R. Sanders

NAVAL POSTGRADUATE SCHOOL

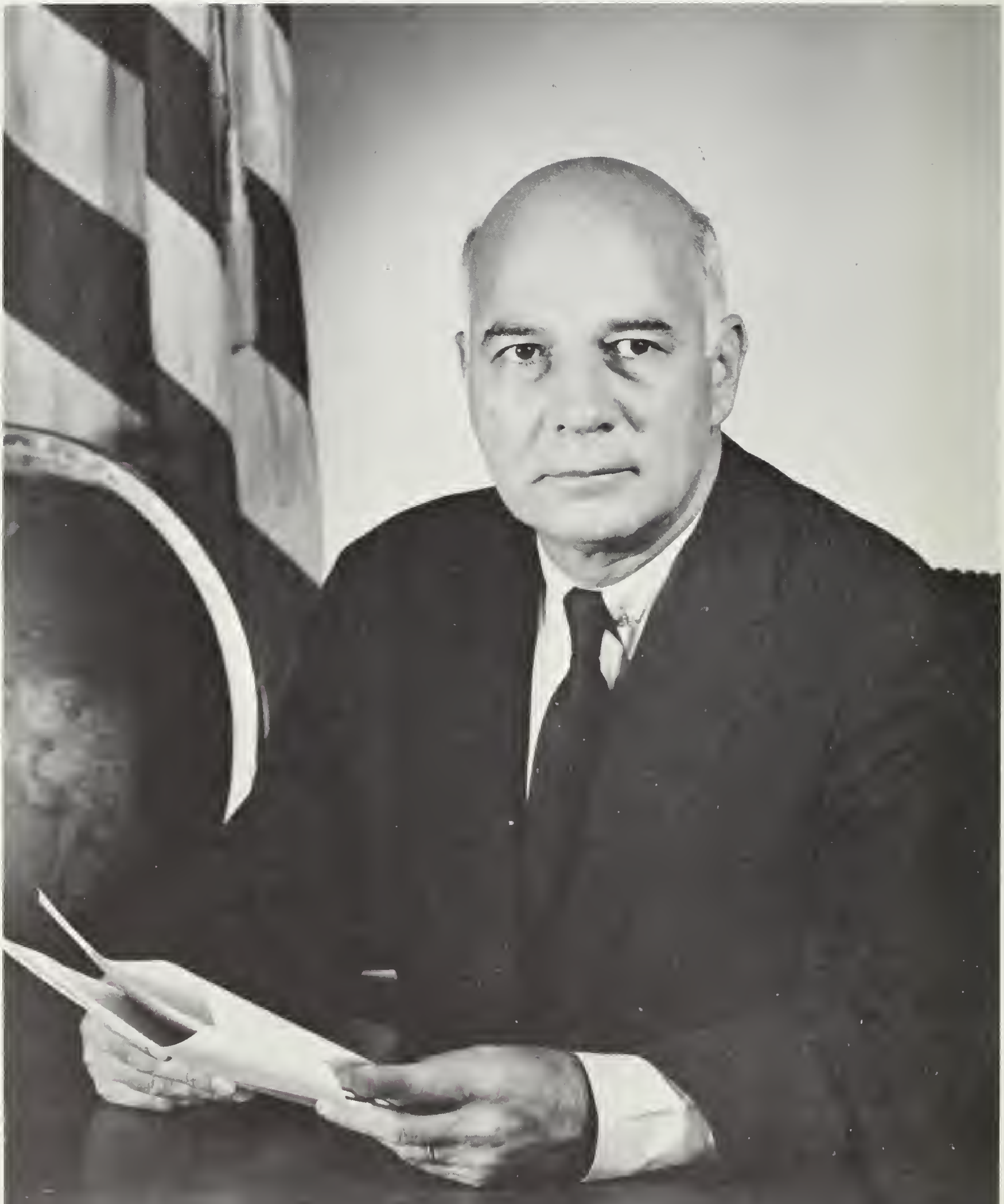
MONTEREY, CALIFORNIA

CATALOGUE FOR 1968-1970

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

CATALOGUE FOR 1968-1970

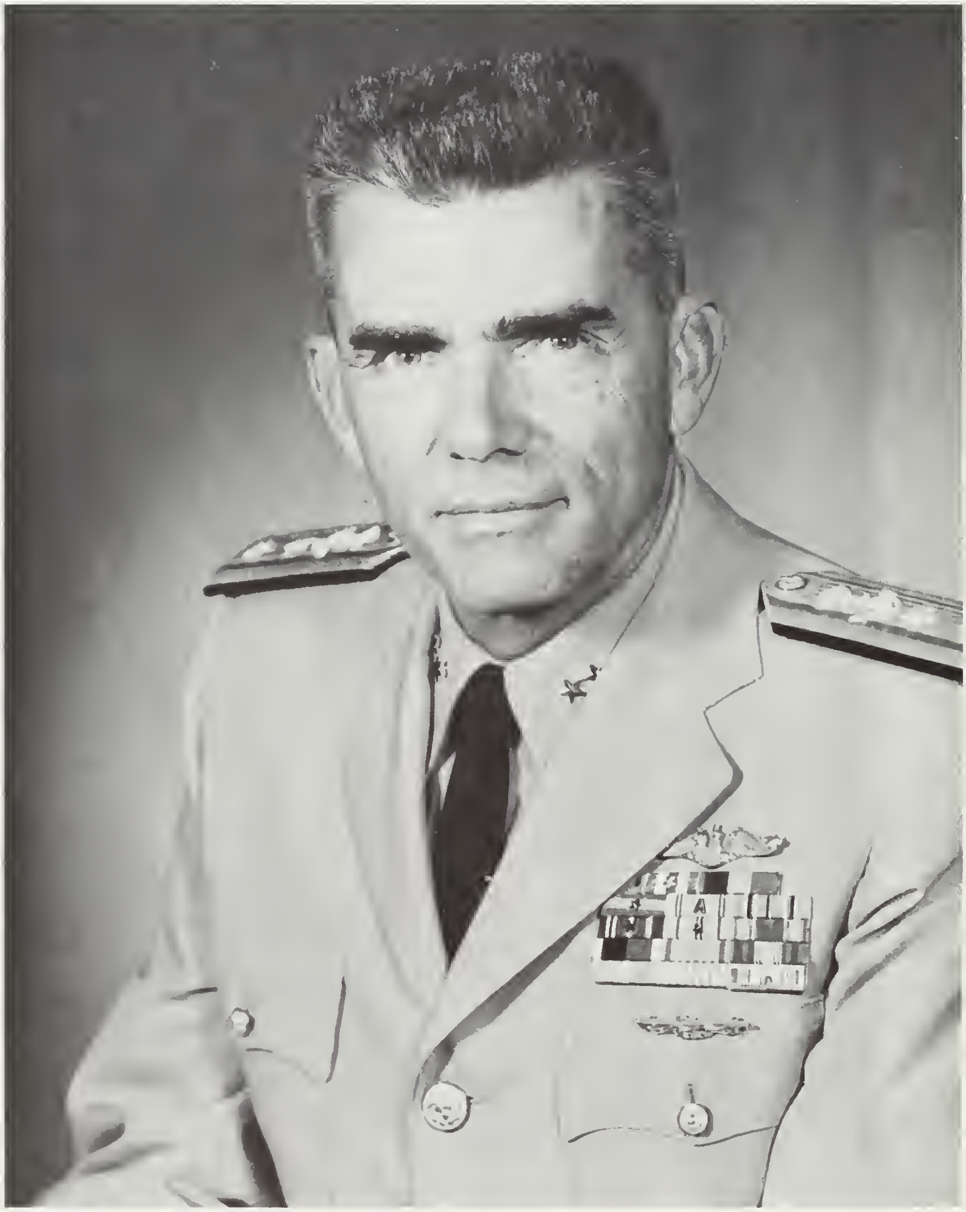


Paul Robert Ignatius
Secretary of the Navy

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, and to provide such other 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

ROBERT WARING MCNITT

Rear Admiral, U.S. Navy

B.S., Naval Academy, 1938; Naval Postgraduate School, 1945;

M.S., Massachusetts Institute of Technology, 1947

Academic Dean

ROBERT FROSS RINEHART

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

Herrmann Hall, the main administration building

NAVAL POSTGRADUATE SCHOOL

Deputy Superintendent for Operations and Programs

FLETCHER HARRIS BURNHAM

Captain, U.S. Navy

B.S., Naval Academy, 1943;
B.S. in Operations Analysis, Naval Postgraduate School, 1954;
M.S., 1954

Deputy Superintendent for Administration and Logistics

THOMAS ANDREW MELUSKY

Captain, U.S. Navy

B.S., Univ. of Washington, 1941;
M.A., George Washington Univ., 1963

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 Deputy Superintendent for Operations and Programs

ORRIE ANDREW HAHS

Captain, U.S. Navy

B.S., Naval Postgraduate School, 1952;
M.S. in Physics, Univ. of California
at Los Angeles, 1953

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

Superintendent's Staff Assistants

Aide to the Superintendent ....Lt. (j.g.) William L. Moll, USN
Comptroller ....Capt. Robert E. Graham, SC, USN
Civilian Personnel Officer ....Mr. Weston B. Lockwood
Officer in Charge (NALF) ....Capt. Mark Twain Whittier, USN
Senior Medical Officer (NALF) ....Capt. Neil V. White, MC, USN

Dean of Curricula Staff

Registrar............Mrs. Cecyle Erskine Eifler
Class Scheduler............Mrs. Jacqueline M. Olson
Cataloguer............Mrs. Mary Klotz Burton

Operations and Programs Administrative Staff

Plans Officer............Cdr Warren A. Higley, USN
Flight Officer............Cdr James R. Bell, USN
Administrative Officer............Lt Evelyn C. Wadsworth, USN
Program Allotment and Material Control Officer....Lcdr Richard L. Wyatt, USN
Academic Liaison Officer............Lcdr Maxine A. Mandt, USN
Foreign Training Officer............Cdr Joseph P. Leo, Jr., USN
Marine Corps Representative............Lt Col Edwin M. Rudzis, USMC
Submarine Liaison Officer............Lcdr Clyde G. Hohenstein, USN

Administration and Logistics Staff

Head, Administration Dept............Cdr Robert L. Pelton, USN
Head, Supply Dept............Cdr Mary J. Aplin, SC, USN
Head, Public Works Dept............Cdr Daniel W. Urish, CEC, USN
Head, Dental Dept. ....Capt Edmund H. Frizzell, DC., USN
Head, Services Department............Cdr Everett R. Pfugh, USN
Catholic Chaplain............Capt Francis J. Fitzpatrick, ChC, USN
Protestant Chaplain............Capt Samuel D. Chambers, ChC, USN
Public Affairs and Visit Liaison............Lt Westinus Boer, II, USN
Legal Officer ....Lcdr Larry W. Gresens, USNR
Communications Officer............Lt Nonna E. Cheatham, USN
Staff Secretary............Lt Donald E. Towne, USN

CALENDAR FOR 1968-69 ACADEMIC YEAR

1968

Registration for Management, BS/BA, IGEP, Meteorology, Nuclear Engineering (Effects) Curricula	Monday, 24 June
Quarter I Begins (1968-69)	Monday, 1 July
Fourth of July (holiday)	Thursday, 4 July
Language Examinations in French, German, Russian, for Ph.D. Candidates	Monday, 5 August
Refresher Course Begins	Monday, 12 August
Labor Day (holiday)	Monday, 2 September
Date for Final Completion of Thesis for Sept. Graduation	Wednesday, 11 September
Registration for all Curricula, except Management, IGEP, Meteorology, Nuclear Engineering (Effects)	Monday, 16 September
Examination Week for Quarter I	16-20 September
Quarter I Ends	Friday, 20 September
Quarter II Begins	Monday, 23 September
Graduation	Wednesday, 25 September
Language Examinations in French, German, Russian, for Ph.D. Candidates	Monday, 21 October
Veterans Day (holiday)	Monday, 11 November
Refresher Course Begins	Monday, 25 November
Thanksgiving Day (holiday)	Thursday, 28 November
Date for Final Completion of Thesis for December Graduation	Wednesday, 4 December
Examination Week for Quarter II	9-13 December
Quarter II Ends	Friday, 13 December
Christmas Holiday Begins	Monday, 16 December
Graduation	Wednesday, 18 December
Registration for Management, IGEP, Meteorology, BS/BA Curricula	Monday, 30 December

1968

JANUARY

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FEBRUARY

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AUGUST

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SEPTEMBER

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DECEMBER

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1969

JANUARY

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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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1969

New Years Day (holiday)	Wednesday, 1 January
Quarter III Begins	Monday, 6 January
Language Examinations in French, German, Russian, for Ph.D. Candidates	Monday, 20 January
Refresher Course Begins	Monday, 17 February
Washington's Birthday (holiday)	Friday, 21 February
Date for Final Completion of Thesis for April Graduation	Wednesday, 19 March
Registration for all Curricula, except Management, BS/BA, IGEP, Meteorology, CEC Electronics, Nuclear Engineering (Effects), Underwater Physics Systems	Monday, 24 March
Examination Week for Quarter III	24-28 March
Quarter III Ends	Friday, 28 March
Quarter IV Begins	Monday, 31 March
Graduation	Wednesday, 2 April
Language Examinations in French, German, Russian, for Ph.D. Candidates	Monday, 21 April
Refresher Course Begins	Monday, 26 May
Memorial Day (holiday)	Friday, 30 May
Date for Final Completion of Thesis for June Graduation	Wednesday, 11 June
Examination Week for Quarter IV	16-20 June
Quarter IV Ends (1968-69)	Friday, 20 June
Graduation	Friday, 27 June

CALENDAR FOR 1969-70 ACADEMIC YEAR

1969

Registration for Management, BS/BA, IGEP, Meteorology, Nuclear Engineering (Effects) Curricula .... Monday, 30 June
Fourth of July (holiday) .... Friday, 4 July
Quarter I Begins (1969-70) .... Monday, 7 July
Refresher Course Begins .... Monday, 18 August
Labor Day (holiday) .... Monday, 1 September
Date for Final Completion of Thesis for October Graduation .... Wednesday, 17 September
Registration for all Curricula, except Management, IGEP, Meteorology, BS/BA Nuclear Engineering (Effects) .... Monday, 22 September
Examination Week for Quarter I .... 22-26 September
Quarter I Ends .... Friday, 26 September
Quarter II Begins .... Monday, 29 September
Graduation .... Wednesday, 1 October
Language Exam in French, German, Russian, for Ph.D. Candidates .... Monday, 20 October
Veterans Day (holiday) .... Tuesday, 11 November
Refresher Course Begins .... Monday, 24 November
Thanksgiving Day (holiday) .... Thursday, 27 November
Date for Final Completion of Thesis for December Graduation .... Monday, 8 December
Exam Week for Quarter II .... 15 - 19 December
Quarter II Ends .... Friday, 19 December
Christmas Holiday Begins .... Monday, 22 December
Graduation .... Monday, 22 December
Registration for Management, IGEP, Meteorology, BS/BA Curricula .... Monday, 29 December

1969

JANUARY

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FEBRUARY

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APRIL

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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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1970

JANUARY

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FEBRUARY

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MARCH

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APRIL

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JUNE

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JULY

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SEPTEMBER

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OCTOBER

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NOVEMBER

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DECEMBER

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1970

New Years Day (holiday) .... Thursday, 1 January
Quarter III Begins .... Monday, 5 January
Language Examinations in French, German, Russian for Ph.D. Candidates .... Monday, 19 January
Refresher Course Begins .... Monday, 16 February
Washington's Birthday (holiday) .... Monday, 23 February
Date for Final Completion of Thesis for April Graduation .... Wednesday, 18 March
Registration for all Curricula, except Management, BS/BA, CEC Electronics, Nuclear Engineering (Effects), IGEP, Meteorology, Underwater Physics Systems .... Monday, 23 March
Examination Week for Quarter III .... 23 - 27 March
Quarter III Ends .... Friday, 27 March
Quarter IV Begins .... Monday, 30 March
Graduation .... Wednesday, 1 April
Language Examinations in French, German, Russian for Ph.D. Candidates .... Monday, 20 April
Refresher Course Begins .... Monday, 25 May
Memorial Day (holiday) .... Friday, 29 May
Date for Final Completion of Thesis for June Graduation .... Wednesday, 10 June
Examination Week for Quarter IV .... 15-19 June
Quarter IV Ends (1969-70) .... Friday, 19 June
Graduation .... Friday, 26 June
Registration for Management, BS/BA, IGEP, Meteorology, Nuclear Engineering (Effects) Curricula .... Monday, 29 June
Fourth of July (holiday) .... Friday, 3 July
Quarter I Begins (1970-71) .... Monday, 6 July
Refresher Course Begins .... Monday, 17 August
Labor Day (holiday) .... Monday, 7 September
Date for Final Completion of Thesis for September Graduation .... Wednesday, 16 September
Registration for all Curricula, except Management, BS/BA, IGEP, Meteorology, Nuclear Engineering (Effects) .... Monday, 21 September
Examination Week for Quarter I .... 21-25 September
Quarter I Ends .... Friday, 25 September
Quarter II Begins .... Monday, 28 September
Graduation .... Wednesday, 30 September

DISTINGUISHED ALUMNI

Among those who have completed a Naval Postgraduate School curriculum who attained flag (USN) or general (USMC) rank on the active list are the following: (The asterisk (*) indicates those on active list as on 1 January 1968.)

Admiral Walter F. Boone
Admiral Arleigh A. Burke
General Clifton B. Cates
Admiral Maurice E. Curts
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 Ephraim P. Holmes*
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
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 Frank E. Beatty
Vice Admiral Fred G. Bennett*
Vice Admiral Robert E. Blick, Jr.
Vice Admiral Charles T. Booth, II*
Vice Admiral Harold G. Bowen, Jr.*
Vice Admiral Carleton F. Bryant*
Vice Admiral William M. Callaghan
Vice Admiral John H. Carson
Vice Admiral John L. Chew*
Vice Admiral Ralph W. Christie
Vice Admiral Oswald S. Colclough
Vice Admiral John B. Colwell*
Vice Admiral Thomas F. Connolly*
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 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
Vice Admiral Truman J. Hedding
Lieutenant General Geo. D. Hermle
Vice Armiral Ira E. Hobbs
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 Tarry 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 Harold O. Larson
Vice Admiral Ruthven E. Libby
Vice Admiral Vernon L. Lowrance*
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 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
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
Rear Admiral James L. Abbot, Jr.*
Rear Admiral John W. Ailes, III
Rear Admiral Frank Akers
Rear Admiral Herbert H. Anderson*
Rear Admiral Roy G. Anderson*
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 Philip A. Beshany*
Rear Admiral Abel T. Bidwell
Major General Arthur F. Binney
Rear Admiral Calvin M. Bolster
Rear Admiral Frank A. Braisted
Rear Admiral Harold M. Briggs
Rear Admiral William A. Brockett
Rear Admiral Charles B. Brooks, Jr.
Rear Admiral James A. Brown*
Rear Admiral Henry C. Bruton
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 Kenan C. Childers, Jr.*
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 Damon C. Cooper*
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 Robert R. Crutchfield*
Rear Admiral Charles A. Curtze
Rear Admiral John E. Dacey*
Rear Admiral James A. Dare*
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 Ernest W. Dobie, Jr.*
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 Louis Dreller
Rear Admiral Norman J. Drustrup, CEC*
Rear Admiral Clifford H. Duerfeldt
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 Francis J. Fitzpatrick*
Rear Admiral Eugene B. Fluckey*
Rear Admiral Norbert Frankenberger*
Rear Admiral Mason B. Freeman*
Rear Admiral Laurence H. Frost
Rear Admiral Robert B. Fulton, II*
Rear Admiral Walter D. Gaddis*
Rear Admiral Daniel V. Gallery
Rear Admiral Fillmore B. Gilkeson*
Rear Admiral Robert O. Glover
Rear Admiral Alexander S. Goodfellow, Jr.*
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 Vincent P. Healey*
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 Husband E. Kimmel
Rear Admiral Denys W. Knoll
Rear Admiral Sydney M. Kraus
Rear Admiral Thomas R. Kurtz, Jr.
Rear Admiral Paul L. Lacy, Jr.*
Rear Admiral David Lambert*
Major General Frank H. Lamson-Scribner
Rear Admiral Martin J. Lawrence
Rear Admiral William H. Leahy
Rear Admiral William E. Lemos*
Rear Admiral Joseph W. Leverton, Jr.
Rear Admiral John K. Leydon
Rear Admiral James C. Longino, Jr.*
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
Major General Keith B. McCutcheon*
Rear Admiral John B. McGovern
Rear Admiral Eugene B. McKinney
Rear Admiral William R. 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 Frederick H. Michaelis*
Rear Admiral Roderick O. Middleton*
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 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 Roger W. Paine, Jr*
Rear Admiral Charles J. Palmer
Rear Admiral Lewis S. Parks
Rear Admiral Goldsborough S. Patrick
Rear Admiral John B. Pearson, Jr.
Rear Admiral Raymond E. Peet*
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 James D. Ramage*
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 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 James H. Smith, Jr.*
Rear Admiral John V. Smith*
Rear Admiral Levering Smith*
Rear Admiral John A. Snackenberg
Rear Admiral Philip W. Snyder
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 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 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.*
Read Admiral David F. Welch*
Rear Admiral Thomas R. Weschler*
Rear Admiral Ralph Weymouth*
Rear Admiral Charles D. Wheelock
Rear Admiral Francis T. Williamson
Rear Admiral Frederick S. Withington
Rear Admiral Mark W. Woods*
Rear Admiral Edward A. Wright
Rear Admiral Elmer E. Yeomans
Brigadier General George C. Axtell, Jr.*
Commodore Harold Dodd
Brigadier General Edward C. Dyer
Brigadier General Jacob E. Glick
Commodore Stanley D. Jupp
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 Albert H. Clancy, Jr.*
- CAPT Jerome H. King, Jr.*
- CAPT James B. Osborn*
- CAPT John B. Davis, Jr.*
- CAPT Parker B. Armstrong*
- CAPT Jack M. James*
- CAPT William M. Harnish*
- CAPT Leslie H. Sell*
- CAPT Thomas R. McClellan*
- CAPT James C. Donaldson, Jr.*
- CAPT Tazewell T. Shepard, Jr.*
- CAPT John K. Beling*
- CAPT Kenneth C. Wallace*
- CAPT Robert E. Adamson, Jr.*

HISTORY

The 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 had become 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 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 Engineering — were added as the Navy's need for officers with technical knowledge in these fields became evident.

In 1921 it again became a "School," changing its name from "Postgraduate Department" to "Postgraduate School," but remaining under the command of the Superintendent of the Naval Academy.

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 wtih 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. During the period 1946 to 1955 the School served to provide such education primarily to Reserve and ex-Temporary officers who had transferred to Regular status.

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 Superindent 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 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 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 the Aerology Department and Curricular office were moved to the new location. Concurrently with this relocation the Naval School (General Line) at Monterey was disestablished as a separate military command and it became a component of the Naval Postgraduate School. At the same time, there was established the Naval Administrative Command, 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 of 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. Subsequently the curriculum was lengthened and led to a master's degree for those who could meet the requirements for such a degree.

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 curriculum included 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.

These baccalaureate curricula eventually replaced the Navy's Five-Term Program which had been conducted in civilian universities and, except for the College Degree Program, now constitute the only programs available to naval officers to complete their undergraduate education.

In August, 1960, the Engineering Science Curriculum was initiated with a concurrent reduction in the number of U. S. officers enrolled in the General Line Curriculum. In August, 1962, input of U. S. officers into the General Line Curriculum was terminated; however, the program was continued for foreign naval officers.

The continuing growth and projected expansion of the School led to a major reorganization in 1962. In June, 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, the three component schools were disestablished and a completely new organization became effective. There is now but one School—the 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 all academic programs was placed under the dual control of a naval officer Director of Programs and a civilian Dean of Programs.

A subsequent reorganization in 1966 resulted in the disestablishment of the position of Deputy Superintendent and the retitling of the positions of the principle military assistants as will be noted in the following section.

In January, 1967, after a thorough re-evaluation and revision of curricula in the light of curricular objectives, plans were approved to shift the operations of the School from a five-term to a four-quarter academic calendar effective 1 July 1967. This resulted in certain personnel economies, and in the overall strengthening of curricula by the elimination of obsolete and unnecessary material and realignment of course content into more logical sequence.

In connection with the foregoing, the General Line Curriculum for foreign officers and the Naval Warfare Department were disestablished. Foreign officers continue to be enrolled in the technical and management curricula.

ORGANIZATION AND FUNCTIONS

The Superintendent of the Postgraduate School is a rear admiral of the line of the Navy. His principal assistants are an Academic Dean who is the senior member of the civilian faculty and two captains of the line, the Deputy Superintendent for Operations and Programs, and the Deputy Superintendent for Administration and Logistics.

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 functions 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
- Management and Operations Analysis
- Engineering Science
- 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 ten academic departments:

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

Over three-fourths of the teaching staff are civilians of varying professorial rank and the remainder naval officers.

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

The Academic Program organization described is supervised by the Deputy Superintendent for Operations and 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 Deputy Superintendent for Operations and 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.

Supplementing category a. above is the Engineering Science program. 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 Deputy Superintendent for Administration and Logistics. Certain other offices such as that of the Comptroller are directly responsible to the Superintendent in a slightly modified but typical naval staff organization.

FACILITIES

The Naval Postgraduate School is located within the City of Monterey, and only a mile east of the downtown business area and the city's Fishermen's Wharf. The site of the School is the former luxury Del Monte Hotel of pre-World War II days. The beautifully landscaped campus contains most of the academic and administration buildings within the main grounds. There is an adjacent beach area for research, a nearby laboratory and recreation area, and the La Mesa Housing area.

The Superintendent and central administrative officers, along with other service functions, are located in Herrmann Hall, the most prominent building on the campus because of its old Spanish architecture.

Most of the academic classrooms, laboratories, and offices are located in Spanagel, Bullard, Halligan and Root Halls. Ingersoll Hall is a new academic building expected to be occupied in late 1968. This building will replace the temporary academic facilities now located in the East Wing of Herrmann Hall, and will provide space for the Computer Facility, classrooms, and academic offices. About one-third of Root Hall is now occupied by the Library and Reference Center. Adjacent to the main academic buildings is King Hall, a large lecture hall used to seat the student body, faculty, and staff when occasions require.

The Laboratory and Recreation area adjacent to the Naval Auxiliary Landing Field contain many laboratories associated with the aeronautical engineering curricula. In addition this area has a nine-hole golf course and a picnic area.

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 759 units of public quarters for naval personnel. An additional 118 units are presently under construction. 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 aviator student's 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 Navy golf course is located near the main campus.

Medical facilities include a Dispensary at the Naval Auxiliary Landing Field, Monterey, supported by the U.S. Army Hospital, Fort Ord (7 miles away) and the U.S. Navy Hospital at Oakland (120 miles away). A Dental Clinic is located in Hermann 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 Educational 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 27 and the list of curricula conducted at civilian institutions on page 59.

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.

Military officers from Allied Countries may be admitted to certain curricula at the Postgraduate School. Such admission is subject to availability of quotas assigned to each country. Applications must be made through normal channels of communication and not sent directly to the Naval Postgraduate School. The academic standards described in this Catalogue for admission to each curricula must be met.

Civilian students are not eligible to attend the Postgraduate School.

DEGREES, ACCREDITATIONS, AND ACADEMIC STANDARDS

The Superintendent is authorized to confer Bachelor's, Master's, Engineer'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 Association of Schools and Colleges. Initial accreditation as an associate member was given in 1955. Specific engineering curricula have been accredited by the Engineers' Council for Professional Development (ECPD) since 1949.

Beginning with the 1967-68 academic year, the Postgraduate School began operation on a 12-week quarter calendar, with the last week of each quarter set aside for final examinations. Prior to this year, the academic schedule was based on 10-week terms.

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 quarter 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 quarter 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.

The courses listed in this Catalogue are assigned a level of academic credit by the numbers assigned.

0001 - 0999	No credit
1000 - 1999	Lower division credit
2000 - 2999	Upper division credit
3000 - 3999	Upper division or graduate credit
4000 - 4999	Graduate credit

The two number 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 quarter 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 quarter hours.

ACADEMIC HONORS

PROFESSIONAL SOCIETIES. Students have the opportunity to attend many professional meetings held at the Naval Postgraduate School. Several local chapters provide for student membership. These include the American Meteorological Society, Association for Computing Machinery, American Society of Mechanical Engineers, The Institute of Electrical and Electronics Engineers, Inc.

DEAN'S LIST. Students who distinguish themselves academically are recognized at the end of each quarter by being placed on the Dean's List. This recognition is awarded to students who earn a Quality Point Rating of 2.65, or higher, while carrying a minimum academic load of 12 quarter hours.

GRADUATION WITH DISTINCTION. This recognition may be awarded to students earning either a Bachelors Degree or a Master of Science Degree. To be eligible a student must have completed in residence a minimum of 90 quarter hours toward a Bachelors degree, and 40 quarter hours toward a Master of Science degree. This recognition is awarded to students who earn a Quality Point Rating of 2.75, or higher.

SIGMA XI. The Naval Postgraduate School has a Chapter of the Society of the Sigma Xi, an honorary society founded to recognize excellence in the scientific and engineering disciplines. Students who have demonstrated marked promise in their research work are considered for membership each year. The number elected is limited only by the quality of the research work done for a graduate degree.

MEWBORN STUDENT RESEARCH AWARD. This award affords recognition for exceptional research talent. It is awarded annually to a student in a program of graduate scientific or engineering studies, leading to an advanced degree, whose thesis exhibits sound scholarship and outstanding research ability.

CAPTAIN J. C. WOELFEL AWARD. This award is given annually to the United States Naval officer student receiving an advanced degree in the Naval Engineering Programs who has demonstrated the most outstanding academic record, and at the same time possesses those attributes best exemplifying a Naval Officer.

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. The Bachelor of Science or the Bachelor of Arts Degree may be awarded for successful completion of a curriculum which has been approved by the Academic Council as meriting the degree. Such curricula shall conform to current practice in other accredited institutions and shall contain a well-defined major.

2. General Postgraduate School minimum requirements for the Baccalaureate Degree are as follows:

a. 180 quarters hours of which at least 72 hours must be at the upper division level from course numbered at or above 2000.

b. One academic year in residence.

c. 36 quarter hours in the Humanities and the Social Sciences.

d. 36 quarter hours in Mathematics and the Physical Sciences.

e. Completion of the departmental requirements for a well-defined major.

f. A quality point rating of at least 1.00 in all courses taken at the Postgraduate School as well as in the courses in the major.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

1. The Masters 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. 32 quarter hours of graduate level credits.

b. A thesis or its equivalent is required. If the thesis is waived, at least 8 quarter hours of approved courses 4000-4999 shall be substituted for it.

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. In order to qualify for a Master's Degree, a student first must be admitted to candidacy for the degree. Application for admission to candidacy must be made subsequent to completion of 50% of his curriculum, and prior to completion of 75% of the curriculum. Students having a quality point rating of 2.00 or greater in all courses of their curricula are qualified for admission to candidacy. Students having a total quality point rating from 1.50 to 1.99, inclusive, may be admitted to candidacy by the Academic Council upon recommendation of the Chairman of the Department of the major. Students with a total quality point rating below 1.50 will be ineligible for admission to candidacy.

5. To be eligible for the Master's Degree, the student must attain a minimum average quality point rating of 2.00 in all the graduate level courses in his curriculum and either 1.50 in the remaining courses or 1.75 in all courses of the curriculum.

REQUIREMENTS FOR THE DEGREE: ENGINEER

1. The Engineer degree may be awarded for successful completion of a curriculum which has the approval of the Academic Council as meriting the degree.

2. Minimum Postgraduate School requirements for the degree of Engineer are as follows:

a. 72 quarter hours of graduate level courses including at least 30 hours in courses 4000-4999.

b. An acceptable thesis.

c. One academic year in residence.

d. Departmental requirements for the degree in a specified Engineering field.

e. A quality point rating of at least 2.00 in all graduate courses in the curriculum and either 1.50 in the remaining courses or 1.75 in all courses of the curriculum.

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 prerequisites 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 consult with two or more selected department chairmen to nominate a doctoral committee for the student. The committee will consist of five or more members with at least one representative from each of the selected departments. The Department Chairman of the student's major will submit the proposed committee names 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 field is essentially complete, the student shall be given qualifying examinations, including those associated with the foreign language requirement. The qualifying examinations in the major and minor fields 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. The foreign language requirement is to be satisfied by the student demonstrating before an examiner appointed by the Academic Dean that he possesses a satisfactory ability to read work related to his special field of study in at least two foreign languages. The accepted languages are French, German and Russian. If the student can demonstrate that enough current technical literature in his major field exists in another foreign language, the Doctoral Committee may substitute this for one of the accepted languages. Preparations for meeting this requirement should begin early in the student's program.

8. Upon successful completion of the qualifying examinations, and the fulfillment of the foreign language requirements, the student becomes a candidate for the Doctorate. The Doctoral Committee will report to the Academic Council the student's advancement to candidacy. After advancement, the candidate must devote at least six months to research before he may expect to present himself for the final examination. All requirements must be satisfied within a maximum period of five years after advancement to candidacy.

9. The distinct requirement of the Doctorate is a 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 are completed, a copy of the dissertation shall be submitted to each member of the Doctoral Committee. The Committee will make the final decision on the acceptance of the dissertation.

10. 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 examination of the candidate. The members of the Academic Council or their delegates will be invited to attend the examination. In this final examation, 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.

11. 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.

SUPERINTENDENT'S GUEST LECTURE PROGRAM

During the third and fourth quarters a weekly series of lectures will be presented on Wednesday afternoons in King Hall for students, faculty and staff. Eminently qualified civilian and military authorities from a wide range of fields and accomplishments will speak on subjects of current and historical interest in international, governmental, sociological, and military affairs. The military speakers are presented on Wednesday afternoons for the officer students, faculty, and staff. Civilian speakers are presented in the evening with wives also invited to attend. The primary purpose of this series is to inform as well as to stimulate and challenge the thinking of the officer students in areas outside of their immediate academic pursuits.

THE COMPUTER FACILITY

STAFF

Douglas George Williams, Professor and Head (1961)*; M.A. (Honours), Univ. of Edinburgh, 1954.

Roger Rene Hilleary, Supervisor, Applications Programming (1962); B.A., Pomona College, 1953.

Edward Norton Ward, Supervisor, Systems Programming (1962), B.A., Univ. of California at Los Angeles, 1952.

Maxwell Joseph Feuerman, Supervisor, Operations (1961).

Ronald David Brunell (1965); B.A., San Fernando Valley State College, 1961.

Hans Welter Doelman (1967); B.S., Univ. of California at Berkeley, 1956.

Ernest Geoffrey Janzen (1965); B.S., California Institute of Technology, 1961.

Patricia Cockrell Johnson (1963); B.S., Univ. of Southern Mississippi, 1962; M.S., Naval Postgraduate School, 1968.

Sally Virginia Kline (1965); B.S.Ch.E., West Virginia University, 1960.

Albert Mario Sbrizzi (1967); B.A., Univ. of California at Los Angeles, 1960.

Kathryn Betty Strutynski (1967); B.S., Brigham Young Univ., 1953.

Lois May Brunner (1961); A.A., Monterey Peninsula College, 1963.

Bernadette Requiro Peavey (1967); B.A., Univ. of California at Berkeley, 1963.

Robert Stephen Walton (1961); B.S., Massachusetts Institute of Technology, 1949.

*The year of joining the Postgraduate School is indicated in Parenthesis.

The Naval Postgraduate School was one of the first educational institutions to utilize digital computers in their academic programs. The first machine, a NCR, 102A, was installed in 1954. The present Computer Facility was created in 1960 as an organizational unit separate from the academic departments. This central Facility provides data processing support for the entire academic program, both classwork and research.

The computational facilities were greatly expanded in April, 1967, with the installation of an IBM 360, Model 67, duplex system. This equipment replaced the CDC 1604 which had been the School's primary computer for seven and one-half years. (This model was of historical interest, as the first computer delivered by Control Data Corporation.)

The present hardware complement includes two Model 67 processing units; four different levels of storage, including 512 thousand bytes of core, four million bytes on a drum, eight disc storage drives holding a total of 56 million bytes, and four magnetic tape units; normal peripheral devices; two high-speed CalComp plotters, twelve remote typewriter terminals, and an IBM 2250 Graphical Display Unit with light-pen and programmed function keyboard. The two processors are identical and can access directly, or control, all components of the system including core storage modules, input/output controllers and devices. The resources of the system can be allocated easily to meet changing operational requirements.

The new configuration not only increases substantially the batch-processing capabilities of the Facility, but also permits a time-sharing mode of operation allowing users simultaneous access to a variety of software aids from a number of remote terminals. This capability and the graphical display unit greatly enhance the possibilities for closer man-machine interaction in problem-solving.

Users can run programs in a variety of programming languages, including Assembly, FORTRAN, COBOL, PL/1, ALGOL and GPSS, under the standard operating system (OS/360). The time-sharing operating system (TSS/360) supports conversational FORTRAN and Assembly work, in addition to batch-processing. Additional terminal facilities include a user's command language and a dynamic program-checking system.

The School has a heavy commitment to computers consistent with their present and future role in military operations. All of the curricula have been affected by the presence of computers on campus. The percentage of active student and faculty participation in the computer field is at a level probably unequalled at any other educational institution. All graduate students take at least one course in the computer field. They are introduced to the computers early in the course of their education at the Naval Postgraduate School and encouraged to use them in subsequent course work and research.

The Computer Facility supports a wide variety of computer science courses offered in the departments of Business Administration and Economics, Electrical Engineering, Mathematics, and Operations Analysis. The School has offered a graduate degree in the data processing field since 1963. In September, 1967, there was added the degree of Master of Science (Computer Science) with emphasis on programming languages and systems, computer systems design and aspects of operations analysis.

The Facility has a staff of 29 people of whom 12 are mathematician programmers. The operations group is responsible for running a CDC 160 computer in addition to the IBM 360/67 system. The professional staff provide a consulting service in applications programming, systems programming and problem formulation to students and faculty members. In addition, there is an active research and development program directed primarily towards improving the present operational environment or introducing new programming facilities to users. Current projects include improvement of operating systems, graphical data processing, time-sharing, and numerical analysis.

Library

THE LIBRARIES

STAFF

GEORGE RIDGELY LUCKETT, Professor and Librarian (1950); B.S., Johns Hopkins Univ., 1949; M.S., Catholic Univ., 1951.

PAUL SPINKS, Associate Professor and Associate Librarian (1959); B.A., Univ. of Oklahoma, 1958; M.S., 1959.

EDGAR RAYMOND LARSON, Assistant Professor and Reader Services Librarian (1959); B.A., Univ. of Washington, 1939; B.S., 1950.

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

JANUSZ TYSZKIEWICZ-LACKI, Assistant Professor and Technical Reports Librarian (1961); Absolutorium, Univ. of Poznan, Poland, 1924; M.S., Univ. of California at Berkeley, 1958.

GEORGIA PLUMMER LYKE, Reference librarian (1952); A.A., Hartnell College, 1940.

MABEL CHARLOTTE VAN VORHIS, Librarian, Physical Sciences and Engineering (1955); B.A., Univ. of California at Berkeley, 1926.

ROBERT MORAN TIERNEY, Acquisitions Librarian (1957); B.A., Columbia Univ., 1937; M.A., San Jose State College, 1962.

ALICE MARIE STUDE, Cataloger (1957); B.S., Univ. of Minnesota, 1930; M.S., Univ. of California at Berkeley, 1961.

ELSA MARIE KUSWALT, Cataloger (1958); B.A., Univ. of California at Berkeley, 1957; M.L.S., Univ. of Southern California, 1966.

DORIS MCNUTT BARON, Librarian, Physical Sciences and Engineering (1961); B.A., Univ. of California at Berkeley, 1946; M.S., Univ. of Southern California, 1960.

MARY THERESE BRITT, Reclassification Librarian (1966); B.S., College of St. Catherine, 1947.

CLEO ELIZABETH PETERSON, Cataloger (1958); A.A., Red Oak College, 1938.

MARY TOBY KUHNS, Cataloger (1966); B.A., Mills College, 1963; M.L.S., Univ. of California at Berkeley, 1964.

CHRISTOPHER KASPAREK-OBST (1967); B.S., University of California at Berkeley, 1966; M.L.S., 1967.

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 114,800 books, bound periodicals and pamphlets, 140,000 technical documents, over 2500 periodical works currently received, and 140,000 abstract cards, microcards, and microfiche. 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 collection.

The Technical Reports and Classified Materials Section is the principal repository for technical research documents received by the School. It houses 140,000 documents, 59,000 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 available for literature searches of documents received since November, 1960. An SDI (Selective Dissemination of Information) service, designed to broaden the scope of the Library's automated services to the Postgraduate School, was initiated in January, 1967.

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. An additional 2,000 volumes are held at Mr. Buckley's residence pending the construction of the new Library building. The establishment of this collection was made possible by the interest and generosity of Mr. Christopher Buckley, Pebble Beach, California, who began donating books to the School for this Library in 1949.

Del Monte Lake and fowl indigenous to the Naval Postgraduate School

LABORATORY FACILITIES

Extensive laboratory experimentation is carried on in connection with the instructional and research programs of the School. Experimental facilities have been greatly improved and expanded in recent years. Further expansion and improvement is planned for the future in response to emerging requirements.

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 special loading floor of the laboratory where static and 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 supersonic wind tunnel having a 4"x4" test section and a vertical free-jet of 1"x1" cross-section, both operating 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. There is a holographic interferometer using a He-Ne laser. A chemical kinetic shock tube is presently being constructed, this will permit high temperature gas dynamic investigation in the area of vibration relaxation, gas disassociation, and ionization.

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. 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, liquid and hybrid or rocket engines. Both experimental and laboratory rocket engines are run in the test cells.

The advanced facilities of the Cascade and Turbomachinery Laboratories are distributed in three buildings, one of which provides low speed tests with rectilinear cascades of large dimensions. The source of air is a 700 HP fan, either to draw or to blow air through the test items, which delivers about 100,000 cfm of air at a pressure difference of about 40 inches of water. 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 used for high speed tests, in three test 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 the 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 radiochemistry ("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, ultra-violet, magnetic resonance, and microwave, spectrometer, and associated high vacuum manifolds; a chemical instruments laboratory for instruction in the use and theory behind obtaining data with infrared 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 on 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 propellant motors.

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 and a direct energy conversion laboratory. Analog computers are available for simulation and analysis of circuits, machines, devices and systems.

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, laser, 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 microwave anechoic chamber and an antenna model range.

The Computer Laboratory of the Department of Electrical Engineering is a School-wide direct access computer complex wherein each student programs and operates the computer system for the solution of his own problems. The facility includes a medium sized digital computer, two high performance input-output display units and a general purpose hybrid/analog computer, all integrated into a single computer system. These facilities support research and instruction in digital and hybrid computation, simulation, control engineering, information processing, and business 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.

When precision measurements are required, calibrated instruments and highly stabilized frequency standard sources 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, plus a programable Instron testing instrument. 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 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 thermo-sciences, fluid dynamics, deformable body mechanics, and dynamics, naval hydrodynamics, and nuclear engineering. 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 cryo-pumping surfaces.

Facilities in the fluid dynamics laboratory include, in addition to facilities for standard experiments, a swirling flow apparatus, a fluid amplifier test system, stratified flow tank, flow meters, a dual channel hot-wire anemometer system, a root-mean-square meters, numerous electronic amplifier and recorder units, and pressure transducers. The laboratory will soon be equipped with a water tunnel and a high pressure test tank for underwater simulation studies.

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 simulations 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 radio 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 in daily operation an automatic picture transmission (APT) receiving apparatus for the reception of pictures from the NIMBUS, ESSA, and ATS weather satellites. Rectification grid templates are used in the laboratories for direct correlation of current satellite pictures with conventional synoptic analyses and nephanalyses.

Four meteorological/oceanographic laboratories are served by a closed circuit television network which has the transmitting studio in close proximity. Some of the equipment in the studio includes TV cameras, slide and movie projectors, sound facilities, and a video tape recorder.

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.

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.

Joint development by the school and the Naval Special Device center of a wave and current generator have progressed to the point of the installation of the prototype on campus.

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

In low temperature and solid state physics the equipment includes nitrogen liquifiers, a Collins helium liquefier, 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 frequency 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 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 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.

A 120 MeV LINEAR ACCELERATOR was officially placed into service at the school in February, 1966.

The new accelerator is a valuable tool in the intermediate energy range. It is being used to investigate the physics of nuclear structure, as distinct from the physics of elementary particles.

The accelerator has a continuous energy range from 5 to 120 MeV with a maximum beam current of 20 microamps. Each of three 10-foot sections is powered by a 21 megawatt klystron. Present experiments include inelastic electron scattering from nuclei.

The accelerator is also used for radiation damage studies on solid state electronics devices.

The SPEECH LABORATORY is equipped with a closed circuit television and video-tape machine and has three cameras that provide a total of seven camera angles for speakers to be videotaped during classroom exercises. It is also equipped with a solid state sound system that is built into a lightweight adjustable lectern. A visual aids room adjoining the laboratory enables the speaker to use many types of audio-visual aids to support his speech.

Work is now being done with classes in conference dynamics which allows both instant replay and the compiling of data for future study and illustration in this area.

CURRICULAR OFFICES
and
PROGRAMS

Aerial view of main Postgraduate School facility

CURRICULA AT THE POSTGRADUATE SCHOOL

Curriculum	*Curriculum Number*	*Length*	*Convening Dates*
Advanced Science			
Chemistry	380	33 mo.	March, September
Hydrodynamics	380	33 mo.	March, September
Mathematics (Applied)	380	33 mo.	March, September
Material Science	380	33 mo.	March, September
Physics (General)	380	33 mo.	March, September
Physics (Nuclear)	380	33 mo.	March, September
Aeronautical Engineering			
General	610	24 mo.	March, September
Advanced	610	24-33 mo.	March, September
Baccalaureate			
Bachelor of Science	461	24 mo.	January, July
Bachelor of Arts	461	24 mo.	January, July
Electronics and Communications Engineering			
Communications Engineering			
Basic	600	21 mo.	March, September
Advanced	600	27-36 mo.	March, September
Engineering Electronics			
Basic	590	21 mo.	March, September
Advanced	590	27-36 mo.	March, September
Information and Control	590	27-36 mo.	March, September
Special (CEC)	472	12-18 mo.	March, September
Staff Communications	620	12 mo.	March, September
Engineering Science	460	9 mo.	March, September
Environmental Sciences			
Meteorology	371	12 mo.	January, July
Advanced Meteorology	372	21 mo.	March, September
General Meteorology	372	21 mo.	March, September
Oceanography	440	21 mo.	March, September
Naval Engineering			
Mathematics	430	9 mo.	July
Naval Engineering (Mechanical)	570	21 mo.	March, September
Naval Engineering (Electrical)	570	21 mo.	March, September
Mechanical Engineering (Advanced)	570	27-36 mo.	March, September
Electrical Engineering (Advanced)	570	27-36 mo.	March, September
Management and Operations Analysis			
Computer Science	368	21 mo.	March, September
Computer Systems Management	367	15 mo.	March, September
Management	814 and 817	12 mo.	January, July
Operations Research/Systems Analysis	360	24 mo.	March, September
Ordnance Engineering			
Nuclear Engineering (Effects)	521	24mo.	July
Underwater Physics Systems	535	21-36 mo.	September
Ordnance Systems Engineering	530	21-36 mo.	March, September

Ingersoll Hall scheduled for occupancy in late 1968

ADVANCED SCIENCE PROGRAMS
CURRICULUM NUMBER 380

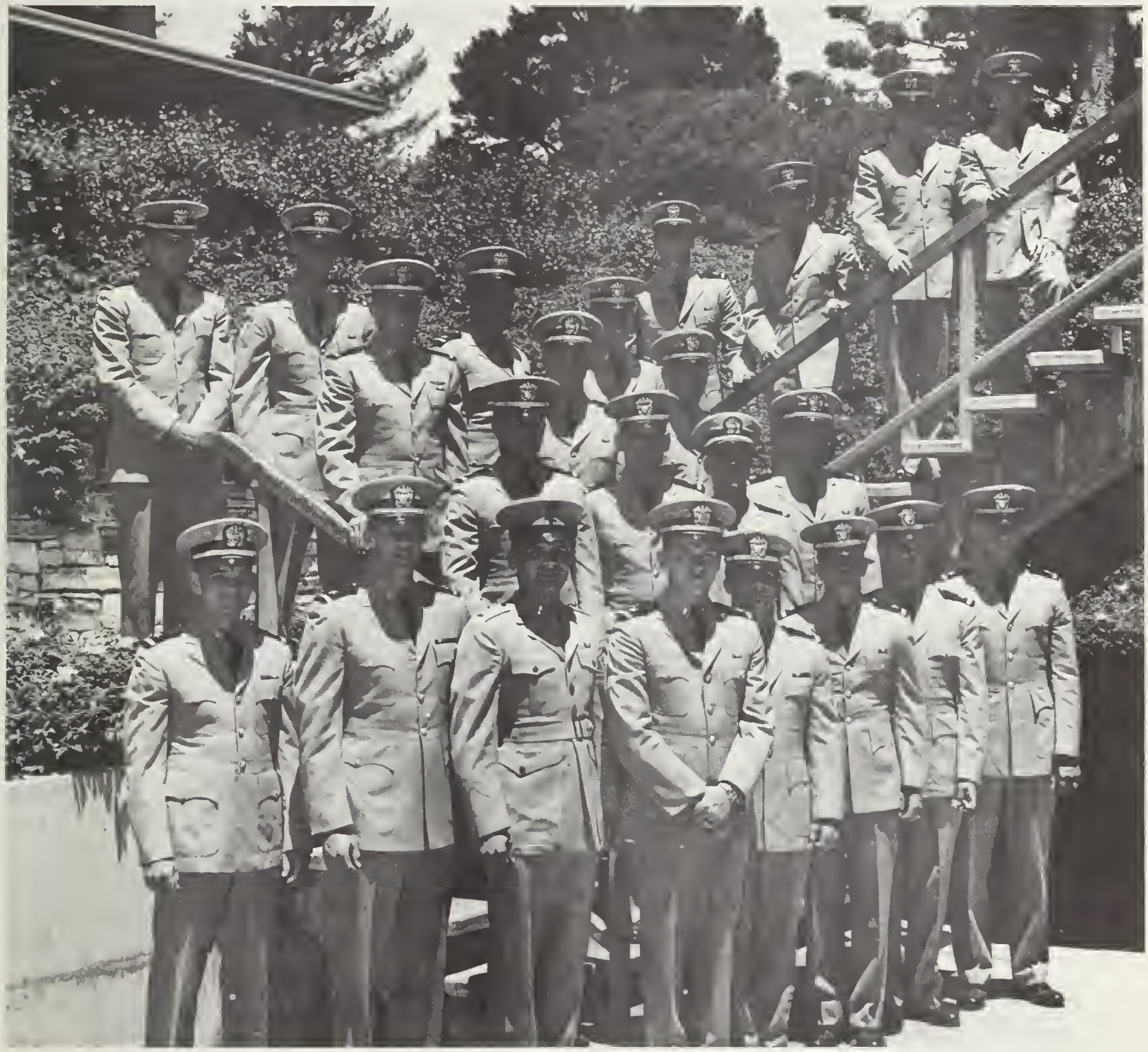
Chemistry
Hydrodynamics
Material Science
General Physics
Nuclear Physics
Applied Mathematics

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.

Qualifications for Admission—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.

Description—Officers selected for Advanced Science Curricula complete their first year at the 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.



Pilot group of Naval Academy graduates (June 1967) pursuing study toward a Master's degree under the Immediate Graduate Education (IGEP) Program

AERONAUTICAL ENGINEERING PROGRAMS CURRICULUM NUMBER 610

ROBERT STANLEY HUTCHES, Commander, U.S. Navy; Curricular Officer; B.S., Naval Academy, 1945; B.S. in Aeronautical Engineering, Naval Postgraduate School, 1953; M.S. in Aeronautical Engineering, Univ. of Minnesota, 1954; Naval War College, 1962.

CHARLES HORACE KAHR, JR., Academic Associate; B.S. Univ. of Michigan, 1944; M.S., 1945.

GORDON BRADFORD HALL, JR., Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.A. in Mathematics, Univ. of North Carolina, 1957; D.C.Ae. (1st Class Honours), College of Aeronautics, Cranfield, England, 1965; M.S. in Aeronautical Engineering, Naval Postgraduate School, 1966.

OBJECTIVE—To provide officers with advanced aeronautical education to meet Navy technical requirements in flight vehicles and their environmental fields. Curricula are designed to provide eleven fields of the major in support of specific Naval Air Systems Command requirements. A basic foundation in broad areas of Operations Analysis, Management and Engineering Materials is also provided.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree with a grade average of B or better in mathematics, physical sciences, and engineering is required. Completion of mathematics through differential and integral calculus, one year of engineering physics, and one year of chemistry is considered minimal preparation. Additional undergraduate coverage in basic engineering, electrical engineering, and mathematics are desirable.

DESCRIPTION—Classes convene twice yearly in March and September. When available, officers are ordered in six weeks in advance of convening dates to take mathematics and aeromechanics refresher courses. All students will take a common core program for the first three academic quarters in residence. Selection is then made to continue graduate or undergraduate study based on academic performance, availability, and results of a comprehensive examination. Those officers selected for the undergraduate program will continue for four additional quarters in either the General or the Flight Performance option leading to the award of the Bachelor of Science in Aeronautical Engineering degree. Officers admitted to graduate status will complete either five additional quarters leading to a Master of Science in Aeronautical Engineering degree or eight additional quarters leading to the degree of Aeronautical Engineer. Officers particularly well qualified may apply for the Ph.D. program. All graduate students must submit a thesis as part of their degree requirements.

September input graduate students may complete their third year at the Postgraduate School or continue their studies at one of the civilian institutions listed at the end of this section. March input graduate students must complete their graduate studies at the Postgraduate School.

Selected Naval Academy graduates may enter directly into a graduate program (in July), and obtain a Master's degree upon completion of three quarters course work, including an acceptable thesis.

All Aeronautical Engineering graduates will be recommended for subspecialty qualification codes 835XP as listed in current BUPERS INST 1210.13 series.

The below listed curricula are representative of current Aeronautical Engineering options.

SUMMARY OF PROGRAMS OFFERED IN AERONAUTICAL ENGINEERING CURRICULA

Curricular Title	*Duration*	*Degree Level*
Aeronautical Engineering (..............................)		
(General)	2 years (7 qtrs)	B.S. (A.E.)
(Flight Performance)	2 years (7 qtrs)	B.S. (A.E.)
(Aerodynamics (Flight Dynamics))	2 years (8 qtrs)	M.S. (A.E.)
(Aerodynamics (Flight Dynamics))	3 years (11 qtrs)	Ae.E.
(Aerodynamics (Gas Dynamics))	2 years (8 qtrs)	M.S. (A.E.)
(Aerodynamics (Gas Dynamics))	3 years (11 qtrs)	Ae.E.
(Information and Control)	2 years (8 qtrs)	M.S. (A.E.)
(Aero/Space Physics)	3 years (11 qtrs)	Ae.E.
(Flight Propulsion (Rockets))	2 years (8 qtrs)	M.S. (A.E.)
(Flight Propulsion (Rockets))	3 years (11 qtrs)	Ae.E.
(Flight Structures)	2 years (8 qtrs)	M.S. (A.E.)
(Flight Structures)	3 years (11 qtrs)	Ae.E.
(Flight Propulsion (Turbomachinery))	2 years (8 qtrs)	M.S. (A.E.)
(Flight Propulsion (Turbomachinery))	3 years (11 qtrs)	Ae.E.
(Underwater Acoustics)	2 years (8 qtrs)	M.S. (A.E.)
(Underwater Acoustics)	3 years (11 qtrs)	Ae.E.
(Air Weapons Systems (Explosive Ordnance))	2 years (8 qtrs)	M.S. (A.E.)
(Air Weapons Systems (Explosive Ordnance))	3 years (11 qtrs)	Ae.E.
(Aeroelectronics)	3 years (11 qtrs)	Ae.E.
(Aeronautical Engineering)	4 years (16 qtrs)	Ph.D.
(Aeronautical Engineering (Immediate Masters Program))	1 years (3 qtrs)	M.S. (A.E.)

AERONAUTICAL ENGINEERING
First Three Quarters
Common Core

First Quarter

AE	2201	Aero-Structures I	3- 2
AE	2301	Technical Aerodynamics I	3- 2
AE	2401	Engineering Thermodynamics	3- 2
AE	2801	Aero-Laboratories, Introduction to	0- 2
MA	1100	Calculus Review	4- 0
			13- 8

Second Quarter

AE	2202	Aero-Structures II	3- 2
AE	2302	Technical Aerodynamics II	3- 2
AE	2402	Elementary Gas Dynamics	3- 2
AE	2802	Aero-Structures Laboratory	0- 3
MA	2121	Differential Equations & Infinite Series	4- 0
			13- 9

Third Quarter

AE	3115	Engineering Dynamics I	3- 2
AE	3303	Aircraft Performance	3- 2
AE	3403	Heat Transfer	3- 2
AE	3803	Subsonic Laboratory	0- 3
MA	3181	Vector Analysis	3- 0
			12- 9

After three quarters on board, students are selected for either graduate or undergraduate sequences.

