr 403B	Introduction to Micrometeorology	4- 0
Oc 617B	Oceanographic Forecasting II	3- 4
LP 102E	Lecture Program II	0- 1
		14-11

Third Term

Mr 208B	Tropical and Southern Hemisphere Meteorology	1- 5
Oc 700B	Oceanographic Instruments and Observations	2- 2
Oc 720B	Field Experience in Oceanography	0- 4
	Research Problem	0- 6
		3-17

Fourth Term

Mr 206C	Naval Weather Service Operation Procedures	1-12
Mr 810B	Seminar in Meteorology and Oceanography	2- 0
Oc 241B	Elementary Dynamic Oceanography	3- 0
Oc 612B	Arctic Oceanography	3- 0
		9-12

For properly qualified entering students, this curriculum affords an opportunity to qualify for a Bachelor of Science degree in Meteorology.

OCEANOGRAPHY CURRICULUM
CURRICULUM NUMBER 440 (MO)
(Group MOZ)
(Entering in August)

Objective — To provide officers with an education in physical oceanography with particular emphasis on naval operations. and to enable them through advanced study to conduct independent research.

First Year

First Term

Ma 120C	Vectors and Matrices	3- 1
Ma 230D	Calculus of Several Variables	4- 0
Mr 200C	Introduction to Meteorology	3- 0
Oc 110C	Introduction to Oceanography	3- 0
Ph 196D	Review of General Physics	4- 2
		17- 3

Second Term

Ma 073C	Differential Equations	5- 0
PS 332B	Statistics I	3- 0
Mr 600C	Introductory Synoptic Meteorology	2- 4
Oc 420B	Introduction to Biological Oceanography	3- 3
		13- 7

Third Term

Ma 261B	Vector Mechanics	5- 0
Oc 220B	Descriptive Oceanography	3- 0
Oc 250B	Environmental Thermodynamics	3- 0
Oc 320B	Introduction to Geological Oceanography	3- 2
PS 333B	Statistics II	2- 2
LP 101E	Lecture Program I	0- 1
		16- 5

Fourth Term

Ma 125B	Numerical Methods for Digital Computers	2- 2
Ma 421C	Introduction to Digital Computers	4- 1
Oc 211A	Ocean Waves	3- 0
Oc 251A	Dynamic Oceanography I	3- 0
LP 102E	Lecture Program II	0- 1
		12- 4

Fifth Term

Ma 128B	Numerical Methods in Partial Differential Equations	3- 1
Oc 710B	Oceanographic & Meteorological Instruments	4- 2
Oc 720B	Field Experience in Oceanography	0- 4
		7- 7

Second Year

First Term

Oc 212A	Tides and Tidal Currents	3- 0
Oc 252A	Dynamic Oceanography II	3- 0
Oc 260B	Sound in the Ocean	3- 0
Oc 611A	Ocean Wave Forecasting	3- 6
		12- 6

Second Term

Oc 213A	Shallow Water Oceanography	3- 1
Oc 253A	Dynamic Oceanography III	3- 0
Oc 520B	Introduction to Chemical Oceanography	3- 2
Oc 613B	Arctic Oceanography	3- 4
		12- 7

Third Term

Oc 340A	Marine Geophysics	2- 0
Oc 615B	Oceanographic Forecasting I	3- 4
Oc 820A	Special Topics in Oceanography	3- 0
LP 101E	Lecture Program I	0- 1
	Thesis I	0- 8
		8-13

Fourth Term

Oc 617B	Oceanographic Forecasting II	3- 4
Oc 810B	Seminar in Oceanography	2- 0
LP 102E	Lecture Program II	0- 1
	Thesis II	0- 8
		5-13

A similar program will be offered if students are ordered to this Curriculum in January.

This curriculum affords the opportunity to qualify for the degree of Master of Science in Oceanography, with a particular capability in physical oceanography. Students entering the curriculum with the baccalaureate in geology, biology, or chemistry may follow a modified curriculum, including preparation of a thesis in geological, biological, or chemical oceanography, which will qualify them for the same degree but with a capability in one of those three fields.

GENERAL LINE AND BACCALAUREATE PROGRAMS

Harold Edward Collins, Commander, U.S. Navy, Curricular Officer; B.S., Naval Academy, 1952; B.S. in Engineering Electronics, U.S. Naval Postgraduate School, 1958.

Raymond Kenneth Houston, Academic Associate; B.S., Worcester Polytechnic Institute, 1933; M.S., 1939.

David Luther Tobias, Lieutenant Commander, U. S. Navy, Assistant Curricular Officer; B.A., U. S. Naval Postgraduate School, 1965.

Nonna Elaine Cheatham, Lieutenant, U. S. Navy, Administrative Officer.

OBJECTIVES:

Baccalaureate Curricula: To raise the educational level, broaden the mental outlook, and increase the professional and scientific knowledge of naval officers who do not have a baccalaureate degree.

The Baccalaureate curricula provide specialized study to meet the professional needs of the commissioned officer. The different educational backgrounds and personal needs of the students are accommodated by providing two baccalaureate curricula. The Bachelor of Science program gives emphasis to the physical environment, without neglecting the social. The Bachelor of Arts program emphasizes the social environment without neglecting the physical.

General Line Curriculum: To provide instruction of about nine and one-half months duration which will prepare those foreign officers enrolled for more responsible duties in their respective operating forces, as well as with combined staffs of allied forces.

GENERAL LINE CURRICULUM

(Group GL)

Required Courses

First Term

SP 001D	Basic Speech	2- 0
GV 012D	American Life and Institutions I	2- 0
Ma 010D	Basic Algebra and Trigonometry I	4- 0
NW 191D	Tactics and Combat Information Center	5- 0
NW 292D	Amphibious Operations	4- 0
		17- 0

Second Term

PH 006D	Survey of Physics	5- 0
GV 013D	American Life and Institutions II	2- 0
NW 393D	Missiles and Space Operations	3- 0
NW 395D	Mine Warfare	3- 0
NW 408C	Seamanship and Marine Piloting	3- 2
		16- 2

Third Term

EE 101D	Electrical Fundamentals	3- 2
NW 201C	Operational Planning	2- 0
NW 591D	Marine Engineering	4- 0
NW 391D	Ordnance-Weapons Systems	3- 0
NW 193D	Anti-Submarine Warfare	3- 0
		15- 2

Fourth Term

EE 205D	Electronics Fundamentals	3- 2
PH 600D	Nucleonics Fundamentals	3- 0
NW 293D	Aviation Survey	3- 0
NW 502C	Damage Control & ABC Warfare Defense	4- 0
NW 404C	Logistics & Naval Supply	3- 0
		16- 2

ELECTIVE COURSES

Naval Warfare Subjects

NW 403C	Celestial Navigation	3- 0

Engineering Subjects

Mr 010D	Meteorology	3- 0

Courses in Mathematics, Physics, Chemistry and Electricity may be taken with the permission of the Curricular Officer and the Chairman of the Department involved.

Government/Humanities Subjects

GV 010D	U.S. Government	4- 0
GC 102C	International Relations	4- 0
GV 122C	International Law	4- 0
GV 142C	International Communism	4- 0
HI 101C	U.S. History I	4- 0
HI 102C	U.S. History II	4- 0
HI 103C	European History I	4- 0
HI 104C	European History II	4- 0

Courses in Literature and other Government and Humanities courses may be taken with the permission of the instructor.

BACCALAUREATE CURRICULUM
CURRICULUM NUMBER 461

The Baccalaureate Curricula include the Naval Professional courses of the General Line Curriculum and, in addition, sufficient coverage in the Humanities and Science-Engineering areas to adequately support Bachelor of Science and Bachelor of Arts degrees. From one to two calendar years are allowed for those enrolled to complete the program. Students pursuing these curricula carry a minimum load of 16 credit hours.

To be eligible for enrollment an officer must have acceptable advanced standing of 45 semester hours which can be applied toward completion of the prescribed course of study. This must include a minimum of five term hours of college-level mathematics, including a course in College Algebra.

The Baccalaureate Curricula meet the general degree requirements of the Postgraduate School. The BS Curriculum consists of 200 term hours distributed in the following academic areas: 110 (55%) in Science-Engineering; 40 (20%) in Naval Professional; 40 (20%) in Government and Humanities; and 10 (5%) electives. The BA Curriculum consists of 200 term hours distributed as follows: 110 (55%) in Government and Humanities; 40 (20%) in Naval Professional; 40 (20%) in Science-Engineering; and 10 (5%) electives.

The Baccalaureate Curricula schedules are shown below. Students are required to complete the courses listed there, or equivalents, either before admission to the curriculum or as part of it.

*BACHELOR OF SCIENCE
(Group BS)

First Term

CH 001D	Introductory General Chemistry I	4- 3
EN 101C	Advanced Writing for Naval Officers	3- 2
Ma 031D	College Algebra and Trigonometry	5- 0
NW 401C	Leadership and Administration	3- 0
		15- 5

Second Term

CH 002D	Introductory General Chemistry II	3- 3
HI 102C	U.S. History II	4- 0
Ma 051D	Calculus and Analytic Geometry I	5- 0
PY 010D	Introduction to Psychology	4- 0
		16- 3

Third Term

Ma 052D	Calculus and Analytic Geometry II	5- 0
PH 011D	General Physics I	4- 3
GV 010D	U.S. Government	4- 0
SP 010D	Public Speaking	3- 0
		16- 3

Fourth Term

Ma 053D	Calculus and Analytic Geometry III	5- 0
PH 012D	General Physics II	4- 3
GV 142C	International Communism	4- 0
SP 011D	Conference Procedures	3- 0
		16- 3

Fifth Term (8 week term)

PH 013D	General Physics III	3- 3
NW 408C	Seamanship and Marine Piloting	3- 2
NW 404C	Logistics and Naval Supply	3- 0
		9- 5

Sixth Term

PH 014C	General Physics IV	4- 2
ME 561C	Mechanics I	4- 0
EE 111C	Fields and Circuits	4- 4
NW 201C	Operational Planning	2- 0
		14- 6

Seventh Term

ME 562C	Mechanics II	4- 0
EE 112C	Circuit Analysis	4- 3
GV 120C	Military Law I	3- 0
NW 303C	Missiles and Space Operations	4- 0
		15- 3

Eighth Term

EE 221C	General Electronics I	3- 3
GV 121C	Military Law II	3- 0
MN 010D	Introduction to Macro-Economics	4- 0
NW 101C	Tactics and Combat Information Center	5- 0
		15- 3

Ninth Term

EE 222C	General Electronics II	3- 3
NW 208C	Aviation Accident Prevention and Crash Investigation	5- 0
NW 209C	Aero Engineering and Safety	5- 2
OC 110C	Introduction to Oceanography	3- 0
		16- 5

Tenth Term (8 week term)

NW 502C	Damage Control & ABC Warfare Defense	4- 0
NW 103C	Anti-Submarine Warfare	5- 0
NW 105C	Anti-Air Warfare	4- 0
		13- 0

*BACHELOR OF ARTS
(Group BA)

First Term

Ma 030D	Intermediate Algebra	5- 0
GV 010D	U.S. Government	4- 0
HI 101C	U.S. History I	4- 0
EN 101C	Advanced Writing for Naval Officers	3- 2
		16- 2

Second Term

SP 010D	Public Speaking	3- 0
Ma 031D	College Algebra and Trigonometry	5- 0
GV 102C	International Relations	4- 0
HI 102C	U.S. History II	4- 0
NW 201C	Operational Planning	2- 0
		18- 0

Third Term

SP 011D	Conference Procedures	3- 0
PS 310C	Elementary Probability and Statistics	3- 1
GV 103C	Strategy for National Security	4- 0
EN 102C	Reasoning and Research Reporting	4- 0
MN 010D	Introduction to Macro-Economics	4- 0
		18- 1

Fourth Term

HI 103C	European History I	4- 0
GV 140C	Development of Western Political Thought	4- 0
LT 010D	Appreciation of Literature	3- 0
PY 010D	Introduction to Psychology	4- 0
PH 007D	General Physics I	3- 2
		18- 2

Fifth Term (8 week term)

GV 142C	International Communism	4- 0
HI 104C	European History II	4- 0
GV	Major Elective	4- 0
		12- 0

Sixth Term

GV 120C	Military Law I	3- 0
MN 111C	Introduction to Micro-Economics	4- 0
PH 008D	General Physics II	3- 2
NW 401C	Leadership and Administration	3- 0
GV	Major Elective	4- 0
		17- 2

Seventh Term

GV 121C	Military Law II	3- 0
GV 122C	International Law	4- 0
GV 141C	American Traditions and Ideals	3- 0
GV	Literature Elective	3- 0
PH 009D	General Physics III	3- 2
		16- 2

Eighth Term

PH 010D	Physics IV	3- 2
NW 101C	Tactics and Combat Information Center	5- 0
NW 303C	Missiles and Space Operations	4- 0
NW 408C	Seamanship and Marine Piloting	3- 2
		15- 4

Ninth Term

NW 103C	Anti-Submarine Warfare	5- 0
NW 208C	Aviation Accident Prevention and Crash Investigation	5- 0
NW 404C	Logistics and Naval Supply	3- 0
NW 209C	Aero Engineering and Safety	5- 2
		18- 2

Tenth Term (8 week term)

NW 105C	Anti-Air Warfare	4- 0
NW 502C	Damage Control & ABC Warfare Defense	4- 0
GV	Major Elective	4- 0
		12- 0

*Electives may be substituted for courses for which exemptions are granted.

Note 1: The above are for an August input; for a January input, leave will occur during the students' 3rd and 8th terms instead of the 5th term with a slight modification in the schedule.

Note 2: 200 term hours are required for graduation. The difference between the number of hours listed above and the total required for graduation is made up by advanced credits and electives.

Note 3: NW 208 and NW 209 comprise the Aviation Safety Program which was implemented in August 1964. These courses are required for aviators only.

NAVAL ENGINEERING PROGRAMS CURRICULUM NUMBER 570

EUGENE MARION HENRY, Commander, U.S. Navy, Curricular Officer; B.S., U.S. Naval Academy, 1946; M.S., U.S. Naval Postgraduate School, 1960.

PAUL FRANCIS PUCCI, Academic Associate; B.S. in M.E., Purdue Univ., 1949; M.S. in M.E., 1950; Ph.D., Stanford Univ., 1955.

ANTONIO NEVAREZ, Lieutenant Commander, U.S. Navy, Assistant Curricular Officer; B.S., U.S. Naval Academy, 1953; B.S., Electrical Engineering, U.S. Naval Postgraduate School, 1959.

OBJECTIVE — To provide selected officers with advanced education in ship engineering, primarily in mechanical and electrical engineering, to meet the requirements of the Navy for officers with technical and administrative competence related to shipboard engineering plants, including machinery systems, and structures. The specific areas of study are designed to include, within the various curricula, the fundamental and advanced theories of mathematics, thermodynamics, statics, dynamics, electrical power, circuits and feedback control, engineering materials, structures, atomic and nuclear physics, and nuclear power.

DESCRIPTION — All students initially enter a common Naval Engineering (General) Curriculum. After completion of two terms, students are selected to pursue studies in a specialty of either Mechanical or Electrical Engineering. Upon completion of the first year of study, a limited number of students in each specialty are further selected to follow an advanced three year curriculum in their specialty (Mechanical or Electrical Engineering).

The criteria for selection are academic performance, assigned quotas, tour availability, and student preference. The Curricula are:

Naval Engineering (Mechanical)	2 year curriculum
Naval Engineering (Electrical)	2 year curriculum
Mechanical Engineering (Advanced)	3 year curriculum
Electrical Engineering (Advanced)	3 year curriculum

For properly qualified students, the two year curricula lead to the award of a designated Bachelor of Science degree and the three year curricula lead to the award of a designated Master of Science degree.

NAVAL ENGINEERING (GENERAL) (Group NG)

OBJECTIVE — This is a two-term, common-core program followed by all officer students entering the Naval Engineering Curricula. The objective is to educate officers in the basic sciences and engineering principles as a foundation for more advanced studies in either an electrical or mechanical engineering specialty.

First Year

First Term

EE 111C	Fields and Circuits	4- 4
Ma 230D	Calculus of Several Variables	4- 0
Ma 120C	Vectors and Matrices	3- 1
ME 501C	Mechanics I	4- 0
		15- 5

Second Term

EE 112C	Circuit Analysis	4- 3
Ma 073C	Differential Equations	5- 0
ME 502C	Mechanics II	4- 0
CH 103C	General Chemistry	4- 2
		17- 5

NAVAL ENGINEERING (MECHANICAL) (Group NH)

Objective — To support the aim of the basic objective to the extent practicable within a two year period by providing officer students with a sound science-engineering basis for assuming increased technical and administrative responsibilities related to naval machinery, with primary emphasis on Mechanical Engineering aspects.

First Year

First and Second Terms

Same as Naval Engineering (General)

Third Term

Ma 416C	Numerical Methods & Fortran Programming	4- 1
EE 331C	Electric Machinery	3- 4
ME 510C	Mechanics of Solids I	4- 2
ME 111C	Engineering Thermodynamics I	5- 0
LP 101E	Lecture Program I	0- 1
		16- 8

Fourth Term

MS 201C	Engineering Materials I	3- 2
ME 721C	Mechanics of Machinery	3- 2
ME 411C	Mechanics of Fluids	4- 2
ME 112C	Engineering Thermodynamics II	5- 0
LP 102E	Lecture Program II	0- 1
		15- 7

Fifth Term

MS 202C	Engineering Materials II	3- 2
EE 281C	General Electronics	4- 2
		7- 4

Second Year

First Term

ME 221C	Gas Dynamics and Heat Transfer	4- 2
ME 504B	Advanced Dynamics	4- 0
ME 521C	Mechanics of Solids II	4- 0
PS 311C	Introduction to Probability and Statistics	4- 1
		16- 3

Second Term

ME 222C	Thermodynamics Laboratory	1- 4
ME 522B	Mechanics of Solids III	4- 0
ME 223B	Marine Power Plant Analysis	2- 4
PH 620C	Elementary Atomic Physics	4- 0
		11- 8

Third Term

CH 403B	Corrosion and Corrosion Protection	3- 2
ME 722B	Mechanical Vibrations	3- 2
MN 301C	Basic Management I	4- 0
PH 621C	Elementary Nuclear Physics	4- 0
LP 101E	Lecture Program I	0- 1
		14- 5

Fourth Term

ME 240B	Nuclear Power Plants	4- 0
ME 622B	Experimental Mechanics	2- 2
ME 820C	Machine Design	2- 4
MN 302C	Basic Management II	4- 0
LP 102E	Lecture Program II	0- 1
		12- 7

MECHANICAL ENGINEERING (ADVANCED) (Group NA)

Objective — To further the aim of the basic objective by providing officer students with a broad background of science-engineering studies in a three-year program designed to prepare them for assuming increased technical and administrative responsibilities related to naval machinery, with primary emphasis on Mechanical Engineering aspects.

First Year

Same as Naval Engineering (Mechanical)

Second Year

First Term

Ma 113B	Vector Analysis and Partial Differential Equations	4- 0
Ma 270C	Complex Variables	3- 0
ME 211B	Thermodynamics of Compressible Flow	3- 0
ME 222C	Thermodynamics Lab	1- 4
Me 511A	Mechanics of Solids II	5- 0
		16- 4

Second Term

ME 412A	Advanced Mechanics of Fluids	4- 2
ME 512A	Mechanics of Solids III	4- 0
ME 712A	Theory of Vibrations	3- 2
EE 113B	Linear Systems Analysis	4- 3
		15- 7

Third Term

EE 411B	Feedback Control Systems I	3- 3
ME 310B	Heat Transfer	4- 2
ME 215B	Marine Propulsion Systems I	2- 4
PH 620C	Elementary Atomic Physics	4- 0
LP 101E	Lecture Program I	0- 1
		13-10

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Fourth Term

ME 216B	Marine Propulsion Systems II	2- 4
ME 503A	Advanced Mechanics	4- 0
ME 811B	Machine Design I	3- 2
PH 621C	Elementary Nuclear Physics	4- 0
LP 102E	Lecture Program II	0- 1
		13- 7

Intersessional Period — A four to six weeks tour at selected industrial or research activities.

Third Year

First Term

ME 612A	Experimental Mechanics	3- 2
ME 812B	Machine Design II	3- 4
MN 301C	Basic Management I	4- 0
ME 241A	Nuclear Propulsion Systems I	4- 0
		14- 6

Second Term

ME 212A	Advanced Thermodynamics	3- 0
ME 242A	Nuclear Propulsion Systems II	3- 3
PS 351B	Probability and Statistics	4- 2
	Thesis	0- 8
		10-13

Third Term

PS 362B	Applied Statistics	3- 1
	Thesis	0-12
LP 101E	Lecture Program I	0- 1
		3-14

Fourth Term

MN 302C	Basic Management II	4- 0
CH 403B	Corrosion and Corrosion Protection	3- 2
OA 151B	Reliability Engineering and Systems Analysis	3- 0
	Thesis	0- 8
LP 102E	Lecture Program II	0- 1
		10-11

NAVAL ENGINEERING (ELECTRICAL) (Group NL)

OBJECTIVE — To support the aim of the basic objective to the extent practicable within a two year period by providing officer students with a sound science-engineering basis for assuming increased technical and administrative responsibilities related to naval machinery, with primary emphasis on Electrical Engineering aspects.

First Year

First and Second Terms

Same as Naval Engineering (General)

Third Term

EE 231C	Electronics I	4- 3
Ma 271C	Complex Variables	4- 0
Ma 416C	Numerical Methods and Fortran Programming	4- 1
ME 510C	Mechanics of Solids I	4- 2
LP 101E	Lecture Program I	0- 1
		16- 7

Fourth Term

EE 131C	Polyphase Circuits	3- 2
EE 232C	Electronics II	4- 3
EE 711C	Electrical Measurements	2- 3
MS 201C	Engineering Materials I	3- 2
LP 102E	Lecture Program II	0- 1
		12-11

Fifth Term

EE 113B	Linear Systems Analysis	4- 3
MS 202C	Engineering Materials II	3- 2
		7- 5

Second Year

First Term

EE 311C	Electric Machinery I	3- 4
EE 611C	Electromagnetic Fields	4- 0
EE 223B	Electronic Control and Measurement	3- 3
PH 620C	Elementary Atomic Physics	4- 0
		14- 7

Second Term

EE 312C	Electric Machinery II	3- 4
EE 411B	Feedback Control Systems I	3- 3
EE 612C	Transmission of Electromagnetic Energy	3- 2
ME 111C	Engineering Thermodynamics I	5- 0
		14- 9

Third Term

EE 419B	Nonlinear and Sampled Systems	3- 4
ME 132C	Engineering Thermodynamics II	4- 2
MN 301C	Basic Management I	4- 0
PS 311C	Introduction to Probability and Statistics	4- 1
LP 101E	Lecture Program I	0- 1
		15- 8

Fourth Term

EE 114B	Communication Theory I	4- 0
EE 233B	Communication Circuits and Systems	4- 3
ME 246B	Nuclear Power Plants	4- 0
MN 302C	Basic Management II	4- 0
LP 102E	Lecture Program II	0- 1
		16- 4

ELECTRICAL ENGINEERING (ADVANCED) (Group NE)

OBJECTIVE — To further the aim of the basic objective by providing officer students with a broad background of science-engineering studies in a three-year program designed to prepare them for assuming increased technical and administrative responsibilities related to naval machinery, with primary emphasis on Electrical Engineering aspects.

First Year

Same as Naval Engineering (Electrical)

Second Year

First Term

EE 223B	Electronic Control and Measurement	3- 3
EE 311C	Electric Machinery I	3- 4
EE 121A	Advanced Network Analysis	3- 2
PH 620C	Elementary Atomic Physics	4- 0
		13- 9

Second Term

EE 312C	Electric Machinery II	3- 4
EE 411B	Feedback Control Systems I	3- 3
ME 111C	Engineering Thermodynamics I	5- 0
PS 351B	Probability and Statistics	4- 2
		15- 9

Third Term

EE 122A	Network Synthesis I	3- 2
EE 419B	Nonlinear and Sampled Systems	3- 4
ME 132C	Engineering Thermodynamics II	4- 2
PS 362B	Applied Statistics	3- 1
LP 101E	Lecture Program I	0- 1
		13-10

Fourth Term

EE 114B	Communication Theory I	4- 0
EE 233B	Communications Circuits and Systems	4- 3
ME 210C	Applied Thermodynamics	3- 2
ME 246B	Nuclear Power Plants	4- 0
LP 102E	Lecture Program II	0- 1
		15- 6

Intersessional Period — A four to six weeks tour at selected industrial or research activities.

Third Year

First Term

Ma 113B	Vector Analysis and Partial Differential Equations	4- 0
OA 151B	Reliability Engineering and Systems Analysis	3- 0
EE 951E	Seminar	0- 1
	*Elective	4- 0
		11- 1

Second Term

EE 621B	Electromagnetics I	3- 2
EE 951E	Seminar	0- 1
	Thesis	0-12
		3-15

Third Term

EE 315B	Marine Electrical Design I	2- 4
EE 622B	Electromagnetics II	4- 0
EE 951E	Seminar	0- 1
MN 301C	Basic Management I	4- 0
	Thesis	0- 8
LP 101E	Lecture Program I	0- 1
		10-14

Fourth Term

EE 316A	Marine Electrical Design II	2- 4
EE 951E	Seminar	0- 1
MN 302C	Basic Management II	4- 0
	Thesis	0- 8
LP 102E	Lecture Program II	0- 1
	*Elective	4- 0
		10-14

*Elective course must be from approved list in curricular office.

Coordinating Studies with Foreign Officer Student

NAVAL MANAGEMENT AND OPERATIONS ANALYSIS PROGRAMS CURRICULA NUMBERS 817, 367, and 360

FLETCHER HARRIS BURNHAM, Captain, U.S. Navy; Curricular Officer; B.S., U.S. Naval Academy, 1944; B.S., Operations Analysis, U.S. Naval Postgraduate School, 1954; M.S., U.S. Naval Postgraduate School, 1954.

DOUGLAS GEORGE WILLIAMS, Academic Associate for Data Processing; M.A. (honors), Univ. of Edinburgh, 1954.

CLAIR ALTON PETERSON, Academic Associate for Management; B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961.

WILLIAM PEYTON CUNNINGHAM, Academic Associate for Operations Analysis; B.S., Yale Univ., 1928; Ph.D., 1932.

CLELL STEWART, Commander, U.S. Navy; Assistant Curricular Officer.

RICHARD HERBERT KALLIES, Commander, U.S. Navy; Assistant Curricular Officer, Ph.B., Univ. of Wisconsin, 1943.

NAVAL MANAGEMENT CURRICULUM CURRICULUM NUMBER 817 (Group MN)

OBJECTIVE — To provide officers with increased education in management which will improve their capabilities for organizing, planning, directing, coordinating and controlling activities in which the resources of men, money, and materials are combined to accomplish Navy objectives.

DESCRIPTION — The curriculum is of twelve months' duration at the graduate level. All officers, regardless of designator, are required to participate in the "core" courses. These courses provide the foundation and tools of management and lead into the electives, which permit limited specialization in fields of interest to sponsoring bureaus and agencies.

Classroom instruction is supplemented by a guest lecturer series which affords the officer an opportunity to hear discussions of management topics by senior military officers, business executives, and prominent educators.

Successful completion of this program leads to the award of a Master of Science degree.

First Term

MN 210C	Macro-Economics	4- 0
MN 221C	Financial Accounting	3- 0
Ma 032C	Mathematics for Management	4- 0
MN 252C	Individual Behavior	4- 0
		15- 0

Second Term

MN 411B	Micro-Economics	4- 0
MN 422A	Managerial Accounting	3- 0
PS 371B	Management Statistics I	4- 1
MN 481A	Computers and Data Processing	4- 0
EN 105C	Thesis Writing	2- 0
		17- 1

Third Term

MN 423A	Planning Programming and Budgeting	4- 0
PS 372B	Management Statistics II	4- 1
MN 460A	Material Management	3- 0
MN 490A	Group and Organizational Behavior	5- 0
		16- 1

Fourth Term

MN 453A	Personnel Administration & Industrial Relations	4- 0
OA 471B	Operations Analysis for Navy Management	4- 1
	Elective Sequence	6- 0 to 7- 0
		14- 1 to 15- 1

Fifth Term

MN 491A	Management Policy	4- 0
	Elective Sequence	10- 0 to 12- 0
		14- 0 to 16- 0

ELECTIVE SEQUENCES

1 — *Economics and Systems Analysis*

Term			
IV	MN 413A	Intermediate Micro-Economic Theory	4- 0
IV	MN 473A	Quantitative Decision Making	3- 0
V	MN 426A	Cost Estimating and Analysis	3- 0
V	MN 432A	Systems Analysis	4- 0
V		Required Elective	4- 0
			3- 0 to 5- 0

2 — *Financial Management*

IV	MN 412A	Managerial Economics	
		or	
	MN 413A	Intermediate Micro-Economic Theory	4- 0
IV	MN 424A	Internal Control and Auditing	3- 0
V	MN 425A	Comptrollership Seminar	4- 0
V	MN 426A	Cost Estimating and Analysis	3- 0
V		Required Elective	3- 0 to 5- 0

3 — *Personnel Management*

IV	MN 412A	Managerial Economics	4- 0
IV	MN 495A	Organization & Management Seminar	3- 0
V	MN 455A	Behavioral Science Seminar	3- 0
V	MN 456A	Labor Relations	4- 0
V		Required Elective	3- 0 to 5- 0

4 — *Material Logistics Management*

IV	MN 412A	Managerial Economics	4- 0
		or	
	MN 413A	Intermediate Micro-Economic Theory	4- 0
IV	MN 480A	Facilities Management	3- 0
V	MN 461A	Procurement and Contract Administration	4- 0
V	MN 462A	Modern Inventory Management	3- 0
V		Required Elective	3- 0 to 5- 0

Other elective courses in the Management subject area are:

V	MN 381A	Data Processing Management	4- 0
V	MN 419A	Economics Seminar	4- 0
V	MN 492A	Government and Business	4- 0

MANAGEMENT (DATA PROCESSING) CURRICULUM
CURRICULUM NUMBER 367
(Group PM)

OBJECTIVE — To provide officers with a comprehensive education in computer theory and practice by which they will gain an appreciation of the capabilities and limitations of digital computers in a variety of applications, and develop their ability to analyze data processing systems and effectively manage computer-based installations.

DESCRIPTION — The curriculum is of twelve months' duration at the graduate level. Classroom instruction is supplemented by guest lecturer and seminar series which afford the officer an opportunity to participate in discussions of management topics with senior military officers, business executives, and prominent educators.

Successful completion of this program leads to the award of a Master of Science degree.

First Term

MN 210C	Macro-Economics	4- 0
MN 490A	Group and Organizational Behavior	5- 0
MA 427C	Programming I — Introduction	3- 1
MA 141D	Review of Analytic Geometry and Calculus	5- 0
		17- 1

Second Term

MN 322A	Managerial Accounting	3- 0
PS 315C	Introduction to Probability & Statistics	4- 2
MA 140B	Linear Algebra and Matrix Theory	4- 0
MA 428B	Programming IIa	3- 1
	Elective: Sequence A or B	3- 0

Third Term

PS 316B	Applied Statistics I	3- 2
MA 429A	Programming IIb	4- 0
OA 111B	Principles of Operations Research/ Systems Analysis	4- 2
	Elective: Sequence A or B	3- 0 to 4- 0
		14- 4 to 15- 4

Fourth Term

PS 317B	Applied Statistics II	3- 0
OA 112A	Advanced Methods in Operations Analysis	4- 0
MN 381A	Data Processing Management	4- 0
MN 411B	Micro-Economics	4- 0
	Elective: Sequence A or B	3- 0 to 4- 0
		18- 0 to 19- 0

Fifth Term

MN 382A	Computer Applications	4- 0
	Elective: Sequence A or B	4- 0 to 3- 1
	Elective: Sequence A or B	3- 0 to 2- 2
	Elective: Sequence A or B	3- 0 to 3- 1
		14- 0 to 12- 4

ELECTIVE COURSES

Sequence A (Recommended for Supply Corps Officer Students)

Term			
II	MN 460A	Material Management	3- 0
III	MN 423A	Planning, Programming & Budgeting	4- 0
IV	MN 453A	Personnel Administration and Industrial Relations	4- 0
V	MN 432A	Systems Analysis	4- 0
V	MN 462A	Modern Inventory Management	3- 0
		Plus one other course from:	
	MN 426A	Cost Estimating and Analysis	3- 0
	MN 461A	Procurement and Contract Administration	3- 0
	MN 492A	Government and Business	4- 0

Sequence B (For Regular Line Officer Students)

Term			
II	MA 241C	Elementary Differential Equations	3- 0
III	MA 146B	Numerical Analysis and Digital Computers	3- 0
IV		One course from:	
	OA 214A	Graph Theory	3- 0
	OA 234A	Queueing Theory	3- 0
	PS 355A	Systems Reliability and Life Testing	3- 0
	EE 812B	Logical Design and Circuitry	4- 0
V		Choice of three courses from:	
	OA 393B	Introduction to War Gaming	2- 2
	PS 305A	Design of Experiments	3- 1
	PS 306A	Selected Topics in Advanced Statistics	3- 1
		Plus courses under Sequence A	

OPERATIONS RESEARCH/SYSTEMS ANALYSIS CURRICULUM
CURRICULUM NUMBER 360
(Group RO)

OBJECTIVE — To develop the analytical ability of officers by providing a sound background and education in scientific and analytical methods so that they may formulate new concepts and programs in operations research/systems analysis, apply the result of operations research/systems analysis with greater effectiveness, and solve operations analysis problems which arise both in the fleet and ashore.

DESCRIPTION — The curriculum is normally of two years' duration at the graduate level, with new students enrolled in January and August of each year. Classroom work is augmented by guest lecturer-seminar series which permit officers to gain first-hand information as to practical applications of operations research/systems analysis principles and techniques. Between the first and second year of the program students are assigned individually as working members of various industrial or military organizations which are engaged in operations analysis of military problems. Successful completion of the two year curriculum leads to the award of a Master of Science degree.

A third year of study may be offered to particularly well qualified officers. Selection is based upon the expressed desires of the individual, the Superintendent's appraisal of his academic ability and prospects, and his availability for the additional year of duty ashore.

First Year

First Term

Ma 180C	Vector, Matrices, and Vector Spaces	3- 1
Ma 181D	Partial Derivatives and Multiple Integrals	4- 1
PS 310C	Basic Probability and Set Theory	4- 0
OA 421C	Introduction to Digital Computers	5- 0
OA 891E	Lecture/Seminar	0- 2
		16- 4

Second Term

Ma 182C	Differential Equations & Vector Analysis	5- 0
PS 302B	Second Course in Probability	3- 2
OA 291C	Introduction to Operations Research	4- 0
OA 892E	Lecture/Seminar	0- 2
Ph 242C	Radiation	3- 0
MN 311C	Macro-Economics	3- 0
		18- 4

Third Term

Ma 196B	Matrix Theory	3- 0
PS 303B	Theory and Technique in Statistics I	3- 2
OA 292B	Methods of Operations Research/ Systems Analysis	4- 0
OA 393B	Introduction to War Gaming	2- 2
OA 893E	Lecture/Seminar	0- 2
MN 312B	Micro-Economics	3- 0
		15- 6

Fourth Term

Ma 193C	Set Theory and Integration	2- 0
PS 304B	Theory and Techniques in Statistics II	3- 0
OA 293B	Search Theory	4- 0
OA 391B	Games of Strategy	3- 2
OA 894E	Lecture/Seminar	0- 2
	Core Sequence I-4	4- 0
		16- 4

Second Year

First Term

Ma 183B	Fourier Series and Complex Variables	4- 0
OA 211A	Linear Programming	4- 1
OA 236A	Utility Theory	3- 0
OA 891E	Lecture/Seminar	0- 2
	Core Sequence II-1	3- 0 to 4- 0
	Elective Sequence (Required) (1)	3- 0 to 5- 0
	Elective Sequence (Optional)	3- 0 to 5- 0
		20- 3 to 25- 3

Second Term

OA 234A	Queueing Theory	3- 0
MN 426A	Cost Estimating and Analysis	3- 0
OA 892E	Lecture/Seminar	0- 2
	Core Sequence II-2	3- 1 to 4- 0
	Elective Sequence (Required) (1)	3- 0 to 5- 0
		15- 3 to 20- 2

Third Term

OA 501A	Introduction to System Analysis	4- 0
OA 893E	Lecture/Seminar	0- 2
	Core Sequence II-3	3- 1 to 4- 0
	Elective Sequence (Required) (1)	3- 0 to 5- 0
	Elective Sequence (Optional)	3- 0 to 5- 0
	Thesis	0- 8
		13-11 to 18-10

Fourth Term

OA 502A	System Analysis	4- 0
OA 894E	Lecture/Seminar	0- 2
	Core Sequence II-4	3- 0 to 4- 0
	Elective Sequence (Required) (1)	3- 0 to 5- 0
	Elective Sequence (Optional)	3- 0 to 5- 0
	Thesis	0- 4
		13- 6 to 18- 6

Core Course Sequences A and B

Core Sequence A is designed to meet the general "Navy need" and is required of all students except Supply Corps officers, who may elect to take Core Sequence B instead.

Core Sequence B is designed primarily to meet the needs of the Supply Corps, and is adaptable to the needs of Marine Corps and U. S. Army officers.

CORE SEQUENCE A

(General

I-4	PH 141B	Analytical Mechanics	4- 0
II-1	PH 424B	Fundamental Acoustics	4- 0
II-2	PH 425B	Underwater Acoustics	3- 2
II-3	PH 360B	Electricity and Magnetism	4- 0
II-4	PH 610C	Modern Physics	4- 0

CORE SEQUENCE B

(Supply Corps, Marine Corps and Army Officers)

I-4	MN 381A	Data Processing Management	4- 0
II-1	PS 307A	Stochastic Process I	3- 0
II-2	PS 305A	Design of Experiments	3- 1
		(Supply Corps Officers)	
II-3	OA 213B	Inventory Systems	3- 0
I -4	OA 218A	Seminar in Supply Systems	3- 0
		(Marine Corps and Army Officers)	
II-3	OA 491B	Methods for Combat Development	4- 0
II-4	OA 297A	Selected Topics in Operations Research	3- 1

Required Elective Sequences

Each student must select one of the following Sequences. In addition, optional electives may be selected from this list. All optional electives selected must, however, be approved by the Chairman, Department of Operations Analysis.

SEQUENCE I (Statistics)

Term			
I	PS 307A	Stochastic Process I	3- 0
II	PS 305A	Design of Experiments	3- 1
III	PS 306A	Advanced Statistics	3- 0
IV	PS 308A	Stochastic Process II	3- 0

SEQUENCE II (Simulation)

I	OA 396A	Advanced Projects in Operations Research	1- 4
II	PS 305A	Design of Experiments	3- 1
III	OA 225A	Air Warfare	3- 0
IV	OA 394A	Advanced War Gaming	3- 0

SEQUENCE III (Logistics)

I	PS 307A	Stochastic Process I	3- 0
II	OA 217A	Theory of Pattern Recognition	3- 0
III	OA 213B	Inventory Systems	3- 0
IV	OA 218A	Seminar in Supply Systems	3- 0

SEQUENCE IV (Computers)

I	OA 396A	Adanced Projects in Operations Research	3- 0
II	Ma 428B	Programming IIa	3- 1
III	Ma 146B	Numerical Analysis & Digital Computers	3- 1
V	OA 394A	Advanced War Gaming	3-1

SEQUENCE V (Economics)

I	MN 313A	Intermediate Micro-Economic Theory	3- 0
II	OA 202A	Econometrics	3- 0
III	MN 316A	Advanced Economic Analysis	3- 0
IV	OA 214A	Graph Theory	3- 0
		or	
	OA 235A	Decision Criteria	3- 0

SEQUENCE VI (Advanced Operations Analysis)

I	OA 216A	Cybernetics	3- 0
II	PS 396A	Decision Theory	3- 0
III	OA 214A	Graph Theory	3- 0
IV	PS 355A	Systems Reliability & Life Testing	3- 0
		or	
	OA 235A	Decision Criteria	3- 0

SEQUENCE VII (Modern Optimization Techniques)

I	OA 396A	Advanced Projects in Operations Research	1- 4
III	PS 306A	Advanced Statistics	3- 0
III	Ma 248B	Differential Equations for Optimum Control	3- 0
IV	OA 297A	Selected Topics in Operations Research	3- 0

ORDNANCE ENGINEERING PROGRAMS CURRICULA NUMBERS 521, 530, and 535

Mark Hopkins, Jr., Commander, U.S. Navy, Curricular Officer; B.S., U.S. Merchant Marine Academy, 1950; M.S., U.S. Naval Postgraduate School, 1958.

Oscar Bryan Wilson, Jr., Academic Associate; B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

NUCLEAR ENGINEERING (EFFECTS) CURRICULUM NUMBER 521 (Group RZ)

Objective — To educate selected officers in such portions of the fundamental sciences as will furnish an advanced technical understanding of the phenomenology of the blast and of the thermal, nuclear, and biological aspects of nuclear weapons effects, including their employment and defensive situations.

Description — Class convenes in August. This curriculum is sponsored by the Defense Atomic Support Agency as a joint-service course for selected officers of the Army, Navy, Air Force, Marine Corps, and Coast Guard. Upon completion of their first four terms students are separated (depending on demonstrated academic potential) into either the 2-year curriculum leading to the degree B.S. in Physics, or the 2-year curriculum leading to the degree M.S. in Physics. Satisfactory completion of the M.S. curriculum requires the writing of a thesis.

For a limited number of exceptionally well-qualified students a third year of instruction may be granted. These students are selected at the end of the first year. The second- and third-year curricula are then tailored to individual needs, consistent with the requirements of DASA and the parent service.

First Year

(First 4 terms of first year are common to both the B.S. and M.S. curricula)

First Term (Term I of Academic Year)

CH 106C	Principles of Chemistry I	3- 2
Ma 120C	Vectors and Matrices with Geometric Applications	3- 1
Ma 230D	Calculus of Several Variables	4- 0
PH 061D	Review of Mechanics and Electromagnetism	4- 2
		14- 5

Second Term (Term II of Academic Year)

CH 109C	General and Organic Chemistry	3- 2
Ma 254C	Taylor and Fourier Series	3- 0
Ma 255C	Differential Equations and Series Solutions	3- 0
PH 151C	Mechanics I	4- 1
PH 530C	Thermodynamics	3- 0
		16- 3

Third Term (Term III of Academic Year)

PH 152B	Mechanics II	4- 0
PH 265C	Physical Optics	4- 2
PH 701C	Introduction to the Methods of Theoretical Physics	4- 0
PS 351B	Probability and Statistics	4- 2
LP 101E	Lecture Program I	0- 1
		16- 5

Fourth Term (Term IV of Academic Year)

PH 153A	Mechanics III	4- 0
PH 365C	Electricity and Magnetism	4- 1
PH 541B	Introductory Statistical Physics	4- 0
PH 635B	Atomic Physics I	5- 0
LP 102E	Lecture Program II	0- 1
	Thesis	0- 1
		17- 3

Upon completion of Term IV students will be separated into either the 2-year Curriculum leading to the degree B.S. in Physics, or the 2-year Curriculum leading to the degree M.S. in Physics; but all students (both B.S. and M.S.) will have an 8-week accelerated Term V to study the courses listed below, followed by a 2-week leave period.

Fifth Term (Term V of Academic Year)—B.S.

PH 366B	Electromagnetism	4- 0
PH 636B	Atomic Physics II	4- 3
		8- 3

Fifth Term (Term V of Academic Year)—M.S.

PH 366B	Electromagnetism	4- 0
PH 636B	Atomic Physics II	4- 3
	Thesis*	0- 2
		8- 5

*Unsupervised study in preparation for subsequent thesis work.

Second Year (B.S. Curriculum)

First Term (Term I of Academic Year)

EE 291C	Electronics I (Nuclear)	3- 3
PH 350B	Special Topics in Electromagnetism	4- 0
PH 441B	Shock Waves in Fluids	4- 0
PH 637B	Nuclear Physics I	3- 0
PH 750E	Physics Colloquium	0- 1
		14- 4

Second Term (Term II of Academic Year)

BI 800C	Fundamentals of Biology	6- 0
EE 292C	Electronics II (Nuclear)	3- 3
PH 638B	Nuclear Physics II	3- 3
PH 750E	Physics Colloquium	0- 1
	Elective	4- 0
		16- 7

Third Term (Term III of Academic Year)

BI 801B	Animal Physiology	6- 0
CH 591B	Blast and Shock Effects	3- 0
ME 547C	Statics and Strength of Materials	5- 0
PH 750E	Physics Colloquium	0- 1
LP 101E	Lecture Program I	0- 1
	Elective	4- 0
		18- 2

Fourth Term (Term IV of Academic Year)

BI 802A	Radiation Biology	6- 0
CH 551A	Radiochemistry I	2- 4
ME 548B	Structural Theory	5- 0
PH 750E	Physics Colloquium	0- 1
LP 102E	Lecture Program II	0- 1
	Elective	4- 0
		17- 6

This curriculum affords the opportunity to qualify for the degree Bachelor of Science in Physics.

Upon completion of their second year of studies, officer-students will take a field trip to Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico, for a specially tailored National Atomic Capabilities Course given by the Atomic Weapons Training Group. This field trip will be taken as temporary duty under instruction en route to their new duty stations under permanent change of station orders issued by their parent services.

Second Year (M.S. Curriculum)

First Term (Term I of Academic Year)

EE 291C	Electronics I (Nuclear)	3- 3
PH 367A	Advanced Electromagnetism I	4- 0
PH 441B	Shock Waves in Fluids	4- 0
PH 637B	Nuclear Physics I	3- 0
PH 750E	Physics Colloquium	0- 1
	Thesis	0- 6
		14-10

Second Term (Term II of Academic Year)

BI 800C	Fundamentals of Biology	6- 0
EE 292C	Electronics II (Nuclear)	3- 3
PH 639A	Nuclear Physics II	4- 3
PH 750E	Physics Colloquium	0- 1
	Thesis	0- 6
		13-13

Third Term (Term III of Academic Year)

BI 801B	Animal Physiology	6- 0
CH 551A	Radiochemistry I	2- 4
ME 547C	Statics and Strength of Materials	5- 0
PH 750E	Physics Colloquium	0- 1
LP 101E	Lecture Program I	0- 1
	Thesis	0- 6
		13-12

Fourth Term (Term IV of Academic Year)

BI 802A	Radiation Biology	6- 0
CH 591B	Blast and Shock Effects	3- 0
ME 548B	Structural Theory	5- 0
PH 750E	Physics Colloquium	0- 1
LP 102E	Lecture Program II	0- 1
	Thesis	0- 6
		14- 8

This curriculum affords the opportunity to qualify for the degree Master of Science in Physics.

Upon completion of their second year of studies, officer-students will take a field trip to Field Command, Defense Atomic Support Agency, Sandia Base, Albuquerque, New Mexico, for a specially tailored National Atomic Capabilities Course given by the Atomic Weapons Training Group. This field trip will be taken as temporary duty under instruction en route to their new duty stations under permanent change of station orders issued by their parent services.

UNDERWATER PHYSICS SYSTEMS CURRICULUM NUMBER 535

OBJECTIVE — To provide selected officers, by means of an advanced technical education: (a) A thorough understanding of the problems of underwater physics and their interrelationships with the anti-submarine warfare system and (b) an introduction to technical management.

DESCRIPTION — Class convenes in August. Upon completion of their first four terms, officer students are separated (depending on expressed choice of the individual, demonstrated academic potential, and length of availability for postgraduate instruction) into either the 2-year curriculum leading to the degree B.S. in Physics, or the 3-year curriculum leading to the degree M.S. in Physics.

First Year

(First 4 terms of first year are common to both the 2-year B.S. and 3-year M.S. curricula)

First Term (Term I of Academic Year)

EE 111C	Fields and Circuits	4- 4
Ma 150C	Vectors and Matrices	4- 1
Ma 230D	Calculus of Several Variables	4- 0
Oc 110C	Introduction to Oceanography	3- 0
		15- 5

Second Term (Term II of Academic Year)

EE 112C	Circuit Analysis	4- 3
EE 231C	Electronics I	4- 3
Ma 244C	Differential Equations and Infinite Series	4- 0
PH 265C	Physical Optics	4- 2
		16- 8

Third Term (Term III of Academic Year)

EE 232C	Electronics II	4- 3
Ma 271C	Complex Variables	4- 0
PH 151C	Mechanics I	4- 1
PH 701C	Introduction to The Methods of Theoretical Physics	4- 0
		16- 4

Fourth Term (Term IV of Academic Year)

EE 113B	Linear Systems Analysis	4- 3
EE 811C	Introduction to Digital Computers	3- 3
PH 152B	Mechanics II	4- 0
PH 365C	Electricity and Magnetism	4- 1
		15- 7

Upon completion of Term IV students will be separated into either the 2-year curriculum leading to the degree B.S. in Physics, or the 3-year curriculum leading to the degree M.S. in Physics; but all students (both B.S. and M.S.) will have an 8-week accelerated Term V to study the courses listed below, followed by a 2-week leave period.

Fifth Term (Term V of Academic Year)—B.S.

MN 320C	Managerial Accounting	4- 0
PH 366B	Electromagnetism	4- 0
PH 530C	Thermodynamics	3- 0
		11- 0

Fifth Term (Term V of Academic Year)—M.S.

EN 104C	Technical Writing	2- 1
PH 530C	Thermodynamics	3- 0
PS 321B	Probability	4- 2
		9- 3

Second Year (2-Year B.S. Curriculum)

First Term (Term I of Academic Year)

EE 114B	Communication Theory I	4- 0
EE 233B	Communication Circuits and Systems	4- 3
PH 431B	Fundamental Acoustics	4- 0
PS 351B	Probability and Statistics	4- 2
		16- 5

Second Term (Term II of Academic Year)

EE 116B	Communication Theory II	3- 2
EE 411B	Feedback Control Systems I	3- 3
PH 432B	Underwater Acoustics	4- 3
PS 352B	Applied Engineering Statistics	2- 2
		12-10

Third Term (Term III of Academic Year)

EE 419B	Non-linear and Sampled Systems	3- 4
MN 310C	Engineering Economics	4- 0
PH 463B	Special Topics in Underwater Acoustics	3- 2
PH 670B	Atomic Physics I	3- 0
		13- 6

Fourth Term (Term IV of Academic Year)

EE 431C	Introduction to Radar	3- 3
EE 455B	Sonar Systems	3- 3
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
PH 671B	Atomic Physics II	3- 3
		13- 9

This curriculum affords the opportunity to qualify for the degree Bachelor of Science in Physics.

Second Year (3-Year M.S. Curriculum)

First Term (Term I of Academic Year)

EE 233B	Communication Circuits and Systems	4- 3
PH 366B	Electromagnetism	4- 0
PH 431B	Fundamental Acoustics	4- 0
PS 322A	Decision Theory and Classical Statistics	3- 2
		15- 5

Second Term (Term II of Academic Year)

PH 367A	Advanced Electromagnetism I	4- 0
PH 432B	Underwater Acoustics	4- 3
PH 670B	Atomic Physics I	3- 0
PS 355A	System Reliability and Life Testing	3- 0
		14- 3

Third Term (Term III of Academic Year)

EE 114B	Communication Theory I	4- 0
PH 433A	Propagation of Waves in Fluids	3- 0
PH 461A	Transducer Theory and Design	3- 3
PH 671B	Atomic Physics II	3- 3
		13- 6

Fourth Term (Term IV of Academic Year)

EE 571A	Statistical Communication Theory	3- 2
MN 310C	Engineering Economics	4- 0
PH 442A	Finite Amplitude Waves in Fluids	3- 0
PH 471A	Acoustics Research	0- 3
PH 480E	Acoustics Colloquium	0- 1
PH 541B	Introductory Statistical Physics	4- 0
		14- 6

Fifth Term (Term V of Academic Year)

Students will have an 8-week accelerated term to study the courses listed below, followed by a 2-week leave period.

MN 320C	Managerial Accounting	4- 0
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
PH 621C	Elementary Nuclear Physics	4- 0
		12- 0

THIRD YEAR
(3-Year M.S. Curriculum)

First Term (Term I of Academic Year)

EE 411B	Feedback Control Systems I	3- 3
EE 451A	Sonar Systems Engineering	4- 3
OA 293B	Search Theory	4- 0
PH 161A	Fluid Mechanics	3- 0
PH 750E	Physics Colloquium	0- 1
	Thesis	0- 1
		14- 8

Second Term (Term II of Academic Year)

EE 419B	Non-linear and Sampled Systems	3- 4
PH 162A	Advanced Hydrodynamics	3- 0
PH 462B	Vibration and Noise Control	3- 0
PH 750E	Physics Colloquium	0- 1
	Thesis	0- 6
		9-11

Third Term (Term III of Academic Year)

Field assignment to an industrial or government laboratory or remain at USNPGS to do thesis work.

Fourth Term (Term IV of Academic Year)

EE 433A	Radar Systems	4- 2
OA 510B	Systems Analysis	4- 0
PH 480E	Acoustics Colloquium	0- 1
PH 481A	Seminar in Applications of Underwater Sound	3- 0
	Thesis	0- 6
		11- 9

This curriculum affords the opportunity to qualify for the degree Master of Science in Physics.

WEAPONS SYSTEMS ENGINEERING CURRICULUM NUMBER 530

Basic Objective — To provide selected officers with an advanced technical education on a broad foundation which encompasses the basic scientific and engineering principles underlying the field of weapons and an introduction to technical management. The specific areas of study and the level to be attained are formulated for each curriculum to insure a sound basis for technical competence and for such subsequent growth as may be required for the operation, maintenance, design, development, or production of advanced weapons systems.

Description — Classes convene in August and January. All officers ordered for instruction in Weapons Systems Engineering initially matriculate in the 2-year General Curriculum. At the end of their first three terms, officer students will be nominated for the 3-year Advanced Weapons Systems Engineering Curricula (Air/Space Physics, Chemistry, or Electronics) to fill the quotas assigned by the Chief of Naval Personnel. This nomination is based on the expressed choice of the individual and the Superintendent's appraisal of his academic ability. For an appropriately qualified entering student, the 2-year General Curriculum leads to the award of a bachelor's degree and any of the 3-year curricula leads to the award of a master's degree in a scientific or engineering field. A 2-year Weapons Systems Engineering (Special) Curriculum is offered to selected officer students of allied countries.

August Input
WEAPONS SYSTEMS ENGINEERING (GENERAL) CURRICULUM
(Group WG)

Objective — To support the aims of the basic objective to the maximum extent practicable within the 2-year period with emphasis on the fundamentals of Weapons Systems Engineering.

August Input—First Year

First Term (Term I of Academic Year)

CH 106C	Principles of Chemistry I	3- 2
*EE 102D	Introduction to Electricity and Magnetism	2- 2
Ma 120C	Vectors and Matrices with Geometric Applications	3- 1
Ma 230D	Calculus of Several Variables	4- 0
*PH 051D	Review of Elementary Mechanics	2- 2
		14- 7

*PH 051D and EE 102D are each 5-week courses and are sequential, not concurrent; PH 051D is prerequisite to EE 102D.

Second Term (Term II of Academic Year)

CH 107C	Principles of Chemistry II	3- 2
EE 103C	Network Analysis I	4- 4
Ma 254C	Taylor and Fourier Series	3- 0
Ma 255C	Differential Equations and Series Solutions	3- 0
Ma 260C	Vector Analysis	3- 0
		16- 6

Third Term (Term III of Academic Year)

EE 231C	Electronics I	4- 3
Ma 271C	Complex Variables	4- 0
PH 151C	Mechanics I	4- 1
PH 265C	Physical Optics	4- 2
LP 101E	Lecture Program I	0- 1
		16- 7

Fourth Term (Term IV of Academic Year)

CH 611C	General Thermodynamics	3- 2
EE 104C	Network Analysis II	4- 3
EE 232C	Electronics II	4- 3
PS 351B	Probability and Statistics	4- 2
LP 102E	Lecture Program II	0- 1
		15-11

Fifth Term (Term V of Academic Year)
(Accelerated 8-week courses)

Ma 416C	Numerical Methods and Fortran Programming	4- 1
MN 320C	Managerial Accounting	4- 0
PS 352B	Applied Engineering Statistics	2- 2
		10- 3

August Input—Second Year

First Term (Term I of Academic Year)

CH 407B	Physical Chemistry	3- 2
EE 115B	Signals, Systems, and Communication	4- 1
EE 321C	Electromechanical Devices	3- 4
EE 611C	Electromagnetic Fields	4- 0
		14- 7

Second Term (Term II of Academic Year)

EE 234C	Pulse Techniques and High Frequency Tubes	3- 3
EE 411B	Feedback Control Systems I	3- 3
EE 612C	Transmission of Electromagnetic Energy	3- 2
PH 630C	Elementary Atomic Physics	4- 0
		13- 8

Third Term (Term III of Academic Year)

EE 419B	Non-Linear and Sampled Systems	3- 4
EE 431C	Introduction to Radar	3- 3
MN 310C	Engineering Economics	4- 0
PH 621C	Elementary Nuclear Physics	4- 0
LP 101E	Lecture Program I	0- 1
		14- 8

Fourth Term (Term IV of Academic Year)

CH 542B	Reaction Motors	3- 2
CH 571B	Explosives Chemistry	3- 2
OA 131B	Methods of Operations Research & Systems Analysis	4- 0
PH 450C	Underwater Acoustics	3- 2
PH 622C	Nuclear Physics Laboratory	0- 3
LP 102E	Lecture Program II	0- 1
		13-10

Successful completion of this curriculum leads to the degree Bachelor of Science in Electrical Engineering.

August Input

ADVANCED WEAPONS SYSTEMS ENGINEERING (AIR/SPACE PHYSICS) CURRICULUM

(Group WP)

Objective — To further the aims of the basic objective by providing officer students with a broad background of selected science-engineering studies underlying air and space weapons systems, with Physics as the major field of study and Electrical Engineering as the principal minor field.

August Input—First Year

First Term (Term I of Academic Year)
Same as Weapons Systems Engineering (General) August Input.

Second Term (Term II of Academic Year)
Same as Weapons Systems Engineering (General) August Input.

Third Term (Term III of Academic Year)
Same as Weapons Systems Engineering (General) August Input.

Fourth Term (Term IV of Academic Year)

CH 611C	General Thermodynamics	3- 2
EE 104C	Network Analysis II	4- 3
EE 232C	Electronics II	4- 3
PH 152B	Mechanics II	4- 0
LP 102E	Lecture Program II	0- 1
		15- 9

Fifth Term (Term V of Academic Year)
(Accelerated 8-week courses)

CH 407B	Physical Chemistry	3- 2
EN 104C	Technical Writing	2- 1
Ma 416C	Numerical Methods and Fortran Programming	4- 1
		9- 4

August Input—Second Year

First Term (Term I of Academic Year)

EE 321C	Electromechanical Devices	3- 4
PH 153A	Mechanics III	4- 0
PH 365C	Electricity and Magnetism	4- 1
PS 351B	Probability and Statistics	4- 2
		15- 7

Second Term (Term II of Academic Year)

EE 234C	Pulse Techniques and High Frequency Tubes	3- 3
PH 366B	Electromagnetism	4- 0
PH 670B	Atomic Physics I	3- 0
PS 352B	Applied Engineering Statistics	2- 2
		12- 5

Third Term (Term III of Academic Year)

EE 411B	Feedback Control Systems I	3- 3
PH 367A	Advanced Electromagnetism I	4- 0
PH 541B	Introductory Statistical Physics	4- 0
PH 671B	Atomic Physics II	3- 3
LP 101E	Lecture Program I	0- 1
		14- 7

Fourth Term (Term IV of Academic Year)

EE 419B	Non-Linear and Sampled Systems	3- 4
Mc 406A	Introductory Control and Guidance	4- 0
PH 637B	Nuclear Physics I	3- 0
PH 725A	Physics of Solids I	4- 0
LP 102E	Lecture Program II	0- 1
	Thesis	0- 1
		14- 6

Fifth Term (Term V of Academic Year)
(Accelerated 8-week courses)

MN 320C	Managerial Accounting	4- 0
PH 726A	Physics of Solids II	4- 2
	*Thesis	0- 2
		8- 4

*Unsupervised time for reading in area of research.

