UNITED STATES NAVAL

POSTGRADUATE SCHOOL

Catalogue for 1962-1963

MONTEREY ★ CALIFORNIA

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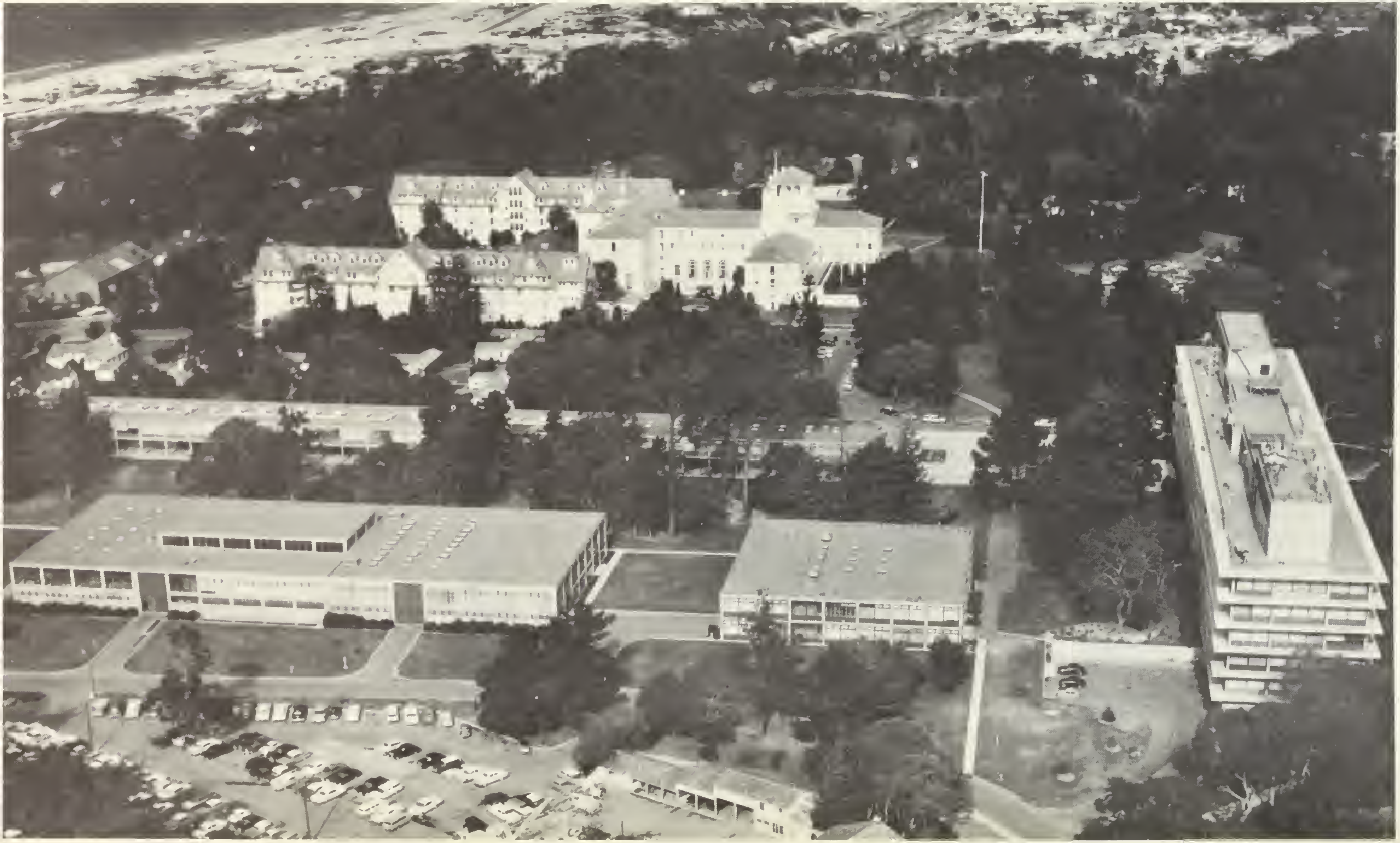
POSTGRADUATE SCHOOL