B.S. (A.E.) PROGRAMS — Seven Quarters
(Groups AF, AG)

Aeronautics Courses:

AE 3271 Fundamentals of Flight Vehicle Design
AE 3321 Flight Dynamics I
AE 3322 Flight Dynamics II
AE 3340 Fundamentals of Automatic Control
AE 3404 Aircraft Propulsion
AE 3501 Fluid Dynamics I
AE 3502 Fluid Dynamics II
AE 3804 Gas Dynamics and Propulsion Laboratory

Special Aeronautics Courses to suit the Option *

Other Courses:

EE 2101 Principles of Electrical Engineering
EE 2102 Circuit Analysis
MA 2232 Numerical Methods and FORTRAN Programming
MS 2218 Elements of Engineering Materials
OA 3201 Fundamentals of Operations Analysis
OA 3202 Methods of Operations Analysis/Systems Analysis
OA 3203 Survey of Operations Analysis/Systems Analysis

*GROUP AF — Flight Performance

AE 3331 Flight Evaluation Techniques I
AE 3332 Flight Evaluation Techniques II
AE 3831 Flight Evaluation Technique Lab I
AE 3832 Flight Evaluation Technique Lab II

*GROUP AG — General

AE 3211 Aero-Structural Performance I
AE 3212 Aero-Structural Performance II

M.S. (A.E.) PROGRAMS — Eight Quarters
(Groups AA, AD, AI, AR, AS, AT, AU, AW)

Master of Science in Aeronautical Engineering programs may lead to specialization in Aerodynamics (Flight Dynamics), Aerodynamics (Gas Dynamics), Information and Control, Flight Propulsion (Rockets), Flight Structures, Flight Propulsion (Turbomachinery), Underwater Acoustics or Air Weapons Sytstems (Explosive Ordnance).

After admission to a graduate degree program, all students take the M.S. (A.E.) common courses below. Nine additional courses in one of the specialization areas are required for completing the Master of Science Degree.

M.S. (A.E.) Common Courses

AE 3805 Engineering Dynamics Laboratory
AE 4116 Engineering Dynamics II
AE 4131 Continuum Mechanics
MA 2232 Numerical Methods and FORTRAN Programming
MA 3132 Partial Differential Equations and Integral Transforms
MS 2218 Elements of Engineering Materials
MS 4811 Mechanical Behavior of Engineering Materials
OA 3202 Methods of Operations Analysis/Systems Analysis
OA 3203 Survey of Operations Analysis/Systems Analysis
PS 3112 Probability and Statistics I
AE 0810 Thesis Research

SPECIALIZATION COURSES
Aerodynamics (Flight Dynamics)
(Group AA)

This specialty includes coverage of the stability and control parameters of a flight vehicle in both the pilot-controlled and automatic-controlled modes. Both manned and unmanned vehicles are investigated. Topics include automatic landing systems, missile control, and optimal design.

AE 3804 Gas Dynamics and Propulsion Laboratory
AE 4304 Flight Vehicle Response
AE 4336 Low Speed Flight Mechanics
AE 4342 Automatic Control I
AE 4343 Automatic Control II
AE 4521 Ideal Fluid Aerodynamics
AE 4522 Boundary Layer Flows
AE 4631 Computer Methods in Aeronautics
EE 2222 Electronic Fundamentals I

SPECIALIZATION COURSES
Aerodynamics (Gas Dynamics)
(Group AD)

Operation of flight vehicles in the broad spectrum ranging from hovering flight to hypersonic reentry is investigated, with particular emphasis being placed on the behavior of the gas (air or near-space) in which the vehicle is operating. Subsonic, compressible, supersonic, hypersonic, and plasma flows are covered in detail.

AE 3804 Gas Dynamics and Propulsion Laboratory
AE 4336 Low Flight Mechanics
AE 4521 Ideal Fluid Aerodynamics
AE 4522 Boundary Layer Flows
AE 4523 Fundamentals of Compressible Flow
AE 4541 Missile Technology I
AE 4542 Missile Technology II
AE 4631 Computer Methods in Aeronautics
EE 2222 Electronic Fundamentals I

SPECIALIZATION COURSES
Information and Control
(Group AI)

This specialty provides knowledge in depth in computer-flight vehicle interface in operation of modern and projected air weapons systems. Computer technology, capability, and applications to the flight vehicle and its mission are stressed.

AE 3804 Gas Dynamics and Propulsion Laboratory
AE 4304 Flight Vehicle Response
AE 4336 Low Speed Flight Mechanics
AE 4342 Automatic Control I
AE 4343 Automatic Control II
AE 4631 Computer Methods in Aeronautics
EE 2811 Digital Machines
EE 3822 Digital Computer Systems
EE 4823 Advanced Digital Computer Systems

SPECIALIZATION COURSES
Flight Propulsion (Rockets)
(Group AR)

Particular emphasis is placed on the combustion processes and phenomena in solid, liquid, and hybrid rocket motors. Additional coverage in supporting areas is included as indicated in the representative course listings.

AE 3804 Gas Dynamics and Propulsion Laboratory
AE 4461 Statistical Thermodynamics
AE 4462 Combustion Thermodynamics I
AE 4463 Combustion Thermodynamics II
AE 4464 Aerothermochemistry
AE 4521 Ideal Fluid Aerodynamics
AE 4522 Boundary Layer Flows
AE 4523 Fundamentals of Compressible Flow
AE 4631 Computer Methods in Aeronautics

SPECIALIZATION COURSES
Flight Structures
(Group AS)

A study in depth of the mechanics of solids is followed by investigations of the behavior of structural components under conditions of static and dynamic (including aeroelastic) loads (both steady and non-steady). Free, forced, and self-excited vibrations; flutter, gusts, buffet, and stall effects; and wing divergence and control reversal are typical of the topical coverage.

AE 3804 Gas Dynamics and Propulsion Laboratory
AE 4132 Solid Mechanics I
AE 4133 Solid Mechanics II
AE 4241 Flight Vehicle Structural Analysis
AE 4242 Theory of Plate and Shell Structures
AE 4251 Structural Dynamics
AE 4252 Advanced Aeroelasticity
AE 4631 Computer Methods in Aeronautics
EE 2222 Electronic Fundamentals I

SPECIALIZATION COURSES
Flight Propulsion (Turbomachinery)
(Group AT)

Fundamental laws of fluid dynamics and thermodynamics are applied in the design and performance prediction of turbomachines. Aircraft and space power plants and advanced concepts in turbopumps and turbopropulsion are discussed; stresses developed and the mechanical behavior of materials under conditions of high rotational speeds at elevated temperatures are investigated. This area requires eleven courses in the specialty.

AE 4431 Aerothermodynamics of Turbomachines
AE 4432 Advanced Theory of Turbomachines
AE 4433 Advanced Turbopropulsion Systems
AE 4434 Turbopropulsion Seminar
AE 4521 Ideal Fluid Aerodynamics
AE 4522 Boundary Layer Flows
AE 4523 Fundamentals of Compressible Flow
AE 4631 Computer Methods in Aeronautics
AE 4851 Turbomachinery Laboratory I
AE 4852 Turbomachinery Laboratory II
AE 4854 Turbomachinery Laboratory III

SPECIALIZATION COURSES
Underwater Acoustics
(Group AU)

This program covers the fundamentals of the propagation of waves in fluids and investigates devices and systems and their application to areas of Naval Air Systems Command interest in the field of underwater acoustics.

AE 3804 Gas Dynamics and Propulsion Laboratory
AE 4521 Ideal Fluid Aerodynamics
AE 4522 Boundary Layer Flows
EE 2222 Electronics Fundamentals I
EE 4451 Sonar Systems Engineering
PH 3451 Fundamental Acoustics
PH 3452 Underwater Acoustics
PH 4453 Propagation of Waves in Fluids
PH 4454 Transducer Theory and Design

SPECIALIZATION COURSES
Air Weapons Systems (Explosive Ordnance)
(Group AW)

The study of chemical explosives and blast and shock effects are emphasized and supplement coverage of core aeronautics courses to prepare the graduate to work in the sub-area of conventional ordnance in air weapons systems.

AE 3804 Gas Dynamics and Propulsion Laboratory
AE 4521 Ideal Fluid Aerodynamics
AE 4522 Boundary Layer Flows
AE 4631 Computer Methods in Aeronautics
CH 2001 General Principles of Chemistry
CH 3709 Explosives Chemistry
CH 3713 Blast and Shock Effects
CH 4800 Special Topics
EE 2222 Electronic Fundamentals I

Ae.E. PROGRAMS — Eleven Quarters

In addition to the course work listed under the respective two-year M.S. (A.E.) programs, the candidate for the degree of Aeronautical Engineer (Ae.E.) will take the following courses according to the area of his specialty:

Group AA — Aerodynamics (Flight Dynamics)

AE 4275 Advanced Flight Vehicle Design
AE 4431 Aerothermodynamics of Turbomachines
AE 4523 Fundamentals of Compressible Flow
AE 4524 Supersonic Aerodynamics
AE 4541 Missile Technology I
AE 4542 Missile Technology II
AE 4543 Missile Technology III
AE 4851 Turbomachinery Laboratory I
MA 3042 Linear Algebra
MA 3172 Complex Variables

Group AD — Aerodynamics (Gas Dynamics)

AE 4275 Advanced Flight Vehicle Design
AE 4431 Aerothermodynamics of Turbomachines
AE 4461 Statistical Thermodynamics
AE 4462 Combustion Thermodynamics I
AE 4463 Combustion Thermodynamics II
AE 4464 Aerothermochemistry
AE 4524 Supersonic Aerodynamics
AE 4543 Missile Technology III
AE 4851 Turbomachinery Laboratory I
MA 3042 Linear Algebra
MA 3172 Complex Variables

Group AR — Flight Propulsion (Rockets)

AE 4275 Advanced Flight Vehicle Design
AE 4336 Low Speed Flight Mechanics
AE 4431 Aerothermodynamics of Turbomachines
AE 4524 Supersonic Aerodynamics
AE 4541 Missile Technology I
AE 4542 Missile Technology II
AE 4543 Missile Technology III
AE 4851 Turbomachinery Laboratory I
EE 2222 Electronic Fundamentals I
MA 3042 Linear Algebra
MA 3172 Complex Variables

Group AS — Flight Structures

AE 4161 Theory of Viscoelasticity
AE 4275 Advanced Flight Vehicle Design
AE 4336 Low Speed Flight Mechanics
AE 4431 Aerothermodynamics of Turbomachines
AE 4521 Ideal Fluid Aerodynamics
AE 4522 Boundary Layer Flows
AE 4523 Fundamentals of Compressible Flow
AE 4851 Turbomachinery Laboratory I
MA 3042 Linear Algebra
MA 3172 Complex Variables

Group AT — Flight Propulsion (Turbomachinery)

AE 4132 Solid Mechanics I
AE 4275 Advanced Flight Vehicle Design
AE 4336 Low Speed Flight Mechanics
AE 4421 Heat Transfer I
AE 4422 Heat Transfer II
AE 4423 Heat Transfer III
AE 4524 Supersonic Aerodynamics
MA 3042 Linear Algebra
MA 3172 Complex Variables

Group AU — Underwater Acoustics

AE 4336 Low Speed Flight Mechanics
AE 4431 Aerothermodynamics of Turbomachines
AE 4523 Fundamentals of Compressible Flow
AE 4631 Computer Methods in Aeronautics
AE 4851 Turbomachinery Laboratory I
MA 3042 Linear Algebra
MA 3172 Complex Variables
OC 2110 Introduction to Oceanography
OC 3220 Descriptive Oceanography
OC 4251 Dynamical Oceanography I
PH 3461 Explosive Shock Waves
PH 4455 Advanced Acoustics Laboratory
PH 4456 Seminar in Applications of Underwater Sound

Group AW — Air Weapons Systems (Explosive Ordnance)

AE 4275 Advanced Flight Vehicle Design
AE 4431 Aerothermodynamics of Turbomachines
AE 4461 Statistical Thermodynamics
AE 4462 Combustion Thermodynamics I
AE 4463 Combustion Thermodynamics II
AE 4464 Aerothermochemistry
AE 4523 Fundamentals of Compressible Flow
AE 4524 Supersonic Aerodynamics
AE 4541 Missile Technology I
AE 4851 Turbomachinery Laboratory I
CH 2402 Introduction to Physical Chemistry
MA 3172 Complex Variables

The following two areas do not have a two-year M.S. (A.E.) program. These curricula are of eleven quarters (total) duration and lead to the award of the degree of Aeronautucal Engineer. Courses listed are in addition to the common core courses of the first three Quarters.

Group AP — Aero/Space Physics

This program, leading to the degree of Aeronautical Engineer, includes the study of electromagnetics, quantum mechanics, and space and near-space physics. These, together with the core aeronautics courses in gas dynamics, engineering dynamics, and propulsion, and sequences in material science and operations analysis prepare the graduate to participate in any of several areas in Navy programs involving missile and space technology.

AE 3804 Gas Dynamics and Propulsion Laboratory
AE 3805 Engineering Dynamics Laboratory
AE 4116 Engineering Dynamics II
AE 4131 Continuum Mechanics
AE 4431 Aerothermodynamics of Turbomachines
AE 4521 Ideal Fluid Aerodynamics
AE 4522 Boundary Layer Flows
AE 4523 Fundamentals of Compressible Flow
AE 4541 Missile Technology I
AE 4542 Missile Technology II

AE	4543	Missile Technology III
AE	4851	Turbomachinery Laboratory I
MA	2232	Numerical Methods and FORTRAN Programming
MA	3132	Partial Differential Equations and Integral Transforms
MS	2218	Elements of Engineering Materials
MS	4811	Mechanical Behavior of Engineering Materials
OA	3202	Methods of Operations Analysis/Systems Analysis
OA	3203	Survey of Operations Analysis/Systems Analysis
PH	2251	Waves and Particles
PH	2351	Electromagnetism I
PH	3352	Electromagnetism II
PH	3561	Introductory Statistical Physics
PH	3651	Atomic Physics
PH	3652	Elements of Molecular, Solid State, and Nuclear Physics
PH	3951	Introduction to Quantum Mechanics
PH	4353	Electromagnetism III
PH	4630	Space Physics I—Physics of the Upper Atmosphere
PH	4631	Space Physics II—Physics of the Solar System
PH	4790	Theory of Quantum Devices
PS	3112	Probability and Statistics I

Group AX — Aeroelectronics

Building upon a background of aeronautics core courses, in-depth studies in electrical and electromagnetic fundamentals and applications prepare the graduate to serve as a specialist in guidance and control aspects of both manned and unmanned flight vehicles in Naval air weapons systems programs.

AE	3805	Engineering Dynamics Laboratory
AE	4116	Engineering Dynamics II
AE	4131	Continuum Mechanics
AE	4304	Flight Vehicle Response
AE	4336	Low Speed Flight Mechanics
AE	4342	Automatic Control I
AE	4343	Automatic Control II
AE	4523	Fundamentals of Compressible Flow
EE	2101	Principles of Electrical Engineering
EE	2102	Circuit Analysis
EE	2211	Electronic Engineering Fundamentals I
EE	2212	Electronic Engineering Fundamentals II
EE	2214	Electronic Pulse and Digital Circuits
EE	3103	Linear Systems Analysis
EE	3114	Communication Theory I
EE	3411	Control Systems
EE	3412	Non-linear and Sampled Systems
EE	3621	Electromagnetics I
EE	3622	Electromagnetics II
EE	4433	Radar Systems
EE	4461	Systems Engineering
EE	4473	Missile Guidance Systems
EE	4571	Statistical Communication Theory
MA	2232	Numerical Methods and FORTRAN Programming
MA	3132	Partial Differential Equations and Integral Transforms
MA	3172	Complex Variables
MS	2218	Elements of Engineering Materials
OA	3202	Methods of Operations Analysis/Systems Analysis
PS	3112	Probability and Statistics I

AERONAUTICAL ENGINEERING M.S. (A.E.) NAVAL ACADEMY DIRECT INPUT

First Quarter

AE	3805	Engineering Dynamics Laboratory	0- 3
AE	4116	Engineering Dynamics II	3- 2
AE	4131	Continuum Mechanics	4- 0
AE	4522	Boundary Layer Flows	4- 0
MA	2232	Numerical Methods and FORTRAN Programming	4- 0
			15- 5

Second Quarter

AE		Sequence # 1	4- 0
AE		Sequence # 2	4- 0
MA	3132	Partial Differential Equations and Integral Transforms	4- 0
		Thesis	4- 0
			16- 0

Third Quarter

AE		Sequence # 1	4- 0
AE		Sequence # 2	4- 0
		Elective	4- 0
		Thesis	4- 0
			16- 0

Graduate at end of Third Quarter.

Note: Sequences # 1 and # 2 above are to be selected from the options offered in the areas of Aerodynamics, Flight Dynamics, Flight Propulsion, and Flight Structures.

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.
- Gas Dynamics
- Structures
- Jet Propulsion

MASSACHUSETTS INST. OF TECHNOLOGY, Cambridge, Mass.
- Astronautics
- Airborne Weapons Systems

PRINCETON UNIVERSITY, Princeton, N.J.
- Flight Mechanics
- Gas Dynamics
- Propulsion (Rockets)

COLLEGE OF AERONAUTICS, Cranfield, England
- Aerodynamics
- Aircraft Design
- Aircraft Electronics
- Guidance and Control

STANFORD UNIVERSITY, Palo Alto, Calif.
- Aero- and Gas Dynamics
- Structures
- Guidance and Control

BACCALAUREATE PROGRAMS

Curriculum Number 461

HAROLD EDWARD COLLINS, Commander, U.S. Navy, Curricular Officer; B.S., Naval Academy, 1952; B.S. in Engineering Electronics, Naval Postgraduate School, 1958.

RAYMOND KENNETH HOUSTON, Academic Associate; B.S., Worcester Polytechnic Institute, 1933; M.S., 1939.

WAYNE CHESTER BENDER, Lieutenant Commander, U.S. Navy, Assistant Curricular Officer; B.S. Ed., State Teachers College, Millersville, Pennsylvania, 1957.

OBJECTIVES—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.

QUALIFICATION FOR ADMISSION — Applicants must have an advanced undergraduate standing of at least 45 semester hours of acceptable credit, and have earned a C average in all previous college courses. Acceptable undergraduate work must include mathematics through College Algebra. A minimum of 15 semester hours is required from an accredited educational institution since a maximum of 30 semester hours credit will be allowed for service schools.

DESCRIPTION—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 curricula.

The Bachelor of Science curriculum emphasizes the physical environment without neglecting the social. It consists of 180 quarter hours distributed as follows: 100 in Science and Engineering; 36 in Government and Humanities; and 44 in electives and/or transfer credit. Successful completion leads to the award of the degree Bachelor of Science in Engineering Science.

The Bachelor of Arts curriculum emphasizes the social environment without neglecting the physical. It consists of 180 quarter hours distributed as follows: 100 in Government and Humanities; 36 in the Physical Sciences; and 44 in electives and/or transfer credit. Successful completion leads to the award of the degree Bachelor of Arts with a major in Government (International Relations).

Classes for both curricula convene in January and July. From one to two calendar years are allowed to complete the program. Students pursuing these curricula carry an average load of 17 credit hours per quarter.

BACHELOR OF SCIENCE IN ENGINEERING SCIENCE

First Quarter

CH	1001	Introductory General Chemistry I	4- 2
MA	1021	College Algebra and Trigonometry	4- 0
GV	1060	U.S. Government	4- 0
LT	1040	Appreciation of Literature	3- 0
			15- 2

Second Quarter

CH	1002	Introductory General Chemistry II	3- 2
MA	1105	Calculus and Analytic Geometry I	5- 0
SP	1020	Public Speaking	3- 0
HI	2032	U. S. History (1865-present)	3- 0
EN	2010	Advanced Writing	3- 0
			17- 2

Third Quarter

MS	1021	Elements of Materials Science I	3- 2
MA	1106	Calculus and Analytic Geometry II	5- 0
PH	1015	Basic Physics I	5- 3
SP	1021	Conference Procedures	3- 0
			16- 5

Fourth Quarter

MS	1022	Elements of Materials Science II	2- 2
MA	1107	Calculus and Analytic Geometry III	3- 0
PH	1016	Basic Physics II	4- 3
HI	2030	European History (1914-1950)	3- 0
PS	2331	Elementary Probability and Statistics	4- 1
			16- 6

Fifth Quarter

ME	2120	Elements of Engineering Thermodynamics	3- 2
PH	2017	Basic Physics III	4- 2
EE	2222	Electronic Fundamentals I	3- 2
GV	2061	National Security	3- 0
			13- 6

Sixth Quarter

EE	2223	Electronic Fundamentals II	3- 3
MN	3941	Engineering Economics	4- 0
ME	2501	Mechanics I	4- 0
CS	2100	Introduction to Computers and Programming	4- 0
			15- 3

Seventh Quarter

ME	2502	Mechanics II	3- 0
EE	2224	Communication Electronics	4- 3
OA	2201	Elements of Operations Research/ Systems Analysis	4- 0
OC	2110	Introduction to Oceanography	3- 0
			14- 3

Eighth Quarter

AO	2302	Aviation Accident Prevention and Crash Investigation (Aviators)	3- 2
AO	2303	Aeronautical Engineering for Aviators	4- 2
PY	2050	General Psychology	3- 0
		Electives (Science and Engineering/ Government and Humanities)	5- 0
			15- 4

BACHELOR OF ARTS WITH MAJOR IN GOVERNMENT (INTERNATIONAL RELATIONS)

First Quarter

EN	2010	Advanced Writing	3- 0
GV	1060	U.S. Government	4- 0
HI	2131	U.S. History (1763-1865)	3- 0
MA	1010	Intermediate Algebra	4- 0
		Elective (Government/Humanities)	3- 0
			14- 0

Second Quarter

SP	1020	Public Speaking	3- 0
HI	2032	U.S. History (1865-present)	3- 0
LT	1040	Appreciation of Literature	3- 0
MA	1021	College Algebra and Trigonometry	4- 0
OC	2110	Introduction to Oceanography	3- 0
			16- 0

Third Quarter

HI	2130	European History (1815-1914)	3- 0
GV	2160	Comparative Government	4- 0
MN	2530	Introduction to Economics	4- 0
SP	1021	Conference Procedures	3- 0
			18- 0

Fourth Quarter

PH	1005	Elementary Physics I	4- 2
GV	2161	Introduction to International Relations	3- 0
HI	2030	European History (1914-1950)	3- 0
MN	2541	Microeconomics	4- 0
PS	2311	Elementary Probability and Statistics	3- 0
			17- 2

Fifth Quarter

GV	2061	National Security	3- 0
GV	2163	Political Thought	4- 0
PH	1006	Elementary Physics II	3- 2
		Electives (Government/Humanities)	8- 0
			18- 2

Sixth Quarter

CS	2100	Introduction to Computers and Programming	4- 0
GV	2164	Comparative Ideologies	3- 0
PH	1007	Elementary Physics III	4- 2
		Electives (Government/Humanities)	7- 0
			18- 2

Seventh Quarter

AO	2301	Aeronautical Engineering for Aviators	4- 2
AO	2302	Aviation Accident Prevention and Crash Investigation (Aviators)	3- 2
		Electives (Government/Humanities)	8- 0
			15- 4

Eighth Quarter

PY	2050	General Psychology	3- 0
		Electives (Government/Humanities)	12- 0
			15- 0

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

ROBERT EDWARD SHELDON, Commander, U.S. Navy; Curricular Officer; B.S.. Naval Academy, 1952; B.S.. in Engr. Electronics, Naval Postgraduate School, 1959.

ABRAHAM SHEINGOLD, Academic Associate; B.S., College of the City of New York, 1936; M.S., 1937.

HAROLD LEWIS REICHART, Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., Naval Academy, 1957.

OBJECTIVE — The engineering curricula in Electronics and Communications (472, 590, and 600) are designed to provide officers with an education of significant depth and breadth in the basic scientific and engineering fields related to electronics and communication. The specific areas of study and level of education to be attained are formulated to provide officers meeting the military service requirements for specialist and subspecialist assignments. An equally important objective is met in the enhancement of the career officer's mental efficiency gained by submission to these vigorous, graduate level academic disciplines. He is thus better prepared for performance in all duty assignments in the sophisticated, technical environment of which he is a part.

QUALIFICATIONS FOR ADMISSION — A Baccalaureate degree is required for admission. Inasmuch as the initial courses constitute a rapid and thorough review of the basic science-engineering disciplines, a background with an above average pattern of grades in differential and integral calculus and physics is considered essential. For otherwise qualified officers who are weak in these subjects or have been away from formal studies a long period of time, attention is called to the preparatory work available in the Engineering Science Programs, Curriculum Number 460.

DESCRIPTION — Classes start twice a year with Quarters II and IV in September and March. Refresher work in mathematics and physics is available for early arrivals (see academic calendar on page 9). Occasionally officers report sufficiently in advance of convening dates to be enrolled in formal courses in Quarters I and III preceding the normal convening quarters. This has proven to be a very effective opportunity for review work.

The typical officer who did not major in Electrical Engineering in his undergraduate work and who has been away from formal studies from four to six years normally enters a basic-core curriculum for the first three quarters. This work is common to both the Engineering Electronics (590) and Communications Engineering (600) Curricula and consists of build-up courses in mathematics and physics and the initial circuits and fundamental courses in Electrical Engineering. Those officers with appropriate academic backgrounds, such as a recent BSEE degree, may by-pass two or more of the initial quarters. Each enrolling officer is individually reviewed, counseled, and programmed by the Curricular Officer/Academic Associate team.

The officer enrolled in Electronics or Communications Engineering may pursue an Electrical Engineering degree to the Bachelor of Science, Master of Science, Engineer, or Doctor of Philosophy level. His success in this endeavor will be determined by his academic performance and approval of requests to his service for any necessary extension of tour beyond the basic seven-quarter availability. Nominations for the advanced programs are normally made near the end of the first year of study. Upon successful completion of any of the B.S., M.S., E.E., or Ph.D. programs, the unrestricted line officers of the Navy are subsequently assigned appropriate subspecialty codes by the Chief of Naval Personnel.

The typical length of time required for pursuit of these degrees is as follows, keeping in mind that, as mentioned above, suitably qualified officers may by-pass two or more of the initial courses, thereby reducing the time requirements.

B.S. in Electrical Engineering	7 quarters
M.S. in Electrical Engineering	9 quarters
ELECTRICAL ENGINEER	12 quarters

BASIC CURRICULUM

(Common to all Engineering Curricula)

EE	2101	Principles of Electrical Engineering
EE	2102	Circuit Analysis
EE	3103	Linear Systems Analysis
EE	2211	Electronic Engineering Fundamentals I
EE	2212	Electronic Engineering Fundamentals II
MA	1100	Calculus Review
MA	2045	Introduction to Linear Algebra
MA	2121	Differential Equations and Infinite Series
MA	3172	Complex Variables
PH	1041	Review of Mechanics and Thermodynamics
PH	2241	Waves and Particles
PH	3641	Atomic Physics

BACHELOR OF SCIENCE PROGRAM
(Group EB)

Courses common to Engineering Electronics and Communications Engineering Curricula:

EE	2611	Electromagnetic Fields
EE	2612	Transmission of Electromagnetic Energy
EE	2213	Electronic Communications Circuits
EE	2214	Electronic Pulse and Digital Circuits
EE	2215	Special Electronic Devices
MA	2232	Numerical Methods & Fortran Programming
EE	2811	Digital Machines
EE	3114	Communication Theory I
EE	2711	Electrical & Electronic Measurements
PS	2111	Introduction to Probability & Statistics I
EE	3411	Control Systems
MN	2900	Management of Human Resources
OA	3202	Methods of Operations Analysis/Systems Analysis
EE	3631	Antenna Engineering and Propagation Theory
		Specializatoin Courses, Engineering Electronics
EE	2311	Principles of Energy Conversion
EE	3432	Pulse Radar
EE	3481	Radar and ECM
		Specialization Courses, Communication Engineering
EE	3116	Communication Theory II
EE	3422	Modern Communications
EE	3482	Communications ECM

MASTER OF SCIENCE PROGRAM
(Groups EA, EI, and CE)

Courses Common to all Options

EE	2711	Electrical and Electronic Measurements
EE	2213	Electronic Communications Circuits
EE	2214	Electronic Pulse and Digital Circuits
EE	3215	Advanced Electronic Devices
MA	2161	Introduction to Mathematical Physics
MA	2232	Numerical Methods and Fortran Programming
EE	2811	Digital Machines
EE	3411	Control Systems
EE	3621	Electromagnetics I
EE	3622	Electromagnetics II
EE	3114	Communication Theory I
PS	3112	Probability and Statistics
EE	4571	Statistical Communication Theory
EE	4541	Signal Processing
EE	4121	Advanced Network Theory I
OA	3202	Methods of Operations Analysis/Systems Analysis
PH	3741	Electronic Properties of Metals and Semi-conductors
EE	4433	Radar Systems

Representative Specialization Courses, Advanced Electronics (Group EA)

EE	4481	Electronics Countermeasures
EE	3631	Antennas and Propagation
EE	3263	Solid State Circuit Design
EE	4652	Microwave Circuits and Measurements

Representative Specialization Courses, Advanced Communications (Group CE) Engineering

EE	4481	Electronic Countermeasures
EE	3422	Modern Communications
EE	3631	Antennas and Propagation

Representative Specialization Courses, Information and Control (Group EI)

EE	4581	Information Theory
EE	3412	Non-linear and Sampled Systems
EE	4414	Statistical Control Theory
EE	4417	Optimal Control

ELECTRICAL ENGINEER PROGRAM
(Group EE)

Individual programs are arranged in consultation with the students' departmental advisor. An Engineer's program will include approximately 10 courses more than those in the M.S. program, as selected from the following representative list.

EE	3264	Advanced Theory of Semi-conductor Devices
EE	3471	Guidance and Navigation
EE	3812	Logical Design and Circuitry
EE	3822	Digital Computer Systems
EE	4122	Advanced Network Theory II
EE	4123	Advanced Network Theory III
EE	4415	Algebraic Methods on Control Theory
EE	4416	Topics in Modern Control Theory
EE	4452	Underwater Acoustic Systems Engineering
EE	4461	Systems Engineering
EE	4623	Advanced Electromagnetic Theory
PH	4790	Theory of Quantum Devices
EE	4823	Advanced Digital Computer Systems

STAFF COMMUNICATIONS CURRICULUM NUMBER 620
(Group CO)

Objective — The Staff Communications Curriculum is designed to prepare officers for assignment to major staff and operational Communication billets, ashore and afloat. Completion of this curriculum provides the officer with a sound understanding of Department of Defense and Naval Communications organization and policies, operational communications planning and direction, procedures and equipment utilization. An education in basic electronics, computer techniques and military material management undertaken in the graduate environment of this school supports the objective in providing technical insight to the engineering theories involved. Upon successful completion, the officer is assigned the subspecialty code 8803P by the Chief of Naval Personnel.

Qualifications For Admission — A Baccalaureate degree to include undergraduate studies in Mathematics and Physics. Additionally, studies in any of the scientific and engineering fields would be particularly helpful.

Description — The typical program is four quarters in length for the officer with minimal preparation. Officers completing the Baccalaureate Programs (Curriculum Number 461) or the Engineering Science Programs (Curriculum Number 460) who elect to transfer to the Staff Communications Curriculum may complete in two or three quarters. Officers who have completed undergraduate studies in Electrical Engineering will be specially programmed to take advantage of their better preparation. Inasmuch as officers successfully completing this curriculum are awarded Diplomas of Completion, academic entrance prerequisites are less stringent than those required for the degree-awarding curricula of Electronics and Communications Engineering. The following is a listing of the courses covered .

EE	2222	Electronic Fundamentals I
EE	2223	Electronic Fundamentals II
EE	2224	Communication Electronics
EE	2225	Pulse Electronics
EE	2811	Digital Machines
CS	2110	Introduction to Computer Processes
EE	2832	Computer Systems Technology
MA	1021	College Algebra and Trigonometry
MA	1105	Calculus and Analytic Geometry I
PS	2111	Introduction to Probability and Statistics I
OA	2201	Elements of Operations Research/Systems Analysis
CO	2111	Communications Organization and Planning
CO	2112	Communications Administration and Procedures I
CO	2113	Communications Administration and Procedures II
CO	2114	Communication Equipment and Systems Application I
CO	2115	Communication Equipment and Systems Application II
MN	2970	Material Management

ENGINEERING SCIENCE PROGRAMS CURRICULUM NUMBER 460

CLYDE GILBERT HOHENSTEIN, Lieutenant Commander, U.S. Navy; Curricular Officer; B.S., Naval Academy, 1956.

ELMO JOSEPH STEWART, Academic Associate; B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Institute, 1953.

BASIC OBJECTIVE—a. To refresh officer students in undergraduate mathematics and physical sciences for twenty-four weeks in preparation for admission into an advanced technical program.

b. To provide an extensive thirty-six week education to supplement and fortify prior undergraduate work.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree and successful completion of at least one college mathematics course in algebra or trigonometry.

DESCRIPTION—There are two annual inputs to the Engineering Science Programs, one in March, the other in September. After successfully completing six months in Engineering Science, almost all officers transfer into an advanced technical curriculum. Acceptance by another curriculum depends upon the number of available quotas there are in that curriculum and the student's academic performance. The academic performance demonstrated in Engineering Science greatly influences the decision with respect to the student's academic ability, regardless of previous scholastic achievement.

There are four basic programs available to each input:

(1) The "high academic background" program is designed for an officer who has completed differential and integral calculus and at least one year of college physics and chemistry.

(2) The "average academic background" program is designed for an officer who has completed at least differential calculus or has had a recent survey course in calculus and who has had one year of college physics and chemistry with average grades.

(3) The "fair academic background (upper)" program is designed for an officer who has never studied calculus, who is weak in college algebra and trigonometry, and who has not taken college physics or chemistry.

(4) The "fair academic background (lower)" program is designed for an officer who has never studied calculus, who is weak in college algebra and trigonometry, and who has not completed a year of college physics or chemistry.

Program placement is based on the officer's age, undergraduate courses taken, grades earned, undergraduate institution at which these grades were earned, and length of time away from formal study.

During his first quarter, each Engineering Science student officer attends a series of lectures given by the other curricular officers in which the details of the other curricular programs are presented. In this way, the new officer student is exposed to every program which is available to him at the Naval Postgraduate School.

No degree or subspecialty qualification results from successful completion of an Engineering Science program.

The Engineering Science curriculum provides a beneficial six-month academic warmup to every officer student who desires advanced technical training. This same officer enjoys the advantage of selecting an advanced technical program after attending the Engineering Science lecture series and being exposed to all the Naval Postgraduate School programs available to him. The terminal officer student receives a thirty-six week education during which his undergraduate education in mathematics and physical sciences has been broadened and updated. By virtue of this improved educational foundation, the terminal student has bettered his ability to understand and cope with the scientific environment of which he is a part. This can only enhance his value and future professional performance as an officer.

HIGH ACADEMIC BACKGROUND
(Group SA)

First Quarter

MA 1115	Calculus I	5- 0
PH 1011	Basic Physics I	4- 0
EE 2221	General Electronics	4- 2
*OC 2110	Introduction to Oceanography	3- 0
		16- 2

Second Quarter

MA 1116	Calculus II	5- 0
PH 1012	Basic Physics II	4- 0
CH 2001	General Principles of Chemistry	3- 2
PS 2111	Introduction to Probability and Statistics I	4- 0
		16- 2

Third Quarter

MA 2121	Differential Equations and Infinite Series	4- 0
PH 2017	Basic Physics III	4- 2
MA 2161	Introduction to Mathematical Physics	3- 0
OA 2201	Elements of Operations Research/ Systems Analysis	4- 0
		15- 2

AVERAGE ACADEMIC BACKGROUND
(Group SB)

First Quarter

MA 1105	Calculus and Analytic Geometry I	5- 0
PH 1011	Basic Physics I	4- 0
EE 2221	General Electronics	4- 2
*OC 2110	Introduction to Oceanography	3- 0
		16- 2

Second Quarter

MA 1106	Calculus and Analytic Geometry II	5- 0
PH 1012	Basic Physics II	4- 0
PS 2321	Introduction to Probability and Statistics	3- 1
CH 2001	General Principles of Chemistry	3- 2
		15- 3

*GV 1368 American Life and Institutions (3-0) replaces OC 2110 for Allied Officers.

Third Quarter

MA	1107	Calculus and Analytic Geometry III	3- 0
PH	2017	Basic Physics III	4-2
OA	2201	Elements of Operations Research/ Systems Analysis	4- 0
MA	1030	Elementary Sets with Applications	3- 0
			14- 2

FAIR ACADEMIC BACKGROUND (UPPER) (Group SC)

First Quarter

MA	1021	College Algebra and Trigonometry	4- 0
PH	1005	Elementary Physics I	4- 2
*OC	2110	Introduction to Oceanography	3- 0
CH	1001	Introductory General Chemistry	4- 2
			15- 4

Second Quarter

MA	1115	Calculus I	5- 0
PH	1006	Elementary Physics II	3- 2
EE	2221	General Electronics	4- 2
CS	2100	Introduction to Computers and Programming	4- 0
			16- 4

Third Quarter

MA	1116	Calculus II	5- 0
PH	1007	Elementary Physics III	4- 2
PS	2321	Introduction to Probability and Statistics	3- 1
MA	1030	Elementary Sets with Applications	3- 0
			15- 3

FAIR ACADEMIC BACKGROUND (LOWER) (Group SD)

First Quarter

MA	1021	College Algebra and Trigonometry	4- 0
PH	1005	Elementary Physics I	4- 2
*OC	2110	Introduction to Oceanography	3- 0
CH	1001	Introductory General Chemistry	4- 2
			15- 4

Second Quarter

MA	1105	Calculus and Analytic Geometry I	5- 0
PH	1006	Elementary Physics II	3- 2
EE	2221	General Electronics	4- 2
CS	2100	Introduction to Computers and Programming	4- 0
			16- 4

Third Quarter

MA	1106	Calculus and Analytic Geometry II	5- 0
PH	1007	Elementary Physics III	4- 2
PS	2321	Introduction to Probability and Statistics	3- 1
MA	1030	Elementary Sets with Applications	3- 0
			15- 3

*GV 1368 American Life and Institutions (3-0) replaces OC 2110 for Allied Officers.

ENVIRONMENTAL SCIENCES PROGRAMS CURRICULA NUMBERS 371, 372, AND 440

Richard Sherry Downey, Commander, U.S. Navy; Curricular Officer; B.S., Meteorology, Naval Postgraduate School, 1961.

Glenn Harold Jung, Academic Associate; B.S., Massachusetts Institute of Technology, 1949; M.S., 1952; Ph.D., Texas Agricultural and Mechanical College, 1955.

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

Basic Objective—To provide advanced education in meteorology and oceanography to meet the Navy's operational and technical requirements in the environmental sciences.

Qualifications for Admission—Admission to curricula in the environmental sciences requires a baccalaureate degree with above average grades in mathematics and the physical sciences. Completion of mathematics through differential and integral calculus and one year of college physics is considered to be minimal preparation. The Oceanography Curriculum additionally requires one year of college chemistry.

The baccalaureate degree and mathematics requirement are waived for admission to the General Meteorology Curriculum provided mathematics prerequisite to calculus has been completed.

Description—Curriculum number 372 consists of two meteorology curricula of seven quarters duration with matriculation scheduled for quarters beginning in September and March.

A Bachelor of Science in Meteorology degree is awarded upon successful completion of the General Meteorology Curriculum if the general requirements for the Bachelor of Science degree are fulfilled; the degree of Master of Science in Meteorology is attainable through the Advanced Meteorology Curriculum.

The Meteorology Curriculum, number 372, consists basically of core sequences of courses in dynamic, synoptic, and physical meteorology. Sufficient practical laboratory work and oceanographic courses are included to prepare officers to become qualified operational meteorologists with a working knowledge of oceanography. Numerical methods are emphasized, and the Advanced Meteorology Curriculum prepares officers to conduct independent scientific research. Upon completion of the curriculum, unrestricted line officers are assigned a subspecialty qualification code 8701P.

The General and Advanced Meteorology Curricula cover the same material but differ in the mathematical requirements and the depth to which the dynamic and physical aspects of meteorology are pursued.

Enrollment in the Meteorology Curriculum number 371 is restricted to graduating students of the Officer Candidate School. This curriculum is of four quarters duration with matriculation in January and and July. Upon completion the officers are assigned a 1535 designator.

Based on their academic performance, officers completing the Meteorology Curriculum 371 will be given an opportunity to be reassigned to the Postgraduate School after one tour in a meteorological billet. During this reassignment, the degree of Master of Science in Meteorology is attainable in four quarters.

The Oceanography Curriculum, number 440, is of seven quarters duration, and classes convene in September and March. Subject to service needs, officers may select a specialization in physical or geophysical oceanography. The Oceanography Curriculum provides a broad basic education in oceanography, including courses in biological, geological, and chemical oceanography. The core of the curriculum is, however, the sequence of courses in physical oceanography with the options in the dynamical and geophysical fields. Emphasis is placed upon the application of oceanography to naval operations, and practical experience in the use of oceanographic instruments and the collection of scientific observations at sea is included. As in meteorology, computer technology is also emphasized, and officers are prepared to conduct independent research.

A Master of Science degree is awarded upon completion of the curriculum provided the general requirements for the master of science degree are met. There is no provision for the awarding of a baccalaureate degree in oceanography. Unrestricted line officers completing the Oceanographic Curriculum, number 440, will be assigned a subspecialty qualification code 8703P.

METEOROLOGY CURRICULUM CURRICULUM NUMBER 371 (Group MG)

First Quarter

MA	2121	Differential Equations and Infinite Series	4- 0
MA	3181	Vector Analysis	3- 0
MR	1105	Weather Codes—Observations—Plotting	0- 3
MR	2200	Introduction to Meteorology	3- 0
MR	3411	Meteorological Thermodynamics	4- 0
			14- 3

Second Quarter

MR	2220	Weather Map Analysis	4- 0
MR	2225	Weather Map Analysis Laboratory	0- 6
MR	4321	Dynamic Meteorology I	4- 0
MR	4412	Heat Transfer Processes	4- 0
			12- 6

Third Quarter

MR	3230	Tropospheric and Stratospheric Meteorology	4- 0
MR	3235	Tropospheric and Stratospheric Meteorology Laboratory	0- 9
MR	4322	Dynamic Meteorology II	4- 0
CS	2100	Introduction to Computers and Programming	4- 0
			12- 9

Fourth Quarter

MR	3250	Tropical and Southern Hemisphere Meteorology	3- 0
MR	3255	Tropical and Southern Hemisphere Meteorology Laboratory	0- 6
MR	3260	Prognostic Charts and Extended Forecasting	3- 0
MR	3265	Prognostic Charts and Extended Forecasting Laboratory	0- 6
MR	3303	Computer Meteorology	3- 0
			9-12

ADVANCED METEOROLOGY CURRICULUM
CURRICULUM NUMBER 372
(Group MM)

First Quarter

MA 1100	Calculus Review	4- 0
MA 2045	Introduction to Linear Algebra	3- 0
OC 3221	Descriptive Oceanography	4- 0
MR 2200	Introduction to Meteorology	3- 0
MR 2410	Meteorological Instruments	3- 2
		17- 2

Second Quarter

MA 3181	Vector Analysis	3- 0
MA 2121	Differential Equations and Infinite Series	4- 0
MR 1105	Weather Codes-Observations-Plotting	0- 3
MR 3510	Statistical Climatology	4- 2
MR 3411	Meteorological Thermodynamics	4- 0
		15- 5

Third Quarter

MA 3132	Partial Differential Equations and Integral Transforms	4- 0
MR 2220	Weather Map Analysis	4- 0
MR 2225	Weather Map Analysis Laboratory	0- 6
MR 4321	Dynamic Meteorology I	4- 0
MR 4412	Heat Transfer Processes	4- 0
		16- 6

Fourth Quarter

MA 2232	Numerical Methods and FORTRAN Programming	4- 0
MR 3230	Tropospheric and Stratospheric Meteorology	4- 0
MR 3235	Tropospheric and Stratospheric Meteorology Laboratory	0- 9
MR 4322	Dynamic Meteorology II	4- 0
		12- 9

Fifth Quarter

MA 3243	Numerical Methods for Partial Differential Equations	4- 1
MR 3250	Tropical and Southern Hemisphere Meteorology	3- 0
MR 3255	Tropical and Southern Hemisphere Meteorology Laboratory	0- 6
MR 4323	Numerical Weather Prediction	4- 2
OC 3260	Sound in the Ocean	3- 0
		14- 9

Sixth Quarter

MR 4422	Upper Atmosphere Physics	3- 0
MR 3260	Prognostic Charts and Extended Forecasting	3- 0
MR 3265	Prognostic Charts and Extended Forecasting Laboratory	0- 6
	Thesis	0- 8
		6-14

Seventh Quarter

MR 2279	Operational Meteorology	1- 6
OC 3611	Ocean Wave and Surf Forecasting	2- 0
OC 3615	Ocean Wave and Surf Forecasting Laboratory	0- 6
MR 4900	Seminar in Meteorology	2- 0
	Thesis	0- 8
		5-20

GENERAL METEOROLOGY CURRICULUM
CURRICULUM NUMBER 372
(Group MA)

First Quarter

MA 1115	Calculus I	5- 0
OC 3221	Descriptive Oceanography	4- 0
MR 2200	Introduction to Meteorology	3- 0
MR 2410	Meteorological Instruments	3- 2
		15- 2

Second Quarter

MA 1116	Calculus II	5- 0
MA 2181	Introduction to Vectors	3- 0
MR 1105	Weather Codes-Observations-Plotting	0- 3
MR 2510	Climatology	4- 2
MR 2411	Introduction to Thermodynamics of Meteorology	4- 0
		16- 5

Third Quarter

CS 2110	Introduction to Computer Processes	3- 0
MR 2220	Weather Map Analysis	4- 0
MR 2225	Weather Map Analysis Laboratory	0- 6
MR 3301	Fundamentals of Dynamic Meteorology I	4- 0
		11- 6

Fourth Quarter

CS 3111	Computer Organization and Programming	4- 0
MR 3230	Tropospheric and Stratospheric Meteorology	4- 0
MR 3235	Tropospheric and Stratospheric Meteorology Laboratory	0- 9
MR 3302	Fundamentals of Dynamic Meteorology II	4- 0
		12- 9

Fifth Quarter

MR 3403	Introduction to Energy-Transfer Processes	4- 0
MR 3250	Tropical and Southern Hemisphere Meteorology	3- 0
MR 3255	Tropical and Southern Hemisphere Meteorology Laboratory	0- 6
MR 3303	Computer Meteorology	3- 0
OC 3260	Sound in the Ocean	3- 0
		13- 6

Sixth Quarter

MR 3260	Prognostic Charts and Extended Forecasting	3- 0
MR 3265	Prognostic Charts and Extended Forecasting Laboratory	0- 6
OC 3616	Oceanographic Forecasting	3- 0
OC 3621	Oceanographic Forecasting Laboratory	0- 4
	Research Problem	0- 6
		6-16

Seventh Quarter

MR 2279	Operational Meteorology	1- 6
OC 3611	Ocean Wave and Surf Forecasting	2- 0
OC 3615	Ocean Wave and Surf Forecasting Laboratory	0- 6
MR 3900	Seminar in Meteorology	2- 0
	Research Problem	0- 6
		5-18

OCEANOGRAPHY CURRICULUM
CURRICULUM NUMBER 440
(Groups OP, OG)

First Quarter

MA 1100	Calculus Review	4- 0
MA 2045	Introduction to Linear Algebra	3- 0
MR 2200	Introduction to Meteorology	3- 0
MR 2205	Meteorology for Oceanographers	0- 4
OC 3221	Descriptive Oceanography	4- 0
		14- 4

Second Quarter

MA 2121	Differential Equations and Infinite Series	4- 0
MA 3181	Vector Analysis	3- 0
OC 3320	Geological Oceanography	3- 3
OC 3520	Chemical Oceanography	3- 2
		13- 5

+ *These courses constitute the Physical Oceanography specialization*
= *These courses constitute the Geophysical Oceanography specialization*

Third Quarter

MA 3132	Partial Differential Equations and Integral Transforms	4- 0
OC 3150	Geophysical Random Processes	4- 2
OC 3420	Biological Oceanography	3- 3
+OC 4251	Dynamical Oceanography I	4- 0
=OC 4260	Sound in the Ocean	3- 0
		15- 5 or 14- 5

Fourth Quarter

MA 2232	Numerical Methods and FORTRAN Programming	4- 0
OC 3700	Oceanographic Instrumentation and Observations	3- 0
OC 3710	Field Experience in Oceanography	0- 4
OC 4211	Waves and Tides	4- 0
+OC 4252	Dynamical Oceanography II	4- 0
=OC 4851	Geophysics: Earth Gravity	3- 2
		15- 4 or 14- 6

Fifth Quarter

MA 3243	Numerical Methods for Partial Differential Equations	4- 1
+OC 3601	Ocean Wave Forecasting	3- 0
+OC 3605	Ocean Wave Forecasting Laboatory	0- 6
+OC 4253	Dynamical Oceanography III	3- 0
+OC 4260	Sound in the Ocean	3- 0
=OC 3250	Dynamical Oceanography	4- 0
=OC 4852	Geophysics: Earth Magnetism and Electricity	3- 2
=OC 4853	Geophysics: Sound and Seismicity	4- 0
		13- 7 or 15- 3

Sixth Quarter

OC 3616	Oceanographic Forecasting	3- 0
OC 3621	Oceanographic Forecasting Laboratory	0- 4
OC 4213	Coastal Oceanography	4- 1
	Thesis	0- 8
=OC 4860	Physics of the Earth	3- 0
		7-13 or 10-13

Seventh Quarter

OC 4900	Seminar in Oceanography	3- 0
	Thesis	0- 8
+OC 4612	Polar Oceanography	3- 0
+	Elective in Oceanography ☆	
=OC 3601	Ocean Wave Forecasting	3- 0
=OC 3605	Ocean Wave Forecasting Laboratory	0- 6
		9- 8, 7-12, 10-10 or 6-14

☆ Electives

OC 4340	Marine Geophysics	3- 0
OC 4421	Marine Ecology	1- 4
PH 3421	Underwater Acoustics	4- 2

Change in Curricula at Press Time

The above curricula in Advanced Meteorology (No. 372) and in Oceanography (No. 440) have been extended to eight quarters in length.

MANAGEMENT AND OPERATIONS ANALYSIS PROGRAMS
CURRICULA NUMBERS 360, 367, 368 and 817

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

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

H. ARTHUR HOVERLAND, Academic Associate for Management; B.S., Miami Univ. (Ohio), 1951; M.S., Univ. of Illinois, 1954; Ph.D., Univ. of Michigan, 1963.

DOUGLAS GEORGE WILLIAMS, Academic Associate for Computer Systems Management and Computer Science; M.A. (Honours), Univ. of Edinburgh, 1954.

THOMAS LELAND MEEKS, Commander, U.S. Navy; Assistant Curricular Officer; B.S., Naval Academy, 1952; M.S. in Operations Research, Naval Postgraduate School, 1964.

OPERATIONS RESEARCH/SYSTEMS ANALYSIS CURRICULUM

CURRICULUM NUMBER 360
(Group RO)

OBJECTIVE—To provide selected officers with a sound education in quantitative methods and to develop their analytical ability in order that they may (1) formulate new concepts and apply the results of operations research/systems analysis with greater effectiveness, and (2) define and solve military problems more effectively.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree with above average grades in mathematics is required. Completion of mathematics through differential and integral calculus is considered minimal preparation. For Navy Line Officers a one-year course in college physics is also necessary. Students lacking these quantitative prerequisites will be accepted, in certain special cases, where their undergraduate records indicate that they are exceptional students and there are other possible indicators of success such as Graduate Record Examination scores, correspondence or extension courses in quantitative areas and outstanding motivation for the program.

DESCRIPTION—The Operations Research/Systems Analysis program in interdisciplinary in nature, consisting of course work in operations analysis, probability and statistics, mathematics, physics, economics, and computer science. Classes convene semiannually, in March and September. All students take a common core curriculum during the first year (four quarters) although there are slight variations designed to meet particular career needs of Navy Line, Supply Corps, Marine Corps, Army and Air Force Officers. Those officers selected for the Master's program continue for a second year of study (for a total of eight quarters, overall) and are afforded the opportunity to qualify for the degree Master of Science in Operations Research. Additionally, students in the Master's program must complete an elective sequence approved by the Department of Operations Analysis, and submit an acceptable thesis on a subject previously approved by the Department.

An integral part of the Master's program is a six-week intersessional experience tour taken during the second half of the fifth quarter in which the student officers are assigned as working members of appropriate military or industrial groups engaged in operations research/systems analysis of military problems. This field trip is designed to permit the student, on an individual basis, to participate in some phase of active operations research in the "real world," and, secondarily, to assist him in finding a problem of interest for subsequent thesis study.

Selection for the Master's program is based on the student's academic performance and potential, his desires, and availability. Those officers not selected for the Master's program are graduated at the end of five quarters, and upon successful completion, are awarded the degree Bachelor of Science in Operations Research.

At present, all Naval officers successfully completing either the eight-quarter Master's program or the five-quarter Bachelor's program are considered qualified to fill Operations Analysis Sub-specialist P-Coded billets (P-8500 and P-8501). The degree awarded, in either case, is considered immaterial in attaining the qualification to fill OA Subspecialist P-Coded billets.

An important adjunct to the formal classroom work is a seminar series in which guest lecturers present first-hand information as to practical principles and techniques in the field of Operations Research/Systems Analysis.

Officers who possess outstanding quantitative backgrounds by virtue of having completed other graduate education, or undergraduate work with a major in operations research or the equivalent, may be enrolled in a special Master's degree program of about one year's duration. The specific curriculum in each case must be approved by the Department of Operations Analysis and will be designed to meet the needs of the service, while complementing the officer's past educational background.

A limited number of officers each year who demonstrate superior academic performance are encouraged to apply for doctoral study in operations research.

First Quarter

MA	1101	Review of Calculus Fundamentals	5- 0
MA	2042	Linear Algebra	4- 0
PS	2301	Probability	4- 0
OA	2601	Introduction to Operations Analysis	4- 0
OA	0001	Seminar	0- 2
			17- 2

Second Quarter

MA	2110	Selected Topics from Advanced Calculus	4- 0
MN	3141	Microeconomic Theory	4- 0
PS	3302	Probability and Statistics	4- 1
PH	2121	Particle Dynamics (Navy Line Officers)	4- 0
		or	
OA	3657	Human Factors in Systems Design I (Supply Corps, USMC, USA, and USAF Officers)	4- 0
OA	0001	Seminar	0- 2
			16- 3

Third Quarter

PS	3303	Statistics	4- 1
OA	2602	War Gaming and Simulation	3- 2
OA	3604	Linear Programming	4- 0
PH	2221	Wave Phenomena (Navy Line Officers)	3- 2
		or	
MN	4182	Data Processing Management (USMC, USA, and USAF Officers)	4- 0
		or	
MN	3150	Financial Accounting (Supply Corps Officers)	4- 0
OA	0001	Seminar	0- 2
			15- 5 or 15- 6

Fourth Quarter

OA	3610	Utility Theory and Resource Allocation Models	4- 0
OA	3611	Systems Analysis I	4- 0
OA	3653	Systems Simulation	4- 0
PH	3421	Underwater Acoustics (Navy Line Officers)	4- 2
		or	
OA	3655	Methods for Combat Development Experiments (USMC, USA, and USAF Officers	4- 0
MN	3161	Managerial Accounting (Supply Corps Officers)	4- 0
OA	0001	Seminar	0- 2
			16- 2 to 16- 4

Fifth Quarter (Master's Program)

During the first six weeks of the Quarter, students will take two courses at an accelerated pace:

OA	3612	Systems Analysis II	4- 0
OA	3620	Inventory I	3- 0
OA	0001	Seminar	0- 2
			7- 2

The student experience tour is taken during the last six weeks of the Quarter.