August Input—Third Year

First Term (Term I of Academic Year)

MN 310C	Engineering Economics	4- 0
PH 639A	Nuclear Physics II	4- 3
PH 654A	Plasma Physics I	4- 0
PH 750E	Physics Colloquium	0- 1
	Thesis	0- 6
		12-10

Second Term (Term II of Academic Year)

Ae 551A	Fundamental Concepts of Fluid Mechanics	4- 2
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
PH 655A	Plasma Physics II	4- 0
PH 750E	Physics Colloquium	0- 1
	Thesis	0- 6
		12- 9

Third Term (Term III of Academic Year)

Ae 552A	Flow of Compressible Fluids	4- 0
MN 315B	Management Planning and Decision Making	4- 0
PH 750E	Physics Colloquium	0- 1
LP 101E	Lecture Program I	0- 1
	Elective	4- 0
	Thesis	0- 6
		12- 8

Fourth Term (Term IV of Academic Year)

Ae 553A	Viscosity, Turbulence and Boundary Layer Effects in Fluid Flow	4- 0
CH 542B	Reaction Motors	3- 2
OA 510B	Systems Analysis	4- 0
PH 750E	Physics Colloquium	0- 1
LP 102E	Lecture Program II	0- 1
	Thesis	0- 6
		11-10

Successful completion of this curriculum leads to the degree Master of Science in Physics.

August Input

ADVANCED WEAPONS SYSTEMS ENGINEERING (CHEMISTRY) CURRICULUM (Group WC)

OBJECTIVE — To further the aims of the basic objective by providing officer students with a broad background of selected science-engineering studies oriented toward those weapons systems dependent upon chemical energy for propulsion or explosive applications, with Chemistry as the major field of study and Electrical Engineering as the principal minor field.

August Input—First Year

First Term (Term I of Academic Year)

Same as Weapons Systems Engineering (General) August Input.

Second Term (Term II of Academic Year)

Same as Weapons Systems Engineering (General) August Input.

Third Term (Term III of Academic Year)

Same as Weapons Systems Engineering (General) August Input.

Fourth Term (Term IV of Academic Year)

CH 611C	General Thermodynamics	3- 2
EE 104C	Network Analysis II	4- 3
EE 232C	Electronics II	4- 3
PH 152B	Mechanics II	4- 0
LP 102E	Lecture Program II	0- 1
		15- 9

Fifth Term (Term V of Academic Year)
(Accelerated 8-week courses)

CH 231C	Quantitative Analysis	2- 4
Ma 416C	Numerical Methods and Fortran Programming	4- 1
EN 104C	Technical Writing	2- 1
		8- 6

August Input—Second Year

First Term (Term I of Academic Year)

CH 108C	Inorganic Chemistry	3- 4
CH 800E	Chemistry Seminar	0- 1
EE 321C	Electromechanical Devices	3- 4
PH 360B	Electricity and Magnetism	4- 0
PS 351B	Probability and Statistics	4- 2
		14-11

Second Term (Term II of Academic Year)

CH 443B	Physical Chemistry I	4- 3
CH 800E	Chemistry Seminar	0- 1
EE 234C	Pulse Techniques and High Frequency Tubes	3- 3
PH 670B	Atomic Physics I	3- 0
PS 352B	Applied Engineering Statistics	2- 2
		12- 9

Third Term (Term III of Academic Year)

CH 150A	Inorganic Chemistry, Advanced	4- 3
CH 311C	Organic Chemistry I	3- 2
CH 444B	Physical Chemistry II	3- 3
CH 800E	Chemistry Seminar	0- 1
PH 671B	Atomic Physics II	3- 3
LP 101E	Lecture Program I	0- 1
		13-13

Fourth Term (Term IV of Academic Year)

CH 312C	Organic Chemistry II	3- 2
CH 454B	Instrumental Methods of Analysis	3- 3
CH 470A	Chemical Thermodynamics	3- 0
CH 800E	Chemistry Seminar	0- 1
PH 621C	Elementary Nuclear Physics	4- 0
LP 102E	Lecture Program II	0- 1
	Thesis	0- 1
		13- 8

Fifth Term (Term V of Academic Year)
(Accelerated 8-week courses)

CH 313B	Organic Chemistry III	3- 2
MN 320C	Managerial Accounting	4- 0
	*Thesis	0- 2
		7- 4

*Unsupervised time for reading in area of research.

August Input—Third Year

First Term (Term I of Academic Year)

CH 328A	Physical Organic Chemistry I	4- 0
CH 467A	Quantum Chemistry I	3- 0
CH 800E	Chemistry Seminar	0- 1
MN 310C	Engineering Economics	4- 0
	Thesis	0- 6
		11- 7

Second Term (Term II of Academic Year)

CH 800E	Chemistry Seminar	0- 1
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
CH	Elective	4- 0
CH	Elective	4- 0
	Thesis	0- 6
		12- 7

Third Term (Term III of Academic Year)

CH 800E	Chemistry Seminar	0- 1
CH 770A	Process Control	3- 2
MN 315B	Management Planning and Decision Making	4- 0
LP 101E	Lecture Program I	0- 1
	Elective	4- 0
	Thesis	0- 6
		11-10

Fourth Term (Term IV of Academic Year)

CH 800E	Chemistry Seminar	0- 1
CH 542B	Reaction Motors	3- 2
CH 771A	Process Control	3- 2
OA 510B	Systems Analysis	4- 0
LP 102E	Lecture Program II	0- 1
	Thesis	0- 6
		10-12

Successful completion of this curriculum leads to the degree Master of Science in Chemistry.

August Input

ADVANCED WEAPONS SYSTEMS ENGINEERING (ELECTRONICS) CURRICULUM (Group WX)

Objective — To provide students with a broad background of science-engineering studies underlying modern weapons control systems with primary emphasis on electronics control systems and methods of digital computation.

August Input—First Year

First Term (Term I of Academic Year)

Same as Weapons Systems Engineering (General) August Input.

Second Term (Term II of Academic Year)

Same as Weapons Systems Engineering (General) August Input.

Third Term (Term III of Academic Year)

Same as Weapons Systems Engineering (General) August Input.

Fourth Term (Term IV of Academic Year)

CH 611C	General Thermodynamics	3- 2
EE 104C	Network Analysis II	4- 3
EE 232C	Electronics II	4- 3
PH 152B	Mechanics II	4- 0
LP 102E	Lecture Program II	0- 1
		15- 9

Fifth Term (Term V of Academic Year)
(Accelerated 8-week courses)

EE 125B	Operational Methods for Linear Systems	3- 1
PH 630C	Elementary Atomic Physics	4- 0
EN 104C	Technical Writing	2- 1
		9- 2

August Input—Second Year

First Term (Term I of Academic Year)

EE 114B	Communication Theory I	4- 0
EE 233B	Communication Circuits and Systems	4- 3
EE 621B	Electromagnetics I	3- 2
PH 723B	Theory of Solid State and Quantum Devices	4- 0
		15- 5

Second Term (Term II of Academic Year)

EE 213C	Electronic Circuits II	4- 3
EE 321C	Electromechanical Devices	3- 4
EE 622B	Electromagnetics II	4- 0
PS 351B	Probability and Statistics	4- 2
		15- 9

Third Term (Term III of Academic Year)

EE 217B	Advanced Electron Devices	4- 2
EE 411B	Feedback Control Systems I	3- 3
EE 811C	Introduction to Digital Computers	3- 3
PS 352B	Applied Engineering Statistics	2- 2
LP 101E	Lecture Program I	0- 1
		12-11

Fourth Term (Term IV of Academic Year)

CH 542B	Reaction Motors	3- 2
EE 412A	Feedback Control Systems II	3- 4
EE 433A	Radar Systems	4- 2
EE 812B	Logical Design and Circuitry	4- 0
LP 102E	Lecture Program II	0- 1
	Thesis	0- 1
		14-10

Fifth Term (Term V of Academic Year)
(Accelerated 8-week courses)

EE 413A	Sampled Data Control Systems	2- 2
MN 320C	Managerial Accounting	4- 0
	*Thesis	0- 2
		6- 4

*Unsupervised time for reading in area of research.

August Input—Third Year

First Term (Term I of Academic Year)

EE 414A	Statistical Design of Control Systems	2- 2
EE 551A	Information Networks	3- 2
EE 951E	Thesis Seminar	0- 1
MN 310C	Engineering Economics	4- 0
	Thesis	0- 6
		9-11

Second Term (Term II of Academic Year)

EE 122A	Network Synthesis	3- 2
EE 951E	Thesis Seminar	0- 1
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
	Elective	4- 0
	Thesis	0- 6
		11- 9

Third Term (Term III of Academic Year)

EE 462A	Automation and System Control	3- 3
EE 473A	Missile Guidance Systems	3- 0
EE 951E	Thesis Seminar	0- 1
MN 315B	Management Planning and Decision Making	4- 0
LP 101E	Lecture Program I	0- 1
	Thesis	0- 6
		10-11

Fourth Term (Term IV of Academic Year)

EE 461A	Systems Engineering	3- 2
EE 821B	Computer Systems Technology	3- 3
EE 951E	Thesis Seminar	0- 1
OA 510B	Systems Analysis	4- 0
LP 102E	Lecture Program II	0- 1
	Thesis	0- 6
		10-13

Successful completion of this curriculum leads to the degree Master of Science in Engineering Electronics.

August Input
WEAPONS SYSTEMS ENGINEERING (SPECIAL) CURRICULUM
(Group WS)

OBJECTIVE — To provide selected foreign officers with a technical education in the principal science-engineering fields of Electrical Engineering, Physics, and Chemistry underlying weapons systems.

Both the first and second year of this 2-year program are the same as the Weapons Systems Engineering (General) Curriculum except for minor modifications to fit the needs of individual students.

This curriculum affords the opportunity to qualify for the degree Bachelor of Science in Electrical Engineering.

January Input
WEAPONS SYSTEMS ENGINEERING (GENERAL) CURRICULUM
(Group WG)

OBJECTIVE — To support the aims of the basic objective to the maximum extent practicable within the 2-year period with emphasis on the fundamentals of Weapons Systems Engineering.

January Input—First Year

First Term (Term III of Academic Year)

CH 106C	Principles of Chemistry I	3- 2
*EE 102D	Introduction to Electricity and Magnetism	2- 2
Ma 120C	Vectors and Matrices with Geometric Applications	3- 1
Ma 230D	Calculus of Several Variables	4- 0
*PH 051D	Review of Elementary Mechanics	2- 2
LP 101E	Lecture Program I	0- 1
		14- 8

*PH 051D and EE 102D are each 5-week courses and are sequential, not concurrent; PH 051D is prerequisite to EE 102D.

Second Term (Term IV of Academic Year)

CH 107C	Principles of Chemistry II	3- 2
EE 103C	Network Analysis I	4- 4
Ma 254C	Taylor and Fourier Series	3- 0
Ma 255C	Differential Equations and Series Solutions	3- 0
Ma 260C	Vector Analysis	3- 0
LP 102E	Lecture Program II	0- 1
		16- 7

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

CH 611C	General Thermodynamics	3- 2
Ma 271C	Complex Variables	4- 0
Ma 416C	Numerical Methods and Fortran Programming	4- 1
		11- 3

Fourth Term (Term I of Academic Year)

EE 104C	Network Analysis II	4- 3
EE 231C	Electronics I	4- 3
PH 151C	Mechanics I	4- 1
PH 265C	Physical Optics	4- 2
		16- 9

Fifth Term (Term II of Academic Year)

EE 115B	Signals, Systems, and Communication	4- 1
EE 232C	Electronics II	4- 3
EE 321C	Electromechanical Devices	3- 4
PS 351B	Probability and Statistics	4- 2
		15-10

January Input—Second Year

First Term (Term III of Academic Year)

CH 407B	Physical Chemistry	3- 2
EE 411B	Feedback Control Systems I	3- 3
MN 320C	Managerial Accounting	4- 0
PH 630C	Elementary Atomic Physics	4- 0
PS 352B	Applied Engineering Statistics	2- 2
LP 101E	Lecture Program I	0- 1
		16- 8

Second Term (Term IV of Academic Year)

EE 234C	Pulse Techniques and High Frequency Tubes	3- 3
EE 419B	Non-Linear and Sampled Systems	3- 4
EE 611C	Electromagnetic Fields	4- 0
MN 310C	Engineering Economics	4- 0
LP 102E	Lecture Program II	0- 1
		14- 8

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

EE 612C	Transmission of Electromagnetic Energy	3- 2
PH 621C	Elementary Nuclear Physics	4- 0
PH 622C	Nuclear Physics Laboratory	0- 3
		7- 5

Fourth Term (Term I of Academic Year)

*CH 542B	Reaction Motors	3- 2
*CH 571B	Explosives Chemistry	3- 2
EE 431C	Introduction to Radar	3- 3
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
*PH 450C	Underwater Acoustics	3- 2
		13- 7

*Students take two of these three courses.

Successful completion of this curriculum leads to the degree Bachelor of Science in Electrical Engineering.

January Input
ADVANCED WEAPONS SYSTEMS ENGINEERING AIR/SPACE PHYSICS) CURRICULUM
(Group WP)

Objective — To further the aims of the basic objective by providing officer students with a broad background of selected science-engineering studies underlying air and space weapons systems, with Physics as the major field of study and Electrical Engineering as the principal minor field.

January Input—First Year

First Term (Term III of Academic Year)
Same as Weapons Systems Engineering (General) January Input.

Second Term (Term IV of Academic Year)
Same as Weapons Systems Engineering (General) January Input.

Third Term (Term V of Academic Year)
Same as Weapons Systems Engineering (General) January Input.

Fourth Term (Term I of Academic Year)
Same as Weapons Systems Engineering (General) January Input.

Fifth Term (Term II of Academic Year)

EE 232C	Electronics II	4- 3
PH 152B	Mechanics II	4- 0
PH 365C	Electricity and Magnetism	4- 1
PS 351B	Probability and Statistics	4- 2
		16- 6

January Input—Second Year

First Term (Term III of Academic Year)

PH 153A	Mechanics III	4- 0
PH 366B	Electromagnetism	4- 0
PH 670B	Atomic Physics I	3- 0
PS 352B	Applied Engineering Statistics	2- 2
LP 101E	Lecture Program I	0- 1
		13- 3

Second Term (Term IV of Academic Year)

EE 234C	Pulse Techniques and High Frequency Tubes	3- 3
Mc 406A	Introductory Control and Guidance	4- 0
PH 367A	Advanced Electromagnetism I	4- 0
PH 671B	Atomic Physics II	3- 3
LP 102E	Lecture Program II	0- 1
		14- 7

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

MN 320C	Managerial Accounting	4- 0
PH 541B	Introductory Statistical Physics	4- 0
PH 637B	Nuclear Physics I	3- 0
		11- 0

Fourth Term (Term I of Academic Year)

EE 321C	Electromechanical Devices	3- 4
PH 639A	Nuclear Physics II	4- 3
PH 654A	Plasma Physics I	4- 0
PH 725A	Physics of Solids I	4- 0
PH 750E	Physics Colloquium	0- 1
	Thesis	0- 1
		15- 9

Fifth Term (Term II of Academic Year)

Ae 551A	Fundamental Concepts of Fluid Mechanics	4- 2
PH 655A	Plasma Physics II	4- 0
PH 726A	Physics of Solids II	4- 2
PH 750E	Physics Colloquium	0- 1
	Thesis	0- 6
		12-11

January Input—Third Year

First Term (Term III of Academic Year)

Ae 552A	Flow of Compressible Fluids	4- 0
EE 411B	Feedback Control Systems I	3- 3
MN 310C	Engineering Economics	4- 0
PH 750E	Physics Colloquium	0- 1
LP 101E	Lecture Program I	0- 1
	Thesis	0- 6
		11-11

Second Term (Term IV of Academic Year)

Ae 553A	Viscosity, Turbulence and Boundary Layer Effects in Fluid Flow	4- 0
EE 419B	Non-Linear and Sampled Systems	3- 4
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
PH 750E	Physics Colloquium	0- 1
LP 102E	Lecture Program II	0- 1
	Thesis	0- 6
		11-12

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

CH 407B	Physical Chemistry	3- 2
MN 315B	Management Planning and Decision Making	4- 0
	*Thesis	0- 2
		7- 4

*Unsupervised time for organization of rough draft of thesis.

Fourth Term (Term I of Academic Year)

CH 542B	Reaction Motors	3- 2
OA 510B	Systems Analysis	4- 0
PH 750E	Physics Colloquium	0- 1
	Elective	4- 0
	Thesis	0- 6
		11- 9

Successful completion of this curriculum leads to the degree Master of Science in Physics.

January Input

ADVANCED WEAPONS SYSTEMS ENGINEERING (CHEMISTRY) CURRICULUM (Group WC)

OBJECTIVE — To further the aims of the basic objective by providing officer students with a broad background of selected science-engineering studies oriented toward those weapons systems dependent upon chemical energy for propulsion or explosive applications, with Chemistry as the major field of study and Electrical Engineering as the principal minor field.

January Input—First Year

First Term (Term III of Academic Year)

Same as Weapons Systems Engineering (General) January Input.

Second Term (Term IV of Academic Year)

Same as Weapons Systems Engineering (General) January Input.

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

Same as Weapons Systems Engineering (General) January Input.

Fourth Term (Term I of Academic Year)

CH 108C	Inorganic Chemistry	3- 4
CH 800E	Chemistry Seminar	0- 1
EE 104C	Network Analysis II	4- 3
EE 231C	Electronics I	4- 3
PH 151C	Mechanics I	4- 1
		15-12

Fifth Term (Term II of Academic Year)

CH 443B	Physical Chemistry I	4- 3
CH 800E	Chemistry Seminar	0- 1
EE 232C	Electronics II	4- 3
PH 152B	Mechanics II	4- 0
PS 351B	Probability and Statistics	4- 2
		16- 9

January Input—Second Year

First Term (Term III of Academic Year)

CH 311C	Organic Chemistry I	3- 2
CH 444B	Physical Chemistry II	3- 3
CH 800E	Chemistry Seminar	0- 1
PH 265C	Physical Optics	4- 2
PH 360B	Electricity and Magnetism	4- 0
PS 352B	Applied Engineering Statistics	2- 2
LP 101E	Lecture Program I	0- 1
		16-11

Second Term (Term IV of Academic Year)

CH 231C	Quantitative Analysis	2- 4
CH 312C	Organic Chemistry II	3- 2
CH 800E	Chemistry Seminar	0- 1
EE 234C	Pulse Techniques and High Frequency Tubes	3- 3
PH 635B	Atomic Physics I	5- 0
LP 102E	Lecture Program II	0- 1
		13-11

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

CH 313B	Organic Chemistry III	3- 2
MN 320C	Managerial Accounting	4- 0
PH 636B	Atomic Physics II	4- 3
		11- 5

Fourth Term (Term I of Academic Year)

CH 328A	Physical Organic Chemistry I	4- 0
CH 467A	Quantum Chemistry I	3- 0
CH 800E	Chemistry Seminar	0- 1
EE 321C	Electromechanical Devices	3- 4
PH 621C	Elementary Nuclear Physics	4- 0
	Thesis	0- 1
		14- 6

Fifth Term (Term II of Academic Year)

CH 454B	Instrumental Methods of Analysis	3- 3
CH 800E	Chemistry Seminar	0- 1
CH	Elective	4- 0
CH	Elective	4- 0
	Thesis	0- 6
		11-10

January Input—Third Year

First Term (Term III of Academic Year)

CH 150A	Inorganic Chemistry, Advanced	4- 3
CH 800E	Chemistry Seminar	0- 1
CH 770A	Process Control	3- 2
MN 310C	Engineering Economics	4- 0
LP 101E	Lecture Program I	0- 1
	Thesis	0- 6
		11-13

Second Term (Term IV of Academic Year)

CH 470A	Chemical Thermodynamics	3- 0
CH 800E	Chemistry Seminar	0- 1
CH 771A	Process Control	3- 2
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
LP 102E	Lecture Program II	0- 1
	Thesis	0- 6
		10-10

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

MN 315B	Management Planning and Decision Making	4- 0
	Elective	4- 0
	*Thesis	0- 2
		8- 2

*Unsupervised time for organization of rough draft of thesis.

Fourth Term (Term I of Academic Year)

CH 800E	Chemistry Seminar	0- 1
CH 542B	Reaction Motors	3- 2
OA 510B	Systems Analysis	4- 0
	Elective	4- 0
	Thesis	0- 6
		11- 9

Successful completion of this curriculum leads to the degree Master of Science in Chemistry.

January Input

ADVANCED WEAPONS SYSTEMS ENGINEERING (ELECTRONICS) CURRICULUM (Group WX)

OBJECTIVE — To provide students with a broad background of science-engineering studies underlying modern weapons control systems with primary emphasis on electronic control systems and methods of digital computation.

January Input—First Year

First Term (Term III of Academic Year)

Same as Weapons Systems Engineering (General) January Input.

Second Term (Term IV of Academic Year)

Same as Weapons Systems Engineering (General) January Input.

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

Same as Weapons Systems Engineering (General) January Input.

Fourth Term (Term I of Academic Year)

Same as Weapons Systems Engineering (General) January Input.

Fifth Term (Term II of Academic Year)

EE 232C	Electronics II	4- 3
EE 321C	Electromechanical Devices	3- 4
PH 152B	Mechanics II	4- 0
PS 351B	Probability and Statistics	4- 2
		15- 9

January Input—Second Year

First Term (Term III of Academic Year)

EE 125B	Operational Methods for Linear Systems	3- 1
EE 213C	Electronic Circuits II	4- 3
EE 233B	Communication Circuits and Systems	4- 3
PS 352B	Applied Engineering Statistics	2- 2
LP 101E	Lecture Program	0- 1
		13-10

Second Term (Term IV of Academic Year)

EE 114B	Communication Theory I	4- 0
EE 411B	Feedback Control Systems I	3- 3
EE 621B	Electromagnetics I	3- 2
EE 812B	Logical Design and Circuitry	4- 0
LP 102E	Lecture Program II	0- 1
		14- 6

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

EE 622B	Electromagnetics II	4- 0
MN 320C	Managerial Accounting	4- 0
PH 630C	Elementary Atomic Physics	4- 0
		12- 0

Fourth Term (Term I of Academic Year)

EE 217B	Advanced Electron Devices	4- 2
EE 412A	Feedback Control Systems II	3- 4
EE 551A	Information Networks	3- 2
EE 951E	Thesis Seminar	0- 1
PH 723B	Theory of Solid State and Quantum Devices	4- 0
	Thesis	0- 1
		14-10

Fifth Term (Term II of Academic Year)

EE 122A	Network Synthesis I	3- 2
EE 413A	Sampled Data Control Systems	2- 2
EE 433A	Radar Systems	4- 2
EE 951E	Thesis Seminar	0- 1
	Thesis	0- 6
		9-13

January Input—Third Year

First Term (Term III of Academic Year)

EE 414A	Statistical Design of Control Systems	2- 2
EE 473A	Missile Guidance Systems	3- 0
EE 951E	Thesis Seminar	0- 1
MN 310C	Engineering Economics	4- 0
LP 101E	Lecture Program I	0- 1
	Thesis	0- 6
		9-10

Second Term (Term IV of Academic Year)

EE 461A	Systems Engineering	3- 2
EE 821B	Computer Systems Technology	3- 3
EE 951E	Thesis Seminar	0- 1
OA 131B	Methods of Operations Research and Systems Analysis	4- 0
LP 102E	Lecture Program II	0- 1
	Thesis	0- 6
		10-13

Third Term (Term V of Academic Year)
(Accelerated 8-week courses)

MN 315B	Management Planning and Decision Making	4- 0
	Elective	4- 0
	*Thesis	0- 2
		8- 2

*Unsupervised time for organization of rough draft of thesis.

Fourth Term (Term I of Academic Year)

CH 542B	Reaction Motors	3- 2
EE 462A	Automation and System Control	3- 3
EE 951E	Thesis Seminar	0- 1
OA 510B	Systems Analysis	4- 0
	Thesis	0- 6
		10-12

Successful completion of this curriculum leads to the degree Master of Science in Engineering Electronics.

January Input

WEAPONS SYSTEMS ENGINEERING (SPECIAL) CURRICULUM

(Group WS)

Objective — To provide selected foreign officers with a technical education in the principal science-engineering fields of Electrical Engineering, Physics, and Chemistry underlying weapons systems.

Both the first and second year of this 2-year program are the same as the Weapons Systems Engineering (General) Curriculum except for minor modifications to fit the needs of individual students.

This curriculum affords the opportunity to qualify for the degree Bachelor of Science in Electrical Engineering.

Electrical Engineering Laboratories

CURRICULA CONDUCTED AT CIVILIAN UNIVERSITIES

Curriculum	*Number*	*Length*	*Institution*	*Liaison Official*	*Curricular Supervisory Control Authority*
Business Administration	810	2- yrs.	Harvard	CO, NROTC	BUSANDA
			Stanford	CO, NROTC	BUWEPS
Civil Engineering (Advanced)	470	1-2 yrs.	Georgia Tech.	CO, NROTC	BUDOCKS
Typical Options:			M.I.T.	CO, NROTC	BUDOCKS
			Princeton	CO, NROTC	BUDOCKS
Structures			Purdue	CO, NROTC	BUDOCKS
Soil Mechanics			R.P.I.	CO, NROTC	BUDOCKS
Sanitary Engineering			Stanford	CO, NROTC	BUDOCKS
Waterfront Facilities			Texas A.&M.	Senior Officer Student	BUDOCKS
Facilities Planning			Tulane	CO, NROTC	BUDOCKS
Construction Engineering			Cal. (Berkeley)	CO, NROTC	BUDOCKS
Civil Engineering Administration			U. of Colo.	CO, NROTC	BUDOCKS
Deep Ocean Construction Engineering			U. of Ill.	CO, NROTC	BUDOCKS
			U. of Mich.	CO, NROTC	BUDOCKS
			U. of Minn.	CO, NROTC	BUDOCKS
			U. of Wash.	CO, NROTC	BUDOCKS
Electrical Engineering(CEC)	471	15-24 mos.	U. of Mich.	CO, NROTC	BUDOCKS
Engineering Electronics (CEC)	472	12-18 mos.	U. of Mich.	CO, NROTC	BUDOCKS
Financial Management	812	1 yr.	Geo. Wash. U.	Senior Officer Student	NAVCOMP
Hydrographic Engineering (Geodesy)	475	2 yrs.	Ohio St. U.	CO, NROTC	OPNAV(Op-09B2)
International Relations	671	1 yr.	American U.	Senior Officer Student	BUPERS
			Harvard	CO, NROTC	USNPGS
Law (Army Judge Advocate Officers Advanced Course)	881	9 mos.	U. of Virginia	CO, NROTC	JAG
Management and Industrial Engineering	540	1 yr.	R.P.I.	CO, NROTC	BUWEPS
Mechanical Engineering (CEC)	473	1 yr.	R.P.I.	CO, NROTC	BUDOCKS
Metallurgical Engineering	640	9 mos.	Carnegie Tech.	Senior Officer Student	BUSHIPS
Naval Construction and Engineering	510	3 yrs.	M.I.T.	CO. NROTC	BUSHIPS
			Webb Inst.	Senior Officer Student	BUSHIPS
Nuclear Engineering (Advanced)	520	14 mos.	M.I.T.	CO, NROTC	BUSHIPS
Nuclear Power Engineering (CEC)	572	15-20 mos.	Penn. State U.	CO, NROTC	BUDOCKS
			U. of Mich.	CO, NROTC	BUDOCKS
Oceanography	440	2 yrs.	U. of Miami (Florida)	Senior Officer Student	USNPGS
			U. of Washington	CO, NROTC	USNPGS
			Texas A.&M.	Senior Officer Student	USNPGS
			U. of Cal. (San Diego)	Senior Officer Student	USNPGS
			M.I.T.	CO, NROTC	USNPGS
Petroleum Administration and Management	880	1 yr.	S.M.U.	Senior Officer Student	JAG
Petroleum Engineering (CEC)	630	1 yr.	U. of Texas	CO, NROTC	BUDOCKS
		1 yr.	Industry		
Petroleum Management	811	16 mos.	U. of Kansas	CO, NROTC	BUSANDA
Political Science	680	2 yrs.	Fletcher School of Law and Diplomacy, Tufts	CO, NROTC	OPNAV(Op-61)
			Univ. of Washington	CO, NROTC	
Procurement Management	815	1 yr.	U. of Mich.	CO, NROTC	BUSANDA
Public Relations	920	1 yr.	U. of Wisc.	CO, NROTC	CHINFO
Religion	970	9 mos.	Various		Chief of Chaplains
Retailing	830	1 yr.	Michigan State	Senior Officer Student	BUSANDA
Subsistence Technology	860	1 yr.	Mich. State	Senior Officer Student	BUSANDA
Systems Inventory Management	819	2 yrs.	Harvard	CO, NROTC	BUSANDA
Textile Technology	580	18 mos.	N. Car. State	Senior Officer Student	BUSANDA
Transportation Management	813	1 yr.	Mich. State	Senior Officer Student	BUSANDA

CURRICULA AT OTHER UNIVERSITIES

The curricula listed in this section are conducted entirely at civilian educational institutions. Quotas for enrollment must be approved by the Chief of Naval Personnel. The table indicates the duration of each curriculum, the location, and the curricular supervisory control authority as set forth in BUPERS INSTRUCTION 1520.50B. Administration of officer students in connection with educational matters is exercised by the Superintendent, U. S. Naval Postgraduate School, through the Commanding Officer, NROTC Unit, or through the Senior Officer Student at those institutions where no NROTC Unit is established.

The information on courses is taken from college catalogues, but is subject to change from year to year. Changes depend on scheduling problems at the educational institutions and on the academic backgrounds of students. Further detailed information can be obtained from the catalogue of the institution concerned, or by writing to the institution.

BUSINESS ADMINISTRATION CURRICULUM NO 810

At Harvard University

Objective — To give emphasis to the following areas of study: (1) recognition of problems, (2) realistic administrative follow-through on decisions, (3) an understanding and realistic handling of human relations, (4) administrative powers in general, (5) the relationship of business to the government and to the public welfare, (6) the integration of business functions, and (7) the point of view of the Chief Executive and the directors responsible for over-all operations so as to give the student an effective start in the development of his managerial skills and an appreciation of the responsibilities of a business administrator.

Course length: Two years
Degree attainable: Master of Business Administration

Typical Curriculum:

First Year (All courses required)
Elements of Administration:
- Finance
- Human Behavior in Organizations I and II
- Organizational Problems
- Managerial Economics, Reporting, and Control I and II
- Managerial Economics, Reporting, and Control III and IV
- Marketing
- Planning and the Business Environment
- Production
- Written Analysis of Cases

Second Year (10 half-year courses required)
- Business Policy (Required)
- Courses in General Business Management
- Courses in Industrial and Financial Accounting
- Courses in Production/Manufacturing
- Courses in Finance/Investment
- Courses in Advanced/International Economics
- Courses in Personnel Administration/Human Relations
- Courses in Marketing/Sales/Merchandising
- Courses in Transportation
- Courses in Military Management
- Courses in Taxation
- Courses in Foreign Operations
- Courses in Probability and Statistics for Business Decisions
- Courses in Industrial Procurement

At Stanford University

Objective — To give the student a foundation in the following areas: (1) the external environment of the commercial firm, (2) the internal and organizational environment of the firm, (3) quantitative methods and tools of control, and (4) the management of major functions; to give the student an opportunity to apply the knowledge, skills, and attitudes acquired to the solution of action-oriented problems involving the entire commercial enterprise.

Course length: Two years
Degree attainable: Master of Business Administration
Typical Curriculum:

Required—First Year
- Organization Behavior
- Marketing Management I & II
- Quantitative Methods I, II & III
- Business Economics I & II
- Management Accounting I & II
- Business Finance I & II
- Manufacturing I & II
- Employment Relationships

Second Year
- Courses in Industrial and Financial Accounting, Audit, Comptrollership
- Courses in Production/Manufacturing
- Courses in Finance/Investment/Banking
- Courses in Personnel Administration/Industrial Relations
- Courses in Marketing/Sales
- Courses in Transportation
- Courses in Insurance/Risk Management
- Courses in Advanced Economics/International Trade
- Courses in Research/Small Business Management
- Courses in Business Information Systems Data Processing
- Courses in Purchasing

CIVIL ENGINEERING (ADVANCED) CURRICULUM NUMBER 470

At: Georgia Institute of Technology
Massachusetts Institute of Technology
Princeton University
Purdue University
Rensselaer Polytechnic Institute

Stanford University
Texas A&M
Tulane University
University of California (Berkeley)
University of Colorado
University of Illinois
University of Michigan
University of Minnesota
University of Washington

OBJECTIVE — To educate officers for civil engineering duties. Options are available in all major fields of civil engineering. Typical options are: construction engineering, structures, soil mechanics, sanitary engineering, waterfront facilities, facilities planning, and civil engineering administration. Officers without previous civil engineering education would undertake a two-year curriculum; officers holding a Bachelor of Civil Engineering degree would undertake a one-year curriculum. This program is to qualify line officers (1100) for civil engineering duties and to provide advanced education for Civil Engineering Corps officers (5100).

Course length: One to two years
Degree attainable: Master of Science in Civil Engineering
Typical Curriculum: (For two-year Structures Option)

First Year:

Contracts and Specifications
Structural Analysis I and II
Reinforced Concrete I and II
Hydraulics
Mechanical Behavior of Materials I
Mathematics
Highway and Airport Engineering
Digital Computation Methods
Building Construction
Structural Design
Structural Mechanics

Second Year:

Advanced Mathematics
Water Supply and Sewerage
Indeterminate Structures
Prestressed Concrete
Analytical Solution of Structural Problems
Long Span Structures
Construction Methods and Estimates
Limit Design of Steel Structures
Structural Analysis for Terminal Loadings
Advanced Indeterminate Structures
Thesis

ELECTRICAL ENGINEERING (CEC) CURRICULUM NUMBER 471

At University of Michigan

OBJECTIVE — To provide advanced education for selected CEC officers in electrical engineering with emphasis on power plants and electrical utility distribution.

Course length: 15-24 months
Degree attainable: Master of Science in Electrical Engineering

ENGINEERING ELECTRONICS (CEC) CURRICULUM NUMBER 472

At University of Michigan

OBJECTIVE — To provide advanced education for selected CEC officers in the field of electronics with options in communication engineering, computer engineering, engineering systems and design, electromagnetic field theory, and microwave engineering.

Course length: 12 to 18 months
Degree attainable: Master of Science in Engineering Electronics

FINANCIAL MANAGEMENT CURRICULUM NUMBER 812

At George Washington University

OBJECTIVE — To develop in officers of mature judgment and a broad background of professional experience the ability to interpret and analyze operational statistics for the purpose of developing standards of performance; to provide a periodic review of operations in order to denote areas of management which are not meeting standards; to review budget estimates; and to plan programs for the improvement of management economy and efficiency through better organization, administration and procedures and better utilization of manpower, materials, facilities, funds and time. The course is designed to give graduates a working knowledge of managerial controls adequate for assignment to financial management duties as a normal preparation for command and executive billets in the shore establishment and leads to degree Master of Business Administration.

Course length: One year
Degree attainable: Master of Science in Business Administration
Typical Curriculum:

Required Undergraduate Courses:

Survey of Accounting
Introduction to Econometrics
Industrial and Governmental Economics
Bases of Statistical Decision Making

Required Graduate Courses:

Decision Systems and Accounting
Managerial Accounting
Advanced Administrative Management
Business Research I & II
Human Relations in Administration
Readings and Conferences in Comptrollership
Governmental Budgeting
Survey of Data Processing

Choice of three from graduate courses in:

Accounting
Business Administration
Business and Public Administration
Public Administration
Statistics

HYDROGRAPHIC ENGINEERING (GEODESY) CURRICULUM NUMBER 475

At Ohio State University

OBJECTIVE — To prepare officers for assignment to duties at the Oceanographic Office, on geodetic survey expeditions, and on fleet staffs. The curriculum presents a fundamental theoretical knowledge of geodesy, cartography, and photogrammetry, particularly as applied to hydrographic surveying and the compilation and production of charts and maps.

Course length: Two years

Degree attainable: Master of Science in Geodesy

INTERNATIONAL RELATIONS CURRICULUM NUMBER 671

At: American University
Harvard University

OBJECTIVE — To provide a broad understanding of the forces and factors in international relations to equip officers to meet responsibilities involving knowledge of the international situation, including awareness of the role of sea power in world affairs.

Course length: One year

Degree attainable: Master of Arts

LAW CURRICULUM NUMBER 881

(Army Judge Advocate Officers Advanced Course)
At University of Virginia

OBJECTIVE—To prepare more experienced Law Specialists (1620) for advanced staff responsibilities in the various legal fields. The course encompasses all branches of military law with emphasis on the administration of the Uniform Code of Military Justice, military affairs, civil affairs arising out of the operation of or litigation of military law, military reservations, international law including the laws of war, procurement and contract law, and legal assistance to military personnel.

Course length: Nine months

MANAGEMENT AND INDUSTRIAL ENGINEERING CURRICULUM NUMBER 540

At Rensselaer Polytechnic Institute

OBJECTIVE — To prepare selected officers for managerial and industrial engineering billets in the Navy's industrial organization. The curriculum majors in industrial engineering and its application to managerial problems.

Course length: One year

Degree attainable: Master of Science in Management Engineering

Typical Curriculum:

Summer:

Review of Quantitative Methods
Statistical Methods
Law in Management and Engineering
Data Processing

Fall:

Cost Finding and Control
New Product Problems or
Organization and Management of Marketing
Organization Planning & Development
Industrial Relations
Production Management I

Spring:

Administrative Practice and Behavior
Financial Planning and Control
Seminar in Management
Production Management II
Analytical Methods in Management

MECHANICAL ENGINEERING (CEC) CURRICULUM NUMBER 473

At Rensselaer Polytechnic Institute

OBJECTIVE — To provide advanced education for selected CEC officers in mechanical engineering with emphasis on power plants, heating and ventilation.

Course length: One year

Degree attainable: Master of Science in Mechanical Engineering

METALLURGICAL ENGINEERING CURRICULUM NUMBER 640

At Carnegie Institute of Technology

OBJECTIVE — To obtain the maximum possible metallurgical background in a short program designed specifically for the graduate of the Naval Construction and Engineering Curriculum.

Course length: Nine months

Degree attainable: Bachelor of Science in Metallurgy

NAVAL CONSTRUCTION AND ENGINEERING CURRICULUM NUMBER 510

At: Massachusetts Institute of Technology
Webb Institute of Naval Architecture

OBJECTIVE — To qualify selected officers for duty assignments in the fields of naval construction and marine engineering. The curricula are arranged to provide a broad capability in naval architecture and an exceptional capability in one option or specialty. Options are available in the following areas: hull design and construction, marine electrical engineering, electronics engineering and ship propulsion engineering. Selection of options is made after completion of the first summer term. Exceptional students are encouraged to pursue advanced work at the doctoral level. Successful completion of this curriculum leads to "Engineering Duty" designation (1400).

Course length: Three years

Degree attainable: Master of Science in Naval Architecture and Marine Engineering and the Degree of Naval Engineer

Typical Curriculum at M.I.T.:
(Hull Design and Construction Option)

First Summer:

- Strength of Materials and Dynamics
- Applied Hydrostatics
- Review of Mathematics

First Year:

- Structural Mechanics
- Fluid Mechanics
- Thermodynamics
- History of Naval Ships
- Advanced Calculus for Engineers
- Naval Structural Engineering
- Heat Transfer
- Introduction to Nuclear Physics
- Principles of Naval Architecture
- Naval Ship General Arrangements I
- Introduction to Probability and Random Variables

Second Summer:

- Digital Computer Program Systems
- Advanced Calculus for Engineers

Second Year:

- Advanced Hydromechanics I and II
- Properties of Metals
- Naval Structural Theory I and II
- Naval Ship Propulsion I
- Mechanical Vibration
- Naval Ship General Arrangements II
- Naval Structural Analysis
- Advanced Mechanics
- Properties of Metals
- Electives: Experimental Hydrodynamics
  - Naval Structural Design I
  - Naval Electrical Engineering

Third Summer:

- Industrial Tour

Third Year:

- Advanced Structural Mechanics
- Experimental Stress Analysis
- Principles of Ship Design
- Principles of Naval Ship Design
- Hydroacoustics
- Naval Ship Propulsion II
- Electives: Naval Structural Design II
  - Buckling of Structures
  - Plasticity
- Thesis

NUCLEAR ENGINEERING (ADVANCED)
CURRICULUM NUMBER 520

At Massachusetts Institute of Technology

Objective — To qualify officers for the technical direction of nuclear power development in the Navy. Graduates of this program can normally expect to be assigned duties within the nuclear power development program under the direction of the Bureau of Ships.

Course length: 14 months

Degree attainable: Master of Science

NUCLEAR POWER ENGINEERING (CEC)
CURRICULUM NUMBER 572

At: The Pennsylvania State University
University of Michigan

Objective — To provide education for selected CEC officers in nuclear power engineering. Graduates of this curriculum will normally be assigned duties in the shore nuclear power program under the technical direction of the Bureau of Yards and Docks.

Course length: 15 to 20 months

Degree attainable: Master of Science

OCEANOGRAPHY
CURRICULUM NUMBER 440

At: University of Washington
Texas A&M College
University of Miami (Florida)
University of California (San Diego)
Massachusetts Institute of Technology

Objective — To prepare officers for assignment to billets requiring comprehensive theoretical and practical foundation in the various aspects of oceanography. Students may specialize in physical, biological, chemical, or geological oceanography. Entering students are expected to have a baccalaureate degree in physics, mathematics, meteorology, geophysics, or engineering, including the following undergraduate work: mathematics through differential equations (about 20 semester hours), physics (about 25 semester hours), chemistry through quantitative analysis, and introductory courses in biology, oceanography, geology, and meteorology.

Course length: Two years

Degree attainable: Master of Science in Oceanography

PETROLEUM ADMINISTRATION AND MANAGEMENT
(Gas, Oil and Water Rights)
CURRICULUM NUMBER 880

At Southern Methodist University

Objective — To provide Law Specialists (1620) with a study of government regulations in oil and gas law taxation problems, and special research and study of the evolution of law concerning water rights, current law affecting these rights, and technical problems attendant thereto so as to prepare them for assignment to billets concerned with the administration and management of the Naval Petroleum and Oil Shale Reserves and with the special problems in the field of water rights.

Course length: One year

Degree attainable: Master of Laws in Oil and Gas

PETROLEUM ENGINEERING (CEC) CURRICULUM NUMBER 630

At University of Texas
and in the petroleum industry

OBJECTIVE — To prepare selected CEC officers for assignments to duty involving the administration and operations of Naval Petroleum and Oil Shale Reserves. The curriculum provides the student with a knowledge of petroleum development and production procedures, geology, petroleum economics and reservoir engineering.

Course length: One year of academic work followed by up to one year in the field with a major oil company

Degree attainable: Master of Science in Petroleum Engineering

PETROLEUM MANAGEMENT CURRICULUM NUMBER 811

At University of Kansas

OBJECTIVE — To provide officers of the Supply Corps with graduate level education in the functional proficiency field of petroleum management and adminstration.

Course length: Sixteen months
Degree attainable: Master of Science
Typical Curriculum:

Fall:
Quantitative Analysis I
Material and Energy
Development of Oil and Gas Lands
Theoretical Principles of Petroleum Production

Spring:
Quantitative Analysis II
Field Practice in Natural Gas
Appraisal of Oil and Gas Properties
Research

Summer:
Personnel Management
Legal Aspects of Business Research

Fall:
Petroleum Management Research

POLITICAL SCIENCE CURRICULUM NUMBER 680

At: The Fletcher School of Law and Diplomacy, Tufts University
Graduate School of Public Affairs, University of Washington

OBJECTIVE — To equip a limited number of intellectually mature officers with a broad professional background in international relations in order that they may provide professional advice and assistance in the formulation and execution of national policy. Studies should be specifically directed toward obtaining sound knowledge and understanding in:

(1) The theory of international politics, economics, law, and U.S. diplomatic history.

(2) The politics, geography and history of one of the following regions of the world: Europe, Asia, Africa, Western Hemisphere.

(3) The history, role and importance of world-wide and regional international organizations.

(4) Development and execution of U.S. political, military and economic policy as it pertains to U.S. foreign relations.

Course length: Two years
Degree attainable: Master of Arts

PROCUREMENT MANAGEMENT CURRICULUM NUMBER 815

At University of Michigan

OBJECTIVE — To provide officers of the Supply Corps with graduate level education in the field of military and commercial procurement:

Course length: One year
Degree attainable: Master of Business Administration

PUBLIC RELATIONS CURRICULUM NUMBER 920

At University of Wisconsin

OBJECTIVE — To provide advanced qualifications of officers in the field of public relations. Officers selected for this program must have previous education or experience in public information and public relations. The curriculum will be made up from regular course offerings of the university and will be based on an officer student's background and particular interest within the curricular area.

Course length: One year
Degree attainable: Master of Arts in Public Relations

RELIGION CURRICULUM NO. 970

At: Harvard University
Yale University
Catholic University
University of Chicago
University of Notre Dame
Fordham University
Union Theological Seminary

OBJECTIVE — To broaden the education of officer students in such fields as psychology, theology, homiletics, and counseling, hospital ministry and education.

Course length: 9 months

RETAILING CURRICULUM NUMBER 830

At Michigan State University

OBJECTIVE — To provide officers of the Supply Corps with graduate level education in the functional proficiency field of retailing. Emphasis is placed on consumer markets, sales promotion, merchandise and merchandising, and the management functions associated therewith.

Course length: One year
Degree attainable: Master of Business Administration

SUBSISTENCE TECHNOLOGY CURRICULUM NUMBER 860

At Michigan State University

OBJECTIVE — To provide officers of the Supply Corps with graduate level education in the field of food management.

Course length: One year

Degree attainable: Master of Business Administration

SYSTEMS INVENTORY MANAGEMENT CURRICULUM NUMBER 819

At Harvard University

OBJECTIVE — To provide officers of the Supply Corps with a well-grounded education at the graduate level in the scientific methods of inventory management.

Course length: Two years

Degree attainable: Master of Business Administration

Typical Curriculum:

First Year: (Required)

Elements of Administration:

- Finance
- Human Behavior in Organizations I and II
- Organizational Problems
- Managerial Economics, Report, and Control I and IV
- Managerial Economics, Reporting, and Control II and III
- Marketing
- Planning and the Business Environment
- Production
- Written Analysis of Cases

Second Year: (Required)

- Management Information Systems
- Business Logistics
- Financial Accounting I and II
- Seminar in Military Marketing and Project Management

Second Year: (Electives) (Four to be selected)

- Cost Administration
- Industrial Procurement
- Managing Technological Change
- Planning and Controlling Production
- *Analysis of Quantitative Data I and II
- *Probability and Statistics for Business Decisions I and II
- *Topics in Operations Analysis I and II
- *Management Economics

*Prerequisite — Mathematics through Differential Calculus

TEXTILE TECHNOLOGY CURRICULUM NUMBER 580

At North Carolina State College

OBJECTIVE — To provide officers of the Supply Corps with graduate level education in the functional proficiency field of textile management.

Course length: 18 months

Degree attainable: Master of Textile Technology

Typical Curriculum:

- Technology Seminar
- Textile Testing II
- Textile Quality Control
- Complex Woven Structures
- Fabric Analytics and Characteristics
- Yarn Manufacture
- Synthetics IV
- Fabric Development and Construction
- Principles of Accounting
- Introduction to Production Costs
- Management Policy and Decision Making
- Management of Industrial Relations

TRANSPORTATION MANAGEMENT CURRICULUM NUMBER 813

At Michigan State University

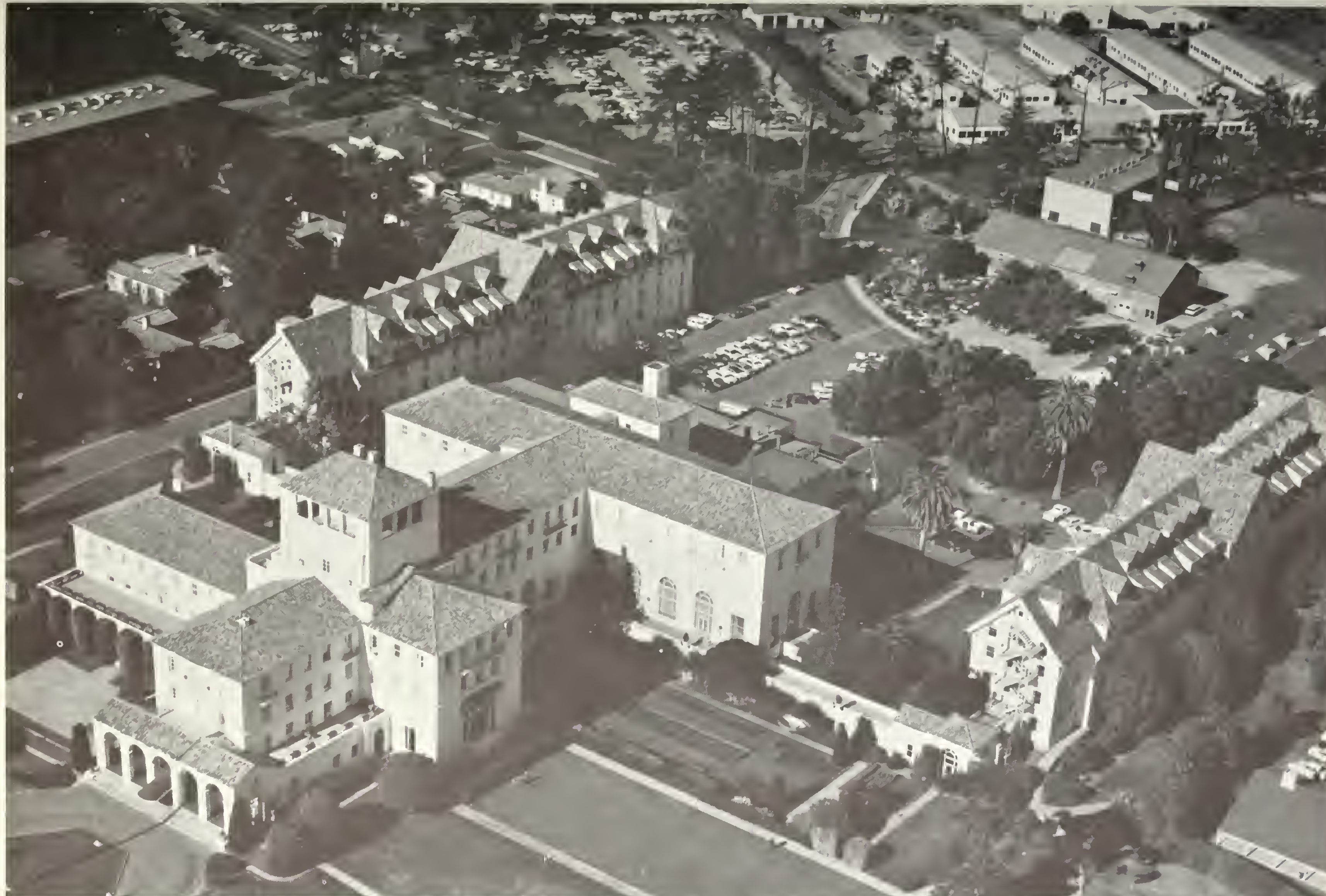
OBJECTIVE — To provide officers of the Supply Corps with graduate level education in the functional proficiency field of transportation management.

Course length: One year

Degree attainable: Master of Business Administration

Typical Curriculum:

- Basic Accounting II
- Financial Management
- Basic Marketing
- Basic Statistics I
- Accounting for Financial and Profit Management II
- Problems in Business Economics
- Basic Statistics II
- Transportation Policy
- Accounting for Financial and Profit Management III
- Human Problems in Administration
- Social Problems in Administration
- Marketing Management
- Transportation Seminar



Aerial View of Herrmann Hall

Chapel

ACADEMIC DEPARTMENTS
and
COURSE DESCRIPTIONS

DEPARTMENT OF AERONAUTICS

Richard William Bell, Professor of Aeronautics; Chairman (1951),* A.B., Oberlin College, 1939; Ae.E., California Institute of Technology, 1941; Ph.D., 1958.

Eric John Andrews, Professor of Aeronautics (1959); Honors B.S., Aero. Eng., Univ. of London, 1936.

Daniel Peter Bencze, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor in Aeronautics (1965); B.S., Univ. of Notre Dame, 1964; M.S., Massachusetts Institute of Technology, 1965.

Larry Trumbull Clark, Instructor in Aeronautics (1965); B.S., Univ. of California, 1961; M.S., 1963.

Wendell Marios Coates, Fellow, Professor of Aeronautics (1931); A.B., Williams College, 1919; M.S., Univ. of Michigan, 1923; D.Sc., 1929.

Theodore Henry Gawain, Professor of Aeronautics (1951); B.S., Univ. of Pennsylvania, 1940; D.Sc., Massachusetts Institute of Technology, 1944.

Ulrich Haupt, Associate Professor of Aeronautics (1954); Dipl. Ing., Institute of Technology, Darmstadt, 1934.

George Judson Higgins, Professor of Aeronautics (1942); B.S., in Eng. (AeE), Univ. of Michigan, 1923; AeE., 1934.

Charles Horace Kahr, Jr., Professor of Aeronautics (1947); B.S., Univ. of Michigan, 1944; M.S., 1945.

Henry Lebrecht Kohler, Professor of Aeronautics (1943); B.S. in M.E., Univ. of Illinois 1929; M.S. in M.E., Yale Univ., 1930; M.E., 1931.

Donald Merrill Layton, Commander, U.S. Navy; Assistant Professor of Aeronautics (1965); B.S., U.S. Naval Academy, 1945; B.S. A.E., U.S. Naval Postgraduate School, 1953; M.S. in A.E., Princeton Univ., 1954.

Gerald Herbert Lindsey, Associate Professor of Aeronautics (1965); B.E.S. in M.E., Brigham Young Univ., 1960; M.S., 1962; Ph.D., California Institute of Technology, 1966.

James Avery Miller, Associate Professor of Aeronautics (1963); B.S. in M.E., Stanford Univ., 1955; M.S. in M.E., Stanford Univ., 1957; Ph.D., Illinois Institute of Technology, 1963.

Roy Earl Reichenbach, Associate Professor of Aeronautics (1962); B.M.E., Ohio State Univ., 1956; M.S., 1956; Ph.D., California Institute of Technology, 1960.

Louis Vincent Schmidt, Associate Professor of Aeronautics (1964); B.S., California Institute of Technology, 1946; M.S., 1948; Ae.E., 1950; Ph.D., 1963.

Cameron MacPherson Smith, Professor of Aeronautics (1965); B.S. in C.E., Univ. of Washington, 1940; M.S. in C.E., 1940; M.E., Yale Univ., 1942; D. Eng., 1947.

*The year of joining the Postgraduate faculty is indicated in parenthesis.

Michael Hans Vavra, Professor of Aeronautics (1947); Dipl. Ing., Swiss Federal Institute of Technology, 1934; Ph.D., Univ. of Vienna, 1958.

Robert Diefendorf Zucker, Associate Professor of Aeronautics (1965); B.S. in M.E., Massachusetts Institute of Technology, 1946; M.M.E., Univ. of Louisville, 1958; Ph.D., Univ. of Arizona, 1966.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN AERONAUTICAL ENGINEERING

The following is a summary of the minimum academic requirements for the award of these degrees as determined by the Aeronautics Department. Any curriculum toward these degrees must also be consistent with the general minimum requirements as determined by the Academic Council.

BACHELOR OF SCIENCE IN AERONAUTICAL ENGINEERING

This degree normally requires a minimum of 96 term hours of upper division courses in residence at the Postgraduate School (unless reduced by validated advanced credit) of which at least 70 term hours are in aeronautics courses. The following requirements must be met:

Subject:	*Approximate Term Hours*
Aerodynamics and aircraft dynamics	21
Solid mechanics and structural design	21
Thermodynamics and propulsion	18
Methods for digital and analog computers	4
Basic electric fields and circuits	8

Every candidate's undergraduate record, at the Naval Postgraduate School or as validated from other institutions, must include:

a. Basic mathematics through differential equations, including adequate preparatory coverage.

b. Basic coverage in physics and chemistry to at least 12 term hours or the equivalent in each field.

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

This degree requires a minimum of 56 graduate level term hours in residence at the Postgraduate School (unless reduced by validated advanced credit) of which at least 36 graduate level hours are to be in aeronautics courses. These requirements include term hours allotted to research. No less than one-half of the remainder of the stated numbers required must be taken in A level courses. The following specific requirements will be met:

a. *Propulsion:* at least one graduate lecture course and pertinent laboratory course in the Ae 400 series.

b. *Gas dynamics:* at least a two-term A-level sequence in the Ae 500 series.

c. *Structures:* at least two A-level courses in solid mechanics.

d. *Systems Engineering:* at least one course to be approved by the Department Chairman.

e. *Computers:* unless previously satisfied, one course in the use of digital/computers.

f. *Options:* specialization in one of the available options such as 1) Aerospace dynamics; 2) Propulsion; 3) Structures; 4) Flight test evaluation; 5) Gas dynamics; or 6) Other recognized specialty in aeronautics.

g. *Research and thesis:* at least 10, but not more than 15, graduate term hours in Ae 000 (Research), plus an acceptable thesis (this requirement may be waived upon recommendation of the Chairman, Aeronautics Department).

AERONAUTICAL ENGINEER

This degree requires a minimum of 115 graduate level term hours in residence at the Postgraduate School (unless reduced by validated advanced credit) of which at least 65 graduate level hours are to be in aeronautics courses. These requirements include term hours allotted to research. Not less than one-half of the remainder of the stated number required must be taken in A level courses. Specific requirements to be met are the same as outlined in items a. through f. of the M.S. program. Additional requirements are:

a. *Major:* at least 3 additional graduate aeronautics lecture courses of the major option, and 2 additional graduate aeronautics lecture courses in support of that option: final coverage in the option to be approved by the Chairman, Aeronautics Department.

b. *Research and thesis:* at least 15 but not more than 20 graduate term hours in Ae 000 (Research), plus an acceptable thesis.

AERONAUTICS

Ae 001E AERONAUTICAL LECTURE SERIES (0-1). Lectures on general aeronautical engineering subjects by prominent authorities from the Navy Department, research laboratories and the industry.

Ae 010E AERONAUTICAL SEMINAR (0-1). Discussion of aeronautical development and reports in research by faculty and students.

Ae 101C AERO-STATICS (3-2). Statics of force fields; equilibrium of particles, distributed systems, rigid bodies; scalar, vector, matrix methods; trusses, frames, mechanisms; shear and bending moment diagrams in beams. Flight vehicle application. TEXT: Beer and Johnston, *Vector Mechanics for Engineers, Statics.* PREREQUISITE: Engineering mechanics and statics.

Ae 102C AEROMECHANICS (3-2). Dynamics of the vehicle in space; flight kinematics; scalar, vector, matrix forms; rectilinear and curvilinear motion, Kepler's Laws: work and energy, potential fields; impulse and momentum, impact; applications to plane motion. TEXT: Beer and Johnston, *Vector Mechanics for Engineers, Dynamics.* PREREQUISITE: AE 101C (may be taken concurrently).

Ae 111B FUNDAMENTALS OF DYNAMICS (3-2). Dynamics of rigid bodies, constraints and degrees of freedom, oscillating systems, vibration modes for small motion, application of matrix algebra to eigenvalue problems. Response traits of free and forced vibrations. TEXTS: Housner and Hudson, *Applied Mechanics, Dynamics;* Pipes, *Matrix Methods for Engineering.* PREREQUISITES: Ae 102C; Ae 181B concurrently.