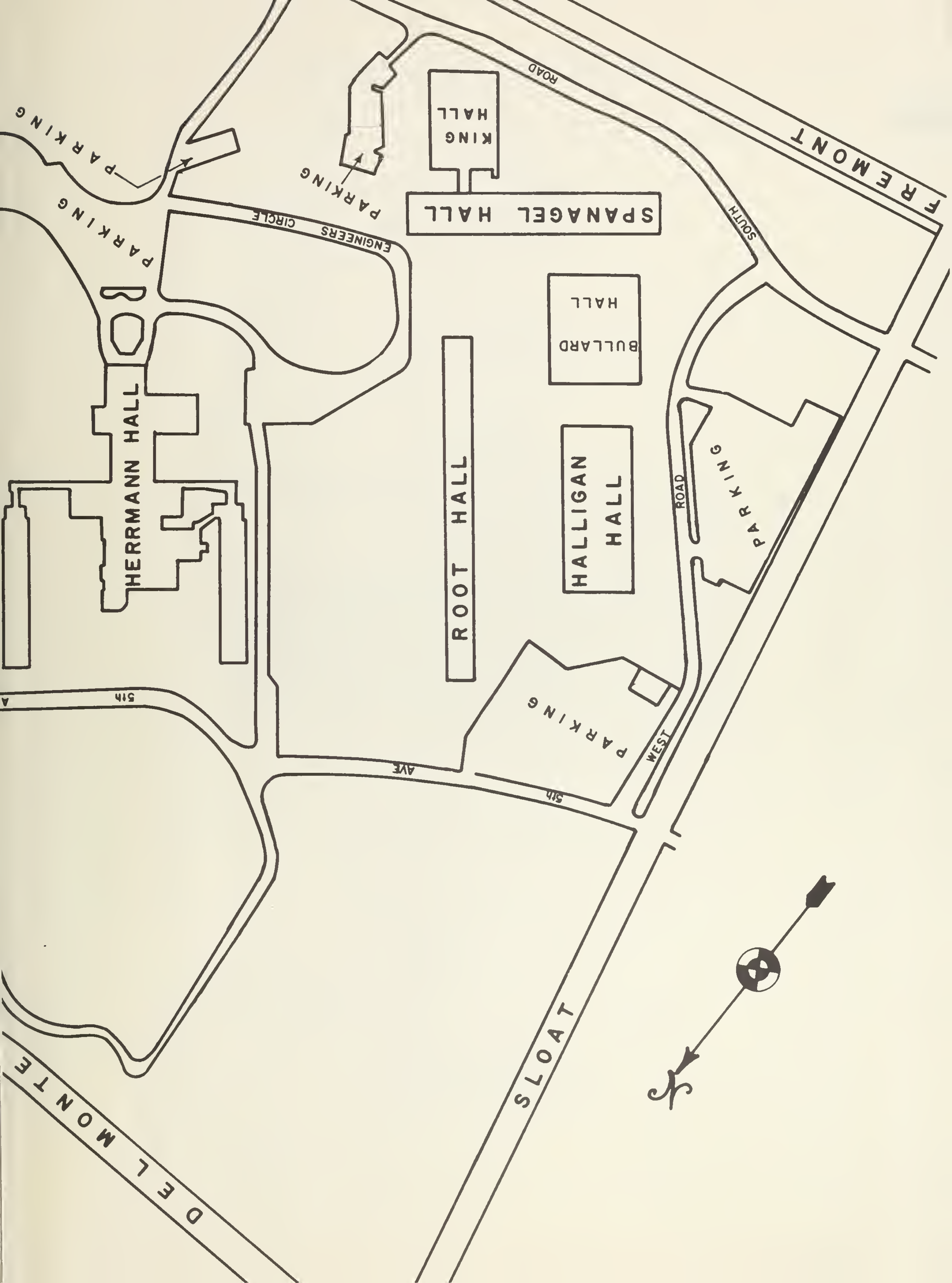
Catalogue for 1962-1963

MONTEREY ★ CALIFORNIA



UNITED STATES NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

(See map opposite page)


FREMONT
SOUTH ROAD
KING HALL
SPANAGEL HALL
PARKING
PARKING
PARKING
ENGINEERS CIRCLE
BULLARD HALL
HALLIGAN HALL
ROOT HALL
HERRMANN HALL
PARKING
WEST ROAD
PARKING
5th AVE
5th
SLOAT
DEL MONTE

MISSION

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

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

U. S. NAVAL POSTGRADUATE SCHOOL

Superintendent

MARSHALL EDGAR DORNIN

Rear Admiral, U. S. Navy
B.S., USNA, 1930; USNPS, 1939;
Naval War College, 1951

Chief of Staff

MERLE FRANCIS BOWMAN

Captain, U. S. Navy
B.S., USNA, 1933; Naval War College,
Senior Course in Naval Warfare, 1955

Academic Dean

ALLEN EDGAR VIVELL

B.E., Johns Hopkins Univ., 1927; D. Eng., 1937

Dean Emeritus

ROY STANLEY GLASGOW

B.S., Washington Univ., 1918;
M.S., Harvard, 1922; E.E., Washington Univ., 1925;
D.Sc. (Hon.), Washington Univ., 1961

Director, Engineering School

ROBERT DUNLAP RISSER

Captain, U. S. Navy
B.S., USNA, 1934; M.S., Univ. of Michigan, 1943

Director, General Line and Naval Science School

ALFRED LEROY GURNEY

Captain, U. S. Navy
A.B., St. Mary's College, 1935; General Line School, 1947;
Industrial College of the Armed Forces, 1956

Director, Navy Management School

HERBERT HENRY ANDERSON

Captain, U. S. Navy
B.S., USNA, 1941; M.B.A., Harvard Univ., 1953;
National War College, 1958

Commanding Officer, Administrative Command

RALPH WILLIAM ARNDT

Captain, U. S. Navy
B.S., USNA, 1936; B.S., USNPS, 1949;
M.S., Univ. of Minnesota, 1950

POSTGRADUATE SCHOOL CALENDAR

Academic Year 1962-1963

1962

Management School Summer Session Begins..............Monday, 2 July
Fourth of July (Holiday)..........................Wednesday, 4 July
General Line & Naval Science School Summer Term ends
(Classes NS-6 and 7)..........................Friday, 6 July
Management School Summer Session Ends................Friday, 27 July
Engineering School, Management School, General Line &
Naval Science School (Classes 1963A and
NS-9) Registration..........................Monday, 30 July
General Line & Naval Science School Fifth Term Ends,
NS-5 Graduation ....Friday, 3 August
Engineering School, Management School, General Line &
Naval Science School First Term Begins.........Monday, 6 August
Labor Day (Holiday).........................Monday, 3 September
Engineering School First Term Ends...............Thursday, 11 October
Management School General Line & Naval Science School
First Term Ends..........................Friday, 12 October
Management School General Line & Naval Science School
Second Term Begins......................Monday, 15 October
Engineering School Second Term Begins.............Tuesday, 16 October
Veterans' Day (Holiday).....................Monday, 12 November
Thanksgiving Day (Holiday).................Thursday, 22 November
General Line & Naval Science School Graduation
(Class 1962B) ....Wednesday, 19 December
Engineering School, Management School, General Line &
Naval Science School Second Term Ends.
Christmas Holiday Begins..................Friday, 21 December

1962

	S	M	T	W	T	F	S
JAN.		1	2	3	4	5	6
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FEB.					1	2	3
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SEP.							1
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DEC.							1
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1963

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SEP.	1	2	3	4	5	6	7
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DEC.	1	2	3	4	5	6	7
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	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
	29	30	31				