Fifth Quarter (Bachelor's Program)

OA	3605	Methods of Operations Research/ Systems Analysis	4- 0
OA	3612	Systems Analysis II	4- 0
OA	3900	Workshop in Operations Research/ Systems Analysis	4- 0
OA	3910	Selected Topics in Operations Research/ Systems Analysis	4- 0
OA	0001	Seminar	0- 2
			16- 2

Sixth Quarter (Master's Program)

OA	3704	Stochastic Models I	4- 0
OA	4631	Non-Linear and Dynamic Programming	4- 0
PH	3921	Conceptual Models of Modern Physics (Navy Line Officers)	4- 0
		or	
OA	3621	Inventory II (Supply Corps Officers)	4- 0
		or	
OA	3664	Theory of Pattern Recognition (USMC, USA, and USAF Officers)	4- 0
		Elective	3- 0 to 4- 0
OA	0001	Seminar	0- 2
			14- 2 to 16- 2

Seventh Quarter (Master's Program)

OA	4705	Stochastic Models II	4- 0
OA	4651	Search Theory and Detection	4- 0
		or	
		Elective (Supply Corps Officers)	3- 0 to 4- 0
		Elective	3- 0 to 4- 0
		Thesis	4- 0
OA	0001	Seminar	0- 2
			14- 2 to 16- 2

Eighth Quarter (Master's Program)

PS	4321	Design of Experiments	3- 1
OA	4632	Mathematical Programming	4- 0
		Elective	3- 0 to 4- 0
		or	
OA	4622	Seminar in Supply Systems (Supply Corps Officers)	4- 0
		Thesis	4- 0
OA	0001	Seminar	0- 2
			14- 3 to 15- 3

ELECTIVES

All students in the Master's program must complete an elective sequence of at least three courses approved by the Department of Operations Analysis. Electives may be chosen from the following list of courses (although it should be noted that only certain courses will be offered in any particular quarter):

OA	3656	Operations Research Problems in Special Warfare	4- 0
OA	3657	Human Factors in Systems Design I	4- 0
OA	3658	Human Factors in Systems Design II	3- 0
OA	3664	Theory of Pattern Recognition	3- 0
OA	3671	Cybernetics	3- 0
OA	4613	Theory of Systems Analysis	4- 0
OA	4615	Econometrics	3- 0
OA	4633	Network Flows and Graphs	3- 0
OA	4634	Games of Strategy	4- 0
OA	4642	Advanced War Gaming	3- 2
OA	4652	Operations Research Problems in Naval Warfare	3- 0
OA	4662	Systems Reliability and Life Testing	4- 0
OA	4910	Selected Topics in OR/SA	4- 0
PS	4510	Selected Topics in Probability and Statistics	3- 0
PS	4306	Applied Statistics	4- 0
PS	4322	Sample Inspection and Quality Assurance	3- 1
PS	4323	Decision Theory	3- 0
PS	4431	Advanced Probability	3- 0
PS	4432	Stochastic Processes	3- 0
MN	3130	Macroeconomic Theory	4- 0
MN	4941	Mathematical Seminar in Microeconomic Theory	4- 0

MN	4931	Mathematical Seminar in Macroeconomic Theory	4- 0
CS	3111	Computer Organization and Programming	4- 0
CS	4112	Systems Programming I	4- 0

COMPUTER SYSTEMS MANAGEMENT CURRICULUM
CURRICULUM NUMBER 367
(Group PM)

OBJECTIVE—To provide officers with a sound understanding of computer technology, enabling them to distinguish the capabilities and limitations of digital computers in various applications and developing the ability to effectively manage computer-based activities or data processing centers.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree with above average grades in mathematics is required. Completion of two semesters of college mathematics at, or above, the level of College Algebra is considered to be minimal preparation for Supply Corps Officers. For Navy Line Officers the completion of differential and integral calculus is also necessary.

DESCRIPTION—The curriculum is of fifteen months duration and encompasses five academic quarters. To best satisfy the requirements of sponsoring activities, two versions of the program have been created. Sequence A, intended primarily for the Navy Line Officer, emphasizes the technical areas of programming, the use of computers, and quantitative decision-making techniques. Sequence B, designed specifically for the Navy Supply Officer, provides for the inclusion of courses in the areas of procurement and logistics and additional emphasis on financial management.

Classes convene semiannually in March and September, however, the Supply Officer variation of the program is available only to the September input.

Students in this curriculum are afforded the opportunity to qualify for the Master of Science in Computer Systems Management. All graduates are assigned educational achievement codes indicating qualification for subspecialist P-coded billets in the 8600P Computer Systems Management series.

First Quarter

MA	1100	Calculus Review (Sequence A)	4- 0
		or	
MA	2300	Mathematics for Management (Sequence B)	5- 0
MN	3130	Macroeconomic Theory	4- 0
MN	3150	Financial Accounting	4- 0
CS	2110	Introduction to Computer Processes	3- 0
			15- 0 to 16- 0

Second Quarter

PS	3101	Management Statistics I	5- 0
MN	3141	Microeconomic Theory	4- 0
CS	3111	Computer Organization and Programming	4- 0
CS	3200	Logical Design of Digital Computers	4- 0
			17- 0

Third Quarter

PS	3102	Management Statistics II	4- 1
CS	4112	Systems Programming I	4- 0
MA	2045	Introduction to Linear Algebra (Sequence A)	3- 0
		or	
MN	3161	Managerial Accounting (Sequence B)	4- 0
CS	3201	Computer Systems Design I (Sequence A)	4- 0
		or	
MN	4151	Internal Control and Auditing (Sequence B)	4- 0
			15- 1 to 16- 1

Fourth Quarter

OA	3211	Operations Analysis for Management	4- 0
MN	4182	Data Processing Management	4- 0
MN	4183	Business Data Processing	4- 0
CS	4113	Systems Programming II (Sequence A)	4- 0
		or	
MN	3171	Resource Management for Defense (Sequence B)	4- 0
			16- 0

Fifth Quarter

MN	4181	Management Information Systems	4- 0
		and	
		Sequence A	
OA	3212	Operations Analysis for Management II	4- 0
CS	4900	Advanced Topics in Computer Science	3- 0
CS	3500	Military Applications of Computers	4- 0
		or	
		Sequence B	
MN	4161	Controllership	4- 0
MN	4171	Procurement and Contract Administration	4- 0
OA	3213	Introduction to Logistics and Supply Systems	4- 0
			16- 0

COMPUTER SCIENCE
CURRICULUM NUMBER 368
(Group CS)

OBJECTIVE—To provide selected officers with an advanced education in computer science in order that they will have a sound technical appreciation of computer theory and technology with the ability to specify, design and manage computer-based systems.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree with a pattern of above average grades in mathematics is required. Completion of mathematics through differential and integral calculus is considered minimal preparation. Courses affording a background in physical science or engineering fields are highly desirable.

DESCRIPTION—A relatively new academic discipline, computer science is concerned with the representation, storage and manipulation of information by techniques and devices applicable to a wide variety of problems. This program is designed to help fulfill the Navy's rapidly expanding needs in the field of automatic data processing, for in recent years the computer has become an indispensable part of almost all Naval activities, both of an operational and supporting nature.

Classes convene semiannually, in March and September. All students take a common curriculum for the first nine months (three quarters). Those officers selected for the Master's program continue for an additional year of study (for a total of seven quarters, overall) and are afforded the opportunity to qualify for the degree Master of Science in Computer Science. This selection is based on the student's academic performance, his preference, and availability. Officers not selected for the Master's program complete one final quarter in the Bachelor's program (four quarters overall) and upon successful completion, are awarded the degree Bachelor of Science with major in Computer Science.

This program involves course work in computer science supported by instruction in mathematics, probability and statistics, operations analysis, and management. In computer science, the emphasis is on programming systems and systems design, particularly those aspects of the theory of relevance to military applications. The Master's program permits further specialization by way of elective courses. The student will acquire significant practical experience on the excellent equipment of the Postgraduate School's Computer Facility. Most of the later courses, and, it is expected, the thesis, will involve heavy use of computers.

All Naval officers successfully completing either the seven-quarter Master's program or four-quarter Bachelor's program are considered qualified to fill any P-Coded billet in the 8600 series (Computer Systems Management).

First Quarter

CS	2110	Introduction to Computer Processes	3- 0
MA	1100	Calculus Review	4- 0
MA	2025	Logic, Sets and Finite Mathematics	4- 0
MA	2045	Introduction to Linear Algebra	3- 0
CS	0001	Seminar	0- 1
			14- 1

Second Quarter

CS	3200	Logical Design of Digital Computers	4- 0
CS	3111	Computer Organization and Programming	4- 0
MA	2121	Differential Equations and Infinite Series	4- 0
PS	2325	Introduction to Probability Theory	3- 1
CS	0001	Seminar	0- 1
			15- 2

Third Quarter

CS	3201	Computer Systems Design I	4- 0
CS	3500	Military Applications of Computers	4- 0
CS	4112	Systems Programming I	4- 0
PS	3326	Probability and Statistics	3- 1
CS	0001	Seminar	0- 1
			15- 2

Fourth Quarter (Bachelor's Program)

CS	4113	Systems Programming II	4- 0
MN	4182	Data Processing Management	4- 0
OA	3203	Survey of Operations Analysis/Systems Analysis	4- 0
MN	4183	Business Data Processing	4- 0
CS	0001	Seminar	0- 1
			16- 1

Fourth Quarter (Master's Program)

CS	4113	Systems Programming II	4- 0
MN	4182	Data Processing Management	4- 0
MA	3063	Algebraic Foundations of Computer Science	3- 0
MA	3232	Numerical Analysis	4- 0
CS	0001	Seminar	0- 1
			15- 1

Fifth Quarter (Master's Program)

CS	3204	Data Communication	4- 0
CS	3601	Automata and Formal Languages	4- 0
OA	3205	Optimization Techniques	4- 0
CS	0001	Seminar	0- 1
		Elective	3- 0 to 4- 0
			15/16- 1

Sixth Quarter (Master's Program)

CS	4200	Computer Systems Design II	4- 0
OA	4910	Selected Topics in Operations Research/Systems Analysis	4- 0
CS	0001	Seminar	0- 1
		Elective	3- 0 to 4- 0
		Thesis	4- 0
			15/16- 1

Seventh Quarter (Master's Program)

CS	4310	Non-numerical Information Processing	4- 0
OA	3653	Systems Simulation	4- 0
CS	0001	Seminar	0- 1
		Electtive	3- 0 to 4- 0
		Thesis	4- 0
			15/16- 1

ELECTIVES

All students in the Master's program must complete an elective sequence of at least three courses approved by the Academic Associate and the Curricular Officer. Electives may be chosen from the following list of courses (although it is noted that only certain courses will be offered in any particular quarter):

MA	3132	Partial Differential Equations and Integral Transforms	4- 0
MA	3243	Numerical Methods for Partial Differential Equations	4- 1
MA	4237	Advanced Topics in Numerical Analysis	4- 0
CS	4900	Advanced Topics in Computer Science	3- 0
CS	4601	Effective Computability	3- 0
MN	3150	Financial Accounting	4- 0
NM	3161	Managerial Accounting	4- 0
MN	4181	Management Information Systems	4- 0
MN	3110	Individual Behavior	3- 0
OA	3671	Cybernetics	3- 0
OA	3657	Human Factors in Systems Design I	4- 0
OA	3704	Stochastic Models I	4- 0
OA	3664	Theory of Pattern Recognition	3- 0
PS	3327	Applied Statistics	3- 1

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.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree with overall academic performance of at least C+ is required. Completion of two semesters of college mathematics at, or above, the level of College Algebra, and a C average in all quantitative courses is considered to be minimal preparation. Courses in differential and integral calculus are very desirable.

DESCRIPTION—The curriculum is of twelve months duration, convening semiannually in January and July. 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 may lead to the award of a Master of Science in Management degree. Educational achievement codes are assigned to graduates by the Chief of Naval Personnel, indicating qualification for appropriate sub-specialist P-Coded billets.

First Quarter

MA 2300	Mathematics for Management	5- 0
MN 3130	Macroeconomic Theory	4- 0
MN 3150	Financial Accounting	4- 0
MN 3180	Computers and Data Processing	3- 0
		16- 0

Second Quarter

EN 3310	Research Methods	2- 0
PS 3101	Management Statistics I	5- 0
MN 3141	Microeconomic Theory	4- 0
MN 3161	Managerial Accounting	4- 0
MN 3110	Individual Behavior	3- 0
		18- 0

Third Quarter

OA 3211	Operations Analysis for Management	4- 0
MN 3121	Group and Organizational Behavior	5- 0
MN 3171	Resource Management for Defense	4- 0
	Elective or Thesis	0- 0 to 4- 0
		13- 0 to 17- 0

Fourth Quarter

MN 4105	Management Policy	4- 0
MN 4145	Systems Analysis	4- 0
	Electives (or 1 elective and thesis)	4- to 8- 0
		12- 0 to 16- 0
	TOTAL	59- 0 to 67- 0

ELECTIVE SEQUENCES

1—Personnel Management

MN 4101	Personnel Management and Labor Relations	4- 0
MN 4111	Seminar in Behavioral Science	4- 0
MN 4121	Seminar in Organization Theory and Management Practice	4- 0
		12- 0

2—Economics

MN 4142	International Economic Studies	4- 0
MN 4131	Economic Theory and Macroeconomic Policy	4- 0
MN 4141	Economic Theory and Microeconomic Policy	4- 0
		12- 0

3—Financial Management

MN 4181	Management Information Systems	4- 0
MN 4151	Internal Control and Auditing	4- 0
MN 4161	Controllership	4- 0
		12- 0

4—Material Management

MN 4171	Procurement and Contract Administration	4- 0
	and	
MN 4131	Economic Theory and Macroeconomic Policy	4- 0
MN 4141	Economic Theory and Microeconomic Policy	4- 0
	or	
MN 4151	Internal Control and Auditing	4- 0
MN 4161	Controllership	4- 0
		12- 0

5—Quantitative Analysis

MN 4181	Management Information Systems	4- 0
MN 4183	Business Data Processing	4- 0
MN 4191	Quantitative Decision Techniques	4- 0
		12- 0

An additional elective course in the Management area is:

MN 4109	Directed Study	4- 0

NAVAL ENGINEERING PROGRAMS
CURRICULUM NUMBER 570

KEVIN JAMES O'TOOLE, Commander, U. S. Navy; Curricular Officer; B.S., Naval Academy, 1951; M.S., Massachusetts Institute of Technology, 1957; Nav. Eng., 1957.

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

CHARLES WILLIAM LEARNED, JR., Lieutenant Commander, U.S. Navy; Assistant Curricular Officer; B.S., Naval Academy, 1954.

OBJECTIVE—To provide selected officers with advanced education in MECHANICAL or ELECTRICAL engineering to meet the requirements of the Navy for officers with technical competence in the areas of engineering mechanics, naval hydrodynamics, thermosciences, nuclear reactor systems and power sources, ocean mechanical engineering, naval electric machinery, electronics, circuits and feedback control, and electric power systems.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree with a grade average of B or better in mathematics, physical sciences, and engineering is required. Completion of mathematics through differential and integral calculus, one year of engineering physics, one year of chemistry. Courses in statics, dynamics, fluid mechanics, thermodynamics, electric fields, electric circuits, and electronics are very desirable.

DESCRIPTION—All students initially enter a common Naval Engineering (General) Curriculum. At the end of the second quarter, students are selected to pursue studies in a specialty of either MECHANICAL or ELECTRICAL engineering. Upon completion of the first year of study, qualified students in each specialty are selected to follow a Master's degree curriculum, and upon completion of seven quarters, students from the M.S. group are further selected to follow an Engineer degree curriculum in various groups of specialty in either mechanical or electrical engineering.

The criteria for selection are academic performance, tour availability, and student preference.

The length of each curriculum is dependent upon the qualifications and prior education of each student. The length of each specialty given below is based on a minimal preparation prior to admission. Some officers could finish their respective curriculum in a shorter time period by receiving credit for the courses they have taken previously.

Mechanical Engineering (B.S. Degree)	7 quarters
Mechanical Engineering (M.S. Degree)	9 quarters
Mechanical Engineering (Engineer's Degree)	12 quarters
Electrical Engineering (B.S. Degree)	7 quarters
Electrical Engineering (M.S. Degree)	9 quarters
Electrical Engineering (Engineer Degree)	12 quarters

The completion of a satisfactory thesis is required for the M.S. and Engineer degree in each specialty.

NAVAL ENGINEERING (GENERAL PROGRAM)
(Group NG)

common to all Naval Engineering students

MA 1100 Calculus Review
MA 2045 Introduction to Linear Algebra
MA 2121 Differential Equations and Infinite Series
ME 2101 Engineering Thermodynamics
ME 2501 Mechanics I
ME 2502 Mechanics II
EE 2101 Principles of Electrical Engineering
EE 2102 Circuit Analysis

MECHANICAL ENGINEERING—B.S.M.E. PROGRAM

The following courses will satisfy the minimum requirements for the degree of Bachelor of Science in Mechanical Engineering when taken in addition to those listed in the Naval Engineering (General) program.

ME 2201 Fluid Mechanics
ME 2410 Mechanical Engineering Laboratory I
ME 2601 Mechanics of Solids I
ME 2711 Machine Design I
ME 3170 Heat Transfer and Gas Dynamics
ME 3301 Nuclear Power Systems
ME 3440 Engineering Systems Analysis
ME 3450 Marine Power Systems Analysis
ME 3521 Mechanical Vibrations
ME 3611 Mechanics of Solids II
ME 3801 Fluid Power Control
ME (Elective)—Two courses
(To be selected from the MSME program)
MA 2232 Numerical Methods and FORTRAN Programming
MA 3132 Partial Differential Equations and Integral Transforms
MS 2201 Engineering Materials I
MS 2202 Engineering Materials II
PH 2810 Survey of Nuclear Physics
EE 2201 General Electronics
OA 3201 Fundamentals of Operations Analysis
MN 2970 Material Management
GV 1368 American Life and Institutions
(Allied Officers only in place of MN 2970)

MECHANICAL ENGINEERING—M.S.M.E. PROGRAMS
(Groups NC, NF, NN, NO)

Master of Science in Mechanical Engineering program may lead to specialization in the areas of engineering mechanics, fluid dynamics and heat transfer, nuclear engineering, or ocean mechanical engineering. An officer selected for this program may, with the approval of the Department Chairman, choose his area of specialization. *All students take the common core courses below after completion of the Naval Engineering (General) program.* Candidates for the Master of Science degree take an additional seven courses in one of the specialization areas. The time devoted to thesis research is equivalent to approximately four courses for the Master of Science degree.

Common Core Courses

ME 2201 Fluid Mechanics
ME 2410 Mechanical Engineering Laboratory I
ME 2601 Mechanics of Solids I
ME 2711 Machine Design I
ME 3202 Gas Dynamics
ME 3430 Mechanical Engineering Laboratory II
ME 3440 Engineering Systems Analysis
ME 3450 Marine Power Systems Analysis

ME 3521 Mechanical Vibrations
ME 3611 Mechanics of Solids II
ME 3801 Fluid Power Control
MA 2232 Numerical Methods and FORTRAN Programming
MA 3132 Partial Differential Equations and Integral Transforms
MS 2201 Engineering Materials I
MS 2202 Engineering Materials II
PH 2810 Survey of Nuclear Physics
EE 2201 General Electronics
OA 3201 Fundamentals of Operations Analysis
MN 2970 Material Management
GV 1368 American Life and Institutions (Allied Officers only in place of MN 2970)
ME 0810 Thesis Research

Specialization Courses, Engineering Mechanics (NC)

This specialization will provide an understanding of the mechanics of deformable bodies, dynamics, mechanical vibrations, and machine design.

ME 3150 Heat Transfer
ME 3301 Nuclear Power Systems
ME 3712 Machine Design II
ME 4512 Advanced Dynamics
ME 4522 Advanced Vibrations
ME 4612 Mechanics of Solids III
ME (Elective)

Specialization Courses, Fluid Dynamics and Heat Transfer (NF)

The objective of this specialization is to provide an understanding of fluid power control, naval hydrodynamics, energy conversion, and heat transfer mechanisms.

ME 3161 Conduction and Radiation Heat Transfer
ME 3301 Nuclear Power Systems
ME 4140 Direct Energy Conversion
ME 4162 Convection Heat Transfer
ME 4211 Hydrodynamics
ME 4220 Boundary Layer Theory
ME (Elective)

Specialization Courses, Nuclear Engineering (NN)

This area provides an understanding of the principles and design of nuclear reactors, nuclear power sources, and related subjects.

ME 3161 Conduction and Radiation Heat Transfer
ME 3315 Nuclear Measurements Laboratory
ME 4140 Direct Energy Conversion
ME 4162 Convection Heat Transfer
ME 4220 Boundary Layer Theory
ME 4311 Nuclear Reactor Theory
ME 4321 Reactor Engineering Principles and Design

Specialization Courses, Ocean Mechanical Engineering (NO)

This set of courses will provide an understanding of deep-water propulsion, underwater power sources, marine geophysics, and strength of materials in an ocean environment.

ME 3150 Heat Transfer
ME 3301 Nuclear Power Systems
ME 4211 Hydrodynamics
ME 4220 Boundary Layer Theory
OC 2110 Introduction to Oceanography
OC 3220 Descriptive Oceanography
OC 3700 Oceanographic Instrumentation and Observations

MECHANICAL ENGINEERING—ENGINEER PROGRAMS (Groups NP, NR, NQ, NS)

To achieve the degree *Mechanical Engineer*, the student must complete an additional three quarters of study beyond the requirements for the Master of Science degree. Eight additional courses are taken to give a more comprehensive understanding of the area of specialization. Thesis research for the Engineer degree is equivalent to approximately seven courses. In addition, an industrial tour of six weeks duration gives opportunity for the student to work directly with engineers on a problem in his area of specialization.

Specialization Courses, Engineering Mechanics (NP)

ME 4140 Direct Energy Conversion
ME 4211 Hydrodynamics
ME 4220 Boundary Layer Theory
ME 4613 Advanced Methods of Analysis in Elasticity
ME 4620 Theory of Continuous Media
ME 4902 Advanced Study in Mechanical Engineering (Hours to be arranged)
ME or MA (Elective)
MA 4611 Calculus of Variations

Specialization Courses, Fluid Dynamics and Heat Transfer (NR)

ME 3811 Automatic Control Systems
ME 4230 Advanced Topics in Fluid Dynamics and Heat Transfer
ME 4240 Advanced Hydrodynamics
ME 4522 Advanced Vibrations
ME 4620 Theory of Continuous Media
ME 4902 Advanced Study in Mechanical Engineering (Hours to be arranged)
ME or MA (Elective)
MA 3172 Complex Variables

Specialization Courses, Nuclear Engineering (NQ)

ME 3341 Radiation Shielding
ME 4230 Advanced Topics in Fluid Dynamics and Heat Transfer
ME 4312 Advanced Nuclear Reactor Theory
ME 4902 Advanced Study in Mechanical Engineering (Hours to be arranged)
ME or MA (Elective)
MA 3172 Complex Variables
EE 4491 Nuclear Reactor Control Systems
MS 3303 Nuclear Reactor Materials

Specialization Courses, Ocean Mechanical Engineering (NS)

ME 3811 Automatic Control Systems
ME 4140 Direct Energy Conversion
ME 4240 Advanced Hydrodynamics
ME 4612 Mechanics of Solids III
ME 4902 Advanced Study in Mechanical Engineering (Hours to be arranged)
MA 3172 Complex Variables
OC 3320 Geological Oceanography
OC 4211 Waves and Tides
OC 4340 Marine Geophysics

ELECTRICAL ENGINEERING—B.S.E.E. PROGRAM (Group NL)

The following courses will satisfy the minimum requirements for the degree of Bachelor of Science in Electrical Engineering, when taken in addition to those listed in the Naval Engineering (General) Program.

EE 2211 Electronic Engineering Fundamentals I
EE 2212 Electronic Engineering Fundamentals II
EE 2213 Electronic Communications Circuits
EE 2311 Principles of Energy Conversion
EE 2312 Electromagnetic Machines
EE 2611 Electromagnetic Fields
EE 2612 Transmission of Electromagnetic Energy
EE 2811 Digital Machines
EE 3103 Linear Systems Analysis
EE 3114 Communication Theory I
EE 3411 Control Systems
MA 2172 Introduction to Complex Variables
MA 2232 Numerical Methods and FORTRAN Programming
PS 3112 Probability and Statistics I
PH 2810 Survey of Nuclear Physics
OA 3202 Methods of Operations Analysis/Systems Analysis
MN 2970 Material Management
Electives (Four are required, two of which must be in Electrical Engineering)

ELECTRICAL ENGINEERING—M.S.E.E. PROGRAM (Group NE)

Master of Science in Electrical Engineering degree programs are designed to provide officer students with a broad background of science or engineering studies to prepare them for assuming increased technical and administrative responsibilities related to shipboard electrical engineering and electric power systems. All students take the common courses listed below, after completion of the Naval Engineering (General) program. Usually six electives are required. The thesis research time required is equivalent to approximately four courses.

EE 2211 Electronic Engineering Fundamentals I
EE 2212 Electronic Engineering Fundamentals II
EE 2213 Electronic Communications Circuits
EE 2311 Principles of Energy Conversion
EE 2312 Electromagnetic Machines
EE 2811 Digital Machines
EE 3103 Linear Systems Analysis
EE 3114 Communication Theory I
EE 3313 Marine Electrical Analysis and Design
EE 3411 Control Systems
EE 3412 Non-Linear and Sampled Systems
EE 3621 Electromagnetics I
EE 4121 Advanced Network Theory I
MA 3132 Partial Differential Equations and Integral Transforms
MA 2172 Introduction to Complex Variables
MA 2232 Numerical Methods and FORTRAN Programming
PH 2810 Survey of Nuclear Physics
PS 3112 Probability and Statistics I
OA 3202 Method of Operations Analysis/Systems Analysis
EE 0810 Thesis Research
Electives

Typical Electives

EE 3261 Nonlinear Magnetic Devices
EE 3263 Solid State Circuit Design
EE 3812 Logical Design and Circuitry
EE 3822 Digital Computer Systems
EE 4122 Advanced Network Theory II
EE 4123 Advanced Network Theory III
EE 4125 Operational Methods for Linear Systems
EE 4414 Statistical Control Theory
EE 4415 Algebraic Methods in Control Theory
EE 4417 Optimal Control
EE 4491 Nuclear Reactor Control Systems
EE 4571 Statistical Communication Theory
EE 4823 Advanced Digital Computer Systems

ELECTRICAL ENGINEERING—ENGINEER PROGRAMS (Groups NU, NV, NW)

Programs leading to the degree of *Electrical Engineer* are individually arranged in consultation with an advisor appointed by the department of Electrical Engineering. Opportunity is provided to specialize in control systems, communications and information theory, or computer technology. In addition to completing the courses listed for the Master of Science degree, the student will take the courses indicated for his area of specialization, plus a minimum of nine electives. Thesis research for the Engineer degree is equivalent to approximately seven courses. An industrial tour of six weeks duration gives opportunity for the student to work directly with engineers on a problem in his area of specialization.

Specialization Courses, Control Systems (NU)

This area provides a comprehensive understanding of the principles and design of control systems and their application to marine electrical engineering.

EE 4414 Statistical Control Theory
EE 4415 Algebraic Methods in Control Theory
EE 4417 Optimal Control

Specialization Courses, Communications and Information Theory (NV)

Emphasis is placed on a comprehensive understanding of the principles of communication and information theory.

EE 4541 Signal Processing
EE 4571 Statistical Communication Theory
EE 4581 Information Theory

Specialization Courses, Computer Technology (NW)

The objective is to provide a comprehensive understanding of electrical engineering with in-depth coverage of computer technology.

EE 3812 Logical Design and Circuitry
EE 3822 Digital Computer Systems
EE 4823 Advanced Digital Computer Systems

MATHEMATICS—M.S. PROGRAM
CURRICULUM NUMBER 430
(Group NMX)

Objective—To provide advanced studies in mathematics for selected college graduates in order to help meet the Navy's need for officers with advanced education in this field.

Description—The curriculum is of three quarters' duration; classes commence in July and terminate in March. Students ordered to this curriculum report direct from their college upon graduation. Candidates for this program must have satisfied the requirements for a major in mathematics, including courses in advanced calculus, matrices, and complex variables. Additionally, candidates must have attained a B average or better for all math courses taken. Successful completion of the curriculum leads to the award of the degree of Master of Science with major in Mathematics.

First Quarter

MA 4635	Functions of Real Variables I
PS 3205	Probability
MA 3565	Modern Algebra I
MA 3730	Numerical Analysis and Computation
MA 3660	Boundary Value Problems

Second Quarter

MA 4636	Functions of Real Variables II
PS 4206	Decision Theory and Classical Statistics
MA 3566	Modern Algebra II
MA 4872	Topics in Calculus of Variations
MA 4945	Problem Seminar I

Third Quarter

MA 4637	Introduction to Functional Analysis
MA 4622	Principles and Techniques of Applied Mathematics
	Elective
MA 4946	Problem Seminar II

ORDNANCE ENGINEERING PROGRAMS CURRICULA NUMBERS 521, 530 and 535

WILLIAM ALFRED TEASLEY, JR., Captain, U.S. Navy; Curricular Officer; B.S., Naval Academy, 1946; B.S.E.E., Naval Postgraduate School, 1954; M.S., Massachusetts Institute of Technology, 1955.

OSCAR BRYAN WILSON, JR., Professor of Physics, 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

OBJECTIVE—To educate officers in those aspects of both classical and modern physics and related disciplines that pertain to the phenomena associated with the effects of nuclear weapons. Fundamental studies include the broad areas of (a) classical particle and continuum mechanics, (b) thermodynamics and statistical physics, (c) electricity and magnetism through wave propagation in various media and radiation theory, and (d) modern physics including quantum mechanics and atomic, nuclear, and solid state physics. This coverage provides a basis for specialized study of nuclear processes, radiation and thermal effects in matter including electronic devices and living organisms, the generation and propagation of explosive shock waves, and radiochemistry. In the second year thesis research is conducted in an area of specialized study.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree with a grade average of B or better in mathematics, physical sciences, and engineering is required. Completion of mathematics through differential and integral calculus, one year of engineering physics and one year of chemistry is considered to be minimal preparation. Courses in mechanics, thermodynamics, and electrical engineering are very desirable.

DESCRIPTION—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. It is a two-year curriculum at the graduate level with new students enrolled in July of each year. Successful completion of the two-year curriculum leads to the award of the degree M.S. in Physics. Students who fail to demonstrate their ability at the graduate level will be terminated at the end of the first year and, if otherwise eligible, will be awarded the B.S. degree in Physics.

A program leading to the Doctor's degree in physics may be offered to a limited number of exceptionally well-qualified students. Students may be selected for this additional education at any time in the curriculum. Participation in this doctoral program will require the approval of both the Defense Atomic Support Agency and the parent service.

Unrestricted line officers of the Navy graduating from this program will be recommended for the subspecialty qualification code of 8407P. Subject to agreement between the Defense Atomic Support Agency and their respective services all officers completing two years or more of the program are eligible for duty assignment within the DASA complex.

NUCLEAR ENGINEERING (EFFECTS) CURRICULUM (Group RZ)

leading to the degree *Master of Science in Physics*

Physics Courses

PH	1051	Review of Vector Mechanics and Optics
PH	2151	Mechanics I
PH	2251	Waves and Particles
PH	2351	Electromagnetism I
PH	3152	Mechanics II
PH	3352	Electromagnetism II
PH	3461	Explosive Shock Waves
PH	3561	Introductory Statistical Physics
PH	3651	Atomic Physics
PH	3652	Elements of Molecular, Solid State, and Nuclear Physics
PH	3951	Introduction to Quantum Mechanics
PH	4353	Electromagetism III
PH	4750	Radiation Effects in Solids
PH	4760	Solid State Physics
PH	4851	Nuclear Physics

Other Courses

BI	2800	Fundamentals of Biology
BI	3801	Animal Physiology
BI	4802	Radiation Biology
CH	2401	General Thermodynamics
CH	3401	Chemical Theory
CH	4501	Radiochemistry
CS	2100	Introduction to Digital Computers
EE	2231	Electronics I (Nuclear)
EE	2232	Electronics II (Nuclear)
MA	1100	Calculus Review
MA	2121	Differential Equations and Infinite Series
MA	2161	Introduction to Mathematical 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.

ORDNANCE SYSTEMS ENGINEERING CURRICULUM NUMBER 530

BASIC OBJECTIVE—To provide officers an advanced technical education based on a broad foundation which emphasizes the scientific and engineering principles underlying the field of ordnance, and an introduction to technical management. Although the principal aim of the curriculum is to qualify officers for technical duty assignment in the shore establishment, particularly the Naval Ordnance Systems Command, the at-sea professional capability of graduating officers will be greatly enhanced. Ashore or afloat technical competence in modern ordnance and related systems is a key to success.

QUALIFICATIONS FOR ADMISSION—A Baccalaureate degree with above average grades in mathematics, physical sciences, and engineering is required. Completion of mathematics through differential and integral calculus, one year of engineering physics and one year of chemistry is considered to be minimal preparation. Courses in mathematics, thermodynamics, and electrical engineering are very desirable.

Description—Classes convene in September and March. Subject to service needs officers may select curricula majoring in chemistry, electrical engineering, or physics. Depending on his academic capability and the length of his availability at the School each officer may enter a curriculum leading to a degree Bachelor of Science (BS), Master of Science (MS), Electrical Engineer (EE), or Doctor of Philosophy (Ph.D.). For most officers all curricula, during the first two quarters, include core courses designed to bridge the gap from undergraduate study. The core courses and subsequent courses serving as prerequisites for advanced study may be omitted by the better academically prepared officers to shorten their time on board or permit a wider variety of graduate level electives. Officers less academically prepared may be enrolled in the Engineering Science Curriculum for one or more quarters in order to improve their probability for success in Ordnance Engineering. On arrival at the School each officer will be counseled and have a personalized curriculum constructed to fit his academic needs.

Near the end of the second quarter each officer will select his major. In subsequent quarters curricula may vary, by courses, depending upon the specialty areas of interest to the student and scheduling limitations.

Early in the second year officers who have demonstrated capability for graduate study will be evaluated for an advanced program. The total length of each curriculum, including the first two quarters of core courses and adequate time for thesis research, depends essentially on the academic requirements for the degree and the officer's availability. Normally BS programs are seven quarters duration, MS programs nine quarters, EE programs 12 quarters, and Ph.D. programs four years. Consistent with the needs of the service and professional career requirements academically qualified officers are encouraged to select the longer programs.

The following are representative curricula of the various programs offered in Ordnance Engineering. Curricula for individual officers are designed to be academically sound, meet the basic qualification requirements of the Naval Ordnance Systems Command, and permit selection of electives of interest.

Unrestricted line officers graduating with advanced degrees will be recommended for subspecialty qualification codes as follows:

Physics Majors	8302P
Chemistry Majors	8303P
Electrical Engineering Majors	8304P

Those awarded a baccalaureate degree will be recommended for 8301P

Core courses common to all Ordnance Systems Engineering Curricula:

First Quarter

MA	1100	Calculus Review
MA	2045	Introduction to Linear Algebra
PH	1051	Review of Vector Mechanics and Optics
EE	2101	Principles of Electrical Engineering
CH	1007	Methods of Modern Chemistry

Second Quarter

MA	2121	Differential Equations and Infinite Series
MA	2161	Introduction to Mathematical Physics
PH	2151	Mechanics I
EE	2102	Circuit Analysis

REPRESENTATIVE ORDNANCE SYSTEMS ENGINEERING (CHEMISTRY) CURRICULUM (Group WC)

leading to the degree *Master of Science in Chemistry*

Objective — To enhance overall professional capability by providing broad coverage of general subject matter and study in depth in one particular aspect of applied or theoretical chemistry of interest to the Navy and to the individual officer. The applied chemistry portions cover practical aspects that range from application through development and manufacture of current and future chemical systems such as explosives, plastics, and fuels. The theoretical portions provide the concepts of molecular engineering and an understanding of basic chemical processes such as those of explosion, corrosion, electrochemical fuel cells, and biological effects. Classroom instruction is complemented by independent thesis research; digital computer computations may be an integral part of each.

Chemistry Courses

CH	2001	General Principles of Chemistry
CH	2101	Inorganic Analysis
CH	2102	Inorganic Chemistry
CH	2301	Organic Chemistry I
CH	2302	Organic Chemistry II
CH	2401	General Thermodynamics
CH	2402	Introduction to Physical Chemistry
CH	2405	Physical Chemistry Topics
CH	3201	Chemical Instruments
CH	3705	Reaction Motors
CH	4101	Advanced Inorganic Chemistry
CH	4301	Physical Organic I
CH	4401	Chemical Thermodynamics
CH	4405	Molecular Dynamics

*Electives related to a specialty area (normally three courses)**

Other Courses

EE	2201	General Electronics
PH	2251	Waves and Particles
PH	3651	Atomic Physics
PS	3112	Probability and Statistics I
OA	3202	Methods of Operations Analysis/Systems Analysis
OA	3203	Survey of Operations Analysis/Systems Analysis

*Specialty Areas

Chemical Engineering. The chemical engineering specialty includes study of chemical systems such as fuels, plastics, propellants, and explosives that are of practical military concern. Associated work in process control theory deals with problems in operation and control, not only of chemical processes, but, also those associated with other systems such as missile guidance, aircraft, and ship control. Applied advanced mathematics and both digital and analogue computer techniques form an essential part of this work.

Radiochemistry — Inorganic Chemistry. The radiochemistry-inorganic chemistry specialty provides for a study in depth in one of the most rapidly developing areas of modern technology. Specific topics available for study are (a) the behavior of materials in a nuclear reactor or in a nuclear explosion, (b) chemistry of the oceans, (c) electrochemistry of batteries, and fuel cells, and corrosion, and (d) the chemistry of such diverse items as semiconductors, alloys for aircraft, and protective armor.

Chemistry of Carbon. The chemistry of carbon specialty leads to an understanding of the processes of importance in carbon-based systems (organic chemistry) such as explosives, fuels, and plastics. It develops the significant parameters in the molecular design and utilization of these and other organic materials. Techniques of modern instrumentation such as the infra-red spectrometer, the atomic absorption spectrometer, and the gas chromatograph are an essential part of these studies.

Chemical Physics. The chemical physics specialty is interdisciplinary, integrating physical measurements with theoretical developments in the areas of both chemistry and physics. The study involves quantum chemistry, statistical mechanics, and molecular spectroscopy. Thesis research is an independent study of the microscopic and macroscopic structure and behavior of matter. This may involve measurements in any part of the electromagnetic spectrum from radio frequency and microwaves to far ultraviolet and x-rays.

REPRESENTATIVE ORDNANCE SYSTEMS ENGINEERING (ELECTRICAL ENGINEERING) CURRICULUM (Group WX)

leading to the degrees *Master of Science in Electrical Engineering* or *Electrical Engineer*

OBJECTIVE — To educate officers in the fundamentals of electrical engineering technology and its application to modern ordnance. Basic principles of electronics, electromagnetic theory, and control theory provide a starting point for advanced study and thesis research in modern feedback control theory, information transfer theory, and electronic systems including radar, sonar, missile guidance, and computers. Graduates of this program will have the technical competence required in the research, design, development, production, maintenance, and operation of advanced electronic and electromechanical systems.

Electrical Engineering Courses

EE	2211	Electronic Engineering Fundamentals I
EE	2212	Electronic Engineering Fundamentals II
EE	2213	Electronic Communication Circuits
EE	2214	Electronic Pulse and Digital Circuits
EE	2811	Digital Machines
EE	3103	Linear Systems Analysis
EE	3114	Communication Theory I
EE	3215	Advanced Electronic Devices
EE	3411	Control Systems
EE	3412	Non-linear and Sampled Systems
EE	3621	Electromagnetics I
EE	3622	Electromagnetics II
EE	4121	Advanced Network Theory I
EE	4433	Radar Systems
EE	4473	Missile Guidance Systems

*Electives related to specialty areas (normally four courses in a Master of Science program and twelve courses in an Electrical Engineer program)**

Other Courses

MA	2232	Numerical Methods and FORTRAN Programming
MA	3172	Complex Variables
PH	2241	Waves and Particles
PH	3641	Atomic Physics
PS	3112	Probability and Statistics I
OA	3202	Methods of Operations Analysis/Systems Analysis
OA	3203	Survey of Operations Analysis/Systems Analysis

**Specialty Areas*

Control Theory. The control theory specialty is designed to provide the student with an understanding of modern methods used in weapon control systems. The concepts and techniques studied are applied to guided missile technology, pursuit-evasion strategies, optimal control policies, and estimation and identification as employed in automatic target tracking and navigational systems.

Electronic Systems. The electronic systems specialty affords students the opportunity for advanced study in the physical principles and processes underlying the operation of modern electronic devices, signal and data processing techniques, electronic circuit design, and systems engineering. These studies are then applied to the understanding of modern electronic systems such as radar, sonar and electronic countermeasure equipments.

Communication and Information Theory. This specialty includes advanced studies in information transfer, signal and data processing, antennas and propagation, and circuit design. These studies are then applied to the understanding of how information is handled in modern systems such as radar, sonar, digital computers, and electronic countermeasure equipments.

REPRESENTATIVE ORDNANCE SYSTEMS ENGINEERING (AIR/SPACE PHYSICS) CURRICULUM (Group WP)

leading to the degree *Master of Science in Physics*

OBJECTIVE — To develop the officers' ability to deal effectively with a broad spectrum of applied technical problems through a study of the fundamental physical processes common to these applications. This is accomplished by a broad coverage of the basic physical principles combined with advanced courses and independent research in one area of specialization. The basic physics courses cover three broad areas (a) mechanics and thermodynamics including the particle, continuum and statistical aspects; (b) classical electricity and magnetism through electromagnetic radiation theory and (c) modern physics including atomic and nuclear, quantum mechanics and space physics.

Physics Courses

PH	2251	Waves and Particles
PH	2351	Electromagnetism I
PH	3152	Mechanics II
PH	3157	Physics of Continuous Media
PH	3352	Electromagnetism II
PH	3561	Introduction to Statistical Physics
PH	3651	Atomic Physics
PH	3652	Elements of Molecular, Solid State and Nuclear Physics

PH 3951 Introduction to Quantum Mechanics
PH 4353 Electromagnetism III
PH 4630 Space Physics I

*Electives related to specialty area (normally two courses)**

Other Courses

AE 2402 Elementary Gas Dynamics
AE 4541 Missile Technology I
AE 4542 Missile Technology II
CH 2401 General Thermodynamics
CH 3705 Reaction Motors
EE 2201 General Electronics
MA 2232 Numerical Methods and FORTRAN Programming
MA 3172 Complex Variables
OA 3202 Methods of Operations Analysis/Systems Analysis
PS 3112 Probability and Statistics I

*Specialty Areas

Space Physics. This specialization concentrates on those fundamental physical processes in the Earth's upper atmosphere and interplanetary space whose understanding is essential to the solution of many applied problems, such as reentry physics, communication blackouts due to the naturally or artificially disturbed ionosphere, energy propagation and dissipation at high altitudes, etc.

Plasma Physics. This specialization concentrates on the collective phenomena of ionized media, in which the continuum properties of the assembly of particles are dominant; such phenomena include interaction of plasma with a magnetic field and the occurrence, propagation and dispersion of waves in inhomogeneous plasma. These topics are basic to an understanding of the formation of the ionosphere, ionospheric communication, whistler propagation, reentry communication, plasma propulsion, MHD power generation and fusion power.

Nuclear Physics. This specialization provides the students with a deeper understanding of basic nuclear processes and phenomena. It acquaints him with the equipment used in nuclear research, especially as needed by an officer to understand the applications of nuclear physics to various branches of current technology.

Radiation Effects (Solids). This specialization concentrates on the effects of radiation on the physical properties of solids and on the operation of solid-state devices. Applications are to microelectronic devices and to other devices in current use.

Solid State. In solid state physics a wealth of topics is studied such as lasers, quantum electronics, the structure of crystals together with their thermal, optical, and acoustic properties, superconductivity, magnetic phenomena, the physics of semiconductors along with their application in various devices, and the electronic properties of metals and insulators. Active research programs are being carried out in several of these areas.

UNDERWATER PHYSICS SYSTEMS CURRICULUM NUMBER 535

OBJECTIVE — To provide officers, by means of an advanced technical education, a thorough understanding of the problems of underwater physics and their interrelationship with antisubmarine warfare and an introduction to technical management. Studies are primarily in the fundamental areas of science and electrical engineering such as electromagnetism, fluid mechanics, physical acoustics, communication theory, and control theory which form a basis for advanced study of technical problems in undersea warfare. In the advanced programs, research for the required thesis may be done in the fields of physical acoustics, hydrodynamics, signal processing, or systems engineering.

QUALIFICATIONS FOR ADMISSION — A Baccalaureate degree with better than average grades in mathematics, physical sciences, and engineering is required. Completion of mathematics through differential and integral calculus, one year of engineering physics and one year of chemistry is considered to be minimal preparation. Courses in mathematics, thermodynamics, and electrical engineering are very desirable.

DESCRIPTION — Programs under this curriculum convene in March and September. The courses are principally from the fields of physics and electrical engineering. As a result of this basic interdisciplinary character, the academic degree to be earned will depend upon several factors, such as the officer student's background, his academic capabilities and interest, and the length of his availability for postgraduate study. The emphasis may be either in physics or electrical engineering and the degree may be the Bachelor of Science, or the Master of Science or the Electrical Engineer.

The first two quarters for the typical officer student are designed to provide the officer, who has only the minimum admission requirements and who has been on sea-duty for several years, an opportunity for review and redevelopment of study habits and a preparation for the graduate level studies which follow. An officer with better than average preparation may be able to exempt portions of the representative program. Counseling of the student is provided in order to optimize his program.

Unrestricted line officers completing this curriculum will be recommended for the subspecialty qualification code 8205P or 8305P.

The following are representative of the course content of the typically nine quarter long programs leading to the Master of Science degree and the typically twelve quarter long programs leading to the degree, Electrical Engineer. The courses listed are in addition to the first two quarters which are common.

First Quarter

MA 1100 Calculus Review
MA 2045 Introduction to Linear Algebra
PH 1051 Review of Vector Mechanics and Optics
EE 2101 Principles of Electrical Engineering
CH 1007 Methods of Modern Chemistry

Second Quarter

MA 2121 Differential Equations and Infinite Series
MA 2161 Introduction to Mathematical Physics
PH 2151 Mechanics I
EE 2102 Circuit Analysis

REPRESENTATIVE UNDERWATER PHYSICS SYSTEMS CURRICULA
(Group UP or UX)

leading to the degrees *Master of Science in Physics, Master of Science in Electrical Engineering,* or *Electrical Engineer*

Common Courses

EE	3103	Linear Systems Analysis
EE	3114	Communication Theory I
EE	4451	Sonar Systems Engineering
EE	4571	Statistical Communication Theory
MA	2232	Numerical Methods and FORTRAN Programming
MA	3172	Complex Variables
OA	3202	Survey of Operations Analysis/Systems Analysis
PH	3157	Physics of Continuous Media
PH	3451	Fundamentals of Acoustics
PH	3452	Underwater Acoustics
PH	4453	Propagation of Waves in Fluids
PH	4454	Transducer Theory and Design
PH	4455	Advanced Acoustics Laboratory
PH	4456	Seminar in Applications of Underwater Sound
PS	3112	Probability and Statistics I

Additional Courses — Master of Science in Physics Program

PH	2251	Waves and Particles
PH	2351	Electromagnetism I
PH	2551	Thermodynamics
PH	3151	Mechanics II
PH	3352	Electromagnetism II
PH	3561	Introduction to Statistical Physics
PH	3651	Atomic Physics
PH	3652	Elements of Molecular, Solid State, and Nuclear Physics
PH	4161	Fluid Mechanics I
PH	4353	Electromagnetism III

Additional Courses—Master of Science in Electrical Engineering Program

EE	2211	Electronic Engineering Fundamentals I
EE	2212	Electronic Engineering Fundamentals II
EE	2213	Electronic Communication Circuits
EE	2811	Digital Machines
EE	3411	Control Systems
EE	3621	Electromagnetics I
EE	3622	Electromagnetics II
EE	4121	Advanced Network Theory I
EE	4541	Signal Processing
PH	2241	Waves and Particles
PH	3641	Atomic Physics

Additional Courses—Electrical Engineer Program

Approximately ten electives would be added to complete the program. These would include selected courses in oceanography, operations analysis, physics, and/or electrical engineering. The last would provide subspecialization in control theory, electronic systems, or communication and information theory.

Students in the Environmental Sciences Curricula

CURRICULA CONDUCTED AT CIVILIAN UNIVERSITIES

Curriculum	*Number*	*Length*	*Institution*	*Curricular-Supervisory Control Authority*
Business Administration	810	2 yrs.	Harvard	NAVSUPSYSCOMD
			Stanford	NAVSUPSYSCOMD
Civil Engineering (Advanced)	470	1-2 yrs.	Georgia Tech	NAVFACENGCOMD
Typical Options:			M.I.T.	NAVFACENGCOMD
			Princeton	NAVFACENGCOMD
Structures			Purdue	NAVFACENGCOMD
Soil Mechanics			R.P.I.	NAVFACENGCOMD
Sanitary Engineering			Stanford	NAVFACENGCOMD
Waterfront Facilities			Texas A.&M.*	NAVFACENGCOMD
Facilities Planning			Tulane	NAVFACENGCOMD
Construction Engineering			U. of Cal. (Berkeley)	NAVFACENGCOMD
Civil Engineering Administration			U. of Colo.	NAVFACENGCOMD
Deep Ocean Construction Engineering			U. of Ill.	NAVFACENGCOMD
			U. of Mich.	NAVFACENGCOMD
			U. of Minn.	NAVFACENGCOMD
			U. of Wash.	NAVFACENGCOMD
Electrical Engineering (CEC)	471	15 mos.	U. of Mich.	NAVFACENGCOMD
Engineering Electronics (CEC)	472	12-18 mos.	U. of Mich.	NAVFACENGCOMD
Financial Management	812	1 yr.	Geo. Wash.U.*	NAVCOMP
Hydrographic Engineering (Geodesy)	475	2 yrs.	Ohio St. U.	OPNAV (OP-09B5)
International Law	672	1 yr.	Geo. Wash. U.*	JAG
International Relations	671	1 yr.	American U.*	BUPERS
			Harvard	BUPERS
Law (Army Judge Advocate Officers Advanced Course)	881	9 mos.	U. of Virginia	JAG
Management and Industrial Engineering	540	1 yr.	R.P.I.	AVORD/AIRSYSCOMD
Mechanical Engineering (CEC)	473	1 yr.	R.P.I.	NAVFACENGCOMD
Naval Construction and Engineering	510	2/3 yrs.	M.I.T.	NAVSHIPSYSCOMD
Nuclear Power Engineering (CEC)	572	18 mos.	Penn. State U.	NAVFACENGCOMD
			U. of Mich.	NAVFACENGCOMD
Oceanography	440	2 yrs.	U. of Miami (Florida)*	NPGS
			U. of Washington	NPGS
			Texas A.&M.*	NPGS
			U. of Cal. (San Diego)*	NPGS
			M.I.T.	NPGS
Petroleum Administration and Management	880	1 yr.	S.M.U.*	JAG
Petroleum Engineering (CEC)	630	1 yr.	U. of Texas	NAVFACENGCOMD
		6-12 mos.	Industry	
Petroleum Management	811	17 mos.	U. of Kansas	NAVSUPSYSCOMD
Political Science	680	2 yrs.	Fletcher School of Law and Diplomacy, Tufts	OPNAV (OP-61)
			Univ. of Washington	OPNOV (OP-61)
Procurement Management	815	1 yr.	U. of Mich.	NAVSUPSYSCOMD
Public Relations	920	1 yr.	U. of Wisc.	CHINFO
Religion	970	9 mos.	Various	Chief of Chaplains
Retailing	830	1 yr.	Michigan State*	NAVSUPSYSCOMD
Subsistence Technology	860	1 yr.	Mich. State*	NAVSUPSYSCOMD
Systems Inventory Management	819	2 yrs.	Harvard	NAVSUPSYSCOMD
Transportation Management	813	1 yr.	Mich. State*	NAVSUPSYSCOMD

* No NROTC unit at Institution.

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. Administration of officer students in connection with educational matters is exercised by the Superintendent, 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 NUMBER 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 Decision
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
Mathematics
Engineering & Construction Economy
Structures Theory I, II
Elementary Mechanics
Geology for Engineers
Digital Computers
Properties of Soils
Properties of Concrete
Behavior and Design of Metal Structures
Sanitary Engineering Processes

Second Year

Reinforced Concrete Design
Advanced Mathematics
Soil Mechanics
Hydraulics-Surface drainage
Advance Structure Analysis
Behavior of Concrete Members
Applied Soil Mechanics
Special Problems
Structural Design in Metals
Applied Structural Mechanics
Foundation Engineering

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.

Course length: One year
Degree attainable: Master of Science in Business Administration
Typical Curriculum:

Undergraduate:

Survey of Accounting
Industrial and Governmental Economics
Statistical Decision Making
Management Communication

Graduate:

Cost Accounting
Managerial Accounting
Internal Control and Auditing
Survey of Data Processing
Financial Management
Seminar in Marketing
Business Organization and Management
Management Engineering
Readings and Conferences in Financial Management
Research Seminar
Research Seminar in Comptrollership
Human Relations in Administration
Governmental Budgeting

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 LAW
CURRICULUM NUMBER 672

At George Washington University

OBJECTIVE—To prepare Law Specialists (1620) for duties involving problems of international law. The course encompasses international law and agreements including the law of air, sea, and space legal aspects of U.S. foreign relations, negotiations, and legal regulation of international coercion. A thesis on a topic of significant international law interest is required. In addition, certain studies of a geographic area selected by the student will be conducted.

Course length: One year
Degree attainable: Master of Laws

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

NAVAL CONSTRUCTION AND ENGINEERING
CURRICULUM NUMBER 510

At Massachusetts Institute of Technology

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, ocean 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) for those officers who request it.

Course length: Two or three years
Degree attainable: Master of Science in Naval Architecture and Marine Engineering, and for students who successfully complete the three-year program, the Degree of Naval Engineer
Typical Curriculum:
(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 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 NAVFACENGCOMD.

Course length: 18 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 administration.

Course length: Seventeen 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
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 NUMBER 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

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

Spanagel Hall

ACADEMIC DEPARTMENTS
and
COURSE DESCRIPTIONS

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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.

WENDELL MAROIS COATES, Professor Emeritus and Distinguished Professor (1931); A.B., Williams College, 1919; M.S., Univ. of Michigan, 1923; D.Sc., 1929.

GEORGE JUDSON HIGGINS, Professor Emeritus (1942); B.S., in Eng. (AeE), Univ. of Michigan, 1923, AeE., 1934.

ROBERT EDWIN BALL, Assistant Professor of Aeronautics (1967); B.S. in C.E., Northwestern Univ., 1958; M.S., 1959; Ph.D., 1962.

OSCAR BIBLARZ, Assistant Professor of Aeronautics (1968); B.S., Univ. of California at Los Angeles, 1959; M.S., 1963; Ph.D., Stanford Univ., 1968.

CHARLES ALBERT CAMPBELL, Lieutenant (junior grade), U.S. Naval Reserve; Instructor in Aeronautics (1967); B.S., Univ. of Notre Dame, 1965; M.S., 1967.

DANIEL JOSEPH COLLINS, Professor of Aeronautics (1967); B.A., Lehigh Univ., 1954; M.S. in M.E., California Institute of Technology, 1955; Ph.D., 1961.

ALLEN EUGENE FUHS, Professor of Aeronautics (1966); B.S.M.E., Univ. of New Mexico, 1951; M.S.M.E., California Institute of Technology, 1955; Ph.D., 1958.

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.

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., Naval Academy, 1945; B.S. A.E., 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., 1957; Ph.D., Illinois Institute of Technology, 1963.

DAVID WILLIS NETZER, Assistant Professor of Aeronautics (1968); B.S.M.E., Virginia Polytechnic Institute, 1960; M.S.M.E., Purdue Univ., 1962; Ph.D., 1968.

LOUIS VINCENT SCHMIDT, Associate Professor of Aeronautics, (1964); B.S., California Institute of Technology, 1946; M.S., 1948; Ae.E., 1950; Ph.D., 1963.

MICHAEL HANS VAVRA, Professor of Aeronautics (1947); Dipl. Ing., Swiss Federal Institute of Technology, 1934; Ph.D., Univ. of Vienna, 1958.

DAVID CLARK WOOTEN, Lieutenant, U.S. Naval Reserve; Assistant Professor of Aeronautics (1967); B.A., Rice Univ., 1960; M.S., 1962; Ph.D., (Applied Mechanics and Physics), California Institute of Technology, 1967.

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.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN AERONAUTICAL ENGINEERING

The following are academic requirements for the award of these degrees as determined by the Aeronautics Department. In addition, the general minimum requirements as determined by the Academic Council must also be satisfied.

The entrance requirement to these programs is a baccalaureate degree in engineering or science, with minimum coverage in basic prerequisite sciences in semester hours as follows: mathematics (20), basic engineering (30), electrical engineering (14), physics (8), and chemistry (8). Students entering with approved standing, but following a significant lapse in continuity with previous academic work, normally will take refresher courses in engineering fundamentals and mathematics at the upper division level before entering into the degree programs.

Final approval of programs leading to degrees in Aeronautical Engineering is to be obtained from the Chairman, Department of Aeronautics.