Ae 115A ENGINEERING DYNAMICS I (4-0). Single degree of freedom systems including solutions to impulse, step and harmonic forcing functions. Duhamel superposition integral. Formulation of eigenvalue problems for lumped and continuous systems. Matrix and integral methods of solution. TEXTS: Greenwood, *Principles of Dynamics*, Karman and Biot, *Mathematical Methods in Engineering.* PREREQUISITE: Ae 102C.

Ae 116A ENGINEERING DYNAMICS II (4-0). Dynamics of rigid bodies, generalized coordinates, Lagrange's equations for a particle and a system of particles, Lagrange multipliers used to find constraint forces. Orbital motion. Variational methods, Hamilton's principle and canonical transforms. TEXTS: Greenwood, *Principles of Dynamics;* Karman and Biot, *Mathematical Methods in Engineering.* PREREQUISITES: Ae 115A and Ae 182A concurrently.

Ae 121B POTENTIAL FLOWS AND BOUNDARY VALUE PROBLEMS (3-2). Review of Gauss' and Stokes' equations. Irrotational and Solenoidal fields; velocity potential and stream function. Elementary flow fields: source, vortex and doublet. Superposition: closed body with circulation. Laplace's equation. Complex potential and conformal mapping. The general boundary value problem; first (Dirichlet), second (Neumann) and third boundary value problems of potential theory. TEXT: Under study. PREREQUISITES: Ma 244C; Ma 262C; Ma 272C (may be taken concurrently).

Ae 131A CONTINUUM MECHANICS I (4-0). A review of elasticity prototypes and applications, description of tensor analysis including geometric interpretations, stress tensor, strain tensor. Application to elastic solids and viscous fluids: Navier-Stokes equations. TEXT: Fung, *Foundations of Solid Mechanics.* PREREQUISITE: Ae 213B.

Ae 132A CONTINUUM MECHANICS II (4-0). A study of conservation laws, elastic behavior of materials, linear elasticity, solutions by potentials, and two-dimensional problems in elasticity. TEXT: Fung, *Foundations of Solid Mechanics.* PREREQUISITE: Ae 131A.

Ae 133A SOLID MECHANICS I (4-0). Variational methods applied by means of energy principles; applications to beams, membranes, and plates. TEXT: Fung, *Foundations of Solid Mechanics.* PREREQUISITE: Ae 132A.

Ae 134A SOLID MECHANICS II (4-0). Elasticity and thermodynamics, basic relations for thermoelasticity, applied examples. Irreversible thermodynamics and introduction to viscoelasticity. TEXT: Fung, *Foundations of Solid Mechanics.* PREREQUISITE: Ae 133A.

Ae 151A COMPUTER METHODS IN AERONAUTICS (3-3). Analog and digital computer formulations of problems in aerodynamics, aero-structures, missile and satellite trajectories, dynamics. Equilibrium, eigenvalue, propagation problems. TEXTS: Crandall, *Engineering Analysis*; Salvadori and Baron, *Numerical Methods in Engineering*. PREREQUISITES: Ma 416C or Ma 125B and Ma 421C.

Ae 180E ENGINEERING ORIENTATION (0-3). Review engineering fundamental concepts: notation and symbols, units and standards, dimensional analysis, graphs; physical laws; mathematical techniques, limit processes, indeterminacies, singularities. Approximations in the formulation and solution of engineering problems; fields; coordinate systems. Aeronautical phenomena illustrated by movies. TEXT: Eshbach, *Handbook of Engineering Fundamentals.*

Ae 181B FUNDAMENTAL DYNAMICS LABORATORY (0-3). Conduct experiments in the fundamentals of dynamics; use of the shaker table. Measure displacements and accelerations; solve systems of equations by analog computer means. TEXT: Under study. PREREQUISITE: Ae 111B concurrently.

Ae 182A ENGINEERING DYNAMICS LABORATORY (0-3). Conduct introductory experiments in the fundamentals of dynamics using analog computer and the shaker table. Set up a dynamics experiment; instrument, conduct, and evaluate results. TEXT: Under study. PREREQUISITE: Ae 116A concurrently.

Ae 211C SOLID MECHANICS (3-2). Stiff elastic bodies; normal stress and strain in ties, struts or beams; analytical and mechanical analogies on beams under redundant restraints, displacement calculation; shear of beams, torsion of circular shafts; linear elastic continua, general expressions for stress, strain, displacement; principal stresses, applications to two dimensional state in beams. TEXTS: Timoshenko, *Strength of Materials, Vol. I*; Shanley, *Strength of Materials.* PREREQUISITE: Ae 101C.

Ae 212C STRUCTURAL ANALYSIS (3-2). Energy principles, deflections, statically indeterminate systems such as beams, frames and trusses. TEXTS: Peery, *Aircraft Structures*; Timoshenko, *Strength of Materials, Vol. I;* Shanley *Strength of Materials.* PREREQUISITE: Ae 211C.

Ae 213B STRUCTURAL COMPONENTS I (3-2). Analysis of thin-sheet structures typical of flight vehicles. Unsymmetrical bending, shear flow in open and closed sections, diagonal tension field webs. Curved beams. TEXTS: Peery, *Aircraft Structures;* Timoshenko, *Strength of Materials, Vols. I and II*; Shanley, *Strength of Materials.* PREREQUISITES: Ae 212C; Ae 281B concurrently.

Ae 214B STRUCTURAL COMPONENTS II (3-2). Columns; beam columns; lateral and torsional buckling of beams. Introduction to plate theory; moments, stresses, curvatures, equilibrium equations. Introduction to numerical methods in structures. TEXTS: Sechler, *Elasticity in Engineering;* Timoshenko, *Strength of Materials, Vol. II;* Wang, *Applied Elasticity.* PREREQUISITE: Ae 213B.

Ae 241B ELEMENTS OF AEROELASTICITY (3-2). Static aeroelastic phenomena; divergence and control reversal; finite wing examples; effects on complete airframe. Vibration of structures, aerodynamic forcing functions, mechanism of flutter. Non-stationary wing theory, with applications to two- and three-dimensional lifting surfaces. TEXTS: Fung, *The Theory of Aeroelasticity*; Bisplinghoff, Ashley, and Halfman, *Aeroelasticity.* PREREQUISITE: Ae 111B.

Ae 242A PRINCIPLES OF AEROELASTICITY (3-2). Static aeroelastic problems, wing divergence, control reversal, and airframe stability. Vibration of structures, aerodynamic forcing functions, mechanism of flutter, non-stationary airfoil theory. Transient loads, gusts, buffet, and stall flutter. TEXTS: Fung, *The Theory of Aeroelasticity;* Bisplinghoff, Ashley, and Halfman, *Aeroelasticity.* PREREQUISITES: Ae 115A, Ae 121B, and Ae 131A.

Ae 243A THERMO-STRUCTURAL ANALYSIS (3-2). Thermoelastic equations; stress, strain, equilibrium, boundary conditions. Basic problems in thermoelasticity; applications to beams, plates, built-up structures. Thermoelastic stability and related problems. TEXTS: Boley and Weiner, *Theory of Thermal Stresses;* Gatewood, *Thermal Stresses.* PREREQUISITE: Ae 131A.

Ae 244A MATRIX STRUCTURAL ANALYSIS (3-2). Influence coefficients and energy theorems. Force (flexibility) and displacement (stiffness) methods applied to beams, frames, plates, box beams. Structural idealizations for wings, fuselages. Digital computer solutions. TEXTS: McMinn, *Matrices for Structural Analysis*; Bruhn and Schmidt, *Analysis and Design of Aircraft Structures.* PREREQUISITE: Ae 213B.

Ae 245A PLATES AND SHELLS (4-0). Applications to flight vehicles. Flat plates: axially and laterally loaded; bending, twisting moments, shearing forces; stresses, equilibrium equations; stability. Axially symmetric shells: geometry, equilibrium, buckling under various loadings; compression, bending, pressure. Applied engineering methods using NASA and industry analyses formulated for numerical solutions. TEXTS: Timoshenko, *Theory of Plates and Shells;* NASA publications. PREREQUISITES: Ae 131A, Ae 213B.

Ae 251A STRUCTURAL DYNAMICS (4-0). Structural response to free, forced, and self-excited oscillations; ground shock, ground wind, and silo firing problems. Testing techniques, design criteria, and methods of analysis and calculation. Wave propagation in solids, with applications; dispersion of waves in bounded solids. TEXT: Under study. PREREQUISITES: Ae 115A, Ae 131A.

Ae 252A PLASTICITY, VISCO-ELASTICITY AND FATIGUE (4-0). Fundamental stress-strain relations for inelastic continuous media. Non-Newtonian fluids. One dimensional creep and relaxation phenomena. Mathematical models and methods. Combined static and dynamic loading theories of plastic and fatique failure. Inelastic bending and buckling. Visco-elastic behavior of rocket propellants. TEXT: Under study. PREREQUISITE: Ae 131A.

Ae 260A STRUCTURAL PROBLEMS IN PROPULSION (2-3). A seminar-type course in structural aspects of propulsion. Problem sessions devoted to a limited number of problems selected in consultation with the instructor, with supporting lecture, reading and discussion material from among the following topics: centrifugal and thermal stresses in rotors and blades; vibration and critical speeds of shafts, discs, and blades; thermal stresses; experimental methods; unsolved problems. TEXTS: Instructor's notes and assigned technical literature. PREREQUISITES: Ae 115A; Ae 213B.

Ae 271B FUNDAMENTALS OF FLIGHT VEHICLE DESIGN (3-3). A terminal course in methods of airplane or missile design and analysis. Preliminary layout; three view drawing; weight and balance; aerodynamic characteristics and basic performance; design criteria; inertia loads, shear and moment curves; detailed structural design and stress analysis of major component. TEXTS: Peery, *Aircraft Structures;* Bonney, *Principles of Guided Missile Design;* Chin, *Missile Configuration Design;* Bruhn, *Analysis and Design of Flight Vehicle Structures;* Merrill, *Operation Research, Armament and Launching.* PREREQUISITES: Ae 214B, Ae 322C.

Ae 275A FLIGHT VEHICLE DESIGN (3-3). Detailed design and analysis of a flight vehicle. Basic aerodynamic characteristics and performance; strength and rigidity requirements. Structural design considerations from the viewpoints of strength, fatigue, production and optimization. Consideration of typical structures and structural trends in airplanes, missiles, launchers and spacecraft. TEXTS: Specifications MIL-A-8860 to 8870 (ASG); MIL-HDBK-5; Peery, *Aircraft Structures;* Corning, *Supersonic and Subsonic Airplane Design;* Bruhn, *Analysis and Design of Flight Vehicle Structures;* Merrill, *Operations Research, Armament and Launching;* Chin, *Missile Configuration Design.* PREREQUISITES: Ae 213B, Ae 326B.

Ae 281B STRUCTURES LABORATORY (0-3). Fundamentals of measuring techniques for structural testing. Experiments with various types of strain gages and data evaluation. Full-scale test of aircraft wing with determination of stress distribution around a cut-out. TEXTS: Perry and Lissner, *Strain Gage Primer;* Lee, *An Introduction to Experimental Stress Analysis.* PREREQUISITE: Ae 213B concurrently.

Ae 282B STRUCTURES PERFORMANCE (2-3). Tests of aircraft and missile components. Correlation between theoretical and experimental results for stress distribution in various structures. Photoelastic coatings. Individual laboratory projects. TEXT: Various references. PREREQUISITE: Ae 214B.

Ae 283B STRUCTURAL PERFORMANCE (1-2). Course concerned with recent developments in the field of flight vehicle structures. Laboratory experiments, including photoelastic methods and large-scale components. Students give seminar-type presentation on topical structural developments. TEXT: Various references. PREREQUISITE: Ae 214B (may be taken concurrently).

Ae 291A SELECTED PROBLEMS IN FLIGHT STRUCTURES (3-2). Advanced design criteria. Structures optimization principles. Composite construction; filament wound shells. Special problems of VTOL, STOL vehicles. TEXTS: NASA Reports; Technical Journals. PREREQUISITE: Ae 214B or equivalent.

Ae 301C TECHNICAL AERODYNAMICS (3-2). The atmosphere. Equations of motion: steady and unsteady flow fields. One-dimensional flows; the venturi. Pitot-static, temperature and velocity measurement. Compressible flow regimes. Boundary layers; separation. Coefficients, and similarity. Vortices, lift and the Kutta-Joukowsky relations. Pressure distributions; aerodynamic center. Airfoil and propeller characteristics. Profile and parasite drag estimation. TEXT: Under study. PREREQUISITES: Ae 102C; Ae 381C concurrently.

Ae 302C AIRFOIL AND WING THEORY (3-2). Airfoil construction and notation. The thin airfoil problem; Glauert's integral. Properties of camber; "ideal" angle of attack; synthesis of thickness. Airfoil design data; high lift and auxiliary devices. The finite wing; elliptic and general planforms, twist. Induced drag and downwash. Aspect ratio and planform effects. Basic and additional spanwise lift. Wing design data. TEXT: Kuethe and Schetzer, *Foundation of Aerodynamics, 2nd ed.* PREREQUISITE: Ae 301C.

Ae 303C FLIGHT VEHICLE PERFORMANCE (3-3). The aerodynamic characteristics of the flight vehicle and its components: lift, drag, and mutual interferences. Wing stall; auxiliary lift devices. The drag polar at high Mach number. Propulsion systems. Steady flight performance in level flight and climb. Ceilings, range, and endurance. High vertical acceleration performance. TEXT: Under study. PREREQUISITE: Ae 302C.

Ae 314B ADVANCED FLIGHT VEHICLE PERFORMANCE (3-2). Aerodynamic characteristics of swept and delta wing flight vehicles; lifting surface theories. Flow patterns. Advanced propulsion systems and methods of performance analysis. Variable weight, dynamic performance. Tactical range and endurance; other special performance problems. TEXT: Under study. PREREQUISITE: Ae 303C.

Ae 321C FLIGHT STABILITY AND CONTROL I (3-3). Longitudinal static stability and controllability; control surface design and performance; stick-fixed and stick-free stability and margins; neutral and maneuver points; c.g. limits; stick force and displacement characteristics. Lateral static stability, control and maneuverability. Dihedral effects; steady turns; rudder lock; adverse yaw. TEXTS: Perkins and Hage, *Aircraft Performance, Stability and Control;* Higgins, USNAVPGSCOL Notes; NACA Report 927. PREREQUISITE: Ae 303C.

Ae 322C FLIGHT STABILITY AND CONTROL II (3-3). The dynamic stability problem: Euler's equation of motion; longitudinal dynamics; stability derivatives, nature of the general or transient solutions. Controllability. Lateral dynamics; lateral stability derivatives; nature of transient motions. Effect of changes of variables. Cross-coupling with large perturbations. TEXTS: Perkins and Hage, *Aircraft Performance, Stability and Control;* Babister, *Aircraft Stability and Control;* Higgins, USNAVPGSCOL Notes. PREREQUISITE: Ae 321C.

Ae 325B FLIGHT DYNAMICS I (3-3). Flight vehicle static longitudinal stability and trim; effect of components. Vehicle control and maneuverability; control surface characteristics. Static margins, neutral points, maneuver points, both stick fixed and stick free. Control surface displacement and stick forces for trim and in maneuvering flight. Lateral static stability and controllability. Dihedral effects, adverse yaw, steady turns, asymmetric power. TEXTS: Perkins and Hage, *Aircraft Performance, Stability and Control;* Higgins, USNAVPGSCOL Notes; NACA Report 927. PREREQUISITE: Ae 303C.

Ae 326B FLIGHT DYNAMICS II (3-3). The dynamics of flight vehicles; Euler's equations of motion; longitudinal dynamics; longitudinal stability derivatives; nature of general or transient solutions. Effect of forcing functions and their response; steady state solutions. Lateral dynamics, lateral stability derivatives; nature of transient solutions, effect of free controls, friction. Cross-coupling with large perturbations. Spins. TEXTS: Perkins and Hage, *Aircraft Performance, Stability and Control;* Higgins, USNAVPG-SCOL Notes; Babister, *Aircraft Stability and Control.* PREREQUISITE: Ae 325B.

Ae 327B SPACE VEHICLE DYNAMICS (3-2). Orbital flight mechanics, launching trajectories, space trajectories, orbital perturbations. Multi-stage rocket performance. Reentry mechanics for lifting and non-lifting type bodies. Special topics in wing theory, lifting surface theory. TEXT: Under study. PREREQUISITES: Ae 115A, Ae 303C.

Ae 332C FLIGHT TEST EVALUATION I (2-0). Relative to flight test methods and procedures, a lecture program encompassing instrument calibrations, measurement of flight speed, cruising performance, stall tests, etc. Definition of requirements in flight test report writing. TEXTS: Dommasch, Sherby and Connolly, *Airplane Aerodynamics;* NATC Patuxent, Flight Test Manual; NAV AERO Publications. PREREQUISITE: Ae 303C; Ae 382C concurrently.

Ae 333B FLIGHT TEST EVALUATION II (2-0). Relative to flight test methods and procedures, a lecture program encompassing climb performance, energy height concept, drag measurement, static and maneuvering longtitudinal stability. TEXTS: Dommasch, Sherby and Connolly, *Airplane Aerodynamics;* NATC Patuxent, Flight Test Manual; NAV AERO Publications. PREREQUISITES: Ae 321C, AE 332C; Ae 383B concurrently.

Ae 334B FLIGHT TEST EVALUATION III (2-0). Relative to flight test methods and procedures, a lecture program encompassing longitudinal and lateral/directional dynamic stability; time vector determination of derivatives. TEXTS: Dommasch, Sherby and Connolly, *Airplane Aerodynamics;* NATC Patuxent; Flight Test Manual; NAV AERO Publications. PREREQUISITES: Ae 322C, Ae 333B; Ae 384B concurrently.

Ae 340B FUNDAMENTALS OF AUTOMATIC CONTROL (3-2). A terminal course encompassing power controls and stability augmentation. Derivation of component transfer functions and block diagram concept. Basic linear servo theory. Frequency response techniques, root locus methods, and transient effects. Performance specifications, response shaping, and application to vehicles and their sub-systems. TEXTS: Perkins and Hage, *Airplane Performance, Stability and Control;* Etkin, *Dynamics of Flight;* Raven, *Automatic Control Engineering.* PREREQUISITE: Ae 322C or Ae 326B.

Ae 341A AUTOMATIC CONTROL I (3-2). Power controls and stability augmentation. Derivation of component transfer functions and block diagram concept. Linear servo theory. Frequency response techniques, root locus methods, and transient effects. Basic references for automation; single axis and multi-axis autocontrols; cross axis coupling. Performance specifications, response shaping, and application to vehicles and their sub-systems. TEXTS: Perkins and Hage, *Airplane Performance, Stability and Control;* Etkin, *Dynamics of Flight;* Raven, *Automatic Control Engineering.* PREREQUISITE: Ae 326B.

Ae 342A AUTOMATIC CONTROL II (3-2). Aeroelastic effects on stability and control, vehicle dynamics and interaction with augmentation devices and automatic controls. Automatic power control for deck recovery. Time modulated aerodynamic controls, applications to small missiles, and overall system analysis. Analog simulation techniques. TEXTS: Perkins and Hage, *Airplane Performance, Stability and Control;* Etkin, *Dynamics of Flight;* Raven, *Automatic Control Engineering.* PREREQUISITE: Ae 341A.

Ae 343A AUTOMATIC CONTROL III (3-2). Random processes, autocorrelation functions, Fourier transforms and power spectral densities. Theory of non-linear systems and applications. Optimum design including self-adaptation. TEXTS: Tsien, *Engineering Cybernetics;* Stoker, *Non-Linear Vibrations;* Minorsky, *Non-Linear Oscillations.* PREREQUISITE: Ae 342A.

Ae 381C SUBSONIC LABORATORY (0-3). An introduction to aerodynamic investigations in a wind tunnel, including selected experiments to illustrate various fundamental principles. TEXTS: Pope, *Wind-Tunnel Testing;* Kuethe and Schetzer, *Foundations of Aerodynamics.* PREREQUISITE: Ae 301C concurrently.

Ae 382C FLIGHT TEST EVALUATION LABORATORY I (0-4). Flight program accompanying Ae 332C. Test flying in Naval aircraft by aviator students primarily for level flight evaluation.

Ae 383B. FLIGHT TEST EVALUATION LABORATORY II (0-4). Flight program accompanying Ae 333B. Test flying in Naval aircraft by aviator students primarily for climb performance and static and maneuvering longitudinal stability.

Ae 384B FLIGHT TEST EVALUATION LABORATORY III (0-4). Flight program accompanying Ae 334B. Test flying in Naval aircraft by aviator students primarily for dynamic stability and derivative measurement.

Ae 391A SELECTED PROBLEMS IN FLIGHT SYSTEMS (3-2). A course in the application of aeronautical engineering technology to recent developments in flight vehicle design. Such vehicles might include V/STOL types with semi-conventional configurations; rotating-wing configurations; hovercraft; and reaction supported vehicles of lunar landing type. TEXTS: Under study. PREREQUISITES: Ae 275A, Ae 342A.

Ae 401C AEROTHERMODYNAMIC FUNDAMENTALS (3-2). Fundamentals of thermodynamics edited especially for application to aerothermodynamics. Topics include fundamental laws, energy concepts, properties of ideal and real gases, vapors, equations of state, and theoretical cycles. TEXTS: Lee and Sears, *Thermodynamics;* Reynolds, *Thermodynamics;* Keenan and Kaye, *Gas Tables;* Keenan and Keys, *Thermodynamic Properties of Steam.* PREREQUISITE: Ma 230D.

Ae 402B AIRCRAFT PROPULSION (3-2). Basic mechanics of thrust or lift production by jets, propellers or rotors. Momentum and blade element theories. Thermodynamic and performance characteristics of air breathing engines and major components. Analysis of reciprocating engines, turbojet and turboprop engines and principal variants, and ramjets. Relation of propulsion characteristics to vehicle performance. TEXT: Hesse, *Jet Propulsion, 2nd ed.* PREREQUISITES: Ae 501B; Ae 481B concurrently.

Ae 410A STATISTICAL THERMODYNAMICS (3-2). Fundamentals of statistical thermodynamics. Topics include kinetic theory of an ideal gas, distribution of molecular velocities, transport phenomena, Maxwell-Boltzman statistics, partition functions, and thermodynamic properties. TEXT: Lee, Sears and Turcotte, *Statistical Thermodynamics.* PREREQUISITE: Ae 401C.

Ae 414B FUNDAMENTALS OF ROCKETS (3-2). Review of nozzle theory and heat transfer as applied to rockets, liquid and solid propellants and systems; flight performance. TEXT: Sutton, *Rocket Propulsion Fundamentals, 3rd ed.* PREREQUISITES: Ae 402B; Ae 486B concurrently.

Ae 420B ELEMENTS OF COMBUSTION AND HEAT TRANSFER (3-2). Chemical reactions, energy release, chemical equilibrium and flame stabilization as applicable to combustion engines. Radiation, convection and conduction heat transfer. TEXT: Under study. PREREQUISITES: Ae 402B; Ae 482B concurrently.

Ae 421A HEAT TRANSFER I (4-0). Introduction, multidimensional and non-steady conductive heat transfer, application to problems of thermal stress analysis, numerical and analogue methods of solution. Laws of similarity, boundary layer solutions, experimental solutions, free and forced convection, compact heat exchangers and gas turbine regenerators, mass transfer, evaporation and condensation. Problems of combined convection and conduction. TEXTS: Carslaw and Jaeger, *Conduction in Solids;* Schneider, *Conduction Heat Transfer;* Jakob, *Heat Transfer, Vols. I and II;* Eckert and Drake, *Heat and Mass Transfer;* Schlichting, *Boundary Layer Theory.* PREREQUISITES: Ma 244C; Ae 522A.

Ae 422A HEAT TRANSFER II (4-0). Continuation of convective heat transfer to include effects of compressibility and problems of high speed flight and re-entry; recovery factor, non-steady flow, and blunt body stagnation point heat transfer. Transpiration, ablation, and rotating machinery. Fundamental laws of radiation, geometrical properties, the shape factor, hemispherical variation of emissivities and gas body radiation. Problems of combined convection and radiation. TEXTS: Eckert and Drake, *Heat and Mass Transfer;* Schlichting, *Boundary Layer Theory;* Jakob, *Heat Transfer, Vols. I and II.* PREREQUISITE: Ae 421A.

Ae 431A PRINCIPLES OF TURBOMACHINES (4-0). Dimensional analysis of turbomachines. Basic momentum, energy and continuity relations for rotors and stators. Absolute and relative motions. Internal aero-thermodynamics. Performance of compressors and turbines. TEXTS: Csanady, *Theory of Turbomachines;* Vavra, *Aerothermodynamics and Flow in Turbomachines.* PREREQUISITES: Ae 402B; Ae 522A; Ae 483A concurrently.

Ae 432A ADVANCED THEORY OF TURBOMACHINES (4-0). Fundamental relations for absolute and relative fluid motions. Compressible flow phenomena in members of turbomachines. Potential flow in cascades. Three-dimensional flows in arbitrary rotors. Design criteria for compressors and turbines of axial and radial type. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines.* PREREQUISITES: Ae 121B, Ae 431A; Ae 523A.

Ae 433A ADVANCED PROPULSION SYSTEMS (4-0). Application of fluid dynamics, thermodynamics and stress analysis to propulsion systems for different flight vehicles using conventional and exotic fluids. Heat transfer elements, effects of temperature. Off-design performance, matching and control. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines.* PREREQUISITE: Ae 432A.

Ae 434A SPACE POWER PLANTS (3-0). Power plants for propulsion and generation of electrical energy for space vehicles with chemical, nuclear, and solar heat sources and radiative heat sinks. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines.* PREREQUISITE: Ae 492A concurrently.

Ae 461A COMBUSTION THERMODYNAMICS (3-2). Thermodynamics of combustion, quantitative evaluation of rocket propellants, phenomenological chemical kinetics. Ionization and dissociation in gases, and relaxation phenomena. TEXTS: Penner, *Chemistry Problems in Jet Propulsion;* Williams, *Combustion Theory.* PREREQUISITE: Ae 410A.

Ae 462A AEROTHERMOCHEMISTRY (3-2). Chemical reactions in flow systems, with emphasis on the interplay between aerodynamics, physics, and chemistry. Topics include reactions during nozzle flow, diffusion flames, detonation, flame propagation, burning mechanism of solid propellants, heterogeneous combustion, and scaling of combustion devices. TEXTS: Penner, *Chemistry Problems in Jet Propulsion;* Williams, *Combustion Theory.* PREREQUISITE: Ae 461A.

Ae 465A ADVANCED ENGINEERING THERMODYNAMICS I (4-0). Review of first and second laws. Corollaries of the second law. Relations among the thermodynamic properties, Maxwell relations. Review of gas mixtures. Thermodynamics of chemical reactions; equilibrium and criteria of equilibrium. TEXTS: Lee and Sears, *Thermodynamics;* Hatsopoulos and Keenan, *Principles of General Thermodynamics.* PREREQUISITE: Ae 410A.

Ae 466A ADVANCED ENGINEERING THERMODY-

NAMICS II (4-0). Equilibrium constant for chemical and electric reactions in gases. Dissociated and ionized gases. Irreversible flow, entropy production, Onsager relations. Diffusion, thermoelectricity, thermionics. TEXTS: Lee and Sears, *Thermodynamics;* Hatsopoulos and Keenan, *Principles of General Thermodynamics.* PREREQUISITE: Ae 465A.

Ae 475A TURBOPROPULSION DESIGN (4-2). Analysis and design of bladings and elements of turbomachines. Centrifugal and thermal stresses, vibrations, critical speeds, and stress analysis of supporting members. Influence of off-design conditions. Design concepts for different applications. TEXT: Instructor's notes. PREREQUISITE: Ae 433A.

Ae 476A ROCKET PROPULSION DESIGN (3-2). Rocket motor and auxiliary equipment design, capacity and arrangement to accomplish specified missions. Thrust variation and thrust vector control systems. TEXT: Under study. PREREQUISITE: Ae 414B.

Ae 481B PROPULSION LABORATORY (0-3). Measurement of component and overall performance of full scale turboprop and turbojet engines. TEXT: USNAVPGSCOL Notes. PREREQUISITE: Ae 402B concurrently.

Ae 482B THERMODYNAMICS LABORATORY (0-3). Laboratory experiments illustrating principles of thermodynamics. TEXT: USNAVPGSCOL Notes. PREREQUISITE: Ae 420B concurrently.

Ae 483A TURBOMACHINERY LABORATORY (0-3). Laboratory work designed to accompany Ae 431A. Measurements and analysis of flows in compressors and turbines, cascades and channels. Performance of jet engines and rocket motors. Emphasis on correlation of test results with theory. TEXTS: Applicable laboratory manuals. PREREQUISITE: Ae 431A concurrently.

Ae 484A ADVANCED TURBOMACHINERY LABORATORY (0-3). Laboratory work designed to augment Ae 432A; three dimensional flow phenomena. Emphasis on off-design performance. TEXTS: Applicable laboratory manuals. PREREQUISITE: Ae 432A.

Ae 485A ADVANCED PROPULSION LABORATORY (0-3). Laboratory work designed to augment AE 433A with advanced methods and instrumentation. Data reduction with electronic computer. Heat transfer and control tests. TEXTS: Applicable laboratory manuals. PREREQUISITE: Ae 433A.

Ae 486B ROCKET LABORATORY (0-3). Instrumentation and measurement of rocket motor performance. Time rate of pressure rise; thrust; strand burning rates. TEXT: USNAVPGSCOL Notes. PREREQUISITE: Ae 414B concurrently.

Ae 491A SELECTED PROBLEMS IN TURBOPROPULSION (3-3). Special application of turbomachinery to propulsion and pumping. VTOL, helicopter, high supersonic, and space vehicle problems. TEXT: Under study. PREREQUISITE: Ae 433A.

Ae 492A POWER PLANTS SEMINAR (1-4). Advanced individual test assigments to supplement Ae 434A. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines.* PREREQUISITE: Ae 434A concurrently.

Ae 493A ADVANCED PROBLEMS IN COMBUSTION AND AEROPHYSICS I (3-2). Selected modern topics chosen by the professor after consultation with interested students. Possible topics include rarefied gas flows, magnetohydrodynamics, combustion of liquid fuel droplets, combustion of metals, combustion of solid propellants, supersonic combustion, and hybrid combustion. TEXT: To be specified. PREREQUISITE: Ae 462A.

Ae 494A ADVANCED PROBLEMS IN COMBUSTION AND AEROPHYSICS II (3-2). Continuation of Ae 493A. TEXT: To be specified. PREREQUISITE: Ae 493A.

Ae 496A ADVANCED POWER GENERATION (0-4). Application of advanced thermodynamic concepts to jet propulsion, thermoelectricity, and other systems. Term problem. TEXTS: Lee and Sears, *Thermodynamics;* Hatsopoulos and Keenan, *Principles of General Thermodynamics.* PREREQUISITE: Approval of Instructor.

Ae 501B THERMODYNAMICS OF COMPRESSIBLE FLOW (3-2). Application of first and second laws of thermodynamics and the equation of state of a perfect gas to compressible flows. Velocity of sound. Physical differences between subsonic and supersonic flows. One-dimensional isentropic flows. Normal shockwaves. Adiabatic flow in constant area ducts with friction. The Fanno Line process. Adiabatic flow in constant area ducts. The Rayleigh Line. Generalized one-dimensional flow. Oblique shocks. TEXT: Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flows, Vol. I.* PREREQUISITES: Ma 244C, Ae 401C; Ae 581B concurrently.

Ae 502B FLOW DYNAMICS (4-0). Subject material of Ae 121B and Ae 521B edited for undergraduate presentation. TEXTS: Schlichting, *Boundary Layer Theory;* Milne-Thompson, *Theoretical Aerodynamics;* Keuthe and Schetzer, *Foundations of Aerodynamics, 2nd ed.* PREREQUISITES: Ma 262C, Ae 501B.

Ae 503B BOUNDARY LAYERS (4-0). Subject material of Ae 522A edited for undergraduate presentation. TEXTS: Schlichting, *Boundary Layer Theory;* Kuethe and Schetzer, *Foundations of Aerodynamics, 2nd ed.* PREREQUISITE: Ae 502B.

Ae 521A FUNDAMENTALS OF FLOW DYNAMICS (4-0). The dynamics of real fluids, including viscous and compressible effects. Stokes Law. Rotational; incompressible; inviscid flows. General properties and some exact solutions of the Navier-Stokes equations, including channel and stagnation flows. The continuity and energy equations; the equation of state. TEXT: Schlichting, *Boundary Layer Theory.* PREREQUISITES: Ae 131A (may be taken concurrently), Ae 501B.

Ae 522A BOUNDARY LAYER FLOWS (4-0). General properties of the Prandtl boundary layer equations for two and three dimensional flows. The Blasius solution. Similarity and the Falkner-Skan wedge flow problem. Non-steady boundary layers; approximate analysis. Transition, and the fundamentals of turbulent boundary layers; approximate analysis. Turbulent skin friction. Boundary layer control. TEXT: Schlichting, *Boundary Layer Theory*. PREREQUISITE: Ae 521A.

Ae 523A FUNDAMENTALS OF COMPRESSIBLE FLOW (4-0). Review: generalized one-dimensional flows, oblique shocks and Prandtl-Meyer flow. General equations of motion. Subsonic flow solutions by hodography, linearization and series expansion. Methods in supersonic flow: characteristics in two dimensions; small perturbations. Similarity laws. Transonic flow. Unsteady motion: shock tubes. Real gas effects: viscosity and heat conductivity. Boundary layers. TEXTS: Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I and II*. PREREQUISITE: Ae 522A.

Ae 524A SUPERSONIC AERODYNAMICS (3-2). Extension of two-dimensional characteristics theory to rotational flows. Supersonic profiles and flow fields, theory and experiment. Effusors and diffusors. Source and doublet distributions, small disturbance methods, conical flows, characteristics method in three dimensions. Lift, pressure drag, induced drag and pitching moment of supersonic wings. TEXT: Ferri, *Elements of Aerodynamics of Supersonic Flows*. PREREQUISITE: Ae 523A.

Ae 525A HYPERSONIC AERODYNAMICS (3-2). General hypersonic flow fields in two and three dimensions. Small disturbances and hypersonic similitude. Newtonian, constant-density, thin shock layer, and other theories. Real gas effects; viscous, free molecule and rarefied gas flows. Minimum drag bodies; slender and blunt bodies. Complete configurations; stability and control. TEXTS: Hayes and Probstein, *Hypersonic Flow Theory;* Truitt, *Hypersonic Aerodynamics*. PREREQUISITE: Ae 523A.

Ae 541A VISCOUS HYPERSONIC FLOW (4-0). One dimensional equilibrium flow of dissociated and ionized gases. One dimensional flow with finite reaction rates. Boundary layers in hypersonic flow with finite reaction rates for dissociated and ionized flow. Stagnation point heat transfer. TEXT: Dorrance, *Viscous Hypersonic Flow*. PREREQUISITES: Ae 465A, Ae 525A.

Ae 542A HYPERSONIC TECHNIQUES (3-2). Shock tubes and tunnels; arc heated tunnels; MHD; term problem. TEXT: USNAVPGSCOL Notes. PREREQUISITE: Ae 541A.

Ae 543A MAGNETOHYDRODYNAMICS (4-0). Dynamic equations for continuous media, and classical equations for electromagnectic fields, as applied to ionized gases moving in a magnetic field; propagation of small disturbances, Alfven waves, fast and slow waves, shock waves; particular solutions of the magnetoaerodynamic equations; motion of charged particles, drift, anisotropic Ohm's Law, applications. TEXTS: Instructor's Notes; Sutton and Sherman, *Magnetohydrodynamics*. PREREQUISITE: Ae 523A.

Ae 551A FUNDAMENTAL CONCEPTS OF FLUID MECHANICS (4-2). A version of Ae 521, edited to the needs of the Ordnance Curriculum. Basic vector and tensor mechanics of real fluids, including viscous and compressible effects. Flow kinematics. Equations of continuity, motion, momentum and energy. Fundamental theorems of Stokes, Gauss, Kelvin, Crocco and Biot-Savart. Velocity potential and stream function. Simple potential flows in two and three dimensions. Introduction to complex potential and conformal mapping. Stress and strain in viscous fluids. Development of Navier-Stokes equations. Selected laboratory exercises and demonstrations. TEXT: Instructor's Notes. Also Kaufmann, *Fluid Mechanics*. PREREQUISITES: At least one term each of thermodynamics, vector analysis, and complex variables.

Ae 552A FLOW OF COMPRESSIBLE FLUIDS (4-0). A combined and accelerated version of Ae 501 and Ae 523, edited to the needs of the Ordnance Curriculum. One dimensional compressible flows with combined area change, friction and heat transfer. Normal and oblique shocks. Prandtl-Meyer flow. Two dimensional subsonic flow and similarity laws. Introduction to supersonic flow and method of characteristics. TEXT: Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. I*. PREREQUISITE: Ae 551.

Ae 553A VISCOSITY, TURBULENCE AND BOUNDARY LAYER EFFECTS IN FLUID FLOW (4-0). A version of Ae 522, edited to the needs of the Ordnance Curriculum. Concept of the boundary layer and associated phenomena of skin friction, flow separation, stall and drag. General properties of the boundary layer equations. Some classical solutions of Blasuis, Falkner-Skan and others. Transition from laminar to turbulent flow. Fundamentals of fluid turbulence. Integral methods and applications to laminar and turbulent boundary layers. Boundary layer control. TEXT: Schlichting, *Boundary Layer Theory*. PREREQUISITE: Ae 551.

Ae 581B GAS DYNAMICS LABORATORY (0-3). Laboratory demonstration of analyses in Ae 501B. One dimensional flows. Normal and oblique shocks. TEXT: Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flows*, Vol. I. PREREQUISITE: Ae 501B concurrently.

Ae 582B EXPERIMENTAL METHODS IN AERODYNAMICS (2-3). A course of experimentation involving the following topics: smoke tunnel, hot-wire anemometer, effect of turbulence on drag, control surface hinge-moments, and q-ball calibration; auto-rotation and flutter, strain gage balances; Schlieren techniques and shock tube techniques; hovercraft. TEXTS: Pope, *Wind Tunnel Testing:* Instructor's Notes. PREREQUISITES: Ae 301C; Ae 501B.

Ae 583A ADVANCED GAS DYNAMICS LABORATORY (0-3). Selected experiments in internal and external compressible flows. TEXT: Instructor's Notes. PREREQUISITE: Ae 523A.

Ae 591A SELECTED PROBLEMS IN FLUID DYNAMICS (3-3). Advanced topics in fluid mechanics including both analysis and experimental methods. Techniques of measurement and the design of experiments. For students doing thesis research in fluid dynamics. TEXT: To be selected. PREREQUISITE: Approval of Instructor.

DEPARTMENT OF BUSINESS ADMINISTRATION AND ECONOMICS

William Richards Baker, Commander, SC, U.S. Navy; Instructor in Management (1965); B.S., U.S. Naval Academy, 1945; Management, U.S. Naval Postgraduate School, 1958.

Barry Castro, Associate Professor of Management (1966); B.A., Hunter College, 1955; M.B.A., New York Univ., 1956; Ph.D., 1966.

William Howard Church, Professor of Management (1956); B.A., Whittier College, 1933; M.S.P.A., University of Southern California, 1941.

James Barrie Cowie, Associate Professor of Management (1963); B.Sc. (honors) Glasgow University, 1958; C.I.A., Glasgow University, 1959.

Jerry Lee Dake, Lieutenant, U.S. Naval Reserve; Assistant Professor of Management (1965); B.S., Purdue University, 1961; M.S., 1962.

Leslie Darbyshire, Professor of Management (1962); B.A., University of Bristol, 1950; D.B.A., University of Washington, 1957.

Roger Nils Folsom, Ensign, U.S. Naval Reserve; Assistant Professor of Economics (1965); A.B., Stanford University, 1959; M.A., Claremont Graduate School, 1964.

James Morgan Fremgen, Associate Professor of Management (1965); B.S.C., Univ. of Notre Dame, 1954; M.B.A., Indiana Univ., 1955; D.B.A., 1961; C.P.A., State of Indiana, 1964.

Timothy Phelps Haidinger, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor in Management (1965); B.S., University of Notre Dame, 1963; M.B.A., Stanford University, 1965.

Fenn Clark Horton, Associate Professor of Management (1964); B.A., State Univ. of Iowa, 1950.

H. Arthur Hoverland, Associate Professor of Management (1963); B.S., Miami Univ. (Ohio), 1951; M.S., Univ. of Illinois, 1954; Ph.D., Univ. of Michigan, 1963.

Sigmund Krauthamer, Associate Professor of Economics (1965); B.S., Ohio State Univ., 1949; Ph.D., Univ. of Minnesota, 1963.

Clair Alton Peterson, Associate Professor of Management (1962); B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961.

Paul Edward Roberts, Jr., Assistant Professor of Economics (1966); A.B., Southern Illinois Univ., 1961; M.A., 1962; Ph.D., Univ. of Iowa, 1966.

John David Senger, Associate Professor of Management (1957); B.S., Univ. of Illinois, 1945; M.S., 1948; Ph.D., 1965.

Melvin John Steckler, Associate Professor of Management (1966); B.S.M.E., Univ. of Washington, 1949; M.B.A., 1957; D.B.A., Harvard Univ., 1966.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MANAGEMENT

BACHELOR OF SCIENCE

1. In addition to satisfying the Postgraduate School's general requirements for a baccalaureate degree, the degree Bachelor of Science with major in Business Administration requires a minimum of 40 term hours in general and functional Management courses at or above the C level.

2. The following requirements must be met:

Subject area	*Term Hours*
Behavioral Science	11
Quantitative Methods	11
Financial Management	11
Economics	4
Material Logistics Management	3
	40

3. The student must achieve a grade point average of at least 1.0 in subjects of the major.

MASTER OF SCIENCE IN MANAGEMENT

1. The degree of Master of Science in Management requires the completion of either (a) a minimum of 54 term hours of graduate level courses (A and B level) and an acceptable thesis or (b) a minimum of 60 hours of graduate level course work without a thesis.

2. Core course requirements in A and B level courses must be successfully completed or validated by advance credit. These requirements are as follows:

Discipline	*Term Hours*
Behavioral Science	13
Economics	4
Financial Management	7
Material Management	3
Quantitative Methods	17
	44

3. In addition to the core course requirements, students will choose elective sequences pertinent to their backgrounds and anticipated future assignments. A minimum

of 10 hours with a thesis or 16 hours without a thesis beyond the core requirements must be selected from the following elective sequences:

Economics and Systems Analysis
Financial Management
Personnel Management
Material Logistics Management

MASTER OF SCIENCE IN MANAGEMENT (DATA PROCESSING)

1. The degree of Master of Science in Management (Data Processing) requires the completion of either (a) a minimum of 54 term hours of A and B level courses and an acceptable thesis or (b) a minimum of 60 hours of graduate level course work without a thesis.

2. Core course requirements in A and B level work must be successfully completed or validated by advance credit in the following areas:

Discipline	*Term Hours*
Management	12
Data Processing	15
Mathematics	4
Probability and Statistics	7
Operations Analysis	9
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	47

3. In addition to the core courses, students will pursue an approved sequence of elective courses pertinent to their future assignments. Such sequences must involve a minimum of 13 hours of A and B level work or 7 hours if a thesis is prepared.

MANAGEMENT

MN 01D INTRODUCTION TO MACRO-ECONOMICS (4-0). A study of the determination of the level of national output and its relationship to the economics of defense. Analysis of the roles of savings, investment, monetary policy, fiscal policy, and their relationships to the national goal of full employment without inflation.

MN 101C INDIVIDUAL STUDY (3-0). Designed to give undergraduate students majoring in business administration opportunities to perform advanced or special studies in various aspects of management. Consent of the proposed study advisor must be secured prior to enrollment.

MN 111C INTRODUCTION TO MICRO-ECONOMICS (4-0). A study of the allocation of resources among competing ends as determined by a price system. Topics covered include supply, demand, consumer choice, and the theory of the firm.

MN 114C INTERNATIONAL TRADE (4-0). A study of the comparative advantages and gains from trade, exchange rates, balance of payments, equilibrium, adjustment mechanisms, tariffs, and international trade organizations. PREREQUISITES: MN 010D and MN 111C.

MN 120C PRINCIPLES OF ACCOUNTING (4-0). An introduction to the basic concepts and principles of financial accounting. Covers the accounting cycle; accounting for assets, liabilities, revenue, and expenses; financial statement content and analysis.

MN 121C PRINCIPLES OF MANAGEMENT ACCOUNTING (4-0). Develops the internal uses of accounting as a management tool. Covers cost accounting and control, including standard costs. Discusses the relationships between costs and volume and the relevance of cost data to decision making. PREREQUISITE: MN 120C.

MN 122C BUDGETING AND COMPTROLLERSHIP (4-0). Introduces modern techniques of capital budgeting. Discusses the Federal budgetary process, with special emphasis on budgeting in the Department of Defense and the program budget approach. Considers appropriation accounting and the accounting practices of the Navy Industrial Fund. Includes a brief survey of the audit function in industry and government. PREREQUISITE: MN 121C.

MN 140C INDUSTRIAL MANAGEMENT (4-0). This course stresses the economic consequences of combining men, machines and money for production purposes. Modern tools of decision making are introduced. Construction of simple models as an aid in determining alternatives and choosing "the best" course of action is required. Subject matter includes production planning and control, facilities layout, wage incentives and measurement of labor effort. An introduction to modern production methods is presented.

MN 152C HUMAN RELATIONS (4-0). The historical background of the American worker and the growth of the modern human relations movement are examined. Such topics as individual differences among workers, communication, motivation, interpersonal relationships and the role of the manager as a leader are investigated. Emphasis is placed on the implications of human relations for the naval officer.

MN 153C PERSONNEL ADMINISTRATION (4-0). The broad area of personnel management is covered, with particular emphasis on recruitment and selection, training, promotion, performance evaluation, and the role of the labor union in both industry and the Federal Government.

MN 163C MATERIAL MANAGEMENT (4-0). This course consists of a broad overview of major and item material management and support functions as performed in the Department of Defense, the Defense Supply Agency, and the military departments, as well as an analysis of selected techniques employed in requirements determination, procurement, and inventory management of secondary items in support of the operating forces and military industrial activities.

MN 191C ORGANIZATION AND MANAGEMENT (4-0). An introduction to the principles and practices of management. The formal aspects of organizational structure, (e.g., hierarchy and control and control spans) are analyzed together with alternative ways of accomplishing objectives. The role of the planning and control functions is studied in addition to the tools of analysis available to managers.

MN 210C MACRO-ECONOMICS (4-0). A study of the determination of the level of national output and its relationship to the economics of defense. Analysis of the roles of savings, investment, monetary policy, fiscal policy, and their relationships to the national goal of full employment without inflation.

MN 221C FINANCIAL ACCOUNTING (3-0). An introduction to the basic concepts, terminology, and principles of financial accounting. Covers the accounting cycle; accounting for assets, liabilities, revenue, and expenses; financial statements and statement analysis. Discusses the implications of alternative accounting principles.

MN 252C INDIVIDUAL BEHAVIOR (4-0). The aspects of individual behavior which relate particularly to the effectiveness of the Naval officer are discussed. Topics include personality structure, motivation, psychological testing, learning, and behavioral conditioning.

MN 253C MANAGEMENT PSYCHOLOGY (3-0). Basic psychological concepts are examined with particular emphasis given those aspects of major importance to the manager. Current theories applicable to such topics as communication, authority, motivation, and leadership are discussed. Attention is given to aiding the manager in developing sound interpersonal relationships both in the military and Civil Service. For students in the Management (Data Processing) curriculum.

MN 301C BASIC MANAGEMENT I (4-0). A survey course covering financial and material management. Topics in financial management include accounting principles, budgeting and control, and appropriation accounting. Topics in material management include the resources available for defense, material management practices in the Department of Defense, procurement, inventory control, and distribution in support of operating forces and industrial activities. For students in engineering curricula.

MN 302C BASIC MANAGEMENT II (4-0). A survey course in personnel management, organization theory, and their applications in industrial management. Topics covered include individual and group behavior, principles of effective organization to achieve managerial goals, and management control of industrial operations. For students in engineering curricula.

MN 310C ENGINEERING ECONOMICS (4-0). Introduces the basic concepts of microeconomics necessary for decision making. Develops consumer and producer choice theory with emphasis on producer choice, concentrating on technological considerations, production and cost, and supply curves. Market models will also be presented. For students in engineering curricula. PREREQUISITE: PS 351B.

MN 311C MACRO-ECONOMICS (3-0). A study of the determination of the level of national output and its relationships to the economics of defense. Analysis of the roles of savings, investment, monetary policy, fiscal policy, and their relationships to the national goal of full employment without inflation. For students in the Operations Analysis Curriculum.

MN 312B MICRO-ECONOMICS (3-0). A study of the allocation of resources among competing ends as determined by a price system. Topics covered include supply, demand, consumer choice, and the theory of the firm. For students in the Operations Analysis Curriculum.

MN 313A INTERMEDIATE MICRO-ECONOMIC THEORY (3-0). More intensive study of the resource allocation problems introduced in MN 312B. Additional topics covered include general equilibrium, welfare economics, and capital theory. For students in the Operations Analysis Curriculum. PREREQUISITE: MN 312B.

MN 315B MANAGEMENT PLANNING AND DECISION MAKING (4-0). Introduces the basic concepts of optimal investment decisions. The primary emphasis will be placed on problem formulation and methods of analysis for decision making, including data necessary and criteria for choice. For students in engineering curricula. PREREQUISITES: PS 351B, MN 310C, MN 320C.

MN 316A ADVANCED ECONOMIC ANALYSIS (3-0). A study of the theoretical foundations of current economic analysis. Topics covered include comparative statics, dynamics, model building, stability conditions, and optimal paths of capital accumulation. For students in the Operations Analysis Curriculum. PREREQUISITES: MN 311C and MN 313A.

MN 319A ECONOMICS SEMINAR (3-0). Topics covered will be selected on the basis of student interest and consent of the instructor. Examples of economic problems that might be considered are international trade, intermediate macro-economics, and economic development. For students in the Operations Analysis Curriculum. PREREQUISITES: MN 311C and MN 313A.

MN 320C MANAGERIAL ACCOUNTING (4-0). Introduces the basic concepts of accounting as used in industry and government. Develops the uses of accounting data by managers in planning, control and decision making. Applications of automatic data processing to accounting systems are illustrated. For students in engineering curricula.

MN 322A MANAGERIAL ACCOUNTING (3-0). Introduces the basic concepts of accounting as used in industry and government. Develops the uses of accounting data by managers in planning, control, and decision making. Applications of automatic data processing to accounting systems are illustrated. For students in the Management (Data Processing) Curriculum.

MN 381A DATA PROCESSING MANAGEMENT (4-0). This course is intended to provide a knowledge of alternative data processing systems from unit record equipment to complex computer systems. Consideration is given to the effective installation and utilization of the most suitable system for representative Data Processing tasks. The role of the manager of such a system is emphasized.

MN 382A COMPUTER APPLICATIONS (4-0). This course discusses the application of computer systems to data processing and scientific problems. This is a continuation of MN 381A.

MN 401A INDIVIDUAL STUDY (3-0). Designed to give the student an opportunity to continue advanced study in some aspect of management. Consent of advisor must be secured.

MN 411B MICRO-ECONOMICS (4-0). A study of the allocation of resources among competing ends as determined by a price system. Topics covered include supply, demand, consumer choice, and the theory of the firm.

MN 412A MANAGERIAL ECONOMICS (4-0). A study of economic principles applied to managerial decision making. Practical tools which can be used to improve the allocation of a firm's resources are discussed. Specific topics include forecasting demand, cost analysis, and optimal capital allocation. PREREQUISITES: MN 411B and MN 423A.

MN 413A INTERMEDIATE MICRO-ECONOMIC THEORY (4-0). More intensive study of the resource allocation problems introduced in MN 411B. Additional topics covered include general equilibrium, welfare economics, and capital theory. PREREQUISITE: MN 411B.

MN 419A ECONOMIC SEMINAR (4-0). Topics covered will be selected on the basis of student interest and consent of the instructor. Examples of economic subjects that might be considered are international trade, intermediate macro-economics, and economic development. PREREQUISITE: MN 210C and MN 413A.

MN 422A MANAGERIAL ACCOUNTING (3-0). Develops the managerial uses of accounting data for planning, control, and decision making. Specific topics covered include cost accounting, flexible budgets, standard costs, cost-volume analysis, and the relevance of cost data to decisions. PREREQUISITE: MN 221C.

MN 423A PLANNING, PROGRAMMING AND BUDGETING (4-0). Introduces modern techniques of capital budgeting. Discusses the Federal budgetary process, with special emphasis on budgeting in the Department of Defense and the program budget approach. Considers the implications of the planning-programming-budgeting cycle for defense decision making. Considers, briefly, appropriation accounting and the accounting practices of the Navy Industrial Fund. PREREQUISITE: MN 422A.

MN 424A INTERNAL CONTROL AND AUDITING (4-0). Develops the fundamental objectives and principles of internal control in industry and government. Discusses the audit function, auditing standards, audit procedures, sampling techniques, and audit reports. The auditing of accounting systems maintained by computer is studied. PREREQUISITES: MN 422A, MN 481A, and PS 372B (or equivalent).

MN 425A COMPTROLLERSHIP SEMINAR (4-0). Develops the comptrollership function in industry and in the military services, including detailed analysis of placement in the organization, operating tasks, staff role and anticipated future trends. Discussion of a broad range of cases to illustrate current practice and problems. PREREQUISITES: MN 423A, PS 372B, and MN 481A, or permission of instructor.

MN 426A COST ESTIMATING AND ANALYSIS (3-0). Develops the concepts of cost estimation, cost behavior, cost allocation, and variance analysis. Introduces the military application of cost estimation and analysis for weapons procurement decision-making and control. PREREQUISITES: MN 422A and PS 372B (or equivalent).

MN 432A SYSTEMS ANALYSIS (4-0). This course covers the application of economic concepts, probability theory, and statistics to problems of choice among various weapons systems. Approximately half of the course is devoted to the theoretical problems involved in optimum resource allocation; the remaining time is devoted to study of current weapons choice problems. PREREQUISITE: MN 413A.

MN 453A PERSONNEL ADMINISTRATION AND INDUSTRIAL RELATIONS (4-0). Current personnel practices in industry are examined. The background, philosophy, and regulations of Civil Service are discussed, with emphasis given industrial relations aspects of administration. Throughout the course comparisons are made between the personnel management techniques of the Federal Government and of civilian industrial organization. PREREQUISITE: MN 252C.

MN 455A BEHAVIORAL SCIENCE SEMINAR (3-0). A combination of directed reading and individual students' presentations in specialized areas is employed. The student is given the opportunity to pursue an area of interest, prepare a paper on the selected topic, and make a presentation to the class and the instructor for their critical comments. PREQUISITE: MN 453A.

MN 456A LABOR RELATIONS (4-0). The nature of labor problems is defined; union history and government studied; the processes of collective bargaining, the economics of the labor market, and governmental regulation of wages and unions examined. Particular emphasis is placed on employee-management relations in the Federal Service in view of the changing status of collective bargaining in this area. PREREQUISITE: MN 453A.

MN 460A MATERIAL MANAGEMENT (3-0). This course presents the functions of material planning, requirements determination, procurement, distribution, and control applied to the introduction, development, and supply support of major military programs. A broad overview is given of the various organizations of the Department of Defense in the material management field. PREREQUISITE: MN 210C.

MN 461A PROCUREMENT AND CONTRACT ADMINISTRATION (4-0). The elements of the procurement cycle are discussed, including the requirements determination, legal, fiscal, technical, production, facilities, inspection, and termination factors involved. The various military procurement laws and regulations are reviewed and analyzed to determine their effect upon the Navy material logistics systems. PREREQUISITE: MN 460A.

MN 462A MODERN INVENTORY MANAGEMENT (3-0). The basic concepts and formulae used to develop material demand forecasting systems and variable inventory levels are reviewed and discussed. The scientific approach to basic inventory decisions is stressed. Opportunities are provided to study and analyze several approaches which introduce mathematical inventory theory as applied to the Navy Supply System. PREREQUISITES: MN 460A and PS 372B.

MN 473A QUANTITATIVE DECISION MAKING (3-0). The course explores the application of science to decision making involving a survey of applicable tools of quantitative analysis. The instruction treats management decision making problems from over-all system point of view with primary emphasis on interaction of separate elements of an enterprise; examining flows of information, money, materials, manpower and capital equipment. The course stresses practical applications of mathematical and statistical tools. PREREQUISITES: PS 372B and OA 471B.

MN 480A FACILITIES MANAGEMENT (3-0). The course includes analysis of the problems involved in development of requirements and programming and procurement of long lead-time support facilities. The complexity of the process brought about by technological change, modification of strategic and tactical concepts, limited budgets and the executive-legislative relationship, are examined. PREREQUISITE: MN 460A.

MN 481A COMPUTERS AND DATA PROCESSING (4-0). An introduction to digital computers, the main emphasis on the principles involved in effective implementation of computer systems. Specific programming problems from the managerial area.

MN 490A GROUP AND ORGANIZATIONAL BEHAVIOR (5-0). The impact of group structure, member interaction, role behavior, and group pressure on small group effectiveness is examined. Current leadership theories and empirical findings are studied. The organization as a system of formally structured, task-oriented groups is examined. Organizational concepts pertinent to the military and the Civil Service — such as power, authority, and bureaucracy — are studied. Methods of effecting coordinated effort toward organizational goals by means of planning, direction and control techniques are investigated. PREREQUISITE: MN 252C.

MN 491A MANAGEMENT POLICY (4-0). An attempt is made to synthesize the various functional areas of management into a composite whole. Stress is placed on the operation of top management rather than on component parts in the processes of analysis, decision-making, action and control in achieving various goals. PREREQUISITES: MN 411B, MN 490A, MN 423A, and OA 471B.

MN 492A GOVERNMENT AND BUSINESS (4-0). Public policies of national government affecting the economic, political and social order; role of government in our society; responsiveness of national government to various interest groups; defense policy, its effect upon the Navy; the budgetary process in the formulation of the National Strategy; interaction of regulatory agencies with Defense. PREQUISITE: MN 210C.

MN 495A ORGANIZATION AND MANAGEMENT SEMINAR (3-0). A research and discussion approach to the problem areas of the theory of organization, their structure and behavior. Particular attention is given to consequences of changes in organizational environments and internal technologies. PREREQUISITE: MN 490A.

DEPARTMENT OF ELECTRICAL ENGINEERING

Charles Harry Rothauge, Professor of Electrical Engineering; Chairman (1949)*: B.E., Johns Hopkins Univ., 1940; D. Eng., 1949.

Allen Edgar Vivell, Professor of Electrical Engineering (1945); B.E., Johns Hopkins Univ., 1927; D.Eng., 1937.

Roy Stanley Glasgow, Dean Emeritus (1949); B.S., Washington Univ., 1918; M.S., Harvard, 1922; E.E., Washington Univ., 1925; D.Sc.. (Hon.), Washington Univ., 1961.

George Robert Giet, Professor Emeritus and Fellow (1925); A.B., Columbia Univ., 1921; E.E., 1923.

Richard Carvel Hensen Wheeler, Professor Emeritus (1929); B.E., Johns Hopkins Univ.. 1923: D.Eng., Rensselaer Polytechnic Institute, 1926.

William Malcolm Bauer, Professor of Electronics (1946); B.S., Northwestern Univ., 1927; E.E., 1928: M.S., Harvard Univ., 1929; D.Sc., 1940.

Bruce Allan Black, Lieutenant Junior Grade, U.S. Naval Reserve, Instructor of Electrical Engineering (1965); B.S., Columbia Univ., 1964; S.M., Massachusetts Institute of Technology, 1966.

John Miller Bouldry, Associate Professor of Electrical Engineering (1946); B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

Stephen Breida, Associate Professor of Electronics (1958); B.S.E.E., Drexel Institute of Technology, 1952; M.S.E.E.. Purdue Univ., 1954.