1963

Engineering School, Management School, General Line &
Naval Science School Third Term Begins........Monday, 7 January
Washington's Birthday (Holiday)..................Friday, 22 February
General Line & Naval Science School (Classes 1963B and NS-10)
and One Year Science Program Registration......Monday, 11 March
Engineering School Third Term Ends................Thursday, 14 March
Management School, General Line & Naval Science School
Third Term Ends, NS-6 Graduation............Friday, 15 March
Management School, General Line & Naval Science School
Fourth Term Begins.......................Monday, 18 March
Engineering School Fourth Term Begins..............Tuesday, 19 March
Engineering School, Management School, General Line &
Naval Science School Fourth Term Ends............Friday, 24 May
General Line & Naval Science School Fifth Term Begins...Monday, 27 May
Memorial Day (Holiday)........................Thursday, 30 May
Engineering School, Management School, General Line &
Naval Science School (Class 1963A) Graduation....Monday, 3 June
Engineering School Special Weapons Orientation Begins....Tuesday, 4 June
Engineering School Special Weapons Orientation Ends.......Friday, 7 June
Engineering School Space and Astronautics Orientation
Course Begins ....Wednesday, 26 June
Engineering School Space and Astronautics Orientation
Course Ends ....Friday, 28 June
Management School Summer Session Begins..............Monday, 1 July
Fourth of July (Holiday)........................Thursday, 4 July
General Line & Naval Science School Summer Term Ends
(Classes NS-8 and 9)..........................Friday, 5 July
Management School Summer Session Ends...............Friday, 26 July
Engineering School, Management School, General Line &
Naval Science School (Classes 1964A and NS-11)
Registration ....Monday, 29 July
General Line & Naval Science School Fifth Term Ends,
NS-7 Graduation ....Friday, 2 August
Engineering School, Management School, General Line &
Naval Science School First Term Begins..........Monday, 5 August

U.S. NAVAL POSTGRADUATE SCHOOL

GENERAL INFORMATION

FUNCTIONS

The Naval Postgraduate School is a naval university which acts as the agent of the Bureau of Naval Personnel for the advanced formal education of Naval Officers. In carrying out its mission, the School performs the following functions:

a. Provides undergraduate education leading to a baccalaureate degree (BS or BA).

b. Provides advanced professional education.

c. Provides advanced engineering education.

d. Provides graduate education in Management.

e. Supervises the education of officer students at various civilian institutions throughout the country.

These functions stem from the mission which in turn has evolved over the years as a result of the recognized need for advanced education. The resulting program is essentially four-fold; technical, non-technical, professional, and special.

The Engineering School seeks, by graduate instruction, to provide officers with the facility for intelligent technical direction of the Navy's activities in such fields as aeronautical engineering, electronics and communications engineering, meteorology and oceanography, naval engineering, and naval ordnance, as well as in the sciences such as operations analysis, general and nuclear physics, chemistry, applied mathematics, hydrodynamics, metallurgy and others.

In addition, a one year science curriculum is offered selected officers to provide an opportunity to increase their knowledge in the fields of mathematics, physics and chemistry.

Although the science curriculum is neither an appropriate prerequisite nor an adequate substitute for the 2 and 3 year technical curricula, it does provide those officers who are available for 2 or 3 years and who demonstrate their academic proficiency during the first two terms (20 weeks) an opportunity to transfer into technical curricula.

The General Line and Naval Science School is designed to broaden and enhance the mental outlook and professional knowledge of line officers, thereby preparing them for more responsible duties in the Navy. In addition this school conducts a general college level course for officer students leading to a baccalaureate degree either in the arts or sciences (BA or BS).

The Management School provides an educational progtam in the application of sound scientific management practice to the complex organizational structure of the Navy with a view to increasing efficiency and economy of operation.

ORGANIZATION

The Naval Postgraduate School, headed by the Superintendent who is a rear admiral of the line of the Navy, consists of four main components: The Engineering School, the General Line and Naval Science School, the Navy Management School, and the Administrative Command. The Administrative Command is the supporting organization for the schools at Monterey and provides logistics and administrative services. Each of the four components is headed by a captain of the line.

The three schools at Monterey are staffed by both military and civilian personnel in direct proportion to the school's specific functions. The civilian faculty of the three schools, headed by the Academic Dean, provides the academic instructions in fields normally found in civilian educational institutions. The officer faculty provides the instruction in the purely naval subjects. The Engineering School faculty is predominantly civilian; the General Line and Naval Science School faculty is predominantly military; and the Management School has approximately an equal number of each. Military organization within the schools provides for student administrative and counseling functions other than academic.

FACILITIES

The U.S. Naval Postgraduate School is located about one mile east of downtown Monterey on the site of the former Del Monte Hotel. Modern classroom and laboratory buildings have been constructed and are situated on a beautifully landscaped, pleasant campus.

The Superintendent and the central administrative offices of the school are located in the main building of the former Del Monte Hotel, now called Herrmann Hall.

The General Line and Naval Science School is located in the East Wing of the main building complex, with CIC, sonar, seamanship and navigation laboratories located in additional small buildings in the vicinity.

The Management School administration is located in the West Wing of the main building complex, while its classes are held in the classroom building, Root Hall.

The Engineering School administration is located in a new building, Spanagel Hall, which also houses classrooms and laboratories. In addition to Spanagel Hall, the Engineering School has Bullard Hall for Electrical Engineering laboratories, and additional buildings for steam and nuclear laboratories.

Root Hall, primarily a classroom building used by all three schools, also houses the Reference and Research Library.

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

On the main School grounds are 149 BOQ rooms, an Open Mess, a Navy Exchange, 4 tennis courts and a large swimming pool.

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

DEGREES, ACCREDITATION, AND ACADEMIC STANDARDS

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

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

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

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

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

When the term hour value of a course is multiplied by the quality point number of the student's grade, a quality point value for the student's work in that course is obtained. The sum of the quality points for all courses divided by the sum of the term hour value of all courses give 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.

Requirements for degrees and certificates applicable to the individual school components are described in the portion of the catalogue relating to that school.

HISTORY

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

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

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

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

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

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 1945 to 1951 emphasizing the academic level of the School, and providing for continued growth in a new location with modern buildings and equipment. This legislation authorized the Superintendent to confer Bachelors, Masters, and Doctors degrees in engineering and related subjects; created the position of Academic Dean to insure continuity in academic policy; established the School as a separate naval activity to be known as the United States Naval Postgraduate School; authorized the establishment of the School at Monterey, California; and provided funds to initiate the construction of buildings to house modern laboratories and classrooms at that location.

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

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

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

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 is to provide an educational program for officers in the application of sound scientific management practice to the complex organizational structure and operations of the Navy with a view to increasing efficiency and economy of operation. The first class included only Supply and Civil Engineering Corps officers and emphasis was placed on general management theory, financial management, and inventory management. In August 1957 this school was expanded to include input from both Line and Staff Corps officers. Since that time the curriculum has been under constant revision to include new areas of import to, and changes of concept in, the field of management. In August 1960 the school curriculum was lengthened from a five to a ten month course leading to a master's degree for those who can meet the requirements for such a degree.