BACHELOR OF SCIENCE IN AERONAUTICAL ENGINEERING

1. The entrance requirement to this program is a baccalaureate degree in engineering or science, with minimum coverage in basic prerequisite sciences in semester hours as follows:

Mathematics	20
Basic engineering	30
Electrical engineering	14
Physics	8
Chemistry	8

Students entering with approved standing, but following a significant lapse in continuity with previous academic work, normally will take refresher courses in engineering fundamentals and mathematics at the upper division level before entering into the degree programs.

2. Students who do not enter candidacy for an advanced degree may earn the Bachelor of Science in Aeronautical Engineering degree in an approved curriculum including a minimum of 60 credits in courses 3000-3999, to be drawn from the four required fields: mathematics, flight structures, flow dynamics, and flight systems technology. These courses normally begin following two quarters of refresher work in fundamentals. Coverage in mathematics will include one course in addition to vector analysis, preferably in probability and statistics. The degree of emphasis among other fields may be varied, but must include modern developments in peformance and control of aerospace vehicles, in gas dynamics,

and in systems design. In addition to mathematics a minimum of 8 credits in courses 2000-3999 usually will be taken outside the major department.

MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

1. Students who have a major in aeronautics, and who have earned the baccalaureate degree in the previous year, may apply for admission directly to graduate status. Other students normally will be selected to graduate standing at the end of three quarters in residence.

2. The Master of Science in Aeronautical Engineering degree requires a minimum of 36 graduate course credits to be completed following selection to graduate standing, at least 20 of them in courses 4000-4999, plus an acceptable thesis (this requirement may be waived by the Chairman, Department of Aeronautics; accordingly, the minimum number of required graduate course credits will be increased to 44). At least one advanced mathematics course in addition to vector calculus is required. Core courses normally will be included in engineering dynamics, continuum mechanics and boundary layer flows.

3. The courses of study may be arranged in consultation with the thesis advisor to meet the needs of the research program. Excessive specialization is not encouraged, but it is expected that beyond the core subjects the candidate will concentrate on two related sequences in Aeronautics plus requisite extra-departmental courses.

AERONAUTICAL ENGINEER

1. Students entering with a time lapse since earning a baccalaureate degree in engineering or science can earn the Aeronautical Engineer degree in three years. Admission to candidacy for this degree occurs during the second year of residence, following completion of the Aeronautics graduate examination.

2. This degree requires a minimum of 80 graduate course credits to be completed following selection to graduate standing, normally to include graduate core coverage as listed under the Master's degree, plus an acceptable thesis. Not less than 40 of these graduate credits must be in courses 4000-4999; aeronautics credits to be counted in this total must also be in courses 4000-4999. The program of study will be developed for each student in consultation with his thesis advisor. A variety of subjects to provide a broad foundation in aero-space science, and in engineering applications suitable to the major specialty, generally will be required.

AERONAUTICS

AE 0001 AERONAUTICAL LECTURE SERIES (0-1). Lectures on general aeronautical engineering subjects by prominent authorities from the Navy Department, research laboratories and the industry.

AE 0010 AERONAUTICAL SEMINAR (0-2), Discussion of aeronautical development and reports in research by faculty, officer-students, and guest lecturers.

AE 0110 REVIEW OF STATICS AND ELEMENTARY STRENGTH OF MATERIALS (4-4). A special six-week course for review of principles of statics of rigid bodies, pin-connected trusses. Stress, strain, Hooke's Law, tension and compression, shearing stresses. Properties of materials and properties of areas and of volumes. TEXTS: Beer and Johnson, *Mechanics for Engineers, Statics;* Timoshenko, *Strength of Materials,* Vol. I. PREREQUISITE: None.

AE 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

AE 2201 AERO-STRUCTURES I (3-2). Elements of aerostructural analysis; relationship between loads, stresses and deflections; stress at a point. Application to typical aero-structures. TEXTS: Peery, *Aircraft Structures;* Shanley, *Strength of Materials.* PREREQUISITE: None.

AE 2202 AERO-STRUCTURES II (3-2). Energy methods, redundant systems, thin-sheet structures typical of flight vehicles; unsymmetrical bending, shear flow in open and closed sections, diagonal tension field webs. TEXTS: Peery, *Aircraft Structures;* Shanley, *Strength of Materials.* PREREQUISITE: None.

AE 2301 TECHNICAL AERODYNAMICS I (3-2). Introduction to fluid mechanics: properties of fluids, conservation laws, and Bernoulli's equation. Dimensional analysis and dynamic similarity. Experimental techniques: wind tunnels, models and measurements; applications to full scale. Airfoils and auxiliary lift devices; concept of viscous flow, boundary layer and flow separation, influence of compressibility. TEXTS: Rauscher, *Introduction to Aeronautical Dynamics;* Kuethe & Schetzer, *Foundations of Aerodynamics.* PREREQUISITE: None.

AE 2302 TECHNICAL AERODYNAMICS II (3-2). Continuation of AE 2301. Fluid forces acting on bodies and wings; downwash and induced drag. Applications to performance, stability and control. Comparison of aircraft types: propeller, jet, rocket, V/STOL, and helicopter. TEXTS: Rauscher, *Introduction to Aeronautical Dynamics;* Kuethe & Schetzer, *Foundations of Aerodynamics.* PREREQUISITE: AE 2301.

AE 2401 ENGINEERING THERMODYNAMICS (3-2). A course in the fundamental laws of thermodynamics. Equations of state for perfect, near perfect and properties of substances, property relationships and processes. Energy availability, entropy and irreversibility. Power cycle analysis, gas-vapor mixtures. This course is taught as a foundation course for future work in compressible flow, internal flow in machinery and aircraft power plants. TEXTS: Doolittle, *Thermodynamics for Engineers;* Keenan & Kaye, *Gas Tables;* Keenan & Keyes, *Thermodynamic Properties of Steam.* PREREQUISITE: None.

AE 2402 ELEMENTARY GAS DYNAMICS (3-2). The thermodynamics and dynamics of fluid flow. One dimensional isentropic flows. Normal and oblique shocks. Prandtl-Meyer flow. Fanno and Rayleigh flow. TEXTS: Rotty, *Introduction to Gas Dynamics;* Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flow. Vol. I.* PREREQUISITES: AE 2401; AE 2301.

AE 2801 INTRODUCTION TO AERO-LABORATORIES (0-2). An introduction to modern experimental techniques and instrumentation, evaluation of errors, data reduction and analysis, report writing. Familiarization with the Aero laboratory facilities and current research projects. TEXTS: Holman, *Experimental Methods for Engineers;* Schenck, *Theories of Engineering Experimentation;* Instructor's notes. PREREQUISITE: None.

AE 2802 AERO-STRUCTURES LABORATORY (0-3). Fundamentals of instrumentation and testing techniques for aerostructures, including strain gages and photo-elasticity. Analysis and test of a full scale wing. TEXT: Dally and Riley, *Experimental Stress Analysis.* PREREQUISITES: AE 2801 or equivalent; AE 2201.

Upper Division or Graduate Courses

AE 3115 ENGINEERING DYNAMICS I (3-2). Particle kinematics and kinetics, orbital motion, Lagrange's equations for a particle and a system of particles, Lagrande multipliers used to determine constraints, rigid body dynamics and inertia tensor. TEXTS: Greenwood, *Principles of Dynamics;* Houser and Hudson, *Dynamics.* PREREQUISITES: AE 2202; AE 2302.

AE 3211 AERO-STRUCTURAL PERFORMANCE I (3-2). Curved beams, torsion of non-circular sections. Elastic stability columns, beam columns, and buckling of thin-sheet structures. Theories of failure. TEXTS: Peery, *Aircraft Structures;* Sechler, *Elasticity in Engineering.* PREREQUISITE: AE 2202.

AE 3212 AERO-STRUCTURAL PERFORMANCE II (3-2). Matrix methods of analysis of wing and fuselage structures. Introduction to the theory of elasticity and thermal stresses. TEXTS: Bruhn and Schmidt. *Analysis and Design of Aircraft Structures;* Martin, *Introduction to Matrix Methods of Structural Analysis;* Boley and Weiner, *Theory of Thermal Stresses.* PREREQUISITE: AE 3211.

AE 3232 ELEMENTS OF AEROELASTICITY (3-2). Fundamentals of static and dynamic aeroelasticity including: divergence, control reversal, lift distributions of elastic wing, flutter, and impulsive loadings. TEXTS: Abramson, *The Dynamics of Airplanes;* Fung, *The Theory of Aeroelasticity;* Bisplinghoff, Ashley, Halfman, *Aeroelasticity.* PREREQUISITE: AE 3115.

AE 3271 FUNDAMENTALS OF FLIGHT VEHICLE DESIGN (3-3). Development of a basic understanding for design problems through the integration of various disciplines into an overall system; evaluating requirements for airworthiness and minimum weight: determining structural strength of component parts. General trends for future developments. TEXTS: Bruhn, *Analysis and Design of Flight Vehicle Structure;* Bonney, *Principle of Guided Missile Design;* Peery, *Aircraft Structures.* PREREQUISITES: None.

AE 3303 AIRCRAFT PERFORMANCE (3-2). Aerodynamics of an aircraft; determination of lift, drag, and drag polar of aircraft. Effect of compressibility, steady state power performance, power requirements, minimum and maximum speed, rate of climb, range and endurance. Energy methods. Take-off, landing, performance. TEXTS: Perkins and Hage, *Aircraft Performance, Stability and Control;* Dommasch, Sherby, Connolly, *Airplane Aerodynamics;* NAVWEPS 00-80T, *Aerodynamics for Naval Aviators.* PREREQUISITE: AE 2302.

AE 3321 FLIGHT DYNAMICS I (3-2). Longitudinal static stability; control surface design and performance. Stick-fixed and stick-free stability and margins, neutral and maneuver points, center of gravity limits. Stick-force and displacements. Dihedral effects, lateral static stability; rudder lock, adverse yaw. Aeroelastic effects on static stability. TEXTS: Perkins and Hage, *Aircraft Performance, Stability and Control;* Dommasch, Sherby, Connolly, *Airplane Aerodynamics;* NACA Report No. 927; MIL SPEC 8785 (ASG). PREREQUISITE: AE 3303.

AE 3322 FLIGHT DYNAMICS II (3-2). The dynamic stability problem; Euler's equation of motion; longitudinal dynamics; stability derivatives. Nature of general and transient motions, effects of cross-coupling, effect of changes of variables, aeroelastic effects on dynamic stability. TEXTS: Perkins and Hage, *Aircraft Performance, Stability and Control;* Babister, *Aircraft Stability and Control;* Seckel, *Stability and Control of Airplanes.* PREREQUISITE: AE 3321.

AE 3331 FLIGHT EVALUATION TECHNIQUES I (2-0). Quantitative and qualitative techniques for evaluation of aircraft performance in flight. Instrumentation. Course work supported by AE 3821, a flying laboratory in suitable Naval aircraft. TEXTS: NATC Patuxent, Performance Test Manual; NATC Patuxent, Engine Performance Manual. PREREQUISITE: AE 3303.

AE 3332 FLIGHT EVALUATION TECHNIQUES II (2-0). Techniques for evaluation of aircraft static and dynamic stability and control characteristics. Course work supported by AE 3832, a flying laboratory in suitable Naval aircraft. TEXTS: NATC Patuxent, Stability and Control Manual; MIL SPEC 8785 (ASG). PREREQUISITE: AE 3331.

AE 3340 FUNDAMENTALS OF AUTOMATIC CONTROL (3-2). The requirements for automatic controls. The basic techniques for achieving and evaluating satisfactory controls. Aeroelastic effects. TEXTS: Etkin, *Dynamics of Flight, Stability and Control;* Raven, *Automatic Control Engineering.* PREREQUISITE: AE 3322.

AE 3341 CONTROL SYSTEMS (3-3). (See listing of EE 3411.)

AE 3403 HEAT TRANSFER (3-2). Elements of heat transfer including steady and nonsteady conduction, free and forced convection, heat transfer with change in phase, thermal radiation, dimensional analysis, numerical and analog methods. TEXT: Holman, *Heat Transfer.* PREREQUISITES: AE 2401; AE 2301.

AE 3404 AIRCRAFT PROPULSION (3-2). Basic mechanics of thrust by jets, propellers or rotors. Momentum and blade element theory. Analysis of reciprocating engines, turbo-jet, turboprop, turbo-fan and ramjets. TEXTS: Nelson, *Airplane Propeller Principles;* Hesse & Mumford, *Jet Propulsion,* 2nd ed. PREREQUISITES: AE 2402; AE 3303.

AE 3501 FLUID DYNAMICS I (4-0). Fundamental concepts and governing equations of fluid dynamics in various coordinate systems. Continuity, momentum and energy equations. Laminar and turbulent flow fundamentals. Mostly restricted to incompressible fluids. TEXT: Shames, *Mechanics of Fluids.* PREREQUISITES: AE 2301; Vector Calculus and Differential Equations.

AE 3502 FLUID DYNAMICS II (4-0). Boundary layer concepts and equations, similarity concepts. Separation, analysis of wakes, universal velocity distributions. Method of small perturbation in compressible flow, theory of weak wave interactions. Unsteady motion. TEXTS: Shames, *Mechanics of Fluids*; Liepmann and Roshko, *Elements of Gas-Dynamics*. PREREQUISITE: AE 3501.

AE 3540 INTRODUCTION TO RE-ENTRY (3-0). The re-entry problem discussed from various viewpoints. Manned and unmanned vehicles; limitations imposed on re-entry. TEXT: Notes. PREREQUISITES: AE 2202; AE 2302; AE 2402.

AE 3803 SUBSONIC LABORATORY (0-3). Introduction to aerodynamic investigations in a wind tunnel. TEXT: Pope, *Wind Tunnel Testing*. PREREQUISITE: AE 2302.

AE 3804 GAS DYNAMICS & PROPULSION LABORATORY (0-3). Laboratory techniques in one- and two-dimensional steady flow, one-dimensional unsteady flow, combustion. Tests of selected complete propulsion systems. TEXT: Keenan & Kaye, *Gas Tables*. PREREQUISITE: AE 2402.

AE 3805 ENGINEERING DYNAMICS LABORATORY (0-3). Experiments in the fundamentals of dynamics using the analog computer, shaker table, accelerometers, reluctance gages and strain gages. TEXT: Prepared Notes. PREREQUISITES: AE 4116 may be concurrent.

AE 3831 FLIGHT EVALUATION TECHNIQUE LAB I (0-4). A flight laboratory in the technical aerodynamics of airplanes pertinent to performance evaluation. TEXT: None. PREREQUISITE: AE 3331 concurrently.

AE 3832 FLIGHT EVALUATION TECHNIQUE LAB II (0-4). A flight laboratory in the technical aerodynamics of airplanes pertinent to static and dynamic stability and control: TEXT: None. PREREQUISITE: AE 3332 concurrently.

Graduate Courses

AE 4116 ENGINEERING DYNAMICS II (3-2). Variational methods and Hamilton's principle. Single degree of freedom systems: impulse, step and harmonic forcing functions; Duhamel superposition integral. Eigenvalue problems for lumped and continuous systems, including application to aircraft dynamics. TEXTS: Greenwood, *Principles of Dynamics*; Pipes, *Applied Mathematics for Engineering and Physics*. PREREQUISITE: AE 3115.

AE 4131 CONTINUUM MECHANICS (4-0). Detailed formulation of the field equations for a continuum using cartesian tensors. Basic definitions of stress, strain, rate of strain tensors. Parallel developments for both linear fluid and linear solid continua. TEXT: Frederick and Chang, *Continuum Mechanics*. PREREQUISITE: AE 2202.

AE 4132 SOLID MECHANICS I (4-0). A problem course in elasticity. St. Venant's theory of bending and torsion, two dimensional problems of plane strain, stress functions, methods of complex variables, strain potentials. TEXTS: Sokolnikoff, *Mathematical Theory of Elasticity*; Fung, *Foundations of Solid Mechanics*. PREREQUISITE: AE 4131.

AE 4133 SOLID MECHANICS II (4-0). A second problem course in elasticity. Introduction to plate theory, energy theorems, variational calculus, approximate methods of solution, numerical methods. TEXTS: Sokolnikoff, *Mathematical Theory of Elasticity*; Fung, *Foundations of Solid Mechanics*. PREREQUISITE: AE 4131.

AE 4161 THEORY OF VISCOELASTICITY (4-0). Linear viscoelastic constitutive law, material characterization through relaxation, creep and constant strain rate histories. Direct application to structural analysis of solid propellant rockets through correspondance principle. TEXT: Instructor's Notes. PREREQUISITE: AE 4131.

AE 4162 THEORY OF PLASTICITY (4-0). A development of the plastic behavior of metals, emphasizing yield criteria, flow laws, and solutions of engineering problems. TEXT: Under study. PREREQUISITE: AE 4131.

AE 4241 FLIGHT VEHICLE STRUCTURAL ANALYSIS (3-2). Matrix analysis of airplane and missile structures: force and displacement methods, structural idealizations, and structural partitioning. TEXTS: Martin, *Introduction to Matrix Methods of Structural Analysis*; Bruhn, *Analysis and Design of Flight Vehicle Structure*. PREREQUISITES: AE 2202; AE 2302.

AE 4242 THEORY OF PLATE AND SHELL STRUCTURES (3-2). The theory of plates and shells applied to aircraft and missile structures. Classical topics: equilibrium, energy, boundary conditions, lateral loadings, buckling. Idealizations for matrix formulations. TEXT: Timoshenko, *Theory of Plates and Shells*; NASA publications; Technical Journal Reprints. PREREQUISITES: AE 4131; AE 4241; MA 3132.

AE 4251 STRUCTURAL DYNAMICS (4-0). Structural response to free, forced, and self-excited oscillations. Ground shock, ground wind, and silo-launch problems. Testing techniques, design criteria, and methods of analysis. Wave propagation in solids; dispersion of waves in bounded solids. TEXT: Hurty and Rubinstein, *Dynamics of Structure*. PREREQUISITES: AE 4116; AE 4131.

AE 4252 ADVANCED AEROELASTICITY (4-0). Static aeroelastic problems; wing divergence, control reversal, airframe stability. Self-excited vibration in structures. Aerodynamic forcing functions, mechanism of flutter, and non-stationary airfoil theory. Transient loads, gusts, buffet and stall flutter. TEXTS: Fung, *Theory of Aeroelasticity*; Bisplinghoff, Ashley, Halfman, *Aeroelasticity*. PREREQUISITE: AE 4251.

AE 4275 ADVANCED FLIGHT VEHICLE DESIGN (3-3). Preliminary design of specific aero-structural components to be integrated in a system, stressing required compromises for effective functional performance. Structural trends in aero-space vehicles and launchers. TEXTS: Pauser, Faget, Smith, *Manned Spacecraft*; Bruhn, *Analysis and Design of Flight Vehicle Structures*; Hall, *Systems Engineering*. PREREQUISITES: None.

AE 4304 FLIGHT VEHICLE RESPONSE (3-2). Dynamic stability and control of flight vehicles: longitudinal, lateral, and directional. Characteristics: controls fixed and free; programmed central inputs. Cross coupling effects. TEXTS: Perkins and Hage, *Aircraft Performance, Stability and Control*; Etkin, *Dynamics of Flight Stability and Control*; Seckel, *Stability and Control of Airplanes*. PREREQUISITE: AE 4116.

AE 4336 LOW SPEED FLIGHT MECHANICS (4-0). Stability and performance characteristics of low-speed aircraft. Ground effect phenomena. VTOL, STOL, and rotary wing aircraft; air cushion vehicles and compound flight vehicles. TEXTS: Gessow and Meyers, *Aerodynamics of the Helicopter*; McCormick, *Aerodynamics of V/STOL Flight*; Nelson, *Airplane Propeller Principles*. PREREQUISITE: AE 3303.

AE 4337 ADVANCED ROTORCRAFT DESIGN (3-2). Powered lift systems and their relative merits. Design aspects of compounds, convertible, and other hybrid rotorcraft. Lifting rotors versus lifting engines. Design trends. Airworthiness criteria. Handling requirements. Selected topics from recent literature. TEXT: Instructor's Notes.

AE 4342 AUTOMATIC CONTROL I (3-2). Power controls and stability augmentation. Aircraft component and pilot transfer functions, and block diagram concept. Application of frequency response techniques, root locus methods and transient effects. System analysis of aircraft controls; cross-axis coupling. Performance specifications and response shaping. Aeroelastic effects on stability. TEXTS: Etkin, *Dynamics of Flight;* Raven, *Automatic Control Engineering*. PREREQUISITES: AE 3341; AE 4304 or AE 3321.

AE 4343 AUTOMATIC CONTROL II (3-2). Vehicle dynamics and interaction with augmentation devices and automatic controls. Automatic power control for deck recovery, time-modulated aerodynamic controls, missile control, and terrain following. Random processes and auto-correlation functions, Fourier transforms and power spectral densities. Optimal design. TEXTS: Etkin, *Dynamics of Flight*; Raven, *Automatic Control Engineering*. PREREQUISITE: AE 4342.

AE 4421 HEAT TRANSFER I (4-0). Introduction to the rate equations of heat and mass transfer; conductive heat transfer in steady and nonsteady state, and in one, two and three dimensions; analytic, analog and numerical methods of solution. TEXTS: Jacob, *Heat Transfer, Vols. I and II;* Schneider, *Conduction Heat Transfer*. PREREQUISITE: AE 4521.

AE 4422 HEAT TRANSFER II (4-0). Convective heat transfer in ducts and from exposed surfaces, laminar and turbulent flows. Analytic techniques, integral methods, experimental correlations. Effects of variations in thermophysical properties. TEXTS: Kays, *Convective Heat Transfer*; Spaulding, *Convective Mass Transfer*. PREREQUISITES: AE 4421; AE 4522.

AE 4423 HEAT TRANSFER III (4-0). Radiant heat transfer. Emissivities of solids and gases, black body radiation, grey body radiation. Geometric problems, net radiation interchange, the method of Oppenheim. TEXTS: Jacob, *Heat Transfer, Vols. I and II*; Sparrow and Cess, *Radiation Heat Transfer*. PREREQUISITE: AE 4422.

AE 4424 HEAT TRANSFER IV (HYPERSONIC) (4-0). Heat transfer by convection and radiation in hypersonic flow, chemical changes, property variations occasioned by large temperature differences; re-entry heat transfer, rentry mass transfer. TEXT: Dorrance, *Viscous Hypersonic Flow*. PREREQUISITES: AE 4423; AE 4462.

AE 4431 AEROTHERMODYNAMICS OF TURBOMACHINES (4-0). Application of fundamental laws of fluid dynamics and thermodynamics to the analysis of flows in tubomachines. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines*. PREREQUISITE: AE 2402.

AE 4432 ADVANCED THEORY OF TURBOMACHINES (4-0). Advanced theory and methods for design and performance prediction of turbomachines. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines*. PREREQUISITES: AE 4431; AE 4521.

AE 4433 ADVANCED TURBOPROPULSION SYSTEMS (4-0). Application of fluid dynamics, thermodynamics and stress analysis to the design of aero and space power plants. TEXT: Vavra, *Aerothermodynamics and Flow in Turbomachines*. PREREQUISITE: AE 4432.

AE 4434 TURBOPROPULSION SEMINAR (3-0). Individual assignments of advanced topics in the field of propulsion. TEXT: Under study. PREREQUISITE: AE 4433.

AE 4461 STATISTICAL THERMODYNAMICS (3-2). Fundamentals of statistical thermodynamics including kinetic theory of an ideal gas distribution of molecular velocities, transport phenomena, Maxwell-Boltzman statistics, partition functions, and thermodynamic properties. TEXTS: Lee, Sears, Turcotte, *Statistical Thermodynamics;* Lee and Sears, *Thermodynamics* PREREQUISITE: AE 2402.

AE 4462 COMBUSTION THERMODYNAMICS I (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 4461.

AE 4463 COMBUSTION THERMODYNAMICS II (3-2). Combustion thermodynamics emphasizing classical chemical kinetics and conservation of mass, momentum, and energy in reacting mixtures. TEXTS: Penner, *Chemistry Problems in Jet Propulsion;* Williams, *Combustion Theory*. PREREQUISITE: AE 4462.

AE 4464 AEROTHERMOCHEMISTRY (3-2). Chemical reactions in flow systems, with emphasis on the interplay between aerodynamics, physics and chemistry. TEXTS: Penner, *Chemistry Problems in Jet Propulsion*; Williams, *Combustion Theory*. PREREQUISITE: AE 4463.

AE 4521 IDEAL FLUID AERODYNMICS (4-0). Mathematical development of the flow of an ideal fluid. Potential function, stream function, Biot-Savart law. Application to airfoils and wings. TEXT: Karamcheti, Principles of Ideal Fluid Aerodynamics. PREREQUISITES: MA 2172 or MA 3675; AE 4131.

AE 4522 BOUNDARY LAYER FLOWS (4-0). Some exact solutions of the Navier-Stokes equations. Boundary layer concept and equations, momentum and energy integrals, stability and transition. The fundamentals of turbulent flow; laminar and turbulent boundary layers with arbitrary pressure gradient. TEXTS: Schlicting, *Boundary Layer Theory;* Instructor's Notes. PREREQUISITE: AE 4521.

AE 4523 FUNDAMENTALS OF COMPRESSIBLE FLOW (4-0). Two dimensional subsonic, transonic, and supersonic flows. Linearized small perturbation theory. Hodograph and series methods, methods of characteristics, wave reflection and interaction. Subsonic and transonic similarity rules. One dimensional nonsteady flow. Moving shocks. Elements of real gas effects. TEXTS: Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I and II;* Liepmann and Roshko, *Elements of Gasdynamics.* PREREQUISITES: AE 2402; AE 4131.

AE 4524 SUPERSONIC AERODYNAMICS (4-0). Three dimensional supersonic flow. Conical flow, slender body theory, similarity rules, wings of finite span. Supersonic lifting line and lifting surface theories. Drag minimization, flow reversal theorems, interference effects and oscillating airfoils in subsonic and supersonic flow. Elements of blast wave theory and similarity analysis. TEXTS: Shapiro, *The Dynamics and Thermodynamics of Compressible Fluid Flow,* Vols. I and II; Ferri, *Elements of Aerodynamics of Supersonic Flow;* Sedov, *Similarity and Dimensional Methods in Mechanics.* PREREQUISITE: AE 4523.

AE 4526 THEORY OF TURBULENCE IN FLUID FLOW (4-0). Hydrodynamic stability and transition to turbulent flow. Orr-Sommerfield equation. Fundamental concepts of turbulence. Navier Stokes equations for turbulent flow. Reynold's stresses. Fourier series and integral methods. Spectral and wave space concepts. Correlation coefficients. Scale of turbulence. Indeterminacy of the basic equations. Auxiliary hypotheses. Isotropic turbulence. Turbulent diffusion. Free and wall turbulence. Turbulent boundary layers. Intermittency. Mixing length and other phenomenological theories. The current state of fundamental knowledge in the field. Review of current research in computer simulation of fluid turbulence at the Postgraduate School. TEXTS: *Hydrodynamic Stability,* Lin; *Turbulence,* Hinze; Instructors Notes. PREREQUISITE: AE 4522 or consent of instructor.

AE 4541 MISSILE TECHNOLOGY I (3-2). The first course in missile science and technology, emphasizing hypersonic flow. TEXTS: Martin, *Atmospheric re-entry;* Cox and Crabtree, *Elements of Hypersonic Aerodynamics;* Instructor's Notes. PREREQUISITE: AE 4523 or PH 3157.

AE 4542 MISSILE TECHNOLOGY II (4-0). The second course in missile science and technology, emphasizing trajectories, dynamics of vehicles, and the plasma sheath. TEXTS: Martin, *Atmospheric Re-entry;* Instructor's Notes. PREREQUISITE: AE 4541.

AE 4543 MISSILE TECHNOLOGY III (3-2). The final course in a three course sequence in missile science and technology, stressing thermal protection of re-entry vehicles, test facilities and re-entry vehicle design. TEXTS: Martin, *Atmospheric Re-entry;* Instructor's Notes. PREREQUISITE: AE 4542.

AE 4550 ENGINEERING MAGNETOHYDRODYNAMICS (4-0). Current and future applications of magnetohydrodynamics including propulsion, power generation, the plasma sheath, and hypersonic test facilities. TEXTS: Sutton and Sherman, *Magnetohydrodynamics;* Arzimovich, *Element Plazma Physics;* Shercliff, *Magnetohydrodynamics.* PREREQUISITES: AE 4522; AE 4523; Electromagnetic Theory.

AE 4631 COMPUTER METHODS IN AERONAUTICS (3-2). Analog and digital computer formulations of problems in aerodynamics, aero-structures, missile and satellite trajectories, dynamics. Design optimization studies. Aerospace vehicle simulations. TEXT: Crandall, *Engineering Analysis.* PREREQUISITES: MA 2232, AE 4116.

AE 4851 TURBOMACHINERY LABORATORY I (0-3). Measurements of overall performance of turbines and compressors. Data reduction, error analysis, and measurement techniques. TEXT: Under study. PREREQUISITE: AE 4431 concurrently.

AE 4852 TURBOMACHINERY LABORATORY II (0-3). Detailed investigations of the stationary and rotating components of turbomachines. Cascade test rigs, inter-stage data of turbomachines, and evaluation of loss coefficients. TEXT: Under study. PREREQUISITE: AE 4432 concurrently.

AE 4854 TURBOMACHINERY LABORATORY III (0-3). Individual assignments to current research projects in the field of turbomachines. TEXT: Under study. PREREQUISITE: AE 4434 concurrently.

AE 4900 SPECIAL TOPICS IN AERONAUTICS (2-0 to 5-0). Directed graduate study of laboratory research. Course may be repeated for additional credit if topic changes. PREREQUISITE: Consent of instructor.

AVIATION SAFETY PROGRAMS

DONALD MERRILL LAYTON, Commander, U.S. Navy, Assistant Professor of Aeronautical Engr. and Safety; Director (1965)*; B.S., Naval Academy, 1945; B.S.A.E., Naval Postgraduate School, 1953; M.S., in A.E., Princeton Univ., 1954.

SHELDON DREWS, Commander, U.S. Navy, Assistant Professor of Aeronautical Engr. and Safety (1965); B.S., Naval Academy, 1952; B.S.A.E., Naval Postgraduate School, 1960; M.S., Massachusetts Institute of Technology, 1961; M.S., Naval Postgraduate School, 1967.

FORREST LEFAY EDWARDS, Lieutenant Commander, U.S. Navy, Instructor in Accident Prevention (1967); B.A., Naval Postgraduate School, 1967.

RICHARD GARDNER MILLS, Associate Professor of Aviation Medicine,(1966); M.D., Univ. of Michigan, 1955.

JAMES CHRISTIAN NIELSEN, Associate Professor of Aeronautical Engr. and Safety (1966); B.S., Univ. of Washington, 1950; M.S., 1957.

LESTER CHARLES WIBLE, Assistant Professor of Aviation Accident Prevention and Crash Investigation (1965); B.S., Naval Academy, 1945.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

The Aviation Safety Officers' Course is offered on a temporary additional duty basis to those Officers so ordered by the Chief of Naval Personnel. The following courses constitute the program and are taken simultaneously: AO 2310, AO 2320, AO 2360, and PY 2352.

Officers regularly enrolled in other curricula at the Postgraduate School may qualify as Aviation Safety Officers by completion of the following courses: AO 2301, AO 2302, and PY 2050.

AVIATION

Upper Division Courses

AO 2301 AERONAUTICAL ENGINEERING FOR AVIATORS (4-2). A survey of aeronautical engineering for the aviator and the Aviation Safety Officer. Basic aerodynamics, subsonic and supersonic aircraft charactertistics, aircraft performance, stability and control, and aircraft structural limitations. PREREQUISITES: Mathematics through college algebra and geometry; physics through mechanics and heat. (This course is for students in the BA program.)

AO 2302 AVIATION ACCIDENT PREVENTION AND CRASH INVESTIGATION (3-2). This course consists of (a) a study of 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) physiological factors of flight. PREREQUISITE: AO 2301 (may be taken concurrently).

AO 2303 AERONAUTICAL ENGINEERING FOR AVIATORS (4-2). A survey of aeronautical engineering for the aviator and the Aviation Safety Officer. Basic aerodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations. Prerequisites: Mathematics through calculus, courses in thermodynamics, statics and dynamics. (This course is for students of the BS program.)

AO 2310 AERO ENGINEERING SAFETY (6-0). A survey of aeronautical engineering for the Aviation Safety Officer. Mathematics review, basic areodynamics, subsonic and supersonic aircraft characteristics, aircraft performance, stability and control, and aircraft structural limitations.

AO 2320 AVIATION ACCIDENT PREVENTION AND CRASH INVESTIGATION (4-0). This course consists of (a) a study of 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.

AO 2360 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.

PSYCHOLOGY

Upper Division Courses

PY 2050 GENERAL PSYCHOLOGY (3-0). A study of principles of rational and emotional processes in human thought and action.

PY 2352 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.

DEPARTMENT OF BUSINESS ADMINISTRATION AND ECONOMICS

John Wallis Creighton, Professor of Management and Chairman (1967)*; B.S., Univ. of Michigan, 1938; B.A., Hastings College, 1939; Ph.D., Univ. of Michigan, 1954.

Edwin Hammer Bailey, Lieutenant, SC, U.S. Navy; Instructor in Management (1967); B.S., Naval Academy, 1960; M.S., Naval Postgraduate School, 1967.

William Richards Baker, Commander, SC., U.S. Navy; Instructor in Management (1965); B.S., Naval Academy, 1945; Management Naval Postgraduate School, 1958.

Barry Castro, Associate Professor of Economics (1966); B.A., Hunter College, 1955; M.B.A., New York Univ., 1956; Ph.D., 1967.

William Howard Church, Professor of Management (1956); B.A., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

James Barrie Cowie, Associate Professor of Management Science (1963); B.Sc. (honors), Glasgow Univ., 1958; C.I.A., 1959.

Leslie Darbyshire, Professor of Management (1962); B.A., Univ. of Bristol, 1950; D.B.A., Univ. of Washington, 1957.

Roger Nils Folsom, Lieutenant (junior grade), U.S. Naval Reserve; Assistant Professor of Economics (1965); A.B., Stanford Univ., 1959; M.A., Claremont Graduate School, 1964.

James Morgan Fremgen, Associate Professor of Accounting (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.

Fenn Clark Horton, Associate Professor of Economics (1964); B.A. State Univ. of Iowa, 1950; M.A., Claremont Graduate School, 1967; Ph.D., Claremont Graduate School, 1968.

H. Arthur Hoverland, Associate Professor of Management (1963); B.S., Miami Univ., 1951; M.S., Univ. of Illinois, 1954; Ph.D., Univ. of Michigan, 1963.

James Kenneth Jobe, Commander, U.S. Navy, Assistant Professor of Management (1967); A.B., George Washington Univ., 1963, M.A., 1964.

Robert Stephen Lande, Assistant Professor of Management (1967); B.A., Swarthmore College, 1961.

Joseph Peter Leo, Commander, U.S. Navy; Instructor in Management (1967); B.A., Yale Univ., 1946.

Richard Keeler Lochridge, Lieutenant (junior grade), U.S. Naval Reserve; Instructor in Management (1967); B.A., Dartmouth College, 1965; M.B.A., Stanford Univ., 1967.

Paul Edward Roberts, Jr., Assistant Professor of Economics (1966); A.B., Southern Illinois Univ., 1961; M.A., 1962; Ph.D., Univ. of Iowa, 1968.

John David Senger, Associate Professor of Management (1967); 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. 1967.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE BACHELOR OF SCIENCE WITH MAJOR IN BUSINESS ADMINISTRATION

1. A candidate for the Bachelor of Science degree with a major in business administration must meet the general requirements for the baccalaureate degree. Additionally, he must meet the following specific requirements for the major:

a. A minimum of 34 quarter hours of course work at or above the 2000 level.

b. Successful completion or validation by advanced credit of approved courses in each of the following areas of study:
Behavioral Sciences
Computers and Programming
Economics
Financial Management and Accounting
Material Management
Statistics

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE IN MANAGEMENT

1. A candidate for the degree of Master of Science in Management must complete satisfactorily either (a) a minimum of 58 quarter hours of graduate level work or (b) a minimum of 50 quarter hours of graduate level course work and a thesis.

2. Core course requirements at the graduate level must be successfully completed or validated by advanced credit in each of the following areas:

Behavioral Sciences
Data Processing
Economics
Financial Management and Accounting
Management Policy
Material Management
Operations Research
Statistics
Systems Analysis

3. In addition to the core requirements, each candidate must complete an approved elective sequence, comprising either (a) a minimum of 12 quarter hours of graduate level course work or (b) a minimul of 4 quarter hours of graduate level course work and a thesis pertinent to the area of the elective sequence.

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE IN COMPUTER SYSTEMS MANAGEMENT

1. A candidate for the degree of Master of Science in Computer Systems Management must complete satisfactorily either (a) a minimum of 68 quarter hours of graduate level course work or (b) a minimum of 60 quarter hours of graduate level course work and an acceptable thesis.

2. Core course requirements at the graduate level must be successfully completed or validated by advanced credit in each of the following areas:

Computer Science
Data Processing
Economics
Financial Management and Accounting
Material Management
Operations Research
Statistics

MANAGEMENT

MN 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MN 1500 PERSONAL AFFAIRS (2-0). The fundamentals of personal estate planning. Including topics: government benefits; life insurance and general insurance; budgeting and banking; borrowing; real estate; securities; wills, trusts and related legal matters.

Upper Division Courses

MN 2510 HUMAN BEHAVIOR (4-0). A survey of some of the important aspects of human behavior that affect performance and satisfaction within an organization. Theories and empirical findings from the behavioral sciences, including motivation, learning, social conditioning, personality, and the measurement of individual behavior patterns.

MN 2521 GROUP BEHAVIOR AND ORGANIZATION THEORY (4-0). A survey of theories and empirical findings concerning group effectiveness, leadership, group pressure, and role behavior. Theories and practices of organizational activities such as planning, direction, and control. Examination of organizational processes of particular importance to military and governmental organizations. PREREQUISITE: MN 2510.

MN 2530 INTRODUCTION TO ECONOMICS (4-0). Economic scarcity and its implications for defense. Comparison of alternative resource allocation systems for an economy. Supply and demand analysis. Debt and financial assets, markets, and intermediaries. The monetary system; international monetary relationships. National income analysis of aggregate output and price level determination and of monetary and fiscal policy.

MN 2541 MICROECONOMICS (4-0). A review of supply and demand in individual markets. The theory of consumer choice and theories of the firm in competitive, monopolistic, monopsonistic, and oligopolistic markets. Methodological issues in microeconomic theory. Introduction to illustrative industry analyses and issues in domestic microeconomic policy, international trade, and economic development and growth. An introduction to applications of microeconomic theory to the efficient allocation of resources in national defense. PREREQUISITE: MN 2530.

MN 2542 INTERNATIONAL ECONOMICS (4-0). Theory of foreign trade, international payments, and exchange rates. Tariffs, quotas, and international trade organizations. Economic growth and development in contrasting economies. Problems of development in underdeveloped countries. PREREQUISITE: MN 2541.

MN 2550 PRINCIPLES OF ACCOUNTING (4-0). Study of the basic principles of accounting in business and government. Topics covered include the basic postulates and principles of financial accounting, the accounting cycle, accounting for assets and equities, financial statement content and analysis, manufacturing cost accounting, and the fundamentals of governmental accounting.

MN 2561 MANAGERIAL CONTROL AND BUDGETING (4-0). Study of the uses of financial data for planning and control. Specific topics include comprehensive business budgeting, flexible budgets, standard costs, the Navy Industrial Fund, cost-volume analysis, incremental profit analysis, capital budgeting, and the planning - programming - budgeting cycle in DOD. PREREQUISITE: MN 2550.

MN 2900 MANAGEMENT OF HUMAN RESOURCES (4-0). A survey course in individual and group behavior and the implications thereof for administering the operational objectives of an organization and for the effective management of personnel.

MN 2960 SURVEY OF MANAGEMENT ACCOUNTING (3-0). Introduction to the basic concepts and principles of accounting in business and government. Emphasis is placed on uses of accounting data by management in planning, control, and decision making. Applications of automatic data processing to accounting systems are discussed.

MN 2970 MATERIAL MANAGEMENT (4-0). Study of the importance of military logistics to our national security and the basic relationships among strategy, tactics, and logistics. Survey of the fundamental elements of the logistics process and the organization in the Navy for logistics administration. Specific topics covered include the planning-programming-budgeting cycle in DOD, budgetary development and execution, and the planning and procurement process, with emphasis on hardware development. The course concludes with a survey of the Navy logistics system, including the Navy Supply System, mobile logistic support forces, joint logistic agencies, and logistics administration at the unit command level.

Upper Division or Graduate Courses

MN 3110 INDIVIDUAL BEHAVIOR (3-0). Study of the basic characteristics and determinants of individual behavior. Specific topics covered include personality, motivation, learning, behavior conditioning, and introduction to tests and measurements. Implications for effective administrative practice.

MN 3121 GROUP AND ORGANIZATIONAL BEHAVIOR (5-0). Studies of small group behavior and the relationship between the individual and the group. Survey of organization theory, including organizaational structure, controls, and systems. Analysis of decision making processes in organizations, of leadership and of factors affecting organizational growth and development. PREREQUISITES: MN 3110 and PS 3101.

MN 3130 MACROECONOMIC THEORY (4-0). Development of formal equilibrium models to analyze the relationships among aggregate supply and demand, money, output and input price levels, and the implications of fiscal and monetary policy in determining the level of national income. Debt and financial assets, markets, and intermediaries. The monetary system and international monetary relationships.

MN 3141 MICROECONOMIC THEORY (4-0). Comparison of alternative resource allocation systems for an economy. Supply and demand analysis: partial and general equilibrium. Introduction to the theory of consumer choice; the theory of the firm in competitive, monopolistic, monopsonistic, and oligopolistic markets. Comparison of calculus and linear programming theories of the firm. Introduction to welfare economics: efficient resource allocation theory. Methodological issues in microeconomic theory. Applications of microeconomic theory to the efficient allocation of resources in national defense. PREREQUISITE: MA 2300.

MN 3150 FINANCIAL ACCOUNTING (4-0). Study of the basic postulates and principles of financial accounting. Specific topics include the accounting cycle, accounting for assets, equities and capital structure, financial statement analysis, and the uses of financial data for decision making by investors. An introduction to governmental accounting.

MN 3161 MANAGERIAL ACCOUNTING (4-0). Study of the principles and practices of cost accounting, including normal overhead rates, job order and process costing, and standard costing. Emphasis is placed upon applications of accounting data to management planning and control. Topics covered include flexible budgets, standard costs and variance analysis, cost-volume analysis, incremental profit analysis, and capital budgeting. PREREQUISITE: MN 3150.

MN 3171 RESOURCE MANAGEMENT FOR DEFENSE (4-0). Introduction to the Resource Management System of the Department of Defense, with particular emphasis on the systems for the management of capital acquisitions and inventory. Study of the problems of allocating resources for defense and providing material support for major military programs. Specific topics include the planning-programming-gudgeting cycle research and development, material acquisition, and inventory management. PREREQUISITE: MN 3130.

MN 3180 COMPUTERS AND DATA PROCESSING (3-0). General description of computing and data processing equipment. Instruction in programming language to equip students to make effective use of the School's computing facility. A survey of applications of computers in business and in the military.

MN 3941 ENGINEERING ECONOMICS (4-0). An introduction to the basic concepts of microeconomics necessary for decision making: alternative market models; theories of production, with particular attention to technological considerations, production and cost functions; and supply curves. The analysis of investment decision problems. PREREQUISITE: A course in probability and statistics.

Graduate Courses

MN 4101 PERSONNEL MANAGEMENT AND LABOR RELATIONS (4-0). Study of the principles and practices of personnel administration in business and government organizations. A survey of the history, development, and current status of labor-management relations in industry and government. Analysis of the economics of the labor market and the implications of government regulations for wages and labor-management bargaining practices. PREREQUISITES: MN 3110 and MN 3141.

MN 4105 MANAGEMENT POLICY (4-0). Study and appraisal of a variety of policies requiring the analysis of problems and the formulation of decisions in both business and governmental enterprises. Use of case materials, management games, and other devices as exercises in decision making and executive action under conditions of uncertainty and change. PREREQUISITES: MN 3121, MN 3130, MN 3141, MN 3161, MN 3171, MN 3180, and OA 3211.

MN 4109 DIRECTED STUDY (2-0 to 8-0). Individual research and study by the student under the supervision of a member of the faculty. Intended primarily to permit interested students to pursue in depth subjects not fully covered in formal class work. PREREQUISITE: Consent of the instructor.

MN 4111 SEMINAR IN BEHAVIORAL SCIENCE (4-0). A combination of directed readings and individual students' research projects presented for discussion in class. Emphasis is placed on empirical analysis of behavioral patterns and relationships. PREREQUISITE: MN 3121 and MN 3180.

MN 4121 SEMINAR IN ORGANIZATION THEORY AND MANAGEMENT PRACTICE (4-0). A research and discussion approach to the problem areas of organization theory, management practice, and the contributions of various theoretical disciplines to the evolving sciences of management. Particular attention is given to the implications of changes in the environment of organizations, in their internal technology, and in the state of knowledge about human behavior. PREREQUISITE: MN 3121.

MN 4131 ECONOMIC THEORY AND MACROECONOMIC POLICY (4-0). Further development and application of formal macroeconomic models and of microeconomic theory to analyze the macro and microeconomic consequences of federal spending, transfer payment, taxation, debt management, monetary policies, and wage and price policies. An introduction to econometric and other impirical models of aggregate economic behavior. PREREQUISITES: MN 3130, MN 3141 and PS 3101.

MN 4141 ECONOMIC THEORY AND MICROECONOMIC POLICY (4-0). Further developments of the concepts of imperfect competition and economic efficiency. Emphasizing applications of theory to analyses of various major U.S. industries and government policies. PREREQUISITES: MN 3130 and MN 3141.

MN 4142 INTERNATIONAL ECONOMIC STUDIES (4-0). International monetary relationships and institutions. Comparative advantage and international trade: relationships, institutions, and barriers. Development and growth in alternative economic systems. The problems of underdeveloped economics. PREREQUISITES: MN 3130 and MN 3141.

MN 4145 SYSTEMS ANALYSIS (4-0). This course will concentrate on the analysis of large scale defense resource allocation problems, using cost-effectiveness models. Topics include: discounting, constrained optimization, estimation problems, and efficiency over time. Systems analysis case studies will be emphasized. PREREQUISITES: MN 3121, MN 3130, MN 3141, MN 3161, MN 3171, MN 3180, and OA 3211.

MN 4151 INTERNAL CONTROL AND AUDITING (4-0). Study of the fundamental objectives and procedures of internal control in business and government. Examination of the audit function in industry and government. Specific topics include auditing standards, audit reports, sampling techniques, and audits of computer-maintained accounting systems. PREREQUISITES: MN 3150, MN 3180, and PS 3101.

MN 4152 DECISION MAKING FOR FINANCIAL MANAGEMENT (4-0). Financial management techniques for decision-making, including internal auditing and its relationship to managerial control; cost center, profit center, and investment center concepts; use of the organizational structure to achieve control of financial problems; capital budgeting and cost of capital theory; simulation; and other quantitative techniques applicable to financial decision-making. Use of case studies. PREREQUISITES: PS 3101, MN 3150, MN 3161, MN 3180.

MN 4161 CONTROLLERSHIP (4-0). Survey of the controllership function in industry and the military. Study of the problems and practices of financial management in large and small organizations. Case studies will be discussed and analyzed in class. PREREQUISITES: MN 3141 and MN 3161.

MN 4171 PROCUREMENT AND CONTRACT ADMINISTRATION (4-0). Study of the elements of the procurement cycle, including the determination of requirements, contract law, technical and production problems, fiscal controls, facilities, inspections, and terminations. Military procurement regulations are analyzed to determine their impact on efficient military logistic systems. PREREQUISITE: MN 3171.

MN 4181 MANAGEMENT INFORMATION SYSTEMS (4-0). Study of the "total systems" concept. Development and discussion of an integrated information system, employing a computer and data processing equipment, used by management for planning and control purposes. Analysis of actual information systems used in industry and the government. PREREQUISITES: MN 3150 and MN 3180, or consent of instructor.

MN 4182 DATA PROCESSING MANAGEMENT (4-0). Study of computer systems analysis and design. Management of ADP in the Federal Government, especially in the Department of Defense. Specific topics covered include: feasibility studies, selection, and acquisition of equipment; evaluation of computer hardware and software; installation and effective utilization of ADP equipment; and various types of computer applications. PREREQUISITE: Course in computer programming.

MN 4183 BUSINESS DATA PROCESSING (4-0). Study of manual, semi-automatic, and automatic systems for the routine processing of data. Specific topics covered include accounting and auditing applications, sequential and random processing with digital computers, and control techniques. Students in small teams will study actual industrial and/or military management situations and recommend appropriate data processing systems. PREREQUISITES: Courses in computer programming and probability and statistics.

MN 4191 QUANTITATIVE DECISION TECHNIQUES (4-0). A study of the applications of scientific techniques, particularly mathematical and statistical, to management decision making. Consideration of applications of quantitative methods of analysis to complex problems with the aid of computers. PREREQUISITES: MN 3180 and OA 3211.

MN 4931 MATHEMATICAL SEMINAR IN MACROECONOMIC THEORY (4-0). Analysis and development of linear and nonlinear disaggregated macroeconomic models. Topics selected from equilibrium, dynamic growth equilibrium, and dynamic cyclical and growth disequilibrium models: stability conditions, short and long run resource allocation consequences, and policy implications. PREREQUISITES: MN 3130, MN 3141, and consent of instructor.

MN 4941 MATHEMATICAL SEMINAR IN MICROECONOMIC THEORY (4-0). Mathematical analysis of microeconomic models. Topics selected from the following: Welfare economics. Theory of efficient resource allocation. Capital theory. Optimal capital accumulation paths. Theory of exchange. Single and multiperiod general equilibrium of competitive, monopolistic, and monopsonistic markets; existence and stability conditions. Oligopoly theories. Consumer and producer choice. PREREQUISITES: MN 3130, MN 3141, and consent of instructor.

El Prado Room

La Novia Terrace

COMPUTER SCIENCE

BACHELOR OF SCIENCE WITH MAJOR IN COMPUTER SCIENCE

1. The requirements for a Bachelor of Science with major in Computer Science will include at least 10 hours in upper division mathematics, 10 hours in probability and statistics, 18 hours in computer science, and 4 hours in management.

MASTER OF SCIENCE IN COMPUTER SCIENCE

1. To obtain the degree, Master of Science in Computer Science, the student must have satisfied the requirements for the degree Bachelor of Science with major in Computer Science.

2. In addition, the student must successfully complete a minimum of 38 quarter hours of graduate credit distributed as follows:

	Min. Hours
Computer Science	20
Mathematics	8
Operations Analysis	10

3. In addition, the student must successfully complete an acceptable thesis.

A section of the computer facilities at the Naval Postgraduate School

DEPARTMENT OF ELECTRICAL ENGINEERING

Charles Harry Rothauge, Professor of Electrical Engineering; Chairman (1949)*; B.E., Johns Hopkins Univ., 1940; D.Eng., 1949.

Roy Stanley Glasgow, Dean Emeritus (1949); B.S., Washington Univ., 1918; M.S., Harvard, 1922; E.E., Washington Univ., 1925; D. Sc., (Hon.), 1961.

George Robert Giet, Professor Emeritus and Distinguished Professor (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.

Orestes Methodius Baycura, Associate Professor of Electrical Engineering (1966); B.S.E.E., Carnegie Institute, 1957; M.S., Univ. of Pittsburgh, 1959; D.Sc., 1963.

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, 1954; 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.

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 at Berkeley, 1954.

James Steve Demetry, Assistant Professor of Electrical Engineering (1960); B.S., Worcester Polytechnic Institute, 1958; M.S., 1960; Ph.D. Naval Postgraduate School, 1964.

Fred Wilson Evans, Jr., Lieutenant, U.S. Naval Reserve; Instructor in Communications; B.S., Univ. of Pittsburgh, 1960.

Gerald Dean Ewing, Associate Professor of Electrical Engineering (1963); A.A., College of Marin, 1965; B.S.E.E., Univ. of California at Berkeley, 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.

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., Naval Postgraduate School, 1961; Ph.D., Univ. of Illinois, 1964.

Clarence Frederick Klamm, Jr., Professor of Electronics, (1951); B.S., Washington Univ., 1943; M.S., 1948.

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.

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.

Sydney Richard Parker, Professor of Electrical Engineering (1966); B.E.E., City College of New York, 1944; M.S., Stevens Institute of Technology, 1948; Sc.D., 1964.

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., Univ. of California at Los Angeles, 1957; M.S., 1959; Ph.D., 1965.

HAROLD LEWIS REICHART, Lieutenant Commander, U.S. Navy; Instructor in Communications; B.S., Naval Academy, 1957; Naval Postgraduate School, 1962.

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.

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., 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 at Berkeley, 1948.

ALLEN EDGAR VIVELL, Professor of Electrical Engineering (1945); B.E., Johns Hopkins Univ., 1927; D.Eng., 1937.

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 is 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

1. Candidates for this degree must generally 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	*Subject*	*Approximate Quarter Hrs.*
Electrical Engineering	Fields and Circuits	13
	Electronic Devices and Circuits	15
	Communication Theory	4
	Electromagnetic Theory	3
	Energy Conversion	4
	Electronic Computers	4
	Control Theory	4
		47
Mathematics	Calculus, vectors, matrices, series, differential equations and complex variables	12

2. An additional 11 quarter hours are to be taken in upper division courses in Electrical Engineering and 9 quarter hours in areas such as mechanics, dynamics, properties of matter, physical chemistry and thermodynamics. Minor departures from these requirements may be approved by the Department as long as the total number of hours in upper division courses is not reduced.

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

A minimum of 40 quarter hours of graduate work beyond the requirements for the BS in EE degree shall be required for the degree of Master of Science in Electrical Engineering. Of the 40 quarter hours, a minimum of four courses of at least 12 hours, must be in the course sequence 4000-4999. At least 30 hours shall be required in Electrical Engineering subjects. An acceptable thesis must be presented.

ELECTRICAL ENGINEER

1. Students with acceptable academic backgrounds may enter a program leading to the degree Electrical Engineer. Normally, this program is of three years' duration. Candidates for the Engineer's degree are selected during their second year in residence.

2. A minimum of 80 graduate course credits are required for the award of the Engineer degree. Of these at least 30 hours are to be in the courses in the sequence 4000-4999. An acceptable thesis must be completed. A departmental advisor will be appointed for consultation in the development of a program of study. Approval of all programs must be obtained from the Chairman. Department of Electrical Engineering.

BIOLOGY

Upper Division Courses

BI 2800 FUNDAMENTALS OF BIOLOGY (4-0). 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 process.

Upper Division or Graduate Courses

BI 3801 ANIMAL PHYSIOLOGY (5-0). A comprehensive course in mammalian physiology, emphasizing human functional aspects. PREREQUISITE: BI 2800.

Graduate Courses

BI 4802 RADIATION BIOLOGY (5-0). Fundamental processes of energy transfer from radiation to living matter. Biochemical, physiological and genetic effects of radiation. Methods of experimental radiation biology. PREREQUISITES: BI 3801 and appropriate courses in nuclear physics.

BI 4822 SPECIAL TOPICS IN RADIATION BIOLOGY (2-0). Study of important current topics in radiation biology. PREREQUISITE: Appropriate biological background.

BI 4823 SPECIAL TOPICS IN RADIATION BIOLOGY II (2-0). A continuation of BI 4822. A study of important current topics in radiation biology.

COMMUNICATIONS

Upper Division Courses

CO 2111 COMMUNICATIONS ORGANIZATION AND PLANNING (4-0). 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 System including the Naval Security Group. Individual Missions and/or integration of the systems are analyzed. The Navy Planning System and Development of the Communication Annex are covered.

CO 2112 COMMUNICATIONS ADMINISTRATION AND PROCEDURES I (3-0). 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 crypto, is studied along with the Registered Publications System (RPS).

CO 2113 COMMUNICATIONS ADMINISTRATION AND PROCEDURES II (4-0). A continuation of CO 2112.

CO 2114 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. Problems and/or solutions associated with compatibility, and installation procedures are studied. The use of Special Communications Systems are covered.

CO 2115 COMMUNICATION EQUIPMENT AND SYSTEM APPLICATION II (3-2). A continuation of CO 2114, operation and adjustment of teletypewriter, facsimile, transmitter and receiver equipments in the laboratory.

COMPUTER SCIENCE

*CS 0001 SPECIAL LECTURES (0-1).

*CS 0810 Thesis Research (0-0).

Upper Division Courses

*CS 2100 INTRODUCTION TO COMPUTERS AND PROGRAMMING (4-0).

*CS 2110 INTRODUCTION TO COMPUTER PROCESSES (3-0).

Upper Division or Graduate Courses

*CS 3111 COMPUTER ORGANIZATION AND PROGRAMMING (4-0).