William John Brenner, Assistant Professor of Electrical Engineering (1964); B.S., Merrimack College, 1962; M.S., Stanford Univ., 1964.

Shu-Gar Chan, Associate Professor of Electrical Engineering (1964); B.S., Univ. of Washington, 1952; M.S., Columbia Univ., 1954; Ph.D., Kansas Univ., 1964.

Jesse Gerald Chaney, Professor of Electronics (1944); A.B., Southwestern Univ., 1924; A.M., Univ. of Texas, 1930.

Richard Henry Chesarek, Ensign, U.S. Naval Reserve, Instructor of Electrical Engineering (1965); B.S., Stanford University, 1964; M.S., 1965.

Paul Eugene Cooper, Professor of Electronics (1946); B.S., Univ. of Texas, 1937; M.S., 1939.

Mitchell Lavette Cotton, Associate Professor of Electronics (1953); B.S.. California Institute of Technology, 1948; M.S., Washington Univ., 1952; E.E.. Univ. of California, 1954.

James Steve Demetry, Assistant Professor of Electrical Engineering (1960); B.S., Worcester Polytechnic Institute, 1958; M.S., 1960; Ph.D., U.S. Naval Postgraduate School, 1964.

Gerald Dean Ewing, Associate Professor of Electrical Engineering (1963); A.A., College of Marin, 1955; B.S.E.E., Univ. of California, 1957; M.S.E.E., 1959; E.E., Oregon State Univ., 1962; Ph.D., 1964.

Edward Markham Gardner, Professor of Electrical Engineering (1948); B.S., Univ. of London, 1923; M.S., California Institute of Technology, 1938.

Alex Gerba, Jr., Associate Professor of Electrical Engineering (1959); B.E.E., Univ. of Louisville, 1947; M.S., Univ. of Illinois, 1957.

Glenn Alvia Gray, Associate Professor of Electronics (1960); B.S., Univ. of California, Berkeley, 1954; M.S.. 1955; Ph.D., 1958.

David Boysen Hoisington, Professor of Electronics (1947); B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

Raymond Kenneth Houston, Professor of Electrical Engineering (1946); B.S., Worcester Polytechnic Institute, 1938; M.S., 1939.

Roy Martin Johnson, Jr., Assistant Professor of Electronics (1959); B.S., Univ. of California, 1954; M.S., 1959.

Donald Evan Kirk, Assistant Professor of Electrical Engineering (1965); B.S., Worcester Polytechnic Institute, 1959; M.S., U.S. Naval Postgraduate School, 1961; Ph.D., University of Illinois, 1964.

Clarence Frederick Klamm, Jr., Professor of Electronics (1951); B.S., Washington Univ., 1943; M.S., 1948.

Jeffrey Bruce Knorr, Lieutenant Junior Grade, U.S. Naval Reserve, Instructor of Electrical Engineering (1964); B.S., Pennsylvania State Univ.. 1963; M.S., 1964.

George Heinemann Marmont. Professor of Electronics (1959); B.S., California Institute of Technology, 1934; Ph.D., 1940.

Carl Ernest Menneken, Professor of Electronics (1942); B.S., Univ. of Florida, 1932; M.S., Univ. of Michigan, 1936.

Robert Lee Miller, Professor of Electronics (1946); B.Ed., Illinois State Normal Univ., 1936; M.S., Univ. of Illinois, 1941.

Raymond Patrick Murray, Associate Professor of Electronics (1947); B.S., Kansas State College, 1937; M.S., Brown Univ., 1953.

Glen Allen Myers, Associate Professor of Electrical Engineering (1965); B.S.E.E., Univ. of North Dakota, 1955; M.S.E.E., Stanford Univ., 1956; Ph.D., 1965.

Herbert Leroy Myers, Assistant Professor of Electrical Engineering (1951); B.S., Univ. of Southern California, 1951.

ROBERT SAMUEL NORIN, Lieutenant Junior Grade, U.S. Naval Reserve, Instructor of Electrical Engineering (1964); B.A., Columbia Univ., 1962; B.S., 1963; M.S., Stanford Univ., 1964.

CHARLES BENJAMIN OLER, Professor of Electrical Engineering (1946); B.S., Univ. of Pennsylvania, 1927; M.S., 1930; D.Eng., Johns Hopkins Univ., 1950.

RUDOLF PANHOLZER, Associate Professor of Electrical Engineering (1964); Dipl. Ing., Technische Hochschule Graz, Austria, 1953; M.S.E.E., Stanford Univ., 1955; D.E., Stanford Univ., 1956; D.Sc., Technische Hochschule Graz, Austria, 1961.

ORVAL HAROLD POLK, Professor of Electrical Engineering (1945); B.S., Univ. of Colorado, 1927; M.S., Univ. of Arizona, 1933; E.E., Univ. of Colorado, 1940.

GEORGE ANTHONY RAHE, Associate Professor of Electrical Engineering (1965); B.S., U.C.L.A., 1957; M.S., 1959; Ph.D., 1965.

MICHAEL ALOYSIUS REILLY, Lieutenant Junior Grade, U.S. Naval Reserve, Instructor of Electrical Engineering (1964); B.S.E.E., Univ. of Santa Clara, 1961; M.S.E.E., 1964.

GEORGE LAWRENCE SACKMAN, Associate Professor of Electrical Engineering (1964); B.M.E., Univ. of Florida, 1954; B.E.E., 1957; M.S.E., 1959; Ph.D., Stanford Univ., 1964.

MAURICE L. SCHILLER, Lieutenant Junior Grade, U.S. Naval Reserve, Instructor of Electrical Engineering (1965); B.S., Texas A&M Univ., 1964; M.Eng., 1965.

ABRAHAM SHEINGOLD, Professor of Electronics (1946); B.S., College of the City of New York, 1936; M.S., 1937.

WILLIAM CONLEY SMITH, Professor of Electrical Engineering (1946); B.S., Ohio Univ., 1935; M.S., 1939.

DONALD ALAN STENTZ, Associate Professor of Electronics (1949); B.S., Duke Univ., 1949; M.S., U.S. Naval Postgraduate School, 1958.

ROBERT DENNEY STRUM, Associate Professor of Electrical Engineering (1958); B.S., Rose Polytechnic Institute, 1946, M.S., Univ. of Santa Clara, 1964.

FREDERICK WALCUTT TERMAN, Assistant Professor of Electrical Engineering (1964); B.S., Stanford Univ., 1949; M.S., 1950.

GEORGE JULIUS THALER, Professor of Electrical Engineering (1951); B.E. Johns Hopkins Univ., 1940; D.Eng., 1947.

HAROLD ARTHUR TITUS, Associate Professor of Electronics (1962); B.S., Kansas Univ., 1952; M.S., Stanford Univ., 1957; Ph.D., 1962.

JOHN BENJAMIN TURNER, JR., Associate Professor of Electronics (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California, 1948.

JOHN ROBERT WARD, Associate Professor of Electrical Engineering (1962); B.Sc., Univ. of Sydney, 1949; B.E., 1952; Ph.D., 1958.

MILTON LUDELL WILCOX, Associate Professor of Electrical Engineering (1958); B.S., Michigan State Univ., 1938; M.S., Univ. of Notre Dame, 1956.

*The year of joining the Postgraduate School Faculty has been indicated in parentheses.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN ELECTRICAL ENGINEERING

In addition to meeting the minimum specific academic requirements for these degrees as given below, candidates must also satisfy the general degree requirements as determined by the Academic Council.

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

BACHELOR OF SCIENCE IN ENGINEERING ELECTRONICS

BACHELOR OF SCIENCE IN COMMUNICATIONS ENGINEERING

It is required that candidates for these degrees satisfy the following requirements while in residence at the Naval Postgraduate School except in the case of candidates entering the school with advanced standing, when due allowance will be made for advanced transfer credits.

Discipline	*Subjects*	*Approximate Term Hrs.*
Electrical Engineering	Fields and Circuits	17
	Electron Devices and Circuits	16
	Electromagnetic Theory	4
	Communication Theory	4
	Electromechanical Devices	5
	Feedback Control Theory	4
	Electronic Computers	4
		—
		54
Mathematics	Vector Algebra	4
	Calculus	4
	Differential Equations and Series	4
	Complex Variables	3
		—
		15
Physics	Properties of Matter	8

In addition to the above 77 term hours, approximately 28 elective term hours will be required in upper division courses. At least 15 of those term hours will normally be elected in the candidate's degree option (Electrical Engineering, Engineering Electronics or Communications Engineering).

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

MASTER OF SCIENCE IN ENGINEERING ELECTRONICS

MASTER OF SCIENCE IN COMMUNICATIONS ENGINEERING

Each student's program must include a total of at least 45 term hours in A or B level courses beyond the requirements for the B.S. degree. At least 20 of these credits shall be in A level courses.

Of the above 45 credits at least 20 must be directed toward a specialty within the candidate's degree option, and in addition at least 22 non-specialty credits must be distributed as follows:

Advanced Circuits	4 term hours
Advanced Devices	4 term hours
Advanced Mathematics	6 term hours
Electives other than Electrical Engineering or Mathematics	8 term hours

In addition candidates must present an acceptable thesis.

BIOLOGY

BI 800C FUNDAMENTALS OF BIOLOGY (6-0). The fundamental principles of the living cell covered from a biochemical and biophysical standpoint. Specialization of cell function, as exemplified in certain animal and plant tissues and organs systems. Genetics and its relation to properties of cell nucleus. Related topics, including the evolutionary progress.

BI 801B ANIMAL PHYSIOLOGY (6-0). A general course in animal physiology, emphasizing human functional aspects. PREREQUISITE: BI 800C.

BI 802A RADIATION BIOLOGY (6-0). Fundamental processes of energy transfer from radiation to living matter. Biochemical, physiological and genetic effects of radiation. Methods of experimental radiation biology. PREREQUISITES: PH 637B, PH 638A, BI 800C, BI 801B.

BI 822A SPECIAL TOPICS IN RADIATION BIOLOGY (2-0). Study of important current topics in radiation biology. PREREQUISITE: Appropriate biological background.

BI 823A SPECIAL TOPICS IN RADIATION BIOLOGY II (2-0). A continuation of BI 822A. A study of important current topics in radiation biology.

ELECTRICAL ENGINEERING

EE 101D ELECTRICAL FUNDAMENTALS (3-2). A presentation of basic electrical phenomena. Topics include: DC circuits and components, magnetism, electromagnetism, instruments, AC circuits and components, resonance, transformers, batteries, and power sources.

EE 102D INTRODUCTION TO ELECTRICITY AND MAGNETISM (2-2). An introductory course that requires no knowledge of mathematics beyond simple differentiation and integration. Topics studied include charge and matter, the electric field, Gauss's law, electrical potential, capacitors and dielectrics, current and resistance, the magnetic field, Ampere's law and Faraday's law, inductance, and magnetic circuits. PREREQUISITE: PH 051D.

EE 103C NETWORK ANALYSIS I (4-4). An introduction to electric circuit analysis with attention given to both time domain and frequency domain topics. Differential equations are written for multi-loop and multi-node networks and are solved by Laplace transform methods. Special case of sinusoidal steady-state analysis, frequency response plots, impedance and admittance functions, and network theorems are studied. PREREQUISITE: EE 102D or EE 105C.

EE 104C NETWORK ANALYSIS II (4-3). A continuation of EE 103C. Topics include: transforms of truncated waveforms, real convolution, network functions, poles and zeros, two-port network parameters, flowgraphs, formulation of problems in state variable notation, Fourier series and signal spectra, an introduction to the Fourier integral and continuous spectra. The analog computer is used to study linear systems in the laboratory. PREREQUISITE: EE 103C.

EE 105C BASIC ELECTRICAL PHENOMENA (3-2). The first of a series of three courses designed to present the fundamentals of fields and circuits. An introduction to the theory of electric and magnetic fields presented in a unified manner which satisfies the prerequisites for circuits, electronics, and machinery. PREREQUISITE: Ordinary Differential Equations.

EE 106C BASIC CIRCUIT ANALYSIS I (3-2). The circuit concept is developed by the complete analysis of simple circuits. Sinusoidal steady-state solution by phasor methods is introduced. Matrix methods are used in the analysis of multi-loop and multi-node circuits. PREREQUISITE: EE 105C.

EE 107C BASIC CIRCUIT ANALYSIS II (3-2). A continuation of EE 106C. Poles and zeros are defined. Driving point, transfer, and hybrid parameters of 2-port networks; polar, logarithmic, and rectangular plots; network theorems; Fourier series; and balanced polyphase circuits are studied. PREREQUISITE: EE 106C.

EE 111C FIELDS AND CIRCUITS (4-4). An introduction to the theory of electric and magnetic fields is presented as a foundation for the study of circuits, electronics, and machinery. The basic circuit elements are defined by the application of this theory. Response of simple circuits and power and energy relations are considered. Sinusoidal steady-state solution by phasor methods is introduced. PREREQUISITE: Differential and Integral Calculus (may be concurrent).

EE 112C CIRCUIT ANALYSIS (4-3). A continuation of EE 111C. Sinusoidal analysis is continued. Poles and zeros are defined. Matrix methods are introduced. Driving point, transfer, and hybrid parameters of 2-port networks; polar, logarithmic and rectangular plots; network theorems and Fourier series are studied. PREREQUISITE: EE 111C.

EE 113B LINEAR SYSTEMS ANALYSIS (4-3). The basic theory of circuit analysis is continued with a thorough study of transient phenomena in linear systems. Laplace transform methods are studied with illustrations in electrical, mechanical, and electromechanical systems. Fourier integral methods for solutions of system response and spectral analysis are considered. Real convolution and its application to inversion techniques in both Laplace and Fourier solutions is illustrated. Methods of analysis in both the time and frequency domain are compared. The analog computer is used to simulate linear systems in the laboratory. PREREQUISITES: EE 112C or EE 107C. Complex Variable Theory (may be concurrent).

EE 114B COMMUNICATION THEORY I (4-0). In this introductory course the following concepts and their mathematical formulations are presented: Information measure; sampling; pulse encoding methods; frequency and time multiplexing; amplitude, frequency and phase modulation. In addition, a comparison of modulation methods is presented. PREREQUISITE: EE 113B.

EE 115B SIGNALS, SYSTEMS, AND COMMUNICATION (4-1). A review of the time and frequency domain representation of signals, as well as the characterization of electric networks by their impulse response. The principles and mathematical formulation of continuous-wave amplitude and angle modulation and of pulse modulation are presented. The relative merits of each type of modulation are considered, and basic modulation and demodulation techniques are studied. In the development of these topics, the following concepts are used: Fourier series, Fourier integral, convolution, delta functions, transfer functions of linear circuits, voltage and power spectra, signal-to-noise ratio, sampling theorem. PREREQUISITE: EE 104C or EE 113B.

EE 116B COMMUNICATION THEORY II (3-2). A continuation of EE 114B. Noise sources and methods of measurement are treated. Statistical methods for handling noise and random signals are presented, followed by a study of detection problems in radar and pulse transmission systems. Correlation functions and their application to communication systems are introduced. PREREQUISITE: EE 114B.

EE 121A ADVANCED NETWORK ANALYSIS (3-2). Network topology, signal flow graphs, sensitivity, and general linear, scattering, and immittance descriptions are considered. Additional topics are chosen from the following partial list: Potential analog, time varying linear system analysis, response of linear systems to random signals, analytic properties of network functions. PREREQUISITE: EE 113B.

EE 122A NETWORK SYNTHESIS I (4-0). Basic principles of system synthesis as exemplified in the synthesis of passive electric networks. Energy relations in such networks and the fundamental properties of physically realizable driving point immittances are studied. Synthesis of one-port networks, in various forms, is illustrated, as is the ladder development of 2-port networks. PREREQUISITE: EE 113B.

EE 123A NETWORK SYNTHESIS II (3-0). Two-port synthesis is continued from EE 122A, with emphasis on series and parallel realizations, lattice networks, and resistively terminated networks. N-port synthesis, synthesis through matrix methods, and linear graph theory methods of synthesis are introduced. Other advanced topics in modern active and passive synthesis will be discussed. PREREQUISITE: EE 122A.

EE 125B OPERATIONAL METHODS FOR LINEAR SYSTEMS (3-1). A study of the mathematical methods employed in the design and analysis of linear systems. Topics include: basic concepts of systems analysis, the Fourier integral and Fourier transform, applications to linear systems (low- and band-pass filters, spectrum analyzers), the bi-lateral Laplace transform, integral theorems, correlation and power spectra. PREREQUISITES: EE 104C or EE 113B, and MA 271C.

EE 131C POLYPHASE CIRCUITS (3-2). Analysis of polyphase circuits with balanced and unbalanced loading. Power and energy measurements in polyphase circuits. Analysis of polyphase circuits with unbalanced voltages using symmetrical components. Fault currents and voltages determined by the application of sequence networks. PREREQUISITE: EE 112C or EE 107C.

EE 205D ELECTRONICS FUNDAMENTALS (3-2). A qualitative approach to the fundamentals of electronics. Topics include: physical processes and operational characteristics of basic vacuum and solid-state devices; rectifiers, amplifiers, oscillators and elementary communication circuits. PREREQUISITE: EE 101D.

EE 211C ELECTRON DEVICES AND CIRCUITS (4-2). An introduction to electronic devices, circuits and systems is followed by the consideration of charge-carrier motion in vacuum, the electrical properties of solids and conduction processes in gases. Physical processes and operational characteristics associated with various diodes and control devices are considered and the basic techniques of signal amplification with active devices and the graphical analysis of amplifier circuits are studied. PREREQUISITES: EE 111C or EE 106C.

EE 212C ELECTRONIC CIRCUITS I (4-3). The topics studied include the equivalent-circuit analysis of linear amplifiers, general analysis of untuned small-signal amplifiers, feedback in amplifiers, operational and DC amplifiers and small-signal tuned amplifiers. PREREQUISITE: EE 211C.

EE 213C ELECTRONIC CIRCUITS II (4-3). The topics studied include broad-band small-signal amplifiers, electronic power supplies, untuned power amplifiers, audio systems, tuned power amplifiers and sine-wave oscillators. PREREQUISITE: EE 212C.

EE 214C ELECTRONIC COMMUNICATION CIRCUITS (4-3). The topics studied include the superheterodyne receiver, frequency conversion, band-pass amplifiers, detectors, automatic gain control, production of FM signals, noise limiters, the AM transmitter, the single-sideband transmitter and the FM transmitter. PREREQUISITE: EE 213C or EE 232C.

EE 215C PULSE AND WAVEFORMING CIRCUITS (4-3). The topics studied include linear waveshaping circuits, device switching characteristics, clipping, clamping and logic circuits, multivibrators and trigger circuits, electronic counters, gating circuits and sweep generators. PREREQUISITE: EE 213C or EE 232C.

EE 216C SPECIAL ELECTRONIC DEVICES (4-2). The topics studied include particle dynamics, microwave devices, negative-resistance and variable reactance devices, and a brief survey of quantum electronics and microelectronics. PREREQUISITES: EE 214C and PH 604C or equivalent.

EE 217B ADVANCED ELECTRON DEVICES (4-2). The topics studied include particle dynamics, electronic beam techniques and devices, microwave tubes, negative-resistance and variable reactance devices, microelectronics and quantum-electronic devices. PREREQUISITES: EE 214C and PH 705B or equivalent.

EE 221C GENERAL ELECTRONICS I (3-3). The first of a two-term terminal course. Topics include: electronic processes in vacuum, gas and solid media; diodes and diode circuits: amplifier devices and basic amplifier techniques. PREREQUISITE: EE 112C.

EE 222C GENERAL ELECTRONICS II (3-3). A continuation of EE 221C. Included topics are: linear amplifier analysis and frequency response; large-signal, tuned and feedback amplifiers; oscillators; power supplies; communication circuits and systems. PREREQUISITE: EE 221C.

EE 223B ELECTRONIC CONTROL AND MEASUREMENT (3-3). Analysis and design of electronic circuits of control, measurement, data transmission and processing. Topics included are: vacuum-tube voltmeters, DC amplifiers, pulse-shaping and switching circuits, oscillators and time-base generators, counting and time-interval measuring circuits, frequency measurement and control circuits, motor-speed and generator-voltage control systems. PREREQUISITES: EE 232C and EE 113B (may be concurrent).

EE 231C ELECTRONICS I (4-3). The topics studied include: Charge motion in a vacuum and in solids; diodes and diode circuits; transistors and multielectrode vacuum tubes, with application to simple amplifier circuits; gaseous tubes. PREREQUISITE: EE 112C, EE 107C, or EE 103C.

EE 232C ELECTRONICS II (4-3). Topics included are: tuned, feedback and power amplifiers; amplifier frequency response; oscillators; power supplies; large-signal amplifiers. PREREQUISITE: EE 231C.

EE 233B COMMUNICATION CIRCUITS AND SYSTEMS (4-3). The following topics are studied: amplitude and frequency modulation and detection, pulse modulation methods, frequency conversion and synthesis, transmitting and receiving systems, multiplexing techniques. PREREQUISITE: EE 232C.

EE 234C PULSE TECHNIQUES AND HIGH FREQUENCY TUBES (3-3). A study of clipping, differentiating, integrating, clamping, and coupling circuits, relaxation oscillators, and pulse amplifiers, using both tubes and transsistors. Following this is a study of microwave tubes most commonly employed in radar systems. PREREQUISITE: EE 232C.

EE 241C ELECTRONIC FUNDAMENTALS (3-2). An introduction to electronic devices, circuits and communication systems followed by the study of electronic processes in vacuum, gas and solid media, diodes and diode circuits, electronic power supplies, amplifier devices and basic amplifier techniques. PREREQUISITE: EE 101D.

EE 242C COMMUNICATION ELECTRONICS I (4-3). The topics studied include linear amplifier analysis and frequency response, untuned power amplifiers, tuned voltage and power amplifiers, frequency multipliers and sine-wave oscillators, with emphasis on frequency-stability consideration. PREREQUISITE: EE 241C.

EE 243C COMMUNICATION ELECTRONICS II (4-3). The topics studied include basic modulation techniques for information transmission, production of AM signals, the AM transmitter, AM detectors, frequency conversion, FM-signal generation and detection, communication receivers, single-sideband systems and multiplex systems. PREREQUISITE: EE 242C.

EE 253A MICROWAVE TUBES (3-2). A study of the theory and operating principles of various microwave tubes, such as traveling-wave tubes, klystrons, plasma devices, crossed-field devices. Topics to be studied will include: formation and control of electron beams, slow-wave structures, interaction between beams and waves, and coupled mode theory. PREREQUISITES: EE 622B, EE 217B.

EE 254B TRANSISTOR AND SOLID STATE DEVICES AND CIRCUITS (3-3). Design and analysis of 2-stage direct-coupled transistor amplifiers—biasing and AC performance; DC amplifiers; wideband amplifiers; tuned IF, RF small signal and power amplifiers: oscillators; FET circuits; Triac devices and circuits for power control: integrated circuits. PREREQUISITE: EE 214C or EE 232C.

EE 256B THEORY OF SEMICONDUCTOR DEVICES (4-0). The application of solid state physics to the analysis and characterization of semiconductor diodes, transistors, and integrated circuits will be studied. Attention will be given to the relationship between the internal physical processes in these devices and their responses to large, high-frequency and transient signals. PREREQUISITES: EE 215C and PH 705B.

EE 261B NONLINEAR MAGNETIC DEVICES (3-3). An introduction to the use of the saturable reactors as a nonlinear circuit element. Pulse, storage, counting circuits as used in data processing and digital computer technology, as well as power modulation applications are considered. Piecewise linear analysis techniques are used to develop the theory of magnetic amplifiers. The transfer function of the amplifier with and without feedback is derived. PREREQUISITES: EE 113B and EE 212C or EE 232C.

EE 271C ELECTRONIC DEVICES AND CIRCUITS I (4-2). The topics include DC and AC circuit theory, introductory principles of electronic devices and circuits, physical processes in vacuum, gaseous and semiconductor and tube devices. PREREQUISITES: Basic calculus and physics.

EE 272C ELECTRONIC DEVICES AND CIRCUITS II (4-2). The study of electronic circuits. Included topics are electronic devices as circuit elements, analysis of linear amplifiers, large-signal amplifiers and basic applications of electronic circuits. PREREQUISITE: EE 271C.

EE 281C GENERAL ELECTRONICS (4-2). A one-term survey course, for non-electrical engineering curricula, with emphasis on the general operational characteristics of representative electronic devices. Topics included are: physical processes in common devices; current-voltage relations of diodes and active devices; basic electronic circuits. PREREQUISITE: EE 112C or EE 107C.

EE 291C ELECTRONICS I (NUCLEAR) (3-3). This is the first of two courses designed to give the Nuclear Engineering student an appreciation of electronic equipment used in this science. Topics are: Steady state circuit analysis, transient concepts, and the basic theory of vacuum and semiconductor diodes, control type tubes, and transistors. PREREQUISITES: Mathematics through calculus.

EE 292C ELECTRONICS II (NUCLEAR) (3-3). This course considers vacuum tube and transistor circuits, such as power supplies, voltage amplifiers, feedback circuits, pulse amplifiers, and pulse shaping circuits. Basic concepts are then applied to a variety of special circuits, including: integral and differential discriminators; coincidence and anti-coincidence circuits, count-rate meters, and scalers. PREREQUISITE: EE 291C.

EE 301D ELECTROMAGNETIC MACHINES (3-2). The fundamentals and applications of electric machinery. Topics include the characteristics of DC machines, induction and synchronous AC machines and parallel operation of generators. PREREQUISITE: EE 101D.

EE 311C ELECTRIC MACHINERY I (3-4). The principles common to translational and rotational electromechanical energy conversion devices are presented. The general approach to the analysis of rotating electric machines is utilized to obtain the characteristics in the dynamic and steady state modes. Transfer functions of control type machines are obtained. PREREQUISITES: EE 113B and EE 131C or equivalent.

EE 312C ELECTRIC MACHINERY II (3-4). This is a continuation of EE 311C. The rotating machines studied are DC motors, generators and control machines and AC induction and synchronous motors and generators including the single-, two-phase and polyphase induction motors. PREREQUISITE: EE 311C.

EE 315B MARINE ELECTRICAL DESIGN I (2-4). The first of two courses concerned with the analysis of shipboard electric power systems and the design of machinery. The design of a transformer, DC machine or AC machine is carried through by use of the digital computer. The study of distribution systems and their protection is started. PREREQUISITE: EE 312C.

EE 316A MARINE ELECTRICAL DESIGN II (2-4). This is a continuation of EE 315B. The design project is carried through to completion. The study of the protection of distribution systems is continued with fault analysis and selection of circuit breakers. A computer study is made of a static excitation and voltage regulator system. PREREQUISITE: EE 315B.

EE 321C ELECTROMECHANICAL DEVICES (3-4). The basic theory and operating characteristics of control machines under steady state and transient conditions is presented. Transformers, synchros, induction motors, DC motors and generators and rotary amplifiers are covered in sufficient detail, including the derivation of transfer functions, to develop the concepts required in control systems analysis. PREREQUISITE: EE 113B or the equivalent.

EE 331C ELECTRIC MACHINERY (3-4). This course is intended for use in the Mechanical Engineering Curriculum. Basic electromechanical energy conversion principles are covered in sufficient depth to provide understanding of the electric machines characteristics. AC and DC motors and generators are covered with emphasis on the steady state performance. Applications are presented as time permits. PREREQUISITE: EE 112C or EE 107C or the equivalent.

EE 411B FEEDBACK CONTROL SYSTEMS I (3-3). The mathematical theory of linear feedback control systems is considered. Topics include: writing system equations; relationship between time and frequency domain characteristics; analysis using root locus concepts and using polar and logarithmic plots; formulation of the state space equations; stability using Nyquist's criterion, Routh's criterion, and root locus; performance criteria and sensitivity. Laboratory work includes simulation of control systems on the analog computer, and testing and evaluation of physical systems. PREREQUISITES: EE 113B, EE 321C, EE 212C or EE 232C, EE 811 or MA 421 or equivalent.

EE 412A FEEDBACK CONTROL SYSTEMS II (3-4). Elements of design of control systems are considered, using both frequency response and s-plane methods. The fundamental methods of analysis of nonlinear control systems are presented. The phase plane and describing function methods are studied. The relay servo is introduced. PREREQUISITE: EE 411B.

EE 413A SAMPLED DATA CONTROL SYSTEMS (2-2). A study of the response of control systems to discontinuous information. The basic theory of sampling, quantizing and data reconstruction is studied. The Z-transformation and the z-plane are presented. State space methods are used. The system transient performance and the design of compensation are studied. PREREQUISITE: EE 411B.

EE 414A STATISTICAL DESIGN OF CONTROL SYSTEMS (2-2). Statistical concepts and random signals are studied. Problems in optimal estimation (filtering), prediction identification and control are developed. PREREQUISITE: EE 411B.

EE 415A LINEAR CONTROL SYSTEM SYNTHESIS (3-0). The synthesis of linear control systems is studied. Performance criteria, advanced root locus methods and Mitrovic's method are presented. The analysis and synthesis of multiloop systems are studied, using determinantal and signal flow methods. PREREQUISITE: EE 411B.

EE 416A NON-LINEAR CONTROL SYSTEMS (3-1). Phase space and state-space concepts are studied. Quasi-optimum, dual-mode and relay-control systems are presented. Optimum control methods are presented. Lyapunov's method is studied. PREREQUISITE: EE 412A.

EE 417A MODERN CONTROL THEORY (3-1). Topics are chosen from the following: the calculus of variations applied to the optimal control problems; Pontryagin's Maximum principle; dynamic programming; self-adaptive systems. Additional topics of current interest may also be included. PREREQUISITE: EE 411B.

EE 419B NONLINEAR AND SAMPLED SYSTEMS (3-4). Phase plane methods, relay control systems, and sampled data systems are studied. Laboratory work includes analog and digital simulation, analysis of a relay servomechanism, and application of digital control to a system. PREREQUISITE: EE 411B.

EE 422B MODERN COMMUNICATIONS (3-3). A study of modern communications trends, with emphasis on theoretical study of current and proposed systems. The topics covered include multiplex systems, coding, and pseudo-random noise modulation systems. PREREQUISITE: EE 116B or EE 571A.

EE 431C INTRODUCTION TO RADAR (3-3). A one-term course designed for students not majoring in electronics. The course includes a study of search, fire-control, and radar-guidance systems with particular emphasis on pulse, FM, doppler, and mono-pulse systems. PREREQUISITES: EE 234C and EE 612C.

EE 432B PULSE RADAR (3-3). The basic special circuits used in pulse radar are discussed and integrated into a complete radar system. These circuits include pulse modulators, display systems, transmitter characteristics (magnetron and oscillator-amplifier arrangements), duplexing systems, receiver (r-f amplifier characteristics, mixers, afc, i-f amplifier-filters). Delay-line MTI, automatic tracking radars, and the basic radar range equation are discussed briefly. PREREQUISITES: EE 116B, EE 216C and EE 612C.

EE 433A RADAR SYSTEMS (4-2). The radar range equation is extended to include probability concepts, cross-section fluctuations, and signal integration. Pulse compression techniques, CW and pulse doppler techniques, doppler navigation, and problems of obtaining MTI operation from a moving platform are discussed. Advanced antenna concepts including the multiple-element steerable array, Luneburg-lens systems, and single-horn monopulse antennas are developed. PREREQUISITES: EE 622B, PS 321B, Secret Clearance.

EE 451A SONAR SYSTEMS ENGINEERING (4-3). A study of the theory and engineering practices of active and passive sonar systems. Emphasis is placed on the new developments in modern underwater sound systems including communications, instrumentation, and the tactical use of these systems. PREREQUISITE: Ph 432A, Secret Clearance.

EE 455B SONAR SYSTEMS (3-3). A study of sonar theory including the active and passive systems, transducers, and characteristics of the transmission medium. PREREQUISITES: Ph 450B and EE 214C, Secret Clearance.

EE 461A SYSTEMS ENGINEERING (3-2). An introduction to the engineering of large scale systems. The primary aim of this course is to increase the student's awareness of the complex interactions of various disciplines and the main recurring problems in systems engineering. Examples from large scale military weapons systems will be studied. PREREQUISITE: EE 571A.

EE 462A AUTOMATION AND SYSTEM CONTROL (3-3). A study of basic techniques and problems encountered in large computer-centered information and control systems. Typical functional requirements for tactical data systems. Analysis of data input functions, data processing functions and data utilization functions. Laboratory work is devoted to solution of problems arising from the integration of electronic computers and radar displays. Interaction between engineering design, programming and system analysis is stressed. PREREQUISITES: EE 811C, EE 433A and Ma 116B or equivalent.

EE 471B GUIDANCE AND NAVIGATION (3-0). A study of the principles underlying systems of guidance and navigation. The principal topics are: radio, radar, infra-red inertial and celestial techniques. PREREQUISITES: PH 105C, EE 214C, and EE 411B.

EE 473A MISSILE GUIDANCE SYSTEMS (3-0). Fundamentals of missile guidance systems: radio, radar, infra-red, inertial and celestial techniques. PREREQUISITES: EE 411B, EE 433A and PH 152B.

EE 481B ELECTRONIC COUNTERMEASURES (3-3). A study of radio-frequency radiation, and the characteristics of devices used for detecting and interfering with these radiations. The course includes active and passive systems, spectrum analyzers, noise problems, antennas, direction-finding systems, frequency scanning and memory systems, and data processing and display. PREREQUISITES: Secret Clearance, EE 116B and EE 214C.

EE 491B NUCLEAR REACTOR INSTRUMENTATION AND CONTROL (3-3). The basic principles and methods of nuclear reactor control are presented. The treatment of the elementary reactor with temperature and poisoning feedback is given using linear feedback control system analysis. The requirements for stable operation and accuracy of automatic neutron flux control are analyzed and demonstrated, using a reactor kinetics simulator. PREREQUISITE: EE 498B or equivalent.

EE 492A NUCLEAR REACTOR POWER PLANT CONTROL (3-4). The elementary thermodynamics of the plant control loop is established and the transfer functions obtained. The dynamic performance of the basic plant is analyzed under various load conditions. Automatic plant control stability and performance using external reactor control systems are investigated. PREREQUISITE: EE 491B.

EE 498B DYNAMICS OF LINEAR SYSTEMS (3-4). This course is intended for non-EE majors. The differential equations of some typical physical systems will be derived. and Laplace transform and pole-zero concepts will be used for their solution. Both time and frequency domains will be covered. The transfer function concept will he introduced, and the discussion will be extended to feedback systems. PREREQUISITE: EE 107C or EE 112C.

EE 541A SIGNAL PROCESSING (4-0). Applications of statistical decision theory to the detection of signals in noise. Ambiguity diagrams for signals and also transducer arrays. Signal processing in detection and tracking systems. PREREQUISITES: EE 411B, EE 571A, and EE 811C.

EE 542A ADVANCED SIGNAL PROCESSING (3-0). Provides an opportunity for directed study and/or creative development of signal processing techniques according to the needs of the group. Emphasis will be placed on radar, sonar, and aerospace tracking and communications applications. PREREQUISITES: EE 541A or graduate standing and consent of the instructor.

EE 551A INFORMATION NETWORKS (3-2). Adaptations of symbolic logic for the analysis of binary information networks using relay, vacuum tubes, transistors, or magnetic cores. Abstract models for switching networks. Combinational and sequential circuits. Logical design of arithmetic and control elements. Dynamic simulation. Transfer function synthesis. Frequency domain treatment of analog and digital computer programs. PREREQUISITES EE 113B, and EE 212C or EE 232C, and EE 812B.

EE 571A STATISTICAL COMMUNICATION THEORY (3-2). This course is a more advanced sequel to EE 114B than EE 116B. It includes a study of noise sources and a mathematical treatment of noise and random signals hased on statistical methods. Transmission of such signals through linear and non-linear networks is analyzed. Statistical decision theory applications to signal detection and interpretation are illustrated by selected problems. PREREQUISITES: EE 114B and PS 321B.

EE 581A INFORMATION THEORY (4-0). Concepts of information measure for discrete and continuous signals. Fundamental theorems relating to channel capacity and coding; coding methods. Effects of noise on information transmission. Selected applications of the theory to systems. PREREQUISITE: EE 571A.

EE 611C ELECTROMAGNETIC FIELDS (4-0). An introduction to electromagnetic field theory. Following a review of static electric and magnetic fields, Maxwell's equations are presented for time-varying fields. Additional topics are skin effect, plane wave propagation, and reflection of waves. PREREQUISITE: EE 112C or EE 107C.

EE 612C TRANSMISSION OF ELECTROMAGNETIC ENERGY (3-2). A study of radio-frequency transmission lines, waveguides, and related components. Classical transmission line theory is developed and applied to practical prohlems. The principles of rectangular and cylindrical waveguides, cavity resonators, and various microwave devices are covered. PREREQUISITES: EE 611C and EE 113B.

EE 621B ELECTROMAGNETICS I (3-2). Classical transmission line theory is developed and illustrated in laboratory exercises. The theory of static electric and magnetic fields is presented, and solutions of boundary value problems are obtained by means of scalar and vector potentials. PREREQUISITES: Ma 113B and EE 112C or EE 107C.

EE 622B ELECTROMAGNETICS II (4-0). The time-varying Maxwell equations and general boundary conditions are presented. Solutions to the wave equation in unbounded regions are studied. Maxwell's equations are applied to systems of guided waves and cavity resonators. PREREQUISITES: EE 621B and EE 113B.

EE 623A ADVANCED ELECTROMAGNETIC THEORY (3-0). Solution of boundary value problems using series solutions, transform theory, and variational techniques. Some of the topics include the dalembertian, generalized circuit theory, driving point impedance of antennas, non-uniform transmission line, and propagation within a homogenous anisotropic medium. PREREQUISITE: EE 622B.

EE 631B ANTENNA ENGINEERING (3-3). This course is intended to make the student familiar with the more common types of antennas and feed systems. The attack is essentially an engineering approach, applying to practical systems the mathematics and field theory presented in earlier courses. The laboratory is directed to the measurement of field intensities, antenna patterns, input impedance and feed systems. PREREQUISITE: EE 612C or EE 622B.

EE 652A MICROWAVE CIRCUITS AND MEASUREMENTS (3-2). A study of microwave components as circuit elements. Topics to he studied will include: waveguides as transmission lines, waveguide impedance concepts, matrix formulation for obstacles in waveguides, and resonant cavities as microwave circuit elements. PREREQUISITE: EE 622B.

EE 671B THEORY OF PROPAGATION (4-0). Properties of the atmosphere and its effect on the propagation of surface, space, and sky waves. Additional topics include: coverage prediction, frequency selection, noise, and tropospheric and ionospheric scatter. PREREQUISITE: EE 612C or EE 622B.

EE 711C ELECTRICAL MEASUREMENTS (2-3). An introduction to the measurement of the fundamental quantities; current, voltage, capacitance, inductance and magnetic properties of materials. Alternating current bridges, their components and accessories; measurement of circuit components at various frequencies; theory of errors and treatment of data. PREREQUISITE: EE 112C.

EE 731C ELECTRONIC MEASUREMENTS (3-4). A study of the theory and techniques of electronic measurement of voltage, current, power, impedance, phase and frequency. Accuracy and precision are stressed. Laboratory work stresses fundamental character of measurement principles and techniques. PREREQUISITE: EE 212C.

EE 811C INTRODUCTION TO DIGITAL COMPUTERS (3-3). Logical organization of general-purpose, stored-program, digital machines. Number systems. Order codes. Procedure flow charting. Assembly language programming of basic machine processes. Subroutines, linkage, and loaders. The FORTRAN compiler language. Practical programming technique, organization, and checkout methods. Elements of error analysis and numerical methods. Selected applications in engineering and tactical data processing. PREREQUISITES: EE 112C or EE 107C, and Ordinary Differential Equations.

EE 812B LOGICAL DESIGN AND CIRCUITRY (4-0). Introduction to Boolean algebra. Symbolic logic and the analysis of basic logical circuits; qualitative description of basic electronic and semiconductor devices; construction of computer circuits using tubes, transistors, etc. Models for switching networks, synthesis of combinational and sequential switching circuits. Logical design of arithmetic and control elements. Memory devices, conventional and exotic. Machine-aided logical design. PREREQUISITE: EE 811C.

EE 821B COMPUTER SYSTEMS TECHNOLOGY (3-3). A course, primarily for the student not specializing in data processing, in the fundamental methods, concepts, and techniques underlying modern naval computer-oriented systems, such as NTDS and the OPCONCEN. Formulation of operational requirements. Evaluation of engineering techniques. Programming methods for large-scale command-control systems. Differing requirements of tactical versus strategic problems. The laboratory work provides the opportunity for the student to gain familiarity with methods for implementing user and command functions in a typical system environment. PREREQUISITE: EE 811C.

EE 911A INFORMATION PROCESSING SEMINAR (0-2). Discussion and reports on related topics of current interest in the field of information processing. PREREQUISITE: EE 462A or EE 551A.

EE 921A SPECIAL TOPICS IN CONTROL THEORY (0-2). An analysis of current developments in control systems, as disclosed by papers in current technical journals. PREREQUISITE: EE 412A.

EE 951E THESIS SEMINAR (0-1). In these seminar sessions, advanced students will present papers on their thesis work, which will then be discussed by other students and faculty. Some topics may be presented by faculty members.

DEPARTMENT OF GOVERNMENT AND HUMANITIES

EMMETT FRANCIS O'NEIL, Professor of Government and Humanities; Chairman (1958)*; A.B., Harvard Univ., 1931; M.A., Univ. of Michigan, 1932; Ph.D., 1941.

KENNETH LEE ABERNATHY, Lieutenant Commander, U.S. Navy; Assistant Professor of Military Law; B.A., Washington and Lee Univ., 1955; LL.B., Yale Univ., 1958.

LOFTUR L. BJARNASON, Professor of Literature (1958)*; A.B., Univ. of Utah, 1934; M.A., 1936; A.M., Harvard Univ., 1939; Ph.D., Stanford Univ., 1951.

WILLIAM CLAYTON BOGGESS, Associate Professor of Speech (1956); B.S., Univ. of Southern California, 1953; M.S., 1954.

RUSSELL BRANSON BOMBERGER, Associate Professor of English (1958); B.S., Temple Univ., 1955; M.A., Univ. of Iowa, 1956; M.S., Univ. of Southern California, 1960; M.A., Univ. of Iowa, 1961; Ph.D., 1962.

LLOYD WILLIAM GARRISON, Commander, U.S. Navy; Assistant Professor of Political Science; B.A., Santa Barbara State College, 1941; M.A., Univ. of Hawaii, 1965.

BOYD FRANCIS HUFF, Professor of Government and History (1958); B.A., Univ. of Washington, 1938; M.A., Brown Univ., 1941; Ph.D., Univ. of California, 1955.

ROBERT LEONARD JACOBS, Ensign, U.S. Naval Reserve; Instructor in Political Science; A.B., North Texas State Univ., 1962; M.A., Pennsylvania State Univ., 1964.

RICHARD MICHAEL LINDENAUER, Lieutenant, U.S. Naval Reserve; Instructor in Political Science; B.A., Stanford Univ., 1962; M.A., 1963.

RICHARD VARLY MONTAG, Lieutenant Commander, U.S. Naval Reserve; Associate Professor of Political Science; A.B., College of St. Charles Borromeo, 1949; M.A., Ohio State Univ., 1952.

ARNOLD BRIAN MYERS, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor in English; B.A., Utica College of Syracuse Univ., 1961; M.A., Duke Univ., 1963.

CARL ERNEST POHLHAMMER, Lieutenant, U.S. Naval Reserve; Assistant Professor of History; B.A., San Jose State, 1954; M.A., Univ. of California, 1957.

BURTON MACLYNN SMITH, Associate Professor of Speech (1955); B.A., Univ. of Wisconsin, 1936; M.A., 1937.

*The year of joining the Postgraduate faculty is indicated in parenthesis.

DEPARTMENTAL REQUIREMENTS FOR BACHELOR OF ARTS DEGREE WITH MAJOR IN POLITICAL SCIENCE (INTERNATIONAL RELATIONS)

1. The following courses, while not part of the major proper, supply foundation and background for many of the upper-division courses that constitute the major. As soon as permitted by the schedule of the B.A. Program, candidates for the departmental major are required to complete:

Course	*Term Hours*
United States Government	4
United States History	8
Introduction to Economics	4
	16

2. The major in Political Science (International Relations) consists of a specified core of uppper-division courses, plus an election of at least one upper-division course in each of three sub-disciplines or "Groups."

a. The specified core to be taken by all students pursuing the major:

Course	*Term Hours*
International Relations	4
Strategy for National Security	4
Principles of International Law	4
Development of Western Political Thought	4
International Communism	4
American Traditions and Ideals	3
European History, 1871-1919	4
European History, 1919 to present	4
Institutions and Practices of International Economics	4
	35

b. All students pursuing the major will also elect at least one course from each of the following groups:

GROUP I — AMERICAN GOVERNMENT

Course	*Term Hours*
American Diplomacy	4
American Parties and Politics	4
Institutional Processes of U.S. Government	4
American Constitutional Development	4
American Political Thought	4

GROUP II — WESTERN COMPARATIVE GOVERNMENT AND FOREIGN POLICIES

Course	*Term Hours*
Latin America	4
Atlantic Community	4
Africa South of the Sahara	4
Government and Politics of the Soviet Bloc	4

GROUP III — EASTERN COMPARATIVE GOVERNMENT AND FOREIGN POLICIES

Course	*Term Hours*
Government and Politics of Major Asian States	4
Government and Politics of Southeast Asia	4
The Middle East	4
The Government and Politics of the Chinese Bloc	4

c. The total hours of course work in the major is 47. It can be less if required courses, specified or elective. were taken before their credits were raised from three to four hours.

3. A candidate for the degree of Bachelor of Arts with Major in Political Science (International Relations) must also satisfy the general requirements for the degree of Bachelor of Arts as determined by the Academic Council. Many of the courses required for this major are included in the B.A. curriculum. The foregoing requirements should be used by the student planning the remainder of his B.A. program.

ENGLISH

EN 101C ADVANCED WRITING FOR NAVAL OFFICERS (3-2). Extensive practice in development of effective writing techniques and individual writing style; study of language with emphasis on its usage and application to effective writing; practice in criticism of writing examples: especially adapted to the educational needs of naval officers. PREREQUISITE: Freshman English or permission of Chairman of Department.

EN 102C REASONING AND RESEARCH REPORTING (4-0). A study of the principles of inductive and deductive logic as they are applied in the preparation of research reports.

EN 103C SEMINAR IN RESEARCH TECHNIQUES (1-0). A study of the principles and techniques of research writing.

EN 104C TECHNICAL WRITING (2-1). A study of principles and practices of research writing in science and technology, applied to the preparation of abstracts of scientific papers, laboratory reports, and theses in the technical curricula.

EN 105C THESIS WRITING (2-0). A study of principles and practices of research writing applied to the preparation and analysis of theses and reports in the Management Curricula.

EN 120C THE ENGLISH LANGUAGE (3-0). Lectures and exercises on the English language: its history, vocabulary, and usage.

GEOGRAPHY

GY 101C POLITICAL GEOGRAPHY (4-0). A study of world areas, regions, and countries, with emphasis on the location and political significance of terrain features.

GOVERNMENT

GV 010D U.S. GOVERNMENT (4-0). A study of American political institutions and processes, the principles of U.S. Constitutional Government, and the U.S. political system (parties, interest groups, elections, and voting behavior) with special emphasis on current issues and problems.

GV 012D AMERICAN LIFE AND INSTITUTIONS I (2-0). A study of American political institutions and political, social and economic aspects of American life. Open only to Allied officers.

GV 013D AMERICAN LIFE AND INSTITUTIONS II (2-0). A continuation of GV 012D.

GV 102C INTERNATIONAL RELATIONS (4-0). An analytical study of the basic concepts, factors and problems of international politics focused on the nature and power of the modern sovereign state and its political and economic modes of acting in its relations with other states. (Military factors in relation to foreign policy are studied in the related course GV 103C.)

GV 103C STRATEGY FOR NATIONAL SECURITY (4-0). An extension of the study of international politics special emphasis on the study of international conflict and the U.S. organization for conflict management. The course includes a study of strategy: the nature of war; the requirements of military security: and the U.S. security organization.

GV 104C AMERICAN DIPLOMACY (4-0). An analysis of the major problems of the United States foreign relations in Europe, Latin America, and the Far East from 1900 to the Korean conflict. PREREQUISITES: HI 102 and HI 104.

GV 106C COMPARATIVE GOVERNMENT (4-0). An analytical and comparative study of the form and functioning of the major types of contemporary government with emphasis on the policy-making process. PREREQUISITE: GV 010D.

GV 108C THEORY AND PRINCIPLES OF INTERNATIONAL RELATIONS (4-0). A seminar in the scope and theories of International Relations and techniques of research in the field; the analysis of problems.

GV 110C GOVERNMENT AND POLITICS OF MAJOR ASIAN STATES (4-0). The international, internal, and military problems of the major Asian states, exclusive of Communist China.

GV 111C GOVERNMENT AND POLITICS OF SOUTHEAST ASIA (4-0). The international, internal, and military problems of the southeast Asian states and of Australia and New Zealand.

GV 112C LATIN AMERICA (4-0). A study of contemporary Latin America with emphasis on the problems and objectives of the constituent states, their regional and international relationships.

GV 113C THE ATLANTIC COMMUNITY (4-0). A study of the states in the Atlantic Community; their political, economic, military, ideological, and sociological relations, both regional and international. PREREQUISITE: HI 104.

GV 114C THE MIDDLE EAST (4-0). A study of political, economic, social, cultural and strategic aspects of the contemporary Middle East and its role in international relations.

GV 116C AFRICA SOUTH OF THE SAHARA (4-0). A study of contemporary Africa south of the Sahara with emphasis on emerging political institutions and analysis of major developing economic, social and cultural patterns.

GV 118C GOVERNMENT AND POLITICS OF THE SOVIET BLOC (4-0). An analysis of the contemporary government, economy, military doctrine, and international relations of the Soviet Union and its satellites. PREREQUISITE: HI 104.

GV 119C GOVERNMENT AND POLITICS OF THE CHINESE COMMUNIST BLOC (4-0). An analysis of the government, economy, institutions, military doctrine, and international relations of Communist China and its satellites.

GV 120C MILITARY LAW I (3-0). The principles of Military Law as included in the Uniform Code of Military Justice, the Manual for Courts-Martial and the Manual of the Judge Advocate General. Topics include: jurisdiction; charges and specifications; substantive law: and the law of evidence.

GV 121C MILITARY LAW II (3-0). Procedural aspects of Military Law and relations with civil authorities in legal matters. Topics include: non-judicial punishment; courts of inquiry; investigations; summary and special courts-martial; trial techniques; civil and criminal process. PREREQUISITE: GV 120C.

GV 122C INTERNATIONAL LAW (4-0). A survey of the basic principles of international law with emphasis on jurisdiction and the rules of warfare. Case and problem discussions.

GV 130C AMERICAN PARTY POLITICS (3-2). The nature and function of political parties; origin, development, structure, internal management and control; relation of parties and pressure groups to legislation and administration; analysis of voting behavior and participation in politics. PREREQUISITE: GV 010D.

GV 131C POLICY MAKING PROCESSES OF U.S. GOVERNMENT (3-2). A seminar in the structure and functioning of American political institutions with particular emphasis upon the forces which shape and condition the decision-making processes in Congress, the Executive branch and the Judicial system. PREREQUISITE: GV 010D.

GV 132C AMERICAN CONSTITUTIONAL DEVELOPMENT (4-0). An examination of the United States Constitution and its development through the years as interpreted by Supreme Court decisions and by Congressional and Presidential traditions and practices. Constitutional issues such as federalism, civil-military relations, public v. private interests, and civil rights will be discussed. PREREQUISITE: GV 010D.

GV 140C DEVELOPMENT OF WESTERN POLITICAL THOUGHT (4-0). An historical and analytical study of major Western political thought from Plato to Rousseau with emphasis on the antecedents of modern democratic and totalitarian philosophies. Readings from original sources.

GV 141C AMERICAN TRADITIONS AND IDEALS (3-0). The traditions, ideals and values of our civilization and the role of the military in implementing the image of America in the world. PREREQUISITES: HI 101C or HI 102C, GV 140C.

GV 142C INTERNATIONAL COMMUNISM (4-0). An introductory course in the theory and practice of Communism. Topics include the philosophical background of Marxism; the basic writings of Marx, Lenin, and subsequent revisers; the evolution of ideology in the Soviet Union and Communist China; the origins and nature of the diversity and disagreements among contemporary Communist systems.

GV 143C THE DEVELOPMENT OF AMERICAN POLITICAL THOUGHT (4-0). A study of American political thought from the colonial period to the present. PREREQUISITES: GV 140C, HI 101C, HI 102C.

GV 150C GREAT ISSUES (3-0). Seminar on the issues confronting the United States correlating the knowledge gained in previous courses in order to develop responses to the challenges facing the United States. PREREQUISITE: Permission of Chairman of Department.

GV 199C DIRECTED STUDIES (2-0 to 4-0). Independent study in government in subjects in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department.

GV 640C AVIATION LAW (1-0). A study of Federal and State laws and regulations relating to military aviation, designed especially for the Aviation Safety Officer Program.

HISTORY

HI 101C U.S. HISTORY (1763-1865) (4-0). The development of the Federal Union from the American Revolution to the end of the Civil War.

HI 102C U.S. HISTORY (1865-present) (4-0). The development of the American nation from the reconstruction crisis to the present.

HI 103C EUROPEAN HISTORY (1871-1919) (4-0). The international, internal and military development of the major European states in the period before World War I.

HI 104C EUROPEAN HISTORY (1919-present) (4-0). The international, internal, and military development of the major European states since World War I.

HI 105C THE AGE OF REVOLUTION AND REACTION IN EUROPE (4-0). The impact of revolution on European power relationships, 1789 to 1870.

HI 199C DIRECTED STUDIES (2-0 to 4-0). Independent study in history in subjects in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department.

LITERATURE

LT 010D APPRECIATION OF LITERATURE (3-0). An introduction to the understanding and enjoyment of literature expressing the enduring problems of mankind. Style and structure will be considered as well as content. Some attention will be paid to genres and periods of literature.

LT 101C MASTERPIECES OF AMERICAN LITERATURE (3-0). A study of those ideas which have shaped American cultural life and reflect American thinking. PREREQUISITE: LT 010D.

LT 102C MASTERPIECES OF BRITISH LITERATURE (3-0). A study of the significant ideas of selected British thinkers as they pertain to social and cultural life. PREREQUISITE: LT 010D.

LT 103C MASTERPIECES OF BRITISH LITERATURE (continued) (3-0). PREREQUISITE: LT 010D.
Prerequisites for all literature courses listed below: LT 010D and at least one course in American or British Literature.

LT 104C, 105C MASTERPIECES OF EUROPEAN LITERATURE (3-0, 3-0). A study of the significant ideas of European writers. Plays, novels. short stories, essays, and criticisms will be read and discussed. 104 covers the period from early times to the end of the Renaissance. 105 covers the period from the Renaissance to the present time.

LT 106C, LT 107C, LT 108C MASTERPIECES OF RUSSIAN LITERATURE (3-0, 2-0, 2-0). A study of selected Russian and Soviet writers to demonstrate the role of literature in Russian and Soviet life and culture. 106, a survey of Russian literature from the early period through the 19th century, exclusive of the novel (3-0). 107, a study of the Russian novel of the 19th century (2-0). 108, a study of Soviet literature (2-0).

LT 109C PHILOSOPHICAL TRENDS IN MODERN LITERATURE (3-0). An examination of modern literature expressing social, psychological, and cultural problems in order to show how literature reflects the aspirations and the frustrations of modern man. PREREQUISITE: Permission of Chairman of Department.

LT 110C THE LITERATURE OF NORTHERN EUROPE (2-0). A study of selected writers of Germany, Scandinavia, and the British Isles, with particular reference to the dramatists such as Hauptmann, Ibsen, Strindberg, and Shaw to demonstrate their influence on the social and philosophical thinking of their times.

LT 111C THE AMERICAN NOVEL (2-0). A study of the novel in the United States from Charles Brockden Brown to William Faulkner.

LT 112C THE BRITISH NOVEL (3-0). A study of selected British novels together with consideration of their effects on the political, social and cultural life of the time.

LT 115C SHAKESPEARE (3-0). A study of selected Shakespearean sonnets and dramas.

PSYCHOLOGY

PY 010D INTRODUCTION TO PSYCHOLOGY (4-0). A survey of principles underlying human behavior with emphasis on the application of these principles to human relations and problems of social adjustment.

PY 101C APPLIED PSYCHOLOGY (3-0). A study of group dynamics, rating procedures, criminology, and personality formation and adjustment; individual projects are assigned. PREREQUISITE: PY 010D.

PY 650C PSYCHOLOGY IN ACCIDENT PREVENTION AND INVESTIGATION (4-0). A study of logical and psychological principles and practices useful in developing mental efficiency and emotional strength, designed especially for the Aviation Safety Officer Program.

SPEECH

SP 001D BASIC SPEECH FOR FOREIGN OFFICERS (2-0). Intensive work in preparation and presentation of public speeches. Emphasis on special problems in public speaking for students with limited experience in English. (SP 001 is a prerequisite for SP 010 for foreign officers.)

SP 010D PUBLIC SPEAKING (3-0). Intensive work in preparation and presentation of public speeches. Emphasis on study of methods of platform techniques and principles of oral style.

SP 011D CONFERENCE PROCEDURES (3-0). Theory and practice in group dynamics applied to conferences, emphasizing completed staff work in group problem-solving.

SP 012D SPEECH COMMUNICATION (2-0). A brief course in speech with emphasis on organization and techniques of communication. Offered only in Term V.

SP 101C ADVANCED SPEECH (2-0). A study of techniques for obtaining desired audience responses. Opportunities are offered to speak to community groups. PREREQUISITE: SP 010D.

SP 630C ART OF PRESENTATION (2-0). A study of principles of speaking with visual aids, with practice in preparing presentations. The course is especially designed for the Aviation Safety Officer Program.

DEPARTMENT OF MATERIAL SCIENCE AND CHEMISTRY

Gilbert Ford Kinney, Professor of Chemical Engineering; Chairman (1942)*; A.B., Arkansas College, 1928; M.S., Univ. of Tennessee, 1930; Ph.D., New York Univ., 1935.

Newton Weber Buerger, Professor of Metallurgy (1942); B.S., Massachusetts Institute of Technology, 1933; M.S., 1934; Ph.D., 1939.

Peter McLauchlin Burke, Assistant Professor of Metallurgy (1960); B.S., Stanford Univ., 1956; M.S., 1957.

Carlos Guillermo Cardenas, Lieutenant Junior Grade, U.S. Naval Reserve, Assistant Professor of Chemistry (1965); B.S., Univ. of Texas, 1962; Ph.D., 1965.

John Robert Clark, Professor of Metallurgy (1947); B.S., Union College, 1935; Sc.D., Massachusetts Institute of Technology, 1942.

John Henry Duffin, Associate Professor of Chemical Engineering (1962); B.S., Lehigh Univ., 1940; Ph.D., Univ. of California, 1959.

William Wisner Hawes, Professor of Metallurgy and Chemistry (1952); B.S., ChE., Purdue Univ., 1924; Sc.M., Brown Univ., 1927; Ph.D., 1930.

Carl Adolf Hering, Professor of Chemical Engineering (1946); B.S., Oregon State College, 1941; M.S., Cornell Univ., 1944.

Benjamin Joseph Lazan, Visiting Professor of Materials Science (1966); B.S., Rutgers, 1938; M.S., Harvard, 1939; Ph.D., Pennsylvania State Univ., 1942.

Joseph Marin, Visiting Professor of Materials Science (1965); B.Sc., Univ. of British Columbia, 1928; M.S., Univ. of Illinois, 1930; Ph.D., Univ. of Michigan, 1935.

George Daniel Marshall, Jr., Professor of Metallurgy (1946); B.S., Yale Univ., 1930; M.S., 1932.