THE LIBRARIES

Description

The Library system serves the research and instructional needs of the community comprised of students, faculty, and staff of the Engineering School, the General Line and Naval Science School, and rhe Management School. It embraces an active collection of 61,000 books, 220,000 technical documents, 1,500 periodical works currently received, and over 200,000 abstract cards and microcards. These materials parallel the School's curricular fields of engineering, physical sciences, industrial engineering, management, naval sciences, government and the humanities.

The Reference Library 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 of 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 220,000 documents, 65,000 of which are classified, and exercises control over the microcard collection. A machine information storage and retrieval system that utilizes the School's computer facilities is now available for literature searches of documents received since November, 1960.

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

Staff

George R. LUCKETT, Professor and Director of Libraries (1950); B.S., Johns Hopkins University, 1949; M.S., Catholic University, 1951.

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

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

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

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

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

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

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

Beth PETERSON, Cataloger (1958).

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

Robert Moran TIERNEY, Acquisitions Librarian (1957); B.A., Columbia University, 1937.

Mabel VAN VORHIS, Librarian, Physical Sciences and Engineering (1955); B.A., University ot California, Berkeley, 1926.

DISTINGUISHED ALUMNI

Among the living who have completed a postgraduate curriculum are the following who attained flag (USN) or general (USMC) rank on the active list: (The asterisk (*) indicates those on the active list as of 1 December 1961.)

Admiral Walter F. Boone
Admiral Arleigh A. Burke
General Clifton B. Cates
Admiral Arthur C. Davis
Admiral Robert Lee Dennison*
Admiral Donald B. Duncan
Admiral Frank G. Fahrion
Admiral Cato D. Glover, Jr.
Admiral Roscoe F. Good
Admiral Byron H. Hanlon
Admiral Royal E. Ingersoll
Admiral Albert G. Noble
Admiral Alfred M. Pride
Admiral James O. Richardson
Admiral James S. Russell*
Admiral Claude V. Ricketts*
Admiral Samuel M. Robinson
Admiral John H. Sides*
General Holland M. Smith
Admiral Felix B. Stump
General Merrill B. Twinning
Admiral John M. Will
Vice Admiral Walter S. Anderson
Vice Admiral Harold D. Baker
Vice Admiral Wallace M. Beakley*
Vice Admiral George F. Beardsley*
Vice Admiral Donald B. Beary
Vice Admiral Frank E. Beatty
Vice Admiral Robert E. Blick, Jr.
Vice Admiral Harold G. Bowen
Vice Admiral Roland M. Brainard
Vice Admiral Carlton F. Bryant
Vice Admiral Edmund W. Burrough
Vice Admiral William M. Callaghan
Vice Admiral John H. Carson
Vice Admiral Ralph W. Christie
Vice Admiral Edward W. Clexton
Vice Admiral Oscar S. Colclough
Vice Admiral Thomas S. Combs
Vice Admiral George R. Cooper
Vice Admiral William G. Cooper
Vice Admiral Maurice E. Curts
Vice Admiral John C. Daniel
Vice Admiral Glen B. Davis
Vice Admiral Harold T. Deuterman*
Vice Admiral James H. Doyle
Vice Admiral Irving T. Duke
Vice Admiral Calvin T. Durgin
Vice Admiral Ralph Earle, Jr.
Vice Admiral Clarence E. Ekstrom*
Vice Admiral Emmet P. Forrestel
Vice Admiral Lawrence H. Frost*
Vice Admiral Roy A. Gano*
Vice Admiral Elton W. Grenfell*
Vice Admiral Charles D. Griffin*
Lieutenant General Field Harris
Vice Admiral Robert W. Hayler
Vice Admiral Truman J. Hedding
Lieutenant General Leo D. Hermle
Vice Admiral Ira H. Hobbs
Vice Admiral George F. Hussey, Jr.
Vice Admiral Olaf M. Hustvedt
Vice Admiral Thomas B. Inglis
Vice Admiral Albert E. Jarrell
Vice Admiral Harold B. Jarrett
Lieutenant General Clayton C. Jerome
Vice Admiral Ingolf N. Kiland
Vice Admiral Fred D. Kirtland
Vice Admiral Willard A. Kitts
Vice Admiral Harold O. Larson
Vice Admiral Ruthven E. Libby
Vice Admiral Frank L. Lowe
Vice Admiral James E. Maher
Vice Admiral William J. Marshall
Vice Admiral Charles B. Martell*
Vice Admiral John L. McCrea
Vice Admiral Ralph E. McShane
Vice Admiral Charles L. Melson*
Vice Admiral Arthur C. Miles
Vice Admiral Milton E. Miles
Vice Admiral Earle W. Mills
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M.S., University of Michigan, 1943

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RICHARD WILIAM BELL, Professor of Aeronautics (1951); A.B., Oberlin College, 1939; Ae. E., California Institute of Technology, 1941; Ph.D., 1958.

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PETER WILLIAM ZEHNA, Associate Professor of Mathematics (1961); A.B., Colorado State College, 1950; M.A., Colorado State College, 1951; M.A., Univ. of Kansas, 1956; Ph.D., Stanford University, 1959.

DEPARTMENT OF MECHANICAL ENGINEERING

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DENNIS KAVANAUGH, Professor Emeritus of Mechanical Engineering (1926); B.S., Lehigh Univ., 1914.

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CHARLES PINTO HOWARD, Associate Professor of Mechanical Engineering (1954); B.S. in M.E., Texas Agricultural and Mechanical College, 1949; M.S. in M.E., 1951; Engr. in M.E., Stanford Univ., 1960.

CECIL DUDLEY GREGG KING, Associate Professor of Mechanical Engineering (1952); B.E., Yale Univ., 1943; M.S. in M.E., Univ. of California (Berkeley), 1952.

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.

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HAROLD MARSHALL WRIGHT, Professor of Mechanical Engineering (1945); B.Sc. in M.E., North Carolina State College, 1930; M.M.E., Rensselaer Polytechnic Institute, 1931.

DEPARTMENT OF METALLURGY AND CHEMISTRY

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JAMES EDWARD SINCLAIR, Associate Professor of Chemistry (1946); B.S., Ch.Eng., Johns Hopkins Univ., 1945; M.S. in Chem., USNPS, 1956.