CS 3200 LOGICAL DESIGN OF DIGITAL COMPUTERS (4-0). Introduction to the techniques of logical design of computer elements and systems. Boolean algebra, propositional logic, truth tables, simplification of expressions. Applications to switching, circuit elements, design of combinatorial and sequential circuits. Reduction of descriptions of processes to Boolean form. Logic of arithmetic and control units, storage elements. Principles of digital systems design. Existing forms of machine organization. PREREQUISITE: CS 3111 or equivalent.

*CS 3201 COMPUTER SYSTEMS DESIGN I (4-0).

*CS 3204 DATA COMMUNICATIONS (4-0).

CS 3300 INFORMATION STRUCTURES (3-0). Study of information representations and the relationships between the form of representation and processing techniques. Transformations between storage media. Referencing of information as related to the structure of its representation and the implications for the design of the referencing language. Structure of data bases; updating and addition to records; serial and parallel files; storage hierarchies. File management. The role of programs in the data base, their relocation and allocation of storage. PREREQUISITE: Consent of instructor.

CS 3500 MILITARY APPLICATIONS OF COMPUTERS (4-0). Role of computer systems in military operations. Principles and techniques of the design of military information systems. Some technical considerations, e.g., effective data storage and retrieval. Large-scale command and control systems. Strategical and tactical data processing. Systems integration. Real-time sensor-oriented applications, weapons control systems. Data reduction and control. PREREQUISITE: CS 3111 or equivalent.

*CS 3601 AUTOMATA AND FORMAL LANGUAGES (3-0).

Graduate Courses

*CS 4112 SYSTEMS PROGRAMMING I (4-0).

*CS 4113 SYSTEMS PROGRAMMING II (4-0).

*CS 4200 COMPUTER SYSTEMS DESIGN II (4-0).

*CS 4310 NON-NUMERICAL INFORMATION PROCESSING (4-0).

*CS 4601 EFFECTIVE COMPUTABILITY (3-0).

*CS 4900 ADVANCED TOPICS IN COMPUTER SCIENCE (3-0).

* See listing under Mathematics Department.

ELECTRICAL ENGINEERING

EE 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

EE 0951 THESIS SEMINAR (0-1). Lectures on subjects of current interest will be presented by invited guests from other universities and from industry, as well as by faculty members of the Naval Postgraduate School.

Upper Division Courses

EE 2101 PRINCIPLES OF ELECTRICAL ENGINEERING (3-2). Basic concepts of electric and magnetic fields with emphasis on electrical engineering applications; the circuit concept; v-i relations; Kirchhoff's voltage and current laws; power and energy. PREREQUISITE: Integral Calculus (may be concurrent).

EE 2102 CIRCUIT ANALYSIS (4-2). Solution of network equations using basic Laplace transform methods; transfer functions; poles and zeros; sinusoidal steady-state analysis including phasor methods, frequency response including resonance, network theorems, two-port parameters, balanced polyphase circuits, and coupled circuits. PREREQUISITE: EE 2101, Differential Equations (may be concurrent).

EE 2201 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 process in common devices; current-voltage relations of diodes and active devices; basic electronic circuits. PREREQUISITE: EE 2102.

EE 2211 ELECTRONIC ENGINEERING FUNDAMENTALS I (4-2). A general introduction to electronic devices, circuits and systems is followed by the consideration of the electronic properties of matter, conduction and emission processes, diodes and diode circuits, multi-terminal control devices, amplifier characteristics, and equivalent-circuit representations and analysis of linear amplifiers. PREREQUISITE. EE 2101.

EE 2212 ELECTRONIC ENGINEERING FUNDAMENTALS II (4-3). The topics studied include untuned small-signal amplifiers, feedback in amplifiers, direct-coupled and operational amplifiers, small-signal tuned amplifiers, electronic power supplies, untuned and tuned power amplifiers. PREREQUISITE: EE 2211.

EE 2213 ELECTRONIC COMMUNICATIONS CIRCUITS (4-3). The topics studied include sine-wave oscillators, reactance modulators, frequency-modulated and amplitude-modulated transmitters, frequency converters, superheterodyne receivers, special band-pass amplifiers, detectors, automatic gain control, and the production and detection of SSB signals. PREREQUISITE: EE 2212.

EE 2214 ELECTRONIC PULSE AND DIGITAL CIRCUITS (4-3). The topics studied include basic waveform characteristics and shaping techniques, wide-band linear amplifiers, characteristics of electronic switching devices, clipping, clamping and switching circuits, multivibrator and trigger circuits, time-base generators, logic circuits, counting and timing circuits. PREREQUISITE: EE 2212.

EE 2215 SPECIAL ELECTRONIC DEVICES (4-2). The topics studied include charged-particle dynamics, microwave tubes, parametric amplifiers, non-reciprocal microwave devices, quantum-electronic devices, microelectronics and other current device developments. PREREQUISITES: EE 2213 and EE 2214.

EE 2221 GENERAL ELECTRONICS (4-2). A one-quarter survey course for nonengineering curricula. Consideration of the basic concepts of electrical circuit analysis is followed by a study of the underlying physical processes and operational characteristics of common electronic devices and some representative device applications in electronic circuits and systems.

EE 2222 ELECTRONIC FUNDAMENTALS I (3-2). The first of a sequence for nonengineering curricula. An introduction to electronic devices, circuits and systems is followed by a consideration of basic concepts of electrical circuit analysis, electronic conduction and emission processes, physical processes in electronic devices and operational properties of diodes and control devices.

EE 2223 ELECTRONIC FUNDAMENTALS II (3-3). A continuation of EE 2222. Included topics are linear amplifier analysis, feedback techniques, tuned amplifiers, power amplifiers, and electronic power supplies. PREREQUISITE: EE 2222.

EE 2224 COMMUNICATION ELECTRONICS (4-3). The topics studied include sine-wave oscillators, basic modulation techniques for information transmission, frequency spectrum of modulated waves, generation of AM and FM waves, communication transmitters, detectors, frequency conversion, communication receivers, SSB systems and multiplex systems. PREREQUISITE: EE 2223.

EE 2225 PULSE ELECTRONICS (3-3). The topics studied include linear wave-shaping circuits, linear amplification of pulse signals, device switching characteristics, clipping and clamping circuits, multivibrators, sweep generators, logic and counting circuits, system application of pulse and waveforming techniques. PREREQUISITE: EE 2223.

EE 2231 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 basic theory of vacuum and semi-conductor diodes, control type tubes, and transistors. PREREQUISITES: Mathematics through calculus.

EE 2232 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 2231.

EE 2311 PRINCIPLES OF ENERGY CONVERSION (3-2). An introduction to the principles of energy conversion. Topics introduced are thermoelectric, thermionic, photovoltaic, electrochemical, electromagnetic, gaseous conduction leading to MHD concepts and other basic methods of energy conversion. PREREQUISITES: EE 2102, a course in Modern and/or Solid State Physics.

EE 2312 ELECTROMAGNETIC MACHINES (3-4). The model oriented approach to the analysis of rotating machines and amplifiers is utilized to obtain their dynamic and steady state characteristics. DC and AC motors, generators and control machines are analyzed. PREREQUISITES: EE 2311, EE 3103.

EE 2332 ELECTRIC MACHINES (3-3). This course is intended for the Mechanical Engineering curriculum. Principles of electromechanical energy conversion are presented 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. However, some dynamics will be studied. Polyphase circuit analysis is included. PREREQUISITE: EE 2102 or equivalent.

EE 2431 INTRODUCTION TO RADAR (3-2). A one-quarter 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 monopulse systems. PREREQUISITES: EE 2214 and EE 2612.

EE 2611 ELECTROMAGNETIC FIELDS (3-0). 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 2102.

EE 2612 TRANSMISSION OF ELECTROMAGNETIC ENERGY (3-1). A study of radio-frequency transmission lines, waveguides, and related components. Classical transmission line theory is developed and applied to practical problems. The principles of rectangular and cylindrical waveguides, cavity resonators, and various microwave devices are covered. PREREQUISITE: EE 2611.

EE 2711 ELECTRICAL AND ELECTRONIC MEASUREMENTS (3-3). A study of methods and techniques for the measurement of electrical quantities such as voltage, current, power, frequency, phase angle, circuit parameters, fields, etc., and including statistical analysis of experimental data with emphasis on precision and accuracy. PREREQUISITES: EE 2102 and EE 2212.

EE 2811 DIGITAL MACHINES (2-0). The topics studied include digital computer organization and internal functions, order codes, arithmetic and logical processes, machine language, assembly and operating systems, storage methods, and input-output control. Students have direct access to and perform experiments on a typical modern small-scale computer system. PREREQUISITE: MA 2232 or CS 2110 (may be taken concurrently).

EE 2832 COMPUTER SYSTEM TECHNOLOGY (3-2). A study of principles underlying modern naval computer-oriented systems. Digital techniques for signal processing, tracking, message switching, error correction, weapons control and information retrieval. Representative current systems provide examples for analysis. Laboratory work involves demonstrations and exercises in use of real-time computer techniques. PREREQUISITES: MA 2232 or CS 2110 or EE 2811.

Upper Division or Graduate Courses

EE 3103 LINEAR SYSTEMS ANALYSIS (4-2). Applications of Fourier series and Fourier transform methods; convolution; state-variable formulation and solution; other operational concepts; signal flow graphs; simulation of linear systems on the analog computer. PREREQUISITE: EE 2102, Complex Variable Theory (may be concurrent).

EE 3114 COMMUNICATION THEORY I (4-0). In this introductory course the following concepts and their mathematical formulations are presented: power spectral density; matched filters; sampling; pulse encoding methods; frequency and time multiplexing; amplitude, frequency and phase modulation. In addition, a comparison of modulation methods is presented. PREREQUISITES: EE 3103 and EE 2211.

EE 3116 COMMUNICATION THEORY II (3-2). A continuation of EE 3114. The concept of information measure (entropy) is introduced and its significance for communication systems is discussed. Noise sources and their 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 applications to communication systems are introduced. PREREQUISITES: EE 3114, PS 2111.

EE 3215 ADVANCED ELECTRONIC DEVICES (4-2). The topics studied include particle dynamics, electron beam-forming focusing techniques, microwave tubes, negative resistance and variable-reactance devices, non-reciprocal microwave devices, quantum - electronic devices, microelectronic and other current device developments. PREREQUISITES: EE 2213 and EE 2214.

EE 3261 NONLINEAR MAGNETIC DEVICES (3-3). An introduction to the use of the saturable reactors as a non-linear 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 2212 and EE 3103.

EE 3262 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 2212 and EE 3103.

EE 3263 SOLID-STATE CIRCUIT DESIGN (3-3). Design and analysis of 2-stage direct-coupled transistor amplifiers—biasing and AC performance; DC amplifiers; wide band amplifiers; tuned IF, RF small signal and power amplifiers: oscillators; FET circuits; Triac devices and circuits for power control; integrated circuits. PREREQUISITE: EE 2212.

EE 3264 ADVANCED 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 3215 or EE 2215 and PH 3741 or equivalent.

EE 3313 MARINE ELECTRICAL ANALYSIS AND DESIGN (3-2). Design principles of electric machines are studied. Symetrical components are presented and applications are made in the short circuit analysis of a portion of a ship's power distribution system. A computer study of a static excitation system is made. PREREQUISITES: EE 2312 and EE 3411.

EE 3411 CONTROL SYSTEMS (3-3). (May be taught as AE 3341 or CH 3701). Introduction to the analysis and design of linear feedback control systems by means of s-plane and frequency response methods. Analysis using state variables; design using frequency and time domain performance indices is discussed. Laboratory work includes simulation using analog and digital computers: testing and evaluation of physical systems. PREREQUISITES: EE 2102 and MA 2232 or their equivalent.

EE 3412 NONLINEAR AND SAMPLED SYSTEMS (3-3). Phase plane and describing function techniques are applied to the analysis of nonlinear systems. Sampled systems are studied using state space and Z-transform methods. Laboratory work includes analog and digital simulation, analysis of a relay servomechanism, and application of digital control to a system. PREREQUISITE: EE 3411.

EE 3422 MODERN COMMUNICATIONS (3-2). 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 3116 or EE 4571.

EE 3432 PULSE RADAR (3-2). The basic special circuits used in pulse radar are discussed and integrated into a complete radar system. These circuits include pulse modulators, display systems, transmitters, duplexing systems, and receivers. The radar range equation is developed, and pulse compression techniques for giving increased range with good range resolution are discussed. Automatic radar tracking systems are introduced. PREREQUISITES: EE 3114, EE 2215 and EE 2612.

EE 3455 SONAR SYSTEMS (3-2). A study of sonar theory including the active and passive systems. The course starts with a study of the basic characteristics of the transmission medium and continues with a study of the problems and limitations of operating an acoustic system in this environment. Modern systems and projects are included in the study. PREREQUISITE: EE 2213, SECRET Clearance.

EE 3471 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: Mechanics, EE 2214, and EE 3411.

EE 3481 RADAR AND ECM (3-2). Continuous wave, frequency modulation, MTI, AMTI, and pulse doppler techniques used in modern military radar systems are discussed. Electronic countermeasure and counter countermeasure (ECM and ECCM) techniques are discussed with particular application to radar. ECM topics covered include signal intercept, signal analysis, masking jammers, deception jammers, confusion reflectors, target masking, and anti-jamming techniques. PREREQUISITES: EE 3432 and SECRET Clearance.

EE 3482 COMMUNICATIONS ECM (3-2). A study of communications signals, and the characteristics of devices used for detecting and interfering with these signals and systems. The course includes both active and passive countermeasures methods and techniques for both radio frequency and underwater acoustic spectrums. Emphasis is placed on modern methods of evaluation of a signal system and its environment. PREREQUISITE: EE 3422, SECRET Clearance.

EE 3498 DYNAMIC SYSTEMS ANALYSIS (3-3). The following topics are considered: state-variable formulation and solution; signal flowgraphs; analysis of linear feedback systems; simulation of linear systems; testing of physical systems. PREREQUISITE: EE 2102.

EE 3621 ELECTROMAGNETICS I (3-1). 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: Vector Analysis, Partial Differential Equations, and EE 2102.

EE 3622 ELECTROMAGNETICS II (3-0). 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 3621 and EE 3103.

EE 3631 ANTENNAS AND PROPAGATION (3-2). An engineering course covering the major classes of antennas for communications and radar followed by a study of the properties of the atmosphere and its effect on the propagation of surface, space, and sky waves. While essentially stressing engineering, the course applies to practical systems the field theory presented in earlier courses. PREREQUISITES: EE 2612 or EE 3622.

EE 3812 LOGICAL DESIGN AND CIRCUITRY (3-2). 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, convential and exotic. Machine-aided logical design. PREREQUISITE: EE 2811.

EE 3822 DIGITAL COMPUTER SYSTEMS (3-3). This course investigates the role and functions of digital and hybrid computing machines and their engineering applications in such fields as signal processing and system control. Digital display techniques are applied. The principle features of such computerized systems are studied. PREREQUISITE: EE 2811.

Graduate Courses

EE 4121 ADVANCED NETWORK THEORY I (3-2). Topology; state-variable formulation for nonlinear, time-varying networks; concepts and tests for passivity, activity, causality; driving-point synthesis; introduction to transfer function synthesis. PREREQUISITE: EE 3103.

EE 4122 ADVANCED NETWORK THEORY II (3-2). Continuation of transfer function synthesis; n-port synthesis; scattering matrix; the approximation problem. PREREQUISITE: EE 4121.

EE 4123 ADVANCED NETWORK THEORY III (3-2). Topics selected from the following: active network synthesis; topological synthesis; time-domain synthesis; computer methods in network synthesis. PREREQUISITE: EE 4122.

EE 4125 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; analytic functions of a complex variable; the Fourier integral and Fourier transform; bilateral Laplace transform; Hilbert transforms. PREREQUISITE: Graduate standing or consent of instructor.

EE 4414 STATISTICAL CONTROL THEORY (2-2). Statistical and probabilistic concepts are applied to the development of optimal methods for estimation, prediction, and identification. These methods are applied to the stochastic control problem. PREREQUISITES: EE 3411 and PS 3112.

EE 4415 ALGEBRAIC METHODS IN CONTROL THEORY (3-0). This course treats advanced concepts in root locus theory including graphical and analytic (algebraic) design of compensation. Extension is made to two parameter analysis and design. The Mitrovic-Siljak relationships are developed, leading to the coefficient plane and parameter plane methods. Stability analysis, adjustment, design and synthesis using parameter plane methods are treated in detail. Extensions to multiparameter problems are discussed. PREREQUISITE: EE 3411.

EE 4416 TOPICS IN MODERN CONTROL THEORY (3-0). A course intended to acquaint the student with recent developments in control as found in the research publications of the profession. Topics are selected at the discretion of the instructor and may include such subjects as: Adaptive Systems, Digital and Hybrid Simulation, Finite State Automata, Learning Systems, Lyapunov Methods, Popov Stability, Sensitivity, etc. PREREQUISITES: EE 4414, EE 4415, and EE 4417, or consent of the Instructor.

EE 4417 OPTIMAL CONTROL (4-0). The optimal control problem is treated using the calculus of variations. Pontryagin's maximum principle, and dynamic programming. Optimal pursuit —evasion strategies are considered. PREREQUISITE: EE 3411.

EE 4433 RADAR SYSTEMS (3-2). The radar range equation is developed in a form including signal integration, the effects of cross-section fluctuations and system and propagation losses. Modern techniques discussed include pulse compression, frequency modulated radar, MTI, AMTI, pulse doppler systems, monopulse tracking systems, and multiple-unit steerable array radars. Laboratory sessions deal with basic pulse radar system from which the advanced techniques have developed. PREREQUISITES: EE 3622, EE 3215 and EE 3114, SECRET Clearance.

EE 4451 SONAR SYSTEMS ENGINEERING (3-2). A study of the theory and engineering practices pertaining to passive and active sonar systems. This study emphasizes underwater acoustic systems under research and development. The objective of the course is to determine how the engineering design of a sonar system is conditioned by the characteristics of the transmission medium, and the operational requirements. PREREQUISITE: PH 4454, SECRET Clearance.

EE 4452 UNDERWATER ACOUSTIC SYSTEMS ENGINEERING (4-2). A study of the theory and engineering principles of underwater acoustics communications, surveillance, and navigation systems. Of particular importance are the problems in design of these systems brought about by the transmission medium and the operational uses. Emphasis is placed on the principles and problems common to all underwater acoustic systems rather than upon specific naval systems. The laboratory periods are used for designing, building and testing a system or subsystem in one of the above mentioned areas. PREREQUISITE: PH 3421.

EE 4461 SYSTEMS ENGINEERING (3-1). 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. PREREQUISITES: EE 4571 and EE 3412.

EE 4473 MISSILE GUIDANCE SYSTEMS (3-0). Fundamentals of missile guidance systems: radio, radar, infra-red inertial and celestial techniques. PREREQUISITES: EE 3412 or EE 4414; and EE 4433 or EE 3481, SECRET Clearance.

EE 4481 ELECTRONIC COUNTERMEASURES (3-2). Active and passive countermeasure techniques are considered, including signal representation, signal analysis and signal interception. Important receiver and system parameters are defined. Various types of receivers are introduced and compared. Masking and deception jamming are treated along with anti-jamming techniques. Communications, infrared and underwater acoustic countermeasures are discussed. PREREQUISITE: EE 4433, SECRET Clearance.

EE 4491 NUCLEAR REACTOR CONTROL SYSTEMS (3-0). The nonlinear reactor kinetic equations are analyzed under controlled and accidental input conditions. The small-signal input method is used and the zero-power and power-to-reactivity feedback transfer functions are obtained. The requirements for stable and accurate operation of automatic flux control are established using linear feedback control theory. Digital computer methods of simulating the non-linear system are used to check on the validity of the linear theory. Modern control theory application to nuclear reactor systems is introduced. PREREQUISITE: EE 3412.

EE 4541 SIGNAL PROCESSING (3-1). Applications of statistical decision theory to the detection of signals in noise. Ambiguity diagrams for signal detection and parameter estimation; signal design. Applications to antenna and transducer arrays. Signal processing in detection and tracking systems. PREREQUISITE: EE 4571.

EE 4571 STATISTICAL COMMUNICATION THEORY (3-2). This course is a more advanced sequel to EE 3114 than EE 3116. Basic concepts of information theory are introduced and their significance for communication systems are discussed. A study of noise source and a mathematical treatment of noise and random signals, based on statistical methods, are presented. 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 3114 and PS 3112.

EE 4581 INFORMATION THEORY (3-1). 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 4571.

EE 4623 ADVANCED ELECTROMAGNETIC THEORY (3-0). Solution of EM boundary value problems by advanced techniques are considered. Topics discussed include: classical modal expansions, variational methods, analog and digital computer simulations, diffraction theory, and spectral operators as applied to multilayer refraction problems. PREREQUISITE: EE 3622.

EE 4631 ANTENNA ENGINEERING (3-2). 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. PREREQUISITES: EE 2612 or EE 3622.

EE 4652 MICROWAVE CIRCUITS AND MEASUREMENTS (3-2). A study of microwave components as circuit elements. Topics to be 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 3622.

EE 4671 THEORY OF PROPAGATION (3-0). 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 2612 or EE 3622.

EE 4823 ADVANCED DIGITAL COMPUTER SYSTEMS (3-1). Selected advanced topics in digital system engineering. Concepts of shared-file processors, real time computing, data collection, multitask processors. State-of-the-art utilization of logical components, machine organization, problem-oriented languages, man-machine interfaces. Representative case studies in such areas as: pattern classification, electronic design automation, information retrieval, weapons control, war-gaming. PREREQUISITE: EE 3822.

EE 4900 SPECIAL TOPICS IN ELECTRICAL ENGINEERING (2-0). Supervised study of the periodicals in selected areas of electrical engineering to meet the needs of the individual student. A written report is required at the end of the quarter. PREREQUISITE: Consent of the instructor and the department chairman.

EE 4911 INFORMATION PROCESSING SEMINAR (0-2). Discussion and reports on related topics of current interest in the field of information processing.

Painting in Chapel showing Father Junipero Serra, Franciscan missionary, landing on the Monterey Peninsula on 3 June 1770

ENGINEERING SCIENCE

BACHELOR OF SCIENCE IN ENGINEERING SCIENCE

1. The following are the minimum requirements for the degree Bachelor of Science in Engineering Science.

2. The degree in Engineering Science requires a minimum of 100 quarter hours in Engineering and Science of which at least 50 hours must be at the upper division level.

3. The following specific requirements must be met. Areas marked with an asterisk must include laboratory work:

	Approximate Quarter Hrs.
a. Mathematics through calculus	17
b. Chemistry and Material Science*	15
c. Classical and modern Physics	16
d. Electrical Engineering including Electronics*	14
e. Mechanical Engineering including Mechanics and Thermodynamics	11
f. Probability and Statistics	3
g. Computers and Data Processing	4
h. Electives in Engineering and Science	20
	100

Electives will be chosen from courses in Mathematics, Chemistry or Physics, Electrical Engineering, Mechanical Engineering, Probability and Statistics, Computer Science, Oceanography, Meteorology, Operations Analysis.

Dean Rinehart congratulating LT Bonifacio C. Lomotan, Jr., Philippine Navy, upon graduation

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.

LOFTUR L. BJARNASON, Professor of Literature (1958); A.B., Univ. of Utah, 1934; 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 Psychology (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.

ERLING ARTHUR ERICKSON, Assistant Professor of History (1966); B.A., Luther College, 1956; M.A., Univ. of North Dakota, 1959; Ph.D., Univ. of Iowa, 1966.

BARBARA LOUISE GABEL, Associate Professor of English (1967); A.B., Dickinson College, 1945; A.M., Peabody College, 1946; Ph.D., Univ. of North Carolina, 1954.

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, Lieutenant, U.S. Naval Reserve (1964); Instructor in Political Science; A.B., North Texas Univ., 1962; M.A., Pennsylvania State Univ., 1964.

BURTON MACLYNN SMITH, Associate Professor of Speech (1955); B.A., Univ. of Wisconsin, 1936; M.A., 1937.

RUSSELL HENRY STOLFI, Assistant Professor of History, (1966); B.S., Stanford Univ., 1954, M.A., 1964; Ph.D., 1966.

FRANK M. TETI, Assistant Professor of Political Science (1966); B.A., Los Angeles State College, 1960; M.A., 1962; Ph.D., Maxwell School of Syracuse Univ., 1966.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR THE DEGREE BACHELOR OF ARTS WITH MAJOR IN GOVERNMENT (INTERNATIONAL RELATIONS)

A minimum of 40 quarter hours of upper division (2000 level) courses in Government, including the following:

	Quarter Hrs.
a. *B.A. Required Courses:* GV 2160 GV 2161, GV 2163 and GV 2164	14
b. *Major Electives:* Three courses each from the fields of International Relations and Comparative Government	24
c. One elective from the field of American Government	3-4

ENGLISH

Upper Division Courses

EN 2010 ADVANCED WRITING (3-0). Intensive writing experience with the grammatical and rhetorical principles underlying sound expository and argumentative prose. PREREQUISITE: Freshman English or permission of Chairman of Department.

EN 2011 TECHNICAL WRITING (3-0). The writing of technical papers.

EN 2239 DIRECTED STUDIES IN WRITING (2-0). Independent study in areas of writing in which formal course work is not offered. PREREQUISITE: EN 2010 and permission of Chairman of Department.

Upper Division or Graduate Courses

EN 3310 RESEARCH METHODS (2-0). A study of principles and practices of research writing applied to the preparation, analysis, and evaluation of reports, scientific papers, theses, and dissertations. PREREQUISITE: Graduate standing or permission of Chairman of Department.

GEOGRAPHY

Upper Division Courses

GY 2291 POLITICAL GEOGRAPHY (4-0). A study of world areas, regions, and countries, with emphasis on the location and political significance of terrain features.

GOVERNMENT

Lower Division Courses

GV 1060 U.S. GOVERNMENT (4-0). American political institutions and processes, the Constitution, parties, interest groups, elections, and voting behavior, with special emphasis on current issues and problems.

GV 1368 AMERICAN LIFE AND INSTITUTIONS (3-0). American political institutions and the political, social, economic, and cultural aspects of American life. Open only to Allied Officers.

Upper Division Courses

GV 2061 NATIONAL SECURITY (3-0). Analysis of the national defense structure, the formulation and execution of strategic concepts; relationships of weapons systems; economic factors and political potentials and requirements to the achievement of national goals. PREREQUISITE: GV 1060.

GV 2160 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 1060.

GV 2161 INTRODUCTION TO INTERNATIONAL RELATIONS (3-0). The relations of nations, including a consideration of the factors of national power and study of international interests, and organizations.

GV 2163 POLITICAL THOUGHT (4-0). The principal political philosophers; Plato to the French Revolution.

GV 2164 COMPARATIVE IDEOLOGIES (3-0). The major ideological forces in contemporary World Affairs and the developmental patterns of Democracy, Socialism, Communism, and Fascism. PREREQUISITE: GV 2163.

GV 2262 THEORY AND PRACTICE OF INTERNATIONAL POLITICS (4-0). A theoretical approach to the study of international relations and an analysis of the factors, organization, strategies, and techniques of international politics. PREREQUISITES: HI 2130; GV 2161.

GV 2263 GOVERNMENT AND POLITICS OF 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 2264 GOVERNMENT AND POLITICS OF THE SOVIET UNION (4-0). The structure and function of the Soviet government and the Communist Party in decision-making and planning in the Soviet Union. PREREQUISITE: HI 2130.

GV 2265 GOVERNMENT AND POLITICS OF SOUTHEAST ASIA (4-0). The international, internal, and military problems of the southeast Asian states.

GV 2266 GOVERNMENT AND POLITICS OF EAST ASIA (4-0). The international, internal, and military problems of China, Japan, and Korea.

GV 2268 RECENT EUROPEAN DIPLOMACY (1945-Present) (4-0). Foreign affairs of the major European states from 1950 to the present. PREREQUISITE: HI 2030.

GV 2270 AMERICAN POLITICAL THOUGHT (3-0). A study of American political thought from the colonial period to the present. PREREQUISITES: GV 1060, 2163; HI 2032, HI 2131.

GV 2271 AMERICAN CONSTITUTIONAL ISSUES (3-0). The United States Constitution and its development, with emphasis on leading constitutional issues such as federalism, civil-military relations, public-private interests and civil rights. PREREQUISITES: GV 1060; HI 2032, 2131.

GV 2272 AMERICAN TRADITIONS AN IDEALS (4-0). 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 2032, HI 2131; GV 2163, GV 2270.

GV 2273 RECENT AMERICAN DIPLOMACY (4-0). An analysis of the major problems of United States foreign relations in Europe, Latin America and the Far East from 1898 to the present. PREREQUISITES: HI 2030, HI 2032.

GV 2274 AMERICAN PARTY POLITICS (3-0). 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 1060.

GV 2275 INTERNATIONAL LAW (3-0). A survey of the basic principles of international law with emphasis on jurisdiction and the rules of warfare. Case and problem discussions.

GV 2279 DIRECTED STUDIES IN GOVERNMENT (Credit Open). Independent study in government in subjects in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department.

GV 2381 AVIATION LAW (1-0). A study of the privileged status of the Aircraft Accident Investigation designed especially for the Aviation Safety Officer Program.

HISTORY

Upper Division Courses

HI 2030 EUROPEAN HISTORY (1914-1945) (3-0). Foreign and domestic affairs of the Major European states from World War I through the immediate aftermath of World War II.

HI 2032 U.S. HISTORY (1865-present) (3-0). A survey of the political, economic and social history of the United States from Reconstruction to the present.

HI 2130 EUROPEAN HISTORY (1815-1914) (3-0). Foreign and domestic affairs of the major European states from the Congress of Vienna to the outbreak of World War I.

HI 2131 U.S. HISTORY (1763-1865) (3-0). A survey of the political, economic and social history of the United States from the American Revolution to the end of the Civil War.

HI 2239 DIRECTED STUDIES IN HISTORY (Credit Open). Independent study in history in which formal course work is not offered. PREREQUISITE: Permission of Chairman of Department.

LITERATURE

Lower Division Courses

LT 1040 APPRECIATION OF LITERATURE (3-0). A study of selected works of literature. The selection is intended to enhance the student's understanding and appreciation of literature as the most commonly used vehicle in expressing the aspirations, the hopes, and the enduring problems of mankind.

Upper Division Courses

LT 2241 MASTERPIECES OF AMERICAN LITERATURE (3-0). A study of selected works of American literature as they reflect the cultural, political, and sociological aspirations of the American people. PREREQUISITE: LT 1040 or permission of the Chairman of Department.

LT 2242 MASTERPIECES OF BRITISH LITERATURE (3-0). A study of British literature with its cultural and historical implications. A modified survey approach is used, but selected works and authors are studied in some depth. PREREQUISITE: Same as for LT 2241.

LT 2243 MASTERPIECES OF EUROPEAN LITERATURE (3-0). A study of selected masterpieces of European literature. An effort is made to impress the student with the continuity of the Western European intellectual heritage. PREREQUISITE: LT 1040 or permission of Chairman of the Department.

LT 2244 MASTERPIECES OF WORLD LITERATURE (3-0). A study of selected masterpieces of world literature. The selection will vary, depending upon the needs and interests of the students. PREREQUISITES: LT 1040, plus at least one of the following: LT 2241, 2242, 2243.

PSYCHOLOGY

Upper Division Courses

PY 2050 GENERAL PSYCHOLOGY (3-0). A study of principles of rational and emotional processes in human thought and action.

PY 2251 APPLIED SOCIAL PSYCHOLOGY (3-0). An application of psychological principles to problems of personality growth, motivation, and interpersonal relations. PREREQUISITE: PY 2050 or permission of Chairman of Department.

PY 2352 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

Lower Division Courses

SP 1020 PUBLIC SPEAKING (3-0). Practice in preparing and delivering extemporaneous speeches, emphasizing principles and techniques of oral style.

SP 1021 CONFERENCE PROCEDURES (3-0). Theory and practice of group dynamics applied to conferences, with emphasis on group problem-solving in completed staff work.

SP 1320 BASIC SPEAKING FOR FOREIGN OFFICERS (2-0). Work in preparing and presenting speeches, with attention to the special problems of students with limited experience in speaking English. PREREQUISITE: SP 1320 is prerequisite to SP 1020 for foreign officer-students.

SP 1321 PUBLIC SPEAKING FOR ENGINEERING STUDENTS (2-0). A condensed version of a basic course, oriented toward the interests and needs of the engineer-speaker. Offered only during the first (summer) quarter.

Upper Division Courses

SP 2221 ADVANCED SPEECH (2-0). Practical application of techniques learned in SP 1020 with stress on composition, platform technique, audience situations and audience response. Opportunity to address off-campus audiences is provided. PREREQUISITE: SP 1020 or equivalent.

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.

JOHN ROBERT CLARK, Professor of Metallurgy (1947); B.S., Union College, 1935; Sc.D., Massachusetts Institute of Technology, 1942.

JOHN HENRY DUFFIN, Professor of Chemical Engineering (1962); B.S., Lehigh Univ., 1940; Ph.D., Univ. of California at Berkeley, 1959.

WILLIAM WISNER HAWES, Professor of Metallurgy and Chemistry (1952); B.S., Ch.E., 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.

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, Professor of Chemistry (1954); B.S., Univ. of California at Berkeley, 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, Professor of Chemistry (1946); B.S., Ch. Eng., Johns Hopkins Univ., 1945; M.S., Naval Postgraduate School, 1956.

GLENN HOWARD SPENCER, Associate Professor of Chemistry (1962); B.S., Univ. of California at Berkeley, 1953; Ph.D., Univ. of Washington, 1958.

WILLIAM MARSHALL TOLLES, Associate Professor of Chemistry (1962); B.A., Univ. of Connecticut, 1958; Ph.D., Univ. of California at Berkeley, 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 parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN IN CHEMISTRY OR MATERIAL SCIENCE

A specific curriculum should be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Department of Material Science and Chemistry at least two quarters 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.

BACHELOR OF SCIENCE IN CHEMISTRY

1. A major in chemistry should include a minimum of 44 quarter hours of chemistry (of which 9 quarter hours are elective), 17 quarter hours of physics (through general and modern physics), 18 quarter hours of mathematics(through differential equations) and 12 quarter hours of elective upper division courses in engineering, mathematics, or science (including chemistry). At least 96 of the quarter hours must be upper division level.

2. The following specific requirements must be met. Courses marked with an asterisk must include laboratory work.

Discipline	*Subject*	*Approximate Quarter Hrs.*
Chemistry	General*	4
	Inorganic*	3
	Analytical*	4
	Organic*	9
	Physical*	14
		34
Physics	General*	13
	Modern (Atomic)	4
		17
Mathematics	College Algebra and Trigonometry	4
	Analytical Geometry and Calculus	11
	Differential Equations	3
		18

3. The 9 elective quarter hours in chemistry must be fulfilled by taking at least upper division courses in chemistry or chemical engineering.

MASTER OF SCIENCE IN CHEMISTRY

1. To obtain a degree, Master of Science in Chemistry, the student must have completed work equivalent to the Bachelor of Science requirements of this department.

2. In addition the student must successfully complete the following with a grade point average of 2.0 in all chemistry courses:

a. One course at the 4000 level in each of the following areas: Chemical Thermodynamics, Inorganic Chemistry, Physical-Organic Chemistry and Quantum Chemistry. Minimum total quarter hours—13.

b. Two or more courses at the 4000 level in the general area chosen for specialization. These courses must have a total of not less than six quarter hours of lecture and must be approved by the Department of Material Science and Chemistry. Minimum total quarters 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 MATERIAL SCIENCE

1. The following is a statement of departmental minimum requirements for the degree of Master of Science in Material Science. 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 16 quarter hours in 4000 level courses in Material Science is required. These shall include at least one course each in the areas of metals, ceramics, and plastics. A minimum of 10 quarter hours of graduate credit must be earned outside the major department. A total of at least 20 quarter hours of 4000 level courses must be included in the program.

3. Completion of a thesis and its acceptance by the department are required. A maximum of 7 quarter hours of graduate credit may be allowed toward satisfaction of the School requirement for 40 quarter hours, but the thesis credit may not be used to satisfy the requirements of paragraph 2.

CHEMISTRY AND CHEMICAL ENGINEERING

CH 0800 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 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

CH 1001 INTRODUCTORY GENERAL CHEMISTRY I (4-2). The first quarter course of a two quarter sequence for students who have not had college chemistry. A study of the principles which govern the physical and chemical behavior of matter. TEXT: Sienko and Plane, *Chemistry, 3rd ed.*

CH 1002 INTRODUCTORY GENERAL CHEMISTRY II (3-2). The second quarter of a two-quarter sequence for students who have not had chemistry before coming to the Postgraduate School. TEXT: Same as CH 1001. PREREQUISITE: CH 1001.

CH 1007 METHODS OF MODERN CHEMISTRY (2-0). A review of selected aspects of chemistry of current importance. The mole concept; the carbon 12 atomic scale; basic stoichiometry. The kinetic-molecular picture of materials in the gas, liquid, and solid phases. Chemical kinetics and rate processes; the concept of activation energy. Description of modern instrumental techniques such as those for pH, for atomic and molecular absorption spectrophotometry, for magnetic resonance and microwave spectroscopy, and for radiochemical counting. Applications of the principles of chemistry to selected areas in corrosion, materials selection, combustion, chemistry of the oceans, propellants, or explosives. Regular assignments, quizzes, and an examination form an integral part of the work. A non-academic course for graduate students in science and engineering. PREREQUISITE: College chemistry.

Upper Division Courses

CH 2001 GENERAL PRINCIPLES OF CHEMISTRY (3-2). 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 and chemical equilibria. Special attention is given to the compounds of carbon. Elementary physical chemistry experiments are performed in the laboratory. TEXT: Mahan, *University Chemistry*. PREREQUISITE: College Chemistry.

CH 2101 INORGANIC ANALYSIS (3-3). Detailed calculation for acid-base and solubility equilibria; the graphical method of Sillen. Oxidation-reduction and the electrode potential. Laboratory work will consist of gravimetric, volumetric and instrumental analyses, especially as used to investigate inorganic reactions. TEXT: Skoog and West, *Fundamentals of Analytical Chemistry*. PREREQUISITE: CH 2402. (May be taken concurrently).

CH 2102 INORGANIC CHEMISTRY (2-3). Introduction to reaction mechanisms. Bonding in inorganic compounds. The typical elements. The laboratory will be a continuation of CH 2101, but with emphasis on descriptive inorganic chemistry. TEXT: Cotton and Wilkinson, *Advanced Inorganic Chemistry, 2nd ed.* PREREQUISITE: CH 2101.

CH 2301 ORGANIC CHEMISTRY I (4-2). The first quarter of a two quarter study of the chemistry of organic compounds. TEXT: Roberts and Caserio, *Basic Principles of Organic Chemistry*. PREREQUISITE: CH 2402. (May be taken concurrently).

CH 2302 ORGANIC CHEMISTRY II (3-3). A continuation of CH 2301. The study of Organic Chemistry is pursued further with emphasis in the laboratory on synthetic techniques. TEXT: Roberts and Caserio, *Basic Principles of Organic Chemistry*. PREREQUISITE: CH 2301.

CH 2401 GENERAL THERMODYNAMICS (3-0). (See listing of PH 2551.)

CH 2402 INTRODUCTION TO PHYSICAL CHEMISTRY (3-3). The course will include such topics as properties of matter, thermochemistry, chemical thermodynamics, chemical equilibria, kinetics, and electrochemistry. TEXT: Moore, *Physical Chemistry, 3rd ed.* PREREQUISITES: CH 2401, CH 2001.

CH 2405 PHYSICAL CHEMISTRY TOPICS (4-3). Completion of study of topics of undergraduate physical chemistry begun in CH 2402. TEXTS: Moore, *Physical Chemistry, 3rd ed.*; Salzberg et al., *Laboratory Course in Physical Chemistry*. PREREQUISITE CH 2402.

Upper Division or Graduate Courses

CH 3201 CHEMICAL INSTRUMENTS (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. TEXTS: Willard, Merritt and Dean, *Instrumental Methods of Analysis, 4th ed.*; Silverstein and Bassler, *Spectrometric Identification of Organic Compounds.* PREREQUISITES: CH 2101, CH 2405.

CH 3401 CHEMICAL THEORY (4-0). An advanced one-term course concerned with topics in chemistry of special interest to physics majors. Topics include chemical bonding and quantum chemistry, molecular spectroscopy, chemical equilibrium, rates of chemical reactions, electrochemical cells, and photo and radiation chemistry. TEXTS: Philips, *Basic Quantum Chemistry;* Moore, *Physical Chemistry, 3rd ed.* PREREQUISITES: College Chemistry, PH 3651, Matrix Mechanics and CH 2401.

CH 3701 CONTROL SYSTEMS (3-3). (See listing of EE 3411.)

CH 3705 REACTION MOTORS (3-0). A study of the fundamentals of rocket motors. The subject matter includes the basic mechanics of rocket engines, properties of solid and liquid propellants, the design and performance parameters of rocket motors. TEXTS: Sutton, *Rocket Propulsion Elements;* Warren, *Rocket Propellants.* PREREQUISITE: CH 2401.

CH 3709 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. TEXTS: Cook, *The Science of High Explosives;* Davis, *Chemistry of Powder and Explosives;* Rinehart and Pearson, *Explosive Working of Metals.* PREREQUISITE: CH 2001.

CH 3713 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: CH 2401, CH 3401, or CH 2402.

CH 3717 UNIT OPERATIONS (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. TEXTS: Foust et al., *Principles of Unit Operations;* Bird et al., *Transport Phenomena;* Smith and McCabe, *Unit Operations of Chemical Engineering.* PREREQUISITES: MA 1100, CH 2402, CH 2401.

Graduate Courses

CH 4101 ADVANCED INORGANIC CHEMISTRY (3-3). Coordination compounds and crystal field theory. Chemistry of the halogens and of nitrogen. The laboratory introduces the student to general methods for investigating chemical reactions. TEXT: Cotton and Wilkinson, *Advanced Inorganic Chemistry, 2nd ed.* PREREQUISITES: CH 2102, CH 2405, PH 3651.

CH 4301 PHYSICAL ORGANIC I (3-0). First quarter of a two-quarter sequence. In this term the tools available for the study of organic mechanisms are discussed and appropriate examples used. TEXTS: Hine, *Physical Organic Chemistry, 2nd ed.*; Gould, *Structure and Mechanism in Organic Chemistry.* PREREQUISITES: CH 2302, CH 3201, CH 4401.

CH 4302 PHYSICAL ORGANIC II (3-0). The techniques discussed in CH 4301 are used in the study of organic reaction mechanisms as currently understood. TEXT: See CH 4301. PREREQUISITE: CH 4301.

CH 4401 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. TEXTS: Klotz, *Chemical Thermodynamics;* Lewis and Randall, *Thermodynamics, 2nd ed.* PREREQUISITE: CH 2402.

CH 4405 MOLECULAR DYNAMICS (3-0). A study of molecular spectra, utilizing symmetry to obtain information about eigenvalues and selection rules. Spectra discussed will include infrared, Raman, and ultraviolet. Symmetry will be used to give an understanding of electronic structure of molecules and ions. TEXT: Phillips, *Basic Quantum Chemistry.* PREREQUISITES: PH 3651, CH 2405, Matrix Algebra.

CH 4406 QUANTUM CHEMISTRY II (3-0). A study of molecular spectra, emphasizing theory, interpretation, and prediction of spectra by utilizing matrix manipulations. Rigorous solutions to problems will be examined in detail for infrared, Raman, ultraviolet, nuclear magnetic resonance, electron spin resonance, and rotational spectra. PREREQUISITE: CH 4405.

CH 4501 RADIOCHEMISTRY (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 assays: TEXT: Johnson, Eichler and O'Kelley, *Nuclear Chemistry.* PREREQUISITE: CH 3401 or equivalent.

CH 4701 PROCESS CONTROL (3-2). A continuation of CH 3701 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. TEXTS: Harriott, *Process Control;* Coughanowr and Koppel, *Process Control.* PREREQUISITE: Common Control Course (CH 3701).

CH 4705 PLASTICS AND HIGH POLYMERS (2-2). A study of the general nature of plastics and high polymers. This includes the correlation between properties and chemical structure. In the laboratory plastics are made, molded, tested and identified. TEXTS: Golding, *Polymers and Resins;* Kinney, *Engineering Properties and Application of Plastics.* PREREQUISITE: CH 2001.

CH 4709 APPLIED MATHEMATICS OF 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. TEXTS: Mickley et al., *Applied Mathematics in Chemical Engineering;* Wylie, *Advanced Engineering Mathematics.* PREREQUISITES: MA 1100, CH 2401, CH 2402.

CH 4800 SPECIAL TOPICS (2-0 to 4-0). 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. Typical topics are listed as follows:

1) Chemical Engineering Kinetics—Chemical engineering applications with emphasis on large scale equipment design.
2) Heat Transfer—Chemical engineering applications with emphasis on large scale and unusual equipment design.
3) Radiochemistry—Theory of chemical nuclear processes and detection methods of their radiations, with emphasis on activation analysis.
4) Statistical Mechanics—Statistical thermodynamics and other applications to chemical systems.
5) Chemical Kinetics—Interpretation of data, theories, mechanism.
6) Natural Products—Study of degradation and synthesis of steroids, alkaloids and terpenes.
7) Advanced Organic Chemistry—Study of new synthetic approaches in depth.
8) The Chemistry of High Polymers—Discussion of chemistry of polymer formation and properties.

TEXT: As appropriate. PREREQUISITE: Consent of the instructor.

MATERIALS

MS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MS 1021 ELEMENTS OF MATERIALS SCIENCE I (3-2). An introduction to the nature and properties of materials for engineering applications. An essentially qualitative treatment of factors which govern the selection of materials. Classification of materials by type based on their chemical, physical and mechanical properties. Methods, processes and problems in the production of commercial materials. Introduction to crystal structure, phase equilibria, plastic deformation, recrystallization, grain growth, and precipitation hardening. TEXT: Van Vlack, *Elements of Materials Science, 2nd ed.* PREREQUISITE: CH 1001 or equivalent.

MS 1022 ELEMENTS OF MATERIALS SCIENCE II (2-2). Continuation of subject matter introduced in MS 1021 with stress on specific materials systems such as steel, plastics, and composites. Discussion of environmental factors and suggestions for avoiding or interpreting service failures. TEXT: Van Vlack, *Elements of Materials Science, 2nd ed.* PREREQUISITE: MS 1021.

Upper Division Courses

MS 2201 ENGINEERING MATERIALS I (3-2). Principles underlying those properties and characteristics of materials which govern their selection and behavior in engineering applications. The importance of crystallographic concepts, imperfections, and dislocations in determing properties is emphasized. Elastic and plastic behavior of crystalline and non-crystalline solids are studied and compared. Specific topics include atomic bonding, crystal structure, grain structure, defects and imperfections, slip, twinning, fracture, phase equilibria, mechanisms of phase changes, recrystallization, grain growth, and precipitation hardening. Materials systems with extensive naval application are used to illustrate the theoretical background. TEXT: Clark and Varney, *Physical Metallurgy for Engineers.* PREREQUISITES: CH 2001 or General Physics.

MS 2202 ENGINEERING MATERIALS II (3-2). Extension of subject matter introduced in MS 2201. Control of reaction rates in solid phase transformation; diffusion and diffusionless transformations; engineering alloy systems including iron, steel, alloy steels, stainless steels, PH stainless steels, high temperature alloys, modern ultra high strength steels; principles of ausforming, marstraining, maraging; cryogenic materials, refractory materials, powder metallurgy, cermets, composite materials; as time permits, mechanical properties such as fatigue, creep, and fracture are discussed, as well as welding problems. TEXT: Clark and Varney, *Physical Metallurgy for Engineers.* PREREQUISITE: MS 2201.

MS 2218 ELEMENTS OF ENGINEERING MATERIALS (3-2). A broad survey of the field of engineering materials with special emphasis on those of importance to the aeronautical engineer. A review of fundamental principles such as crystallography, imperfections, dislocations, polymorphism, solid solution, equilibrium diagrams, non-equilibrium phenomenon, recrystallization, grain growth, and precipitation hardening. Effect of various mechanical and thermal treatments on the structure and properties of cryogenic and aerospace materials, including steels, stainless steels, precipitation hardening alloys, the light alloys, cermets, composites, and a correlation of the foregoing principles with corrosion, creep, and fatigue type failures. TEXTS: Guy, *Physical Metallurgy for Engineers;* Clark and Varney, *Physical Metallurgy for Engineers;* Parker, *Materials for Missiles and Spacecraft.* PREREQUISITES: Recent elementary courses in physics and chemistry.

MS 2228 INTRODUCTION TO ENGINEERING MATERIALS (3-2). A survey emphasizing the relations between composition, thermal and mechanical treatments and the engineering properties of materials of interest to the naval engineer. Topics covered include crystal fracture concepts, phases present under equlibrium and non-equilibrium conditions, kinetics of phase transformation, plastic deformation and recrystallization. The variation of mechanical properties by dislocations is examined. Magnetic materials and other topics of particular interest to electrical engineers will be discussed in the time available. TEXTS: Guy, *Physical Metallurgy for Engineers;* Clark and Varney, *Physical Metallurgy for Engineers.* PREREQUISITES: Recent elementary courses in physics, chemistry and mechanics.

Upper Division or Graduate Courses

MS 3303 NUCLEAR REACTOR MATERIALS (3-0). A discussion of materials used in reactor construction including fuels, moderators, absorbers, shielding materials, structural materials and coolants. While the nuclear requirements dictating the use of specific materials are pointed out and radiation effects are discussed, emphasis is on the technology of the materials. TEXTS: Reactor Handbook, 2nd ed.; Kaufmann, *Nuclear Reactor Fuel Elements.* PREREQUISITE: MS 2202.

MS 3304 CORROSION (3-2). Presents the basic chemical, electrochemical, mechanical and metallurgical factors which influence the corrosion, oxidation and deterioration of materials. Discusses standard methods of corrosion control such as cathodic protection, coatings, cladding, alloy selection and inhibitors; special problems encountered in unfamiliar environments. TEXT: Uhlig, *Corrosion and Corrosion Control.* PREREQUISITE: MS 1022 or MS 2202.

MS 3601 PHYSICAL GEOLOGY (3-2). The study of the various geological phenomena. Topics discussed are: brief fundamentals of crystallography; mineralogy; the rock forming minerals; igneous, sedimentary, and metamorphic rocks; weathering and erosion; steam sculpture; glaciation; surface and sub-surface waters; volcanism, isostacy, and dynamic processes; continents; submarine geology and topography; interpretation of topographic and geologic maps; plane table surveying. TEXTS: Hurlbut, *Dana's Manual of Mineralogy;* Gulluly, *Principles of Geology.* PREREQUISITES: CH 1001 or CH 2001.

MS 3701 CRYSTALLOGRAPHY AND X-RAY DIFFRACTION TECHNIQUES (2-3). The essential concepts of crystallography including atomic bonding, symmetry, point groups, lattices, space groups, coordinate systems, crystal classes, crystal systems; the orthogonal, spherical, gnomonic, and stereographic projections; the optical goniometer; fundamentals of optical crystallography, and the use of the polarizing microscope; twinning isomorphism, polymorphism; the structure of the silicates; the theory of X-ray diffraction, and the various diffraction techniques used in the study of crystalline materials. TEXTS: Wood, *Crystals and Light;* Azaroff and Buerger, *The Powder Method.* PREREQUISITE: Recent course in general physics.

Graduate Courses

MS 4205 THE STRUCTURE OF SOLIDS (3-4). The principal topic considered in this course is the identification and description of the phases present in alloys or other aggregates. The course is not only concerned with the methods by which structures are determined but also considers the correspondence between mechanical, electrical and magnetic properties and structure. X-ray diffraction methods of studying single crystals and polycrystalline aggregates are described and correlated with optical crystallography and microscope examination. Extensive individual initiative is allowed and expected in the laboratory. TEXTS: Rhines, *Phase Diagrams in Metallurgy;* Cullity, *Elements of X-ray Diffraction;* Guinier, *X-ray Diffraction.* PREREQUISITES: MS 2202 or PH 3651.

MS 4206 THE STRUCTURE AND MECHANICAL PROPERTIES OF CRYSTALS (3-0). A discussion of dislocations in crystals and the mechanical properties to be expected in real crystals. The topics discussed include the forces between dislocations, stacking faults and partial dislocations, the generation of dislocations during crystal growth and during plastic deformation, the locking of dislocations. The experimental investigation of dislocations by optical methods, decorating techniques, electron transmission microscopy, and diffraction methods are discussed. TEXTS: Fridel, *Dislocations;* Weertman and Weertman, *Elementary Dislocation Theory;* Amelinck, *The Direct Observation of Dislocations.* PREREQUISITES: MS 2202, PH 3651.

MS 4215 PHASE TRANSFORMATIONS (3-4). The thermodynamics and kinetics of transformations in solids. The free energy of alloys, solidification, precipitation, recrystallization, diffusion and diffusionless transformations. Extensive individual initiative is allowed and expected in the laboratory. TEXTS: Reed-Hill, *Physical Metallurgy Principles;* Fine, *Introduction to Phase Transformations in Condensed Systems;* Wayman, *Introduction to the Crystallography of Martensite Transformation.* PREREQUISITE: MS 2202.

MS 4300 MATERIALS SCIENCE COLLOQUIUM (1-0). Topics of current interest are presented by invited speakers, faculty members and students. PREREQUISITE: Consent of the instructor.

MS 4302 SPECIAL TOPICS IN MATERIAL SCIENCE (hours by arrangement). Independent study of advanced subjects not regularly offered. PREREQUISITE: Consent of the instructor.

MS 4304 ENVIRONMENTAL DETERIORATION OF MATERIALS (3-3). The role of corrosive atmosphere, metallurgical structure, surface physics and stress state in leading to catastrophic embrittlement of high strength materials. Particular reference to stress corrosion, hydrogen embrittlement, liquid-metal embrittlement and corrosion fatigue. TEXTS: Fontana and Greene, *Corrosion Engineering;* Staehle, *Proceedings of the International Conference on Fundamental Aspects of Stress Corrosion Cracking.* PREREQUISITE: MS 3304.

MS 4305 MATERIALS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS (3-0). The properties and preparation of materials used in electrical and electronic applications. Among the materials discussed are ferromagnetic materials, both hard and soft, ferrimagnetic materials, semiconductors, both elemental and compound, insulators and dielectrics, piezoelectric and ferroelectric crystals. The electronic, crystallographic and thermodynamic principles controlling these materials are discussed and the heat treatments, compositions and methods of fabrication of commercial materials are emphasized. TEXT: Nusbaum, *Electronic and Magnetic Behavior of Materials.* PREREQUISITE: MS 2202.

MS 4312 MATERIALS SYSTEMS (3-0). Attempts to establish criteria of standard environment and standard behavior of engineering materials. Examines properties of materials at extremes of temperature, rate and duration and frequency of loading, corrosive environment, and the conditions of outer space. Examines factors amenable to control at the molecular and structural levels and illustrates with real materials. Development of materials to meet requirements of extreme environmental conditions is illustrated by alloy steels, refractory metals and alloys, composites, cermets and special materials. TEXT: Dorn, *Mechanical Behavior of Materials at Elevated Temperatures.* PREREQUISITE: MS 2202.

MS 4320 PROPERTIES OF CERAMIC MATERIALS (4-0). Occurrences, 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*. PREREQUISITE: CH 2402.

MS 4401 PHYSICS OF SOLIDS (3-0). A course intended for students particularly interested in material science and which will cover topics being developed in the literature but with emphasis on crystallographic and mechanical subjects such as order-disorder, symmetry and anti-symmetry, twinning, brittle fracture, transition temperatures, etc. TEXTS: Instructors Notes, Current Literature. PREREQUISITES: MS 4205 or MS 4215 or PH 3651 or PH 4751.

MS 4811 MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS (3-0). The response of single crystals and polycrystalline aggregates to mechanical stress. The plastic deformation and fracture of real materials including metals and alloys, ceramics and cermets, composites, and polymers. Fracture resulting from fatigue and environmental conditions will be discussed Creep and mechanical properties at elevated temperature will be described and current theories discussed. TEXT: Dieter, *Mechanical Metallurgy*. PREREQUISITES: MS 2202, Engineering Mechanics.

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.

WARREN RANDOLPH CHURCH, Professor Emeritus (1938); B.A., Amherst, 1926; M.A., Univ. of Pennsylvania, 1930; Ph.D., Yale Univ., 1935.

ALADUKE BOYD MEWBORN, Professor Emeritus and Distinguished Professor (1946); B.S., Univ. of Arizona, 1927; M.S., 1931; Ph.D., California Institute of Technology, 1940.

CHARLES HENRY RAWLINS, JR., Professor Emeritus (1922); Ph.B., Dickinson College, 1910; M.A., 1913; Ph.D., Johns Hopkins Univ., 1916.

RICHARD DONALD AMORI, Lieutenant, U.S. Navy; Instructor in Mathematics (1965); B.S., Univ. of Scranton, 1964; M.S., Bucknell Univ., 1965.