George Harold McFarlin, Professor of Chemistry (1948); B.A., Indiana Univ., 1925; M.A., 1926.

Richard Alan Reinhardt, Associate Professor of Chemistry (1954); B.S., Univ. of California, 1943; Ph.D., 1947.

Melvin Ferguson Reynolds, Professor of Chemistry (1946); B.S., Franklin and Marshall College, 1932; M.S., New York Univ., 1935; Ph.D., 1937.

Charles Frederick Rowell, Assistant Professor of Chemistry (1962); B.S., Syracuse Univ., 1956; M.S., Iowa State Univ., 1959; Ph.D., Oregon State Univ., 1964.

John Wilfred Schultz, Associate Professor of Chemistry (1958); B.S., Oregon State College, 1953; Ph.D., Brown Univ., 1957.

James Edward Sinclair, Associate Professor of Chemistry (1946); B.S., Ch.Eng., Johns Hopkins Univ., 1945; M.S., USNPGS, 1956.

Glenn Howard Spencer, Associate Professor of Chemistry (1962); B.S., Univ. of California, 1953; Ph.D., Univ. of Washington, 1958.

William Marshall Tolles, Assistant Professor of Chemistry (1962); B.A., Univ. of Connecticut, 1958; Ph.D., Univ. of California, 1962.

James Woodrow Wilson, Professor of Chemical Engineering (1949); B.A., Stephen F. Austin State, 1935; B.S. in Ch.E., Univ. of Texas, 1939; M.S. in Ch.E., Texas A.&M. College, 1941.

*The year of joining the Postgraduate School faculty is indicated in parenthesis.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN CHEMISTRY

BACHELOR OF SCIENCE IN CHEMISTRY

1. A specific curriculum should be consistent with the general minimum requirements for a Bachelor of Science degree as determined by the Academic Council.

2. A major in chemistry should include a minimum of 54 term hours in chemistry (of which 11 term hours are elective), 21 term hours of physics (through general and modern physics), 18 term hours of mathematics (through calculus), and 15 term hours of elective upper division courses in engineering, mathematics, or science (including chemistry). At least 108 of the term hours must be of upper division level.

3. The following specific requirements must be met. Courses marked with an asterisk must include laboratory work.

Discipline	*Subject*	*Approximate Term Hours*
Chemistry	General*	8
	Inorganic*	5
	Analytical*	4
	Organic*	12
	Physical*	14
		—
		43
Physics	General*	16
	Modern (Atomic)	5
		—
		21
Mathematics	College Algebra and Trigonometry	5
	Analytical Geometry and Calculus	13
		—
		18

4. The 11 elective term hours in chemistry must be fulfilled by taking at least upper division courses in chemistry or chemical engineering.

5. In addition to the general requirement of an overall 1.0 grade point average, an overall chemistry grade point average of 1.0 is required.

MASTER OF SCIENCE IN CHEMISTRY

1. To obtain the degree, Master of Science in Chemistry, the student must have completed work equivalent to the

following: Two terms of General Chemistry, one term of Intermediate Inorganic Chemistry or Inorganic Qualitative Analysis, one term of Quantitative or Instrumental Analysis, one term of Thermodynamics, two terms of Physical Chemistry, three terms of Organic Chemistry, one term of Elementary Differential Equations and four terms of Physics.

2. In addition the student must successfully complete the following:

a. One course at the A level in each of the following areas: Chemical Thermodynamics, Inorganic Chemistry, Physical-Organic Chemistry, and Quantum Chemistry. Minimum Total term hours — 12.

b. Two or more courses at the A level in the general area chosen for specialization. These courses must have a total of not less than six term hours of lecture and must be approved by the Department of Material Science and Chemistry. Minimum Total term hours — 6.

c. A thesis demonstrating ability to perform independent and original work.

d. Sufficient supporting courses in science, mathematics and engineering to meet school requirements.

MASTER OF SCIENCE IN MATERIALS SCIENCE

1. The following is a statement of department minimum requirements for the degree of Master of Science in Materials Science. It is noted that the candidates for this degree must also satisfy the general degree requirements determined by the Academic Council. A candidate shall previously have satisfied the requirements for a Bachelor's degree with a major in science or engineering. Credit requirements in succeeding paragraphs must be met by courses in addition to those used to satisfy this requirement.

2. A minimum credit of 20 term hours in A level courses in Materials Science is required. These shall include at least one course each in the areas of metals, of ceramics, and of plastics. A minimum of 12 term hours of graduate credit must be earned outside the major department. A total of at least 24 term hours of A level courses must be included in the program.

3. Completion of a thesis and its acceptance by the department are required. A maximum of eight term hours of graduate credit may be allowed towards satisfaction of the School requirement for 48 term hours, but the thesis credit may not be used to satisfy the requirements of paragraph 2.

4. Any program leading to award of this degree must be approved by the Department of Material Science and Chemistry at least three terms before completion. In general, approved programs will require more than minimum degree requirements in order to conform to the needs and objectives of the United States Navy.

CHEMISTRY AND CHEMICAL ENGINEERING

CH 001D INTRODUCTORY GENERAL CHEMISTRY I (4-3). The first term of a two-term course in elementary chemistry for students who have not had college chemistry. A study of the principles which govern the physical and chemical behavior of matter with sufficient descriptive chemistry to illustrate these principles. Laboratory experiments will be related to the lecture material. TEXTS: Sienko and Plane, *Chemistry;* Ritter, *An Introductory Laboratory Course in Chemistry.*

CH 002D INTRODUCTORY GENERAL CHEMISTRY II (3-3). The second term of the sequence described under CH 001D. Particular emphasis on the properties of compounds as related to the periodic table is used to organize the study. PREREQUISITE: CH 001D.

CH 103C GENERAL CHEMISTRY (4-2). A survey of the principles governing the chemical behavior of matter. Descriptive chemistry is limited almost entirely to the compounds of carbon on the assumption that students will have had college chemistry. TEXT: Pauling, *General Chemistry.* PREREQUISITE: College Chemistry.

CH 105C AEROMATERIALS (3-2). Review of selected principles in inorganic, organic and physical chemistry and their application to problems in aero materials. TEXT: Popovich and Hering, *Fuels and Lubricants.* PREREQUISITE: None.

CH 106C PRINCIPLES OF CHEMISTRY I (3-2). The first course of a two-term sequence. A study of the fundamental principles of chemistry governing the physical and chemical behavior of matter. Current theories of atomic structure and chemical bonding are particularly emphasized. Also studied are the states of matter, chemical kinetics, and chemical equilibria. Elementary physical chemistry experiments are performed in the laboratory. TEXT: Mahan, *University Chemistry.* PREREQUISITE: College Chemistry.

CH 107C PRINCIPLES OF CHEMISTRY II (3-2). A continuation of CH 106D. The principles of chemistry are applied to the study of the chemical properties of the elements and their compounds. Special attention is given to the compounds of carbon. Laboratory experiments are used to illustrate the chemical behavior of matter. TEXT: Mahan, *University Chemistry.* PREREQUISITE: CH 106C.

CH 108C INORGANIC CHEMISTRY (3-4). An intensive treatment at an intermediate level of the chemistry of the common ions in aqueous solution. The course will supplement general chemistry and will emphasize facility in the use of equilibria, kinetics, and structure in correlating the chemistry of the more familiar elements. TEXTS: Clifford, *Inorganic Chemistry oj Qualitative Analysis;* King, *Qualitative Analysis and Electrolytic Solutions.* PREREQUISITE: CH 107C.

CH 109C GENERAL AND ORGANIC CHEMISTRY (3-2). This course providese a continuation of the chemical principles begun in CH 106C and also provides the minimal coverage of organic chemistry for students who will take courses in biology. TEXTS: Sienko and Plane, *Chemistry;* Hart and Schuetz, *A Short Course in Organic Chemistry.* PREREQUISITE: CH 106C.

CH 112A FUELS, COMBUSTION, HIGH TEMPERATURE THERMODYNAMICS (3-2). A brief survey of the organic and physical chemistry necessary for a study of the problems associated with fuels. The nature of conventional fuels and of high-energy fuels, their limitations, and possible future development. Also methods of reaction rate control. TEXTS: Popovich and Hering, *Fuels and Lubricants*, and Penner, *Chemical Problems in Jet Propulsion.* PREREQUISITES: Physical Chemistry and Thermodynamics.

CH 150A INORGANIC CHEMISTRY, ADVANCED (4-3). Applications of thermodynamics, chemical kinetics, and reaction mechanisms to inorganic systems. Structures of inorganic species. Aqueous solution chemistry of selected elements. A systematic approach to the chemistry of the halogens is studied in the laboratory. TEXT: Cotton and Wilkinson, *Advanced Inorganic Chemistry.* PREREQUISITES: CH 108C; CH 231C; CH 444B (may be taken concurrently).

CH 231C QUANTITATIVE ANALYSIS (2-4). A study of the principles and calculations of quantitative analysis, accompanied by typical volumetric and gravimetric determinations in the laboratory. TEXT: Pierce and Haenisch, *Quantitative Analysis.* PREREQUISITE: CH 107C.

CH 311C ORGANIC CHEMISTRY I (3-2). The first term of a three-term study of the chemistry of organic compounds with appropriate laboratory supplementation. TEXT: Cram and Hammond, *Organic Chemistry.* PREREQUISITE: CH 107C.

CH 312C ORGANIC CHEMISTRY II (3-2). A continuation of CH 311C. The study of organic chemistry is pursued further with the emphasis in the laboratory on synthetic techniques. TEXT: Cram and Hammond, *Organic Chemistry.* PREREQUISITE: CH 311C.

CH 313B ORGANIC CHEMISTRY III (3-2). The final term in a three-term sequence. The discussion of organic chemistry is extended to the areas of current advances in both organic and biochemistry as applications of the material in the two earlier terms. PREREQUISITE: CH 312C or the permission of the instructor.

CH 320A ADVANCED ORGANIC CHEMISTRY I (3-2). First of a two-term sequence in which modern synthetic techniques are discussed and the application of kinetic and steric control considered. PREREQUISITE: CH 313B.

CH 323A THE CHEMISTRY OF HIGH POLYMERS (3-0). A treatment of the principal classes of natural and synthetic high polymers, including preparation, structure, and properties. TEXT: Golding, *Polymers and Resins.* PREREQUISITE: CH 313B.

CH 324A QUALITATIVE ORGANIC CHEMISTRY (2-4). Identification of organic compounds on the basis of physical properties, solubility, classification reactions, and the preparation of derivatives. TEXT: Shriner, Fuson and Curtin, *Identification of Organic Compounds.* PREREQUISITE: CH 313B.

CH 327A NATURAL PRODUCTS (4-0). A limited introduction to the chemistry of steroids, terpenes, and alkaloids, with emphasis on the role of stereochemistry in the physiological and chemical properties of these systems. TEXT: Fieser and Fieser, *Steroids.* PREREQUISITE: CH 313B.

CH 328A PHYSICAL ORGANIC CHEMISTRY I (4-0). First term of a two-term sequence. In this term the tools available for the study of organic mechanisms are discussed and appropriate examples used. PREREQUISITE: CH 313B.

CH 329A PHYSICAL ORGANIC CHEMISTRY II (3-0). The techniques discussed in CH 328A are used in the study of organic reaction mechanisms as currently understood. PREREQUISITE: CH 328A.

CH 403B CORROSION AND CORROSION PROTECTION (3-2). A course designed to give a knowledge of the chemical and electrochemical mechanism of corrosion and the environmental and stress factors that affect the rate of corrosion. Methods of control such as cathodic protection, alloying, protective coatings, and inhibitors will be considered. TEXT: Uhlig, *Corrosion and Corrosion Control.* PREREQUISITE: General Chemistry.

CH 407B PHYSICAL CHEMISTRY (3-2). A one-term course in physical chemistry for students who have had thermodynamics. Gases, liquids, solids, solutions, thermochemistry, chemical equilibria and kinetics are studied. TEXTS: Cole and Coles, *Physical Principles of Chemistry;* Daniels, et al., *Experimental Physical Chemistry.* PREREQUISITES: CH 107C or CH 103C; and one term of thermodynamics.

CH 433B PHYSICAL CHEMISTRY I (4-3). The first term of a two-term sequence in physical chemistry. The sequence will include such topics as properties of matter, thermochemistry, chemical thermodynamics, chemical equilibria, kinetics, and electrochemistry. TEXTS: Sheehan, *Physical Chemistry;* Daniels, et al., *Experimental Physical Chemistry.* PREREQUISITES: CH 107C, CH 611C.

CH 444B PHYSICAL CHEMISTRY II (3-3). The second term of the sequence begun by CH 443B. PREREQUISITE: CH 443B.

CH 454B INSTRUMENTAL METHODS OF ANALYSIS (3-3). A course designed to familiarize the student with modern instrumental techniques of chemical analysis. Emphasis is given to the theoretical basis of the various kinds of measurements made in the laboratory and the principles involved in the design and construction of analytical instruments. Laboratory experiments will deal with representative analytical problems. TEXT: Willard, Merritt and Dean, *Instrumental Methods of Analysis.* PREREQUISITE: CH 444B.

CH 466A CHEMICAL KINETICS (3-0). Experimental methods and interpretation of data. Mechanisms of reactions. Collision theory and activated-complex theory. TEXT: Frost and Pearson, *Kinetics and Mechanism.* PREREQUISITE: CH 444B.

CH 467A QUANTUM CHEMISTRY I (3-0). A study of the fundamental principles governing the quantum behavior of matter. Topics will include the Heisenberg uncertainty principle, the Pauli exclusion principle, and the use of quantum mechanics in describing the electronic structures of atoms and simple molecular systems. TEXT: Pauling and Wilson, *Introduction to Quantum Mechanics.* PREREQUISITE: CH 444B.

CH 468A QUANTUM CHEMISTRY II (3-0). The application of quantum mechanics to polyatomic molecules. Use will be made of valence-bond and molecular-orbital methods along with group theory in constructing approximate wave functions for describing typical molecular systems. The discussion will extend to current journal articles. PREREQUISITE: CH 467A.

CH 469A QUANTUM CHEMISTRY III (3-0). The application of quantum chemistry to prediction of molecular structure; theoretical and experimental methods. Modern uses of ultraviolet, visible, infrared, microwave, electron paramagnetic resonance, and nuclear magnetic resonance spectra. PREREQUISITE: CH 468A.

CH 470A CHEMICAL THERMODYNAMICS (3-0). Application of thermodynamics to real gases, non-electrolytes, electrolytic solutions, multicomponent solutions. Calculations of equilibria, estimation of thermodynamic quantities and brief discussion of calculations of thermodynamic properties from spectroscopic and other molecular data. TEXT: Lewis and Randall, *Thermodynamics, 2nd Ed.* PREREQUISITES: CH 611C and CH 444B.

CH 480A STATISTICAL MECHANICS I (3-0). A general treatment of the basic principles of quantum and classical statistical mechanics with applications to chemical systems. Topics to be covered: distribution laws and the relationships of Fermi-Dirac, Bose-Einstein, and corrected Boltzmann statistics; statistical entropy and thermodynamic functions for systems of corrected Boltzons; applications to chemical equilibrium, diatomic molecules including ortho and para hydrogen; black-body radiation. TEXT: Davidson. *Statistcial Mechanics.* PREREQUISITE: CH 444B or equivalent.

CH 521A PLASTICS AND HIGH POLYMERS (3-2). A study of the general nature of plastics and high polymers, their application and limitations as engineering materials. Also, correlation between properties and chemical structure. In the laboratory plastics are made, molded, tested and identified. TEXT: Kinney, *Engineering Properties and Applications of Plastics.* PREREQUISITE: CH 103C or CH 107C.

CH 540A NUCLEAR CHEMISTRY I (4-0). An introduction to the reactions of nuclei. Behavior and properties of unstable species. TEXT: Friedlander and Kennedy, *Nuclear and Radiochemistry.* PREREQUISITE: CH 150A.

CH 541A NUCLEAR CHEMISTRY II (3-4). A continuation of CH 540A with emphasis on techniques peculiar to chemical studies of radioactive materials; methods of isolation, purification and analysis of mixtures. TEXT: Friedlander and Kennedy, *Nuclear and Radiochemistry.* PREREQUISITE: CH 540A.

CH 542B REACTION MOTORS (3-2). A study of the fundamentals of Rocket Motors. The subject matter includes the basic mechanics of Jet Propulsion engines, properties of solid and liquid propellants, the design and performance parameters of rocket motors. In the laboratory periods representative problems are solved. TEXT: Sutton, *Propulsion Elements.* PREREQUISITE: CH 611C or consent of instructor.

CH 551A RADIOCHEMISTRY I (2-4). Discussion of important aspects of radioactivity from standpoint of the chemical transformations which accompany it and which it may induce; techniques for measurement and study of ionizing radiation; methods of separation of unstable nuclides, identification and assay. TEXT: Friedlander and Kennedy, *Nuclear and Radiochemistry.* PREREQUISITES: CH 109C or CH 107C; and PH 638B.

CH 554A RADIOCHEMISTRY, ADVANCED (2-3). An advanced course in radiochemical techniques and applications offered to well-qualified students only. Experiments in analysis of complex mixtures of active nuclides; activation analysis. Consent of the instructor required. PREREQUISITE: CH 551A or CH 541A.

CH 571B EXPLOSIVES CHEMISTRY (3-2). Chemical and physical properties of explosives are related to modes of behavior and physical principles of use. Basic principles of testing and evaluation of explosives. Trends in new developments are surveyed. Independent exploratory work in the laboratory in such areas as manner of initiation, sensitivity, brisance, power, heats of explosion and combustion. TEXT: Cook, *Science of High Explosives.* PREREQUISITES: Thermodynamics and Physical Chemistry.

CH 581A PROPERTIES OF CERAMIC MATERIALS (4-0). Occurrence, syntheses and properties of ceramic raw materials. Kinetic and phase equilibrium principles underlying the production of ceramics and glasses. Structure of typical ceramics and glasses. TEXT: Kingery, *Introduction to Ceramics.* PREREQUISITES: Physical Chemistry and Thermodynamics.

CH 591B BLAST AND SHOCK EFFECTS (3-0). Generation of blast and shock waves by explosions, propagation of shock waves in air, scaling laws for explosions, shock and blast loads on structures, damage and damage mechanisms, thermal and ionizing radiation effects, principles of protection against damage. TEXT: Kinney, *Shocks in Air.* PREREQUISITES: Physical Chemistry and Thermodynamics.

CH 600C READING AND CONFERENCE IN CHEMISTRY (1-0 to 4-0). A closely supervised individual study to be pursued by students whose backgrounds or future plans require additional or exceptional treatment of material at the undergraduate level. PREREQUISITE: Permission of the instructor.

CH 611C GENERAL THERMODYNAMICS (3-2). A treatment of the laws of classical thermodynamics with emphasis on the analysis of processses by use of the thermodynamic state functions. Applications are made to simple systems, but principles developed provide a foundation for specialized material. TEXTS: Zemansky, *Heat and Thermodynamics, 4th Ed.;* Kiefer, Kinney and Stuart, *The Principles of Engineering Thermodynamics.* PREREQUISITES: Ch 107C or Ch 103C.

CH 711B CHEMICAL ENGINEERING CALCULATIONS (3-2). Engineering problems involving mass and energy relations in chemical and physical-chemical processes. TEXT: Hougen, Etc., *Chemical Process Principles, Part I.* PREREQUISITE: Ch 103C or Ch 107C.

CH 721B UNIT OPERATIONS I (3-2). An introduction to the study of the unit operations of chemical engineering. Selection of and primary emphasis on particular unit operations will be made on the basis of current student specialties. TEXT: Smith and McCabe, *Unit Operations of Chemical Engineering.* PREREQUISITE: Physical Chemistry.

CH 741A HEAT TRANSFER (3-2). The fundamentals of heat transfer by conduction, convection and radiation and their application to problems in ordnance. In the laboratory periods problems illustrating these principles are solved. TEXTS: Schenck, *Heat Transfer Engineering;* McAdams, *Heat Transmission.* PREREQUISITE: Consent of instructor.

CH 750A APPLIED MATHEMATICS IN CHEMICAL ENGINEERING (3-2). The differential equations describing various chemical engineering processes are derived and solved using analytic and numeric techniques. Electronic computers will be used to obtain solutions to problems. TEXT: Sherwood, Mickley and Reed, *Applied Mathematics in Chemical Engineering.* PREREQUISITE: CH 721B.

CH 760A CHEMICAL ENGINEERING KINETICS (3-2). Rate equations are postulated for various chemical reactions and the application of these equations studied using electronic computers. Chemical reactors will be designed using rate equations obtained. Design variations will be studied by using computers. TEXT: Smith, *Chemical Engineering Kinetics.* PREREQUISITE: CH 721B.

CH 770A PROCESS CONTROL (3-2). Differential equations are set up to describe the behavior of processes occurring in chemical and physical plants. Response of these equations to various forcings are determined. Feed-back control elements are incorporated in the processes and system response determined. Stability and frequency behavior are investigated. Use is made of digital and analog computers to simulate processes and their feed-back control. TEXT: Shilling, *Process Dynamics and Control.* PREREQUISITE: Physical Chemistry and Thermodynamics.

CH 771A PROCESS CONTROL (3-2). A continuation of EC 770 wherein complex control systems are studied. These include valves and transmission lines, heat exchangers, level control, flow control, control of distillation columns and chemical reactors and finally blending and pH control. Sampled data systems and optimization techniques are considered. TEXT: Harriott, *Process Control.* PREREQUISITE CH 770A.

CH 800E CHEMISTRY SEMINAR (0-1). A departmental program in which invited speakers and resident faculty speak on current topics in chemistry and related areas. Mature students may be assigned topics from the literature or may be requested to report on their research. PREREQUISITE: Consent of the Instructor.

CH 850A SPECIAL TOPICS IN CHEMISTRY (Credit to be arranged). Pursuit of deeper understanding of some topic chosen by the student and the instructor; may involve directed reading and conference or a lecture pattern. May be repeated for credit with a different topic. PREREQUISITE: Permission of the Instructor.

CH 900E RESEARCH (0-2 to 0-10). Experimental investigation of original problems. PREREQUISITE: Permission of the professor in charge.

MATERIALS

MS 021C ELEMENTS OF MATERIALS SCIENCE I (3-2). An introduction to the science and application of engineering materials. The subject matter covers many of the principles underlying the properties and behavior of materials, including atomic and crystal structure, mechanical properties and phase equilibria. PREREQUISITE: A course in general chemistry.

MS 022C ELEMENTS OF MATERIALS SCIENCE II (3-2). A continuation of Mt 021C in which basic principles are applied in studying the properties, application, fabrication and corrosion of metals and other materials. PREREQUISITE: MS 021C.

MS 101C PHYSICAL GEOLOGY (3-2). The study of the various geological phenomena. Topics discussed are: rock-forming minerals; igneous, sedimentary, and metamorphic rocks; weathering and erosion; stream sculpture; glaciation; surface and sub-surface waters; volcanism, dynamic processes; structural geology; and interpretations of topographic maps. TEXT: Gilluly, *Principles of Geology.*

MS 201C ENGINEERING MATERIALS I (3-2). Principles underlying the properties and behavior of materials which make them useful in structures, machines, and devices, including atomic arrangements and imperfections in crystalline and non-crystalline phases; equilibrium and non-equilibrium phase relationships in one-, two-, and three-component systems; elasticity and fracture; recovery, recrystallization and grain growth; mechanisms and kinetics of diffusion and phase transformation; chemical behavior and corrosion. Introduction to metallic, ionic, and polymeric materials to correlate structure with properties in illustrating the above subjects. TEXT: Clark and Varney, *Physical Metallurgy for Engineers,* 3rd ed., 1962. PREREQUISITES: General Chemistry, General Physics.

MS 202C ENGINEERING MATERIALS II (3-2). Extension of the principles of materials science to the metallic state; nucleation and growth; diffusion-controlled and diffusionless transformation; heat treatment and hardenability; thermal and transformation stresses; relaxation processes; quench aging and strain aging; engineering alloy systems including iron, steel, alloy steels, stainless steels, PH stainless steels, high temperature alloys; corrosion problems. TEXT: Clark and Varney, *Physical Metallurgy for Engineers,* 3rd ed., 1962. PREREQUISITE: MS 201C.

MS 203B PHYSICAL METALLURGY (Special Topics) (2-2). A continuation of material presented in MS 201C and MS 202C, including a discussion of powder metallurgy, welding and casting, fatigue, properties of metals at low temperatures, and surveys of the alloys of aluminum and magnesium. TEXTS: Coonan, *Principles of Physical Metallurgy;* Heyer, *Engineering Physical Metallurgy;* Clark and Varney, *Physical Metallurgy for Engineers;* Woldman. *Metal Process Engineering.* PREREQUISITE: MS 202C.

MS 204A NON-FERROUS METALLOGRAPHY (3-3). An expansion of material introduced in MS 201C, MS

202C and MS 203B with greater emphasis on the intrinsic properties of specific non-ferrous metals and alloys. PREREQUISITE: MS 202C.

MS 205A ADVANCED PHYSICAL METALLURGY (3-4). The subject matter includes equilibrium in alloy systems, the crystallography of metals and alloys, phase transformations and diffusion. The laboratory time is devoted to x-ray techniques used in metallurgical studies. TEXTS: Barrett, *Structure of Metals;* Cullity, *Elements of X-ray Diffraction;* Rhines, *Phase Diagrams in Metallurgy.* PREREQUISITE: MS 202C, PH 620B or equivalent.

MS 206A ADVANCED PHYSICAL METALLURGY (3-4). The subject matter is an extension of that offered in MS 205A but is primarily concerned with dislocations and other imperfections and their influences on the physical properties of metals. TEXTS: Cottrell, *Dislocation and Plastic Flow in Crystals;* Read, *Dislocation in Crystals.* PREREQUISITE: MS 205A.

MS 207B PHYSICS OF SOLIDS (3-0). A course for engineers intended as an introduction to the physics of solids. Topics discussed include introductory statistical mechanics, atomic structure and spectra, introductory quantum mechanics, binding and energy bands, crystal structure and imperfections in crystals. TEXT: Sproull, *Modern Physics.* PREREQUISITE: MS 202C.

MS 208B PROPERTIES OF MATERIALS (3-2). This course is designed for the specific needs of the aeronautical engineer, and includes the effects of various mechanical and thermal treatments on the structures and properties of aircraft and space materials including steels, titanium, aluminum, magnesium, and other alloys. Discussion of corrosion and oxidation-resisting materials, including chromium-nickel stainless steels, precipitation hardening alloy steels, ceramics, cermets, and plastics. A correlation of the foregoing principles with corrosion, creep, and fatigue type failures. TEXT: Clark and Varney, *Physical Metallurgy for Engineers,* 2nd ed., 1962. PREREQUISITE: MS 201C.

MS 221B PHASE TRANSFORMATIONS (3-0). Kinetics, thermodynamics and mechanisms of nucleation and growth; solidification, precipitation, recrystallization, martensitic transformations, eutectoid transformations and order-disorder phenomena. PREREQUISITE: MS 202C.

MS 222A MECHANICAL PROPERTIES OF SOLIDS (3-0). Elements of elastic and plastic deformations; discussion of mechanical properties; deformation and fracture in single crystal and polycrystalline metals; the effect of temperature; the correlation of mechanical properties and phenomena with microstructures and imperfections. PREREQUISITE: MS 202C.

MS 223A MATERIALS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS (3-0). The fundamental principles underlying the electrical, electronic, and magnetic properties of solids. Perfect and imperfect crystals; noncrystalline materials. The nature and properties of conductors, semiconductors, insulators and magnetic materials. The relation between structure and properties; the effect of impurities and of fabrication. Theoretical aspects are illustrated by describing typical materials. PREREQUISITE: A course in introductory materials science or equivalent.

MS 271A CRYSTALLOGRAPHY AND X-RAY TECHNIQUES (3-2). The essential concepts of crystallography, the stereographic projection, modern x-ray diffraction and radiographic apparatus and techniques, the theory of x-ray diffraction, high temperature diffraction techniques. The laboratory work includes a study of crystal models for symmetry, forms, and combinations; the construction of stereographic projections; and actual practice in making and interpreting of x-ray diffraction photographs. TEXTS: Buerger, *Elementary Crystallography;* Azaroff and Buerger, *The Powder Method.* PREREQUISITE: CH 107C.

MS 302A ALLOY STEELS (3-3). A study of the effects of alloying elements including carbon commonly used in steel making, plus precipitation hardening and dispersion hardening effects. Descriptive material includes super high strength alloys, high temperature alloys, corrosion resistant alloys. TEXT: E. C. Bain, *The Alloying Elements in Steel.* PREREQUISITE: MS 202C.

MS 303A METALLURGY SEMINAR. Hours to be arranged. Papers from current technical journals will be reported on and discussed by students. PREREQUISITE: MS 203B or MS 205A.

MS 304A SPECIAL TOPICS IN MATERIALS SCIENCE (credit by arrangement). An advanced course in which theoretical and practical problems of materials properties, applications and fabrication are discussed. PREREQUISITE: Consent of Instructor.

MS 308A MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS (3-2). Mechanical properties of materials for various environmental conditions including static, fatigue, damping, impact, shock, creep and temperature of loading. Evaluation of properties for metals and alloys, plastics and polymers, ceramics and cermets, composite and reinforced plastics. Interpretation and utilization of properties in engineering. TEXT: J. Marin, *Mechanical Behavior of Engineering Materials.* PREREQUISITE: ME 510C or equivalent.

MS 312A MATERIALS SYSTEMS FOR ADVERSE ENVIRONMENTS (4-0). Discussion of environmental factors such as temperature, corrosion, thermal and mechanical shock, vibration, and sustained loading. Response of materials to environmental factors. Characteristics of metallic alloy systems, ceramics, plastics, and composite materials as they relate to performance under adverse conditions. PREREQUISITE: MS 202C or MS 208B.

MS 402B NUCLEAR REACTOR MATERIALS — EFFECTS OF RADIATION (3-0). A course designed for students in nuclear engineering. Includes a study of materials of reactor construction; factors in materials selection; commercially available materials; liquid metal coolants; nature of radiation damage on materials. TEXTS: *The Reactor Handbook—General Properties Materials;* Finniston and Howe, *Metallurgy and Fuels;* Drenes and Vineyard, *Radiation Effects in Solids.* PREREQUISITE: MS 207B, or equivalent.

MS 900E RESEARCH (0-2 to 0-10). Experimental investigations of original problems. PREREQUISITE: Consent of Instructor.

DEPARTMENT OF MATHEMATICS

ROBERT EUGENE GASKELL, Professor of Mathematics; Chairman (1966)*; A.B., Albion College, 1933; M.S., Univ. of Michigan, 1934; Ph.D., 1940.

CHARLES HENRY RAWLINS, JR., Professor Emeritus of Mathematics and Mechanics (1922); Ph.B., Dickinson College, 1910; M.A., 1913; Ph.D., Johns Hopkins Univ., 1916.

RICHARD D. AMORI, Ensign, U.S. Navy; Instructor in Mathematics (1965); B.S., Univ. of Scranton, 1964; M.S., Bucknell Univ., 1965.

HORACE CROOKHAM AYRES, Professor of Mathematics and Mechanics (1958); B.S., Univ. of Washington, 1931; M.S., 1931; Ph.D., Univ. of California, 1936.

WILLARD EVAN BLEICK, Professor of Mathematics and Mechanics (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

RICHARD CROWLEY CAMPBELL, Professor of Mathematics and Mechanics (1948); B.S., Muhlenberg College, 1940; M.A., Univ. of Pennsylvania, 1942.

WARREN RANDOLPH CHURCH, Professor of Mathematics (1938); B.A., Amherst, 1926; M.A., Univ. of Pennsylvania, 1930; Ph.D., Yale Univ., 1935.

FRANKLIN L. DANIELS, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor of Mathematics (1966); B.A., Oklahoma City Univ., 1964; M.A., 1966.

DONALD MACALLISTER FAIRBORN, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor in Mathematics (1964); B.S., George Peabody College, 1963.

FRANK DAVID FAULKNER, Professor of Mathematics and Mechanics (1950); B.S., Kansas State Teachers College, 1940; M.S., Kansas State College, 1942.

JOSEPH GIARRATANA, Professor of Mathematics and Mechanics (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

HERBERT J. HAUER, Assistant Professor of Mathematics and Mechanics (1963); B.S., Queens College, 1949; M.A., Univ. of California, 1955.

WALTER JENNINGS, Professor of Mathematics and Mechanics (1947); B.A., Ohio State Univ., 1932; B.S., 1932; M.A., 1934.

WILLIAM JOSEPH KENNEDY, JR., Lieutenant, U.S. Naval Reserve; Instructor in Mathematics (1963); B.A., Whitman College, 1960.

UNO ROBERT KODRES, Associate Profeessor of Mathematics and Mechanics (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

ERIC SIDDON LANGFORD, Assistant Professor of Mathematics (1964); B.S., Massachusetts Institute of Technology, 1959; M.S., Rutgers Univ., 1960; Ph.D., 1963.

KENNETH ROBERT LUCAS, Associate Professor of Mathematics (1958); B.S., Washburn Univ., 1949; Ph.D., Kansas Univ., 1957.

HERMAN BERNHARD MARKS, Associate Professor of Mathematics (1961); B.S., Southern Methodist Univ., 1950; M.A., Univ. of Texas, 1959.

HUGO MURUA MARTINEZ, Associate Professor of Mathematics (1964); B.A., Univ. of California, 1952; M.S., Stanford Univ., 1961; Ph.D., Univ. of Chicago, 1963.

ALADUKE BOYD MEWBORN, Professor of Mathematics and Mechanics (1946); B.S., Univ. of Arizona, 1927; M.S., 1931; Ph.D., California Institute of Technology, 1940.

ROBERT RUSSELL PEARSON, Lieutenant, U.S. Naval Reserve; Instructor in Mathematics (1963); B.A., Univ. of Connecticut, 1959.

ROBERT MERLIN PICKRELL, Commander, U.S. Navy; Instructor of Mathematics (1963); B.S., U.S. Naval Academy, 1945.

JOHN PHILIP PIERCE, Professor of Mathematics (1948); B.S. in E.E., Worcester Polytechnic Institute, 1931; Master of E.E., Polytechnic Institute of Brooklyn, 1937.

FRANCIS MCCONNELL PULLIAM, Professor of Mathematics and Mechanics (1949); B.A., Univ. of Illinois, 1937; M.A., 1938; Ph.D., 1947.

GEORGE DONALD SCHMEIG, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor in Mathematics (1963); B.A., Univ. of South Dakota, 1963.

ELMO JOSEPH STEWART, Professor of Mathematics (1955); B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Institue, 1953.

CHARLES CHAPMAN TORRANCE, Professor of Mathematics and Mechanics (1946); M.E., Cornell Univ., 1922; M.A., 1927; Ph.D., 1931.

THURMAN BADER WENZL, Lieutenant Junior Grade, U.S. Navy; Instructor in Mathematics (1965); B.S., Rensselaer Polytechnic Institute, 1963; M.S., Univ., of Virgina, 1965.

FRANCIS MERRILL WILLIAMS, Assistant Professor of Mathematics (1965); B.S., New Mexico State Univ., 1958; M.S., 1960; Ph.D., 1964.

RICHARD PAUL WOODRING, Lieutenant, U.S. Naval Reserve; Instructor in Mathematics (1964); B.A., Washington and Jefferson College, 1957; M.S., Univ. of Utah, 1959.

*The year of joining the Postgraduate School faculty is indicated in parenthesis.

DEGREES WITH MAJOR IN MATHEMATICS

Officer students may, under special conditions, he offered the opportunity to qualify for either a Bachelor of Science or Master of Science degree with major in mathematics. Any interested student should consnlt the Chairman of the Department of Mathematics for an evaluation of his previous work to determine his potential for obtaining either degree and to consider the possibility of scheduling the necessary work. Evaluation of courses presented upon entering the Postgraduate School for credit toward these degrees must be completed prior to entering a program leading to these degrees. The requirements in mathematics for these degrees are given helow. They provide, on the bachelor's or master's level, a working knowledge of one fieeld of mathematics and a well-rounded hackground in three of the major fields of mathematics.

1. Requirements for the degree of *Bachelor of Science* with major in Mathematics.

   a. Of the total term hours specified in the general requirements for the degree of Bachelor of Science, a student majoring in mathematics must complete at least 36 term hours of approved course work in mathematics beyond the calculus, and must have an average QPR of 1.25 or better in these 36 term hours.

   b. These 36 term hours in mathematics must include at least 6 hours of approved course work in each of three fields of mathematics and two of these fields must be analysis and algebra.

   c. Each student majoring in mathematics will set up in advance, in consultation with the Chairman of the Department, and approved by him, a mathematics curriculum fitted to his aims, aptitudes, preparation, and interests. This original curriculum may, however, be modified as work progresses, but only in consultation with and with the approval of the Chairman of the Department.

2. Requirements for the degree of *Master of Science* with major in Mathematics.

   a. A student pursuing a program leading to a Master of Science degree with major in mathematics must have completed work which would qualify him for a Bachelor of Science degree with major in mathematics as defined in paragraph 1. A student whose background does not satisfy this requirement may take course work to eliminate this deficiency while simultaneously pursuing the Master of Science Program. However, course work pursued to eliminate this deficiency cannot be counted toward satisfying either the general or departmental requirements for the degree of Master of Science.

   b. Of the total term hours specified in the general requirements for the degree of Master of Science, a student majoring in mathematics must complete at least 24 term hours of approved A or B level course work in mathematics, and must have an average QPR of 2.125 or better in these 24 term hours. These 24 term hours must include at least 6 hours in each of the fields of analysis and algebra. Each student majoring in mathematics will set up in advance, in consultation with the Chairman of the Department, and approved by him, a mathematics curriculum fitted to the student's aims, aptitudes, preparation and interests. This original curriculum may, however, be modified as work progresses, but only in consultation with and with the approval of the Chairman of the Department.

   c. A student pursuing a program leading to the degree of Master of Science with major in mathematics will be required to write a thesis in Mathematics. The nature of the thesis may but need not he an original contribution to knowledge. The purpose of the thesis is to demonstrate the student's ability to recognize a prohlem, define that problem, investigate and successfully complete various facets of the problem and then be able to document and present his work on the problem. For the completion of the thesis the student will be given 8 hours credit, which will be in addition to the required 24 hours.

   d. In addition to the above requirements, a student must pass a written comprehensive examination in mathematics. This examination is given twice each year and normally a student will take his examination within the year preceding the award of the Master of Science degree.

3. The thesis director, topic, and subject of specialization shall be chosen, with the consent of the chairman of the department, as early as possible (but in all events, not later than two terms prior to the time for granting the degree). Minor departures from the preceding requirements may be authorized hy the Chairman of the Department of Mathematics.

MATHEMATICS

Ma 000E, Ma 001E PROBLEM SESSION (0-1). Noncredit prohlem session to supplement other courses.

Ma 010D BASIC ALGEBRA AND TRIGONOMETRY I (4-0). Review of arithmetic processes. The real number system. Engineering notation and the slide rule. Algebraic operations. Linear equations. Graphs. Laws of exponents. Quadratic equations; the quadratic formula. Logarithms. Definition of trigonometric functions. Solution of the right triangle. PREREQUISITE: None.

Ma 025D ELEMENTARY SETS WITH APPLICATIONS (3-0). Study of the vital role played by set theory throughout contemporary mathematics. A brief introduction to naive set theory is followed hy an elementary treatment of logic and the nature of mathematical proof. Techniques of informal proof are implemented in proving standard theorems about sets. Following a study of relation and function as an application of set theory a Boolean algebra is defined and used to summarize the algebra of both sets and logic. A final application is given through a systematic treatment of finite prohahility theory from a set point of view. PREREQUISITE: None.

Ma 030D INTERMEDIATE ALGEBRA (5-0). The set of real numbers and postulates for the development of the algebra of real numbers. Proofs of some elementary theorems for the algebra of the real numbers. Applications of the postulates and theorems to addition, subtraction, multiplication, division and factorization of algebraic expressions. Application to word problems, first degree equations and equations of higher degree. Functions, graphs and inequalities. Exponents and logarithms. Sequences, series and the binomial theorem. Complex numbers. PREREQUISITE: None.

Ma 031D COLLEGE ALGEBRA AND TRIGONOMETRY (5-0). Brief review of algebraic fundamentals. Slide rule and logarithmic methods of computation. Algebra of complex numbers, quadratic equations. Systems of equations, determinants: Cramer's rule. Binomial Theorem. Mathematical induction. Trigonometric functions of the general angle. Identities. Solution of right and oblique triangles. Elements of the theory of equation. PREREQUISITES: Previous courses in College Algebra and Trigonometry.

Ma 032C MATHEMATICS FOR MANAGEMENT (4-0). This course is designed to provide the mathematical background needed to understand modern managerial tools and techniques. Specific areas covered include a review of algebra, probability, and a survey of calculus. PREREQUISITE: Consent of Instructor.

Ma 051D CALCULUS AND ANALYTIC GEOMETRY I (5-0). Fundamentals of plane analytic geometry, concepts of function, limit, continuity. The derivative and differentiation of algebraic and trigonometric functions with applications. Derivatives of higher order. Differentials. Formal integration of elementary functions. Rolles' theorem, areas, volumes of revolution. PREREQUISITE: Ma 031D or its equivalent.

Ma 052D CALCULUS AND ANALYTIC GEOMETRY II (5-0). Selected topics from plane geometry. Differentiation and integration of transcendental functions. Hyperbolic functions. Parametric equations. Formal integration. Numerical integration. Improper integrals. Polar coordinates. Plane vectors. PREREQUISITE: Ma 051D.

Ma 053D CALCULUS AND ANALYTIC GEOMETRY III (5-0). Partial derivatives, directional derivatives, total differential. Chain rule differentiation. Introduction to vector analysis. Del operator. Line integrals. Multiple integration and applications. Introduction to infinite series. PREREQUISITE: Ma 052D.

Ma 071D CALCULUS I (5-0). The calculus of functions of a single independent variable with emphasis on basic concepts. Derivatives, differentials, applications, Rolles' theorem and the mean value theorem. Definite integral with applications. Elementary transcendental functions. Topics from plane analytic geometry to be introduced as necessary. Polar coordinates. PREREQUISITES: Ma 031D or its equivalent, and previous work in calculus.

Ma 072D CALCULUS II (5-0). Advanced transcendental functions including hyperbolic functions. Methods of formal integration. Numerical methods. Improper integrals. Partial derivatives, directional derivatives. Total differential. Chain rule differentiation. Introduction to vector analysis. Del operator. Line integrals. Multiple integrals with applications. PREREQUISITES: Ma 071D.

Ma 073C DIFFERENTIAL EQUATIONS (5-0). A continuation of Ma 072D. Series of constants; power series; Fourier series; first order ordinary differential equations; ordinary linear differential equations with constant coefficients; simultaneous solution of ordinary differential equations. Series solution of ordinary differential equations, including Bessel's Equation. PREREQUISITE: Ma 072D.

Ma 100C THEORY OF EQUATIONS (3-0). Polynomials in one variable algebraic equations and their roots, rational roots, cubic and bi-quadratic equations, symmetric functions, approximate evaluation of roots. PREREQUISITE: Calculus.

Ma 101B LINEAR ALGEBRA I (3-0). Systems of Linear Equations. Vector Spaces. Algebra of Matrices. Determinants. PREREQUISITE: Consent of Instructor.

Ma 102B LINEAR ALGEBRA II (3-0). Bilinear and Quadratic Forms. Linear Transformation on a Vector Space. Canonical Representations of Matrices. PREREQUISITE: Ma 101B.

Ma 103C PROJECTIVE GEOMETRY (3-0). Transformations in Euclidean geometry; invariants; perspectives; Desargue's triangle theorems; principle of duality; homogeneous coordinates of points and lines; linear combinations of points and lines; cross ratio, a projective invariant; harmonic division, properties of complete quadrangles and complete quadrilaterals; projective transformations, the projective properties. PREREQUISITE: Consent of Instructor.

Ma 104A ALGEBRAIC CURVES (3-0). An introduction to study of algebraic geometry is given by means of a solution of topics from the theory of curves, centering around birational transformations and linear series. PREREQUISITES: Ma 103C and Ma 105B or consent of Instructor.

Ma 105B FUNDAMENTALS OF MODERN ALGEBRA I (3-0). Concept of group; subgroups; composition of groups; basic theorems for Abelian groups. Rings; integral domains; ideals; polynomial rings; basis theorems for rings. PREREQUISITE: Consent of Instructor.

Ma 106B FUNDAMENTALS OF MODERN ALGEBRA II (3-0). Continuation of Ma 105B. Fields; field extensions; algebraic numbers; algebraic integers; root fields and their Galois groups; properties of the Galois group and its subgroups; finite fields; insolvability of the quintic polynomial. PREREQUISITE: Ma 105B.

Ma 107B INTRODUCTION TO GENERAL TOPOLOGY (3-0). Review of usual topology in *En* fundamentals of point set topology, e.g., compactness, connectivity, homeomorphism, etc. Hausdorff, metrizable, regular spaces, and embedding theorems. Applications. PREREQUISITE: Ma 109B or consent of Instructor.

Ma 109B FUNDAMENTALS OF ANALYSIS I (3-0). Elemements of set theory and topology in *En;* vector valued functions, differentials and Jacobians; functions of bounded variation. PREREQUISITE: Consent of Instructor.

Ma 110B FUNDAMENTALS OF ANALYSIS II (3-0). Theory of Reimann-Stieltges integration, multiple integrals, sequences and series of functions. PREREQUISITE: Ma 109B.

Ma 111A FUNDAMENTALS OF ANALYSIS III (3-0). Continuation of Ma 110B. Line and surface integrals, Stokes theorem, improper integrals, Fourier series and Fourier integrals. PREREQUISITES: Ma 109B and Ma 110B.

Ma 113B VECTOR ANALYSIS and PARTIAL DIFFERENTIAL EQUATIONS (4-0). Calculus of vectors; differential operators; line and surface integrals; Green's, Stokes, and divergence theorems. Separation of variables: boundary conditions; applications to heat flow. PREREQUISITES: Ma 120C, Ma 240C and Ma 251C.

Ma 116B MATRICES AND NUMERICAL METHODS (3-2). Finite differences, interpolation, numerical differentiation and integration; numerical solution of polynomial equations; numerical methods for initial value and boundary value problems involving ordinary and partial differential equations; solution of systems of linear algebraic equations; latent roots and characteristic vectors of matrices; numerical methods for inversion of matrices. PREREQUISITES: Ma 113B, or Ma 183B, or Ma 245B, or Ma 246B.

Ma 120C VECTORS AND MATRICES WITH GEOMETRICAL APPLICATIONS (3-1). Algebra of complex numbers. Vector algebra. Points, lines and planes in vector and scalar notation. Surfaces and space curves. Matrices, determinants, linear systems and linear dependence. Laboratory periods devoted to a review of essential topics in algebra, trignometry and plane analytic geometry. PREREQUISITE: A course in plane analytic geometry.

Ma 125B NUMERICAL METHODS FOR DIGITAL COMPUTERS (2-2). Numerical solution of systems of linear algebraic equations, polynomial equations, and systems of non-linear algebraic equations; finite differences, numerical interpolation, differentiation, integration; numerical methods for solving initial value and boundary value problems involving ordinary and partial differential equations. PREREQUISITE: Ma 113B or Ma 183B. or Ma 245B or Ma 246B.

Ma 126B NUMERICAL METHODS FOR DIGITAL COMPUTERS (3-2). Lagrangian polynomial approximations to real functions. Introduction to best polynomial approximations in the sense of least squares. Minimax polynomial approximations. Numerical methods for solving equations and systems of equations. Difference calculus. numerical differentiation and integration. Selected numerical methods for solving initial value and boundary value problems involving ordinary and partial differential equations. The laboratory periods include sample problems solved on hand-operated keyboard calculators; emphasis is given to methods which are useful with large scale automatic digital computers. PREREQUISITE: Ma 240C or equivalent.

Ma 128B NUMERICAL METHODS IN PARTIAL DIFFERENTIAL EQUATIONS (3-1). Finite difference expressions for derivatives. Boundary value problems in ordinary differential equations. Iterative methods for solving systems of linear algebraic equations. Relaxation methods. Basic numerical methods for linear second order partial differential equations of Laplace, Poisson, heat-flow and the one-dimensional wave equation. Introduction to difference equations. Stability. Discretization and round-off errors. PREREQUISITES: Ma 125B and Ma 421C.

Ma 140B LINEAR ALGEBRA AND MATRIX THEORY (4-0). Systems of linear equations, equalities and inequalities. Vector spaces, bases. Determinants and matrices. Linear transformations, bilinear and quadratic forms. Canonical representations. Geometrical interpretations. Latent roots and vectors of a matrix. PREREQUISITE: Ma 141D or the equivalent.

Ma 141D REVIEW OF ANALYTIC GEOMETRY AND CALCULUS (5-0). Cartesian coordinates; analytical geometry of straight line and second degree curves. Trigonometry. Concepts of function, limit and continuity. Differential and integral calculus. Functions of several variables. Algebra and the theory of equations. Inequalities. PREREQUISITE: Previous course in analytic geometry and calculus.

Ma 146B NUMERICAL ANALYSIS AND DIGITAL COMPUTERS (3-0). Finite differences. Interpolation and function representation. Difference equations. Numerical integration. Algebraic and transcendental equations. Matrix manipulation: linear simultaneous algebraic equations, latent roots and vectors of matrices. (Computer methods will be emphasized throughout.) PREREQUISITE: Ma 140B.

Ma 150C VECTORS AND MATRICES WITH GEOMETRICAL APPLICATIONS (4-1). Algebra of complex numbers. Vector algebra. Points, lines and planes in scalar and vector notation. Surfaces and space curves. Frenet-Serret formulae. Directional derivatives, gradient and curl. Determinants, matrices, linear systems and linear dependence. Laboratory periods devoted to a review of essential topics in algebra, trigonometry and plane analytic geometry. PREREQUISITE: A course in plane analytic geometry.

Ma 151C DIFFERENTIAL EQUATIONS (4-1). Review of calculus. Partial derivatives. Polar coordinates and change of variables. Elements of differential equations; first order; linear, total; systems of linear equations. PREREQUISITE: A course in differential and integral calculus.

Ma 158B COMPLEX VARIABLES AND LAPLACE TRANSFORMS (4-0). Analytic functions. Cauchy's theorem and formula. Taylor and Laurent series, residues, contour integration, conformal mapping. The Laplace transform and its use in solving ordinary differential equations; inversion integral. Systems of linear differential equations. Stability criteria. PREREQUISITES: Ma 120C and Ma 151C.

Ma 180C VECTORS, MATRICES & VECTOR SPACES (3-1). Algebra of complex numbers. Vector algebra. Points, lines and planes in scalar and vector notation. Surfaces and space curves. Matrices, determinants and systems of linear equations and linear inequalities. Abstract vector spaces. Laboratory periods devoted to a review of essential topics in algebra, trigonometry and analytic geometry. PREREQUISITE: A course in plane analytic geometry.

Ma 181D PARTIAL DERIVATIVES AND MULTIPLE INTEGRALS (4-1). Review of elementary calculus. Hyperbolic functions. Infinite series. Partial and total derivatives. Directional derivatives and and gradients and their physical interpretation. Jacobians. Leibnitz's Theorem for differentiating integrals. Line integrals. Double and triple integrals. PREREQUISITES: A course in differential and integral calculus and Ma 120C to be taken concurrently.

Ma 182C DIFFERENTIAL EQUATIONS AND VECTOR ANALYSIS (5-0). Differential equations. Series solutions of ordinary differential equations. Systems of differential equations, including matrix methods. Vector differentiation. Vector integral relations. PREREQUISITE: Ma 181D.

Ma 183B FOURIER SERIES AND COMPLEX VARIABLES (4-0). Expansion of functions. Fourier series and solution of partial differential equations. Algebra of complex numbers. Analytic functions of a complex variahle, and the elementary transcendental functions. Complex integration. Residues. PREREQUISITE: Ma 182C.

Ma 193C SET THEORY AND INTEGRATION (2-0). Set theoretic concepts. Basic concepts in the theories of Riemann, Lebesgue, and Stieltjes integrals with emphasis on applications to probability theory. PREREQUISITE: Ma 181D or the equivalent.

Ma 196B MATRIX THEORY (3-0). Advanced topics in matrix theory; characteristic equation of a matrix; Cayley-Hamilton and Sylvester theorems; positive definite and semidefinite quadratic forms; canonical forms of a matrix and reduction of a matrix to a canonical form. PREREQUISITE: Ma 120C or Ma 180C, or equivalent.

Ma 220C PARTICLE DYNAMICS (2-2). Review of vector algebra and statics. Moment of a force about a point and about an axis. Axial and polar vectors. Reduction of a general force system and Poinsot's central axis. Centroids. Vector kinematics referred to a rotating coordinate frame. The Coriolis theorem and application to curvilinear coordinates. Potential energy and stability. Particle dynamics. PREREQUISITE: A previous course in mechanics.

Ma 230D CALCULUS OF SEVERAL VARIABLES (4-0). Review calculus of one variable. Taylor series, Leibnitz and L'Hospitals rules. Differential calculus of functions of several variables, directional derivatives, gradient vectors, geometry of tangent planes to surfaces. Double and triple integration in rectangular coordinates. PREREQUISITE: A previous course in calculus and Ma 120C or Ma 150C (may be taken concurrently).

Ma 231C REVIEW OF SELECTED TOPICS OF ENGINEERING MATHEMATICS (4-0). Taylor and Fourier expansions. Differential equations, including series solutions. Bessel and Legendre functions with applications to solutions of partial differential equations. PREREQUISITE: Consent of instructor.

Ma 232D CALCULUS REVIEW (5-0). A review of selected topics in the calculus of one variable including the solution of linear differential equations. PREREQUISITE: A previous course in calculus.

Ma 240C ELEMENTARY DIFFERENTIAL EQUATIONS (2-0). Elements of differential equations including basic types of first order equations and linear equations of all orders with constant coefficients. Systems of linear equations. PREREQUISITE: Ma 230D (may he taken concurrently).

Ma 241C ELEMENTARY DIFFERENTIAL EQUATIONS (3-0). A longer version of Ma 240C including more emphasis on first order equations. PREREQUISITE: Ma 230D (may be taken concurrently).

Ma 244C ELEMENTARY DIFFERENTIAL EQUATIONS AND INFINITE SERIES (4-0). An abbreviated version of Ma 073C not including series solution of differential equations. PREREQUISITE: Ma 230D.

Ma 245B PARTIAL DIFFERENTIAL EQUATIONS (3-0). Solution of boundary value problems by separation of variables; Sturm-Liouville theory; Fourier Bessel series solution. PREREQUISITES: Ma 251C and Ma 240C.

Ma 246B PARTIAL DIFFERENTIAL EQUATIONS (4-0). Series solution of linear differential equations, generalized orthogonal functions; solution of boundary value problems by separation of variables; Sturm-Liouville theory; Fourier-Bessel series solutions. PREREQUISITE: Ma 240C.

Ma 248B DIFFERENTIAL EQUATIONS FOR OPTIMUM CONTROL (3-0). Methods in differential equations for calculating differentials based on the adjoint system of differential equations. Applications to problems in optimum control, particularly trajectories and minimum time problems. Numerical methods for determining and correcting trajectories, particularly optimum trajectories, on a digital computer. PREREQUISITES: Ma 240C or equivalent, and Ma 421C or consent of Instructor.

Ma 251C ELEMENTARY INFINITE SERIES (3-0). Sequences, series, convergence tests, Taylor's series, Fourier series, series solution of linear differential equations. Bessel and Legendre functions. PREREQUISITES: Ma 230D and Ma 240C.

Ma 254C TAYLOR AND FOURIER SERIES (3-0). Sequences and series; power series; Taylor series expansions; uniform convergence; Fourier series. PREREQUISITE: Ma 230D.

Ma 255C DIFFERENTIAL EQUATIONS AND SERIES SOLUTIONS (3-0). First order differential equations; linear equations with constant coefficients; systems of linear equations; series solutions of differential equations; separation and solution of boundary value problem equations in terms of Fourier series, Legendre and Bessel functions. PREREQUISITE: Ma 254C (may be taken concurrently).

Ma 260C VECTOR ANALYSIS (3-0). Vector differential and integral calculus including differential geometry of lines and surfaces, line and surface integrals, change of variable formulas and curvilinear coordinates. PREREQUISITES: Ma 120C and Ma 230D.

Ma 261B VECTOR MECHANICS (5-0). Line, surface and volume integrals, Green's divergence, and Stokes' theorems. Vector differential calculus, and the vector differential operators in rectangular and curvilinear coordinates. The integral theorems in vector form. The vector equations of motion. Irrotational, solenoidal and linear vector fields with applications to fluid mechanics in meteorology. Total differential equation and systems of total differential equations. PREREQUISITES: Ma 240C and Ma 251C.

Ma 262B VECTOR ANALYSIS (4-0). A longer version of Ma 260C including a discussion of the divergence and curl operators in fluid flow from the Lagrange viewpoint, and applications of vector analysis to boundary value problems in fluid and heat flow. PREREQUISITES: Ma 120C and Ma 230D.

Ma 270C COMPLEX VARIABLES (3-0). Analytic functions; series expansion; integration formulas; residue theory. PREREQUISITES: Ma 120C, Ma 230D.

Ma 271C COMPLEX VARIABLES (4-0). A longer version of Ma 270C including more emphasis on Contour integration as required for transform theory. PREREQUISITES: Ma 120C, Ma 230D.

Ma 272C COMPLEX VARIABLES (4-0). A longer version of Ma 270C including a treatment of potential flow around a cylinder with circulation, and Joukowski transformation of a circle into an airfoil with application of the Blasius lift and moment formulas. PREREQUISITE: Ma 230D.

Ma 280B LAPLACE TRANSFORMATIONS (2-0). Definitions and existence conditions; applications to systems involving linear differences, differential and integral equations; inversion integral. PREREQUISITES: Ma 240C and Ma 270C (the latter may be taken concurrently).

Ma 282B LAPLACE TRANSFORMS (3-0). A longer version of Ma 280B with more emphasis on the solution of boundary value problems. PREREQUISITE: A course in differential equations and in complex variables (the latter may be taken concurrently).

Ma 401B ANALOG COMPUTERS (4-0). Elementary analog devices which may be used to perform addition, multiplication, vector resolution, function generation, integration, etc. Combinations of such devices for solution of differential equations, systems of linear equations, algebraic equations, harmonic analysis, etc. Gimbal solvers. Digital differential analyzers. PREREQUISITE: Ma 240C or equivalent.

Ma 402B ANALOG COMPUTERS (2-0). Theory of D.C. Amplifiers, servos, plotters and function multipliers. Analog solution to simultaneous differential equations of any order. Solution of the Legendre, Bessel and Hermite equations. PREREQUISITE: Ma 240C or equivalent.

Ma 405C DIGITAL COMPUTERS AND BUSINESS APPLICATIONS (4-0). Description of a general purpose digital computer. Programming fundamentals. Specific programming problems from the managerial area. A current survey of business applications. TEXT: McCracken, *A Guide to Fortran Programming*. PREREQUISITE: None.

Ma 411C DIGITAL COMPUTERS AND MILITARY APPLICATIONS (4-0). Description of a general purpose digital computer. Programming fundamentals. The use of subroutines, assembly routines and compilers in programming. Applications such as war gaming, simulation of systems, logistics and data processing, demonstrations on a computer. PREREQUISITE: Ma 073C or equivalent.

Ma 412C SMALL SCALE DIGITAL COMPUTERS (3-2). Octal and binary number systems. Description of general purpose digital computers. Operating characteristics and fundamentals of programming for the CDC-160A. Programming with meteorological applications, and operation of the 160. Course designed for meteorology students who may be expected to program for, and operate similar equipment upon completion of study. PREREQUISITE: PS 381C.