JAMES WOODROW WILSON, Professor of Chemical Engineering (1949); B.A., Stephen F. Austin State College (Texas), 1935; B.S. in Ch.E., Univ. of Texas, 1939; M.S. in Ch.E., Texas A. and M. College, 1941.

DEPARTMENT OF METEOROLOGY AND OCEANOGRAPHY

WILLIAM DWIGHT DUTHIE, Professor of Meteorology; Chairman (1945); A.B., Univ. of Washington, 1935; M.S., 1937; Ph.D., Princeton Univ., 1940.

GEORGE JOSEPH HALTINER, Professor of Meteorology (1946); B.S., College of St. Thomas, 1940; Ph.M., Univ. of Wisconsin, 1942; Ph.D., 1948.

GLENN HAROLD JUNG, Associate Professor of Oceanography (1958); B.S., Massachusetts Institute of Technology, 1949; M.S., 1952; Ph.D., Texas Agricultural and Mechanical College, 1955.

FRANK LIONEL MARTIN, Professor of Meteorology (1947); B.A., Univ. of British Columbia, 1936; M.A., 1938; Ph.D., Univ. of Chicago, 1941.

ROBERT JOSEPH RENARD, Assistant Professor of Meteorology (1952); M.S., Univ. of Chicago, 1952.

CHARLES LUTHER TAYLOR, Associate Professor of Meteorology (1954); B.S., The Pennsylvania State Univ., 1942; M.S., 1947.

WARREN CHARLES THOMPSON, Professor of Oceanography (1953); A.B., Univ. of California at Los Angeles, 1943; M.S., Scripps Institution of Oceanography, 1948; Ph.D., Texas Agricultural and Mechanical College, 1953.

WILLEM VAN DER BIJL, Associate Professor of Meteorology and Oceanography (1961); B.Sc., Free University of Amsterdam, 1941; M.Sc., Free University of Amsterdam, 1943; Ph.D., State University, Utrecht, 1952.

JACOB BERTRAM WICKHAM, Associate Professor of Oceanography (1951); B.S., Univ. of California, 1947; M.S., Scripps Institution of Oceanography, 1949.

DEPARTMENT OF OPERATIONS RESEARCH

THOMAS EDMOND OBERBECK, Professor of Operations Research, Chairman (1951); A.B., Washington University, 1938; A.M., Univ. of Nebraska, 1940; Ph.D., California Institute of Technology, 1948.

LOUIS B. KAHN, Associate Professor of Operations Research (1962); B.S., Illinois Institute of Technology, 1940; M.S., Univ. of Wisconsin, 1948; Ph.D., 1951.

DEPARTMENT OF PHYSICS

AUSTIN ROGERS FREY, Professor of Physics; Chairman (1946); B.S., Harvard Univ., 1920; M.S., 1924; Ph.D., 1929.

FRED RAMON BUSKIRK, Assistant Professor of Physics (1960); B.S., Western Reserve Univ., 1951; Ph.D., Case Institute of Technology, 1958.

THOMAS THADEUS COLE, JR., Lieutenant, U.S. Navy; Instructor in Physics (1961); B.S., Duke University, 1953; M.S., Univ. of Colorado, 1961.

ALFRED WILLIAM MADISON COOPER, Assistant Professor of Physics (1957); B.A., Univ. of Dublin, 1955; M.A., 1959; Ph.D., The Queen's Univ. of Belfast, 1961.

JOHN NIESSINK COOPER, Professor of Physics (1956); A.B., Kalamazoo College, 1935; Ph.D., Cornell Univ., 1940.

EUGENE CASSON CRITTENDEN, JR., Professor of Physics (1953); A.B., Cornell Univ., 1934; Ph.D., 1938.

PETER PEIRCE CROOKER, Instructor in Physics (1960); B.S., Oregon State College, 1959.

WILLIAM PEYTON CUNNINGHAM, Professor of Physics (1946); B.S., Yale Univ., 1928; Ph.D., 1932.

JOHN NORVELL DYER, Assistant Professor of Physics (1961); A.B., Univ. of California, 1956; Ph.D., 1960.

HARRY ELIAS HANDLER, Associate Professor of Physics (1958); A.B., Univ. of California at Los Angeles, 1949; A.M., 1951; Ph.D., 1955.

DON EDWARD HARRISON, JR., Associate Professor of Physics (1961); B.S., College of William and Hary, 1949; M.S., Yale Univ., 1950; Ph.D., 1953.

OTTO HEINZ, Associate Professor of Physics (1962); B.A., University of California, 1948; Ph.D., 1954.

SYDNEY HOBART KALMBACH, Associate Professor of Physics (1947); B.S., Marquette Univ., 1934; M.S., 1937.

RAYMOND LEROY KELLY, Associate Professor of Physics (1960); A.B., 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., Worchester 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, Associate 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.

John Dewitt RIGGIN, Professor of Physics (1946); B.S., Univ. of Mississippi, 1934; M.S., 1936.

George Wayne RODEBACK, Associate Professor of Physics (1960); B.S., Univ. of Idaho, 1943; M.S., Univ. of Illinois, 1947; Ph.D., 1951.

James Vincent SANDERS, Assistant Professor of Physics (1961); B.S., Kent State Univ., 1954; Ph.D., Cornell Univ,. 1961.

Oscar Bryan WILSON, Jr., Associate Professor of Physics (1957); B.S., Univ. of Texas, 1944; M.A., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

GENERAL INFORMATION

Function: The Engineering School accomplishes that part of the mission of the Postgraduate School "to conduct . . . advanced education . . . and technical instruction . . . as may be prescribed to meet the needs of the service." Many curricula at both the undergraduate and graduate level are offered by the school at Monterey in a number of technical fields of naval interest. In addition, students are placed in civilian universities throughout the country for graduate study in fields such as civil engineering or naval architecture which are not offered in the Navy's own Postgraduate School facilities.

Organization: The Engineering School is organized with a naval administrative staff for professional supervision of curricula and an academic faculty for technical instruction and educational advice.

Under the Director the naval staff is organized in five curricular offices each headed by an officer experienced in his field designated as "Officer-in-Charge" of the curricula.