HORACE CROOKHAM AYRES, Professor of Mathematics (1958); B.S., Univ. of Washington, 1931; M.S., 1931; Ph. D., Univ. of California at Berkeley, 1936.

GERALD LEONARD BARKSDALE, JR., Lieutenant (junior grade), U. S. Naval Reserve; Instructor in Mathematics (1967); B.S., Rice Univ., 1965; M.S., 1966.

WILLARD EVAN BLEICK, Professor of Mathematics (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

WALTER SCOTT BRAINERD, Assistant Professor of Mathematics (1967); B.A., Univ. of Colorado, 1958; M.A., Univ. of Maryland, 1961; Ph.D., Purdue Univ., 1967.

RICHARD CROWLEY CAMPBELL, Professor of Mathematics (1948); B.S., Muhlenberg College, 1940; M.A., Univ. of Pennsylvania, 1942.

FRANKLIN LEE DANIELS, Lieutenant, U.S., Naval Reserve; Instructor in Mathematics (1966); B.A., Oklahoma City Univ., 1964; M.A., Univ. of Oklahoma, 1966.

LEONARD WILLIAM DEATON, Lieutenant (junior grade), Instructor in Mathematics (1967); B.S., California State Polytechnic College, 1965; M.S., Univ. of Iowa, 1967.

FRANK DAVID FAULKNER, Professor of Mathematics (1950); B.S., Kansas State Teachers College, 1940; M.S., Kansas State College, 1942.

JOSEPH GIARRATANA, Professor of Mathematics (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

HERBERT J. HAUER, Assistant Professor of Mathematics (1963); B.S., Queens College, 1949; M.A., Univ. of California at Berkeley, 1955.

ROBERT WELDON HUNT, Associate Professor of Mathematics (1968); B.S., West Texas State Univ., 1956; M.S., Univ. of Utah, 1958; Ph.D., 1961.

TOKE JAYACHANDRAN, Assistant Professor of Mathematics (1967); B.A., V.R. College, Nellore India, 1951; M.S., Univ. of Wyoming, 1962; Ph.D., Case Institute of Technology, 1967.

WALTER JENNINGS, Professor of Mathematics (1947); B.A., Ohio State Univ., 1932; B.S., 1932; M.A., 1934.

UNO ROBERT KODRES, Associate Professor of Mathematics (1963); B.A., Wartburg College, 1954; M.S., Iowa State Univ., 1956; Ph.D., 1958.

LADIS DANIEL KOVACH, Visiting Professor of Mathematics (1967); B.S., Case Institute of Technology, 1936; M.S., Western Reserve Univ., 1948; Ph.D., Purdue Univ., 1951.

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.

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 (1949); B.A., Univ. of Illinois, 1937; M.A., 1938; Ph.D., 1947.

ELMO JOSEPH STEWART, Professor of Mathematics (1955); B.S., Univ. of Utah, 1937; M.S., 1939; Ph.D., Rice Institute, 1953.

DONALD HERBERT TRAHAN, Associate Professor of Mathematics (1966); B.S., Univ. of Vermont, 1952; M.A., Univ. of Nebraska, 1954; Ph.D., Univ. of Pittsburgh, 1961.

CARROLL ORVILLE WILDE, Associate Professor of Mathematics (1968); B.S., Illinois State Univ., 1958; Ph.D., Univ. of Illinois, 1964.

FRANCIS MERRILL WILLIAMS, Assistant Professor of Mathematics (1965); B.S., New Mexico State Univ., 1958; M.S., 1960; Ph.D., 1964.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEGREES WITH MAJOR IN MATHEMATICS

Officer students may, under certain conditions, be offered the opportunity to qualify for either a Bachelor of Science or Master of Science degree with major in mathematics. Any interested student should consult 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 below.

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 with the approval of the Chairman of the Department.

BACHELOR OF SCIENCE WITH MAJOR IN MATHEMATICS

1. Of the total quarter hours specified in the general requirements for the degree of Bachelor of Science, a student majoring in mathematics must complete at least 30 quarter hours of approved course work in mathematics beyond the calculus, and must have an average QPR of 1.25 or higher in these 30 quarter hours.

2. These 30 quarter hours in mathematics will include course work in differential equations and complex variables, and in addition at least six quarter hours in each of the two fields, analysis and algebra.

MASTER OF SCIENCE WITH MAJOR IN MATHEMATICS

1. 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. 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.

2. A curriculum satisfying the requirements for the Master of Science degree with major in mathematics consists of at least 45 quarter hours of approved course work in mathematics, or approved course work in mathematics and related subjects. Of these 45 hours, there will be at least six hours in each of the fields of analysis and algebra. A student must have an average QPR of 2.0 or better in the mathematic courses in his curriculum.

3. At the discretion of the Chairman of the Department of Mathematics a student pursuing a program leading to the Master of Science degree with major in mathematics may (or may not) be required to write a thesis in mathematics. If a student writes an acceptable thesis, then he will be given the equivalent of nine quarter hours of course work for the thesis.

4. In addition to the above requirements, a student must pass a comprehensive examination in mathematics. This examination is given twice each year, and normally the student will take his examination within the academic year of the award of the Master of Science degree.

COMPUTER SCIENCE

CS 0001 (0-1) Special lectures; guest lectures; discussion of student thesis research, faculty research projects. PREREQUISITE: None.

CS 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

CS 2100 INTRODUCTION TO COMPUTERS AND PROGRAMMING (4-0). Characteristics of general purpose digital computers. Fundamentals of programming, Programming aids. Use of assembly routines and compilers. Procedure-oriented languages, e.g., FORTRAN. Problems selected from numerical and non-numerical areas. Military applications of computers. PREREQUISITE: None.

CS 2110 INTRODUCTION TO COMPUTER PROCESSES (3-0). Concept and properties of an algorithm; language and notation of describing algorithms. Problem analysis and solution. Application of a specific procedure-oriented language, such as FORTRAN, to solve simple numerical and non-numerical problems using a computer. PREREQUISITE: None.

Upper Division or Graduate Courses

CS 3111 COMPUTER ORGANIZATION AND PROGRAMMING (4-0). Logical organization of a computer. Machine representations of information, machine language and instruction repertoires. Input-output considerations. Sub-routines, macros, interpretive and assembly systems. Monitor systems. PREREQUISITE: CS 2110 or equivalent.

*CS 3200 LOGICAL DESIGN OF DIGITAL COMPUTERS (4-0).

CS 3201 COMPUTER SYSTEMS DESIGN I (4-0). Some considerations in the design of a computer system. Storage, accessing, data paths, control, logical and arithmetical units. Sequential control, concurrent operations. Input-output devices. PREREQUISITES: CS 3200 and CS 3111.

CS 3204 DATA COMMUNICATIONS (4-0). Quantitative study of communication processes. Concepts fundamental to the engineering of accurate, efficient communication links and systems. Elements of information theory. Communication channels and their capacity; encoding and decoding of data over noisy channels. Error detection and correction. Coding schemes; binary systems. Design of effective transmission links in computer-based systems. Survey of devices available for data communications in a military environment. Real-time control systems. PREREQUISITES: CS 3111, CS 3200, MA 2232.

*CS 3300 INFORMATION STRUCTURES (3-0).

*CS 3500 MILITARY APPLICATIONS OF COMPUTERS (4-0).

CS 3601 AUTOMATA AND FORMAL LANGUAGES (3-0). Logical networks, neural networks, finite automata, construction of minimal automata, regular expressions, context-free languages and push-down automata, context-sensitive languages and linear bounded automata. PREREQUISITE: MA 3063 or MA 3565.

* See listing under Electrical Engineering Department.

Graduate Courses

CS 4112 SYSTEMS PROGRAMMING I (4-0). Design of programs which process programs. Natural and artificial language. Theory and construction of assembly, interpretive and compiler programs. Executive routines, input-output control systems and operating systems. PREREQUISITE: CS 3111.

CS 4113 SYSTEMS PROGRAMMING II (4-0). Continuation of CS 4112. Further study of operating systems for both batch-processing and interactive computing. Special software considerations for multi-programming and multi-processing operations. Design of conversational languages and compilers. PREREQUISITE: CS 4112.

CS 4200 COMPUTER SYSTEMS DESIGN II (4-0). Hardware-software design for different types of computer systems. Concepts such as multi-programming, multi-processing, time-sharing, priority systems, real-time control hybrid computation. Data acquisition devices and the computers. Study of military command and control systems. Requirements for tactical and strategic processing. PREREQUISITE: CS 3201.

CS 4310 NON-NUMERICAL INFORMATION PROCESSING (4-0). Heuristic and algorithmic methods. Artificial intelligence and simulation of cognitive behavior. Pattern recognition. Simulation of learning and concept formation, decision-making, man-machine relationships. Self-organizing systems. PREREQUISITE: CS 3111.

CS 4601 EFFECTIVE COMPUTABILITY (3-0). Intuitive properties of algorithms. Turing machines, unlimited register machines, Markov algorithms, Post systems, recursive functions. Complexity of computation.

CS 4900 ADVANCED TOPICS IN COMPUTER SCIENCE (3-0). Analysis and discussion of selected aspects of the field of current research interest, e.g., multi-processing computer systems, formal languages, artificial intelligence, automata theory. PREREQUISITE: Consent of Instructor.

MATHEMATICS

MA 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MA 1000 BASIC ALGEBRA AND TRIGONOMETRY (4-0). 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. Definition of trigonometric functions. Solution of the right triangle. PREREQUISITE: None.

MA 1010 INTERMEDIATE ALGEBRA (4-0). 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 factoring 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 1021 COLLEGE ALGEBRA AND TRIGONOMETRY (4-0). 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 equations. PREREQUISITE: MA 1010 or equivalent.

MA 1030 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 by 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 probability theory from a set theory point of view. PREREQUISITE: None.

MA 1100 CALCULUS REVIEW (4-0). Functions of one variable, limits, derivatives, continuity, indefinite and definite integrals, transcendental functions, Taylor's theorem, vectors in two and three dimensions, functions of several variables, partial derivatives, multiple integration. PREREQUISITE: A previous course in calculus.

MA 1101 REVIEW OF CALCULUS FUNDAMENTALS (5-0). Development of the real numbers as an ordered field. Study of limits. Review of elementary calculus, including basic differentiation and integration formulas, Taylor's theorem. Calculus of functions of several variables, partial derivatives, chain rule differentiation, Jacobians, multiple integrals and transformation of integrals. PREREQUISITE: A previous course in calculus.

MA 1105 CALCULUS AND ANALYTIC GEOMETRY I (5-0). Introduction to plane analytic geometry, functions of one variable, limits, derivative of rational functions, indefinite integrals, definite integration with applications, elementary transcendental functions. PREREQUISITE: MA 1021.

MA 1106 CALCULUS AND ANALYTIC GEOMETRY II (5-0). Methods of integration, improper integrals, conic sections, hyperbolic functions, polar coordinates, introduction to vector algebra in two and three dimensional space, functions of several variables, tangent plane and normal line, partial differentiation. PREREQUISITE: MA 1105.

MA 1107 CALCULUS AND ANALYTIC GEOMETRY III (3-0). Higher order partial derivatives, maxima and minima for functions of two variables, multiple integrals with applications, infinite series. L'Hospital's rule, introduction to differential equations. PREREQUISITE: MA 1106.

MA 1110 REVIEW OF ELEMENTARY CALCULUS (5-0). A review of selected topics in the calculus of one variable including an introduction to differential equations. PREREQUISITE: A previous course in calculus.

MA 1115 CALCULUS I (5-0). Introduction to plane analytic geometry, functions of one variable, limits continuity, derivatives, indefinite and definite integrals, transcendental functions, conic sections, elementary vector algebra, vector differentiations. PREREQUISITE: Some previous work in calculus.

MA 1116 CALCULUS II (5-0). Polar coordinates, vector algebra and vector calculus in three dimensional space, functions of several variables, double and triple integrals, infinite series, introduction to differential equations. PREREQUISITE: MA 1115.

Upper Division Courses

MA 2025 LOGIC, SETS AND FINITE MATHEMATICS (4-0). Propositional logic and elements of set theory. Relations, functions and partitions. Elements of finite probability theory. PREREQUISITE: None.

MA 2042 LINEAR ALGEBRA (4-0). Elementary matrix algebra. Vector spaces, linear dependence, basis, dimension, rank. Systems of linear equations. Determinants. Linear transformations, change of basis, characteristic, equation, roots and vectors of a matrix. Special matrices: symmetric, orthogonal, inverse. Orthogonal reduction of symmetric matrix. Inverse by partitioning. Introduction to quadratic forms. Cayley Hamilton theorem. Algebra of vectors through triple products. Calculus of vectors including introduction to gradient, divergence, curl. PREREQUISITE: MA 1101 (may be taken concurrently).

MA 2045 INTRODUCTION TO LINEAR ALGEBRA (3-0). Complex numbers. Systems of linear algebraic equations. Matrix algebra. Vector spaces. Rank. Inverse by Gauss' method. Determinants. Adjoint and inverse. Characteristic equation, roots and vectors—proper axes for quadric surface, solution of system of differential equations. Orthogonal reduction to diagonal form. PREREQUISITE: MA 1100 or equivalent.

MA 2110 SELECTED TOPICS FROM ADVANCED CALCULUS (4-0). A selection of topics from Advanced Calculus, such as infinite series, differential equations, improper integrals, introduction to functions of a complex variable. PREREQUISITE: MA 1101 or equivalent.

MA 2121 DIFFERENTIAL EQUATIONS AND INFINITE SERIES (4-0). Ordinary differential equations: infinite series of constants and functions; Taylor series in one and two variables with remainder; series solutions of ordinary differential equations including Bessel's equation; Fourier series. PREREQUISITE: MA 1100 or equivalent.

MA 2130 REVIEW OF SELECTED TOPICS OF ENGINEERING MATHEMATICS (4-0). Taylor and Fourier expansions. Linear differential equations, including series solutions. Bessel functions and Legendre polynomials; applications in the solution of partial differential equations. Sturm Liouville systems and orthogonal-function expansions in solving boundary-value problems. PREREQUISITE: Consent of Instructor.

MA 2161 INTRODUCTION TO MATHEMATICAL PHYSICS (3-0). 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. PREREQUISITES: MA 1110 and MA 2121 (the latter may be taken concurrently).

MA 2172 INTRODUCTION TO COMPLEX VARIABLES (3-0). Complex numbers and their algebra. Regions of the complex plane. Analytic functions, elementary functions, integration and series representations. Residue theory. PREREQUISITE: MA 2121 or equivalent.

MA 2181 INTRODUCTION TO VECTORS (3-0). A course in vector algebra and analysis designed for students unable to satisfy the MA 1100 prerequisite for MA 3181. Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems; applications in various fields of engineering. PREREQUISITES: MA 1115 and MA 1116 (the latter may be taken concurrently).

MA 2232 NUMERICAL METHODS AND FORTRAN PROGRAMMING (4-0). Structure of computers and basic FORTRAN. Error propagation. Evaluation of functions by power series and Chebyshev series. Telescoping of series. Rational approximations. DO loops and arrays. Roots of nonlinear equations. Subroutines, evaluation of integrals by trapezoidal, Simpson's and Gauss' quadrature formulae. Elimination and iteration techniques to solve linear systems of equations. Curve and surface fitting. Runge-Kutta and predictor-corrector methods for differential equations. The students are expected to complete eight to ten FORTRAN programs of increasing complexity. PREREQUISITE: MA 2121 or equivalent.

MA 2300 MATHEMATICS FOR MANAGEMENT (5-0). This course is designed to provide the mathematical basis for modern managerial tools and techniques. It includes a review of algebra, systems of linear equations and linear inequalities, introductory material from linear programming, vectors and matrices, a brief survey of differential and integral calculus and fundamentals of probability. PREREQUISITE: None.

MA 2550 ELEMENTARY NUMBER THEORY (3-0). Divisibility, congruences, quadratic reciprocity, Diophantine equations, continued fractions, partitions. PREREQUISITE: Consent of Instructor.

MA 2580 PROJECTIVE GEOMETRY (3-0). A brief intuitive introduction to projective geometry, Desargues' theorem, projectivities, cross-ratios after which the subject is begun on an axiomatic basis. Coordinates are introduced in the projective plane on the basis of Desargues' theorem in the noncommutative case, and Pappus' theorem (in the commutative case). Higher dimensional spaces, conics and linear transformations. PREREQUISITE: Consent of Instructor.

Upper Division or Graduate Courses

MA 3042 LINEAR ALGEBRA (5-0). Systems of linear algebraic equations. Matrix algebra. Vector spaces. Rank. Inverse by Gauss' method. Determinants. Adjoint and inverse. Characteristic equation, roots, vectors—proper axes for a quadric surface, applications to systems of differential equations. Similarity to a diagonal matrix. Special types of matrices. Orthogonal reduction to diagonal form. Quadratic forms and reductions. Lambda matrices and related topics. Cayley-Hamilton theorem and reduced characteristic function. Canonical forms of a matrix and applications—systems of differential equations, stability criteria, matrix equations. PREREQUISITE: MA 2121 or equivalent.

MA 3046 LINEAR ALGEBRA (3-0). Special types of matrices. Orthogonal reduction of a real symmetric matrix to diagonal form. Quadratic forms and reductions to expressions involving only squares of the variables. Applications to maxima and minima. Lambda matrices and related topics. Cayley-Hamilton theorem. PREREQUISITE: MA 2045.

MA 3047 LINEAR ALGEBRA (3-0). Reduced characteristic function. Canonical forms. Idempotent and nilpotent matrices. Solutions to matrix polynomial equations. Functions of a square matrix. Applications such as to differential equations, stability criteria. PREREQUISITE: MA 3046.

MA 3053 GRAPH THEORY AND COMBINATORIAL ANALYSIS (3-0). Permutations and combinations. Generating functions. The principle of inclusion and exclusion. Partitions, compositions. Trees and networks. Paths, circuits, chains and cycles of a graph. The fundamental numbers in graph theory. Associated matrix and incidence matrix. Transportation networks. PREREQUISITE: MA 1030 or equivalent.

MA 3063 ALGEBRAIC FOUNDATIONS OF COMPUTER SCIENCE (3-0). Semi-groups, groups, rings and fields. Order relations, lattices and Boolean algebras. Universal algebras and relational systems. Finite automata as algebraic systems. PREREQUISITE: MA 2025 or equivalent.

MA 3132 PARTIAL DIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORMS (4-0). Solution of boundary value problems by separation of variables; Sturm-Liouville problems; Fourier, Bessel and Legendre series solutions; Laplace and Fourier transforms; classification of second order equations; applications. PREREQUISITE: MA 2121 or equivalent.

MA 3172 COMPLEX VARIABLES (4-0). Analytic functions, integration and series representations. Residue theory and application to Laplace transform. Conformal mapping and applications. PREREQUISITE: MA 2121 or equivalent.

MA 3173 LAPLACE TRANSFORM (3-0). Definition and some elementary properties of the Laplace transform. Application of these properties to the solution of a differential and/or difference equation. Laplace integral as a complex integral. The inversion integral. The inverse transform by residues. Further properties and applications of the transform to include application to boundary value problems. PREREQUISITE: MA 3172.

MA 3181 VECTOR ANALYSIS (3-0). Vector differential and integral calculus in rectangular and orthogonal curvilinear coordinate systems; applications in various fields of engineering. PREREQUISITE: MA 1100 or equivalent.

MA 3185 TENSOR ANALYSIS I (3-0). Definition of a tensor. Algebra of tensors. The metric tensor. The geometric representation of vectors in general coordinates. The co-variant derivative and its application to geodesics. The Riemann tensor, parallelism, and curvature of space. PREREQUISITE: Consent of Instructor.

MA 3212 SELECTED TOPICS IN APPLIED ANALYSIS (4-0). First and higher order iterative processes. Approximations of functions and/or data by polynomials and rational functions. Least squares. Orthogonal functions to include Legendre, Laguerre, Hermite and Chebyshev polynomials. Continued fractions, representation of elementary functions as continued fractions. Rational approximations of functions by continued fractions and relation to Pade approximation. Linear difference equations, their solutions and relation to the theory of ordinary differential equations. Solutions of difference equations as approximations to continued fractions. PREREQUISITE: MA 2172 or equivalent.

MA 3232 NUMERICAL ANALYSIS (4-0). Solution of equations. Iterative methods for solving systems of equations. Zeros of polynomials. Interpolation and approximation. Numerical differentiation and quadrature. Matrix manipulations; linear simultaneous algebraic equations. Numerical solutions of ordinary differential equations. PREREQUISITE: MA 2121 and FORTRAN programming or equivalent.

MA 3243 NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS (4-1). Finite difference approximations for derivatives. Truncation and discretization errors. Parabolic and hyperbolic equations. Explicit and implicit methods. The Crank-Nicolson method. The implicit alternating direction method. Approximations at irregular boundaries. Elliptic equations. The Liebmann method. Systems of partial differential equations. Students are expected to write FORTRAN programs for the above methods. A term project involving the solution of a suitably difficult boundary value problem is required. PREREQUISITES: MA 2232 and MA 3132 or equivalent.

MA 3352 MISSILE MECHANICS (3-0). A survey of ballistic missile dynamics including discussions of atmospheric structure; 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.

MA 3362 ORBITAL MECHANICS (3-0). Review of kinematics, Lagrange's equation of motion. The earth's gravitational field. Central force motion. The two body problem. The determination of orbits. The three body problem. Perturbations. PREREQUISITE: A course in dynamics.

MA 3372 DIFFERENTIAL EQUATIONS FOR OPTIMUM CONTROL (3-0). Variational equations, adjoint system of differential equations, Green's functions, Duhamel and convolution integrals. Calculus of variations, Euler equations, maximum principle, properties of extremals, region of attainability. Numerical methods for determining and correcting trajectories, particularly optimum trajectories, on a digital computer; methods of steepest ascent, variation of extremals, dynamic programming. Applications to ship routing and rocket trajectories. PREREQUISITE: MA 2121 (programming experience desirable).

MA 3393 TOPICS IN APPLIED MATHEMATICS (Credit Variable). The subject matter of this seminar will vary according to the interests of the participants. Topics will be chosen from the fields of modern optimization theory, applied functional analysis, trajectory, orbit analysis, special functions of applied mathematics, relativity theory, or from the other fields. PREREQUISITE: Consent of Instructor.

MA 3510 FOUNDATIONS OF MATHEMATICS (3-0). Propositional and predicate calculus with proof theory and formal number theory. Godel theorems on undecidability and completeness and the Lowenheim-Skolem theorem. PREREQUISITE: Consent of Instructor.

MA 3520 SET THEORY (3-0). An intuitive development of Cantor's set theory, including a theory of cardinal and ordinal numbers with a discussion of well-ordering and the choice axiom, followed by a brief introduction to the Zermelo-Fraenkel axioms. PREREQUISITE: Consent of Instructor.

MA 3565 MODERN ALGEBRA I (3-0). Elements of set theory, equivalence relations and sets. Mappings and composition of mappings. Some elementary properties of integers, e.g., Euclidean algorithm, g.c.d., l.c.m., congruence relation. Group theory, subgroups. Normal subgroups and quotient groups. Homomorphisms, isomorphisms and automorphisms. Counting principles. PREREQUISITE: Consent of Instructor.

MA 3566 MODERN ALGEBRA II (3-0). Rings, ideals and quotient rings, Euclidean rings and polynomial rings. Linear vector spaces. Fields, extension fields, Galois groups and solvability. PREREQUISITE: MA 3565.

MA 3580 DIFFERENTIAL GEOMETRY (3-0). Curvature, evolutes and involutes transformation groups, lie algebras. Space curves, surfaces, geodesics and Riemannian geometry. PREREQUISITES: MA 2045 and MA 3606.

MA 3590 TOPICS IN ALGEBRA AND ANALYSIS (3-0). This course is one of variable content and is designed to meet occasional needs of groups of students interested in some particular aspects of algebra and/or analysis. Topics that might be treated: group theory, theory of numbers, theory of equations; theories of integration, et cetera. PREREQUISITE: Consent of Instructor.

MA 3591 TOPICS IN GEOMETRY (3-0). The subject matter of this seminar will vary according to the interests of the participants. Usually, the content will be topics from algebraic geometry, projective differential geometry, foundations, metric geometry. PREREQUISITE: Consent of Instructor.

MA 3605 FUNDAMENTALS OF ANALYSIS I (3-0). Elements of set theory, the real number system, and the usual topology in En. Properties of continuous functions. Differentials of vector-valued functions, Jacobians, and applications (implicit function, inverse function theorems, extremum problems). PREREQUISITE: Consent of Instructor.

MA 3606 FUNDAMENTALS OF ANALYSIS II (3-0). Functions of bounded variation and theory of Riemann-stieltjes integration. Multiple and iterated integrals. Convergence theorems for sequences and series of functions. PREREQUISITE: MA 3605.

MA 3610 INTRODUCTION TO GENERAL TOPOLOGY (3-0). Topologies, bases and subbases, compactness and connectivity. Moore-Smith convergence theorems. Metrization and embedding theorems, uniform structures, Tychonoff product theorem, Alexandroff and Stone-Cech compactification. PREREQUISITE: MA 3605.

MA 3660 BOUNDARY VALUE PROBLEMS (3-0). The partial differential equations of physics and their solutions by separation of variables. Orthogonal sets of functions; Fourier series, their convergence and other properties. Applications to boundary value problems, verification and uniqueness of solutions. Continuation to include Bessel functions and Legendre polynomials. PREREQUISITE: MA 2121 or equivalent.

MA 3675 THEORY OF FUNCTIONS OF A COMPLEX VARIABLE I (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 3676 THEORY OF FUNCTIONS OF A COMPLEX VARIABLE II (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 3675.

MA 3691 SEMINAR IN ANALYSIS (3-0). 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 3730 NUMERICAL ANALYSIS AND COMPUTATION (3-0). Algorithms, flow charts, and FORTRAN statements. Difference equations. Iterative procedures to solve equations and systems of equations. Linear difference equations. Quotient-difference algorithms. FORTRAN subroutines. The interpolating polynomial and its contruction. Numerical differentiation and integration. Numerical solution of differential equations. PREREQUISITE: Graduate standing in engineering or sciences.

Graduate Courses

MA 4186 TENSOR ANALYSIS II (3-0). A continuation of MA 3185. Introduction to special relativity theory, with emphasis upon axiomatic and philosophical foundations. Formulation of the laws of mechanics and electromagnetism in relativistic form. Introduction to general relativity. PREREQUISITE: MA 3185 and a sound background in classical mechanics and electromagnetism.

MA 4237 ADVANCED TOPICS IN NUMERICAL ANALYSIS (4-0). The subject matter will vary according to the abilities and interests of those enrolled. PREREQUISITE: MA 3243.

MA 4362 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: A course in dynamics.

MA 4520 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: Consent of Instructor.

MA 4581 ALGEBRAIC CURVES (3-0). Algebraic varieties, Hilbert Nullstellensatz, absolute theory of varieties, normal varieties, Riemann-Roche theorem. PREREQUISITES: MA 3565 and MA 3566.

MA 4607 FUNDAMENTALS OF ANALYSIS III (3-0). Continuation of MA 3606. Line and surface integrals, Stokes' theorem, improper integrals. Fourier series and Fourier integrals. PREREQUISITE: MA 3606.

MA 4611 CALCULUS OF VARIATIONS (3-0). Bliss' differential methods, Euler equations, Weierstrass-maximum principle, Legendre conditions. Perturbation techniques, numerical procedures for determining solutions, and applications to engineering and control problems. PREREQUISITE: MA 2121 (programming experience desirable).

MA 4612 TOPICS IN NONLINEAR MATHEMATICS (3-0). Linear and nonlinear transformations. Nonlinear algebraic and transcendental equations.. Nonlinear optimization; nonlinear programming and systems of inequalities. Nonlinear ordinary differential equations. Introduction to automatic control and the maximum principle. PREREQUISITE: MA 4622 or Consent of Instructor.

MA 4622 PRINCIPLES AND TECHNIQUES OF APPLIED MATHEMATICS (3-0). Generalized functions and direct operational methods for solving linear problems; Green's functions and solution of ordinary and partial differential equations; eigenvalue problems of ordinary differential equations. PREREQUISITES: MA 3047 and MA 4637 (the latter may be taken concurrently).

MA 4635 FUNCTIONS OF REAL VARIABLES I (3-0). Axiomatic set theory, development of the real numbers, semicontinuous functions, absolutely continuous functions, functions of bounded variation. Classical Lebesgue measure and integration theory in E1, convergence theorems and Lp spaces. PREREQUISITE: MA 3606.

MA 4636 FUNCTIONS OF REAL VARIABLES II (3-0). Abstract measure and integration theory, signed measures, Radon-Nikodym theorem, Lebesgue decomposition and product measures. Daniell integrals and integral representation of linear functionals. PREREQUISITE: MA 4635.

MA 4637 INTRODUCTION TO FUNCTIONAL ANALYSIS (3-0). An introduction to Banach and Hilbert spaces, including open mapping-closed graph theorem, weak and weak* topologies, spectral theorems for compact Hermitian operators. Hermitian bounded and normal bounded operators. PREREQUISITE: MA 4636.

MA 4662 INTEGRAL EQUATIONS (3-0). 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 4672 INTEGRAL TRANSFORMS (3-0). The Laplace, Fourier and Hankel transforms and their inversions. Applications to problems in engineering and physics. PREREQUISITE: MA 3172.

MA 4677 THEORY OF FUNCTIONS OF A COMPLEX VARIABLE III (3-0). Special functions of a complex variable. Analytic theory of differential equations. PREREQUISITE: MA 3676.

MA 4691 SEMINAR IN ANALYSIS (Variable). Topics to be chosen from functional analysis, integration theory, partial differential equations and differential manifolds. PREREQUISITE: Consent of Instructor.

MA 4872 TOPICS IN CALCULUS OF VARIATIONS (3-0). Recent developments in the numerical solution of problems in the calculus of variations. Foundations of numerical methods, applied to control problems. Differentials, perturbations, variational equations, adjoint system, conditions for optimum. Euler equations, maximum principle of Weierstrass and Pontryagin, the Legendre condition. Methods of solution: special variations, variation of extremals, dynamic programming. Applications in ship routing and missile control. PREREQUISITES: MA 2121, MA 3046 and computer programming or Consent of Instructor.

MA 4945 PROBLEM SEMINAR I (3-0). Under the guidance of several faculty members, the student is exposed to a variety of problems from diverse fields with the purpose of enhancing problem-solving ability and breadth of conceptualization. The problems fall into five or six classes, each representing a central theme of a mathematical topic or problem-solving technique. Approximately half the time is devoted to lectures by the participating faculty, during which time problems are posed and relevant techniques for their solution discussed. The other half is devoted to the presentation and discussion of solutions by the students. PREREQUISITES: B.S. in Mathematics, or equivalent.

MA 4946 PROBLEM SEMINAR II (6-0). Toward the end of Problem Seminar I, the student is expected to select a topic from those presented (or another suitable one) and then develop this into an up-to-date expository paper of the survey type. Depth of conceptualization and experience in independent inquiry are the key objectives. Each student will be under the guidance of a faculty member. Toward the end of the quarter, each student will present a summarized version of his findings to the other students and the participating faculty. PREREQUISITE: MA 4945.

PROBABILITY AND STATISTICS

Upper Division Courses

PS 2111 INTRODUCTION TO PROBABILITY AND STATISTICS I (4-0). Elementary probability concepts. Finite sample outcome spaces. Discrete probability laws and their application to meteorology, operations analysis, engineering and management. Data reduction. Properties of probability laws. Conditional probability and Bayes theorem. Random variables. Selected continuous probability laws and their applications. Central limit properties. Elements of sampling and its use in statistics. PREREQUISITE: A previous course in differential calculus.

*PS 2301 PROBABILITY (4-0).

PS 2311 ELEMENTARY PROBABILITY AND STATISTICS (3-0). 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: MA 1021 or equivalent.

PS 2321 INTRODUCTION TO PROBABILITY AND STATISTICS (3-1). 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 1021 or equivalent.

PS 2325 INTRODUCTION TO PROBABILITY THEORY (3-1). A basic axiomatic development of probability theory. Sets and probability axioms. Discrete random variables and probability laws. Moments, Bayes theorem, law of large numbers. Some of the topics will be explored on the School's computer system.

PS 2331 ELEMENTARY PROBABILITY AND STATISTICS (4-1). Elements of the theory of probability. The classical probability distributions. Elements of statistical inference with applications in the field of the group. PREREQUISITE: MA 1100 or equivalent.

Upper Division or Graduate Courses

PS 3101 MANAGEMENT STATISTICS I (5-0). 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. Discussion of tests of hypothesis and parameter estimation. Regression and correlation theory. Bayesian methods. Applications to management problems. PREREQUISITE: MA 2300.

PS 3102 MANAGEMENT STATISTICS II (4-1.) A continuation of PS 3101. Emphasis on statistical inference applied to management problems.

PS 3112 PROBABILITY AND STATISTICS I (4-0). Discrete and continuous probability laws with engineering, meteorological, operations analysis, and systems analysis applications. Fundamental properties of probability laws and their role in assessing measurement of random events. Derived distributions. Elements of sampling and sample distributions and moments. Central limit theorems with applications. Introduction to statistical estimation. Reliability applications. PREREQUISITE: A thorough knowledge of differential and integral calculus.

PS 3113 PROBABILITY AND STATISTICS II (4-0). Confidence interval estimation and hypothesis testing. Life testing and system reliability estimation. Linear and multiple regression with application to prediction and estimation. Systems analysis pertaining to redundancy reliability, and maintainability. Selected topics in applied areas. PREREQUISITE: PS 3112 or equivalent.

PS 3205 PROBABILITY (3-0). Elements of set theory. Foundations of probability and basic rules of computation. Sample space, random variable, discrete and continuous distribution of 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 2121 and MA 3172.

*PS 3302 PROBABILITY AND STATISTICS (4-1).

*PS 3303 STATISTICS (4-1).

PS 3315 PROBABILITY AND STATISTICS (4-1). 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 distributions. 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 1100 or equivalent.

PS 3316 APPLIED ENGINEERING STATISTICS (3-0). Tests of hypothesis and estimation. Analysis of variance. Statistical quality control, control charts. Sampling inspection. Reliability theory and application. PREREQUISITE: PS 3315.

PS 3326 PROBABILITY AND STATISTICS (3-1). A continuation of PS 2325. Continuous random variables and their probability laws. Moments. Elements of sampling, sampling distributions and moments. Introduction to statistical point and interval estimation. Use will be made of the School's digital computer to determine, for example, probability distributions by simulation.

PS 3327 APPLIED STATISTICS (3-1). A continuation of PS 3326. Statistical inference. Correlation theory, multiple regression analysis, analysis of variance. Role of the computer in solving complex statistical problems. Use will be made of the comprehensive library of statistical programs available in the School.

PS 3332 APPLIED STATISTICS (3-0). 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 3315.

PS 3335 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 1100 of equivalent.

PS 3336 STATISTICS II (3-0). 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 3335.

*PS 3510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0).

Graduate Course

PS 4206 DECISION THEORY AND CLASSICAL STATISTICS (3-0). 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 3205.

*PS 4306 APPLIED STATISTICS (4-0).

*PS 4321 DESIGN OF EXPERIMENTS (3-1).

*PS 4322 SAMPLE INSPECTION AND QUALITY ASSURANCE (3-1).

*PS 4323 DECISION THEORY (3-0).

*PS 4431 ADVANCED PROBABILITY (3-0).

*PS 4432 STOCHASTIC PROCESSES (3-0).

*PS 4510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0).

* See listing under Operations Analysis Department.

DEPARTMENT OF MECHANICAL ENGINEERING

TURGUT SARPKAYA, Professor of Mechanical Engineering; Chairman (1967)*; M.S. in M.E., Tech. Univ. of Istanbul, 1951; Ph.D., Univ. of Iowa, 1954; Research Professor, Univ. of Manchester, 1966.

DENNIS KAVANAUGH, Professor Emeritus (1926); B.S., Lehigh Univ., 1914.

HAROLD MARSHALL WRIGHT, Professor Emeritus (1945); B.Sc. in M.E., North Carolina State College, 1930; M.M.E., Rensselaer Polytechnic Instiute 1931.

JOHN ANTHONY DAVID ACKROYD, Visiting Associate Professor of Mechanical Engineering (1968); B.Sci., Univ. of London, 1960; Ph.D., 1964; Previously lecturer in the Department of the Mechanics of Fluids of the University of Manchester.

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.

JOSEPH 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.

MATTHEW DENNIS KELLEHER, Assistant Professor of Mechanical Engineering (1967); B.S. in Eng. Sci., Notre Dame Univ. 1961; M.S.M.E., 1963; Ph.D., 1966.

CECIL DUDLEY GREGG KING, Associate Professor of Mechanical Engineering (1952); B.E., Yale Univ., 1943; M.S. in M.E., Univ. of California at Berkeley, 1952.

EUGENE FRANCIS LYNCH, JR., Lieutenant (junior grade), U.S. Naval Reserve; Instructor in Mechanical Engineering (1968); B.S. in M.E., Univ. of Notre Dame, 1964; M.S., 1960; Ph.D., 1968.

PAUL JAMES MARTO, 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.

ROBERT EUGENE NEWTON, Professor of Mechanical Engineering (1951); B.S. in M.E., Washington Univ., 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951.

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. Professor of Mechanical Engineering (1956); B.S. in M.E., Purdue Univ., 1949; M.S. in M.E., 1950; Ph.D., Stanford Univ., 1955.

NILS PER TYVAND, Assistant Professor of Mechanical Engineering (1968); B.S. in M.E., Royal College of Science and Technology (Glasgow), 1964; M.S. in M.E., Univ. of Strathclyde, 1965; Ph.D. in Aerospace Engineering, Univ. of Florida, 1968.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN MECHANICAL ENGINEERING

A specific curriculum should be consistent with the general minimum requirements for the degree as determined by the Academic Council.

Any program leading to award of a degree must be approved by the Chairman of the Department of Mechanical Engineering at least two quarters 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.

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

1. 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.

2. Mechanical Engineering Courses. A minimum of 58 quarter hours in mechanical engineering courses is required, at least 30 of them being in courses 3000-4999.

3. 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: linear algebra, differential equations and series, numerical methods and digital computers, and partial differential equations.

ELECTRICAL ENGINEERING—10 quarter hours.

MATERIAL SCIENCE—4 quarter hours.

Some of these requirements may, with the consent of the departmental chairman, be met by transfer credit.

4. UPPER DIVISION CREDIT. Minimum credit of 94 quarter hours in upper division or higher level courses is required.

5. Sample Program. A sample program satisfying the above requirements is given under Naval Engineering Programs, Curriculum No. 570.

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

1. Areas of Specialization. The Department of Mechanical Engineering offers Master of Science degrees with specialization in the following four areas: Engineering Mechanics, Fluid Dynamics and Thermo-Sciences, Nuclear Engineering, and Ocean Mechanical Engineering.

2. Undergraduate Preparation. A candidate shall have satisfied the requirements for the degree of Bachelor of Science in Engineering. Credit requirement in succeeding paragraphs must be met by courses in addition to those used to satisfy this requirement.

3. Mechanical Engineering Courses. The Master of Science degree in Mechanical Engineering requires a minimum of 36 quarter hours of graduate level credits, at least 10 of them in courses 4000-4999, plus an acceptable thesis.

4. Courses in Other Departments. A minimum of 8 quarter hours of graduate credit must be earned outside of the Mechanical Engineering Department.

5. Sample programs in various areas of specialization leading to the Master of Science degree in Mechanical Engineering are given under Naval Engineering Programs, Curriculum No. 570.

THE PROGRAM LEADING TO THE DEGREE OF MECHNICAL ENGINEER

Graduate students may, upon satisfactory completion of seven quarters of academic work, enter the program leading to the degree of Mechanical Engineer. Normally, this program is of three years duration.

The Engineer's degree requires a minimum of 80 graduate course credits, at least 30 of them in courses 4000-4999, plus an acceptable thesis pertinent to the area of specialization among the following four areas: Engineering Mechanics, Fluid Dynamics and Thermo-Sciences, Nuclear Engineering, and Ocean Mechanical Engineering.

An advisor will be appointed by the departmental chairman for consultation in the development of a program of study and research. Approval of all programs must be obtained from the Chairman, Department of Mechanical Engineering.

MECHANICAL ENGINEER

ME 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

ME 2101 ENGINEERING THERMODYNAMICS (4-1). The fundamental laws of thermodynamics. Equations of state. Thermodynamic properties of substances. Entropy, irreversibility and availability. Cycle analysis including reversed cycles. Gas-vapor mixtures. Combustion and dissociation. Application of thermodynamic principles to marine power plant equipment. TEXT: Faires, *Thermodynamics*, 4th ed. PREREQUISITE: MA 1100.

ME 2120 ELEMENTS OF ENGINEERING THERMODYNAMICS (3-2). The fundamental concepts of thermodynamics; thermodynamic properties and equations of state; the first law of thermodynamics; entropy and the second law of thermodynamics; cycle analysis with some applications. TEXT: Durham, *Thermodynamics*, 2nd ed. PREREQUISITE: PH 1015.

ME 2201 FLUID MECHANICS (4-2). Mechanical properties of fluids, hydrostatics, metacenter and stability analysis; energy considerations in steady flow; principles of impulse-momentum and dynamic forces; dimensional analysis and theory of modelling; viscous effects, energy loss, laminar and turbulent flows; fluid flow measurements; analysis of fluid machinery; associated laboratory experiments and problem work. TEXT: Daugherty and Franzini, *Fluid Mechanics with Engineering Applications*, 6th ed. PREREQUISITES: ME 2502 and MA 2232 (May be concurrent).

ME 2410 MECHANICAL ENGINEERING LAB I (1-3). Fundamentals of mechanical measurements. Structured laboratory experiments using resistance strain gages, pressure transducers, temperature and flow measurement devices. Performance characteristics of an operating system. TEXTS: Beckwith and Buck, *Mechanical Measurements*, Perry and Lissner. *The Strain Gage Primer*. PREREQUISITES: ME 2101, ME 2201, ME 2502, and ME 2601.

ME 2501 MECHANICS I (4-0). Laws of statics. Applications to structures and machines. Kinematics. Dynamics of a particle. TEXT: Beer and Johnston, *Vector Mechanics*. PREREQUISITE: A course in vector algebra (may be concurrent) or its equivalent.

ME 2502 MECHANICS II (3-0). Principles of dynamics. Work and energy. Impulse and momentum. Rigid body kinematics. Dynamics of rigid bodies. TEXT: Beer and Johnston, *Vector Mechanics*. PREREQUISITE: ME 2501 (or equivalent).

ME 2601 MECHANICS OF SOLIDS I (3-2). Stress, strain, Hooke's law, tension and compression, shearing stresses, connections, thin vessels, torsion, statics of beams, stresses in beams, deflection 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: ME 2501 and MA 1100.

ME 2641 STRUCTURAL MECHANICS (4-0). Review of statics of rigid bodies and applications to determine structures. Stress, strain, Hooke's law, tension and compression, shearing stresses. Connections, thin vessels, torsion. Statics of beams, flexural stresses and deformations, numerical methods. Simple indeterminate structures. Combined loadings and combined stresses. Columns. TEXT: Timoshenko and Young, *Elements of Strength of Materials*. PREREQUISITE: A course in mechanics.

ME 2711 MACHINE DESIGN I (3-2). Material selection, tolerances and allowances, variable loads and stress concentration, screw fastenings, springs, theories of failure, shafts, journal and plane surface bearings, ball and roller bearings; gears, flexible power-transmitting elements, brakes and clutches. TEXT: Faires, *Design of Machine Elements*. PREREQUISITE: ME 3611.

ME 2901 INDIVIDUAL STUDY IN MECHANICAL ENGINEERING (Hours 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.

Upper Division or Graduate Courses

ME 3150 HEAT TRANSFER (4-2). Elementary treatment of the principles of heat transfer applicable to problems in Mechanical Engineering. Steady-state conduction in one and two dimensions; unsteady-state conduction, principles of forced and natural convection; thermal radiation; boiling; condensation; heat exchanger analysis. Use of the thermal circuit, analog, numerical, and graphical techniques. Laboratory experiments. TEXT: Holman, *Heat Transfer*. PREREQUISITES: ME 3202 and MA 3132.

ME 3161 CONDUCTION AND RADIATION HEAT TRANSFER (3-0). Steady-state heat conduction in one and multi-dimensions with and without sources; transient conduction; numerical and analog methods for heat conduction; mechanical engineering application; black body radiation; radiation from real surfaces; radiation exchange between finite surfaces; radiation in absorbing and emitting media. TEXT: Chapman, *Heat Transfer*, 2nd ed. PREREQUISITES: ME 2101 and MA 3132.

ME 3170 HEAT TRANSFER AND GAS DYNAMICS (4-2). The fundamental heat transfer mechanisms; conduction, convection, and radiation; and the use of various techniques in the solution of heat transfer problems relating to mechanical engineering. Fundamentals of one-dimensional compressible flow including effects of area change, normal shock and friction. TEXTS: Holman, *Heat Transfer;* Shapiro, *The Dynamics and Thermodynamics of Compressible Flow.* PREREQUISITES: ME 2101 and ME 2201.

ME 3202 GAS DYNAMICS (3-0). Application of the continuity, momentum and energy theorems to the flow of compressible fluids through devices encountered in mechanical engineering. One dimensional isentropic flow. Normal shock waves. Adiabatic flow in constant area ducts with friction. Flow in ducts with heating or cooling. Generalized one-dimensional continuous flow. Oblique shocks. TEXT: Shapiro. *The Dynamics and Thermodynamics of Compressible Flow.* PREREQUISITES: ME 2101 and ME 2201.

ME 3301 NUCLEAR POWER SYSTEMS (4-0). Fundamentals of nuclear reactor physics. Diffusion and slowing down of neutrons. Reactor kinetics and control. Radiation shielding. Engineering considerations in nuclear reactors including core thermal and hydraulic design. Principal reactor types. Radioisotopic power generation. TEXT: King, Nuclear Power Systems; El Wakil, *Nuclear Power Engineering.* PREREQUISITES: ME 3170 or equivalent and PH 2810.

ME 3315 NUCLEAR MEASUREMENTS LAB (1-4). Laboratory experiments on the interaction of radiation with matter, radiation detection principles, neutron physics and nuclear reactor operation. The use of various health physics instruments and radiation detectors employed in nuclear reactor technology. Shielding length and Fermi age. Experiments involving reactor operation such as control rod calibration. TEXT: Glower, *Experimental Reactor Analysis and Radiation Measurements.* PREREQUISITES: ME 2410 and ME 4311.

ME 3341 RADIATION SHIELDING (4-0). Radiation sources. Interaction of electromagnetic radiation, charged particles and neutrons with matter. The damage of radiation to materials and organisms. Shielding problems including radiation streaming in ducts and heating within the shield. The mechanical engineering design of radiation shields. TEXTS: Goldstein, *Fundamental Aspects of Reactor Shielding;* Rockwell, *Reactor Shielding Design Manual.* PREREQUISITES: PH 2810, ME 3315, and ME 4311.

ME 3430 MECHANICAL ENGINEERING LAB II (2-3). A project-oriented continuation of mechanical measurement principles with emphasis on dynamic response characteristics and systems theory. Application of measurement techniques using projects in thermodynamics, mechanics of solids, heat transfer, fluid flow, vibrations, and nuclear radiation detection. TEXT: Beckwith and Buck, *Mechanical Measurements.* PREREQUISITES: ME 2410 and ME 3521.

ME 3440 ENGINEERING SYSTEMS ANALYSIS (3-0). Analogs and mechanical engineering analogies; dynamical systems and their characteristics; methods of solution for analogous and mixed systems; dimensional analysis and applications; principles of feedback and control; analog and digital computer applications of system analysis. TEXT: Sutherland, *Engineering Systems Analysis;* Crandall, *Engineering Analysis.* PREREQUISITES: ME 2101, ME 2201, ME 3611, and ME 3801.

ME 3450 MARINE POWER SYSTEMS ANALYSIS (2-4). Preliminary design planning, involving project work, of ship propulsion systems. Hull selection and estimation of hull power requirements, inter-relationship of components, heat balances, flow diagrams, computation and presentation of ship and plant performance indices. Preliminary investigation of major equipment items including steam generators, turbines and condensers. Seminars and field trips on occasion. TEXTS: Seward, *Marine Engineering,* Vols. I and II; Church, *Steam Turbines,* 3rd ed. PREREQUISITES: ME 2101, ME 2201 and ME 3150 or its equivalent.

ME 3521 MECHANICAL VIBRATIONS (3-2). Kinematics and kinetics of free and forced vibration of linear systems having one or two degrees of freedom. Energy methods. Applications to vibration isolation and suppression in mechanical systems. Vibration of bars, shafts and beams. Numerical solutions. Laboratory experiments with mechanical and simulated systems. TEXT: Thomson, *Vibration Theory and Applications.* PREREQUISITES: ME 2502, ME 2601, and MA 3132.

ME 3611 MECHANICS OF SOLIDS II (4-0). 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. TEXT: Timoshenko, *Strength of Materials,* Parts I and II. PREREQUISITES: ME 2601 and MA 2121.

ME 3642 STRUCTURAL THEORY (4-0). Stability and determinacy of simple structures. Energy methods. Matrix methods. Flexibility and stiffness methods. Dynamic response of systems having one, two, and many degrees of freedom. TEXTS: Gere and Weaver, *Analysis of Framed Structures;* Rogers, *Dynamics of Framed Structures.* PREREQUISITES: ME 2641 and MA 2121.

ME 3712 MACHINE DESIGN II (3-4). Machine design projects which require complete design studies. TEXT: Faires, *Design of Machine Elements.* PREREQUISITES: ME 2711 and ME 3521.

ME 3801 FLUID POWER CONTROL (3-2). Fluid power transmission; pressure-flow relationships; pneumatic systems and steady state operations; electromagnetic and electro-hydraulic actuators; dynamic performance of physical systems; power steering; servomechanisms and servos for high-pressure hot gases. TEXT: Bulliet, *Servomechanisms.* PREREQUISITES: MA 3132 and either ME 3170 or ME 3202.

ME 3811 AUTOMATIC CONTROL SYSTEMS (3-2). Ordinary linear automatic control systems; automatic regulation systems; special linear regulation systems; non-linear systems; methods of plotting the regulation-process curve; the stability of linear feedback systems; the design and compensation of feedback control systems and mechanical engineering applications. TEXT: Popov, *The Dynamics of Automatic Control Systems;* Dorf, *Modern Control Systems.* PREREQUISITES: MA 3132 and ME 3440.

Graduate Courses

ME 4140 DIRECT ENERGY CONVERSION (3-0). Introduction to the principles of direct energy conversion employing thermoelectric, thermionic, photovoltaic, magneto-hydrodynamic, and fuel cell power generators. TEXT: Angrist, *Direct Energy Conversion*. PREREQUISITES: ME 2101, ME 3202, EE 2101, and MA 2121.

ME 4162 CONVECTION HEAT TRANSFER (3-0). Fundamental principles of forced and free convection; dimensionless correlations of convection; heat transfer during phase changes; combined conduction, convection and radiation heat transfer systems; heatexchanger with mechanical engineering applications. TEXT: Chapman, *Heat Transfer*, 2nd ed. PREREQUISITE: ME 3161 and ME 4220.

ME 4211 HYDRODYNAMICS (4-0). Potential and stream functions; vortex dynamics; body hydrodynamics; acquisition of potential solutions; conformal transformation and mapping; approximate solutions; discontinuous flows and free-streamline solutions; naval engineering applications. TEXT: Robertson, *Hydrodynamics in Theory and Application*. PREREQUISITES: MA 3132 and either ME 3170 or ME 3202.

ME 4220 BOUNDARY LAYER THEORY (4-0). Boundary layer equations; similar boundary-layers; study of the relationships between various boundary-layer functions with mechanical engineering applications; solutions of the velocity and thermal-energy equations; axisymmetric, non-similar, and time-dependent boundary layers; stability of steady and unsteady boundary layers; transition and turbulence; equations of isotropic and homogeneous turbulence. TEXTS: Evans, *Laminar Boundary Layers*; Schlichting, *Boundary Layer Theory*, 6th ed. PREREQUISITES: MA 3132 and either ME 3170 or ME 3202.

ME 4230 ADVANCED TOPICS IN FLUID DYNAMICS AND HEAT TRANSFER (4-0). Linearized steady theory of fully wetted hydrofoils; viscous resistance of ships; methods of predicting ship resistance from model experiments; reduction of friction resistance; transport processes in turbulent flows; unsteady problems in conduction and convection; mass transfer; radiation gas dynamics. TEXTS: Sedov, *Two-Dimensional Potential Flow Problems in Hydrodynamics*; Hinze, *Turbulence*; Kudryavtsev, *Unsteady State Heat Transfer*; and instructor's notes. PREREQUISITES: ME 3161, ME 4162, ME 4211, ME 4220, and MA 3172 taken concurrently.

ME 4240 ADVANCED HYDRODYNAMICS (4-0). Jets, wakes, and cavities; free-streamline theory; cavitation and cavity flows; screw-propeller theory with applications to turbo-machinery; real-fluid limitations and experimental verifications; steady and unsteady separated flows; analysis of the motion of rotating masses of fluids; special problems. TEXT: Robertson, *Hydrodynamics in Theory and Application*; Lamb, *Hydrodynamics*. PREREQUISITE: ME 4230.

ME 4311 NUCLEAR REACTOR THEORY (5-0). Nuclear reactions induced by neutrons. Neutron cross sections. The fission process. Diffusion and slowing down of neutrons in media with and without absorption. Fermi age theory. Reactor kinetics and control. Emphasis on reactor design parameters and their relation to reactor engineering problems. TEXT: Lamarsh, *Introduction to Nuclear Reactor Theory*. PREREQUISITES: PH 2810 and MA 3132.

ME 4312 ADVANCED NUCLEAR REACTOR THEORY (4-0). Multigroup diffusion methods. Reflected reactor systems. Design parameters in heterogeneous reactors. Numerical techniques in reactor analysis. Introduction to transport theory. Perturbation theory. TEXT: Lamarsh, *Introduction to Nuclear Reactor Theory* with class notes. PREREQUISITES: ME 4311 and MA 3172.

ME 4321 REACTOR ENGINEERING PRINCIPLES AND DESIGN (4-2). Reactor heat generation and removal. Thermal stress analysis. Nuclear cycles and nuclear energy conversion. Principal types of reactor systems. The synthesis of reactor physics, heat transfer and hydraulics, properties of materials and safety requirements in reactor design. Design optimization procedures. Student group design project. TEXT: Glasstone and Sesouske, *Nuclear Reactor Engineering*. PREREQUISITES: ME 4311, ME 3161 and ME 4162.

ME 4512 ADVANCED DYNAMICS (4-0). Mechanical systems treated by advanced methods. Particle and rigid body kinematics in three dimensions. Systems of particles. The inertia tensor. Matrix formulations of rigid body kinematics. Hamiltonian and Lagrangian formulations and applications to electromechanical systems. TEXT: Synge and Griffith, *Principles of Mechanics* (or equivalent), plus classroom notes. PREREQUISITES: ME 2502 and ME 3521.

4522 ADVANCED VIBRATIONS (3-1). Matrix analysis of mechanical systems with many degrees of freedom. Transient response. Shock isolation. Non-linear systems. Digital computer solutions. TEXT: Tong, *Theory of Mechanical Vibration*. PREREQUISITES: ME 3521 and MA 2232 (or equivalent).

ME 4612 MECHANICS OF SOLIDS III (4-0). Elements of theory of elasticity. Stress tensor and theories of failure. Torsion of noncircular sections. Plastic analysis. Matrix methods in structural analysis. Brittle fracture. TEXTS: Timoshenko, *Strength of Materials*, Part II; Timoshenko and Goodier, *Theory of Elasticity*; Parker, *Brittle Behavior of Engineering Structures*. PREREQUISITES: MA 3132 and ME 3611.

ME 4613 ADVANCED METHODS OF ANALYSIS IN ELASTICITY (4-0). Modern methods of analysis for complex problems of elasticity. Plate and shell structures. Applications to ship structures, submarine hulls, nuclear reactors. TEXT: Zienkiewicz, *The Finite Element Method*. PREREQUISITE ME 4612.

ME 4620 THEORY OF CONTINUOUS MEDIA (4-0). Tensor analysis. Stress and strain tensors. Motion of a continuum. Energy and entropy. Constitutive equations. Mechanical applications in the theory of elasticity and fluid dynamics. TEXT: Frederick and Chang, *Continuum Mechanics*. PREREQUISITES: ME 3611 and MA 3132.

ME 4902 ADVANCED STUDY IN MECHANICAL ENGINEERING (2-0 to 6-0). 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.

DEPARTMENT OF METEOROLOGY

GEORGE JOSEPH HALTINER, Professor of Meteorology; Chairman (1946)*; B.S., College of St. Thomas, 1940; Ph.M., Univ. of Wisconsin, 1942; Ph.D., 1948.

RONNIE LEE ALBERTY, Assistant Professor of Meteorology (1967); B.S., Univ. of Missouri (Columbia Campus), 1963; M.S. 1965; Ph.D., 1967.