Ma 416C NUMERICAL METHODS AND FORTRAN PROGRAMMING (4-1). Numerical solutions of systems of linear and nonlinear algebraic equations; finite differences; numerical interpolation, differentiation; integration; numerical methods of solving initial value and boundary value problems. The first half of course is devoted to learning the Fortran language and writing programs of increasing complexity. In the last half of the course attention is focused mainly on the numerical methods, making use of already existing library subroutines to supplement theory with examples. PREREQUISITE: Calculus, Differential Equations.

Ma 420E COMPUTER OPERATION (1-1). (For 5 wks.). This is a non-credit course designed for students whose course or thesis work requires a knowledge of computer operation. In a combination of lecture and laboratory periods details of operation of computer and peripheral equipment are covered as well as input-output techniques and power-on power-off procedures. PREREQUISITE: Ma 412C or equivalent.

Ma 421C INTRODUCTION TO DIGITAL COMPUTERS (4-1). Octal and binary number systems. Description of general purpose digital computer. Operating characteristics and fundamentals of programming. Programming, using assembly routines and compilers. Engineering applications of digital computers. PREREQUISITE: None.

Ma 423B ADVANCED DIGITAL COMPUTER PROGRAMMING (4-0). Theory and design of sub-routines, assembly routines and compilers. Symbol manipulation. Problem oriented languages and control languages. PREREQUISITE: Ma 421C.

Ma 426B ADVANCED NUMERICAL METHODS (4-1). Representations of functions and/or data by Chebyshev approximation, Continued Fractions, Economization of Series, Quadrature Methods and Multivariate Interpolation by least squares. Matrices and Linear Systems. Methods for Numerical Quadrature. Multiple Quadrature by Monte Carlo Methods. Numerical Solution of Differential Equations. PREREQUISITE: Consent of Instructor.

Ma 427C PROGRAMMING I — INTRODUCTION (3-1). General description of data processing equipment. History and development of computing devices. Characteristics of a general-purpose digital computer and its operation. Programming in a procedure-oriented language, e.g., FORTRAN, COBOL or ALGOL. PREREQUISITE: None.

Ma 428B PROGRAMMING IIa (3-1). Number systems. Programming in machine language. Assembly routines. Problem solving and program planning techniques. Use of subroutines, program testing aids and monitor systems. Input and output considerations. PREREQUISITE: Ma 427C or consent of instructor.

Ma 429A PROGRAMMING IIb (4-0). Programming languages. Systems programming. Theory and construction of assembly and compiler programs. Executive routines and operating systems for modern computer systems. PREREQUISITE: Ma 428B or equivalent.

Ma 501C THEORY OF NUMBERS (3-0). Divisibility, congruences, quadratic reciprocity, diophantine equations, continued fractions, partitions. PREREQUISITE: Consent of Instructor.

Ma 502B DIFFERENTIAL GEOMETRY (3-0). Curves and surfaces. Parametric representation. Curvature. Principal normal. Binomial. Torsion. The Frenet formula. Transformations of coordinates. Covariant and contravariant vectors. Symmetric and skew-symmetric tensors. Christoffel symbols. Reimannian tensor. Gaussian curvature Goedesics. PREREQUISITE: Consent of Instructor.

Ma 503B FOUNDATION OF MATHEMATICS (3-0). Fundamental concepts of mathematics with some emphasis on the axiomatic method including consistency, completeness and independence of axioms in an axiom system. PREREQUISITE: Consent of Instructor.

Ma 504C CALCULUS OF FINITE DIFFERENCES (3-0). Finite differences, factorial polynomials, sums, infinite products, Bernoulli numbers and polynomials, linear difference equations. PREREQUISITE: Consent of Instructor.

Ma 524A BOOLEAN ALGEBRA (3-0). A treatment of Boolean algebra as an abstract mathematical system. The interrelationships between Boolean algebra, set theory and logic are stressed through the algebra of sets and the statement calculus. Stone representation theorem for a Boolean algebra is covered in detail. PREREQUISITE: Ma 705B or equivalent.

Ma 541B APPLIED MATHEMATICS (3-0). Green's function techniques for solving Sturm-Liouville problems for ordinary differential equations as well as boundary and initial value problems for partial differential equations of mathematical physics are introduced. Operational calculus. PREREQUISITE: Consent of Instructor.

Ma 542B APPLIED MATHEMATICS (3-0). A continuation of Ma 541B. The material introduced in Ma 541B is studied more extensively. PREREQUISITE: Ma 541B.

Ma 546B SPECIAL FUNCTIONS (3-0). Special functions of mathematical physics. Orthogonal polynomials. Legendre functions. Bessel functions. Mathieu functions. Spherical harmonics. Recursion formulas, Rodrigues' formulas. Generating functions. Addition theorems. Relationship with hypergeometric differential equation. Expansion and orthogonality properties. PREREQUISITES: Consent of Instructor.

Ma 548B PARTIAL DIFFERENTIAL EQUATIONS (3-0). The Cauchy problem for partial differential operators. Cauchy-Kowalewsky Theorems. Methods of characteristics. Well-posed problems for elliptic, hyperbolic and parabolic partial differential equations. PREREQUISITE: Consent of Instructor.

Ma 549B FOURIER BESSEL EXPANSIONS AND CALCULUS OF VARIATIONS (2-0). Partial differential equations, separation of variables, Sturm-Liouville systems, Fourier Bessel expansions, orthogonal functions, Bessel's inequality. Euler equations, Hamilton's principle, application to physics. PREREQUISITE: Consent of Instructor.

Ma 555A INTEGRAL EQUATIONS (3-0). Fredholm integral equations of the first and second kinds. The Fredholm alternative. Volterra equations. Neumann series. Integral equations with symmetric kernels. Hilbert-Schmidt theory. Singular equations. Applications. PREREQUISITE: Consent of Instructor.

Ma 571B THEORY OF FUNCTIONS OF A COMPLEX VARIABLE (3-0). Selected topics from the theory of functions of a real variable. Complex functions and analytic functions. Integration in the complex plane. Series of complex functions. Power series. Laurent series. PREREQUISITE: Consent of Instructor.

Ma 572B THEORY OF FUNCTIONS OF A COMPLEX VARIABLE (3-0). Singularities of complex functions. Residues and contour integration. Zeros of analytic functions, factors of and infinite product representations for analytic functions. Maximum modulus theorems for analytic and harmonic functions. Conformal mapping. PREREQUISITE: Ma 571B or consent of Instructor.

Ma 573A THEORY OF FUNCTIONS OF A COMPLEX VARIABLE (3-0). Special functions of a complex variable. Analytic theory of differential equations. PREREQUISITE: Ma 572B or consent or Instructor.

Ma 576A LAPLACE TRANSFORMATIONS (3-0). Theory of the Laplace transform with particular reference to its properties as a function of a complex variable. Applications of the transform to difference, differential, integral equations of convolution type and boundary value problems.

Sturm-Liouville systems. PREREQUISITE: Ma 573A or consent of Instructor.

Ma 701B SEMINAR IN ANALYSIS (2-0). Topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of Instructor.

Ma 705B SET THEORY (3-0). Elementary logic and methods of proof in mathematics; properties of sets and operations with sets; relations and function from a set-theoretic point of view; equivalence of sets and their cardinality; infinite sets and their classification by cardinal numbers. PREREQUISITE: Differential and integral calculus or consent of Instructor.

Ma 709A FUNCTIONS OF REAL VARIABLES (3-0). Review of set theory and real numbers. Topological and metric spaces, convergence of directed functions, continuity and semicontinuity. Functions of bounded variation, absolutely continuous functions, differentials. PREREQUISITE: Ma 109B.

Ma 710A FUNCTIONS OF REAL VARIABLES (3-0). Continuation of Ma 709. Lebesque-Stieltjcs integrals, measure and measurable function. Radon-Nikodym theorem, function spaces. L*p* spaces. PREREQUISITE: Ma 709A.

Ma 711A INTRODUCTION TO FUNCTIONAL ANALYSIS (3-0). Linear spaces and functionals. Banach and Hilbert spaces. Weak and weak* topologies, completely continuous operators, spectral theorems. PREREQUISITE: Consent of Instructor.

Ma 740A CALCULUS OF VARIATIONS (3-0). Bliss's differential methods, adjoint differential equations. Euler equations, maximum principle. Weirstrass and Legendre conditions. Perturbation techniques, numerical procedures for determining solutions, and application to control problems. PREREQUISITES: Ma 240C or the equivalent and Ma 421C or consent of Instructor.

Ma 751B TENSOR ANALYSIS I (3-0). The basic concepts of differential geometry. Definition of a tensor. Physical interpretations. The metric tensor. Covariant differentiation. Geodesics. PREREQUISITES: Ma 120C, Ma 181D, Ma 182C or the equivalent.

Ma 752A TENSOR ANALYSIS II (3-0). A continuation of Ma 751B. Introduction to special relativity theory, with emphasis upon axiomatic and philosophical foundations. Formulation of the laws of mechanics and electromagnetism in relativistic form. PREREQUISITE: Ma 751B and a sound background in classical mechanics and electromagnetism.

Ma 753A TENSOR ANALYSIS III (3-0). A continuation of Ma 752A. Introduction to general relativity theory. Parallel displacement and the curvature tensor. PREREQUISITE: Ma 752A.

Ma 801A SEMINAR IN ANALYSIS. Subject matter of this seminar will in general be left to the discretion of instructors; usually content will be special topics from the fields of functional analysis and partial differential equations. Number of hours subject to arrangement. PREREQUISITE: Consent of Instructor.

Ma 842A DATA PROCESSING SEMINAR (3-0). A working seminar on advanced topics in informaiton processing. The selection of topics will depend on the instructor and the class interest. PREREQUISITE: Consent of Instructor.

MECHANICS

Mc 101D ENGINEERING MECHANICS I (2-2). Review of statics, free-body diagrams; distributed forces; centroids; moments and products of inertia of areas; hydrostatics; friction, general principles of dynamics; dimensional analysis; kinematics of a particle; relative and absolute time rate of change of a vector; Coriolis acceleration. PREREQUISITES: Ma 120C or Ma 150C (may be taken concurrently).

Mc 102D ENGINEERING MECHANICS II (2-2). Dynamics of a particle; impulse and momentum; work and energy; potential; conservation of energy; vibrating systems, free and forced, with and without damping; impact; dynamics of rigid bodies; moments and products of inertia; principal axes of inertia; the gyroscope. PREREQUISITE: Mc 101D.

Mc 111C VECTOR MECHANICS I (4-0). Review of vector algebra and statics. Reduction of a general force system and Poinsot's central axis. Axial and polar vectors. Centroids. Vector kinematics referred to a rotating coordinate frame. The Coriolis theorem and its application to curvilinear coordinates. Potential energy and stability. Particle dynamics. Spherical pendulum. PREREQUISITE: A previous course in mechanics.

Mc 112C VECTOR MECHANICS II (4-0). Vector dynamics of rigid bodies. The instantaneous screw axis. Euler angles. Body and space centrodes. Ellipsoid of inertia and principal axes. Poinsot's force free motion and the forced precession of a gyro, with application to the earth. Dynamical stability of a gyro by complex variable. Elementary theory of missile stability. PREREQUISITE: Mc 111C.

Mc 201B METHODS IN DYNAMICS (2-2). The principles of linear momentum, angular momentum, work and energy, power and energy, conservation of energy, virtual work, and d'Alembert are developed and discussed in detail. This work is followed by a development and interpretation of Lagrange's equations of motion. Application of these various principles to obtain the differential equations of motion of dynamical systems is given particular attention. PREREQUISITE: Mc 102D.

Mc 311C VIBRATIONS (3-2). Kinematics of vibrations; free and forced vibrations of systems with one degree of freedom; theory of vibration measuring instruments and of vibration insulation; systems with many degrees of freedom; normal modes of vibration; computation of fastest and slowest modes by matrix methods; vibrations of strings; beams, shafts and membranes, Rayleigh's method; Stodola's method; critical speeds; self-excited vibrations; effects of impact on elastic structures. PREREQUISITES: Mc 102D and a course in beam deflection theory.

Mc 402B MECHANICS OF GYROSCOPIC INSTRUMENTS (3-0). Review of the vector kinematics and dynamics involved in the angular motion of rigid bodies; steady, free and forced precession and general motion of a gyro; stability of a free gyro; the gyrocompass and gyropendulum; gyro angular velocity indicator; the stable platform; Shuler tuning of inertial guidance instruments. PREREQUISITE: Mc 102D.

Mc 403B KINEMATICS OF GUIDANCE (3-0). Kinematics and geometry of guidance and interception systems; special coordinates; inertial references frames; accelerometers; inertial guidance; Dovap; guidance of a ballistic missile and of an interceptor; perturbations and the adjoint differential equations in guidance and optimum control; introductory orbit theory. PREREQUISITE: A course in differential equations and Mc 102D.

Mc 404B MISSILE MECHANICS (3-0). A survey of ballistic missile dynamics including discussions of atmospheric structures; standard conditions; drag; stability derivatives; equations of yawing, swerving and angular motion; electronic digital integration of equations of motion; effects of variations from standard conditions; rocket motor thrust and torque; tricyclic motion; aeroballistic range measurements of stability derivatives; contributions of aerodynamic jump and drift to dispersion; dynamic wind tunnel tests; dynamic stability. PREREQUISITE: A course in dynamics.

Mc 405B ORBITAL MECHANICS (3-0). Review of kinematics. Lagrange's equation of motion. The earth's gravitational field. Control force motion. The two body problem. The determination of orbits. The three body problem. Perturbations. PREREQUISITE: Mc 102D.

Mc 406A INTRODUCTORY CONTROL AND GUIDANCE (4-0). Elements of orbits, orbit determination, gravitational harmonics due to oblateness. Equation of motion of a rocket; integration for thrust constant. Variational and adjoint equations in trajectory determination and optimization; perturbations. Rendezvous and interception trajectories, impulse solutions, error correction. Closed form solutions for nearly circular orbits. Pitch, yaw, roll stabilization. Stable platform. Inertial guidance of airplanes and missiles. PREREQUISITE: Ph 153A.

PROBABILITY AND STATISTICS

PS 310C ELEMENTARY PROBABILITY AND STATISTICS (3-1). An introduction to probability and statistics. Methods of data summary. Tests of hypotheses and estimation. This course is limited to students in the BA/BS Program. PREREQUISITE: A previous course in college algebra.

PS 311C INTRODUCTION TO PROBABILITY AND STATISTICS (4-1). An elementary treatment of probability with some statistical applications. Topics discussed are probability models, discrete and continuous random variables, moment properties, testing statistical hypotheses, and statistical estimation. PREREQUISITE: Ma 031D or equivalent.

PS 321B PROBABILITY (4-2). Elements of set theory. Foundations of Probability and basic rules of computation. Sample space, random variable, discrete and continuous distribution functions. The classical distribution functions. Joint, marginal and conditional distribution functions. Characteristic functions. Limit theorems. Introduction to random processes. Applications to fields of interest of the class. Markov chains. PREREQUISITES: Ma 244C and Ma 271C or the equivalent.

PS 322A DECISION THEORY AND CLASSICAL STATISTICS (3-2). Testing statistical hypotheses, point estimation, interval estimation, regression analysis. Decision theoretic problem with specific attention given to minimax strategies. Bayes strategies, and admissibility. PREREQUISITE: PS 321B and consent of Instructor.

PS 332B STATISTICS I (3-0). Introduction to probability theory. Derivation and properties of principal frequency functions of discrete and continuous random variables. Joint distributions and introduction to regression and correlation. PREREQUISITE: Ma 230D or the equivalent.

PS 333B STATISTICS II (2-2). A continuation of Ma 332B. Applications of probability in statistics. Derived distributions. Estimators of parameters and their frequency functions. Mathematical expectation. Introduction to sampling theory. Applications in meteorology. PREREQUISITE: PS 332B or the equivalent.

PS 351B PROBABILITY AND STATISTICS (4-2). Elements of set theory. Foundations of probability and basic rules of computation. Sample space, random variable, discrete and continuous distribution functions. Bayes Theorem. The classical distribution functions. Expectations, propagation of error. Joint, Marginal, and conditional distribution functions, least squares. Limit theorems. Derivation of Poisson process. Elements of hypothesis testing and estimation. PREREQUISITE: Ma 230D.

PS 352B APPLIED ENGINEERING STATISTICS (2-2). Tests of hypothesis and estimation. Analysis of variance. Statistical quality control, control charts. Sampling inspection. Reliability theory and application. PREREQUISITE: PS 351B.

PS 362B APPLIED STATISTICS (3-1). Elements of statistical estimation and hypothesis testing. Regression analysis, selected topics in quality assurance and sampling inspection. Elementary topics in reliability theory and maintainability. PREREQUISITE: PS 351B.

PS 381C ELEMENTARY PROBABILITY AND STATISTICS (4-2). Elements of the theory of probability. The classical probability distributions. Elements of statistical inference with applications in the field of the group. PREREQUISITE: Ma 181D or equivalent.

DEPARTMENT OF MECHANICAL ENGINEERING

Robert Eugene Newton, Professor of Mechanical Engineering; Chairman (1951)*; B.S. in M.E., Washington Univ., 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951.

Dennis Kavanaugh, Professor Emeritus of Mechanical Engineering (1926); B.S., Lehigh Univ., 1914.

John Edison Brock, Professor of Mechanical Engineering (1954); B.S.M.E., Purdue Univ., 1938; M.S.E., 1941; Ph.D., Univ. of Minnesota, 1950.

Gilles Cantin, Associate Professor of Mechanical Engineering (1960); B.A.Sc., Ecole Polytechnique (Montreal), 1950; M.Sc., Stanford Univ., 1960.

Virgil Moring Faires, Professor of Mechanical Engineering (1958); B.S. in M.E.. Univ. of Colorado, 1922; M.S., 1925; M.E., 1926.

Ernest Kenneth Gatcombe, Professor of Mechanical Engineering (1946); B.S., Univ. of Maine, 1931; M.S., Purdue Univ., 1939; Ph.D., Cornell Univ., 1944.

Cecil Dudley Gregg King, Associate Professor of Mechanical Engineering (1952); B.E., Yale Univ., 1943; M.S. in M.E., Univ. of California (Berkeley), 1952.

Paul James Marto, Lieutenant, U.S. Naval Reserve; Assistant Professor of Mechanical Engineering (1965); B.S., Univ. of Notre Dame, 1960; M.S. in Nuc. Sci., Massachusetts Institute of Technology, 1962; Sc.D., 1965.

Roy Walters Prowell, Professor of Mechanical Engineering (1946); B.S. in I.E., Lehigh Univ., 1936; M.S. in M.E., Univ. of Pittsburgh, 1943.

Paul Francis Pucci, Associate Professor of Mechanical Engineering (1956); B.S. in M.E., Purdue Univ., 1949; M.S. in M.E., 1950; Ph.D., Stanford Univ. 1955.

Harold Marshall Wright, Professor of Mechanical Engineering (1945); B.Sc. in M.E., North Carolina State College, 1930; M.M.E., Rensselaer Polytechnic Institute, 1931.

*The year of joining the Postgraduate School faculty is indicated in parenthesis.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MECHANICAL ENGINEERING

Following is a statement of departmental minimum requirements for degrees in Mechanical Engineering. It is noted that candidates for these degrees must also satisfy general degree requirements as determined by the Academic Council.

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

a. Entrance Requirements. Prior to entering an approved curriculum, a student must have successfully completed college courses as follows: Mathematics through integral calculus, one year of chemistry, and one year of physics. In addition, through completed course work or examination, the student must demonstrate a knowledge of the fundamentals of engineering graphics.

b. Mechanical Engineering Courses. Minimum credit of 65 term hours in mechanical engineering courses is required. These must include the following minimum number of term hours in the indicated areas. The minimum acceptable quality point ratio in these courses is 1.0.

Area	*Minimum Term Hours*
Energy Conversion (Includes thermodynamics, gas dynamics, heat transfer, internal combustion engines. Must include a course in power plants.)	18
Applied Mechanics (Includes statics, dynamics, fluid mechanics, and vibrations.)	15
Mechanics of Solids and Machine Design (Includes kinematics of machinery. Must include a course in machine design.)	15

c. Other Specific Coverage. The following minimum requirements must be met in each of the indicated disciplines.

MATHEMATICS — One course in each of the following subjects: vector algebra, differential equations, and digital computers.

ELECTRICAL ENGINEERING — 15 term hours.

METALLURGY — 6 term hours.

Some of these requirements may, with the consent of the department, be met by transfer credit.

d. Upper Division Credit. Minimum credit of 105 term hours in upper division or higher level courses is required.

e. Department Approval. Any program leading to award of this degree must be approved by the department at least 3 terms before completion. In general, approved programs will require more than the minimum degree requirements in order to conform to the needs and objectives of the U.S. Navy.

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

a. Undergraduate Preparation. A candidate shall have satisfied the requirements for the degree Bachelor of Science in Mechanical Engineering. Credit requirements in succeeding paragraphs must be met by courses in addition to those used to satisfy this requirement.

b. MECHANICAL ENGINEERING COURSES. Minimum credit of 20 term hours in A level courses in mechanical engineering is required.

c. COURSES IN OTHER DEPARTMENTS. A minimum of 12 term hours of graduate credit must be earned outside the major department.

d. A LEVEL COURSES. At least 24 term hours of A level courses must be included in the program. Courses used to meet the requirement of paragraph b may also be counted to meet this requirement.

e. THESIS. Completion of a thesis and its acceptance by the department are required. For this a maximum of 8 term hours of graduate credit may be allowed toward satisfaction of the school requirement for 48 term hours. The thesis credit may not be used to satisfy any of the requirements of paragraphs b and d.

f. DEPARTMENT APPROVAL. Any program leading to award of this degree must be approved by the department at least 3 terms before completion. In general, approved programs will require more than the minimum degree requirements in order to conform to the needs and objectives of the U.S. Navy.

MECHANICAL ENGINEERING

ME 111C ENGINEERING THERMODYNAMICS I (5-0). The laws and processes of transforming energy from one form to another; first law analysis; second law analysis and cycle analysis for reversible processes; transient flow; irreversible processes and available energy. Applications to ideal gas cases; internal combustion engines, gas turbines, turbojets, rockets. TEXT: Faires, *Thermodynamics*. PREREQUISITE: Ma 230D.

ME 112C ENGINEERING THERMODYNAMICS II (5-0). Continuation of ME 111C. Applications of thermodynamic principles to marine steam power plants; reversed cycles; gas-vapor mixtures; combustion with dissociation problems. TEXT: Faires, *Thermodynamics*. PREREQUISITE: ME 111C.

ME 132C ENGINEERING THERMODYNAMICS II (4-2). Continuation of ME 111C. Applications of thermodynamic principles to marine power plant equipment, steam power plants and cycles, refrigeration and heat-pump systems, gas-vapor mixtures. Methods of handling imperfect gases. Complementary laboratory experiments. TEXT: Faires, *Thermodynamics*. PREREQUISITE: ME 111C.

ME 142C THERMODYNAMICS (4-0). Survey of engineering thermodynamics with emphasis on the application of thermodynamic principles to marine nuclear power plants. Review of first and second laws of thermodynamics, and properties of two phase fluids. Power plant cycles. Steam turbines. Elementary fluid mechanics and heat transfer. TEXT: Faires, *Thermodynamics*. PREREQUISITE: PH 530C.

ME 210C APPLIED THERMODYNAMICS (3-2). Continuation of the application of thermodynamic principles, fluid mechanics and the thermodynamics of compressible flow, turbine blading, elements of heat transfer. Complementary laboratory experiments. TEXT: Faires, *Thermodynamics*. PREREQUISITE: ME 132C.

ME 211B THERMODYNAMICS OF COMPRESSIBLE FLOW. (3-0). The thermodynamic and dynamic fundamentals of compressible fluid flow. One-dimensional analyses including the effects of area change, friction, and heat transfer. TEXT: Shapiro, *Thermodynamics and Dynamics of Compressible Fluid Flow, Vol. I.* PREREQUISITES: ME 112C, ME 411C, and Ma 113B.

ME 212A ADVANCED THERMODYNAMICS (3-0). Mathematical development of property relations and their use with experimental data; energy conversion systems employing thermoelectricity, thermionics, MHD, photovoltaic effect, and fuel cells. TEXTS: Faires, *Thermodynamics*; Chang, *Energy Conversion*. PREREQUISITES: ME 112C and Ma 113B.

ME 215B MARINE PROPULSION SYSTEMS I (2-4). Preliminary planning of marine power plants. Estimation of hull, main engine and auxiliary power requirements, inter-relationship of components, heat balances and flow diagrams, computation of ship and plant performance indices. TEXTS: Seward, *Marine Engineering*, Vols. I and II; Church, *Steam Turbines*, 3rd Ed. PREREQUISITE: ME 211B.

ME 216B MARINE PROPULSION SYSTEMS II (2-4). This course is a continuation of ME 215B, carries to completion the project work of the latter, with additional project work in preliminary investigation of main propulsion equipment and other major equipment items. TEXTS: Seward, *Marine Engineering*, Vols. I and II; Church, *Steam Turbines*, 3rd Ed. PREREQUISITE: ME 215B.

ME 217B INTERNAL COMBUSTION ENGINES (3-2). Theoretical and real-fuel cycles, combustion processes for spark-ignition and compression-ignition engines. Combustion chambers, carburetion and fuel-injection phenomena. Factors affecting engine performance and design. TEXT: Taylor and Taylor, *Internal Combustion Engines*. PREREQUISITE: ME 112C.

ME 221C GASDYNAMICS AND HEAT TRANSFER (4-2). Fundamentals of one-dimensional compressible fluid flow including effects of area change, friction, and heat addition. Fundamentals of conduction, convection, and radiation heat transfer, including heat exchanger analysis. TEXT: Giedt, *Principles of Engineering Heat Transfer*. PREREQUISITES: ME 112C and ME 411C.

ME 222C THERMODYNAMICS LABORATORY (1-4). Laboratory experiments applying thermodynamic principles to a gas turbine engine, refrigeration plant, air compressor, compressible flow metering and heat transfer. TEXT: Faires, *Thermodynamics*. PREREQUISITES: ME 112C and ME 411C.

ME 223B MARINE POWER PLANT ANALYSIS (2-4). Preliminary planning of marine power plants. Estimation of hull, main engine and auxiliary power requirements, interrelationship of components, heat balances and flow diagrams, computation of ship and plant performance indices, preliminary investigation of major equipment items. TEXTS: Seward, *Marine Engineering*, Vols. I and II; Church, *Steam Turbines*, 3rd Ed. PREREQUISITE: ME 221C or equivalent.

ME 230B MARINE POWER PLANT ANALYSIS (2-4). Preliminary planning of ship propulsion plants. Estimation of hull, main engine and auxiliary power requirements, interrelationship of components, heat balances, computation of ship and plant performance indices, preliminary investigation of some major equipment items. PREREQUISITE: ME 211B or equivalent.

ME 240B NUCLEAR POWER PLANTS (4-0). Survey of nuclear power engineering. The reactor as a power source as affected by technical feasibility and economics. Elementary nuclear reactor physics. Engineering considerations in core design, including problems of core design, power removal and utilization and shielding. Discussion of reactor types. TEXT: King, *Nuclear Power Systems*. PREREQUISITES: ME 210C or ME 221C; PH 621B.

ME 241A NUCLEAR PROPULSION SYSTEMS I (4-0). The first of a two-course sequence covering engineering aspects of nuclear power reactors. Reactor types, characteristics, and criteria for selection. Advanced heat transfer, fluid mechanics and thermodynamics as applied to characteristic cycles. TEXT: Glasstone, *Principles of Nuclear Reactor Engineering*. PREREQUISITES: ME 310B and PH 652A.

ME 242A NUCLEAR PROPULSION SYSTEMS II (3-3). Reactor shielding. Elementary thermal core and plant design. Detailed study of existing reactor plants. TEXT: Glasstone, *Principles of Nuclear Reactor Engineering*. PREREQUISITE: ME 241A.

ME 246B NUCLEAR POWER PLANTS (4-0). A general survey of nuclear reactor principles intended for other than Mechanical Engineering students. Essential elements of neutron physics, reactor physics, and reactor control. Materials for reactors, reactor shielding and reactor types. Discussion of reactor thermal and hydraulic problems. TEXT: King, *Nuclear Power Systems*. PREREQUISITE: Ph 620B.

ME 310B HEAT TRANSFER (4-2). The fundamentals of heat transfer mechanisms; one- and two-dimensional conduction, free and forced convection, condensation, boiling, thermal radiation, transient and periodic systems, and heat exchanger analysis. Use of the thermal circuit, analog, numerical and graphical techniques. TEXT: Holman, *Heat Transfer*. PREREQUISITES: ME 112C, ME 412A, and Ma 113B.

ME 411C MECHANICS OF FLUIDS (4-2). Mechanical properties of fluids, hydrostatics, buoyancy and stability analysis. Energy aspects of ideal and real fluid flow, flow metering and control. Impulse-momentum principles and analysis. Dimensional analysis and similitude. Elements of hydrodynamic lubrication. Analysis of fluid machinery and fluid systems. Laboratory experiments and problem work. TEXT: Streeter, *Fluid Mechanics*. PREREQUISITES: Ma 230D and ME 502C.

ME 412A ADVANCED MECHANICS OF FLUIDS (4-2). Potential flow theory. Linearized compressible flow. Oblique shock relations. Viscous flow and boundary layer theory. TEXTS: Shapiro, *Thermodynamics and Dynamics of Compressible Flow*, Vols I and II; Li and Lam, *Principles of Fluid Mechanics*. PREREQUISITES: ME 211B, ME 411C and Ma 113B.

ME 501C MECHANICS I (4-0). Laws of statics. Force systems, equilibrium, simple structures, distributed forces, friction, virtual work. Basic concepts of kinematics. TEXT: Beer and Johnston, *Vector Mechanics*. PREREQUISITE: Ma 120C (may be concurrent).

ME 502C MECHANICS II (4-0). Kinematics, Newton's laws, kinetics of particles. Work and energy, impulse and momentum. Moment of inertia of mass. Kinetics of rigid bodies. TEXT: Beer and Johnston, *Vector Mechanics*. PREREQUISITE: ME 501C and Ma 240C (may be concurrent).

ME 503A ADVANCED MECHANICS (4-0). Intensive treatment of vector kinematics. Orbital mechanics including major perturbations for earth satellites. The inertia tensor (dyadic). Rigid body kinetics. Jacobian elliptic functions. Lagrangian methods. TEXTS: Yeh and Abrams, *Mechanics of Solids, Vol. I;* Synge and Griffith, *Principles of Mechanics*. PREREQUISITE: ME 502C.

ME 504B ADVANCED DYNAMICS (4-0). Restatement of laws of mechanics. Particle kinetics in different coordinate systems. Effects of earth's rotation. Tensor of inertia. General motion of a rigid body. Gyroscopes. Numerical procedures. Generalized coordinates and Lagrange's equations. TEXTS: Yeh and Abrams, *Mechanics of Solids, Vol. I;* Timoshenko and Young, *Advanced Dynamics*. PREREQUISITE: ME 502C.

ME 510C MECHANICS OF SOLIDS I (4-2). Stress, strain, Hooke's law, tension and compression, shearing stresses, connections, thin vessels, torsion, statics of beams, stresses in beams, deflections of beams, combined loadings and combined stresses, columns. Strain energy, impact, simple indeterminate structures. Supporting laboratory work. TEXT: Timoshenko and Young, *Elements of Strength of Materials*. PREREQUISITES: Ma 230D and ME 501C.

ME 511A MECHANICS OF SOLIDS II (5-0). Further elastic analysis of statically indeterminate structures, beam columns, curved beams, unsymmetrical bending, shear center, beams on elastic foundations, plates and shells, thick-walled cylinders, rotating discs, and elementary thermal stresses. TEXTS: Timoshenko, *Strength of Materials, Vols. I and II*. PREREQUISITES: ME 510C and Ma 240C.

ME 512A MECHANICS OF SOLIDS III (4-0). Elements of theory of elasticity. Stress tensor and theories of failure.

Torsion of non-circular sections. Plastic analysis. Matrix methods in structural analysis. Brittle fracture. TEXTS: Timoshenko, *Strength of Materials, Vol. II;* Timoshenko and Goodier, *Theory of Elasticity;* Parker, *Brittle Behavior of Engineering Structures.* PREREQUISITES: Ma 113B and ME 511A.

ME 521C MECHANICS OF SOLIDS II (4-0). Statically indeterminate problems in bending, symmetrical beams of variable cross section, beams of two materials, unsymmetrical bending, thick-walled cylinders, rotating disks, curved bars, beams with combined axial and lateral loads. TEXTS: Timoshenko, *Strength of Materials, Vols. I and II.* PREREQUISITES: ME 510C and Ma 240C.

ME 522B MECHANICS OF SOLIDS III (4-0). Stress concentration, deformations beyond the elastic limit, mechanical properties of materials, strength theories, impact, fatigue, torsion of non-circular sections, thin plates and shells. TEXT: Timoshenko, *Strength of Materials, Vol. II.* PREREQUISITE: ME 521C.

ME 540C MECHANICS OF SOLIDS (3-2). Fundamental concepts of the mechanics of solids. Stress, strain, Hooke's law, tension, compression, shearing stresses, bending stresses, beam deflections, combined stresses, columns. Laboratory experiments based on standard mechanical tests. TEXT: Timoshenko and Young, *Elements of Strength of Materials.* PREREQUISITES: Ma 240C, PH 151C.

ME 547C STATICS AND STRENGTH OF MATERIALS (5-0). Review of principles of statics, statics of determinate structures, pin-connected trusses. Stress, strain, Hooke's law, tension and compression, shearing stresses. Connections, thin vessels, torsion. Statics of beams, flexural stresses and deformations, numerical procedures. Simple indeterminate structures. Combined loadings and combined stresses. Columns. TEXT: Timoshenko and Young, *Elements of Strength of Materials.* PREREQUISITE: PH 151C.

ME 548B STRUCTURAL THEORY (5-0). Fundamental concepts. Stability and determinacy of simple structures. Energy methods. Matrix methods. Flexibility and stiffness methods. Dynamic disturbances. Systems with one, two and many degrees of freedom. TEXTS: Gere and Weaver, *Analysis of Framed Structures;* Rogers, *Dynamics of Framed Structures.* PREREQUISITES: ME 547C and Ma 240C.

ME 561C MECHANICS I (4-0). Principles of statics. Force systems. Two dimensional problems of equilibrium. Centroids and center of gravity. Friction. Basic kinematics. Basic kinetics. TEXT: Meriam, *Mechanics,* 2nd Ed. PREREQUISITE: Ma 052D.

ME 562C MECHANICS II (4-0). Work and energy. Impulse and momentum. Rocket motion. Kepler's laws. Artificial satellites. Space vehicles. TEXT: Meriam, *Mechanics,* 2nd Ed., and Notes. PREREQUISITES: ME 561C and Ma 053D.

ME 612A EXPERIMENTAL MECHANICS (3-2). Fundamentals of mechanical measurements, resistance strain gages, transducers and instrumentation systems, dynamic response characteristics, brittle lacquer, photoelasticity, analog methods, model theory. Complementary laboratory experiments. TEXTS: Beckwith and Buck, *Mechanical Measurements;* Perry and Lissner, *Strain Gage Primer;* Lee, *An Introduction to Experimental Stress Analysis.* PREREQUISITES: ME 512A and ME 712A.

ME 622B EXPERIMENTAL MECHANICS (2-2). Fundamentals of mechanical measurements, resistance strain gages, transducers and instrumentation systems, dynamic response characteristics, photoelasticity. Complementary laboratory experiments. TEXTS: Lee, *An Introduction to Experimental Stress Analysis;* Perry and Lissner. *Strain Gage Primer.* PREREQUISITES: ME 522B and ME 722B.

ME 711B MECHANICS OF MACHINERY (3-2). Algebraic analysis of the motion of cam followers; design of cams. Velocities and acceleration of machine parts. Kinematics of gearing. Synthesis. Dynamic forces on machine members. TEXT: Faires, *Kinematics.* PREREQUISITE: ME 502C.

ME 712A THEORY OF VIBRATIONS (3-2). The single degree of freedom linear system. Multidegree linear systems. Emphasis is on matrix treatments, including the complex eigenvalue problem and approximations valid for small damping. Transfer matrix methods. Introduction to nonlinear systems. Laboratory experiments to illustrate principles and introduce use of analog computer. TEXTS: Duplicated notes and Den Hartog, *Mechanical Vibrations.* PREREQUISITES: Ma 280B, ME 503A, and ME 511A.

ME 713A ADVANCED DYNAMICS OF MACHINERY (3-0). Special topics such as: shock and vibration mounts, torsional vibrations of crank shafts, vibration absorbers, special bearings, gear lubrication, sleeve bearings with pulsating loads, oil film whirl, turbine blade vibrations, nonlinear vibration problems. Additional matrix methods. TEXTS: Den Hartog, *Mechanical Vibrations;* Karman and Biot, *Mathematical Methods in Engineering.* PREREQUISITE: ME 712A.

ME 721C MECHANICS OF MACHINERY (3-2). Algebraic analysis of the motion of cam followers; design of cams. Velocity and acceleration of machine parts. Kinematics of gearing. Static and dynamic forces on machine members. TEXT: Faires, *Kinematics.* PREREQUISITE: ME 502C.

ME 722B MECHANICAL VIBRATIONS (3-2). Free and forced vibration of linear systems having one, two, and many degrees of freedom. Matrix methods. Vibration isolation and absorbers, torsional vibration, continuous systems. Laboratory experiments with prototype and simulated systems. TEXTS: Den Hartog, *Mechanical Vibrations;* Thomson, *Mechanical Vibrations.* PREREQUISITES: Ma 073C, ME 504B, and ME 521C.

ME 811B MACHINE DESIGN I (3-2). First of a two-course sequence. Studies of fits, tolerances, allowances, material selection, stress concentration, bearings, shafting, screws, belts, chains, brakes, clutches and cams. TEXT:

Faires, *Design of Machine Elements.* PREREQUISITES: ME 512A and ME 711B.

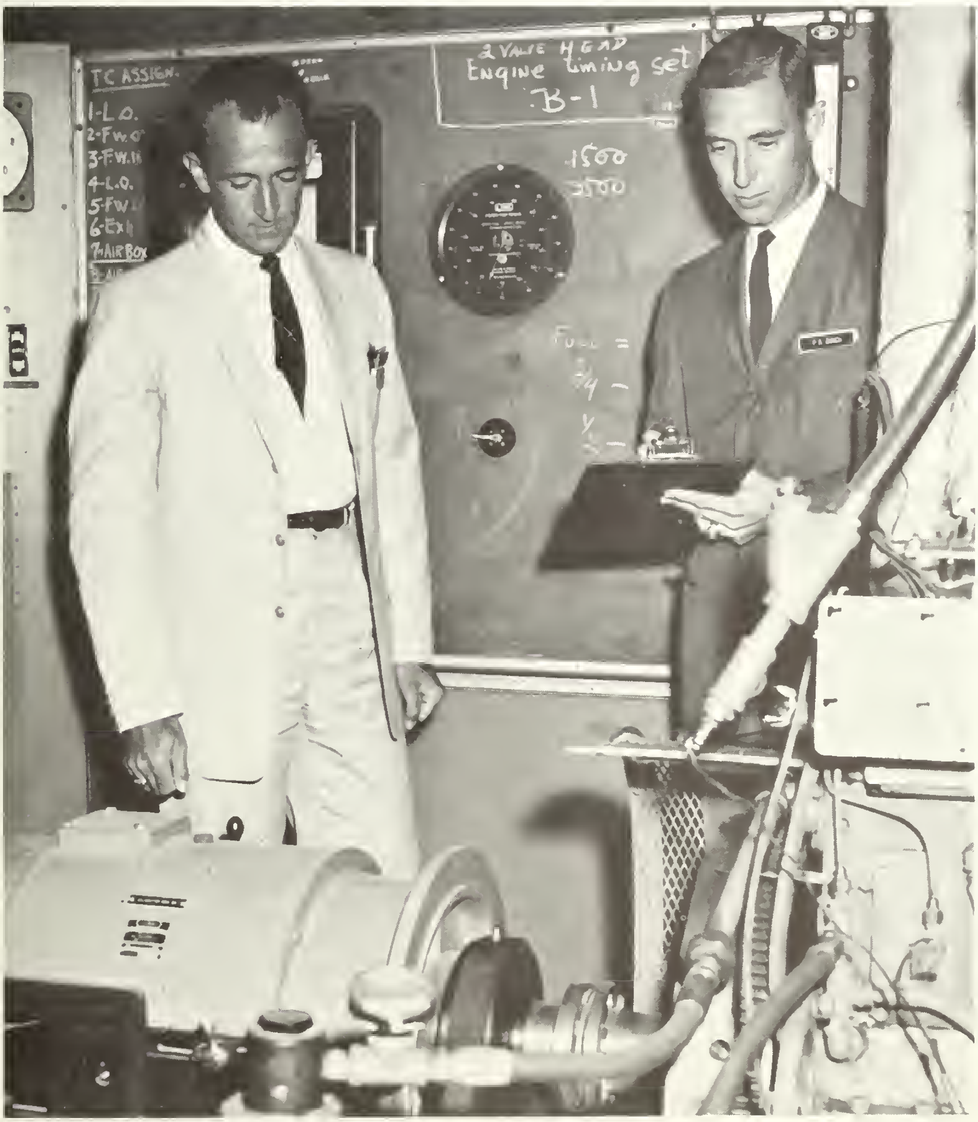
ME 812B MACHINE DESIGN II (3-4). Continuation of ME 811B; springs, gearing, and advanced design problems. Machine design projects of a comprehensive nature. TEXT: Faires, *Design of Machine Elements.* PREREQUISITES: ME 811B and ME 712A.

ME 820C MACHINE DESIGN (2-4). Studies of fits, tolerances, allowances, stress concentration, material selection, bearings, gears, shafts, cams, springs, screws, brakes and clutches. TEXT: Faires, *Design of Machine Elements.* PREREQUISITES: ME 522B and ME 711B.

ME 901C INDIVIDUAL STUDY IN MECHANICAL ENGINEERING (Credit to be arranged). Directed individual study by a student whose background or future plans require additional or exceptional treatment of material at the undergraduate level. PREREQUISITE: Permission of Department Chairman.

ME 902A ADVANCED STUDY IN MECHANICAL ENGINEERING (Credit to be arranged). Directed advanced study in mechanical engineering on a subject of mutual interest to student and staff member. May be repeated for credit with a different topic. PREREQUISITE: Permission of Department Chairman.

ME 910E NAVAL ARCHITECTURE SEMINAR (3-0). Seminar discussions of various phases of naval architecture. Typical discussion subjects will be: drydocking, launching procedures and calculations, elements of ship resistance, action of ship propulsion devices, hull efficiencies and some aspects of small craft design. PREREQUISITE: ME 223B or ME 230B.



Checking Data in Laboratory

DEPARTMENT OF METEOROLOGY AND OCEANOGRAPHY

George Joseph Haltiner, Professor of Meteorology; Chairman (1946)*; B.S., College of St. Thomas, 1940; Ph.M., Univ. of Wisconsin, 1942; Ph.D., 1948.

Harry Llewellyn Bixby, Lieutenant Commander, U.S. Navy; Assistant Professor of Meteorology; B.S., U.S. Naval Academy, 1952; M.S., U.S. Naval Postgraduate School, 1962.

Burford Arlen Carlson, Lieutenant Commander, U.S. Navy; Assistant Professor of Meteorology; M.S., U.S. Naval Postgraduate School, 1960.

Edmund Theodore Clark, Commander, U.S. Navy; Assistant Professor of Meteorology; B.S., U.S. Naval Academy, 1945; M.S.. U.S. Naval Postgraduate School, 1959.

Warren Wilson Denner, Assistant Professor of Oceanography (1964); B.S., Portland State College, 1961; M.S., Oregon State Univ., 1963.

William Dwight Duthie, Fellow, Professor of Meteorology (1945); B.A., Univ. of Washington, 1935; M.S., 1937; Ph.D., Princeton Univ., 1940.

Theodore Green, III, Assistant Professor of Oceanography (1965); A.B., Amherst College, 1959; M.S., Stanford Univ., 1961; Ph.D., 1965.

Eugene Clinton Haderlie, Associate Professor of Oceanography (1965); A.B., Univ. of California, 1943; M.A., 1948; Ph.D., 1950.

Glenn Harold Jung, Professor of Oceanography (1958); B.S., Massachusetts Institute of Technology, 1949; M.S., 1952; Ph.D., Texas Agricultural and Mechanical College, 1955.

Frank Lionel Martin, Professor of Meteorology (1947); B.A., Univ. of British Columbia, 1936; M.A., 1938; Ph.D., Univ. of Chicago, 1941.

Robert Joseph Renard, Associate Professor of Meteorology (1952); M.S., Univ. of Chicago, 1952.

William Stevens, Lieutenant Commander, U.S. Navy; Instructor in Meteorology; B.S., U.S. Naval Academy, 1955; M.S., U.S. Naval Postgraduate School, 1961.

Donald Allen Still, Lieutenant Commander, U.S. Navy; Instructor in Oceanography; B.S., Oregon State College, 1950; Scripps Institution of Oceanography, 1955.

Charles Luther Taylor, Associate Professor of Meteorology (1954); B.S., Pennsylvania State Univ., 1942; M.S., 1947.

Warren Charles Thompson, Professor of Oceanography (1953); B.A., Univ. of Calif., at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas Agricultural and Mechanical College, 1953.

William van der Bijl, Associate Professor of Meteorology (1961); B.Sc., Free Univ. of Amsterdam, 1941; M.Sc., 1943; Ph.D., State Univ. Utrecht, 1952.

Jacob Bertram Wickham, Associate Professor of Oceanography (1951); B.S., Univ. of California, 1947; M.S., Scripps Institution of Oceanography, 1949.

*The year of joining the Postgraduate School Faculty is indicated in parenthesis.

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN METEOROLOGY AND OCEANOGRAPHY

BACHELOR OF SCIENCE

Subject	*Term Hours Required* B.S. in Meteorology
I Meteorology	
a. Descriptive	6
b. Dynamics	8
c. Physical	13
d. Synoptic	22
II Oceanography	
a. Descriptive	6
b. Dynamic	
c. Field and Lab	
III Electives	20
	—
	75

Electives may be chosen from any of I or II plus mathematics courses covering the following subjects: Probability and Statistics, Vector Analysis. Digital Computation, and Differential Equations. A research paper is required.

MASTER OF SCIENCE

Subject	*Term Hours Required* M.S. in Meteorology	M.S. in Physical Oceanography
I Meteorology		
a. Dynamic	15	
b. Physical	11	
c. Synoptic	7	
II Oceanography		
a. Descriptive		12
b. Physical		20
c. Field and Lab		6
III Electives	29	18
	—	—
	62	56

Electives may be chosen from any of I or II plus mathematics courses covering the following subjects: Probability and Statistics, Vector Analysis, Digital Computation, and Partial Differential Equations. At least 20 term hours must be A-level Meteorology and Oceanography courses with the remainder not less than B level. An acceptable thesis is required. B.S. in Meteorology or equivalent is prerequisite to M.S. in Meteorology.

METEOROLOGY

Mr 001D WEATHER CODES AND ELEMENTARY ANALYSIS (0-3). Designed to acquaint Environmental Science students with weather codes and observation, stressing utility and application and to introduce the essential elements of meteorological analysis. TEXTS: WBAN Manual for Synoptic Codes: WBAN Manual for Radiosonde Code; WBAN Manual for Upper Wind Code; International Cloud Atlas. PREREQUISITE: None.

Mr 010D METEOROLOGY (3-0). The principles of meteorology and the effects of weather phenomena on naval operations. Included topics: structure of the atmosphere; weather elements; the station model, pressure and winds; theory of air masses and fronts; tropical storms; sources of weather information; sea and swell condiitons; climatology and the principles of weather map analysis and forecasting. TEXT: Donn, *Meteorology with Marine Applications.* PREREQUISITE: None.

Mr 200C INTRODUCTION TO METEOROLOGY (3-0). A general course which treats descriptively the composition and vertical structure of the atmosphere, physical processes, general circulation, air masses, fronts, cyclones and anticyclones. TEXTS: Petterssen, *Introduction to Meteorology;* AMS *Glossary of Meteorology.* PREREQUISITE: None.

Mr 201C ELEMENTARY WEATHER-MAP ANALYSIS (0-9). Laboratory course taught in conjunction with Mr 211C. Practice in upper-air and surface analysis stressing basic techniques and continuity. TEXT: Same as Mr 211C. PREREQUISITES: Mr 200C and a knowledge of weather codes and observations.

Mr 202C WEATHER-MAP ANALYSIS (0-6). Laboratory course taught in conjunction with Mr 212C. Practice in sea-level and frontal analysis, graphical arithmetic, analysis of upper-air soundings, and vertical space/time cross sections. Introduces local forecasting techniques and mesoscale synoptic analysis. TEXT: Same as Mr 212C. PREREQUISITE: Mr 201C.

Mr 203C ANALYSIS AND FORECASTING OF OPERATIONAL WEATHER ELEMENTS (0-6). Laboratory course taught in conjunction with Mr 213B. Practice in objective and quantitative forecasting techniques on meso and synoptic scales; applications of meteorological satellite observations and numerical products. TEXT: Same as Mr 213B. PREREQUISITE: Mr 202C.

Mr 204B THE MIDDLE ATMOSPHERE (0-6). Laboratory course taught in conjunction with Mr 214B. Practice in analysis of contour, temperature and wind fields (jet stream and maximum-wind layer) and tropopause on vertical cross sections and constant pressure surfaces in upper tropopause and stratosphere (to 10 mb); vertical extrapolation techniques. TEXT: Same as Mr 214B. PREREQUISITE: Mr 203C.

Mr 205B UPPER-AIR AND SURFACE PROGNOSIS (0-6). Laboratory course taught in conjunction with Mr 215B. Practice in prognosis of upper-air and surface charts using current and classical methods. Practice in graphical techniques and local forecasting. TEXT: Same as Mr 215B. PREREQUISITE: Mr 204B.

Mr 206C NAVAL WEATHER SERVICE OPERATIONAL PROCEDURES (1-12). Instruction and laboratory practice in the operational functions and responsibilities of the Naval Weather Service activities ashore and afloat. TEXTS: Selected NavWeps, AWS and NWRF publications; departmental notes. PREREQUISITES: Mr 204B and Mr 205B.

Mr 208B TROPICAL AND SOUTHERN HEMISPHERE METEOROLOGY (1-5). Laboratory course associated with Mr 228B. Southern hemisphere analysis; contour (isobaric), streamline, and isotach analysis and forecasting with emphasis on tropical cyclones and meteorological satellite observations. TEXT: Same as Mr 228B plus Harding and Kotsch, Heavy Weather Guide; departmental notes. PREREQUISITES: Mr 215B and Mr 228B.

Mr 211C ELEMENTARY WEATHER-MAP ANALYSIS (3-0). Objectives and techniques of surface and upper-air analysis, including contours (isobars), isotherms and fronts. TEXTS: Berry, Bollay, and Beers, *Handbook of Meteorology;* departmental notes. PREREQUISITES: Mr 001D and Mr 200C.

Mr 212C INTRODUCTION TO WEATHER ELEMENTS (3-0). Continuation of Mr 211C. Structure and behavior of extratropical cyclones; graphical arithmetic; stability analysis and air masses; space/time cross sections; extended analyses. TEXTS: Same as Mr 211C plus the NAWAC Manual, departmental notes. PREREQUISITE: Mr 211C.

Mr 213B ANALYSIS AND FORECASTING OF OPERATIONAL WEATHER ELEMENTS (3-0). Continuation of Mr 212C. Objective and quantitative forecasting of hydrometeors, temperature and wind, with emphasis on observations from meteorological satellites and utilization of numerical products. TEXTS: Widger, Meteorological Satellites; various USN, AWS and ESSA publications, reprints, departmental notes. PREREQUISITE: Mr 212C.

Mr 214B THE MIDDLE ATMOSPHERE (3-0). Objectives and techniques of high-tropospheric (above 500 mb) and stratospheric (to 10 mb) analysis and prognosis, including jet stream, maximum-wind layer and tropopause. Synoptic climatology: interpolation and extrapolation of height, temperature and wind data. TEXTS: Riehl, *Jet Streams of the Atmosphere;* Craig, *The Upper Atmosphere;* various USN, AWS ESSA publications, reprints and departmental notes. PREREQUISITES: Mr 213B, Mr 301B or Mr 321A.

Mr 215B UPPER-AIR AND SURFACE PROGNOSIS (4-0). Qualitative and quantitative application of mechanisms of pressure change and kinematics to surface and upper-air prognosis (up to 500 mb) of height, thickness and temperature fields. Manually applied graphical and numerical techniques; extended forecasting by weather-type methods. TEXTS: Petterssen, Vol. I, *Weather Analysis and Forecasting;* NavWeps 50-1P-548, NAWAC Manual. PREREQUISITES: Mr 214B, Mr 302B or Mr 322A.

Mr 228B TROPICAL AND SOUTHERN HEMISPHERE METEOROLOGY (3-0). Tropical meteorology, especially climatology and synoptic models; Southern hemisphere synoptic meteorology with emphasis on the Antarctic. TEXT: Riehl, *Tropical Meteorology.* PREREQUISITE: Mr 301B or Mr 321A.

Mr 301B ELEMENTARY DYNAMIC METEOROLOGY I (4-0). The equations of motion; trajectories and streamlines; thermal wind; mechanism of pressure changes and kinematics of pressure systems. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology.* PREREQUISITES: Mr 200C, Mr 402C, PH 191D.

Mr 302B ELEMENTARY DYNAMIC METEOROLOGY II (4-0). A continuation of Mr 301B. Vorticity and circulation; dynamical forecasting by numerical methods; selected topics including fronts and frontogenesis. TEXT: Same as Mr 301B. PREREQUISITE: Mr 301B.

Mr 321A DYNAMIC METEOROLOGY I (3-0). The equations of motion; horizontal flow; geostrophic and gradient winds; vertical variation of wind and pressure systems; kinematics of pressure systems; continuity and tendency equations. TEXT: Same as Mr 301B. PREREQUISITES: Mr 413B, Ma 240C and Ma 261B concurrently.

Mr 322A DYNAMIC METEOROLOGY II (3-0). A continuation of Mr 321A. Circulation theorems, vorticity equation and applications, solution of hydrodynamic equations by (a) perturbation methods, (b) by numerical integration; barotropic and baroclinic models; fronts and frontogenesis. TEXT: Same as Mr 301B. PREREQUISITES: Ma 125B concurrently and Mr 321A.

Mr 323A DYNAMIC METEOROLOGY III (TURBULENCE AND DIFFUSION) (3-0). Viscosity and turbulence; equations of motion for viscous and turbulent flows; wind in the friction layers; diffusion of momentum, heat, water vapor, chemicals, etc.; diurnal temperature variation; air-mass transformation; statistical properties of turbulence. TEXTS: Same as Mr 301B plus Lumley and Panofsky, *The Structure of Atmosphere Turbulence.* PREREQUISITES: Mr 322A and PS 333B.

Mr 324A DYNAMICAL PREDICTION (3-3). The solution of the hydrodynamical equations for meteorological phenomena by analytical and numerical methods. Objective analysis. TEXT: Thompson, *Numerical Wecther Analysis and Prediction.* PREREQUISITES: Mr 323A and Ma 128B.

Mr 325A ENERGETICS OF THE GENERAL CIRCULATION (2-0). The equations for energy and momentum balance in the atmosphere; zonal and eddy energy; adiabatic heating and its conversion into kinetic energy. Models of the general circulation. Transport of enthalpy, momentum, kinetic energy, etc., using Fourier transforms. TEXTS: Pfeffer, *Dynamics of Climate;* departmental notes. PREREQUISITES: Mr 323A and Ma 128B.

Mr 335A THEORETICAL METEOROLOGY (3-0). Advanced topics in theoretical meteorology to fit the needs of the students. PREREQUISITE: Consent of the Instructor.

Mr 402C INTRODUCTION TO METEOROLOGICAL THERMODYNAMICS (3-2). A treatment of elementary thermodynamics and its application in meteorology, with particular emphasis on thermodynamic charts and diagrams. Theories of condensation and precipitation processes. Static stability and instability phenomena. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology.* PREREQUISITES: PH 191D and Ma 052D or equivalent.

Mr 403B INTRODUCTION TO MICROMETEOROLOGY (4-0). Properties of radiating matter in general; solar and terrestrial radiation and their effects on the temperature distribution; the heat budget; structure of the wind (in the friction layer) and its significance in turbulent transfer; air-mass modification; forecasting the micrometeorological variables and their use in diffusion from point and line sources. TEXT: Same as Mr 402C. PREREQUISITES: Mr 302B and PS 381C or equivalent.

Mr 410C METEOROLOGICAL INSTRUMENTS (2-2). Principles of design and operation of meteorological instruments used in naval meteorology with special emphasis on new developments and requirements. Application of electronic meteorological instruments used by the fleet meteorologist. TEXTS: Middleton and Spilhaus, *Meteorological Instruments;* selected papers and departmental notes. PREREQUISITES: Ma 052D or equivalent and PH 196C or equivalent.

Mr 412A PHYSICAL METEOROLOGY (3-0). Solar and terrestrial radiation; absorption, scattering and diffuse reflection of solar radiation; terrestrial radiation and the atmosphere radiation chart; applications to air-mass modification and minimum-temperature forecasting; heat budget of earth-atmosphere system. TEXTS: Same as Mr 402C; plus Fleagle and Businger, *An Introduction to Atmospheric Physics;* Craig, *The Upper Atmosphere.* PREREQUISITE: Mr 413B.

Mr 413B THERMODYNAMICS OF METEOROLOGY (3-2). The physical variables; equations of state; first law of thermodynamics; properties of gases; properties of water and moist air; theories of condensation and precipitation processes; thermodynamic diagrams; air-mass identification indices; geopotential determinations; altimetry; instability phenomena and criteria. TEXTS: Same as Mr 402C; departmental notes. PREREQUISITES: Ma 230D and PH 196C.

Mr 415B RADAR METEOROLOGY (2-0). Characteristics of radar sets; propagation of electromagnetic waves in standard and non-standard atmospheres; scattering by hydrometeors; attenuation; quantitative precipitation estimates; applications of radar in convective clouds, mesometeorology and larger-scale weather systems. TEXT: Battan, *Radar Meteorology.* PREREQUISITES: Mr 321A or Mr 301B; PS 333B or PS 381C.

Mr 420B UPPER-ATMOSPHERE PHYSICS (4-0). The fundamental laws of atmospheric flow; balloon and rocket research; sounding the atmosphere by acoustic and radio techniques; the ozonosphere; aerial tides and magnetic effects; solar, magnetic and ionospheric disturbances, meteors, cosmic rays and satellites. TEXTS: Massey and Boyd, *The Upper Atmosphere;* Fleagle and Businger, *An Intro-*

duction to Atmosphere Physics; departmental notes. PREREQUISITES: PH 365C, PH 541B and PH 671B.

Mr 422A THE UPPER ATMOSPHERE (4-0). The composition of the upper atmosphere; temperature and wind structure as deduced from several lines of observation; variations of electron concentration in the ionosphere; terrestrial magnetic variations; solar disturbances and their effects in the upper atmosphere; the aurora. TEXTS: Same as Mr 420B, plus Goody, *The Physics of the Stratosphere.* PREREQUISITE: Mr 323A.

Mr 510C CLIMATOLOGY (2-0). The distribution with respect to season, geography, and orography of the major meteorological elements. Definitions of climatic zones and types according to Koeppen and their meteorological descriptions; micrometeorology; regional climatology of the oceans; climatology as a tool in objective forecasting. TEXT: Landsberg, *Physical Climatology.* PREREQUISITE: Mr 200C.

Mr 521B SYNOPTIC CLIMATOLOGY (2-2). The study and statistical evaluation of meteorological elements in relation to the macro- and microclimates; the Koeppen system; methods of presenting climatological data to non-meteorological personnel; construction and use of forecast registers; climatological techniques in objective forecasting. TEXT: Landsberg, *Physical Climatology.* PREREQUISITES: Mr 200C and PS 381C or PS 333B concurrently.