The titles of the curricular offices are:

- Aeronautical Engineering
- Electronics and Communications Engineering
- Meteorology
- Naval Engineering
- Ordnance Engineering
- Science

The Officers-in-Charge are the reporting seniors for officer students and they handle all military matters which concern the officers enrolled in their curricula. In addition, the Officers-in-Charge are responsible to ensure that the curricula provide the scope and kind of education that is required to meet the needs of the Navy. This responsibility extends to supervision of curricula in allied fields conducted at civilian institutions.

The faculty consists of all professors, associate professors, assistant professors and instructors headed by the Academic Dean of the Postgraduate School, but for purposes of instruction the faculty is divided into nine departments each headed by a chairman. The departments provide the technical instruction in the engineering and physical sciences in much the same manner as in most civilian graduate institutions.

The titles of the academic departments are:

- Aeronautics
- Electrical Engineering
- Electronics
- Mathematics and Mechanics
- Mechanical Engineering
- Metallurgy and Chemistry
- Meteorology and Oceanography
- Operations Research
- Physics

A close working relationship between the Officers-in-Charge who are responsible for curricula and the academic departments which are responsible for instruction is achieved through the assignment of an Academic Associate for each curriculum to advise and assist the Officers-in-Charge. The assignment of Academic Associates is shown in Table I. The Officer-in-Charge of a curriculum and the Academic Associate between them share the responsibility that each curriculum meets the needs of the Navy and the academic standards required for good instruction.

The curricular offices also provide instruction in specifically naval subjects such as communications or ordnance, where an officer's experience is the most valuable background for the education to be imparted. Thus the naval staff and civilian faculty together provide a broad course of instruction.

Academic Records. The course designation and marking system in use by the Engineering School is designed to evaluate both the curricula and the student achievement for degree awards. The letter in parentheses following a course number indicates the level of instruction or graduate standing for that course as follows:

(A) Full graduate course

(B) Partial graduate course

(C) Undergraduate course

(L) Lecture course—no academic credit

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

Academic Prerequisite Qualifications. In general, the entrance requirements for all technical curricula are established as either:

a. A degree from a Service Academy, its equivalent, or

b. A baccalaureate degree, including a sufficient number of hours in those science-engineering fields which will provide a foundation for the selected curriculum.

In addition, the candidate must meet the following minimum specific prerequisites: Mathematics through differential and integral calculus and 1 year of college level physics required for all curricula. Candidates for M.S. curricla should have in addition a course in mechanics and a pattern of above average grades in the prerequisite courses.

REQUIREMENTS FOR DEGREES

The following paragraphs set forth the requirements for the degrees:

(1) *Requirements for the Bachelor of Science Degree:*

(a) The Bachelor's degree in engineering or other scientific fields may be awarded for successful completion of a curriculum which serves the needs of the Navy and has the approval of the Academic Council as meriting a degree. Such a curriculum shall conform to current practice in accredited engineering institutions and shall contain a well-defined major, with appropriate cognate minors. The degree Bachelor of Science requires a minimum of 186 term hours, including at least 36 term hours in non-technical subjects. Awards of the degree in engineering or a designated specialty requires that these minima be 216 hours and 36 hours, respectively.

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

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

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

(2) *Requirements for the Master of Science Degree:*

(a) The Master's degree in engineering and related fields is awarded for the successful completion of a curriculum which complements the basic scientific education of a student and which has been approved by the Academic Council as meriting a degree, provided the student exhibits superior scholarship, attains scientific proficiency, and meets additional requirements as stated in the following paragraphs.

(b) Since curricula serving the needs of the Navy ordinarily contain undergraduate as well as graduate courses, a minimum of two academic years of residence at the Naval Postgraduate School is normally required. With the approval of the Academic Council, the time of residence may be reduced in the case of particular students who have successfully pursued graduate study at other educational institutions. In no case will the degree be granted for less than one academic year of residence at the Naval Postgraduate School.

(c) A curriculum leading to a Master's Degree shall comprise not less than 48 term hours (32 semester hours) of work that is clearly of graduate level, and shall contain a well-supported major, together with cognate minors. At least six of the term hours shall be in advanced mathematics. The proposed program shall be submitted to the cognizant department chairman for review and approval. If the program is satisfactory to the department chairman, it shall be forwarded by him to the Academic Council for final action.

(d) To become a candidate for the Master's degree the student shall have completed at least half of the final year of his curriculum with an average quality point rating in all his courses of not less than 1.75 as defined in the section on scholarship.

(e) To be eligible for the Master's degree the student must attain a minimum average quality point rating of 2.0 in all the (A) and (B) level courses of his curriculum and either 1.5 in the (C) level courses or 1.75 in all course of the curriculum. In special cases, under very extenuating circumstances, small deficiencies from the figures noted in paragraphs (d) and (e) may be waived at the discretion of the Academic Council.

(f) A reasonable proportion of the graduate work leading to the Master's degree shall be composed of research and a thesis reporting the results obtained. The thesis topic is selected by the student in conjunction with a faculty advisor, and is subject to the approval of the cognizant department chairman. The research must indicate ability to perform independent work. In addition, the completed thesis must indicate an ability to report on the work in a scholarly fashion. The thesis in final form is submitted via the faculaty advisor to the cognizant department chairman for review and evaluation. Upon final approval of the thesis the student shall be certified as eligible for examination.

(g) If the thesis is accepted, the candidate for the degree shall take a final oral examination, the duration of which will be approximately one hour. An additional comprehensive written examination may be required at the discretion of the cognizant department chairman. Not more than one half of the oral examination shall be devoted to questions directly related to the candidate's thesis topic; the remainder of the candidate's major and related areas of study.

(h) With due regard for the above requirements, the Academic Council will decide whether or not to recommend the candidate to the superintendent of the Naval Postgraduate School for the award of the Master's degree.

(3) *Requirements for the Doctor's Degree:*

(a) 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 independent investigation, research, and analysis. He shall further meet the requirements described in the following paragraphs.

(b) Any program leading to the Doctor's degree shall require the equivalent of at least three academic years of study beyond the undergraduate level, and shall meet the needs of the Navy for advanced study in the particular area of investigation. At least one academic year of the doctorate work shall be spent at the Naval Postgraduate School.