RICHARD CONRAD CARRIGAN, Lieutenant Commander, U.S. Navy; Instructor in Meteorology (1957); B.S., Naval Academy, 1956; M.S., Naval Postgraduate School, 1965.

DONALD CHIN, Commander, U.S. Navy; Instructor in Meteorology; B.S., Rutgers Univ., 1952; M.S., Cornell Univ., 1953; M.S., Naval Postgraduate School, 1964.

WILLIAM DWIGHT DUTHIE, Distinguished Professor and Professor of Meteorology (1945); B.A., Univ. of Washington, 1935; M.S., 1937; Ph.D., Princeton Univ., 1940.

CLAUDE FINLEY GILES, Commander, U.S. Navy; Instructor in Meteorology; B.S., Parks College of St. Louis Univ., 1948; B.S. in Meteorology, Naval Postgraduate School, 1955.

JERRY DAVID MAHLMAN, Assistant Professor of Meteorology (1967); A.B., Chadron State College, 1962; M.S., Colorado State Univ., 1964; Ph.D., 1967.

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.

CHARLES LUTHER TAYLOR, Associate Professor of Meteorology (1954); B.S. Pennsylvania State Univ., 1942; M.S., 1947.

WILLEM VAN DER BIJL, Associate Professor of Meteorology (1961); B.Sc., Free Univ. of Amsterdam, 1941; M.Sc., 1943; Ph.D., State Univ., Utrecht, 1952.

ROGER TERRY WILLIAMS, Associate Professor of Meteorology, (1968); A.B., Univ. of California at Los Angeles, 1959; M.A., 1961; Ph. D., 1963.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN METEOROLOGY

BACHELOR OF SCIENCE IN METEOROLOGY

1. The degree of Bachelor of Science in Meteorology requires completion of:

a. Mathematics courses including differential and integral calculus, vectors, digital computers, and numerical methods.

b. Thirty-six quarter hours of meteorology courses including the basic sequences in dynamic, physical and synoptic meteorology.

c. An acceptable research paper.

MASTER OF SCIENCE IN METEOROLOGY

1. Entrance to a program leading to a Master of Science degree in Meteorology requires mathematics through differential and integral calculus and a minimum of one year of college physics.

2. The degree of Master of Science in Meteorology requires completion of:

a. Mathematics courses in vector analysis, partial differential equations, and application of numerical methods and computers to the solution of partial differential equations.

b. Thirty-five quarter hours of graduate meteorology courses of which eighteen hours must be in the 4000 series.

c. The basic sequence of graduate courses in the fields of dynamical, physical and synoptic meteorology, must be included in these 35 hours.

d. An acceptable thesis.

METEOROLOGY

MR 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Lower Division Courses

MR 1105 WEATHER CODES—OBSERVATIONS—PLOTTING (0-3). Acquaintance with weather codes and observation stressing utility and application; introduction to analysis of scalar fields stressing basic techniques and continuity. TEXTS: WBAN Manuals for Synoptic, Radiosonde and Upper Wind Codes; International Cloud Atlas; Weather Station Index Manual; departmental notes. PREREQUISITE: MR 2200.

Upper Division Courses

MR 2100 METEOROLOGY (3-0). The principles of meteorology and the effects of weather phenomena on naval operations. Topics include: structure of the atmosphere; weather elements; pressure and winds; theory of air masses and fronts; tropical storms; sources of weather information; sea and swell conditions; principles of weather map analysis and forecasting. TEXT: Petterssen, *Introduction to Meteorology.* PREREQUISITE: None.

MR 2200 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 anti-cyclones, tropical disturbances, storms, and hurricanes. TEXTS: Petterson, *Introduction to Meteorology*; AMS Glossary of Meteorology. PREREQUISITE: None.

MR 2205 METEOROLOGY FOR OCEANOGRAPHERS (0-4). A laboratory course in weather observations, codes, and the technique of synoptic analysis. The emphasis is on the surface chart and the determination of meteorological parameters for application to problems in oceanography. TEXTS: WBAN Manual for Synoptic Codes; Weather Station Index Manual; departmental notes; ASWEPS Series Manual, Vol. 3. PREREQUISITE: MR 2200 concurrently.

MR 2220 WEATHER MAP ANALYSIS (4-0). Graphical arithmetic; techniques of scalar and frontal analysis; evaluation of surface and upper-air data; structure and behavior of extratropical cyclones; stability analysis and air masses;/objective forecasting of weather elements; space/time cross sections. TEXTS: Berry, Bollay, Beers, *Handbook of Meteorology;* departmental notes. PREREQUISITES: MR 1105, MR 2200, MR 2411 or MR 3411; MR 3301 or MR 4321 concurrently.

MR 2225 WEATHER MAP ANALYSIS LABORATORY (0-6). Laboratory course taught in conjunction with MR 2220 Graphical arithmetic practice in upper-air and surface analysis; analysis of upper-air soundings, and vertical space/time cross-sections; introduction of meteorological satellite observations, local forecasting techniques and mesoscale synoptic analysis. TEXTS. Berry, Bollay, Beers, *Handbook of Meteorology;* departmental notes. PREREQUISITES: MA 1105, MR 2220.

MR 2279 OPERATIONAL METEOROLOGY (1-6). Instruction and laboratory practice in operational functions and responsibilities of the Naval Weather Service. TEXTS: Selected publications of the Air Systems Command, Air Weather Service, and Naval Weather Research Facility; departmental notes. PREREQUISITE: MR 3255.

MR 2410 METEOROLOGICAL INSTRUMENTS (3-2). The application of the basic principles of mechanics, heat electricity, sound, and optics to meteorological instruments. Design and operation of meteorological instrumentation employed by the Navy with special emphasis on electronic and satellite developments. TEXTS: Middleton and Spilhaus, *Meteorological Instruments;* selected papers and departmental notes. PREREQUISITE: MA 1115 concurrently.

MR 2411 INTRODUCTION TO THERMODYNAMICS OF METEOROLOGY (4-0). A treatment of elementary thermodynamics and its application to meteorology with particular emphasis on thermodynamic charts and diagrams. Theories of condensation and precipitation processes. Geopotential determinations and instability criteria. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology*. PREREQUISITE: MA 1116 concurrently.

MR 2510 CLIMATOLOGY (4-2). Statistical evaluation of meteorological elements in theory and in practice. (Frequency distributions. Correlation and regression.) Verification systems. Techniques of objective forecasting. Classification of climates. TEXTS: Conrad and Pollak, *Methods in Climatology*; Schaum (Spiegel), *Statistics*; departmental notes. PREREQUISITE: MA 1116 concurrently.

Upper Division or Graduate Courses

MR 3230 TROPOSPHERIC AND STRATOSPHERIC METEOROLOGY (4-0). Observation, computation, analysis, and synoptic interpretation of tropospheric and stratospheric data (to 10 mb) with emphasis on the middle and high altitude aspects of satellite meteorology, jet streams, tropopauses, vertical motion, hydrometeors, and related numerical products. TEXTS: Widger, *Meteorological Satellites;* Riehl, *Jet Streams of the Atmosphere;* Craig, *The Upper Atmosphere;* Webb, *Structure of the Stratosphere and Mesosphere;* various U.S. Navy, Environmental Science Services Administration and Air Weather Service publications; reprints and departmental notes. PREREQUISITES: MR 2220; MR 4322 or MR 3302 concurrently.

MR 3235 TROPOSPHERIC AND STRATOSPHERIC METEOROLOGY LABORATORY (0-9). Practice in the meso- and synoptic-scale analysis of parameters considered in MR 3230 with emphasis on objectivity, interrelationships, and application to forecast problems. TEXTS: Widger, *Meteorological Satellites;* Riehl, *Jet Streams of the Atmosphere;* Craig, *The Upper Atmosphere;* various U.S. Navy, Environmental Science Services Administration, and Air Weather Service publications; reprints and departmental notes. PREREQUISITE: MR 2225; MR 3230 concurrently.

MR 3250 TROPICAL AND SOUTHERN HEMISPHERE METEOROLOGY (3-0). The general circulation and air masses of the Southern Hemisphere; climatology and synoptic models in the tropics; analysis and forecasting tropical weather systems with emphasis on cyclones and meteorological satellite observations. TEXTS: Berry, Bollay, Beers, *Handbook of Meteorology;* Riehl, *Tropical Meteorology;* Harding and Kotsch, *Heavy Weather Guide;* departmental notes, reprints. PREREQUISITES: MR 4322 or MR 3302, MR 3230.

MR 3255 TROPICAL AND SOUTHERN HEMISPHERE METEOROLOGY LABORATORY (0-6). Laboratory course associated with MR 3250. Contour (isobaric), streamline, and isotach analysis and forecasting with emphasis on climatology, tropical cyclones, and meteorological satellite observations. TEXT: Berry, Bollay, Beers, *Handbook of Meteorology;* Riehl, *Tropical Meteorology;* reprints and departmental notes. PREREQUISITES: MR 3235; MR 3250 concurrently.

MR 3260 PROGNOSTIC CHARTS AND EXTENDED FORECASTING (3-0). Subjective and objective methods, both kinematical and dynamical, for constructing prognostic charts, upper-air and surface, with greater emphasis on the latter; graphical numerical techniques; interpretation and alternation of computer-generated prognoses. Extended forecasting by weather type methods; interpretation of National Meteorological Center extended forecasts. TEXTS: George, *Weather Forecasting for Aeronautics;* Petterssen, *Weather Analysis and Forecasting Vol. I;* Environmental Science Services Administration and Fleet Numerical Weather Facility Manuals; departmental notes. PREREQUISITES: MR 4323 or MR 3303 concurrently.

MR 3265 PROGNOSTIC CHARTS AND EXTENDED FORECASTING LABORATORY (0-6). Laboratory course taught in conjunction with MR 3260. Extended analysis; practice in construction and interpretation of prognostic charts. Weather typing; interpretation of National Meteorological Center extended forecasts and charts. TEXTS: George, *Weather Forecasting for Aeronautics;* Environmental Science Services Administration and Fleet Numerical Weather Facility Manuals; departmental notes. PREREQUISITES: MR 3235; MR 3260 concurrently.

MR 3301 FUNDAMENTALS OF DYNAMIC METEOROLOGY I (4-0). Equations of motion; wind types; trajectories and streamlines; vertical variation of wind; friction, surface and spiral layers; continuity and tendency equations; mechanism of pressure changes, vorticity and divergence equations. TEXT: Haltiner and Martin *Dynamical and Physical Meteorology.* PREREQUISITES: MA 2181, MR 2411.

MR 3302 FUNDAMENTALS OF DYNAMIC METEOROLOGY II (4-0). Simple types of wave motion, filtering; objective analysis and numerical prediction; barotropic and baroclinic models; baroclinic instability; vertibal velocity; finite differencing relaxation; numerical errors. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology;* departmental notes: PREREQUISITE: MR 3301.

MR 3303 COMPUTER METEOROLOGY (3-0). Continuation of MR 3302; Computer products of Fleet Numerical Weather Facility and other groups; pressure-height, temperature, cloud, ocean wave, and clear-air turbulence, forecasting, etc. TEXT: U.S. Naval Weather Service Manual for Computer Products and departmental notes: PREREQUISITES: MR 3302, CS 3111 or equivalent.

MR 3403 INTRODUCTION TO ENERGY-TRANSFER PROCESSES (4-0). Properties of radiating matter in general; solar and terrestrial radiation and their effects on 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; interpretation of satellite radiation measurements from thermodynamic and heat budget considerations. TEXTS: Haltiner and Martin, *Dynamical and Physical Meteorology;* departmental notes. PREREQUISITE: MR 3302.

MR 3411 METEOROLOGICAL THERMODYNAMICS (4-0), The physical variables; equations of state; first law of thermodynamics; properties of gases, water, and moist air; theories of condensation and precipitation processes; cloud physics, meteorological thermodynamic diagrams; air-mass identification indices; geopotential determinations; instability phenomena and criteria. TEXT: Haltiner and Martin. *Dynamical and Physical Meteorology.* PREREQUISITE: MA 2121 concurrently.

MR 3510 STATISTICAL CLIMATOLOGY (4-2). Statistical evaluation of meteorological elements in theory and in practice. (Frequency distribution, correlation and regression, analysis of variance, and time series analysis.) Verification systems. Techniques of objective forecasting. Classification of climates. TEXTS: Barger, *Climatology at Work*; Panofsky and Brier, *Some Applications of Statistics to Meteorology;* departmental notes. PREREQUISITE: MA 1100 concurrently.

MR 3900 SEMINAR IN METEOROLOGY (2-0). Students present original research or prepare summaries of recent findings in the field of meteorology and present synopses for group discussion. PREREQUISITE: None.

Graduate Courses

MR 4321 DYNAMIC METEOROLOGY I (4-0). Equations of motion; coordinate systems and mapping; wind types; baroclinicity; vertical variation of wind; friction; diffusion of momentum; surface and spiral layers; continuity and tendency equations; structure of pressure systems; vorticity and divergence equations. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology;* departmental notes. PREREQUISITES: MA 3181, MR 3411.

MR 4322 DYNAMIC METEOROLOGY II (4-0). Scale analysis; perturbation method; solutions of equations of motion for simple sound, gravity, and synoptic waves; filtering; baroclinic and barotropic instability; energy equations; integral constraints. TEXT: Haltiner and Martin, *Dynamical and Physical Meteorology;* departmental notes; PREREQUISITE: MR 4321.

MR 4323 NUMERICAL WEATHER PREDICTION (4-2). Objective analysis; barotropic and baroclinic models; vertical velocity; finite-difference equations; computational instability; boundary conditions; relaxation techniques, inclusion of heat, friction, and moisture; energetic and general circulation models. TEXT: Thompson, *Numerical Weather Analysis and Prediction;* departmental notes. PREREQUISITES: MR 4322, MA 3243 concurrently.

MR 4412 HEAT TRANSFER PROCESSES (4-0). Black bodies and their properties; the fundamental laws of radiation flux transfer both in beam and diffused form, methods of terrestrial-flux computations by numerical methods with application of sounding data; interpretation of satellite radiation measurements both in terrestrial and solar regions. Surface-layer heat and water-vapor transports by turbulence and stability effects upon such transports including that of momentum; eddy-spectral analysis. The heat budget of the atmosphere. TEXTS: Elasser and Culbertson, *Atmospheric Radiation Tables*; Lumley and Panofsky, *The Structure of Atmospheric Turbulence.* PREREQUISITE: MR 4321 concurrently.

MR 4422 UPPER ATMOSPHERE PHYSICS (3-0). Composition, temperature, and wind above 30 km. Physics and chemistry of ozonosphere and ionosphere. Atmospheric tides, earth's magnetic field, airglow, Van Allen belts. TEXTS: Craig, *The Upper Atmosphere;* Massey and Boyd, *The Upper Atmosphere;* departmental notes. PREREQUISITE: MR 4412.

MR 4800 SPECIAL TOPICS IN METEOROLOGY (3-0). Independent study of advanced topics in Meteorology not regularly offered. PREREQUISITE: Consent of the instructor.

MR 4900 SEMINAR IN METEOROLOGY (2-0). Students present results of their thesis work for group discussion. PREREQUISITE: Preparation of Master's degree thesis concurrently.

DEPARTMENT OF OCEANOGRAPHY

Dale Frederick Leipper, Professor of Oceanography; Chairman (1968)*; B.S., Wittenberg Univ., 1937; M.A., Ohio State Univ., 1939; Ph.D., Scripps Institution of Oceanography (La Jolla), 1950.

Robert Sanborn Andrews, Assistant Professor of Oceanography (1968); B. of Geol. Engr., Univ. of Minnesota, 1958; M.S., Univ. of Washington, 1965; Ph.D., Texas A&M Univ., 1968.

Noel Edward James Boston, Assistant Professor of Oceanography, (1968); B.A.Sc., Univ. of British Columbia, 1959; M.S., Texas A&M, 1963.

Robert Lawrence Ceres, Lieutenant Commander, U.S. Navy; Instructor in Oceanography; B.S., Naval Academy, 1959; M.S., Naval Postgraduate School, 1965.

Henry Crew, Assistant Professor of Oceanography (1968); B.A., Pomona College, 1955; M.S., Univ. of Washington, 1958; Ph.D., Texas Agricultural & Mechanical College, 1968.

Warren Wilson Denner, Assistant Professor of Oceanography (1964); B.S., Portland State College, 1961; M.S., Oregon State Univ., 1963.

Jack Ellsworth Geary, Commander, U. S. Navy; Instructor in Oceanography; B.S., Univ. of California, 1954; M.S., Naval Postgraduate School, 1961.

Theodore Green, III, Assistant Professor of Oceanography (1965); A.B., Amherst College, 1959; M.S., Stanford Univ., 1961; Ph.D., 1965.

Eugene Clinton Haderlie, Professor of Oceanography (1965); A.B., Univ. of California at Berkeley, 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.

Raymond James Smith, Professor of Oceanography (1967); B.S., California Institute of Technology, 1945; M.S., 1948; M.A., Princeton Univ., 1950; Ph.D., 1951.

Warren Charles Thompson, Professor of Oceanography (1953); B.A., Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas Agricultural and Mechanical College, 1953.

Edward Bennett Thornton, Assistant Professor of Oceanography (1968); B.S., Stanford Univ., 1962; M.S., Oregon State Univ., 1964; M.E. in C.E., Univ. of Florida, 1966; Ph.D., 1968.

Stevens Parrington Tucker, Assistant Professor of Oceanography (1968); B.S., Stanford Univ., 1955; M.S., Oregon State Univ., 1963; Ph.D., 1968.

Joseph John von Schwind, Associate Professor of Oceanography (1957); B.S., Univ. of Wisconsin, 1952; M.S., Univ. of Utah at Salt Lake City, 1960.

Jacob Bertram Wickham, Associate Professor of Oceanography (1951); B.S., Univ. of California at Berkeley, 1947; M.S., Scripps Institution of Oceanography, 1949.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN OCEANOGRAPHY

MASTER OF SCIENCE IN OCEANOGRAPHY

1. Entrance to a program leading to a Master of Science degree in Oceanography requires mathematics through differential and integral calculus, a minimum of one year of college physics, and a year of college chemistry.

2. The degree of Master of Science in Oceanography requires completion of:

a. Mathematics courses in vector analysis, partial differential equations, and application of numerical methods and computers to the solution of partial differential equations.

b. Thirty-seven quarter hours of graduate oceanography courses, of which fifteen hours must be in the oceanography 4000 series.

c. The basic sequences of descriptive courses in the fields of instrumentation biological, chemical, geological and physical oceanography must be included in these 37 hours.

d. Also to be included in these 37 hours are: for the physical oceanography option—courses in waves and tides, and in dynamical oceanography; for the geophysical oceanography option—courses in geophysics.

e. An acceptable thesis.

OCEANOGRAPHY

OC 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

OC 2110 INTRODUCTION TO OCEANOGRAPHY (3-0). An introductory course treating physical and chemical properties of sea water, submarine geology, and marine biology; the heat budget of the oceans; water masses and general circulation; currents, waves, and tides. TEXTS: Pickard, *Descriptive Physical Oceanography;* Coker, *This Great and Wide Sea.* PREREQUISITE: None.

Upper Division or Graduate Courses

OC 3150 GEOPHYSICAL RANDOM PROCESSES (4-2). Statistical evaluation of measurements in random media: ocean, atmosphere and earth. Frequency distributions, correlation and regression, analysis of variance. Time series analysis: covariance, convolution, energy density spectrum, cross spectrum: TEXTS: Panofsky and Brier, *Some Applications of Statistics to Meteorology;* departmental notes. PREREQUISITE: MA 3132 concurrently.

OC 3221 DESCRIPTIVE OCEANOGRAPHY (4-0). Properties of sea water; geomorphology of the ocean basins; distribution of temperature, salinity, and oxygen; heat budget of the oceans; water masses and the three-dimensional circulation of the oceans; currents, waves, and tides. TEXTS: Pickard, *Descriptive Physical Oceanography;* Sverdrup, Johnson, and Fleming, *The Oceans;* Neumann and Pierson, *Principles of Physical Oceanography.* PREREQUISITE: None.

OC 3250 DYNAMICAL OCEANOGRAPHY (4-0). Properties of sea water, the equations of motion in rotating frame of reference; special cases of motion: geostrophic, inertial, frictional flow, etc.; turbulence and mixing; convection; models of general circulation. Current measurements, direct and indirect. TEXTS: Von Arx, *Introductory Physical Oceanography.* Proudman, *Dynamical Oceanography.* PREREQUISITES: MA 3132 concurrently; OC 3220.

OC 3260 SOUND IN THE OCEAN (3-0). Designed for students in the meteorology curricula. A brief introduction to physics of underwater acoustics followed by detailed discussion of oceanographic factors affecting sound transmission in the ocean including absorption, reflection from the surface and from the bottom, refraction, scattering, and ambient noise. TEXT: Selected references. PREREQUSITE: OC 2110.

OC 3320 GEOLOGICAL OCEANOGRAPHY (3-8). Physiography of the sea floor, especially continental shelves and slopes, submarine canyons, coral reefs, and the deep-sea floor; properties 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: None.

OC 3420 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;* Hedgpeth, *Seashore Life of the San Francisco Bay Region and the Coast of Northern California.* PREREQUISITE: None.

OC 3520 CHEMICAL OCEANOGRAPHY (3-2). Basic chemistry of solutions; chemical compositions 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; desalination; corrosion; geochemistry. TEXT: Strickland and Parsons, *Methods in Chemical Oceanography.* PREREQUISITES: OC 3220, CH 1001 or CH 2001 or equivalent.

OC 3601 OCEAN WAVE FORECASTING (3-0). Statistical and spectral properties of ocean waves; the generation, propagation, and attenuation of surface wind waves in deep water; spectral and other forecasting techniques; wave observations and analysis of data. TEXTS: Kinsman, *Wind Waves;* H.O. Pub. 603. PREREQUISITE: OC 4211.

OC 3605 OCEAN WAVE FORECASTING LABORATORY (0-6). Laboratory course taught in conjunction with OC 3601. Exercises in wave observation, the analysis of wave records, forecasting of seas generated under various synoptic weather conditions, and forecasting of swell. TEXT: H.O. Pub. 603. PREREQUISITE: OC 3601 concurrently.

OC 3611 OCEAN WAVE AND SURF FORECASTING (2-0). Course designed for students in the meteorology curricula. Statistical and spectral properties of waves; wave observations and analysis of wave records; the generation propagation, and attenuation of sea and swell; techniques used in the forecasting of sea and swell; transformation of waves in shallow water. TEXT: H.O. Pub. 603 and H.O. Pub. 234. PREREQUISITE: OC 2110.

OC 3615 OCEAN WAVE AND SURF FORECASTING LABORATORY (0-6). Laboratory course taught in conjunction with OC 3611. Exercises in forecasting sea and swell generated under various synoptic weather conditions and in surf forecasting. TEXT: H.O. Pub. 603 and H.O. Pub. 234. PREREQUISITE: OC 3611 concurrently.

OC 3616 OCEANOGRAPHIC FORECASTING (3-0). Space and time variation of ocean density structure and associated parameters; behavior of vertical and horizontal temperature gradients; development of synoptic forecasting techniques applied to the upper ocean; air-sea interaction; advection and mixing effects on ocean density structure. Interpretation in terms of sound propagation paths and sonar range. TEXTS: James, *Antisubmarine Warfare Environmental Prediction System Manual No. 5*; selected publications. PREREQUISITES: OC 3260; OC 4253 concurrently or MR 2411.

OC 3621 OCEANOGRAPHIC FORECASTING LABORATORY (0-4). Laboratory exercises illustrate principles developed in OC 3616 using actual air and ocean data, available forecasting techniques (ASWEPS, and others), and range manuals. Forecasting of sea surface temperature, mixed-layer depth, and sonar range. TEXTS: ASWEPS Manual Series Vol. 7, Conversion Techniques (CONFIDENTIAL); selected publications. PREREQUISITE: OC 3616 concurrently.

OC 3700 OCEANOGRAPHIC INSTRUMENTATION AND OBSERVATIONS (3-0). Theory of design and operation of oceanographic instruments; recording of oceanographic observations, measurements, and samples on log sheets. TEXTS: H.O. 607, selected references. PREREQUISITES: OC 2110 or OC 3220.

OC 3710 FIELD EXPERIENCE IN OCEANOGRAPHY (0-4). Laboratory course taught in conjunction with OC 3700. Use of standard oceanographic instruments in the conduct of a comprehensive oceanographic survey; processing and storage of data and samples; interpretation of results. TEXTS: H.O. 607; selected references. PREREQUISITES: OC 3320, OC 3420, OC 3520, and OC 3700 concurrently.

Graduate Courses

OC 4211 WAVES AND TIDES (4-0). Theory of surface waves of small amplitude; theory of finite amplitude waves; wind-wave spectra; theory of the astronomical tides; tide analysis and prediction; tidal oscillations in ocean basins; tidal currents. TEXTS: Kinsman, *Wind Waves;* Defant, *Ebb and Flow;* Defant, *Physical Oceanography, Vol. II,* PREREQUISITE: OC 4251 or OC 3250 concurrently.

OC 4213 COASTAL OCEANOGRAPHY (4-1). Transformation of waves in shoal water; surf forecasting; storm tides; near-shore water circualtion and littoral drift; chacateristics of beaches and coasts. TEXTS: Weigel, *Oceanographical Engineering;* H.O. 234, Breakers and Surf. PREREQUISITES: OC 3601 and OC 3605.

OC 4251 DYNAMICAL OCEANOGRAPHY I (4-0). The equations of relative motion, incompressible flow, energy conservation, vorticity, turbulence and diffusion, and boundary layer flow in the ocean. Special cases of flow in the sea, particularly geostrophic motion. TEXTS: Haltiner and Martin, *Dynamical and Physical Meteorology;* Stommel, *The Gulf Stream;* Fomin, *The Dynamical Method.* PREREQUISITES: OC 2110 and MA 3132 concurrently.

OC 4252 DYNAMICAL OCEANOGRAPHY II (4-0). The wind-driven circulation and topographical influence on ocean currents; non-linear 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 4251.

OC 4253 DYNAMICAL OCEANOGRAPHY III (3-0). Laws of thermodynamics with applications to ideal gases, to the real atmosphere, and to sea water; thermohaline circulation; stability analysis. TEXTS: Haltiner and Martin, *Dynamical and Physical Meteorology;* Defant, *Physical Oceanography.* PREREQUISITE: OC 4252.

OC 4260 SOUND IN THE OCEAN (3-0). An introduction to the physics of underwater acoustics followed by a detailed discussion of the oceanographic factors affecting sound transmission in the ocean, including absorption, reflection from the surface and bottom, refraction, scattering, and ambient noise in the ocean; normal mode propagation; recent Navy developments. TEXTS: Selected references; Kinsler and Frey, *Fundamentals of Acoustics, 2nd ed.* PREREQUISITES: OC 3220, OC 3320, OC 3420, or OC 3520 concurrently and MA 3132.

OC 4340 MARINE GEOPHYSICS (3-0). Gravity, magnetism, seismicity, and other geophysical characteristics of the oceans and sea floor. Physical properties and composition of the sea floor. Structure of the earth's crust and upper mantle. Origin of the ocean basins and formation of major sea-floor features. TEXTS: Dobrin, *Geophysical Prospecting, 2nd ed.;* selected publications. PREREQUISITE: OC 3320.

OC 4421 MARINE ECOLOGY (1-4). The habits, classification, development, and adaptations of marine animals and plants with particular reference to the ecology of Monterey Bay. The relationships of physical, chemical, geological, and biological factors of the environment to marine organisms. Primarily laboratory investigations and field work dealing with the intertidal area, harbors, estuaries, and the near-shore pelagic and benthic environments of the associated organisms. TEXT: Ricketts and Calvin, *Between Pacific Tides.* PREREQUISITE: OC 3420.

OC 4612 POLAR OCEANOGRAPHY (3-0). Marine geography of the Arctic; sea-ice observations, properties, formation, growth, deformation, and disintegration; sea-ice drift due to wind and currents. TEXT: Sea Ice Manual (unpublished). PREREQUISITE: OC 4211.

OC 4851 GEOPHYSICS: EARTH GRAVITY (3-2). Study of the earth's gravity field; size and shape of the earth; deflection of the vertical; isostasy. Gravity instruments, techniques, and data interpretation in geophysical exploration. Gravimetric field will be conducted in vicinity of Monterey. TEXTS: Heiskanen and Vening Meinesz, *The Earth and its Gravity Field;* Garland, *The Earth's Shape and Gravity;* Dorbin, *Geophysical Prospecting.* PREREQUISITES: MA 3132, MA 3181.

OC 4852 GEOPHYSICS: EARTH MAGNETISM AND ELECTRICITY (3-2). Introduction to the earth's magnetic and electrical fields. Theory, instruments, and field techniques in magnetic and electorial exploration. Field work will be conducted. TEXTS: Jacob, *The Earth's Core and Geomagnetism;* Jakowsky, *Exploration Geophysics.* PREREQUISITES: MA 3132, MA 3181.

OC 4853 GEOPHYSICS: SOUND AND SEISMICITY (4-0). Development of fundamental elastic wave equations; ray and normal mode theory; wave propagation in layered media, reflectivity, and attenuation; seismicity of the earth; mechanics of earthquakes; time-distance curves; geophysical interpretation of seismic records. TEXTS: Officer, *Introduction to the Theory of Sound Transmission;* Richter, *Elementary Seismology;* Bullen, *Introduction to the Theory of Seismology.* PREREQUISITES: OC 4260 or consent of the instructor.

OC 4860 PHYSICS OF THE EARTH (3-0). Physical properties and composition of the earth's interior; review of the theories of the earth's formation; study of the crustal structure through gravity, magnetic, seismic and other geophysical evidence. TEXTS: Gutenberg, *Physics of the Earth.* PREREQUISITE: Consent of the Instructor.

OC 4900 SEMINAR IN OCEANOGRAPHY (3-0). Students in the oceanography curricula report results of their own original research and summarize recent literature in presentations for group discussion. TEXT: Selected publications. PREREQUISITE:

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.

EAMON BOYD BARRETT, Assistant Professor of Operations Research (1966); B.A., Univ. of Oregon, 1953; M.A., 1958; Ph.D., Stanford Univ., 1967.

RICHARD MAX BURTON, Assistant Professor of Operations Research (1967); B.S., Univ. of Illinois, 1961; M.B.A., 1963; D.B.A., 1967.

ROBERT NEAGLE FORREST, Associate Professor of Operations Research (1964); B.S., Univ. of Oregon, 1950; M.S., 1952; M.S., 1954; Ph.D., 1959.

HAROLD GREENBERG, Associate Professor of Operations Research (1967); B.A., Brooklyn College, 1949; M.S., New York Univ., 1958; Ph.D., 1964.

GILBERT THOREAU HOWARD, Assistant Professor of Operations Research (1967); B.S., Northwestern Univ., 1963; Ph.D., Johns Hopkins Univ., 1967.

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.

RONALD KOCHEMS, Assistant Professor (1965); B.S., Purdue Univ., 1961; M.S., 1962.

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.

KNEALE THOMAS MARSHALL, Assistant Professor of Operations Research (1968); B.Sc., Univ. of London, 1958; M.S., Univ. of California, 1964; 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, Associate Professor of Operations Research (1963); B.S., Brown Univ., 1958; Ph.D., Stanford Univ., 1966.

CLAIR ALTON PETERSON, Associate Professor of Operations Research (1962); B.B.A., Univ. of Minnesota, 1951; Ph.D., Massachusetts Institute of Technology, 1961 .

STEPHEN MICHAEL POLLOCK, Associate Professor of Operations Research (1965); B.E.P., Cornell Univ., 1958; M.S., Massachusetts Institute of Technology, 1960; Ph.D., 1964.

GARY KENT POOCK, Assistant Professor of Operations Research (1967); B.S., Iowa State Univ., 1961; M.S., Univ. of Miami, 1965; Ph.D., Univ. of Michigan, 1967.

ROBERT RICHARD READ, Associate Professor of Operations Research (1961); B.S., Ohio State Univ., 1951; Ph.D., Univ. of California, 1957.

DAVID ALAN SCHRADY, Assistant Professor of Operations Research (1965); B.S.M.S., Case Institute of Technology, 1961; M.S., 1963; Ph.D., 1965.

HERBERT SCHWARTZ, Assistant Professor of Operations Research (1968); B.A., Pomona College, 1961; M.A., Claremont Graduate School, 1967; Ph.D., 1968.

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.

JAMES GROVER TAYLOR, Assistant Professor of Operations Research (1968); B.S., Stanford Univ., 1961; M.S., 1962; Ph.D., 1966.

GARY ALLEN TUCK, Assistant Professor of Operations Research (1966); B.A., Univ. of Oklahoma, 1955; M.S., 1964; Ph.D., 1966.

JOSEPH BRYCE TYSVER, Associate Professor of Operations Research (1966); B.A., Washington State Univ., 1942; M.A., 1948; Ph.D., Univ. of Michigan, 1957.

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 W. ZEHNA, 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.

* *The year of joining the Postgraduate School Faculty is indicated in parentheses.*

DEPARTMENT REQUIREMENTS FOR DEGREES IN OPERATIONS RESEARCH

Programs leading to degrees in Operations Research must be arranged in consulation with the Chairman, Department of Operations Analysis.

BACHELOR OF SCIENCE IN OPERATIONS RESEARCH

1. The basic requirements for the degree of Bachelor of Science in Operations Research consists of a minimum of 60 upper division quarter hours at the Naval Postgraduate School and including at least:

   a. 36 quarter hours of Operations Research/Systems Analysis and Probability and Statistics.

   b. 12 quarter hours outside the Department of Operations Analysis.

2. The student must maintain a QPR of at least 1.2 courses offered by the Department of Operations Analysis.

MASTER OF SCIENCE IN OPERATIONS RESEARCH

1. A candidate shall previously have satisfied the requirements for the degree of Bachelor of Science in Operations Research or the equivalent.

2. Completion of a minimum of 48 quarter hours of graduate level courses, including at most 8 quarter hours for a thesis.

a. At least 18 quarter hours of 4000 level Operations Research/Systems Analysis courses.

b. An elective sequence approved by the Department of Operations Analysis.

3. Submission of an acceptable thesis on a subject previously approved by the Department of Operations Analysis. This credit shall not count toward the requirement stated in 2 a.

OPERATIONS ANALYSIS

OA 0001 SEMINAR (0-2). Guest Lecturers. Review of summer assignments, Thesis and research presentations. PREREQUISITE: None.

OA 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

Upper Division Courses

OA 2201 ELEMENTS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). An introductory course. 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. PREREQUISITE: PS 2111 or equivalent.

OA 2601 INTRODUCTION TO OPERATIONS ANALYSIS (4-0). Development of the fundamental concepts of operations and systems analysis. History of operations analysis. Formulation of mathematical models. Determination of effectiveness as a product of measures of search, contact, attack, and kill probabilities. Lanchester's equations. The nature of proof and model building. PREREQUISITE: None.

OA 2602 WAR GAMING AND SIMULATION (3-2). 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. Construction of digital simulation using FORTRAN and SIMSCRIPT. PREREQUISITE: None.

Upper Division or Graduate Courses

OA 3201 FUNDAMENTALS OF OPERATIONS ANALYSIS (4-0). An introduction to quality assurance elements including design reliability assessment, production assessment testing, environmental testing, system reliability demonstration. Introduction to hardware performance measures. Introduction to cost effectiveness analysis. Elements of probability and statistics developed as needed. PREREQUISITE: Differential and Integral Calculus.

OA 3202 METHODS OF OPERATIONS ANALYSIS/SYSTEMS ANALYSIS (4-0). Methodology of operations analysis/-systems analysis. Statistical estimation, and hypothesis testing. Life testing plans, point and interval estimates and reliability parameters. Elements of systems analysis pertaining to redundancy, maintainability, and spares. The role of systems analysis in solving military problems. PREREQUISITE: OA 3201 or equivalent.

OA 3203 SURVEY OF OPERATIONS ANALYSIS/SYSTEMS ANALYSIS (4-0). A survey of the military applications of operations analysis/systems analysis techniques of particular interest to the student. The applications usually covered are selected from decision, waiting lines resource allocation, replacement, cost-effectiveness, inventory theory, and search models. The techniques needed for these applications are developed as required and usually include topics in linear programming (including the simplex method), probability theory, nonlinear programming, statistics (including Bayesian and classical), dynamic programming and simulation. PREREQUISITE: PS 3112 or equivalent.

OA 3204 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 field of interest of the class will be discussed. PREREQUISITE: PS 3112 or equivalent.

OA 3205 OPTIMIZATION TECHNIQUES (4-0). Problems in the analysis of complex systems, and in the solution of single-stage and multi-stage decision problems in management science. Constrained extrema, Lagrangian multipliers, gradient methods, search strategies, optimization properties of convex functions; linear, quadratic and dynamic programming. Capabilities and limitations of various computational techniques. Applications in areas such as optimal control, econometrics and resource allocation. PREREQUISITE: PS 3303 or equivalent.

OA 3211 OPERATIONS ANALYSIS FOR MANAGEMENT I (4-0). Introduction to the philosophy and methodology of operations research. Survey of some of the more elementary techniques relating to decision making and optimization. PREREQUISITE: PS 3101.

OA 3212 OPERATIONS ANALYSIS FOR MANAGEMENT II (4-0). A continuation of OA 3211. Topics include: queueing, reliability, linear and dynamic programming, and gaming. PREREQUISITE: OA 3211.

OA 3213 INTRODUCTION TO LOGISTICS AND SUPPLY SYSTEMS (4-0). An introduction to logistic and supply management problems. Elements of inventory model building, allocation schemes, supply point locations, and correlation of specific logistic support activities. Emphasis on data source, collection, and reporting systems needed for management to operate supply systems economically. PREREQUISITE: OA 3212.

OA 3604 LINEAR PROGRAMMING (4-0). Theory of optimization of linear functions subject to linear constraints. The simplex algorithm, duality, dual simplex algorithm, sensitivity analysis, transportation algorithm, parametric linear programming, matrix payoff games, and integer linear programming. PREREQUISITE: MA 2042.

OA 3605 METHODS OF OPERATIONS RESEARCH/SYSTEMS ANALYSIS (4-0). A first course designed to survey the methodology of operations research and systems analysis. Topics in this sequence include: dynamic programming, PERT and PERT/COST, queueing, reliability, maintenance, replacement, networks, stochastic models, and allocation of search. PREREQUISITE: OA 3604.

OA 3610 UTILITY THEORY AND RESOURCE ALLOCATION MODELS (4-0). The nature of individual preferences and their utility function representation in certain and risk environments. Introduction to utility functions (social welfare functions) for groups. The resource allocation problem of firms and economies interpreted as linear programming models. Introduction to non-linear resource allocation models. PREREQUISITES: MN 3141, OA 3604.

OA 3611 SYSTEMS ANALYSIS I (4-0). Principles of systems analysis and their relationship to the planning, programming, and budgeting system (PPBS), and the traditional OR models. Analysis of effectiveness measures and models. Cost estimating and analysis. Overall structure of cost-effectiveness models and decision criteria. Risk and uncertainty problems. Current case studies and student design of studies. PREREQUISITES: OA 3604, OA 3610 (concurrently), PS 3303.

OA 3612 SYSTEMS ANALYSIS II (4-0). Continuation of Systems Analysis I. Detailed study of effectiveness models, cost models, and cost-effectiveness techniques. Major emphasis on individual and group projects. Student play of a military planning game, including a student designed PPBS with cost-effectiveness studies. PREREQUISITE: OA 3611.

OA 3620 INVENTORY I (3-0). A study of deterministic inventory models. Operating doctrines and their dependence upon costs. Constraints and optimization techniques. Periodic review models. PREREQUISITES: MA 2110, PS 3303 (may be taken concurrently).

OA 3621 INVENTORY II (4-0). A study of stochastic inventory models. Reorder point models with stochastic demands. Dynamic inventory models. Applications to logistics and Navy supply systems. PREREQUISITE: OA 3620.

OA 3653 SYSTEMS SIMULATION (4-0). Development of logical, numerical and statistical models of systems. The computer as an experimental tool. Basic elements such as entities, events, queues, routing, priorities, etc., and their interrelation. Sampling theory. The generation, termination, and flow of entities possessing prescribed attributes through storage and processing facilities. Balancing systems, sharing facilities, and using priorities to modify performance. Collection and evaluation of statistics on passage times, flow volumes, queue lengths, manpower and equipment utilization. Use of computer simulation languages, e.g., GPSS, SIMSCRIPT, DYNAMO, to simulate actual systems such as a communication network or real-time, multi-processing computer systems. PREREQUISITE: PS 3303 or equivalent.

OA 3655 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. PREREQUISITES: OA 3604, PS 3303.

OA 3656 OPERATIONS RESEARCH PROBLEMS IN SPECIAL WARFARE (4-0). The applicability of operations research to unconventional warfare and counterinsurgency. Normative and descriptive models. Consideration of special problems with emphasis on problem formulation. PREREQUISITES: OA 3604, PS 3303.

OA 3657 HUMAN FACTORS IN SYSTEMS DESIGN I. (4-0). The human element in man-machine systems. Selected topics in human engineering and psychophysics with emphasis on their relation to military systems. PREREQUISITES: OA 3604, PS 3303.

OA 3658 HUMAN FACTORS IN SYSTEMS DESIGN II (3-0). A continuation of OA-3657, Man-machine interface and man's motor and sensory capacities. PREREQUISITES: OA 3657, OA 3604, or consent of instructor.

OA 3664 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. Basic visual and auditory anatomy, along with the concepts and theories applicable to solving man's visual behavior problems in his role as a photo interpreter, radar operator, sonor operator or similar vigilance and tracking tasks. PREREQUISITE: PS 3303 or equivalent.

OA 3671 CYBERNETICS (3-0). This course deals with the problems of controlling complex man-machine systems in which man plays an essential active role. Organization of motor functions and learning theory are related to the properties of closed feedback control which an individual maintains over his own behavior. PREREQUISITES: OA 3657, PS 3303.

OA 3704 STOCHASTIC MODELS I (4-0). Markov chains. Basic concepts, transition probabilities, and classification characteristics of Markov chains, random walks, and branching processes. Applications to basic systems models and queues. PREREQUISITES: PS 3303.

OA 3900 WORKSHOP IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQPISITE: Consent of instructor.

OA 3910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research.

OA 3930 READING IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Consent of instructor.

OA 3940 SEMINAR IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Content of course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of instructor.

Graduate Courses

OA 4613 THEORY OF SYSTEMS ANALYSIS (4-0). Systems analysis (cost-effectiveness analysis) formulated as commensurable and incommensurable physical capital investment choice models. Emphasis on decision rules and the nature of opportunity costs with respect to scale and timing of investment. Interpretation of methods of risk modeling and solution computation. Theory of the second best; theory of the social discount rate. Introduction to models of planning and control emphasizing and decentralization of the decision-making problem. PREREQUISITES: OA 3612, OA 4631.

OA 4615 ECONOMETRICS (3-0). An introduction to the construction of testing of econometric models, analysis of economic time series, and the use of multivariate statistical analysis in the study of economic behavoir. PREREQUISITES: PS 3303, OA 3604. Macroeconomic theory desirable.

OA 4622 SEMINAR IN SUPPLY SYSTEMS (4-0). 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. PREREQUISITES: OA 3621, OA 3704, or consent of instructor.

OA 4631 NONLINEAR AND DYNAMIC PROGRAMMING (4-0). Introduction to modern optimization techniques and multistage decision processes. Topics include: Kuhn-Tucker theory, quadratic programming, stochastic programming, chance-constrained programming, gradient and search methods, and dynamic programming. PREREQUISITES: OA 3604, MA 2110.

OA 4632 MATHEMATICAL PROGRAMMING (4-0). The bounded variable algorithm, decomposition principle, primal-dual algorithm. Special topics such as linear fractional programming, stochastic programming, chance-constrained linear programming, theory of degeneracy procedures, and the generalized transportation problem. Applications: PERT and PERT/COST, warehouse problem, caterer problem, assignment problems, overtime production, etc. PREREQUISITE: OA 3604.

OA 4633 NETWORK FLOWS AND GRAPHS (3-0). Survey of solution techniques for problems which can be formulated in terms of flow in networks. Elements of graph theory, max-flow min-cut theorem, shortest route, minimum cost flows, out-of-kilter algorithm, optimum flows with gains, and multi-commodity network flows. Application to transportation problems, critical path scheduling, production scheduling, and inventory problems. PREREQUISITE: OA 3604.

OA 4634 GAMES OF STRATEGY (4-0). Continuous games on the unit square, n-person games, non-zero sum games, and introduction to differential games. Applications and case studies. PREREQUISITES: OA 3604, PS 3303, or equivalent.

OA 4642 ADVANCED WAR GAMING (3-2). Development of event-store and time-step digital war games. Advanced Monte Carlo techniques. Simulation laboratory concepts and use of remote terminal displays. PREREQUISITES: OA 2602, PS 3303, or equivalent.

OA 4651 SEARCH THEORY AND DETECTION (4-0). Search and detection as stochastic processes. Characterization of detection devices, use and interpretation of sweep widths, lateral range curves, true range curves. Measures of effectiveness of search-detection systems. Allocation of search effort, sequential search. Introduction to the statistical theory of signal detection. Models of surveillance fields, barriers, tracking, and trailing. PREREQUISITE: PS 3303 or equivalent.

OA 4652 OPERATIONS RESEARCH PROBLEMS IN NAVAL WARFARE. (3-0). Analyses of fleet exercises. Changes in tactics and force disposition arising from the introduction of nuclear weapons and missiles. Relationship of air defense to strike capability and ASW. Current radar, sonar, communication, and ECM problems. PREREQUISITE: OA 4651.

OA 4662 SYSTEMS RELIABILITY AND LIFE TESTING (4-0). 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. PREREQUISITE: OA 4705 or equivalent.

OA 4673 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. PREREQUISITE: OA 3610.

OA 4705 STOCHASTIC MODELS II (4-0). Poisson processes. Renewal theory and semi-Markov processes. Stochastic models of complex military systems and applications in economics, communications and inventory models. Maintenance policies. PREREQUISITE: OA 3704.

OA 4900 WORKSHOP IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Consent of instructor.

OA 4910 SELECTED TOPICS IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Presentation of a wide selection of topics from the current literature. This course may be repeated for credit if course content changes. PREREQUISITE: A background of advanced work in operations research.

OA 4930 READING IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). This course may be repeated for credit if course content changes. PREREQUISITE: Consent of instructor.

OA 4940 SEMINAR IN OPERATIONS RESEARCH/SYSTEMS ANALYSIS (2-0 to 5-0). Content of course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of instructor.

PROBABILITY AND STATISTICS

Upper Division Courses

*PS 2111 INTRODUCTION TO PROBABILITY AND STATISTICS I (4-0).

PS 2301 PROBABILITY (4-0). Axiomatic development of probability and its use in model building. Random variables and their probability distributions. Moments and other characteristics of probability laws and their importance in formulating and solving operations analysis problems. Jointly distributed random variables and their use in defining behavior of complex systems. PREREQUISITE: A previous course in differential and integral calculus.

*PS 2311 ELEMENTARY PROBABILITY AND STATISTICS (3-0.)

*PS 2321 INTRODUCTION TO PROBABILITY AND STATISTICS (3-1).

*PS 2325 INTRODUCTION TO PROBABILITY THEORY (3-1).

*PS 2331 ELEMENTARY PROBABILITY AND STATISTICS (4-1).

Upper Division or Graduate Courses

*PS 3101 MANAGEMENT STATISTICS I (5-0).

*PS 3102 MANAGEMENT STATISTICS II (4-1).

*PS 3112 PROBABILITY AND STATISTICS I (4-0).

*PS 3113 PROBABILITY AND STATISTICS II (4-0).

*PS 3205 PROBABILITY (3-0).

PS 3302 PROBABILITY AND STATISTICS (4-1). Independence and conditional distributions. Stochastic inequalities, approximations, and limit properties, and their use in operations analysis/ systems analysis. Derived distributions of functions of random variables. Random sampling and distribution of sampling statistics with application to model building and Bayesian techniques. PREREQUISITE: PS 2301.

PS 3303 STATISTICS (4-1). Confidence interval estimation and hypothesis testing. Regression and correlation analysis. Elements of the analysis of variance. Nonparametric inference. Applications to reliability, quality assurance, and operations analysis problems. PREREQUISITE: PS 3302.

*PS 3315 PROBABILITY AND STATISTICS (4-1).

*PS 3316 APPLIED ENGINEERING STATISTICS (3-0).

*PS 3326 PROBABILITY AND STATISTICS (3-1).

*PS 3327 APPLIED STATISTICS (3-1).

*PS 3332 APPLIED STATISTICS (3-0).

*PS 3335 STATISTICS I (3-0).

*PS 3336 STATISTICS II (3-0).

PS 3510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0). Topics will be selected by instructor to fit the needs and background of the students. The topics may include advanced probability, sampling inspection, quality assurance, nonparametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: PS 3303 or consent of the instructor.

Graduate Courses

*PS 4206 DECISION THEORY AND CLASSICAL STATISTICS (3-0).

PS 4306 APPLIED STATISTICS (4-0). Multivariate analysis with applications. Multiple comparisons. Bayesian and classical classification models. Outliers. Use of digital computer in multivariate problems. PREREQUISITE: PS 3303.

PS 4321 DESIGN OF EXPERIMENTS (3-1). Theory of the general linear hypotheses. Analysis of variance. Planning of experiments. Randomized block and Latin squares. Simple factorial experiments. PREREQUISITE: PS 3303 or consent of instructor.

PS 4322 SAMPLE INSPECTION AND QUALITY ASSURANCE (3-1). Attribute and variables sampling plans. MIL. STD. sampling plans with modifications. Multi-level continuous sampling plans and sequential sampling plans. Structure of quality assurance programs and analysis of selected quality assurance problems. PREREQUISITE: PS 3303.

PS 4323 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 evaluations trials. PREREQUISITE: PS 3303.

PS 4431 ADVANCED PROBABILITY (3-0). Convergence almost surely, in probability and in quadratic mean. Distribution function and characteristic functions. Infinitely divisible laws. Strong and weak laws of large numbers. Classical central limit problems, modern central limit problems. PREREQUISITE: MA 4635 and consent of the instructor.

PS 4432 STOCHASTIC PROCESSES (3-0). Orthogonal representation of stochastic processes. Stationary time series; harmonic analysis of the auto-correlation function. Ergodic properties. Applications. PREREQUISITE: OA 4705.

PS 4510 SELECTED TOPICS IN PROBABILITY AND STATISTICS (2-0 to 5-0). Topics will be selected by instructor to fit the needs and background of the students. The topics may include advanced probability, sampling inspection, quality assurance, nonparametric methods, and sequential analysis. The course may be repeated for credit if the topic changes. PREREQUISITE: PS 3303 or consent of the instructor.

* See listing under Mathematics Department.

DEPARTMENT OF PHYSICS

OTTO HEINZ, Professor of Physics, Chairman (1962)*; B.A., Univ. of California at Berkeley, 1948; Ph.D., 1954.

AUSTIN ROGERS FREY, Professor Emeritus and Distinguished Professor (1946); B.S., Harvard Univ., 1920; M.S., 1924; Ph.D., 1929.

ROBERT LOUIS ARMSTEAD, Assistant Professor of Physics (1964); B.S., Univ. og 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.

THOMAS BRACKENRIDGE COCHRAN, Lieutenant , U.S. Naval Reserve; Assistant Professor of Physics (1967); B.E., Vanderbilt Univ., 1962; M.S., 1965; Ph.D., 1967.

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., 1965.

EUGENE CASSON CRITTENDEN, JR., Professor of Physics (1953); Cornell Univ., 1934; Ph.D., 1938.

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 at Berkeley, 1956; Ph.D., 1960.

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., Professor of Physics (1961); B.S., College of William and Mary, 1949; M.S., Yale Univ., 1950; Ph.D., 1953.

WILLIAM LEWIS JOHNSON, Instructor in Physics ,1963); B.S. Univ. of Southern Mississippi, 1962; M.S., Naval Postgraduate School, 1966.

SYDNEY HOBART KALMBACH, Professor of Physics (1947); B.S., Marquette Univ., 1934; M.S., 1937.

RAYMOND LEROY KELLY, 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, Associate 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, Associate Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ., 1961.

GORDON EVERETT SCHACHER, Associate Professor of Physics (1964); A.B., Reed College, 1956; Ph.D., Rutgers, 1961.

THEODORE JOSEPH WILLIAMSON, Lieutenant (junior grade), U.S. Naval Reserve; Assistant Professor of Physics (1967); B.S., Univ. of Washington, 1964; M.S., 1965; Ph.D., 1967.

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 parentheses.*

DEPARTMENTAL REQUIREMENTS FOR DEGREES IN PHYSICS
BACHELOR OF SCIENCE IN PHYSICS

1. A major in physics must include a minimum of 45 quarter hours in physics, including required courses and electives, a minimum of 24 quarter hours in mathematics, and the equivalent of a course in general chemistry. In addition a minimum of 17 quarter hours of elective credits must be chosen from the natural sciences or engineering, other than physics or mathematics. Ninety quarter hours must be clearly of upper division level.

2. The following specific requirements must be met: (courses marked with an asterisk must includ a laboratory).

Subject	Approximate Quarter Hrs.
General Physics*	13
Analytical Mechanics	7
Electricity and Magnetism	6
Modern Physics*	10
	36

The math courses shall include differential equations and vector analysis.

3. The student must maintain grade point averages of at least 1.2 in both physics and mathematics.

MASTER OF SCIENCE IN PHYSICS

1. Each student's program of study must have a minimum of 30 quarter hours of physics courses (not including thesis) distributed between courses in the 3000 and 4000 series; of this 30 hours, a minimum of 10 hours must be from the 4000 series. 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 20 hours entirely of 4000 level physics courses. In addition, all students must engage in research in at least 3 quarters and present an acceptable thesis.

2. In addition to the courses normally leading to a B.S. in physics, 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-quarter sequence or present equivalent preparation in this area.

b. A course in Advanced Mechanics or Quantum Mechanics.

c. A course in Electromagnetism at the 4000 level.

d. An advanced course in Modern Physics.

e. Specialization, to include at least two advanced courses, in one of the following areas:

(1) Acoustics
(2) Atomic Physics
(3) Nuclear Physics
(4) Plasma Physics
(5) Solid State Physics
(6) Underwater Physics
(7) Other, subject to Department approval

PHYSICS

PH 0499 ACOUSTICS COLLOQUIUM (0-1). Reports on current research and study of recent research literature in conjunction with the student thesis. PREREQUISITE: PH 3452 or equivalent.

PH 0810 THESIS RESEARCH (0-0). Every student conducting thesis research will enroll in this course.

PH 0999 PHYSICS COLLOQUIUM (0-1). Discussion of topics of current interest in the field of physics and student thesis reports.

Lower Division Courses

PH 1005, PH 1006, *and* PH 1007 *comprise a series of courses intended for students with limited backgrounds in mathematics.*

PH 1005 ELEMENTARY PHYSICS I (4-2). Mechanics, Heat, and Sound. Lectures, problem sessions, and laboratory. Physical quantities and the concepts of motion, force, momentum, and energy. The mechanics of gases, heat transfer, and thermodynamics. Simple harmonic motion and propagation of sound. TEXT: Sears and Zemansky, *College Physics*, or equivalent.

PH 1006 ELEMENTARY PHYSICS II (3-2). Electricity and Magnetism. Electrostatics, electric current, and magnetism. Lectures, problem sessions, and laboratory. TEXT: Sears and Zemansky, *College Physics*, or equivalent. PREREQUISITE: PH 1005.

PH 1007 ELEMENTARY PHYSICS III (4-2). Optics and Modern Physics. Lectures, problem sessions and laboratory dealing with geometrical optics, mirrors and lenses. Atomic structure, optical spectra, radioactivity and nuclear structure. TEXT: Sears and Zemansky, *College Physics,* or equivalent. PREREQUISITES: PH 1005 and PH 1006.

PH 1011, PH 1012, *and* PH 2017 *comprise a series of courses intended primarily for Engineering Science students with a prior knowledge of calculus.*

PH 1011 BASIC PHYSICS I (4-0). Mechanics, Heat, and Sound. Review of Newtonian Mechanics. Conservation laws. Rotational motion. Thermal properties of gases, liquids and solids. Laws of Thermodynamics. Wave motion and propagation of sound. TEXT: Resnick-Halliday. *Physics, Part I.* PREREQUISITES: Courses in College Physics and College Mathematics through calculus.

PH 1012 BASIC PHYSICS II (4-0). Electricity and Magnetism. Electrostatics stressing Gauss's Law and the theory of electric fields and potentials. Alternating current. Elecromagnetism. TEXT: Halliday-Resnick, *Physics, Part II.* PREREQUISITE: PH 1011.

PH 1015, PH 1016, *and* PH 2017 *comprise a series of courses intended primarily for BS students, and provides a knowledge of the principles of physics and a scientific background for the study of engineering.*

PH 1015 BASIC PHYSICS I (5-3). Mechanics, Heat, and Sound. Lectures, problem sessions, and laboratory. Concepts of force, motion, energy, momentum, thermal properties of gases, liquids, and solids, and wave motion. TEXT: Halliday-Resnick, *Physics, Part I.* PREREQUISITE: One term of calculus.