Mr 600C INTRODUCTORY SYNOPTIC METEOROLOGY (2-4). Designed to acquaint oceanography students with weather codes and observations; techniques of synoptic analysis with emphasis on surface charts; determination of meteorological parameters for application to problems in oceanography. TEXTS: Same as Mr 010D. PREREQUISITES: None.

Mr 810B SEMINAR IN METEOROLOGY AND OCEANOGRAPHY (2-0). Students present original research or prepare summaries of recent findings in the fields of meteorology or oceanography and present synopses for group discussion. PREREQUISITES: Mr 422A or Mr 403B, Mr 521B.

OCEANOGRAPHY

Oc 110C INTRODUCTION TO OCEANOGRAPHY (3-0). A survey course treating physical and chemical properties of sea water, marine biology, and submarine geology; the heat budget of the oceans; water masses and the general circulation; currents, waves, and tides. TEXT: Pickard, *Descriptive Physical Oceanography.* PREREQUISITE: None.

Oc 201B OCEAN WAVES AND TIDES (3-1). The properties of waves of small amplitude in all water depths; wave spectra and analysis; refraction; near-shore circulations; tide-producing forces, tides and tidal currents, and analysis of tidal records; internal waves. TEXT: Departmental notes. PREREQUISITES: Oc 110C and PH 196C, or equivalent.

Oc 211A OCEAN WAVES (3-0). Theory of surface waves of small amplitude; approximations for finite amplitudes. Internal waves in stratified water on a rotating earth. Wind wave spectra. TEXTS: Kinsman, *Wind Waves.* Defant, *Physical Oceanography II.* PREREQUISITES: Oc 251A or Mr 321A concurrently.

Oc 212A TIDES AND TIDAL CURRENTS (3-0). Theories of the astronomical tides; the tide-producing forces; tidal oscillations in ocean basins; geographical variation of the tides; analysis and prediction of tides; tidal datum planes. Meteorological tides. Seiches. Tidal currents. TEXTS: Defant, *Physical Oceanography;* Marmer, *Tidal Datum Planes.* PREREQUISITE: Oc 211A.

Oc 213A SHALLOW-WATER OCEANOGRAPHY (3-1). Transformation of waves in shoal water; nearshore water circulation and littoral drift; beaches and coasts. TEXTS: Weigel, *Oceanographical Engineering;* H.O. 234, *Breakers and Surf.* PREREQUISITES: Oc 110C and Oc 610B or Oc 611A (one of the latter may be taken concurrently).

Oc 220B DESCRIPTIVE OCEANOGRAPHY (3-0). Properties of sea water; water masses, currents and three-dimensional circulation in all oceans; distribution of temperatures, salinity and oxygen; temperature-salinity relationship. TEXTS: Sverdrup, Johnson and Fleming, *The Oceans;* selected references. PREREQUISITE: Oc 110C.

Oc 241B ELEMENTARY DYNAMIC OCEANOGRAPHY (3-0). The equations of motion; geostrophic currents and their calculation by the indirect method; inertial motion; vorticity; frictional effects and wind-driven currents; dynamic models of the ocean circulation. TEXTS: von Arx, *Introduction to Physical Oceanography;* Stommel, *The Gulf Stream.* PREREQUISITES: Oc 110C and Mr 302B.

Oc 250B ENVIRONMENTAL THERMODYNAMICS (3-0). Basic thermodynamics; applications to an ideal gas; radiation in the atmosphere and the sea. TEXTS: Haltiner and Martin, *Dynamical and Physical Meteorology;* Defant, *Physical Oceanography.* PREREQUISITES: PH 196C, Ma 230D.

Oc 251A DYNAMIC OCEANOGRAPHY I (3-0). The equations of relative motion, incompressible flow, energy conservation, vorticity; special cases of frictionless flow in the sea, particularly the "dynamic method" for calculation of the geostrophic current. TEXTS: Haltiner and Martin, *Dynamical and Physical Oceanography;* Stommel, *The Gulf Stream;* Fomin, *The Dynamical Method.* PREREQUISITES: Oc 110, Ma 261.

Oc 252A DYNAMIC OCEANOGRAPHY II (3-0). Turbulence and diffusion in the ocean; boundary-layer flow; the wind-driven circulation; topographical influences on currents. TEXTS: Defant, *Physical Oceanography;* Stommel, The Gulf Stream. PREREQUISITE: Oc 251A or Mr 321A.

Oc 253A DYNAMIC OCEANOGRAPHY III (3-0). Nonlinear theories of the wind-driven circulation; the equation of state; convection cells; general treatment of thermal motions; theories of the thermocline and the deep thermohaline circulation. TEXTS: Defant, *Physical Oceanography;* Stommel, *The Gulf Stream.* PREREQUISITE: Oc 252A.

Oc 260B SOUND IN THE OCEAN (3-0). The oceanographic factors involved in sound ranging, including thermal gradients, sound absorption properties of sea water, sound scattering and reflection characteristics of the sea surface and sea floor, scattering properties of marine organisms, and ambient noise arising in the sea. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics (2nd ed.)*; departmental notes. PREREQUISITES: Oc 110C and PH 196C or equivalent.

Oc 320B INTRODUCTION TO GEOLOGICAL OCEANOGRAPHY (3-2). Physiography of the sea floor, especially continental shelves and slopes, submarine canyons, coral reefs, and the deep-sea floor; character and distribution of sediments and rates of deposition; structure and origin of the ocean basins. TEXTS: Shepard, *Submarine Geology (2nd ed.)*; Gilluly, Waters and Woodford, *Principles of Geology (2nd ed.)*. PREREQUISITE: Oc 110C.

Oc 340A MARINE GEOPHYSICS (2-0). Geophysical measurements of the earth; gravity, magnetism and seismicity of the oceans; acoustical studies of the sea floor; earth's crust beneath the ocean basins. TEXTS: Dobrin, *Geophysical Prospecting (2nd ed.)*; and selected publications. PREREQUISITE: Oc 320B.

Oc 420B INTRODUCTION TO BIOLOGICAL OCEANOGRAPHY (3-3). General biological principles; the sea as an environment for life; major plant and animal groups in the sea; plankton and food cycles; primary productivity; boring and fouling organisms; bioacoustics, bioluminescence and deep scattering layers; dangerous marine organisms; physiology of shallow water diving. Laboratory work and field trips dealing with marine organisms. TEXTS: Russell and Yonge, *The Seas*; Hedgepeth, *Seashore Life of the San Francisco Bay Region and the Coast of Northern California*. PREREQUISITE: Oc 110C.

Oc 520B INTRODUCTION TO CHEMICAL OCEANOGRAPHY (3-2). Basic chemistry of solutions; chemical composition of the oceans (dissolved solids, gases, nutrients, etc.); distribution of constituents in the ocean; analytical methods used in chemical oceanography; carbonate, nutrient and other cycles in the sea: desalinization; corrosion; geochemistry. TEXTS: Strickland and Parsons, *Methods in Chemical Oceanography*. PREREQUISITES: Oc 110C and either CH 001D or Ch 106D, or equivalent.

Oc 601B OCEAN WAVE FORECASTING (3-6). The generation, propagation and attenuation of surface wind waves; their spectral and statistical properties; wave observations and analysis of data; forecasting wind waves from meteorological data. TEXT: *H.O. Pub.* 603. PREREQUISITE: Oc 201B taken concurrently.

Oc 610B OCEAN WAVE FORECASTING (3-0). The generation and propagation of ocean wind waves; their spectral and statistical properties; wave observations and analysis of data; forecasting wind waves from meteorological data; applications to operations at sea. TEXTS: *H.O.* 603; departmental notes. PREREQUISITES: Oc 211A or Oc 201B.

Oc 611A OCEAN WAVE FORECASTING (3-6). Same as Oc 601C with more rigorous treatment of wave generation and application of digital methods to forecasting. TEXTS: *H.O. Pu.* 603; Kinsman, *Wind Waves*. PREREQUISITE: Oc 211A, PS 333B.

Oc 612B ARCTIC OCEANOGRAPHY (3-0). Marine geography of the Arctic; sea ice observations, formation, properties, growth, deformation and disintegration; sea ice drift due wind and currents. TEXT: *Sea Ice Manual* (unpublished). PREREQUISITES: Oc 201B and Oc 241B.

Oc 613B ARCTIC OCEANOGRAPHY (3-4). Same as Oc 612B with laboratory exercises in forecasting sea ice drift, growth and disintegration. TEXT: *Sea Ice Manual* (unpublished). PREREQUISITES: Oc 201B and Oc 241B.

Oc 615B OCEANOGRAPHIC FORECASTING I (3-4). Space/time distributions of mixed-layer thickness; diurnal variations in the vertical temperature structure. Analysis of charts of surface temperature, mixed-layer depth, temperature gradients and currents; synoptic forecasting of these elements in the laboratory. TEXTS: Laevastu, *Factors Affecting the Temperature of the Surface of the Sea*; Selected publications. PREREQUISITES: Oc 220B; Mr 201C, or Mr 600C.

Oc 617B OCEANOGRAPHIC FORECASTING II (3-4). Reviews variation of ocean thermal structure and processes involved; techniques in forecasting thermal structure illustrated by laboratory exercises; practice in developing forecast methods from air and sea data. Applications of oceanography in ASWEPS and other Navy operations; radar propagation. TEXTS: Selected references. PREREQUISITES: Oc 260B and Oc 615B.

Oc 619B OCEANOGRAPHIC FORECASTING (3-4). Reviews variation of ocean thermal structure and processes involved; space-time distributions of mixed-layer thickness; analysis of oceanographic charts of surface temperature, temperature gradients, currents; synoptic forecasting of these elements. Applications in ASWEPS and other Navy operations. TEXTS: Laevastu, *Factors Affecting the Temperature of the Surface Layer of the Sea*; selected publications. PREREQUISITES: Oc 220B, Oc 260B and Mr 201C.

Oc 700B OCEANOGRAPHIC INSTRUMENTS AND OBSERVATIONS (2-2). Theory and operation of oceanographic instruments; instructions in recording oceanographic observations, measurements and samples on log sheets. TEXTS: H.O. 607; selected references. PREREQUISITE: Oc 220B.

Oc 710B OCEANOGRAPHIC AND METEOROLOGICAL INSTRUMENTS (4-2). Principles of design and field use of primary meteorological and oceanographic instrumentation; survey of recent developments in instrumentation and problems in environmental measures. TEXTS: Middleton and Spilhaus, *Meteorological Instruments*, H.O. 607; selected references, departmental notes. PREREQUISITES: Ma 052D or equivalent and PH 196C or equivalent.

Oc 720B FIELD EXPERIENCE IN OCEANOGRAPHY (0-4). Field operation of instruments to accomplish a comprehensive oceanographic survey, processing and storage of the data and samples, and interpretation of the results. TEXTS: H.O. 607; selected references. PREREQUISITE: Oc 220B.

Oc 810B SEMINAR IN OCEANOGRAPHY (2-0). Students in the environmental sciences curricula conduct original research or summarize the literature in oceanography concerning a selected topic, and during their last term present their results for group discussion. PREREQUISITE: None.

Oc 820A SPECIAL TOPICS IN OCEANOGRAPHY (3-0). Lectures or seminars on topics in oceanography not contained in other courses, including a review by the student of recent research papers of significance; course taken by students in the environmental sciences curricula toward the end of their program. TEXT: Selected publications. PREREQUISITE: Consent of Instructor.

Oc 830A SPECIAL TOPICS IN OCEANOGRAPHY (3-0). Lectures or seminars on specialized subjects in oceanography of particular interest to students enrolled in curricula other than those in the environmental sciences; taken toward the end of the student's program. TEXT: Selected publications. PREREQUISITE: Consent of Instructor.

Oceanographic Studies Under Environmental Sciences Curriculum

DEPARTMENT OF NAVAL WARFARE

Carl Calvin Schmuck, Commander, U.S. Navy, Chairman; Associate Professor of Operational Planning; B.S.M.E., Purdue Univ., 1939.

James Roy Bell, Commander, U.S. Navy; Instructor in Tactics and CIC.

Wayne Chester Bender, Lieutenant, U.S. Navy; Instructor in Navigation; B.A., State Teachers College, Millersville, Pennsylvania, 1957.

Harry William Bergbauer, Jr., Lieutenant Commander, U.S. Navy; Instructor in Anti-Air Warfare; B.S., U.S. Naval Academy, 1953.

Richard Franklin Campbell, Lieutenant Commander, U.S. Navy; Instructor in Missiles and Space Operations; B.A., Ohio State Univ., 1960.

Thomas Hanford Cathcart, Lieutenant, U.S. Navy; Instructor in Tactics and CIC; B.A., Yale Univ., 1960.

Sheldon Drews, Lieutenant Commander, U.S. Navy; Assistant Professor of Aeronautical Engineering and Safety; B.S. U.S. Naval Academy, 1952; U.S. Naval Postgraduate School, 1960; M.S., Massachusetts Institute of Technology, 1961.

George William Fairbanks, Commander, U.S. Navy; Instructor in Damage Control.

Edward Dree Jackson, Commander, U.S. Navy; Instructor in Operational Planning and Naval Aviation Survey; B.A.E., Univ. of Mississippi, 1958.

James Kenneth Jobe, Commander, U.S. Navy, Instructor in Leadership; A.B., George Washington Univ., 1963; M.A., 1964.

James Robert Johnson, Lieutenant Commander, Supply Corps, U.S. Navy; Assistant Professor of Logistics and Naval Supply; B.S., Univ. of Michigan, 1951; M.B.A., 1953.

Nathan Hughes King, Commander, U.S. Navy; Instructor in Naval Tactical Data System.

Glenn Elwood Kitzelman, Lieutenant Commander, U.S. Navy; Instructor in Celestial Navigation, Piloting and Seamanship; B.A., U.S. Naval Postgraduate School, 1962.

Charles William Learned, Jr., Lieutenant Commander, U.S. Navy; Instructor in Marine Nuclear Propulsion and Marine Engineering; B.S., U.S. Naval Academy, 1954.

Thomas Leigh Lindsay, Lieutenant Commander, U.S. Navy; Assistant Professor of Aeronautical Engineering and Safety; B.S., Univ. of Notre Dame, 1954; M.S., Massachusetts Institute of Technology, 1961.

Alan J. Margeson, Lieutenant Commander, U.S. Navy; Instructor in Anti-Submarine Warfare; B.S., Tufts Univ., 1952.

William Theodore Sorensen, Commander, U.S. Navy; Instructor in Naval Intelligence, and Personal Affairs.

Boone Case Taylor, Commander, U.S. Navy; Instructor in Anti-Submarine Warfare; B.A., U.S. Naval Academy, 1948; M.S., George Washington Univ., 1965.

Lester Charles Wible, Assistant Professor of Aviation Accident Prevention and Crash Investigation; B.S., U.S. Naval Academy, 1945.

NAVAL WARFARE

NW 101C TACTICS AND COMBAT INFORMATION CENTER (5-0). Shipboard tactical doctrine and procedures, and functions and organization of CIC. Course includes basic maneuvering board fundamentals, and introduction to operational communications doctrine, organization, and command responsibilities. Usual basis for exemption: Qualified Destroyer Type OOD underway, or CIC School of 4 weeks or longer or qualified CIC officer. Foreign officers take NW 191D.

NW 103C ANTI-SUBMARINE WARFARE (5-0). Surface, air, and sub-surface ASW doctrine. Submarine operating characteristics, offensive and defensive tactics, and weapons. ASW search, detection and attack procedures, weapons systems, and coordinated ASW operations. PREREQUISITE: NW 101C (or exempt therefrom). USUAL BASIS FOR EXEMPTION: Recent completion of: Coordinated ASW Course at NORFOLK, SAN DIEGO, LONDONDERRY, or HALIFAX, or ASW Officer or CO/XO Anti-Submarine Course at Fleet Sonar School. Foreign Officers take NW 193D.

NW 105C ANTI-AIR WARFARE (4-0). Study of AAW Tactical doctrine and capabilities of U.S. Naval Forces; concepts and procedures for Fast Carrier Strike Force AAW operations; future developments in AAW including command and control, weapons and communications. PREREQUISITES: NW 101C and NW 303C or exemptions therefrom.

NW 162C COMMUNICATIONS ORGANIZATION (5-0). Organization and functions of the Department of Defense Communication Systems including Command and Control functions. A study of the National Communications System, Defense Communications Systems and the complete Naval Communications Systems including the Naval Security Group. Individual missions and/or integration of the systems are analyzed.

NW 163C OPERATIONAL AND COMMUNICATION PLANNING (4-0). Material covers the Navy Planing System in general, including the Estimate of the Situation, Development of the Plan and the Preparation of the Directive. Emphasis given to the communication aspects of planning.

NW 164C COMMUNICATIONS ADMINISTRATION AND PROCEDURES I (5-0). Basic organization of unit including departmental organization. Communications Center functions with emphasis on Message Center handling and/or routing by semi-auto or automatic methods including precedence procedures. Security in general, both physical and electrical, is studied along with the Registered Publication System (RPS).

NW 165C COMMUNICATIONS ADMINISTRATION AND PROCEDURES II (3-0). A continuation of NW 164C. PREREQUISITE: NW 164C.

NW 166C COMMUNICATION EQUIPMENT AND SYSTEM APPLICATION I (4-0). A "hardware" course which includes all equipment from basic primary source to sophisticated antennas and transmission lines. Synthesized transmitters and receivers, terminal equipment and microwave relay equipment usage. Frequency compatibility and management and use of propagation prediction charts. Ancillary equipment associated with transmission and/or reception of electromagnetic energy is also studied.

NW 167C COMMUNICATION EQUIPMENT AND SYSTEM APPLICATION II (3-2). A continuation of NW 166C, operation and adjustment of teletypewriter, facsimile, transmitter and receiver equipments in the laboratory. PREREQUISITE: NW 166C.

NW 168C SPECIAL COMMUNICATIONS TOPICS (CLASSIFIED) (5-0). Crypto Systems and environmental control are studied. Special Communication Systems for either multiple or singular purpose are discussed. Problems and/or solutions associated with compatibility, hardward procurement, and installation procedures are studied.

NW 191D TACTICS AND COMBAT INFORMATION CENTER (5-0). Shipboard tactical doctrine and procedures, and functions and organization of CIC. Foreign Officers course.

NW 193D ANTI-SUBMARINE WARFARE (3-0). Surface, air, sub-surface ASW doctrine. Submarine operating characteristics, offensive and defensive tactics, and weapons. ASW search, detection and attack procedures, and weapons systems. PREREQUISITE: NW 191D (or exempt therefrom). Foreign Officers course.

NW 201C OPERATIONAL PLANNING (2-0). Purpose and procedure for the Estimate of the Situation, the Development of the Plan, and the Preparation of the Directive (OpOrder); including the preparation of each under supervision. Staff organization. The Navy Planning System. USUAL BASIS FOR EXEMPTION: Naval War College Correspondence course "Strategy and Tactics (Part I)" or "Operational Planning and Staff Organization."

NW 208C AVIATION ACCIDENT PREVENTION AND CRASH INVESTIGATION (4-2). This course consists of (a) a study of all existing Navy Department instructions covering all aspects of accident investigation and reporting procedures, (b) methods and techniques of accident investigation, (c) implementation and use of a prevention program, and (d) aero medicine lectures on physiological factors in flight. PREREQUISITE: NW 209C or may be taken concurrently with NW 209C.

NW 209C AERO ENGINEERING SAFETY (5-2). A survey of aeronautical engineering for the aviator and the Aviation Safety Officer. Material covered includes basic aerodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations. PREREQUISITES: Ma 031D and PH 008D, or equivalents.

NW 292D AMPHIBIOUS OPERATIONS (4-0). Basic Orientation to include doctrine, planning and fundamentals of troop organization, helicopter operations, embarkation, ship-to-shore movement, and coordination of supporting arms. USUAL BASIS FOR EXEMPTION: Completion of a Marine Corps or Amphibious Forces School and/or a tour of duty with an amphibious staff at PhibRon level or higher. Foreign officer course.

NW 293D NAVAL AVIATION SURVEY (3-0). Organizational structure and command relationship of entire naval aviation system; research and development, procurement, testing and evaluation of naval aircraft; specific discussions based on latest material available on missions, tasks, current and projected equipment, as well as present and future employment of aircraft squadrons, carriers and seaplane tenders. USUAL BASIS FOR EXEMPTION: Extensive aviation duty. Foreign officer course.

NW 303C MISSILES AND SPACE OPERATIONS (4-0). Principles of guidance and propulsion, operational capabilities and limitations of guided missile systems. Orientation in space technology, problems and potentialities of operations in outer space. USUAL BASIS FOR EXEMPTION: Equivalent experience or educational background. Foreign officers take NW 393D.

NW 304C INTRODUCTION TO NAVAL TACTICAL DATA SYSTEM (3-0). A brief review of number systems with concentration in octal and binary operations. An introduction to Boolean algebra and logic circuitry of modern computers. Modern high-speed digital computer principles. An introduction to operational programming for NTDS. A comprehensive coverage of the Naval Tactical Data System and its associated elements, its capabilities and limitations as planned for CVA(N), CG(N) and DLG types.

NW 391D ORDNANCE-WEAPON SYSTEMS (3-0). A survey of the fields of surface ordnance, including guns, ammunition, and associated fire control systems. An analysis of weapon systems capabilities and limitations. Foreign officers course.

NW 393D MISSILES AND SPACE OPERATIONS (3-0). Principles of guidance and propulsion. Orientation in space technology, problems and potentialities of operations in outer space. Foreign officers course.

NW 395D MINE WARFARE (3-0). Fundamentals of mine laying and mining planning. Principles of mine countermeasures operations, planning, and harbor defense. Foreign officers course.

NW 401C LEADERSHIP AND ADMINISTRATION (3-0). The improvement of Naval Leadership by broadening the line officer's knowledge and understanding of the following topics: methods and techniques of enlisted personnel administration; applications of the principles of management to the naval unit; philosophy of authority and responsibility with major emphasis on the principles of effective naval leadership. Instruction methods emphasize individual study projects and group study discussion.

NW 403C CELESTIAL NAVIGATION (3-0). The theory and practice of celestial navigation as applicable to the navigator's work at sea. Included topics: introduction to nautical astronomy; the use of the nautical almanacs and the H. O. 214; the applications of celestial navigation. Practical work covers the navigator's day's work at sea.

NW 404C LOGISTICS AND NAVAL SUPPLY (3-0). The initial phase of the course stresses the importance of military logistics to our national security. Topics covered are: the fundamental elements of the logistics process; the planning, programming, and organizational aspects of logistical administration; the budget process; and joint logistical procedures. The final phase of the course emphasizes naval logistics and its relationship to combat readiness. Topics included are: the Navy Supply System; the role of bases, mobile support, and the operating unit in naval logistics; and logistics management at the unit command level.

NW 405D PERSONAL AFFAIRS (3-0). The fundamentals of personal estate planning. Included topics: government benefits; life insurance and general insurance; budgeting and banking; borrowing; real estate; securities; wills, trusts, and related legal matters.

NW 407D NAVAL INTELLIGENCE (3-0). An overview of intelligence functions. Included topics: nature of intelligence; development of modern intelligence; the role of intelligence in planning national policy and military strategy; the rise of Russia and Communism as international forces; the intelligence cycle, including the line officer's role in intelligence collection; employment of intelligence by operational commanders; counterintelligence.

NW 408C SEAMANSHIP AND MARINE PILOTING (3-2). The fundamentals of seamanship as applicable to the responsibilities and duties assigned to the commanding officer of a naval vessel. Practical aspects of shipboard navigation, including marine piloting, radar and loran navigation. Practical work covers the use of hydrographic publications and performance of chart work. USUAL BASIS FOR EXEMPTION: Successful completion of USNA, NROTC, OCS or equivalent course; or previous assignment as navigator (assistant navigator of a large ship) for one year.

NW 502C DAMAGE CONTROL AND ATOMIC BIOLOGICAL CHEMICAL WARFARE DEFENSE (4-0). Fundamentals of ship construction and stability, stability calculations and analysis, damage control systems and organization, repair of damage; effects of ABC weapons, ABC detection, decontamination and personnel protection; disaster control ashore. USUAL BASIS FOR EXEMPTION: Completion of 10 weeks "Officers' Basic Damage Control" Course, or completion of correspondence courses "Practical Damage Control" (NAVPERS 10936), "Theoretical Damage Control" (NAVPERS 10937), and "Radiological Defense" (NAVPERS 10771).

NW 503C MARINE NUCLEAR PROPULSION (2-0). An introduction to nuclear power plants of possible use in marine propulsion. Includes principles of operation, fuels and materials, limitations and economy of various reactors, and a brief description of reactor power plants currently in use.

NW 591D MARINE ENGINEERING (4-0). Shipboard steam and diesel main propulsion plants and auxiliaries, shipboard electrical distribution, miscellaneous naval auxiliary machinery, and organization and administration of shipboard engineering department. USUAL BASIS FOR EXEMPTION: Qualification as Engineering Officer of the Watch of a steam-propelled ship. Foreign officer course.

AVIATION SAFETY OFFICER PROGRAM

The following listed courses comprise the Aviation Safety Officers Program and are available only to those officers so ordered by the Chief of Naval Personnel. All courses are taken simultaneously during one term.

NW 610C AERO ENGINEERING CAFETY (6-0). A survey of aeronautical engineering for the aviator and the Aviation Safety Officer. Material covered includes basic aerodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations. (Includes mathematics review.)

NW 620C AVIATION ACCIDENT PREVENTION AND CRASH INVESTIGATION (4-0). This course consists of (a) a study of all existing Navy Department instructions covering all aspects of accident investigation and reporting procedures, (b) methods and techniques of accident investigation, and (c) implementation and use of a prevention program.

SP 630C ART OF PRESENTATION (2-0). A study of principles of speaking with visual aids, with practice in preparing presentations. The course is especially designed for the Aviation Safety Program.

GV 640C AVIATION LAW (1-0). A study of Federal and State laws and regulations relating to military aviation, designed especially for the Aviation Safety Program.

PY 650C PSYCHOLOGY IN ACCIDENT PREVENTION AND INVESTIGATION (4-0). A study of logical and psychological principles and practices useful in developing mental efficiency and emotional strength, designed especially for the Aviation Safety Program.

NW 660C AVIATION PHYSIOLOGY (2-0). A review of basic fundamentals of physiology with emphasis on the circulatory and respiratory systems with the objective of understanding the principles associated with the physiological stresses encountered in aviation. The role of the squadron flight surgeon in the squadron training program and his duties in aviation accident prevention, investigation and reporting.

DEPARTMENT OF OPERATIONS ANALYSIS

Jack Raymond Borsting, Professor of Operations Research, Chairman (1959); B.A., Oregon State Univ., 1951; M.A., Univ. of Oregon, 1952, Ph.D., 1959.

Alvin Francis Andrus, Associate Professor of Operations Research (1963); B.A., Univ. of Florida, 1957; M.A., 1958.

Donald R. Barr, Assistant Professor of Operations Research (1966); B.A., Whittier College, 1960; M.S., Colorado Univ., 1962; Ph.D., 1965.

Robert Neagle Forrest, Associate Professor of Operations Research (1964); B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

Carl Russell Jones, Associate Professor of Operations Research (1965); B.S., Carnegie Institute of Technology, 1956; M.B.A., Univ. of Southern California, 1963; Ph.D., Claremont Graduate School, 1965.

Harold Joseph Larson, Associate Professor of Operations Research (1962); B.S., Iowa State Univ., 1956; M.S., 1957; Ph.D., 1960.

Glenn Frank Lindsay, Assistant Professor of Operations Research (1965); B.Sc., Oregon State Univ., 1960; M.Sc., The Ohio State Univ., 1962; Ph.D., 1966.

Alan Wayne McMasters, Assistant Professor of Operations Research (1965); B.S., Univ. of California, 1957; M.S., 1962; Ph.D., 1966.

Paul Robert Milch, Assistant Professor of Operations Research (1963); B.S., Brown Univ., 1958; Ph.D., Stanford Univ., 1966.

Samuel Howard Parry, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor in Operations Research (1964); B.I.E., Georgia Institute of Technology, 1963; M.S., Northwestern Univ., 1964.

Stephen Michael Pollock, Assistant Professor of Operations Research (1965); B.E.P., Cornell Univ., 1958; M.S., Massachusetts Institute of Technology, 1960; Ph.D., 1964.

Rorert Richard Read, Associate Professor of Operations Research (1961); B.S., Ohio State Univ., 1951; Ph.D., Univ. California, 1957.

David Alan Schrady, Assistant Professor of Operations Research (1965); B.S.M.S., Case Institute of Technology, 1961; M.S.O.R., 1963; Ph.D., 1965.

Rex Hawkins Shudde, Associate Professor of Operations Research (1962); B.S., B.A., Univ. of California at Los Angeles, 1952; Ph.D., Univ. of California, 1956.

Roger Glenn Schroeder, Lieutenant Junior Grade, U.S. Navy, Assistant Professor of Operations Research (1965); B.S., Univ. of Minnesota, 1962; M.S.I.E., 1963; Ph.D., Northwestern Univ., 1966.

Gary Allen Tuck, Assistant Professor of Operations Research (1966); B.A., Univ. of Oklahoma, 1955; M.S., 1964; Ph.D., 1965.

Walter Max Woods, Associate Professor of Operations Research (1961); B.S., Kansas State Teachers College, 1951; M.S., Univ. of Oregon, 1957; Ph.D., Stanford Univ., 1961.

Peter William Zehna, Associate Professor of Operations Research (1961); B.A., Colorado State College, 1950; M.A., 1951; M.A., Univ. of Kansas, 1956; Ph.D., Stanford Univ., 1959.

Hans Jacob Zweig, Associate Professor of Operations Research (1965); B.A., Univ. of Rochester, 1949; M.A., Brown Univ., 1951; Ph.D., Stanford Univ., 1963.

*The year of joining the Postgraduate School faculty is indicated in parenthesis.

DEPARTMENTAL REQUIREMENTS FOR DEGREE IN OPERATIONS RESEARCH BACHELOR OF SCIENCE

The basic requirement for the degree Bachelor of Science with major in Operations Research consists of a minimum of 64 term hours in residence at the Postgraduate School and including at least:

a. 24 term hours of Operations Research
b. 15 term hours of Probability and Statistics
c. 10 term hours of mathematics beyond elementary Calculus
d. 10 term hours of upper division Physical Science, Engineering, or Management courses.

The degree of Bachelor of Science with major in Operations Research will be granted to a student who has successfully completed the above requirements and can demonstrate that he has met the general requirements of the Naval Postgraduate School for a Bachelor of Science degree.

MASTER OF SCIENCE IN OPERATIONS RESEARCH

In order to qualify for the degree Master of Science in Operations Research in accordance with the requirements listed below, a student must first meet the requirements for the degree Bachelor of Science with major in Operations Research. Specific course requirements include a minimum of 48 term hours of A and B level courses of which:

a. At least 18 term hours must be in A level Operations Research courses including: Linear Programming, Dynamic Programming and Queueing Theory.
b. At least 12 term hours must be in advanced physics eourses.
c. At least one of the sequences of elective courses recommended by the Department of Operations Analysis.

In addition a student must submit a thesis on a subject approved by the Department of Operations Analysis and demonstrate that he has met the general requirements of the Naval Postgraduate School for a Master of Science degree.

OPERATIONS ANALYSIS

OA 101C ELEMENTS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-1). An introductory course primarily for students in the Engineering Science Curriculum. Topics covered include: nature, origin, and contemporary status of operations analysis; problem formulations, measures of effectiveness; brief introduction to linear programming, game theory, and system reliability. TEXTS: McCloskey and Trefethen, *Operations Research for Managements*, Vols. I and II; Sasieni, *Operations Research Methods and Problems;* Instructor's Notes. PREREQUISITE: PS 311C.

OA 111B PRINCIPLES OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-2). An introductory course, primarily for students in the Management Data Processing Curriculum. The definition of operations and systems analysis and its relation to management science. Topics include: Linear Programming, Game Theory, Reliability Theory, and Dynamic Programming. TEXTS: McCloskey and Trefethen, *Operations Research for Management*, Vols. I and II; Blackett, *Studies of War;* Gass, *Linear Programming;* Williams, *The Compleat Strategyst;* Lloyd and Lipow, *Reliability;* Bellman and Dreyfus, *Applied Dynamic Programming;* Roberts, *Mathematical Methods in Reliability Engineering.* PREREQUISITES: Ma 140B or its equivalent; PS 315C or its equivalent; PS 316B or its equivalent (may be taken concurrently).

OA 112A ADVANCED METHODS IN OPERATIONS ANALYSIS (4-0). A continuation of OA 111B. A survey of such techniques as queueing theory, inventory control, simulation and Monte Carlo methods; computer gaming, PERT and CPM, and a selected case study in systems analysis. TEXTS: Saaty, *Elements of Queueing Theory;* Sasieni, Yaspan, and Friedman, *Operations Research — Methods and Problems;* Moder and Phillips, *Project Management with CPM and PERT.* PREREQUISITES: OA 111B, and a second course in probability and statistics to be taken concurrently.

OA 121A PRINCIPLES OF OPERATIONS ANALYSIS (4-1). The nature, origin, and contemporary status of operations analysis; fundamental concepts with special emphasis on applications; introduction to game theory, search theory, linear programming, and other advanced techniques. TEXTS: Morse and Kimball, *Methods of Operations Research;* McCloskey and Trefethen, *Operations Research for Management*, Vols. I and II; *Gass, Linear Programming;* Hitch and McKean, *The Economics of Defense in the Nuclear Age;* Williams, *The Compleat Strategyst;* Koopman, *Search and Screening.* PREREQUISITES: PS 321B and PS 322A.

OA 131B METHODS OF OPERATIONS RESEARCH & SYSTEMS ANALYSIS (4-0). This course is an introduction to the technique of Operations Research and Systems Analysis, primarily for students in the technical curricula. The primary emphasis of the course will be on problem formulation using the techniques of operations analysis and management science. The use of digital computer as an aid to problem solution will be emphasized throughout. PREREQUISITES: PS 351B, MN 310C.

OA 141B FUNDAMENTALS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-1). The role of operations analysis in the solution of military problems. Measures of effectiveness. Special techniques such as search theory, game theory and linear programming. TEXTS: McCloskey and Trefethen, *Operations Research for Management*, Vols. I and II; Gass, *Linear Programming;* Hitch and McKean, *The Economics of Defense in the Nuclear Age;* Williams, *The Compleat Strategyst;* Koopman, *Search and Screening.* PREREQUISITE: PS 321B.

OA 151B RELIABILITY ENGINEERING AND SYSTEMS ANALYSIS (3-0). Elements of life testing plans, point and interval estimates of systems reliability. Elements of systems analysis pertaining to redundancy, maintainability, spares, and preventative maintenance policies. TEXTS: To be announced. PREREQUISITE: PS 362B.

OA 202A ECONOMETRICS (3-0). An introduction to the construction and testing of econometric models, analysis of economic time series and the use of multivariate statistical analysis in the study of economic behavior. TEXTS: To be announced. PREREQUISITES: Mn 436A and PS 304B.

OA 211A LINEAR PROGRAMMING (4-1). Theory of optimization of linear functions subject to linear constraints. The simplex algorithm, duality, sensitivity analysis, transportation problem algorithm, parametric linear programming, relation of linear programming to the theory of games, the dual simplex algorithm, and integer linear programming. TEXTS: Hadley, *Linear Programming;* Gass, *Linear Programming.* PREREQUISITE: Ma 196B or its equivalent.

OA 212A NONLINEAR AND DYNAMIC PROGRAMMING (3-1). Introduction to modern optimization techniques and multistage decision processes. Topics include: integer linear programming, quadratic programming, Kuhn-Tucker theory and dynamic programming. TEXTS: Bellman, *Dynamic Programming;* Bellman and Dreyfus, *Applied Dynamic Programming;* Hadley, *Nonlinear and Dynamic Programming;* Bellman, *Adaptive Control Processes.* PREREQUISITE: OA 211A.

OA 213B INVENTORY SYSTEMS (3-0). A study of the nature of inventory systems involving the construction of increasingly complicated models and the determination of operating doctrines based on penalty costs. Both deterministic and random demands are discussed within the structure of reorder point models as well as periodic review models. TEXTS: Hanssman, *Operations Research in Production and Inventory Control;* Hadley and Whitin, *Analysis of Inventory Systems.* PREREQUISITE: PS 302B.

OA 214A GRAPH THEORY (3-0). Elements of the theory of graphs, with emphasis on applications to the study of organizations, communication systems, and transportation networks. TEXTS: Berge, *The Theory of Graphs and Its Applications;* Ore, *Theory of Graphs;* Ford and Fulkerson, *Flows in Networks.* PREREQUISITES: Ma 196B and Ma 193C.

OA 215A GRAPH THEORY II (3-0). A continuation of OA 214A. TEXTS: Berge, *The Theory of Graphs and Its Applications;* Ore, *Theory of Graphs;* Ford, and Fulkerson, *Flows in Networks.* PREREQUISITE: OA 214A.

OA 216A CYBERNETICS (3-0). This course deals with the problems of controlling very complex systems by feedback and "black boxes." Contributions to the theory of cybernetics from logic, biophysics, and other sources are developed. Applications are made to mechanical, social, and mental systems. TEXTS: W.R. Ashby, *An Introduction to Cybernetics;* S. Beer, *Cybernetics and Management.* PREREQUISITES: OA 291C and OA 292B.

OA 217A THEORY OF PATTERN RECOGNITION (3-0). Survey of principles governing the design of pattern recognition and detection devices of both the adaptive and non-adaptive type. Elements of learning theory; separability of object space using quadratic and linear decision functions; convergence of deterministic and stochastic adaptive techniques; survey of important, concrete applications. TEXTS: Instructor's notes and selected papers from technical journals. PREREQUISITE: PS 307A or equivalent.

OA 218A SEMINAR IN SUPPLY SYSTEMS (3-0). A survey of supply systems not only from an inventory point of view but also as a critical area in logistics. Topics for discussion will be selected from the current literature and will be chosen according to students' interests. Periodically, experts in the supply field will provide guest lectures on current research areas. TEXTS: Arrow, Karlin and Scarf, *Studies in the Mathematical Theory of Inventory and Production;* Arrow, Karlin and Scarf, *Studies in Applied Probability and Management Science;* Scarf, Gilford and Shelly, *Multistage Inventory Models and Techniques.* PREREQUISITES: OA 213B and PS 307A or consent of Instructor.

OA 225A AIR WARFARE (3-0). Analyses of fleet air defense exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Active and passive air defense. Relationship of air defense to strike capability and ASW. TEXT: Classified official publications. PREREQUISITES: OA 292B and OA 293B.

OA 234A QUEUEING THEORY (3-0). Basic principles of stochastic processes applied to a class of queueing models: connection between Poisson and exponential distributions; derivation of queue length and waiting time distributions for single and parallel channel models. TEXT: Cox and Smith, *Queues.* PREREQUISITE: PS 304B.

OA 235A DECISION CRITERIA (3-0). Survey and critique of the current literature dealing with decision criteria. Philosophy of values and allocation of effort. Applications to problems of human relations. TEXT: Luce and Raiffa, *Games and Decisions.* PREREQUISITE: OA 292B.

OA 236A UTILITY THEORY (3-0). General concept of utility and its measurement. Survey and critique of the current literature dealing with the concept and measurement of utility. Applications to problems of human relations. TEXTS: Davidson, Supper, Siegel, *Decision Making;* Churchman, *Prediction and Optimal Decision;* Hagen, *Theory of Social Change;* Thorp, *Biology and the Nature of Man.* PREREQUISITE: OA 292B.

OA 237A UTILITY THEORY II (3-0). The philosophy of measurement. The relation between the concept of utility and parallel concepts in psychophysics. The relation between utility and social philosophy. The selection and procurement of data necessary for social decisions. The first part of this course is based on a suitable text; but the main part of this course consists of student reports on the current literature. TEXT: C. W. Churchman and P. Ratoosh. *Measurement.* PREREQUISITE: OA 236A.

OA 291C INTRODUCTION TO OPERATIONS ANALYSIS (4-0). Development of fundamental concepts of operations and system analysis. Concepts of operations analysis illustrated in depth in the fields of submarine and anti-submarine warfare. Overall measures of effectiveness of a submarine as a weapon system. Determination of effectiveness as a product of measures of detection, attack, and kill probabilities. Lanchester's equations. TEXTS: Blackett, *Studies of War;* McCloskey and Trefethen, *Operations Research for Management,* Vols. I and II; Morse and Kimball, *Methods of Operations Research;* Shudde, *Introduction to Military Operations Research,* U.S. Naval Postgraduate School Notes. PREREQUISITES: PS 302B and Ma 182C (both may be taken concurrently).

OA 292B METHODS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). The methodologies and objectives of operations research and systems analysis. Topics include: reliability theory, PERT and PERT/COST networks, dynamic programming, recent developments in operations research and systems analysis. TEXTS: Lloyd and Lipow, *Reliability;* Roberts, *Mathematical Methods in Reliability Engineering;* Evarts, *Introduction to PERT;* Moder and Phillips, *Project Management with CPM and PERT;* Bellman, *Dynamic Programming;* Bellman and Dreyfus, *Applied Dynamic Programming.* PREREQUISITES: OA 291C and Mn 211C.

OA 293B SEARCH THEORY (4-0). Detection devices and their characteristics. Sweep rates and lateral range curves. Evaluation of search radars. Theories of radar detection. The design of screen and barrier patrols. Allocation of search effort. TEXTS: Morse and Kimball, *Methods of Operations Research;* Koopman, *Search and Screenings;* Classified publications. PREREQUISITE: OA 292B.

OA 296A DEVELOPMENT OF WEAPONS SYSTEMS (3-0). The areas of application of the various techniques of operations research which the student has learned are reviewed and placed in perspective relative to the procedure for evolving new weapons systems. Emphasis is placed upon the role of operations research in formulating operational requirements, developing prototype systems, and determining military specifications for selected systems and the role of operations analysis in various phases of operational testing of the system. The contributions of operations research to the coordination of the functions of those segments of the military establishment concerned with weapons systems development are analyzed. TEXTS: Classified official publications and instructor's notes. PREREQUISITE: OA 211A.

OA 297A SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS I (2-0 to 5-0). Presentation of a wide selection of reports from the current literature. At the end of the term an attempt will be made to summarize the philosophy and principal methodologies of operations research. TEXT: None. PREREQUISITE: A background of advanced work in operations research.

OA 298A SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS II (2-0 to 5-0). A continuation of OA 297A. TEXT: None. PREREQUISITE: A background of advanced work in operations research.

OA 299A SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS III (2-0 to 5-0). A continuation of OA 298A. TEXT: None. PREREQUISITE: A background of advanced work in operations research.

OA 391B GAMES OF STRATEGY (3-2). Two-person zero-sum games, the minimax theorem. Methods of solving finite games. Specific games with appropriate application. Methods of solving continuous games on unit square with continuous payoff functions. Applications. TEXTS: Dresher, *Theory and Applications of Games of Strategy;* Luce and Raiffa, *Games and Decisions;* McKinsey, *Introduction to the Theory of Games.* PREREQUISITES: PS 301C or the equivalent; Ma 196B. (The latter may be taken concurrently.)

OA 393B INTRODUCTION TO WAR GAMING (2-2). Simulation and Monte Carlo techniques employing manual and computer methods; random number generation; analysis of results of war games. TEXTS: Instructor's notes and prepared handouts. PREREQUISITES: OA 291B, PS 303B, OA 421C or consent of the instructor.

OA 394A WAR GAMING (2-2). Consideration of the problems inherent in the construction and use of manual and computer war games. Problems in the analysis of results of such games. Utilization of decision laboratory techniques. Construction of simulations. TEXT: Instructor's notes and classified official publications. PREREQUISITE: OA 393B or consent of the instructor.

OA 396A ADVANCED PROJECTS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS I (2-0 to 5-0). A course in solving special problems by the use of advanced techniques of Operations Research. Emphasis is upon extending the student's ability to formulate and solve sophisticated models of problems arising in Operations Research/Systems Analysis. TEXT: None. PREREQUISITE: Consent of the instructor.

OA 397A ADVANCED PROJECTS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS II (2-0 to 5-0). Continuation of OA 396A. TEXT: None. PREREQUISITE: Consent of the instructor.

OA 398A ADVANCED PROJECTS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS III (2-0 to 5-0). Continuation of OA 397A. TEXT: None. PREREQUISITE: Consent of the instructor.

OA 399A ADVANCED PROJECTS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS IV (2-0 to 5-0). Continuation of OA 398A. TEXT: None. PREREQUISITE: Consent of the instructor.

OA 421C INTRODUCTION TO DIGITAL COMPUTERS (5-0). Description of general purpose digital computers and peripheral equipment; data processing and problem formulation with emphasis on military environment. Binary and octal number systems. Basic FORTRAN and CODAP programming. TEXTS: McCracken, *Digital Computer Programming;* McCracken, *A Guide to FORTRAN IV Programming;* Organick, *A FORTRAN Primer;* Selected Control Data Corporation 1604 Manuals. PREREQUISITES: None.

OA 471B OPERATIONS ANALYSIS FOR NAVY MANAGEMENT (4-1). The nature, origin and contemporary status of operations analysis. Fundamental concepts with special emphasis on application in the fields of transportation, inventory control and personnel management. Introduction to game theory. TEXTS: McCloskey and Trefethen, *Operations Research for Management*, Vols. I and II; Gass, *Linear Programming;* Williams, *Complete Strategyst;* Chernoff and Moses, *Elementary Decision Theory.* PREREQUISITE: PS 371C.

OA 491B METHODS FOR COMBAT DEVELOPMENT EXPERIMENTATION (4-0). Introduction to the intent, design, procedures, analysis, and reporting of field experiments. Rationale for combat experiments, criteria selection, statistical analysis, and interpretation of results. TEXT: None. PREREQUISITES: OA 291C and PS 304B.

OA 501A INTRODUCTION TO SYSTEMS ANALYSIS (4-0). A survey of military economic problems including the determination of the total budget level and its allocation among the services and weapons systems. TEXT: Hitch and McKean, *The Economics of Defense in the Nuclear Age.* PREREQUISITE: MN 413A.

OA 502A SYSTEMS ANALYSIS (4-0). Detailed examination of resources allocation among weapons systems. Examination of criteria problems, the treatment of intangibles, spillovers, uncertainty and related problems. The use of mathematical, statistical and economic methods to arrive at "preferred," if not optimum allocation decisions. TEXT: Quade, *An Appreciation of Analysis for Military Decisions,* plus current systems studies. PREREQUISITE: OA 501A.

OA 510B SYSTEMS ANALYSIS (4-0). The aim of this course is to present the nature, the aims, and limitations of analysis as it exists today and contributes to military problems. The common principles of cost/effectiveness analysis, design and formulation of the study, methods of solution, sensitivity analysis, pitfalls and limitations. Case studies from the fields of interest of the class will be discussed. PREREQUISITES: PS 351B, MN 310C, OA 131B.

OA 891E SEMINAR I (0-2). Review of summer assignments; selection of thesis topics; special lectures. TEXT: None.

OA 892E SEMINAR II (0-2). A continuation of OA 891E. Special lectures. TEXT: None. PREREQUISITE: None.

OA 893E SEMINAR III (0-2). Presentation of thesis developments. Special lectures. TEXT: None. PREREQUISITE: None.

OA 894E SEMINAR IV (0-2). A continuation of OA 893E. TEXT: None. PREREQUISITE: None.

PROBABILITY AND STATISTICS

PS 301C BASIC PROBABILITY AND SET THEORY (4-0). Elements of set theory and set algebra. Axioms for a probability function and models for finite sample spaces. Random variables and their probability distributions. Families of distributions and their characteristics. Chebyshev's inequality and the law of large numbers. Normal family and normal approximations. PREREQUISITE: A course in differential and integral calculus.

PS 302B SECOND COURSE IN PROBABILITY (3-2). A continuation of PS 301C. Jointly distributed random variables and the distribution of functions of random variables. Independence and conditional distributions. Sums of random variables and the Central Limit Theorem. PREREQUISITES: PS 301C and Ma 181D or the equivalent.

PS 303B THEORY AND TECHNIQUES IN STATISTICS I (3-2). Descriptive statistics. Point estimation. Principles of choice and properties of estimators. Methods for calculation. Confidence intervals. Applications. Testing hypotheses. Concepts of power, most powerful tests. Applications. PREREQUISITE: PS 302B.

PS 304B THEORY AND TECHNIQUES IN STATISTICS II (3-0). A continuation of PS 303B. Regression and correlation. Least squares. Elements of analysis of variance. Multiple comparisons. Sequential sampling. Quality control. Sampling inspection. PREREQUISITE: PS 303B.

PS 305A DESIGN OF EXPERIMENTS (3-1). Theory of the general linear hypothesis. Analysis of variance. Planning of experiments. Randomized blocks and Latin Squares. Simple factorial experiments. PREREQUISITE: PS 304B or consent of Instructor.

PS 306A SELECTED TOPICS IN ADVANCED STATISTICS (3-1). Topics will be selected by instructor to fit the needs and background of the students. Areas of choice to include the fields of sequential analysis, non-parametric methods and multivariate analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: PS 304B, or consent of Instructor.

PS 307A STOCHASTIC PROCESS I (3-0). Poisson and Wiener processes. Markov chains. Discrete and continuous parameter cases. Ergodic properties and passage probabilities. Birth and death processes and their application to queueing theory. PREREQUISITE: PS 304B or consent of the Instructor.

PS 308A STOCHASTIC PROCESS II (3-0). Orthogonal representation of stochastic processes. Stationary time series; harmonic analysis of the auto correlation function. Ergodic properties. Applications. PREREQUISITE: PS 307A.

PS 309A SELECTED TOPICS IN ADVANCED STATISTICS II (3-0). A continuation of PS 306A. PREREQUISITE: PS 306A.

PS 315C INTRODUCTION TO PROBABILITY AND STATISTICS (4-2). Elements of set theory. Foundations of probability and basic rules of computation. Sample space, random variable, discrete and continuous distribution functions. Classical distribution functions. Limit theorems, Markov chains. Applications in fields of particular interest to class. PREREQUISITE: A previous course in calculus.

PS 316B APPLIED STATISTICS I (3-2). Descriptive Statistics. Introduction to decision theory. Point estimation; principles of choice and properties of estimators; methods for calculation. Confidence intervals; applications. Testing hypotheses; concepts of power, most powerful tests; applications. PREREQUISITE: PS 315C.

PS 317B APPLIED STATISTICS II (3-0). A continuation of PS 316B. Regression and correlation; least squares. Elements of Analysis of Variance; multiple comparison. Sequential sampling. Non-parametric procedure. PREREQUISITE: PS 316B.

PS 326A ADVANCED PROBABILITY I (3-0). Probability viewed as a measure. Sets, measures and integration. Convergence almost surely, in probability and in quadratic mean. Distribution function and characteristic functions. PREREQUISITE: Consent of Instructor.

PS 327A ADVANCED PROBABILITY II (3-0). Infinitely divisible laws. Strong and weak laws of large numbers. Classical central limit problems, modern central limit problems. PREREQUISITE: Consent of Instructor.

PS 355A SYSTEM RELIABILITY AND LIFE TESTING (3-0). Reliability functions and their point and interval estimates under various sampling plans. Standard and accelerated life testing plans. Analysis of serial, parallel, and mixed systems. Analysis of reliability apportionment and inherent design reliability. Reliability growth models and methods for updating reliability estimates. Properties of functions with monotone failure rate. PREREQUISITES: PS 303B and PS 304B, or PS 321B and PS 322A.

PS 371B MANAGEMENT STATISTICS (4-0). Elements of probability theory with emphasis on random variables and their probability distributions. Distributions of estimators of parameters. Applications of these concepts as aids in decision making. PREREQUISITE: Ma 032C.

PS 372B MANAGEMENT STATISTICS II (4-1). A continuation of PS 371B. Further discussion of tests of hypothesis and parameter estimation. Regression and correlation theory. Bayesian Methods. Applications to Management Problems. PREREQUISITE: PS 371B.

PS 396A DECISION THEORY (3-0). Basic concepts. Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluation trials. PREREQUISITES: PS 304A, Ma 193C and OA 391B. (The latter may be taken concurrently.)

PS 397A THEORY OF INFORMATION COMMUNICATION (3-0). Markov chains; surprisal of events and uncertainty of distributions; characterization of uncertainty; noise and rate of information transmission; limit distributions connected with sequences from an ergodic Markov chain; Shannan-Fano coding; detection. PREREQUISITES: Ma 120C or Ma 150C and PS 321B.

PS 398B SAMPLING INSPECTION AND QUALITY CONTROL (3-1). Attribute and variables sampling plans. MIL. STD., sampling plans with modifications. Multi-level continuous sampling plans and sequential sampling plans. Distribution of effort in related sampling plans. Quality control with emphasis on recent developments. PREREQUISITE: PS 304B or PS 322A.

PS 831B SEMINAR IN PROBABILITY AND STATISTICS. Content of the course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of Instructor.

PS 832A SEMINAR IN PROBABILITY AND STATISTICS. Content of the course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of Instructor.

PS 931B READING IN PROBABILITY AND STATISTICS. Content of the course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of Instructor.

PS 932B READING IN PROBABILITY AND STATISTICS. Content of the course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of Instructor.

DEPARTMENT OF PHYSICS

EUGENE CASSON CRITTENDEN, JR., Professor of Physics, Chairman (1953)*; B.A., Cornell Univ., 1934; Ph.D., 1938.

ROBERT LOUIS ARMSTEAD, Assistant Professor of Physics (1964); B.S., Univ. of Rochester, 1958; Ph.D., Univ. of California at Berkeley, 1965.

FRANZ AUGUST BUMILLER, Professor of Physics (1962); M.S., Univ. of Zurich, 1951; Ph.D., 1955.

FRED RAMON BUSKIRK, Associate Professor of Physics (1960); B.S., Western Reserve Univ., 1951; Ph.D., Case Institute of Technology, 1958.

ALFRED WILLIAM MADISON COOPER, Associate Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's University of Belfast, 1961.

JOHN NIESSINK COOPER, Professor of Physics (1956); B.A., Kalamazoo College, 1935; Ph.D., Cornell Univ., 1940.

ALAN BERCHARD COPPENS, Assistant Professor of Physics (1964); B.Eng.Phy., Cornell Univ., 1959; M.S., Brown Univ., 1962; Ph.D., Brown Univ., 1965.

PETER PIERCE CROOKER, Instructor in Physics (1960); B.S., Oregon State College, 1959.

WILLIAM PEYTON CUNNINGHAM, Professor of Physics (1946); B.S., Yale Univ., 1928; Ph.D., 1932.

HARVEY ARNOLD DAHL, Assistant Professor of Physics (1964); B.S., Stanford Univ., 1951; Ph.D., 1963.

JOHN NORVELL DYER, Associate Professor of Physics (1961); B.A., Univ. of California, 1956; Ph.D., 1960.

AUSTIN ROGERS FREY, Professor of Physics (1946); B.S., Harvard Univ., 1920; M.S., 1924; Ph.D., 1929.

HARRY ELIAS HANDLER, Professor of Physics (1958); B.A., Univ., of California at Los Angeles, 1949; M.A., 1951; Ph.D., 1955.

DON EDWARD HARRISON, JR., Associate Professor of Physics (1961); B.S., College of William and Mary, 1949; M.S., Yale Univ., 1950; Ph.D., 1953.

OTTO HEINZ, Associate Professor of Physics (1962); B.A., Univ. of California, 1948; Ph.D., 1954.

WILLIAM LEWIS JOHNSON, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor in Physics (1963); B.S., Univ. of Southern Mississippi, 1962.

SYDNEY HOBART KALMBACH, Professor of Physics (1947); B.S., Marquette Univ., 1934; M.S., 1937.

RAYMOND LEROY KELLY, Associate Professor of Physics (1960); B.A., Univ. of Wichita, 1947; M.S., Univ. of Wisconsin, 1949; Ph.D., 1951.

LAWRENCE EDWARD KINSLER, Professor of Physics (1946); B.S., California Institute of Technology, 1931; Ph.D., 1934.

HERMAN MEDWIN, Professor of Physics (1955); B.S., Worcester Polytechnic Institute, 1941; M.S., Univ. of California at Los Angeles, 1948; Ph.D., 1953.

EDMUND ALEXANDER MILNE, Associate Professor of Physics (1954); B.A., Oregon State College, 1949; M.S., California Institute of Technology, 1950; Ph.D., 1953.

JOHN ROBERT NEIGHBOURS, Professor of Physics (1959); B.S., Case Institute of Technology, 1949; M.S., 1951; Ph.D., 1953.

NORMAN LEE OLESON, Professor of Physics (1948); B.S., Univ. of Michigan, 1935; M.S., 1937; Ph.D., 1940.

LEONARD OLIVER OLSEN, Professor of Physics (1960); B.A., Iowa State Teachers College, 1932; M.S., State Univ. of Iowa, 1934; Ph.D., 1937.

WILLIAM REESE, Assistant Professor of Physics (1963); B.A., Reed College, 1958; M.S., Univ. of Illinois, 1960; Ph.D., 1962.

JOHN DEWITT RIGGIN, Professor of Physics (1946); B.S., Univ. of Mississippi, 1934; M.S., 1936.

GEORGE WAYNE RODEBACK, Associate Professor of Physics (1960); B.S., Univ. of Idaho, 1943; M.S., Univ. of Illinois, 1947; Ph.D., 1951.

JAMES VINCENT SANDERS, Assistant Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

GORDON EVERETT SCHACHER, Assistant Professor of Physics (1964); A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

RONALD WAYNE STAAB, Lieutenant Junior Grade, U.S. Naval Reserve; Instructor in Physics (1965); B.S., Columbia Univ., 1964; M.S., 1965.

OSCAR BRYAN WILSON, JR., Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

KARLHEINZ EDGAR WOEHLER, Associate Professor of Physics (1963); B.S., Univ. of Bonn, 1953; M.S., Technical Univ., Aachen, 1955; Ph.D., Univ. of Munich, 1962.

WILLIAM BARDWELL ZELENY, Associate Professor of Physics (1962); B.S., Univ. of Maryland, 1956; M.S., Syracuse Univ., 1958; Ph.D., 1960.

*The year of joining the Postgraduate School faculty is indicated in parenthesis.

DEPARTMENTAL REQUIREMENTS FOR DEGREE IN PHYSICS

BACHELOR OF SCIENCE IN PHYSICS

1. It is required that any specific curriculum must be consistent with the general minimum requirements for any degree of Bachelor of Science as determined by the Academic Council.

2. A major in physics must include a minimum of 54 term hours in physics, including required courses and elec-

tives, a minimum of 38 term hours in mathematics, and the equivalent of a course in general chemistry. In addition, a minimum of 20 term hours of elective credits must be chosen in other specified areas. 108 term hours must be clearly of upper division level.

3. The following requirements must be met: (courses marked with an asterisk must include a laboratory).

Discipline	*Subject*	*Approximate Term Hours*
Physics	General Physics*	16
	Pbysical Optics*	5
	Analytical Mechanics	8
	Electricity and Magnetics	8
	Atomic Physics*	7
		44
Mathematics	College Algebra and Trigonometry	5
	Analytic Geometry and Calculus	13
	Differential Equations	3
	Infinite Series	3
	Vector Algebra and Vector Analysis	6
		30
Chemistry	General Chemistry*	10

4. The remaining required hours in physics and mathematics are elective and must be of clearly upper division level. By choosing appropriate elective sequences in physics the student can begin a specialty-area on the undergraduate level. Suggested elective courses in physics are: Thermodynamics, Statistical Mechanics, Physics of the Solid State, Nuclear Physics, and Acoustics; in mathematics are: Complex Variables, Partial Differential Equations, and Probability and Statistics.

20 term hours of electives must be chosen in the areas of (a) electric circuits, (b) electronics, and (c) chemistry beyond general chemistry. At least 10 of the 20 term hours must be from one of these three areas.

5. The student must maintain grade point averages of at least 1.0 in both physics and mathematics.

MASTER OF SCIENCE IN PHYSICS

1. It is required that any specific curriculum be consistent with the general minimum requirements for any degree of Master of Science as determined by the Academic Council.