(c) 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 Academic Council, via the chairman of the department of the major subject, for determination of the adequacy of his preparation.

(d) This chairman will specify one or more minor subjects and, with the chairmen of the corresponding departments, will nominate a Doctorate Committee consisting of five or more members, at least three of whom are under different departments. The chairman of the department of the major subject will submit to the Academic Council for its approval the choice of minor fields and the names of the faculty members nominated for the Doctorate Committee.

(c) After a sufficient period of study in his major and minor fields, the student shall submit to qualifying examinations, including tests of his reading knowledge of foreign languages. The selection of these languages depends on the field of study. The minimum is a reading knowledge of German and a second language to be suggested by his Doctorate Committee and approved by the Academic Council. The language examinations will be conducted by a committee especially appointed by the Academic Council. The other qualifying examinations will cover material previously studied in his major and minor fields; they will be written and oral and will be conducted by the Doctorate Committee. The members of the Academic Council or their delegates may be present at the oral examinations. The Doctorate Committee will report the results of the qualifying examinations to the Academic Council for consideration and, upon approval, the student becomes a candidate for the Doctorate. The qualifying examinations are not given, ordinarily, before the completion of the first year of residence at the Naval Postgraduate School; they must be passed successfully at least two years before the degree is granted.

(f) Upon successful qualification as a candidate the student will be given a further program of study by the Doctorate Committee. This program must be approved by the Academic Council.

(g) The distinct requirement of the doctorate is the successful completion of an original, significant, and scholarly investigation in the candidate's major area of study. The results of the investigation, in the form of a publishable dissertation, must be submitted to the Academic Council at least two months before the time at which it is hoped the degree will be granted. The Academic Council will select two or more referees, who will make individual written reports on the dissertation. Lastly, the Academic Council will vote upon the acceptance of the dissertation.

(h) After the approval of the dissertation, and not later than two weeks prior to the award of the degree, the candidate will be subject to written and oral examination in his major and minor subjects. Written examinations will be conducted by the department having cognizance of the particular subject. The occasion and scope of each examination will be arranged by the Doctorate Committee, after consultation with the departments concerned and the members of the Academic Council. The Doctorate Committee will notify the Academic Council of the time of the oral examination and will invite their attendance, or that of their delegates. The Committee will also invite the attendance of such other interested persons as it may deem desirable. In this oral examination, approximately one half of the allotted time will be devoted to the major subject and one half to the minor subjects. The Doctorate Committee will submit the results of all examinations to the Academic Council for their approval.

(i) With due regard for all of the above requirements, the Academic Council will decide whether to recommend the candidate to the Superintendent of the Naval Postgraduate School for the award of the doctorate.

(j) It is not to be expected that the course requirements for the doctorate can be met while pursuing one of the three-year curricula shown in this catalogue unless the student has previously had suitable graduate work and signifies his desire to become a candidate within three months of the beginning of his curriculum.

LABORATORY FACILITIES

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

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

The laboratory facilities include a nuclear physics laboratory centering around a two million volt Van de Graaff accelerator and an Aerojet Nucleonics nuclear reactor operating at power levels up to 1000 watts. In low temperature and solid state physics the equipment includes nitrogen liquifiers, a Collins helium liquifier, He^3 refrigeration equipment to reach temperatures below 1^0K, 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. 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 AERONAUTICAL LABORATORIES contain facilities for experimentation and research in aerodynamics, structural and stress analysis, aerothermodynamics and propulsion problems.

The Subsonic Aerodynamics Laboratory consists of two subsonic wind tunnels with 32 x 45 inches and 42 x 60 inches test sections, each with a speed range up to 200 knots. Force and moment beam balances measure aerodynamics reactions. A small classroom wind tunnel 7 x 10 inches in cross-section is also in use. Equipment for operating powered propeller aircraft models is available. Experiments in boundary layers, pressure distribution, performance and dynamics are run. In the subsonic wind tunnel area are located two additional test setups, a shock tube, and a plasma jet rig.

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 P2V wing, F8U-3 wing, A3D tail are accommodated on the loading floor section of the laboratory where static and vibration tests are carried out. An electromagnetic shaker is used for vibration testing of turbomachine components and other aeronautics structures components.

The facilities of the Compressibility Laboratory include a transonic wind tunnel having a 4″ x 16″ test section and operating in the Mach number range from 0.4 to 1.4 and a supersonic wind tunnel having a 4″ x 4″ test section and a vertical free-jet of 1″ x 1″ cross-section, both operating in the Mach number range from 1.4 to 4. Instruments associated wit these wind tunnels include a 9″ Mach-Zehnder interferometer and a 9″ and two 5″ Schlieren systems for flow observations.

The CHEMICAL LABORATORIES of the Department of Metallurgy and Chemistry are well equipped for instructional purposes at both the undergraduate and graduate level in chemistry and chemical engineering. These laboratories include a radio-chemistry ("hot") laboratory with Geiger and scintillation counters and special apparatus for handling and testing radioactive materials; a well-equipped fuel and lubricant laboratory; a plastics laboratory and shop where plastics are synthesized, molded in compression or injection presses, and their mechanical, physical and chemical properties determined; an explosives laboratory with impact tester, ballistics mortar, chronograph and other apparatus for evaluating explosives. Space is also available for faculty and student research projects.

The METALLURGY LABORATORIES are completely equipped with the standard mechanical testing machines and heat-treating furnaces. The latest type of microscopes and metallographs are available for metallographic examination. Facilities for the study of crystal structures include X-ray diffraction units, powder cameras and heating cameras. Weissenberg X-ray goniometers and a recording photo densitometer. Metal fabricating and melting equipment include a swaging machine, rolling mill, induction and vacuum melting furnaces, a die-casting machine and a welding laboratory. Studies of the effect of high and low temperatures on metals are made in a laboratory equipped with creep testing apparatus and facilities for obtaining low temperatures.

The ELECTRICAL ENGINEERING LABORATORIES separately housed in a modern two-story building designed for the purpose, have facilities for instruction and research in feedback control systems, electronics, electrical machinery, circuits and measurements. The building and the equipment are arranged for the most effective utilization by students and faculty. Ample equipment is available so that each student may take an active part in the laboratory work.