PH 1016 BASIC PHYSICS II (4-3). Electricity and Magnetism. Lectures, problem sessions, and laboratory. Electrostatics, electromagnetism, and electrochemistry. Direct and alternating currents. TEXT: Halliday-Resnick, *Physics, Part II.* PREREQUISITE: PH 1015.

PH 1041 REVIEW OF MECHANICS AND THERMODYNAMICS (4-2). First quarter of a sequence of fundamental physics for students in Electrical Engineering and Electronics. (*The sequence includes* PH 1041, PH 2241, PH 3641, *and* PH 3741.) The first course subject matter includes: kinematics, particle dynamics, energy, momentum, rotational motion, orbital motion, oscillations; temperature, entropy, first and second law of thermodynamics. The laboratory sessions will be devoted to guided problem-solving. TEXT: Resnick and Halliday, *Physics for Students of Science and Engineering.*

PH 1051 REVIEW OF VECTOR MECHANICS AND OPTICS (4-2). A review of the basic concepts of elementary vector mechanics and geometrical optics, including: statics, motion in one dimension and in a plane, particle dynamics, energy, momentum, rotational dynamics, and the laws of reflection and refraction applied to lenses, mirrors, and prisms. The laboratory sessions are devoted to guided problem - solving. TEXT: Resnick-Halliday, *Physics,* Parts I and II. PREREQUISITES: Previous courses in general physics and calculus.

Upper Division Courses

PH 2017 BASIC PHYSICS III (4-2). Optics and Modern Physics (PH 2017 *is the third course for both the* PH 1011, PH 1012, *and the* PH 1015, PH 1016 *series of Basic Physics.*) Lectures, problem sessions, and laboratory. Geometrical optics, mirrors and lenses. Interference and diffraction. Special relativity, quantum effects of waves and particles, structure of the hydrogen atom, nuclear structure, and nuclear reactions. TEXTS: Halliday-Resnick, *Physics, Part II,* and Weidner and Sells, *Elementary Modern Physics.* PREREQUISITES: PH 1011 and PH 1012 or PH 1015 and PH 1016.

PH 2121 PARTICLE DYNAMICS (4-0). Review of Newton's Laws of motion, work and energy, conservation laws. Central forces, moving reference systems. The motion of a particle in electromagnetic fields. TEXT: Resnick and Halliday, *Physics for Students of Science and Engineering, Parts I and II.*

PH 2151 MECHANICS I (4-0). Particle dynamics including oscillatory motion and central force motion. Motion of a system of particles. TEXT: Symon, *Mechanics, 2nd ed.* PREREQUISITES: PH 1051, Calculus, Vector Algebra and Ordinary Differential Equations (the latter may be taken concurrently).

PH 2221 WAVE PHENOMENA (3-2). Wave phenomena and wave propagation, refraction, reflection, interference and diffraction, polarization. Thermal radiation. The electromagnetic nature of light and Maxwell's equations. TEXTS: Sears, *Optics;* Jenkins and White, *Fundamentals of Optics,* PREREQUISITE: PH 2121.

PH 2241 WAVES AND PARTICLES (4-0). Second quarter of a sequence of fundamental physics for students in Electrical Engineering and Electronics. Wave propagation, interference, diffraction, polarization. Electromagnetic waves. Photoelectric and Compton effects. Wave particle dualism. Black body radiation, spectra. TEXTS: Halliday and Resnick, *Physics for Students of Science and Engineering,* Vol. II; Pearson, *A Theory of Waves.* PREREQUISITES: PH 1041 or PH 1051.

PH 2251 WAVES AND PARTICLES (4-2). A course designed to provide the background and fundamental ideas in modern physics which are utilized in atomic, molecular, solid state, and nuclear physics. Wave properties; propagation, interference, diffraction, polarization. Electromagnetic waves. The special theory of relativity. Photoelectric and Compton effects. Wave-particle dualism; de Broglie hypothesis; electron diffraction; wave packets. Continuous and line spectra; black-body radiation; hydrogen atom spectrum. TEXTS: Eisberg, *Fundamentals of Modern Physics;* Instructor's Notes. PREREQUISITES: PH 2151, MA 2161.

PH 2351 ELECTROMAGNETISM I (3-0). Electrostatics: Coulomb's law, electric field and potential dielectrics. Magnetostatics: magnetic fields due to currents and charges. Magnetic induction. Magnetic materials. Maxwell's wave equation. TEXT: Corson and Lorrain, *Introduction to Electromagnetic Fields and Waves.* PREREQUISITES: MA 2161, PH 1051.

PH 2551 THERMODYNAMICS (3-0). (may be taught as CH 2401) Fundamental theory of thermodynamics and applications to physical systems. First and second laws of thermodynamics; entropy; thermodynamic potentials; applications to gases, liquids, radiation, and magnetic materials; equilibrium. TEXT: Vanderslice, Schamp, and Mason, *Thermodynamics,* PREREQUISITES: PH 1051 and Calculus of Several Variables.

PH 2641 MODERN PHYSICS (4-0). Third quarter in the sequence of fundamental physics for students in Electrical Engineering and Electronics not planning on taking PH 3741. Bohr model, periodic table, atomic spectra, molecules, solids, band structure, semiconductor devices. TEXTS: Sproull, *Modern Physics, 2nd ed;* Weidner and Sells, *Elementary Modern Physics.* PREREQUISITES: PH 2241 or PH 2251.

PH 2810 SURVEY OF NUCLEAR PHYSICS (4-0). A course designed to introduce the student to the ideas of nuclear physics, with emphasis on neutron physics and reactors. Atomic nature of matter; wave-particle duality: the nuclear atom. Basic nuclear properties; reactions, neutrons and fission. Reactors. TEXTS: Weidner and Sells, *Elementary Modern Physics;* Murray, *Introduction to Nuclear Engineering.*

Upper Division or Graduate Courses

PH 3152 MECHANICS II (4-0). Motion of a system of particles continued. Rotation of a rigid body. Moving coordinate systems. Some mechanics of continuous media. Generalized coordinates. Lagrange equations. TEXT: Symon, *Mechanics, 2nd ed.* PREREQUISITE: PH 2151.

PH 3157 PHYSICS OF CONTINUA (4-0). The continuum hypothesis. Cartesian tensors. The concept of stress. Deformation. Conservation of mass, momentum and energy. Theory of constituative equations. Applications to fluid mechanics, solid mechanics and wave phenomena. TEXT: Scipio, *Principles of Continua With Applications.* PREREQUISITE: PH 3152.

PH 3280 PHYSICAL OPTICS (4-2). Wave phenomena and wave propagation, superposition principle and interference, dispersion, polarization. Stokes vector representation, Kirchoff integral. TEXT: Stone. *Radiation and Optics.* PREREQUISITE: Consent of Instructor.

PH 3352 ELECTROMAGNETISM II (3-0). Electromagnetic Waves: Wave equations, plane wave solutions, energy and momentum in electromagnetic waves. Plane waves in dielectrics and refraction, waves in conductors and ionized media, guided waves. TEXT: Corson and Lorrain, *Introduction to Electromagnetic Fields and Waves.* PREREQUISITE: PH 2351.

PH 3421 UNDERWATER ACOUSTICS (4-2). An analytical survey of acoustics with an emphasis on sound propagation in the ocean. Simple harmonic oscillations, the wave equation is an ideal fluid, simple harmonic solutions for plane and spherical waves, radiation of sound, propagation effects due to boundaries, inhomogeneities, and absorbing processes, development of the basic equation for sonar, transducers for underwater sound. Laboratory experiments on underwater acoustics, spectrum analysis and transducers. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics, 2nd ed.*; Urick, *Principles of Underwater Sound for Engineers.* PREREQUISITES: PH 2151 or PH 2121.

PH 3451 FUNDAMENTAL ACOUSTICS (4-1). Mechanics of free, forced, and damped simple vibratory systems. Mechanical impedance. Development of, and solutions to, the acoustic wave equations in extended media. Propagation of plane waves in fluids and between media. Specific acoustic impedance. Spherical waves and simple sources. The acoustical behavior of the piston source. Radiation impedance. Steady state response of acoustic waveguides. Group and phase velocities. Normal Modes. Laboratory experiments on selected topics. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* Instructor's Notes. PREREQUISITES: PH 2151 and MA 2161.

PH 3452 UNDERWATER ACOUSTICS (4-2). Electromechanical transduction and lumped acoustical elements. Sound absorption and dispersion for classical and relaxing fluids. Transmission of sound in the ocean: the eikonal equation and necessary conditions for ray acoustics, method of images, refraction and ray diagrams, mode propagation in shallow water and refraction channels. Ambient noise and reverberation. Target strength. The sonar equations for active and passive systems. Laboratory experiments on selected concepts. TEXTS: Kinsler and Frey, *Fundamentals of Acoustics;* Officer, *Introduction to the Theory of Sound Transmission;* Tolstoy and Clay, *Ocean Acoustics: Theory and Experiment in Underwater Sound;* Urick, *Principles of Underwater Sound for Engineers.* PREREQUISITE: PH 3451.

PH 3461 EXPLOSIVE SHOCK WAVES (4-0). Generation and propagation of explosive shock waves in air and water including Rankine-Hugoniot equations, scaling laws, reflection and refraction phenomena, and experimental data. Shock loads on ships and blast loads on structures. Damage mechanism and principles of protection against damage. TEXTS: Instructor's Notes; Cole, *Underwater Explosions;* Kinney, *Shocks in Air.* PREREQUISITES: PH 3152, PH 2551 or CH 2401.

PH 3463 SPECIAL TOPICS IN UNDERWATER ACOUSTICS (3-2). A terminal course following PH 3452 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 3452 or equivalent.

PH 3561 INTRODUCTORY STATISTICAL PHYSICS (4-0). Distribution functions, kinetic theory, transport processes, introduction to classical and quantum distributions. Applications to gases, solids, and radiation. TEXT: Andrews, *Equilibrium Statistical Mechanics.* PREREQUISITES: PH 3152, PH 2551 or CH 2401, PH 3651.

PH 3641 ATOMIC PHYSICS (4-2). Third quarter in the sequence of fundamental physics for students in Electrical Engineering and Electronics who will take PH 3741. Bohr model, Schroedinger equation, exact solution for hydrogen atom, electron spin, periodic table, atomic spectra, ls and jj coupling, vector model, molecules, statistics. TEXT: Beiser, *Concepts of Modern Physics.* PREREQUISITE: PH 2241.

PH 3651 ATOMIC PHYSICS (4-2). Properties of the electron, the nuclear atom, the Bohr theory of the hydrogen atom, atomic energy levels, the Schroedinger Equation and properties of its solutions, application of the Schroedinger Equation to the square potential well and to the hydrogen atom, angular momentum operators, electron spin, identical particles, the Pauli Principle, multielectron atoms, the Periodic Table, the vector model of the atom and complex spectra, the Zeeman effect, Einstein coefficients and stimulated emission of radiation. TEXT: Eisberg, *Fundamentals of Modern Physics.* PREREQUISITES PH 2251 and MA 2161.

PH 3652 ELEMENTS OF MOLECULAR, SOLID STATE, AND NUCLEAR PHYSICS (4-2). X-ray spectra, Bragg Law. Molecular bonds, excited states of molecules, molecular spectra. Bonding in crystals. Conduction in solids, band theory. Semiconductors. Fundamentals of nuclear physics, radioactivity and the decay law. Interactions of charged particles and photons with matter. TEXTS: Sproull, *Modern Physics;* Enge, *Introduction to Nuclear Physics;* Instructor's Notes. PREREQUISITE: PH 3651.

PH 3687 ELECTRICAL DISCHARGES IN GASES (3-0). A course covering the fundamental processes occurring in electrical discharges 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: McDaniel, *Collision Phenomena in Gases;* Von Engle, *Ionized Gases;* Francis, *Ionization Phenomena in Gases.* PREREQUISITES: PH 3641 or PH 3651.

PH 3741 ELECTRONIC PROPERTIES OF METALS AND SEMI-CONDUCTORS (4-2). Fourth quarter 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 semi-conductors, diodes, transistors, thermo-electric effects, magnetic properties. TEXTS: Kittel, *Introduction to Solid State Physics, 2nd ed.;* Azaroff and Brophy, *Electronic Processes in Materials.* PREREQUISITES: PH 3641 or PH 3651.

PH 3921 CONCEPTUAL MODELS OF MODERN PHYSICS (4-0). A review of recent developments in physics selected to illustrate the principles of model-building and the general methodology of science. The topics selected include: special relativity, wave particle duality, nuclear reactions, and fundamental particles. TEXTS: Weidner and Sells, *Elementary Modern Physics;* Beiser, *Concepts of Modern Physics.* PREREQUISITE: PH 2221.

PH 3951 INTRODUCTION TO QUANTUM MECHANICS (3-0). The general principles of quantum mechanics. Schroedinger equation. Harmonic oscillator. Angular momentum, many particle systems, electron spin, the Pauli exclusion principle. Time independent and time dependent perturbation, and the semi-classical theory of radiation applied to atomic transitions. TEXT: Sherwin, *Introduction to Quantum Mechanics.* PREREQUISITES: PH 2351, MA 2161, PH 3651.

Graduate Courses

PH 4161 FLUID MECHANICS I (3-0). Fundamental concepts of continuum mechanics. Fluid mechanical models. Euler equation and solution of potential flow problems. Navier-Stokes equation. TEXTS: Instructor's Notes; Li and Lam, *Principles of Fluid Mechanics*. PREREQUISITES: PH 3152, MA 2161.

PH 4162 FLUID MECHANICS II (3-0). Laminar boundary lary, hydrodynamic stability, turbulence, and hydrodynamic noise. Fluid dynamic discontinuities, shock waves, and the method of characteristics. TEXTS: Schlichting, *Boundary Layer Theory;* Instructor's Notes. PREREQUISITE: PH 4161.

PH 4171 ADVANCED MECHANICS (4-0). Hamilton's principle. The equations of motion in Lagrangian and Hamiltonian form. Rigid body motion. Canonical transformation, Poisson brackets, Hamilton-Jacobi theory. Small oscillations. Classical perturbation theory. TEXT: Goldstein, *Classical Mechanics*. PREREQUISITES: PH 3152, PH 3352.

PH 4353 ELECTROMAGNETISM III (3-0). Classical radiation theory. Scalar and vector potentials, radiation from a dipole, classical theory of Bremsstrahlung, Thompson scattering, field due to fast electron. Selected topics: relativity, scattering from a random medium, Rayleigh scattering. TEXT: Marion, *Classical Electromagnetic Radiation*. PREREQUISITE PH 3352.

PH 4371 CLASSICAL ELECTRODYNAMICS (3-0). Tensors in special relativity. Classical relativistic 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 4353, PH 4171, and familiarity with the special theory of relativity.

PH 4453 PROPAGATION OF WAVES IN FLUIDS (4-0). An advanced treatment of special topics related to sound propagation in the ocean, including: multipole radiation fields; incoherence and coherence; scattering from inhomogeneities and from randomly rough surfaces; high intensity sound and shock wave phenomena. TEXTS: Beckmann and Spizzichino, *The Scattering of Electromagnetic Waves from Rough Surfaces;* Lindsay, *Mechanical Radiation;* Morse and Ingard, *Theoretical Acoustics;* Tolstoy and Clay, *Ocean Acoustics*. PREREQUISITES: PH 3452 or consent of instructor.

PH 4454 TRANSDUCER THEORY AND DESIGN (3-3). A theoretical treatment of the fundamental phenomena basic to the design of piezoelectric and magnetostrictive transducer elements and arrays of elements with the emphasis placed on underwater applications. Laboratory experiments on properties of piezoelectric materials, characteristics of various transducer types and measurement techniques. TEXTS: Mason, *Physical Acoustics, Vol. I, Part A;* Heuter and Bolt, *Sonics*. PREREQUISITES: PH 3452 or equivalent.

PH 4455 ADVANCED ACOUSTICS LABORATORY (0-3). Advanced laboratory projects in acoustics. PREREQUISITE: PH 3452 or equivalent.

PH 4456 SEMINAR IN APPLICATIONS OF UNDERWATER SOUND (3-0). A study of current literature on applications of acoustics to problems of naval interest. PREREQUISITE: PH 4453 or consent of instructor.

PH 4571 STATISTICAL PHYSICS I (3-0). Kinetic theory and the Boltzmann theorem, configuration and phase space, the Liouville theorem, ensemble theory, microcanonical, canonical, and grand canonical ensemblies, quantum statistics. TEXT: Huang, *Statistical Mechanics*. PREREQUISITES: PH 3152, PH 3651, PH 2551.

PH 4572 STATISTICAL PHYSICS II (3-0). A continuation of PH 4571 with applications to molecules, Bose-Einstein gases, Fermi-Dirac liquids, and superconductivity. TEXT: Huang, *Statistical Mechanics*. PREREQUISITE: PH 4571.

PH 4630 SPACE PHYSICS I—PHYSICS OF THE UPPER ATMOSPHERE (4-0). Structure of the upper atmosphere. Atmospheric absorption in the infrared, visible and ultraviolet. The ionosphere. Geomagnetic-field and the radiation belts. Disturbances of the upper atmosphere. Experimental instrumentation in space research. TEXTS: Hines et al, *Physics of the Earth's Upper Atmosphere;* Hess, *Introduction to Space Science*. PREREQUISITES: PH 3652 and PH 3352 or consent of instructor.

PH 4631 SPACE PHYSICS II—PHYSICS OF THE SOLAR SYSTEM (4-0). Solar interior and surface. Solar magnetic field, sunspots and flares. Emissions from the sun. The interplanetary medium, solar wind, magnetic field, the magnetopause. Introduction to stellar evolution and cosmology. TEXTS: Brandt, *Solar System Astrophysics;* Hess, *Introduction to Space Science*. PREREQUISITE: PH 4630.

PH 4661 PLASMA PHYSICS I (3-0). Introduction to physical and mathematical concepts fundamental to various branches of plasma physics, such as ionospheric communications, ion propulsion, plasma amplifiers and controlled fusion. Topics covered are collision phenomena, including surface effects, the Boltzmann equation, breakdown of a gas, diffusion both in presence and absence of space charge. The general hydrodynamic macroscopic equation is derived and from this the momentum transport and energy transport equations are obtained. The hydromagnetic equations for the two particle plasma are considered. TEXTS: Rose and Clark, *Plasma and Controlled Fusion;* Uman, *Introduction to Plasma Physics;* Glasstone and Loveberg, *Controlled Thermonuclear Reactions*. PREREQUISITES: PH 4371, PH 3561, PH 3651 or the equivalent.

PH 4662 PLASMA PHYSICS II (3-0). A continuation of Plasma Physics I. Application of hydromagnetic equations to study of macroscopic motions of a plasma, including conductivity of a magnetized Lorentzian gas. Simple shocks. Effect of coulomb interactions, including discussion of relaxation times and runaway electrons. Study of small amplitude waves occurring in a plasma. Types of radiation from plasmas, including bremmsstrahlung and cyclotron radiation. Plasma instabilities. TEXTS: Rose and Clark, *Plasma and Controlled Fusion;* Uman, *Introduction to Plasma Physics;* Glasstone and Loveberg, *Controlled Thermonuclear Reactions*. PREREQUISITE: PH 4661.

PH 4681 ADVANCED PLASMA PHYSICS I (3-0). Topics covered will be related to research problems in progress or contemplated and will depend somewhat on students enrolled. Possible topics are: diffusion in plasma, turbulence and fluctuations in plasmas, radiation from plasmas, propagation of various types of plasma waves. Use will be made of current scientific literature. TEXTS: Allis Buchsbaum and Bers, *Waves in Anisotropic Plasmas;* Kadomtser, *Plasma Turbulence;* Lecture Notes. PREREQUISITE: PH 4662.

PH 4682 ADVANCED PLASMA PHYSICS II (3-0). A continuation of PH 4681 with emphasis on the current scientific literature. PREREQUISITE: PH 4681.

PH 4685 ATOMIC SPECTROSCOPY (3-0). Spectroscopic instrumentation, vector model of the atom and applications to complex spectra, line broadening problems and applications to diagnostic measurements in plasma systems, selected topics in astrophysics. TEXTS: Kuhn, *Atomic Spectra;* Griem, *Plasma Spectroscopy.* PREREQUISITE: PH 3651 and consent of instructor.

PH 4686 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. Experimental techniques and instrumentation. TEXT: McDaniels, *Collision Phenomena in Ionized Gases.* PREREQUISITE: PH 3651 and consent of instructor.

PH 4750 RADIATION EFFECTS IN SOLIDS (3-0). The effects of nuclear radiation and the effects of shock waves on the properties of solids: interaction of radiation with solids, displacement of atoms in solids and the effects on solid state properties; effects on electrons in the solids; effects of shock compression of solids, behavior beyond the elastic limit, phase changes. TEXTS: Dienes and Vineyard, *Radiation Effects in Solids;* Instructor's Notes. PREREQUISITES: PH 4760, PH 3461.

PH 4751 PHYSICS OF SOLIDS I (3-0). Theory of the structure and properties of solids; crystal symmetry and the anisotropy of physical properties, binding in solids, imperfections, lattice vibrations, lattice specific heat, magnetic properties. TEXT: Kittel, *Introduction to Solid State Physics.* PREREQUISITES: PH 3561, PH 3651, PH 3951 or PH 4971.

PH 4752 PHYSICS OF SOLIDS II (3-2). A continuation of PH 4751 with laboratory experiments relating to both terms. Electronic properties of solids: free electron theory, transport properties, band theory, Brillouin zones, effective mass, physics of semiconductors and solid state devices, optical properties, super-conductivity, ferromagnetism. TEXTS: Kittel, *Introduction to Solid State Physics;* Ziman, *Electrons in Metals.* PREREQUISITE: PH 4751.

PH 4760 SOLID STATE PHYSICS (4-2). Fundamental theory and related laboratory experiments dealing with solids: crystals, binding energy, lattice vibration, disclocations and mechanical properties, free electron theory, band theory, properties of semiconductors and insulators, magnetism. TEXT: Kittel, *Introduction to Solid State Physics, 3rd ed.* PREREQUISITE: PH 3651.

PH 4781 ADVANCED SOLID STATE PHYSICS I (3-0). Detailed studies of selected topics in solid state physics. The material selected will be chosen to meet current requirements. PREREQUISITES: PH 4752 or consent of instructor.

PH 4782 ADVANCED SOLID STATE PHYSICS II (3-0). Detailed studies of selected topics in solid state physics. PH 4781 and PH 4782 are normally given in alternate years. PREREQUISITES: PH 4752 or consent of instructor.

PH 4790 THEORY OF QUANTUM DEVICES (3-0). 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, parametric amplifiers, magnetic instruments. TEXTS: Siegman, *Microwave Solid State Masers;* Pake, *Paramagnetic Resonance;* Heavens, *Optical Masers;* Bloembergen, *Nonlinear Optics.* PREREQUISITES: PH 3641 or PH 3651.

PH 4851 NUCLEAR PHYSICS (4-2). Nuclear forces; the deuteron; low energy scattering. Nuclear models; spin and moments. Nuclear reactions; fission; reactors. Weak interactions; B-decay. TEXTS: Enge, *Introduction to Nuclear Physics,* Elton, *Introductory Nuclear Theory.* PREREQUISITES: PH 3652, PH 3352, PH 3951.

PH 4881 ADVANCED NUCLEAR PHYSICS I (3-0). Selected topics in nuclear and particle physics. The particular subjects covered will depend on the needs of the students and choice of the Instructor. PREREQUISITES: PH 4851, PH 3951, or PH 4971.

PH 4882 ADVANCED NUCLEAR PHYSICS II (3-0). A continuation of PH 4881. PREREQUISITE: PH 4881.

PH 4885 REACTOR THEORY (3-0). The diffusion and slowing down of neutrons. Homogeneous thermal reactors; time behavior; reactor control. Multigroup theory. Heterogeneous systems and perturbation theory. TEXTS: Glasstone and Edlund, *The Elements of Nuclear Reactor Theory;* Murray, *Nuclear Reactor Physics.* PREREQUISITE: PH 4851.

PH 4971 QUANTUM MECHANICS I (3-0). Matrix formulation of quantum mechanics. Stationary states of the square well, the harmonic oscillator, and the hydrogen atom. TEXTS: Dirac, *Quantum Mechanics;* Schiff, *Quantum Mechanics.* PREREQUISITES: PH 3651 and PH 4171.

PH 4972 QUANTUM MECHANICS II (3-0). Addition of angular momenta. Time independent and time dependent perturbation theory. Partial wave analysis of scattering. Identicals particles and spin. TEXTS: Dirac, *Quantum Mechanics;* Schiff, *Quantum Mechanics.* PREREQUISITE: PH 4971.

PH 4973 QUANTUM MECHANICS III (3-0). Atoms and molecules, properties and solutions of relativistic particle wave equations. TEXTS: Schiff, *Quantum Mechanics;* Bjorken and Drell, *Relativistic Quantum Mechanics.* PREREQUISITE: PH 4972.

PH 4981 QUANTUM FIELD THEORY I (3-0). Quantization of scalar, spinor, and massless vector fields. TEXT: Schweber, *Introduction to Relativistic Quantum Field Theory.* PREREQUISITES: PH 4371 and PH 4973.

PH 4982 QUANTUM FIELD THEORY II (3-0). Interacting Fields. The S-matrix and renormalization. Strong, electromagnetic, and weak interactions. Introduction to dispersion relations. TEXT: Schweber, *Introduction to Relativistic Quantum Field Theory.* PREREQUISITE: PH 4981.

PH 4991 RELATIVITY AND COSMOLOGY (3-0). Introduction to the general theory of relativity. The three classical tests of the general theory. The Schwarzschild singularity. Cosmological models. TEXTS: Eddington, *The Mathematical Theory of Relativity;* Bondi, *Cosmology.* PREREQUISITE: PH 4371.

PH 4993 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 4972.

PH 4998 READING IN ADVANCED PHYSICS (2-0). Supervised reading from the periodicals in fields of advanced physics selected to meet the needs of the student.

Officers Club waiting room

NAVY MANAGEMENT SYSTEMS CENTER

Robert Waring McNitt, Rear Admiral, U.S. Navy; Director; B.S., Naval Academy, 1938; M.S., Massachusetts Institute of Technology, 1947.

Herman Paul Ecker, Professor; Associate Director (1957)*; B.A., Pomona College, 1948; M.A., Claremont Graduate School, 1949; Ph.D., 1967.

Miles Edminston Twaddell, Commander, U.S. Navy; Curricular Officer and Assistant Professor (1965); B.S., Ohio State Univ., 1959; M.S., Naval Postgraduate School, 1962.

Sherman Wesley Blandin, Jr., Assistant Professor (1968)*; B.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.

Roger Sterling Clark, Lieutenant Commander, U.S. Navy; Assistant Professor (1966); B.S., Univ. of California at Berkeley, 1953; M.S. Naval Postgraduate School, 1966.

James Patrick Connolly, Lieutenant Colonel, U.S. Marine Corps; Associate Professor (1967); B.S., Virginia Military Institute, 1951; M.S. Naval Postgraduate School, 1963.

John Edward Dawson, Associate Professor (1966); B.A., The Principia College, 1953; M.P.A., Syracuse Univ., 1954; Ph.D. (pending).

Daniel Wesley DeHayes, Jr., 1st Lieutenant, U.S. Army; Assistant Professor (1967); B.S., Ohio State Univ., 1963; M.B.A., 1964; 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.

Donald Alfred Messick, Lieutenant Colonel, U.S. Air Force; Associate Professor (1968); M.B.A., Univ. of Chicago, 1958; Armed Forces Staff College, 1964.

Burton Ross Pierce, Assistant Professor (1964); A.B., Harvard Univ., 1956; M.B.A., Stanford Univ., 1962; Ph.D. (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, 1963; M.B.A., Ohio State Univ., 1956; Ph.D., Univ. of Maryland, (pending).

Ivon William Ulrey, Professor (1966); B.S. Ohio State Univ., 1931; M.B.A., New York Univ., 1937; Ph.D., Ohio State Univ., 1953.

Robert von Pagenhardt, Professor, (1967)*; A.B., Stanford Univ., 1948; M.S., 1954; Ph.D., (pending).

Carlton Leroy Wood, Professor (1966); B.A., Univ. of Washington, 1932; M.A., Columbia Univ., 1944; Ph.D., Heidelberg Univ., 1936.

* The year of joining the Postgraduate School Faculty is indicated in parentheses.

The Navy Management Systems Center was established as a separate Naval Activity in February, 1966, for the purpose of fulfilling Department of Defense requirements for educating high level military and civilian personnel working in planning, programming, budgeting, systems analysis or resource management activities of Department of Defense components in the office of the Secretary of Defense, Departmental or Agency Headquarters, and selected major commands. Quotas to the Defense Management Systems Course are controlled by the sponsoring agency; i.e., the Departments of Army, Navy, Air Force, and the Office of the Secretary of Defense.

In addition, the Navy Management Systems Center conducts a four-week Management Course for Commanding Officers, Executive Officers and others directly concerned with Navy shore station management. The purpose of this course is to provide those responsible for managing shore station complexes the most modern management concepts in such areas as facility management, resource management systems, systems and operations analysis, organization and personnel management, and public affairs. Quotas to the Navy Shore Station Management Systems Course are controlled by the Bureau of Naval Personnel, Pers C-3.

The Center has also conducted short courses for foreign governments in their countries and in Monterey.

Faculty members of the Center are a part of the regular faculty of the Postgraduate School.

DEFENSE MANAGEMENT SYSTEMS COURSE

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 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 covers force planning, Department of Defense programming, program budgeting, and their interrelationships with resource management systems. Emphasis is placed on the analytical aspects of management, including requirements studies, systems analysic 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 decisionmaking, understanding of the principles, methods and techniques used, and awareness of the interfaces between management requirements of the Department of Defense components and the Office of the Secretary of Defense.

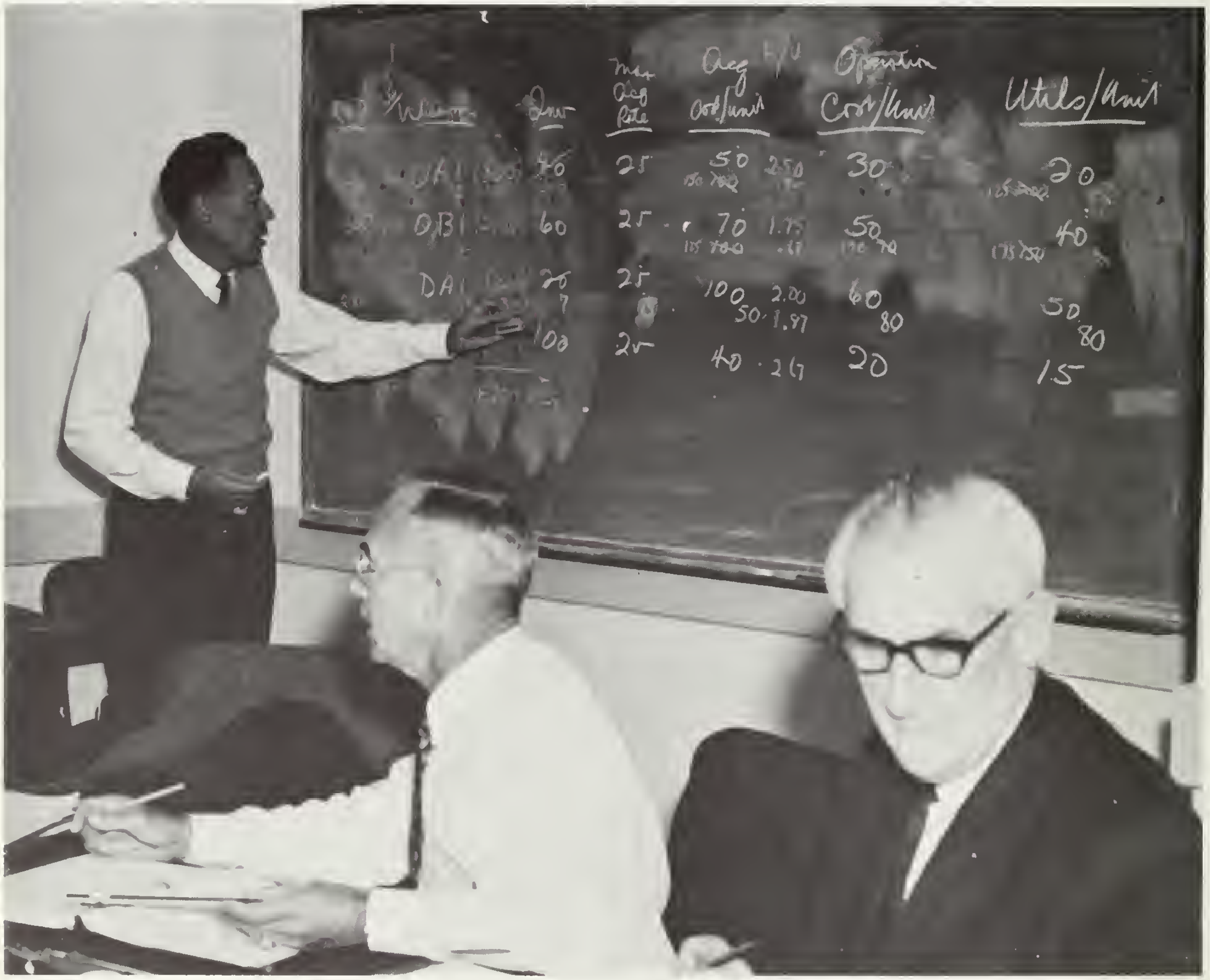
NAVY SHORE STATION MANAGEMENT SYSTEMS COURSE

The need for efficient management of Navy shore stations in support of the Fleet has been emphasized by recent developments in Defense Management. Among these are the Planning-Programming-Budgeting System at the headquarters level, and the Resources Management System emanating from the office of the Secretary of Defense. In addition, recent developments in the fields of Management Science and Operations Analysis have provided concepts and methods which must be applied to management of operations in a systematic and comprehensive manner if full realization of their benefits is to be achieved.

The objective of the Navy Shore Station Management Systems Course is to provide Navy Commanding Officers, Executive Officers, and senior staff assistants an understanding of the most modern management concepts, procedures, and techniques as applied in the shore station environment. The relationship to the Defense Planning-Programming-Budgeting System and higher level objectives are stressed in order to focus attention on the necessary transition in outlook from command afloat to management ashore. The course covers organization and mission accomplishment, resources management, Navy budgeting and financial management, information and control systems, facilities management, behavioral science, and public affairs. Throughout the course emphasis is placed on the application of economic analyses and quantitative methods to improve the overall management of Navy shore stations.

CALENDAR—Academic Year 1968-69

Date	Class No.	Type
1 July - 12 July 1968	#69-1	Symposium (DMSC)
14 July - 20 July 1968	#69-2	Flag/General (DMSC)
4 Aug. - 30 Aug. 1968	#69-3	Regular (DMSC)
18 Aug. - 13 Sept. 1968	#69-4	CO/XO
3 Sept. - 14 Sept. 1968	#69-5	NATO (Greek)
22 Sept. - 18 Oct. 1968	#69-6	Regular (DMSC)
20 Oct. - 15 Nov. 1968	#69-7	CO/XO
27 Oct. - 22 Nov. 1968	#69-8	Regular (DMSC)
8 Dec. - 13 Dec. 1968	#69-9	Flag/General (DMSC)
5 Jan. - 31 Jan. 1969	#69-10	Regular (DMSC)
26 Jan. - 21 Feb. 1969	#69-11	CO/XO
24 Feb. - 21 March 1969	#69-12	Regular (DMSC)
13 April - 9 May 1969	#69-13	Regular (DMSC)
27 April - 23 May 1969	#69-14	CO/XO
1 June - 27 June 1969	#69-15	Regular (DMSC)



TEMPO military planning game being conducted by Rear Admiral Stuart H. Smith, USN, DCLOG CINCLANT FLT, General Theodore J. Conway, USA, CINCSTRIKE, and Gunter Schoner, Ministry of Defense, Bonn, Germany

POSTGRADUATE SCHOOL STATISTICS
GRADUATES BY YEARS

	1946-1950	1951-1955	1956-1960	1961-1965	1966	1967	Total
Bachelor in Arts	......	......	......	180	113	89	382
B.S. in Aeronautical Engineering	73	212	212	181	34	16	728
B.S. in Chemistry	......	......	3	3	1	......	7
B.S. in Communications Engineering	......	......	42	95	24	21	182
B.S. in Electrical Engineering	62	115	98	253	43	38	609
B.S. in Engineering Electronics	94	177	92	172	42	39	616
B.S. in Environmental Science				12	......	......	12
B.S. in Management	......	......	......	53	1	......	54
B.S. in Mechanical Engineering	43	116	52	82	24	15	332
B.S. in Meteorology	16	104	77	108	21	13	339
B.S. in Physics	......	15	36	75	16	12	154
Bachelor of Science	......	56	94	583	117	116	966
Total Baccalaureate Degrees	288	795	706	1,797	436	359	4,381
M.S. in Aeroelectronics				4	......	3	7
M.S. in Aeronautical Engineering	......	......	......	36	24	20	80
M.S. in Chemistry	......	......	16	5	9	3	33
M.S. in Communications Engineering	......	......	......	......	6	5	11
M.S. in Material Science				5	4	3	12
M.S. in Electrical Engineering	7	34	46	86	21	28	222
M.S. in Engineering Electronics	68	120	78	104	19	21	410
M.S. in Management	......	......	......	406	89	116	611
M.S. in Management/Data Processing	......	......	......	22	22	44	88
M.S. in Mechanical Engineering	20	36	48	49	11	18	182
M.S. in Meteorology	23	19	40	53	18	12	165
M.S. in Operations Research	......	......	......	63	45	44	152
M.S. in Oceanography	......	......	......	......	12	11	23
M.S. in Physics	......	25	104	135	23	31	318
Master of Science	......	17	65	102	15	3	202
Total Master's Degrees	118	251	397	1,070	318	362	2,516
Aeronautical Engineer	......	......	......	4	6	8	18
Doctor of Philosophy	......	......	1	14	7	2	24
TOTAL DEGREES	406	1,046	1,104	2,885	767	731	6,939

Guest speaker Major General Thomas A. Kenan, Commanding General, Fort Ord, with Admiral McNitt congratulating LCDR Herbert E. Lotze, Jr., upon graduation

GRADUATES OF THE POSTGRADUATE SCHOOL 1967

DIPLOMAS OF COMPLETION ENGINEERING SCIENCE

ALBRIGHT, John D., LCDR, USN
BASHAM, Darell C., LT, USN
BERNDT, Donald J., LCDR, USN
BLANKINSHIP, John H., LT, USN
DALTON, Richard V., LCDR, USN
FREUND, Herman C., LCDR, USN
LEMING, Billy J., LT, USN
MANN, John P., LCDR, USN
MOSELEY, Leo O., LT, USN
ROTH, Conrad W., LCDR, USN

DIPLOMAS OF COMPLETION GENERAL LINE

CEVALLOS, V., Fausto Leonel, LT, Ecuadorian Navy
DUMANCAS, Mariano J., Jr., LT(jg), Philippine Navy
HO, Hong Pom, LCDR, Republic of Korea Navy
HSIEH, Kuan-huan, LCDR, Republic of China Navy
ISRANGKUL, Chavalit, LT, Royal Thai Navy
KANG, Young O., LT, Republic of Korea Navy
KIM, Chong Ho, LT, Republic of Korea Navy
LUAN, Ngo Khac, LCDR, Vietnam Navy
MARCELO, Virgilio, Q., LT(jg), Philippine Navy
MOSHTAGH, Shahmiri M., LT, Imperial Iranian Navy
OLMEDO B., Germanico, LT, Ecuadorian Navy
PHONG, Le-Thuan, LT, Vietnam Navy
RIVADENEIRA S., Rodrigo R., LT, Ecuadorian Navy
TUAN, Pham Manh, LT, Vietnam Navy
WANG, Yang, LCDR, Republic of China Navy
ZANGENEH, Esfandiar T., LT (jg), Imperial Iranian Navy

DIPLOMAS OF COMPLETION MANAGEMENT

BAKER, Donald E., LT, USN
DAVIS, Thomas A., LCDR, USN
ELLIS, Richmond K., CAPT, USMC
LANAGHAN, Harriett M., LCDR, USN
MARTIN, Donald, LCDR, USN
NESBITT, Harry J., LCDR, USN
POTTER, Thomas B., Jr., LCDR, USN
WARREN, Billy R., CDR, USN

DIPLOMAS OF COMPLETION MANAGEMENT (DATA PROCESSING)

AIAU, Harvey C. K., LCDR, USN
BARNETTE, George W., III, LCDR, USN
DEAN, Victor E., LT, USN
HICKAM, Aubrey W., Jr., LT, USN
MAYS, Clayton P., LCDR, USN
SIKES, James H., LCDR, USN

DIPLOMAS OF COMPLETION STAFF COMMUNICATIONS

ANDERSON, Larry F., LT, USN
BATIE, Howard F., LT, USN
BROWN, David C., LT, USN
DeCROSTA, Ernest L., LT, USNR
DIETZ, Eugene P., LT, USN
ENGQUIST, Gordon W., CDR, USN
HORNBECK, Arthur G., LT, USN
JETTON, James R., Jr., LT, USN
KEENE, Charles R., LCDR, USN
KNIGHT, Dennis R., LT, USN
KRISTOF, John J., LCDR, USN
MEEKER, Harold L., LT, USN
MELENDY, David R, LT, USN
McBURNETT, Kenneth S., LCDR, USN
McINTIRE, Lloyd G., LT, USN
NELSON, John P., LT, USN
ROWE, Arthur E., Jr., LT, USN
SCHRIEFER, Luther F., LT, USN
SMITH, Don L., LCDR, USN
SPAUGY, Donald A., Jr., LT, USN
SWEAT, Arthur J., LT, USN

DIPLOMAS OF COMPLETION TECHNICAL

FLEMING, Charles H., Jr., LT, USN
MACAULEY, William F., LCDR, USN
McCULLOUGH, Larry D., LT, USN
SEYFARTH, Robert E., LT, USN

BACHELOR OF ARTS

ADCOX, James R., LCDR, USN
ANGEL, John D., LT, USN
AUCOIN, Leonard L., LCDR, USN
BAILEY, Richard C., LCDR, USN
BARTZ, Donald P., LCDR, USN
BEAL, John S., LT, USN
BEGUIN, Larry W., LT, USN
BENNETT, Phillip L., LCDR, USN
BENTLEY, Robert E., LCDR, USN
BEVERSDORF, Donald W., LCDR, USN
BILODEAU, James H., LCDR, USN
BITTICK, Marshall V., Jr., LCDR, USN
BOAZ, George L., LCDR, USN
BOERNER, Delbert D., LCDR, USN
BOSWELL, Freddie L., Jr., LT, USN
CAHILL, Lionel A., Jr., LCDR, USN
CALDWELL, Charles B., LCDR, USN
CARLSON, George R., CDR, USN
CARR, Samuel L., LCDR, USN
CHAMPION, Andrew A., LCDR, USN
CHRISTIAN, Robert R., LCDR, USN
CLARKE, John R., CDR, USN
CLEMENS, Eugene M., LCDR, USN
CONNOLLY, Paul P., LCDR, USN
COTSONAS, John P., LCDR, USN
DAILY, Hubert D., Jr., LCDR, USN
DANIELS, Hal B., LCDR, USN
DeLOACH, John W., LCDR, USN
DIMON, Charles G., Jr., CDR, USN
DORSEY, James F., Jr., LCDR, USN
DRYLIE, Herbert D., Jr., LT, USN
DUFF, Robert G., LCDR, USN
EDWARDS, Forrest L., LCDR, USN
EDWARDS, William F., LCDR, USN
EMSLEY, Albert P., Jr., LCDR, USN
FITZGERALD, John W., LCDR, USN
FRANKENFIELD, Robert T., CDR, USN
FUESTON, Vernon M., Jr., LCDR, USN
GATEWOOD, Tommy L., CDR, USN
GERL, Neil D., LCDR, USN
GIEDZINSKI, Henry B., LCDR, USN
GILLINGHAM, Roger D., LT, USN
GLEIM, James M., LCDR, USN
GROSS, Sidney L., LCDR, USN
HAIDINGER, Timothy P., LT, USNR
HARTER, Gary L., LT, USN
HOLMES, Gary L., LT, USN
HOLT, Arvil A., LCDR, USN
JASKOLSKI, Kenneth J., LT, USN
JONES, Kenneth W., LCDR, USN
KATZMANN, Gerald H., LCDR, USN
KILGORE, William H., LCDR, USN
KINCAID, Rodney C., LCDR, USN
KING, William D., LT, USN
KIRKPATRICK, Hollis H., LCDR, USN
LANGNER, David S., LCDR, USN
LAUX, Arno H., LCDR, USN
LAYE, John E., LCDR, USN
LESTER, Roy E., LT, USN
LIPFORD, William L., LCDR, USN
LOTZE, Herbert E., Jr., LCDR, USN
MABE, James M., LCDR, USN
MANKE, Leo O., LCDR, USN
MONTGOMERY, Donald J., LCDR, USN
NIDER, Kenneth E., LCDR, USN
O'BOYLE, John R., Jr., LT, USN
PEEK, Luther W., LCDR, USN
PETTYJOHN, James R., LT, USN
PLATT, Ralph E., LCDR, USN
PORTER, Robert W., LCDR, USN
PRESTON, Edgar H., CDR, USN
REINHARDT, Jerry B., LCDR, USN
SIMON, Roger O., LCDR, USN
SMALLEY, Phyllis E., LT(jg) USN
SMITH, Woodrow W., Jr., LT, USN
SPIEGLER, Felix R., LCDR, USN

STECHMANN, Donald H., LCDR, USN
STILGEBOUER, Larry R., LT, USN
WALDEN, Warren L., LCDR, USN
WALLING, Samuel E., LCDR, USN
WEAVER, Daniel C., LCDR, USN
WEBB, James E., LCDR, USN
WEEDON, Robert E., CDR, USN
WITTHOFT, Ronald D., LCDR, USN
WOLFF, John D., LT, USN
WRIGHT, Rodger W., LT, USN
WRIGHT, William A., LT, USN
WYNN, Hugh J., LT, USN
YOUNG, Benjamin L., LCDR, USN

BACHELOR OF SCIENCE IN AERONAUTICAL ENGINEERING

CLARK, Maurice E., LT, USN
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HENDERSON, Tomas G., LT, USN
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KENDRICK, William O., CDR, USN
LLOYD, Roger M., LT, USN
LLOYD, Roger W., LT, USN
MERRIMAN, Gene D., LT, USN
MILLER, Leon R., LT, USN
POLAND, James B., LCDR, USN
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THOMSON, John A., LT, USN

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COWARD, Jimmie "K", LT, USN
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FAZEKAS, Alex E., MAJ, USMC
FOSKO, Paul D., LCDR, USN
GARNER, William D., LCDR, USN
HAMMOND, Edwin S., LT, USN
HINES, Stephen H., LT, USCG
HOLT, Robert B., LT, USN
KOONTZ, Ronald L., LT, USN
KUPLINSKI, Stanley J., LCDR, USN
MARTINO, Frank W., MAJ, USMC
METCALF, Robert E., LT, USN
PAINTER, Clarence M., Jr., LT, USN
ROSS, Ernest E., LT, USN
ROSSON, Vernon L., LT, USN
RUSSELL, Paul D., LT, USCG
TETTLEBACH, Frederick M., LCDR, USN
VOLK, John S., LT, USN
WILLIAMS, James G., LT, USCG

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AMROSE, Lawrence A., LT, USNR
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DONEHOWER, Howard R., CAPT, USMC
DUNN, Will-Matthis, Jr., LT, USN
ETZLER, Larry L., LT, USN
FEENEY, Harry J., III, LT, USN
GODDARD, Charles D., MAJ, USMC
GOMEZ, Roberto, LT, Colombian Navy
GRIMM, Thomas D., LT, USN
GRINNELL, Donald P., LT, USN
HARBORTH, William M., CAPT, USMC
HARDISON, Robert P., Jr., LT, USN
HENDRY, James D., LCDR, USN
KISTLER, George K., LCDR, USN
KOEHLER, Robert L., LCDR, USN
LEPAK, Ronald R., LT, USN
LOHSE, Hans J., LCDR, Federal German Navy
LOMOTAN, Bonifacio C., Jr., LT, Philippine Navy
LONG, William C., LT, USN
LUND, Jon R., LT, USN
MANAZIR, Charles H., CAPT, USMC
MAYS, George G., LT, USN
McCAMMON, Peter L., LT, USN
McKEE, Samuel K., III, CAPT, USMC
MEYER, Frank W., LCDR, USN
NEUHARD, Henry H., LCDR, USN
OEHRL, Wolfgang K., LCDR, Federal German Navy
RITZ, Merlin C., LCDR, USN
ROGERS, Torrence W., CAPT, USMC
RUDOLPH, Ralph M., LT, USNR
SCHIRMER, Theodore C., LT, USNR
SHEPHERD, Terry A., LT, USNR
STEINBERG, Mitchell, CAPT, USMC
VAN GORDER, Jan H., MAJ, USMC
VON KOLNITZ, Henry, Jr., LT, USN
WOMACK, Thomas F., LT, USN

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BOMAN, Bruce B., CAPT, USMC
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DARROW, Donnie L., CAPT, USMC
DEVINS, Gerald L., LT, USN
DeWALT, Donald H., CAPT, USMC
EVANS, Donald G., CAPT, USMC
FORDHAM, Ellis F., CAPT, USMC
FLYNN, Joseph F., CAPT, USMC
GARDNER, Dayne G., CAPT, USMC
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JACOBS, Edward J., LCDR, USN
KELLY, John A., CAPT, USMC
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MADER, Joseph W., LT, USN
McDANIEL, Jerry P., LT, USN
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MILLS, Brent C., LT, USCG
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SCHUETZ, Gerhard, LCDR, Federal German Navy
SZANTAI, Frank M., LT, USN
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TAYLOR, Turner W., LT, USN
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KLINE, Robert L., LT, USN
LLEDO, Jose J., LT, Chilean Navy
O'CONNELL, Philip J., Jr., LT, USN
OLSAKER, Knut, LCDR, Royal Norwegian Navy
PETERSON, Joel N., CAPT, USMC
PETHICK, John A., II, LT, USN
SANTOS, Alfred J., Jr., LT, USN
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STRAIGHT, William D., LT, USN
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FRIEDERICH, Bruce, LCDR, USN
GIERSCH, George J., LT, USN
GRAHAM, Sidney R., LCDR, USN
HITCHBORN, James B., LT, USN
KRUSE, Henry J., LCDR, USN
MAIER, William H., LT, USN

McREE, James D., LT, USN
RAUCH, Wayne N., LT, USN
SHARP, John B., Jr., LT, USN
STANLEY, James E., LT, USN
STREY, Carol G., LT, USNR
WENTWORTH, David C., LT, USN

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BREEDING, Donald C., LT, USN
BROWN, Buell L., Jr., LT, USN
CLARK, Daniel B., LT, USN
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DIEHM, William C., III, LCDR, USN
GRAFF, Paul E., LCDR, USN
HENDERSON, Ronald G., LT, USN
HOPKINS, Granville, J., LT, USN
JOYCE, John P., CAPT, USAF
MAHON, Edward J., Jr., LCDR, USN
MURTLAND, James B., III, MAJ, USMC
PAPPAS, Constantine J., LT, USN

BACHELOR OF SCIENCE

ARDALAN, Abolfath, LCDR, Imperial Iranian Navy
ARNER, William S., Jr., LT, USN
BACKMAN, Wallace W., LT, USN
BAILEY, Stanley J., Jr., LT, USN
BARKER, Ernest W., LCDR, USN
BEATTY, John R., LCDR, USN
BOORIAKIN, Walter A., LCDR, USN
BOTTENBERG, Foster L., LCDR, USN
BRANDQUIST, Roland, LT, USN
BRICKNER, John S., LCDR, USN
BROWN, Robert B., MAJ, USA
BRYANT, Don M., LCDR, USN
BULL, Norman S., LCDR, USN
CAMPBELL, William, Jr., LCDR, USN
CARLSON, Patrick J., LT, USN
CARPENTER, Lawrence J., LCDR, USN
CARTWRIGHT, James P., LT, USN
CASSANI, Henry L., CDR, USN
CHIDER, Thomas J., LT, USN
CHITURAS, Charles C., LT, USN
COE, Raymond P., LCDR, USN
COLEMAN, James O., CDR, USN
CONNOLLY, Timothy W., LCDR, USN
COYNE, William L., LCDR, USN
CUCCIAS, Leo P., LCDR, USN
CUDDY, John V., LT, USN
DOUCET, Richard E., LCDR, USN
DUNN, Gerald L., LT, USN
DUNN, John F., LCDR, USN
DVORAK, Robert, LCDR, USN
EMERSON, Jesse R., III, CDR, USN
EMMERSON, Milo E., LCDR, USN
FERTIG, Lanny L., LT, USNR
FITZGERALD, John F., LCDR, USN
FLESHER, Elbert E., Jr., LT, USN
GEER, David W., LT, USN
GLASIER, John M., LT, USN
GRAHAM, Genie K., LT, USN
GREGORY, George B., CDR, USN
GOODALE, Charles N., LCDR, USN
HAMILTON, John W., CDR, USN
HANSEN, Kirby W., LT, USN
HANSEN, Laurence R., LT, USN
HARBER, Russell L., LCDR, USN
HARMS, Stanley J., LCDR, USN
HAYES, Fay C., LCDR, USN
HAYES, Newton G., LCDR, USN
HEILAND, Charles E., LCDR, USN
HENRY, John A., Jr., LCDR, USN
HILL, Frank W., LCDR, USN
HOLZSCHUH, Jacob R., LCDR, USN
HUGO, James W., LT, USN
HUSTON, William G., LCDR, USN
IVES, Richard H., LCDR, USN
JACOBS, Paul H., LCDR, USN
JOHNSON, Robert E., LCDR, USN
KAVANAGH, Robert G., LCDR, USN
KENNEDY, Jerry F., LT, USN
KENNEY, Daniel J., LCDR, USN
KLEIN, Harry L., LCDR, USN
LAWSON, Herbert F., MAJ, USMC
LINO, Norman J., LCDR, USN
LOCKWOOD, Robert K., Jr., LCDR, USN
LOEFFLER, William H., LCDR, USN
MAGNER, Lawrence R., LCDR, USN
MARTIN, William G., LT, USN
MAYO, Lester M., Jr., LT, USN
McELMURRY, Joe A., LT, USN
McRAE, James F., LCDR, USN
MILLER, Blount R. Jr., CDR, USN
MILLER, Everett R., LT, USN
MONROE, Charles H., LCDR, USN
MONTGOMERY, Samuel S., LCDR, USN
MYERS, Carroll E., CDR, USN
NEWMAN, Alvin S., LCDR, USN
PALOMBO, Robert A., LT, USN
PATRICK, Andrew K., LCDR, USN
PERKINS, James E., LCDR, USN
PETERSON, Charles E., LT, USN
POWELL, William B., LT, USN
PRICE, Harold R., LT, USN
RAITER, Richard F., LCDR, USN
RAMSEY, Roger C., LT, USN
RASAVAGE, John R., MAJ, USMC
REDINGTON, Jerome J., LCDR, USN
REED, Richard L., LCDR, USN
REHFIELD, Austin W., LT, USN
RITCHEY, Donald D., CDR, USN
RUBY, Scott M., LT, USN
RUHSENBERGER, John F., LT, USN
SAUNDERS, Richard E., LCDR, USN
SELGRATH, James J., LCDR, USN
SHARP, Gail J., LCDR, USN
SHELTON, Donald, LT, USN
SHOEMAKER, Leroy E., LCDR, USN
SLEDGE, Carl M., LCDR, USN
SNYDER, Herman L., Jr., LCDR, USN
STALCUP, Jimmie M., LCDR, USN
STALLINGS, Arthur C., Jr., LCDR, USN
TAYLOR, Robert G., LT, USN
THOMPSON, Richard G., LCDR, USN
TRANCHINI, Joseph, LT, USN
TULLIS, James V., LCDR, USN
TURCZYN, Daniel W., LT, USN
URSITTI, Gerald F., LT, USNR
USTICK, Richard C., LCDR, USN
VADEN, Stephen J., LT, USN
VAUGHN, Harold J., LT, USN
VINSON, John T., LCDR, USN
WALKER, James R., LT, USN
WALL, Joseph E., LCDR, USN
WALL, Richard H., LCDR, USN
WHITE, Steve C., LT, USN
YAKUBEK, Paul M., LT, USN
YELLF, A., Courtney, LCDR, USN
ZIPSE, Robert L., LCDR, USN

MASTER OF SCIENCE IN AEROELECTRONICS

DAVIS, Walter J., Jr., LT, USN
HOWARD, Phillip S., LT, USN
WASMUND, Thomas L., LT, USN

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