2. Each student's program of study must have a minimum of 36 term hours of physics *courses*, not including thesis, distributed between A and B level; of this 36 hours, a minimum of 12 hours must be A level. In lieu of the preceding requirement, students who are qualified to pursue graduate courses in physics when they arrive at the Postgraduate School may complete a minimum of 24 hours entirely of A level courses. In addition, all students must register for research and present an acceptable thesis.

3. The following specific course requirements must be successfully completed for a student to earn the degree of M.S. in Physics:

a. Thermodynamics and Statistical Mechanics—The student must take a two-term sequence (for example, PH 530 and PH 541) or present equivalent undergraduate preparation in this subject matter area.

b. Advanced Mechanics and Hydrodynamics—for example, PH 153 or PH 161.

c. Special Topics in Electromagnetism—for example, PH 367.

4. The student will be expected to specialize in one of the available options such as: (a) Acoustics, (b) Nuclear Physics, (c) Plasma Physics, (d) Solid State Physics, or (e) other recognized Physics specialization.

PHYSICS

PH 001(D) - PH 004(D)
This series of courses is intended primarily for Engineering Science students with limited background in mathematics.

PH 001D GENERAL PHYSICS I (4-0). Mechanics—The purpose of this course as well as the following 3 units is to provide a knowledge of the principles of physics and thus to help the student understand the scientific background of modern civilization. The first unit deals with physical quantities and the concepts of motion, force, momentum and energy. TEXT: Sears and Zemansky, *College Physics.*

PH 002D GENERAL PHYSICS II (4-0). Harmonic Motion, Sound and Heat — This is a continuation of Ph 001D and considers simple harmonic motion, oscillating systems including those producing sound, the propagation of sound and wave motion. The mechanics of gases, thermometry, transfer of heat, the thermodynamics are among other topics considered. TEXT: Sears and Zemansky, *College Physics.* PREREQUISITE: PH 001D.

PH 003D GENERAL PHYSICS III (4-0). Electricity and Magnetism. This is a further continuation of General Physics I and II and presents the subject of electrostatics, including Coulomb's Law, potential and capacitance, electric current and electric circuits, magnetics, and induced electromotive force. TEXT: Sears and Zemansky, *College Physics.* PREREQUISITES: PH 001D and PH 002D.

PH 004D GENERAL PHYSICS IV (4-0). Light and Modern Physics. This is the final unit of a four-term sequence of General Physics and treats selected topics in light including the geometrical optics of mirrors and lenses, interference and diffraction and optical instruments. A brief introduction to modern physics is also given. This includes the topics of atomic structure, optical and X-ray spectra, radioactivity, and nuclear structure. TEXT: Sears and Zemansky, *College Physics.* PREREQUISITES: PH 001D, PH 002D, and PH 003D.

PH 006D SURVEY OF PHYSICS (5-0). An introduction to the fundamental concepts and laws of statics and dynamics, including Newton's laws of motion, force, energy, momentum, and harmonic motion. Survey of gas laws, heat, wave propagation, sound and the properties of light. US-

UAL BASIS FOR EXEMPTION: Equivalent educational background. TEXT: White, *Modern College Physics*, 3rd ed. PREREQUISITE: Ma 010D or equivalent.

PH 007(D) - PH 010(D)
This series of courses is intended primarily for BA students.

PH 007(D) GENERAL PHYSICS I (3-2). Mechanics concepts of velocity, acceleration, force, torque linear and angular momenta, energy. Conservation laws of mechanics and applications. Laboratory exercises. TEXT: Smith and Cooper, *Elements of Physics*.

PH 008(D) GENERAL PHYSICS II (3-2). Harmonic Motion, Sound and Heat. This is a continuation of PH 008(D). Simple harmonic motion, oscillating systems; wave motion, production and propagation of sound waves. Properties of gases, heat transfer and thermodynamics. Laboratory exercises. TEXT: Smith and Cooper, *Elements of Physics*. PREREQUISITE: PH 007(D).

PH 009(D) GENERAL PHYSICS III (3-2). Electricity and Magnetism, Coulomb's Law, electrostatics, potential concept, DC currents, simple circuits, magnetism, induced EMF. Laboratory exercises. TEXT: Smith and Cooper, *Elements of Physics*. PREREQUISITE: PH 008(D).

PH 010(D) GENERAL PHYSICS IV (3-2). Light and Modern physics, geometric optics, interference and diffraction, optical instruments. Brief introduction to modern physics: Atomic structure, optical and X-ray spectra, radioactivity and nuclear structure. TEXT: Smith and Cooper, *Elements of Physics;* PREREQUISITES: PH 007(D), PH 008(D), PH 009(D).

PH 011(D) - PH 014(C)
This series of courses is intended primarily for BS students.

PH 011D GENERAL PHYSICS I (4-3). Mechanics. This course is designed to provide a knowledge of the principles of physics and to provide a scientific background for the study of engineering. It consists of lectures, recitations, problem sessions, and laboratory work dealing with force, motion, energy, momentum, elasticity, and hydrodynamics. TEXT: Sears and Zemansky, *University Physics*, and Resnick and Halliday, *Physics for Students of Science and Engineering*. PREREQUISITE: One term of calculus.

PH 012D GENERAL PHYSICS II (4-3). Heat, Sound, and Light. This is a continuation of General Physics I and deals with molecular mechanics, behavior of gases, thermal expansion, calorimetry, the laws of hermodynamics, wave motion, vibrating bodies, reflection and refraction of light, dispersion, interference and diffraction, and optical instruments. TEXTS: Sears and Zemansky, *University Physics;* Resnick and Halliday, *Physics for Students of Science and Engineering*. PREREQUISITE: PH 011D.

PH 013D GENERAL PHYSICS III (3-3). Electricity and magnetism. This is a continuation of General Physics I and II and deals with the fundamental principles of electrostatics, electromagnetism, electrochemistry, direct and alternating currents. TEXTS: Sears and Zemansky, *University Physics;* Resnick and Halliday, *Physics for Students of Science and Engineering*. PREREQUISITES: PH 011D and PH 012D.

PH 014C GENERAL PHYSICS IV (4-2). Modern Physics. This is a continuation of General Physics I, II, and III and deals with the fundamentals of atomic and nuclear physics. Topics include: atomic and nuclear structure, optical spectra, radioactivity, nuclear processes, and particle accelerators. TEXT: Weidner and Sells, *Introductory Modern Physics*. PREREQUISITES: PH 011D, PH 012D and PH 013D.

PH 016(D) - PH 019(C)
This series of courses is intended primarily for Engineering Science students with some prior knowledge of calculus.

PH 016D GENERAL PHYSICS MECHANICS (4-0). This course is a review in depth of that portion of General Physics dealing with Newtonian Mechanics and stressing quantitative use of such concepts as force, conservation of energy, conservation of momentum, rotational motion, elasticity and hydrodynamics. It is primarily for engineering science students needing physics review at that level. TEXTS: Sears and Zemansky, *University Physics;* Resnick and Halliday, *Physics for Students of Science and Engineering*. PREREQUISITES: Previous exposure to college mathematics through calculus and one course in college physics.

PH 017D GENERAL PHYSICS—THERMODYNAMICS SOUND AND LIGHT (4-0). This course is a continuation of PH 016D and is a further review in depth of General Physics, stressing the concepts of temperature, heat transfer, thermal properties of solids, liquids and gases and the laws of thermodynamics. The propagation of waves in various media is considered with emphasis on sound waves. In optics, the geometrical optics of mirrors, lenses and optical instruments will be considered; and in physical optics interference and diffraction will be stressed. TEXTS: Sears and Zemansky, *University Physics;* Resnick and Halliday, *Physics for Students of Science and Engineering*. PREREQUISITE: PH 016D.

PH 018D GENERAL PHYSICS — ELECTRICITY AND MAGNETISM. (4-0). This course is a study of the concepts of electrostatics stressing Gauss' Law and the theory of electric fields and potentials. Attention will also be given to direct the alternating current flow, electromagnetic phenomena and ferromagnetism. TEXTS: Sears and Zemansky, *University Physics;* Resnick and Halliday, *Physics for Students of Science and Engineering*. PREREQUISITES: Successful completion of PH 016D and PH 017D.

PH 019C MODERN PHYSICS (4-0). This is a final course of a four-term sequence and consists of a moderately rigorous study of some of the most fundamental concepts of atomic and nuclear physics. Topics included are atomic structure, radiation from atoms, nuclear structure and nuclear processes. TEXT: Weidner and Sells, *Introductory Modern Physics*. PREREQUISITES: Successful completion of PH 016D, PH 017D, and PH 018D.

PH 021(D) - PH 025(C)
This series of courses is intended primarily for Engineering Science students with good background in mathematics and some previous work in physics.

PH 021D MECHANICS (4-0). This course is a review and extension of the Mechanics portion of General College Physics. Emphasis is placed on a study in depth of the important concepts of physical mechanics. Representative topics are Newton's Laws of Motion, Conservation of Energy, Conservation of Momentum, Rotational Motion and Simple Harmonic Motion. TEXT: Halliday and Resnick, *Physics for Students of Science and Engineering.* PREREQUISITE: 8 to 10 semester hours of College Physics and 8 to 10 hours of Calculus, with acceptable grades, or demonstrated aptitude in Science and Mathematics.

PH 022D FLUID MECHANICS WAVE MOTION AND THERMODYNAMICS (4-0). This course is a continuation of PH 021D. The emphasis will be on developing a thorough understanding of the important concepts of physics which are normally catalogued under the title of this course. The relationship of Wave Motion and Acoustics will be stressed as will the laws of Thermodynamics. TEXT: Halliday and Resnick, *Physics for Students of Science and Engineering.* PREREQUISITE: Successful completion of PH 021D.

PH 023D ELECTRICITY AND MAGNETISM (4-0). This course is a continuation of PH 021D and PH 022D. A careful study will be made of the concepts of electrostatics, Electric Fields and Gauss' Law, Electrical Potential, Magnetic Effects of Currents, Electromagnetism and the Phenomena of Ferromagnetism. DC and AC electric currents will be studies. TEXT: Resnick and Halliday, *Physics for Students of Science and Engineering.* PREREQUISITE: Successful completion of PH 021D.

PH 024D ELECTROMAGNETIC RADIATION AND OPTICS (4-0). This course is a continuation of PH 021D, PH 022D and PH 023D and gives the student a better understanding of the electrical and magnetic character of radiation. Maxwell's Laws will be studied. In Optics, maximum attention will be given to understanding interference and diffraction. Polarization of Radiation will also be studied. TEXT: Resnick and Halliday, *Physics for Students of Science and Engineering.* PREREQUISITES: Successful completion of PH 021D and PH 023D.

PH 025C MODERN PHYSICS (4-0). This is the concluding course in a sequence of courses designed to provide the student with a substantial understanding of some of the most important and basic concepts of physics. Several topics classified as "modern physics" will be studied in depth. Among these are atomic structure, radiation from atomic systems, nuclear structure, nuclear processes and the tools of modern physics experimentation. TEXT: Weidner and Sells, *Introductory Modern Physics.* PREREQUISITES: Successful completion of PH 021D, PH 022D, PH 023D and PH 024D.

PH 051D REVIEW OF ELEMENTARY MECHANICS (2-2). Basic concepts of mechanics: Force, Newton's Laws of Motion, Work and Energy, Momentum, Conservation Laws. TEXT: Resnick and Halliday, *Physics for Students of Science and Engineering,* Part I. PREREQUISITES: Previous courses in general physics and calculus.

PH 061D REVIEW OF MECHANICS AND ELECTROMAGNETISM (4-2). Review of basic concepts of mechanics and of electricity and magnetism: Force, Newton's Laws of Motion, Work and Energy, Momentum, Conservation Laws of Mechanics, Electric Charge and Field, Potential Concept, Direct Currents, Kirchhoff's Laws, Magnetic Effects of Direct Currents. TEXT: Resnick and Halliday, *Physics for Students of Science and Engineering,* Parts I and II. PREREQUISITES: Previous courses in general physics and calculus.

PH 105D MECHANICS AND THERMODYNAMICS (4-0). The first term in a sequence of fundamental physics for students in Electrical Engineering and Electronics. The sequence includes PH 105C, PH 205C, and either PH 604C or PH 605B and PH 705B. The subject matter in the first term includes: kinematics, dynamics of a particle, energy, momentum, rotational motion, orbital motion, oscillations and introductory thermodynamics. TEXT: Resnick and Halliday, *Physics for Students of Science and Engineering, Vol. I.*

PH 141B ANALYTICAL MECHANICS (4-0). Kinematics and dynamics of a particle, moving reference systems, central forces and celestial mechanics. TEXT: Fowles, *Analytical Mechanics.* PREREQUISITES: At least 8 semester hours of College Physics and 8 semester hours of Calculus; Ma 182C (may be taken concurrently).

PH 142B ANALYTICAL MECHANICS (4-0). Dynamics of a system of particles, rigid bodies, Lagrange's equations and the Hamiltonian theory of vibrations. TEXT: Fowles, *Analytical Mechanics.* PREREQUISITES: Ma 183B (may be taken concurrently) and PH 141B.

PH 151C MECHANICS I (4-1). Brief review of elementary mechanics. Motion of a particle in one dimension with emphasis on oscillatory motion. Statics of a particle. Motion of a particle in two and three dimensions with emphasis on projectile trajectories and motion in a central force field. The laboratory periods will be devoted to demonstrations and problem solving. TEXTS: Resnick and Halliday, *Physics for Students of Science and Engineering, Part I;* Symon, *Mechanics,* 2nd ed. PREREQUISITES: A previous college course in General Physics, Calculus, Vector Algebra, and Ordinary Differential Equations (the latter may be taken concurrently).

PH 152B MECHANICS II (4-0). A continuation of PH 151C. Motion of a system of particles, including the conservation laws, center of mass, and collision problems. Coupled harmonic oscillators. Rotation of a rigid body about an axis. Motion of a pendulum. Statics of rigid bodies. Stress and strain. Rotating coordinate systems. The vibrating string and wave propagation along a string. TEXTS: Resnick and Halliday, *Physics for Students of Science and Engineering, Part II;* Symon, *Mechanics,* 2nd ed. PREREQUISITE: PH 151C.

PH 153A MECHANICS III (4-0). A continuation of PH 152B. Topics selected from: mechanics of continuous media; gravitational theory; Lagrange's equations; Hamilton's equations; tensor algebra and the rotation of a rigid body in three dimensions; theory of small vibrations; perturbation theory. TEXT: Symon, *Mechanics*, 2nd ed. PREREQUISITE: PH 152B.

PH 154A SPACE AND MISSILE MECHANICS (4-0). The solar system. Missile and satellite trajectories including intercept problems and perturbations. Equations of motion of a missile including yawing, swerving, drag, and angular motion. Stability considerations. TEXT: Instructor's notes. PREREQUISITE: PH 153A.

PH 155A ADVANCED MECHANICS I (3-0). Review of elementary principles, Lagrange's formulations with applications. Hamilton's principle with applications to non-conservative and non-holonomic systems. The two body central force problem. Kinematics of rigid body motion. Orthogonal transformation. Formal properties of transformation matrix. Infinitesimal rotation. Coriolis force. Rigid body motion, the inertia tensor, Euler's equation, the symmetrical top. TEXT: Goldstein, *Classical Mechanics*. PREREQUISITES: PH 142B or PH 153A, PH 365C (the latter may be taken concurrently).

PH 156A ADVANCED MECHANICS II (3-0). Special relativity in classical mechanics, including Lorentz transformation and Lagrange formulation. Hamilton's equations of motion. Canonical transformations. Hamilton-Jacobi equation. Small oscillations, classical perturbation theory. TEXT: Goldstein, *Classical Mechanics*. PREREQUISITE: PH 155A.

PH 161A FLUID MECHANICS (3-0). The fundamental concepts of fluid mechanics from the continuum and kinetic theory points of view; development and interpretation of the equation of continuity, the Navier-Stokes equation, the equation of state. TEXT: Landau and Lifshitz, *Fluid Mechanics* and instructor's notes. PREREQUISITES: PH 541B, Ma 260C and Ma 245B or equivalents.

PH 162A ADVANCED HYDRODYNAMICS (3-0). Solutions to the equations of fluid dynamics; potential flow, exact solutions of the Navier-Stokes equation, laminar and turbulent boundary layers, transitions, non-steady flow, hydrodynamic noise. TEXTS: Landau and Lifshitz, *Fluid Mechanics*, Schlichting, *Boundary Layer Theory*. PREREQUISITE: PH 161A.

PH 190D SURVEY OF PHYSICS I (3-0). Elementary concepts and laws of statics and dynamics. Introduction to the statics and dynamics of fluids. Temperature, heat, radiation, kinetic theory and the gas laws. Fundamentals of vector representation and notation. TEXT: Smith and Cooper, *Elements of Physics*.

PH 191D SURVEY OF PHYSICS II (3-0). A continuation of PH 190D. A survey of wave propagation, sound, electricity and magnetism, atomic structure, the properties of light, and other electromagnetic wave phenomena. TEXT: Smith and Cooper, *Elements of Physics*. PREREQUISITE: PH 190D or equivalent.

PH 192D SURVEY OF PHYSICS III (3-0). A continuation of PH 191D. Survey of physical optics. Introduction to atomic structure including kinetic theory. TEXT: Smith and Cooper, *Elements of Physics*. PREREQUISITE: PH 191D or equivalent.

PH 196D REVIEW OF GENERAL PHYSICS (4-2). Principles of statics and dynamics, oscillatory motion, wave motion fields, electricity and magnetism. TEXT: Resnick and Halliday, *Physics for Students of Engineering and Science*. PREREQUISITES: Ma 230D and Ma 120C or equivalent.

PH 205C WAVES AND PARTICLES (4-0). Second term in the sequence of fundamental physics for students in Electrical Engineering and Electronics. The properties of waves, propagation, Doppler effect, waves in three dimensions, reflection, refraction, interference and diffraction, polarization, wave-particle duality, photons, electron waves, phonons, indeterminacy principle, Bohr model of the atom and its defects. TEXT: Halliday and Resnick, *Physics for Students of Science and Engineering*, Vols. I and II, Weidner and Sells, *Elementary Modern Physics*. PREREQUISITE: PH 105D.

PH 240C OPTICS AND SPECTRA (3-3). Reflection and refraction of light, optical systems, dispersion, interference, diffraction, polarization. Basic atomic structure, photoelectric effect, radiation from atoms, molecules and solids. TEXTS: Sears, *Optics*; Jenkins and White, *Fundamentals of Optics*.

PH 241C RADIATION (3-3). Fundamentals of geometric and physical optics. Wave phenomena and wave propagation. Origin of the quantum theory, photoelectric effect, radiation from atoms, molecules and solids, target detection by optical and infrared devices. TEXTS: Sears, *Optics*; Jenkins and White, *Fundamentals of Optics*.

PH 242C RADIATION (3-0). Fundamentals of geometric and physical optics. Wave phenomena and wave propagation. Particles and waves. Radiation from atoms, molecules, and solids. Sensors used for target detection. TEXTS: Sears, *Optics*; Jenkins and White, *Fundamentals of Optics*.

PH 260C PHYSICAL OPTICS (3-2). Reflection and refraction of light, optical systems, dispersion, interference, diffraction, polarization. Basic atomic structure, photoelectric effect, radiation from atoms, molecules and solids. TEXTS: Sears, *Optics*; Jenkins and White, *Fundamentals of Optics*.

PH 265C PHYSICAL OPTICS (4-2). Elementary geometrical optics. Wave phenomena and wave propagation, interference and diffraction, polarization. Properties of light sources. TEXTS: Sears, *Optics*; Jenkins and White, *Fundamentals of Optics*.

PH 270B PHYSICAL OPTICS (4-2). Review of geometrical optics. Wave phenomena and wave propagation, interference, diffraction, polarization, double refraction, dispersion. TEXT: Jenkins and White, *Fundamentals of Optics*.

PH 350B SPECIAL TOPICS IN ELECTROMAGNETISM (4-0). Development and applications of Maxwell's Equations for selected students. TEXTS: Whitmer, *Electromagnetics;* Kraus, *Electromagnetics.* PREREQUISITE: Consent of Instructor.

PH 360B ELECTRICITY AND MAGNETISM (4-0). Electrostatics. Electric currents. The magnetic field, Maxwell's equations. Plane waves, reflection, radiation. TEXT: Skilling, *Fundamentals of Electric Waves.* PREREQUISITES: PH 241C, PH 141B.

PH 365C ELECTRICITY AND MAGNETISM (4-1). Electrostatics. Dielectric media. Direct currents. Magnetostatics. Induced emf. Magnetic media. Maxwell's equations. The laboratory periods will be devoted to demonstrations and problem solving. TEXT: Schwarz, *Intermediate Electromagnetic Theory.* PREREQUISITE: PH 701C or equivalent.

PH 366B ELECTROMAGNETISM (4-0). A continuation of PH 365C. Applications of Maxwell's equations: plane waves in unbounded media; refraction and reflection of plane waves; transmission lines; wave guides; introduction to relativity. TEXT: Schwarz, *Intermediate Electromagnetic Theory.* PREREQUISITE: PH 365C.

PH 367A ADVANCED ELECTROMAGNETISM I (4-0). Solutions to Laplace's and Poisson's equations. Applications of Hertz potential or vector potential to radiation problems. Scattering and dispersion. TEXT: Jackson, *Classical Electrodynamics.* PREREQUISITE: PH 366B.

PH 368A ADVANCED ELECTROMAGNETISM II (3-0). Tensors in special relativity. Relativistic classical electromagnetic field theory. The Lienard-Wiechert potentials. Lorentz electron theory. TEXTS: Landau and Lifshitz, *Classical Theory of Fields;* Barut, *Electrodynamics and Classical Theory of Fields and Particles.* PREREQUISITES: PH 367A and PH 155A.

PH 400C SURVEY OF UNDERWATER SOUND AND ITS APPLICATIONS (3-0). This course is designed to acquaint the student wtih the physical properties of underwater sound, its environment and the related laws which pertain to its detection, especially in naval applications. The noise environment, sonar equation, range prediction, and passive and active detection mechanisms are some of the topics covered. PREREQUISITES: Ma 051D or its equivalent and SECRET clearance.

PH 424B FUNDAMENTAL ACOUSTICS (4-0). This course is designed to provide a background in vibration and sound for students of operations analysis. An analytical study of the dynamics of free, forced and damped simple harmonic oscillators, strings, bars and membranes. Development of, and solutions to, the acoustic wave equation. Propagation of plane waves in fluids and between different media. Acoustic filters. Beam patterns and directivity of acoustic radiation from a piston. Radiation reaction. Transducers for underwater sound. TEXT: Kinsler and Frey, *Fundamentals of Acoustics.* PREREQUISITES: Ma 182C and PH 141B.

PH 425B UNDERWATER ACOUSTICS (3-2). A continuation of PH 424B for students of operations analysis. An analytical survey of the propagation of underwater acoustic waves as influenced by boundary conditions, refraction, scattering, and attenuation. Physical characteristics of sonar transducers. Sonar systems and developments. Experiments in underwater acoustics and noise analysis. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* NDRC Technical Summary, *Principles of Underwater Sound;* NDRC Technical Summary, *Physics of Sound in the Sea.* PREREQUISITE: PH 424B.

PH 431B FUNDAMENTAL ACOUSTICS (4-0). This course is designed to provide a background in vibration and sound for students of electronics or ordnance. An analytical study of the dynamics of free, forced, and damped simple harmonic oscillators, strings, bars, and membranes. Development of, and solutions to, the acoustic wave equation. Propagation of plane waves in fluids and between media. Acoustic filters. Beam patterns and directivity of acoustic radiation from a piston, radiation reaction. Loudspeakers and microphones. TEXT: Kinsler and Frey, *Fundamentals of Acoustics.* PREREQUISITES: MA 113B and PH 105C, PH 151C.

PH 432B UNDERWATER ACOUSTICS (4-3). A continuation of PH 431B for students of electronics or ordnance. Transmission of sound in the ocean, including problems of refraction, attenuation, scattering, reverberation, and channel propagation. Physical principles used in sonar systems. Experiments in acoustical measurements, transducer measurements and noise analysis. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* NDRC Technical Summary—*Principles of Underwater Sound;* and NDRC Technical Summary—*Physics of Sound in the Sea.* PREREQUISITE: PH 431B.

PH 433A PROPAGATION OF WAVES IN FLUIDS (3-0). A theoretical treatment of the propagation of sound in fluids including molecular relaxation effects and both ray and wave propagation characteristics in bounded, inhomogeneous media. TEXTS: Lindsay, *Mechanical Radiation;* Officer, *Introduction to the Theory of Sound Transmission.* PREREQUISITE: PH 432B.

PH 441B SHOCK WAVES IN FLUIDS (4-0). Hydrodynamic equations. Propagation of acoustic waves in fluids. Shock waves propagated from nuclear explosions; Rankine-Hugoniot equations for the shock front, scaling laws, experimental measurements. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* Cole, *Underwater Explosions.* PREREQUISITES: Ma 183B and PH 152B, or equivalents.

PH 442A FINITE AMPLITUDE WAVES IN FLUIDS (3-0). Non-linear effects of intense sounds. Theory of propagation of shock waves in fluids. TEXTS: Cole, *Underwater Explosions;* Lindsay, *Mechanical Radiation;* and Landau and Lifshitz, *Fluid Mechanics.* PREREQUISITE: PH 432B or equivalent.

PH 450C UNDERWATER ACOUSTICS (3-2). A survey of the fundamentals of acoustics, with particular emphasis on the radiation, transmission and detection of sound in the sea. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* NDRC Technical Summary — *Principles of Underwater Sound;* NDRC Technical Summary—*Physics of Sound in the Sea.* PREREQUISITE: Ma 073C or Ma 244C or equivalent.

PH 461A TRANSDUCER THEORY AND DESIGN (3-3). A theoretical treatment of the fundamental phenomena in the design of crystal, magneto-strictive, and ceramic sonar transducers. Characteristics and parameters of various sonar transducer systems are studied in the Laboratory. TEXTS: Hueter and Bolt, *Sonics;* NDRC Technical Summary, *Magnetostriction Transducers;* Kinsler and Frey, *Fundamentals of Acoustics.* PREREQUISITE: PH 432B or equivalent.

PH 462B VIBRATION AND NOISE CONTROL (3-0). An analytical treatment of the physics of the generation of mechanical vibration and noise with particular emphasis on its control in naval applications. TEXT: Instructor's notes. PREREQUISITE: PH 432B or equivalent.

PH 463B SPECIAL TOPICS IN UNDERWATER ACOUSTICS (3-2). A terminal course following PH 432 for students in a two-year program. Topics may include additional material in underwater acoustics, transducer theory, nonlinear phenomena in acoustics, explosive waves in water, noise and vibration control. Laboratory experiments on related material. TEXT: Instructor's notes. PREREQUISITE: PH 432B or equivalent.

PH 471A ACOUSTICS RESEARCH (0-3). Advanced laboratory projects in acoustics. PREREQUISITE: PH 432B or equivalent.

PH 480E ACOUSTICS COLLOQUIUM (0-1). Reports on current research and study of recent research literature in conjunction with the student thesis. PREREQUISITE: PH 432B or equivalent.

PH 481A SEMINAR IN APPLICATIONS OF UNDERWATER SOUND (3-0). A study of current literature on applications of acoustics to problems of naval interest. PREREQUISITE: PH 433 or consent of the instructor.

PH 530C THERMODYNAMICS (3-0). Fundamental theory of thermodynamics and applications to physical problems. First and second laws of thermodynamics, equations of state, phase changes, thermodynamic potentials. TEXT: Sears, *Thermodynamics.* PREREQUISITES: Calculus of Several Variables. Introduction to Mechanics.

PH 531A ADVANCED THERMODYNAMICS (3-0). Principles of classical thermodynamics. Extremum principles and thermodynamic stability. Applications to gases, solids, and to electric and magnetic systems. Introduction to fluctuations and irreversible thermodynamics. TEXT: Callen, *Thermodynamics.* PREREQUISITES: PH 153A or PH 155A, PH 366B, PH 636B or PH 671B, PH 530C or equivalent.

PH 541B INTRODUCTORY STATISTICAL PHYSICS (4-0). Distribution functions, kinetic theory, introduction to classical and quantum statistics. Applications to gases, solids, and radiation. TEXTS: Sears, *Thermodynamics;* Andrews, *Equilibrium Statistical Mechanics.* PREREQUISITES: PH 152B, PH 530C, Ordinary Differential Equations.

PH 545A STATISTICAL PHYSICS (3-0). Kinetic theory and the Boltzmann theorem; configuration and phase space; the Liouville Theorem; ensemble theory: microcanonical, canonical, and grand canonical ensembles; quantum statistics. TEXT: Huang, *Statistical Mechanics.* PREREQUISITES: PH 153A or PH 156A, PH 636B or PH 671B, PH 541B, and PH 366B.

PH 546A STATISTICAL PHYSICS II (3-0). A continuation of PH 545A with selected applications to molecules, Bose-Einstein gases, Fermi-Dirac liquids and superconductivity. TEXT: Huang, *Statistical Mechanics.* PREREQUISITE: PH 545A.

PH 600D NUCLEONICS FUNDAMENTALS (3-0). A study of atomic structure, natural and artificial radioactivity, nuclear structure, nuclear fission, and chain reaction. Introduction to reactor principles, reactor components, and nuclear power plants. USUAL BASIS FOR EXEMPTION: Equivalent educational background. TEXTS: Hoisington, *Nucleonics Fundamental* and NAVPERS 10786, *Basic Nuclear Physics.*

PH 604C STRUCTURE OF ATOMS AND SOLIDS (4-0). Third term in the sequence of fundamental physics for those students in Electrical Engineering and Electronics, not planning to take PH 705B. Kinetic theory of gases, fundamental particles, brief treatment of nuclear physics, special relativity, the general principles of quantum mechanics, periodic chart of the elements, vector model of the atom, electrons in solids, semi-conductors and semiconducting devices. TEXTS: Weidner and Sells, *Elementary Modern Physics;* Sproull, *Modern Physics, 2nd ed.* PREREQUISITE: PH 205C.

PH 605B ATOMIC PHYSICS (4-0). Third term in the sequence of fundamental physics for students in Electrical Engineering and Electronics planning to take PH 705B. Kinetic theory of gases, Boltzmann function, statistical distributions, quantum mechanics, free and bound particles, emission and absorption of radiation, the one-electron atom, periodic table of the elements, many-electron atoms, electron spin, X-rays, vibration-rotation spectra for molecules. TEXTS: Sproull, *Modern Physics, 2nd ed.;* Weidner and Sells, *Elementary Modern Physics.* PREREQUISITE: PH 205C.

PH 610C SURVEY OF MODERN PHYSICS (4-0). An introductory course in modern physics. Particle aspects of radiation and wave aspects of material particles, atomic and nuclear structure, nuclear reactions, nuclear fission. TEXT: Weidner and Sells, *Elementary Modern Physics.* PREREQUISITE: PH 360B or equivalent.

PH 620C ELEMENTARY ATOMIC PHYSICS (4-0). Fundamental particles, forces on particles, kinetic theory, photons as waves and particles, electrons as particles and waves, elementary quantum physics, binding energies in atoms and nuclei. Atomic structure and spectra, X-rays, molecular structure, atoms in solids. TEXT: Weidner and Sells, *Elementary Modern Physics.* PREREQUISITE: PH 141B or equivalent.

PH 621C ELEMENTARY NUCLEAR PHYSICS (4-0). A descriptive and phenomenological course including properties of nucleons, nuclear structure, radioactivity, nuclear reactions, fission, and fusion. TEXT: Kaplan, *Nuclear Physics.* PREREQUISITE: PH 620C or PH 630C.

PH 622C NUCLEAR PHYSICS LABORATORY (0-3). Discussions and experiments on the interaction of nuclear radiations with matter. Detection techniques. PREREQUISITE: PH 621C (may be taken concurrently).

PH 630C ELEMENTARY ATOMIC PHYSICS (4-0). Elementary particles, interaction of particles, photoelectric effect, electron diffraction, the nuclear atom. Bohr model of the atom, energy levels in atoms, optical and X-ray spectra. Pauli exclusion principle. Zeeman effect, Schroedinger's equation. TEXT: Weidner and Sells, *Elementary Modern Physics.* PREREQUISITES: PH 152B and PH 240C or equivalents.

PH 631C ATOMIC PHYSICS LABORATORY (0-3). Quantitative laboratory exercises in atomic physics. PREREQUISITE: PH 620C or PH 630C (must be taken concurrently).

PH 635B ATOMIC PHYSICS I (5-0). Special theory of relativity. Fundamental particles, interactions of particles, photoelectric effect, wave-particle duality, Rutherford scattering, elementary quantum mechanics, Schroedinger equation, quantum mechanical operators, Bohr theory of the atom, quantum mechanical solution for the hydrogen atom, vector model of the atom, quantum numbers, Pauli exclusion principle, periodic table of the elements. TEXTS: Richtmyer, Kennard and Lauritsen, *Modern Physics,* and Sproull, *Modern Physics.* PREREQUISITES: Ma 230D and PH 240C.

PH 636B ATOMIC PHYSICS II (4-3). Fine structures in the hydrogen atom, Zeeman effect, selection rules in atomic spectra, X-rays, binding energies in molecules, molecular structure, band theory of solids, semi-conductors, electron and nuclear spin resonance. Laboratory: Quantitative experiments related to the lecture material of PH 635B and PH 636B. TEXTS: Richtmyer, Kennard and Lauritsen, *Modern Physics;* Sproull, *Modern Physics.* PREREQUISITE: PH 635B.

PH 637B NUCLEAR PHYSICS I (3-0). Basic nuclear concepts; mass, binding energy and stability; radioactivity and decay law; passage of charged particles and photons through matter. TEXTS: Segré, *Nuclei and Particles;* Kaplan, *Nuclear Physics;* others as required by instructor. PREREQUISITES: PH 365C, PH 636B or PH 671B.

PH 638B NUCLEAR PHYSICS II (3-3). Further nuclear properties; electric and magnetic moments; nuclear models; nuclear reactions; fission; theories of alpha-, beta-, and gamma-decay. Laboratory: experiments on the interactions of nuclear radiations with matter; statistics of decay; detection techniques. TEXTS: Segré, *Nuclei and Particles;* Kaplan, *Nuclear Physics;* Valente, *A Manual on Experiments in Reactor Physics.* PREREQUISITE: PH 637B.

PH 639A NUCLEAR PHYSICS II (4-3). Quantitative treatment of nuclear moments and angular momentum; models; partial wave analysis of reactions; the deuteron; quantum mechanical treatment of radioactive decay processes; nuclear fission and reactors. Laboratory: Same as PH 638B. TEXTS: Same as PH 638B. PREREQUISITE: PH 637B.

PH 646A ADVANCED NUCLEAR PHYSICS I (3-0). Partial wave analysis of scattering, the theories of nuclear reactions, nuclear forces. TEXTS: Blatt and Weisskopf, *Theoretical Nuclear Physics;* Sachs, *Nuclear Theory;* Bethe and Morrison, *Elementary Nuclear Theory;* the periodicals of nuclear physics. PREREQUISITES: PH 639A, PH 367A, and PH 712A.

PH 647A ADVANCED NUCLEAR PHYSICS II (3-0). Nuclear models, theory of beta-decay, theory of gamma emission, theory of alpha-decay. TEXTS: Blatt and Weisskopf, *Theoretical Nuclear Physics;* Sachs, *Nuclear Theory;* Bethe and Morrison, *Elementary Nuclear Theory;* the periodicals of nuclear physics. PREREQUISITE: PH 646A.

PH 648A HIGH ENERGY PHYSICS (3-0). Introduction to techniques and theories. Topics selected from scattering, relativistic particle dynamics, nuclear reactions, elementary particles, and accelerators and other experimental equipment. TEXTS: Jackson, *Physics of Elementary Particles;* Ritson, *Techniques of High Energy Physics.* PREREQUISITES: PH 636B or 671B, PH 638B, PH 711A.

PH 650B PHYSICS OF ELECTRICAL DISCHARGES IN GASES (4-0). A course covering the fundamental processes occurring in electrical discharge in gases. Emission of electrons from surfaces, excitation, ionization, recombination, deexcitation of atoms and molecules. Mobility and diffusion, electrical breakdown in gases. Glow and arc discharges, sheaths, experimental methods. TEXTS: Cobine, *Gaseous Conductors;* Von Engel, *Ionized Gases;* Francis, *Ionization Phenomena in Gases.* PREREQUISITES: PH 630C or PH 635B.

PH 651A REACTOR THEORY I (3-0). Nuclear fission, the diffusion and slowing down of neutrons, homogeneous thermal reactors. TEXTS: Glasstone and Edlund, *The Elements of Nuclear Reactor Theory;* Murray, *Nuclear Reactor Physics.* PREREQUISITES: PH 638B and Ma 113B or equivalent.

PH 652A REACTOR THEORY II (3-0). A continuation of PH 651A. Time behavior, reactor control, reflected systems, multigroup theory, heterogeneous systems, perturbation theory. TEXTS: Glasstone and Edlund, *The Elements of Nuclear Reactor Theory;* Murray, *Nuclear Reactor Theory.* PREREQUISITE: PH 651A.

PH 653A REACTOR PHYSICS LABORATORY (0-2). Experiments using the AGN-201 reactor including the measurement of the basic reactor parameters and the study of its transient behavior. TEXTS: Aerojet-General, *Elementary Reactor Experimentation;* Hughes, *Pile Neutron Research;* Glasstone and Edlund, *The Elements of Nuclear Reactor Theory.* PREREQUISITES: PH 651A and PH 652A. (The latter may be taken concurrently.)

PH 654A PLASMA PHYSICS I (4-0). Introduction to physical and mathematical concepts fundamental to various branches of plasma physics such as ionospheric communications, ion propulsion, plasma amplifiers and controlled fusion. Hydromagnetic and Boltzmann equations. Behavior of charged particles in electric and magnetic fields. Interaction of electromagnetic waves with plasmas. Magnetic pressure. Debye length. TEXTS: Uman, *Introduction to Plasma Physics;* Rose and Clark, *Plasma and Controlled Fusion;* Glasstone and Loveberg, *Controlled Thermonuclear Reactions.* PREREQUISITES: PH 367A, PH 541B, and PH 636B or PH 671B.

PH 655A PLASMA PHYSICS II (4-0). A continuation of Plasma Physics I. Collisions of plasma particles, relaxation times. Bremsstrahlung and cyclotron radiation. Longitudinal oscillations of electrons and ions. Hydromagnetic waves in plasmas. Transport theory using the Boltzmann equation. Pinch effect, plasma instabilities. TEXTS: Same as PH 654A. PREREQUISITE: PH 654A.

PH 656A ADVANCED PLASMA THEORY (3-0). Topics covered will be related to research problems in progress or contemplated and will depend somewhat on the interests of the students enrolled. Possible topics are: diffusion in plasmas, radiation from plasmas and the propagation of hydromagnetic waves in plasmas. Use will be made of the current scientific literature. TEXTS: Allis, Buchsbaum and Bers, *Waves in Anisotropic Plasmas;* Lecture Notes. PREREQUISITE: PH 655A.

PH 657A ADVANCED PLASMA PHYSICS II (3-0). A continuation of Physics 656A with emphasis on the current scientific literature. PREREQUISITE: PH 656A.

PH 670B ATOMIC PHYSICS I (3-0). Fundamental particles, kinetic theory, forces on particles, special theory of relativity, wave-particle duality, quantum mechanics of simple systems, quantum mechanical operators, Bohr model of the atom, quantum mechanical solution for the hydrogen atom. TEXTS: Richtmyer, Kennard and Lauritsen, *Modern Physics;* Eisberg, *Fundamentals of Modern Physics;* Lecture Notes. PREREQUISITES: PH 152B or equivalent. Ma 240C or equivalent, and PH 270B.

PH 671B ATOMIC PHYSICS II (3-3). Fine structure in the hydrogen atom, vector model of the atom, spectroscopic notation, Zeeman effect, many-electron atoms, periodic table in terms of quantum numbers, X-rays, binding in molecules. Laboratory: Quantitative experiments related to lecture material of PH 670B and PH 671B. TEXTS: Richtmyer, Kennard and Lauritsen, *Modern Physics;* Eisberg, *Fundamentals of Modern Physics;* Lecture Notes. PREREQUISITE: PH 670B.

PH 672A ATOMIC SPECTROSCOPY (3-0). Vector model of the atom and applications to complex spectra, selection rules, line broadening problems and applications to diagnostic measurements in plasma systems, spectroscopic techniques, selected topics on physics of the upper atmosphere. TEXTS: Griem, *Plasma Spectroscopy;* Kuhn, *Atomic Spectra.* PREREQUISITES: PH 636 or PH 671 or consent of instructor.

PH 675A ATOMIC COLLISION PROCESSES (3-0). Atomic interactions of interest in low density gases. Classical and quantum description of the collision process. Selected applications from the physics of the upper atmosphere, effects of solar radiation on atmospheric and interplanetary gases. Discussion of pertinent experimental techniques. TEXT: McDaniels, *Collision Phenomena in Ionized Gases.* PREREQUISITES: PH 636B or PH 671B, or consent of instructor.

PH 701C INTRODUCTION TO THE METHODS OF THEORETICAL PHYSICS (4-0). An introduction to the techniques used in solving problems in the classical field theories. Vector and scalar fields are studied. Solutions to the source-free equations most often encountered in physics are discussed. TEXT: To be chosen by instructor. PREREQUISITES: Calculus of Several Variables, Algebra of Complex Numbers, Vector Algebra, and Ordinary Differential Equations (the latter may be taken concurrently).

PH 705B ELECTRONIC PROCESSES IN MATERIALS (4-2). Fourth term in the sequence of fundamental physics for students in Electrical Engineering and Electronics. Crystals and lattice properties, X-ray diffraction, free-electron theory, electrical conductivity, band theory, Brillouin zones, effective mass, holes, intrinsic and impurity semiconductors, diodes, transistors, thermoelectric effects, brief treatment of magnetic properties. TEXTS: Kittel, *Introduction to Solid State Physics*, 2nd ed.; Azaroff and Brophy, *Electronic Processes in Materials.* PREREQUISITE: PH 605B.

PH 711A QUANTUM MECHANICS I (3-0). The need for quantum theory. Matrix formulation of quantum mechanics. The square well potential and the harmonic oscillator. TEXTS: Dirac, *Quantum Mechanics;* Schiff, *Quantum Mechanics.* PREREQUISITES: PH 156A, PH 366B, PH 636B or PH 671B.

PH 712A QUANTUM MECHANICS II (3-0). The hydrogen atom. Time independent and time dependent perturbation theory. Identical particles and spin. TEXTS: Dirac, *Quantum Mechanics;* Schiff, *Quantum Mechanics.* PREREQUISITE: PH 711A.

PH 713A QUANTUM MECHANICS III (3-0). Atoms, relativistic particle wave equations and solutions. TEXTS: Schiff, *Quantum Mechanics;* Bjorken and Drell, *Relativistic Quantum Mechanics.* PREREQUISITE: PH 712A.

PH 714A QUANTUM FIELD THEORY I (3-0). Quantization of scalar, spinor, and vector fields. Interacting fields. TEXT: Schweber, *Introduction to Relativistic Quantum Field Theory.* PREREQUISITE: PH 713A.

PH 715A QUANTUM FIELD THEORY II (3-0). The S-matrix and renormalization. Strong, electromagnetic, and weak interactions. Introduction to dispersion relations. TEXT: Schweber, *Introduction to Relativistic Quantum Field Theory*. PREREQUISITE: PH 714A.

PH 718A PHYSICAL GROUP THEORY (3-0). Invariance of quantum mechanical systems to certain groups of transformations. Topics to be selected from finite rotation groups and crystal symmetries, the continuous rotation group in three dimensions, transformation groups associated with elementary particle symmetries. PREREQUISITE: PH 712A.

PH 719A RELATIVITY AND COSMOLOGY (3-0). Foundations of the special theory of relativity, tensor calculus, introduction to the general theory of relativity. Experimental tests of the general theory. Introduction to cosmology. TEXTS: Eddington, *The Mathematical Theory of Relativity;* Bondi, *Cosmology*. PREREQUISITES: PH 636B or PH 671B, Ma 260C, PH 368A.

PH 723B THEORY OF SOLID STATE AND QUANTUM DEVICES (4-0). Theory of the structure of solids with emphasis on the electronic structure. Topics in quantum mechanics with special emphasis on quantum behavior as applied to quantum electronic devices: stimulated emission, spin resonance, rotating coordinate, relaxation times. Applications to masers, lasers, parametric amplifiers, magnetic instruments, extreme constant frequency oscillators, etc. TEXTS: Decker, *Introduction to Solids;* Herzberg, *Atomic Spectra;* Singer, *Masers*. PREREQUISITE: PH 630C.

PH 724A THEORY OF QUANTUM ELECTRONIC DEVICES (4-0). Theory of the operation of electronic devices depending on energy states and the quantum nature of radiation; topics in quantum mechanics, spin resonance, rotating coordinates, relaxation times, internal fields; application to specific electronic devices such as masers, microwave and optical pumping devices, paramagnetic amplifiers, magnetic instruments. TEXTS: Herzberg, *Atomic Spectra;* Townes, *Microwave Spectroscopy*. PREREQUISITE: PH 620C or equivalent.

PH 725A PHYSICS OF SOLIDS I (4-0). Theory of the structure and properties of solids; crystal symmetry and the anisotropy of physical properties, binding energy, lattice specific heat, thermal conductivity, properties of phonons. TEXTS: Wannier, *Solid State Theory;* Kittel, *Introduction to Solid State Physics*. PREREQUISITES: PH 635B, PH 636B.

PH 726A PHYSICS OF SOLIDS II (4-2). A continuation of PH 725A, with laboratory experiments relating to both terms. Electronic properties of solids, band theory, effective electron masses, Brillouin zones, semiconductors, and solid state electronic devices, magnetic properties, spin resonance, dielectrics, superconductivity, imperfections in solids and the related mechanical properties. TEXTS: Wannier, *Solid State Theory;* Kittel, *Introduction to Solid State Physics*. PREREQUISITE: PH 725A.

PH 730A PHYSICS OF THE SOLID STATE (4-2). Fundamental theory and related laboratory experiments dealing with solids, with emphasis on electronic properties; crystals, binding energy, anisotropy, lattice oscillations, band theory of electrons, Brillouin zones, "hole" concept, effective mass, electrical conductivity, insulators and semiconductors, fluorescence, junction rectifiers, transistors, magnetism, and dielectrics. TEXTS: Dekker, *Solid State Physics;* Kittel, *Introduction to Solid State Physics*. PREREQUISITES: PH 636B or PH 671B.

PH 731A ADVANCED SOLID STATE PHYSICS I (3-0). Fundamental studies of selected topics in solid state physics. The material selected will be chosen from: Theory of specific heats, transport properties, one electron approximations, the cohesive energy, mechanical properties, optical properties, magnetic properties, and resonance methods. TEXTS: Kittel, *Introduction to Solid State Physics;* Seitz, *Modern Theory of Solids;* Seitz and Turnbull, *Solid State Physics;* and current literature. PREREQUISITES: PH 730A and PH 711A.

PH 732A ADVANCED SOLID STATE PHYSICS II (3-0). A continuation of PH 731A with emphasis on the study of the current scientific literature. PREREQUISITE: PH 731A.

PH 750E PHYSICS COLLOQUIUM (0-1). Discussion of topics of current interest in the field of physics and student thesis reports.

PH 770A READING IN ADVANCED PHYSICS (3-0). Supervised reading from the periodicals in fields of advanced physics selected to meet the needs of the student.

NAVY MANAGEMENT SYSTEMS CENTER

EDWARD JOSEPH O'DONNELL, Rear Admiral, U.S. Navy; Director; B.S., U.S., Naval Academy, 1929; U.S. Naval Postgraduate School, 1939.

HERMAN PAUL ECKER, Professor; Associate Director (1957)*; B.A., Pomona College, 1948; M.A., Claremont Graduate School, 1949; Ph.D. (pending).

MILES EDMINSTON TWADDEL, Commander, U.S. Navy; Curricular Officer/Assistant Professor (1965); B.S., Ohio State Univ., 1959; M.S., U.S. Naval Postgraduate School, 1962.

ROSCOE LLOYD BARRETT, JR., Lieutenant Colonel, U.S. Marine Corps; Assistant Professor (1966); B.J., Univ. of Missouri, 1947; M.S., U.S. Naval Postgraduate School, 1964.

SHERMAN WESLEY BLANDIN, JR., Captain, SC, U.S. Navy, Associate Professor (1962); B.S., U.S. Naval Academy, 1944; B.S., Georgia Institute of Technology, 1952; M.S., 1953.

FRANK ELMER CHILDS, Professor (1965); B.A., Willamette Univ., 1934; M.B.A., Univ. of Southern California, 1936; Ph.D., Univ. of Minnesota, 1956.

RONALD KOCHEMS, Assistant Professor (1965); B.S., Purdue Univ., 1961; M.S., 1962; Ph.D. (pending).

WILLIAM ALAN MAUER, Associate Professor (1966); A.B., San Jose State, 1955; M.S., Agricultural and Mechanical College of Texas, 1957; Ph.D., Duke Univ., 1960.

BURTON ROSS PIERCE, Assistant Professor (1964); A.B., Harvard Univ., 1956; M.B.A., Stanford Univ., 1962.

DONALD BLESSING RICE, JR., Lieutenant, U.S. Army; Assistant Professor (1965); B.S., Univ. of Notre Dame, 1961; M.S., Purdue Univ., 1962; Ph.D., 1965.

JOHN DANCY RICHARDSON, Associate Professor (1966); B.S., Univ. of North Carolina, 1953; M.A., George Washington, 1960; Ph.D., Univ. of North Carolina (pending).

CHARLES ERNEST TYCHSEN, Lieutenant Colonel, U.S. Air Force; Associate Professor (1965); B.S., Princeton Univ., 1943; M.S., Air Force Institute of Technology, 1953; M.B.A., Ohio State Univ., 1956; Ph.D., Univ. of Maryland (pending).

*The yeor of joining the Postgroduote School faculty is indicated in porenthesis.

DEFENSE MANAGEMENT SYSTEMS COURSE

The Navy Management Systems Center has been established at the U.S. Naval Postgraduate School to conduct the Defense Management Systems Course. Faculty members have been drawn from the regular faculty of the Postgraduate School to insure the academic excellence of the program.

The Planning-Programming-Budgeting System developed since 1961 by the Office of the Secretary of Defense has provided a framework for examining various force mixes, allocation of resources, and relationships to military capabilities.

The objective of the Defense Management Systems Course is to provide an appreciation of the concepts, principles, and methods of defense management as they concern planning, programming, budgeting, and related activities. The course will cover force planning, and DoD programming, program budgeting, and their interrelationships with resource management systems. Emphasis will be placed on the analytical aspects of management; including requirements studies, systems analysis, cost/effectiveness, cost estimating and analysis.

Students are not expected to become experts or technicians in the various disciplines and subjects included in the curriculum. The objectives are to provide orientation on the overall functioning of the defense management process, insights as to what defense management requires in the way of inputs and analyses for decision making, understanding of the principles, methods and techniques used, and awareness of the interfaces between the management requirements of the DoD components and the Office of the Secretary of Defense.

CALENDAR—Academic Year 1966-67

26 June - 22 July 1966	Symposium
31 July - 5 August 1966	Flag Rank/General
16 October - 11 November 1966	Class #1
27 November - 20 December 1966	Class #2
8 January - 3 February 1967	Class #3
12 February - 10 March 1967	Class #4
19 March - 24 March 1967	Flag Rank/General
2 April - 28 April 1967	Class #5
7 May - 2 June 1967	Class #6
11 June - 7 July 1967	Class #7

POSTGRADUATE SCHOOL STATISTICS
GRADUATES BY YEARS

	1946-1950	1951-1955	1956-1960	1961	1962	1963	1964	1965	Total
Bachelor of Arts	......	......	......	......	4	59	47	70	180
B.S. in Aeronautical Engineering	73	212	212	57	36	29	34	25	678
B.S. in Chemistry	......	......	3	......	......	3	......	......	6
B.S. in Communications Engineering	......	......	42	12	13	7	30	33	137
B.S. in Electrical Engineering	62	115	98	50	60	31	59	53	528
B.S. in Engineering Electronics	94	177	92	18	45	28	44	37	535
B.S. in Environmental Science								12	12
B.S. in Management	......	......	......	9	3	14	27	......	53
B.S. in Mechanical Engineering	43	116	52	22	14	10	16	20	293
B.S. in Meteorology	16	104	77	25	30	16	21	16	305
B.S. in Physics	......	15	36	8	21	16	16	14	126
Bachelor of Science	......	56	94	103	116	115	119	130	733
Total Baccalaureate Degrees	288	795	706	304	342	328	413	410	3586
M.S. in Aeroelectronics								4	4
M.S. in Aeronautical Engineering	......	......	......	3	4	12	7	10	36
M.S. in Chemistry	......	......	16	......	......	2	1	2	21
M.S. in Materials Science								5	5
M.S. in Electrical Engineering	7	34	46	26	19	15	15	11	173
M.S. in Engineering Electronics	68	120	78	11	23	24	22	24	370
M.S. in Management	......	......	......	74	87	89	71	85	406
M.S. in Management/Data Processing	......	......	......	......	......	......	7	15	22
M.S. in Mechanical Engineering	20	36	48	11	14	9	8	7	153
M.S. in Meteorology	23	19	40	14	14	6	10	9	135
M.S. in Operations Research	......	......	......	......	......	......	31	32	63
M.S. in Physics	......	25	104	20	28	39	15	33	264
Master of Science	......	17	65	16	20	25	25	16	184
Total Master's Degrees	118	251	397	175	209	221	212	253	1836
Aeronautical Engineer	......	......	......	......	......	1	......	3	4
Doctor of Philosophy	......	......	1	1	2	3	5	3	15
TOTAL DEGREES	406	1046	1104	480	553	553	630	670	5442

GRADUATES OF THE POSTGRADUATE SCHOOL 1965

DIPLOMAS OF COMPLETION, ENGINEERING SCIENCE

ALLGOOD, Dempsey E., LT, USN
AUSTIN, Paul B., LT, USN
BAXTER, Robert C., LT, USN
BELL, John M., LT, USN
BLACKMON, Thomas L., LT, USN
BLOSE, Larry E., LT, USN
BORDEN, Douglas H., Jr., LCDR, USN
BOTHWELL, Michael P., LT, USN
BROWN, Michael J., LT, USN
CALVERT, William R., LT, USN
CAMPBELL, Carlos C., LT, USN
CAMPBELL, Craig S., LT, USN
CARRELL, Douglas E., LT, USNR
CASEY, Richard J., LT, USN
CRABBS, Edward H., Jr., LT, USN
CREIGHTON, George C., III, LT, USN
CROWSON, Christopher G., LT, USN
DEFFET, Thomas L., LT, USN
DESROSIERS, Roland J., LCDR, USN
DICK, Calvin R., LT, USN
DRAKE, James A., Jr., LT, USNR
DUPLER, Larry N., LT, USN
EASTMAN, Leonard C., LT, USN
EIBERT, Don C., LCDR, USN
EKSTROM, John S., LT, USN
ELLINGWOOD, Arthur R., Jr., LT, USN
EYER, Jack W., LT, USN
FLYNN, Samuel C., Jr., LT, USN
FOSS, Donald M., LT, USN
FULLERTON, George E., Jr., LT, USN
GALBRAITH, William R., LT, USN
GEANEY, John R., LT, USN
GIERSCH, Albert E., LT, USN
GOODE, Martin, CDR, USN
GUDMUNDSON, Marvin L., LT, USN
GUILBAULT, Roland G., LT, USN
HAAS, William R., LT, USN
HARWELL, Layne H., LT, USN
HEADLEY, Allen B., LCDR, USN
HEAL, Charles W., Jr., LT, USNR
HEATON, John E., LT, USN
HENDREN, Edward D., LTJG, USN
HERBERGER, Albert J., LCDR, USN
HERIG, Richard W., LT, USN
HILL, Edward R., LT, USN
HILL, Lucio W., LCDR, USN
HITTSON, Ward Y., T, USN
HODAPP, David H., LT, USN
HOPF Elwood J., LCDR, USN
HOSPES, Alan E., LT, USN
HOUGHTON, Harry A., Jr., LT, USN
HUBBARD, Charles W., Jr., LT, USN
HUYSER, Harvey L., LT, USN
JOHNSON, Dale W., LCDR, USN
KARRE, David H., LT, USN
KEATHLEY, Charles C., LCDR, USN
KILLINGER, Edwin E., LT, USN
KRAMER, George, CDR, USN
KUNKEL, Barry E., LT, USN
LARKIN, Robert J., LT, USN
LIGHTON, Paul G., LT, USN
LUPFER, Alexander M., Jr., LT, USN
MATTSON, Donald J., LCDR, USN
MESTON, Stanley S., LTJG, USN
MONSON, Arthur C., LT, USNR
MORR, James F., LT, USNR
OAKSMITH, David E., Jr., LCDR, USN
O'CONNELL, Michael J., LTJG, USN
O'MALLEY, Anthony V., Jr., LTJG, USN
O'NEILL, Daniel I., LT, USN
ORD, George D., Jr., LT, USN
PARKER, Robert C., Jr., LT, USN
PATTERSON, Larry L., LT, USN
QUAST, Harry S., LT, USN
RAYNIS, Harrison R., LT, USN
REDMAN, John B., LT, USN
RICE, Edward J., LT, USNR
RODERICK, John T., LT, USN
ROSS, William M., Jr., LT, USN
ROTH, Charles J., Jr., LT, USNR
ROUDEBUSH, Loren K., LT, USNR
SALISBURY, Herbert D., LT, USN
SAUNDERS, William H., III, LCDR, USN
SELTZER, James L., LT, USN
SIMON, James W., LT, USN
SMITH, Frank W., LT, USN
SMITH, Samuel, Jr., LT, USN
STEPHENS, William L., LT, USN
SWANSON, Matthew C., LT, USN
TOPP, David P., LT, USN
VAN SLYKE, James C., Jr., LTJG, USN
WALLACE, Robert C., LCDR, USN
WALTER, Merritt N., LTJG, USNR
WARDWELL, Arthur F., Jr., LT, USN
WELCH, William C., Jr., LT, USN
WHITE, Tramel A., Jr., LTJG, USNR
WICKERT, Alan J., LTJG, USN
WILSON, Alger L., LT, USN
WITHERSPOON, Emanuel E., LT, USN

DIPLOMAS OF COMPLETION, MANAGEMENT

BARRETT, Charles W., LCDR, USN
DUNHAM, Chester J., Jr., LT, USN
HARRIS, Richard A., LT, USN
HEELEY, Eric W. L., LT, USN
HIBBARD, Grant W., LT, USN
HINES, Kenneth F., LT, USN
JANIEC, Roy T., CDR, USN
JEFFRIES, Rollin E., Jr., LCDR, USN
KARGE, Ronald E., LCDR, USN
KENNEDY, Walter J., LCDR, USN
KROLLMAN, Richard W., LT, USN
LANGFORD, John A., Jr., LT, USN
LOTTON, Donald E., LCDR, USN
McVEIGH, Paul J., CDR, USN
PETRIE, Roland A., LCDR, USN
TYSON, Billie C., LCDR, USN

DIPLOMAS OF COMPLETION, MANAGEMENT/DATA PROCESSING

KATZ, Donald L., LT, USN
SMITH, Jay R., LCDR, USN

DIPLOMAS OF COMPLETION, TECHNICAL CURRICULUM

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Ecuadorian Navy
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Imperial Ethiopian Navy
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TELAHOUN, Demissei, LT
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Imperial Iranian Navy
SANGELAJI, Ali, LTJG
Imperial Iranian Navy
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Republic of Korea Navy
PAK, Tong Kyu, LT
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Republic of Korea Navy
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Philippine Navy
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AN, Nguyen-Van, LT
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