In addition to the conventional instructional type equipment, the laboratories provide many items of a specialized nature suitable for research projects. Items of special interest in this category include precision primary and secondary standard instruments, a five unit harmonic generating set, a generalized machine laboratory set, a high voltage test set and Schering bridge, a large electronic analog computer with thirty amplifiers and associated function generators and readout equipment, eight Donner analog computers, X-Y recorders, servo analyzers including oscilloscopes with attached Polaroid-Land cameras, an Esiac computer for algebraic functions of a complex variable, Tektronix transistor curve tracer, magnetic amplifiers, wave analyzers, special bridges and electromechanical oscillographs.

The Machinery Laboratory has many motors and motor-generator sets with control and measurement benches. Dynamometer sets permit of control system study and analysis. The harmonic generator is available for magnetic material studies at higher power frequencies. The generalized machine set permits a quantitative study of basic electro magnetic phenomena. Machine design calculations may be verified by measurements of the characteristics of laboratory equipment.

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

The Computer Laboratory, used in conjunction with the work of the other laboratories, has ten electronic analog computers and accessories. The equipment is used to solve and analyze many electrical circuit and control system problems. In addition the electronics control and measurement laboratory has many devices, used in modern control systems, and magnetic amplifiers with their accessory equipment.

A well equipped standards and calibration laboratory is used for precision measurements and to calibrate the laboratory instruments used for instruction and research. Photographic records of test results are obtained from electro magnetic oscillographs, oscilloscope cameras, and Polariod-Land cameras. The film is processed in a completely outfitted dark room. Brush recorders are used extensively to obtain test results in graphic form. A number of research rooms are assigned to students and faculty for the study of special projects and research.

The MECHANICAL ENGINEERING LABORATORIES provide facilities for instruction and reasearch in elastic-body mechanics and dynamics, in hydromechanics and in heat-power and related fields. Noteworthy equipment in the heat-power laboratories includes a gas or oil-fired boiler, 200 psi, and 8000 lb/hr, fully 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; a packaged steam power plant; an experimental single cylinder diesel engine; and a CFR diesel fuel test engine. Facilities of the mechanics laboratories include a universal fatigue tester, for testing in tension, compression, bending or torsion, a Chapman polariscope for stress determination by photoelastic method; vibration inducer units and associated equipment for inducing vibrations in mechanical systems with controlled amplitudes and frequencies from 20 to 20,000 cycles per second; dynamic balancing machines; and a linear accelerometer and calibrator unit.

The ELECTRONICS LABORATORIES are equipped for carrying on programs of extensive study and research in all branches of the electronics field, and constructing special electronic equipment as may be needed. Facilities are available for investigating the operational characteristics of radio and electronic circuits and equipments at frequencies ranging from d-c to the microwave region. For precision measurements and accurate calibration of instruments, there are standard frequency sources and standardizing equipment.

To illustrate modern communications practices, the laboratories are furnished with representative systems covering a wide range of operating frequencies, power outputs and methods of modulation. These include systems for transmitting manual and automatic telegraphy, voice and video signals.

Improved facilities are now provided for the study of telemetering systems, computing systems, modern radar systems, antenna radiation characteristics, microwave phenomena, and transistors as well as for advanced work in circuit measurements. Additional space is also available for conducting individual research and project work.

Laboratory equipment for MATHEMATICS AND MECHANICS now available includes an electronic analogue computer and a digital differential analyzer both of which are used to find the solutions of differential equations; a specially modified accounting machine used in finite difference computations; a variety of planimeter type instruments including a large precision moment integrator, a Stieltjes integrator and a harmonic analyzer. A large number of modern electric desk calculators are available in the laboratory for numerical methods and statistics. Many special models and demonstrators, including the only two automatic relay controlled Wald Sequential Sampling Machines ever made, and other devices and visual aids in mathematics, problability 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 COMPUTER CENTER of the U.S. Naval Postgraduate School provides a variety of services to the School. Its primary function is to support the academic programs. In this capacity it serves as a laboratory adjunct to courses in computer principles or courses which require large scale digital computers in the solution of the problems studied. This would include, as well, work or courses concerned with the application of computers to naval problems, including the study of input and output devices required in such applica-cation. In addition, the Computer Center makes it possible for faculty and student engaged in research fields to obtain solutions to the problems generated in the course of such research. The use of the computer facilities for other applications is being developed. These include information retrieval for the Library, inventory control, processing of data associated with the Registrar's office, etc.

The basic computer in the Center is a Control Data Corporation 1604. A Control Data Corporation 160 computer is installed for use as an independent smaller scale computer or it can be operated in the satellite mode with the CDC 1604. Peripheral equipment includes an IBM 1401 printer complex.

A second CDC 1604 computer is available for use by the Fleet Numerical Weather Facility. This permits independent use by the School of one computer and by the Fleet Numerical Weather Facility of the other with combined operation of both computers possible.

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

The instruments for gathering weather data include rawinsonde equipment, which provides a continuous recording of temperature, pressure, humidity and wind directions 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, an inversion meter designed for remote recordings of free air temperature at designated heights in the boundary layer; a bathythermograph for recording sea temperature gradients; and a shore wave recorder for measuring wave heights and periods.

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

NOTES and MEMORANDA

TABLE 1

CURRICULA AT THE ENGINEERING SCHOOL

Curricula	*Group*	*Length*	*Academic Associate*
ADVANCED MATHEMATICS	...		Prof. Lockhart
ADVANCED SCIENCE			
Chemistry	RC	3 yrs.	Prof. Kinney
Hydrodynamics	RH	3 yrs.	Prof. Howard
Mathematics (Applied)	RM	3 yrs.	Prof. Pulliam
Metallurgy	RMT	3 yrs.	Prof. Buerger
Physics (General)	RP	3 yrs.	Prof. Frey
Physics (Nuclear)	RX	3 yrs.	Prof. Frey
AERONAUTICAL ENGINEERING			
General	AG	2 yrs.	Prof. Coates
Advanced (1)	AA	3 yrs.	Prof. Coates
ELECTRONICS AND COMMUNICATIONS ENGINEERING			
Communications Engineering	CE	2 yrs.	Prof. Stentz
Engineering Electronics			
Basic	EB	2 yrs.	Prof. Klamm
Advanced	EA	3 yrs.	Prof. Klamm
Informative and Control Systems	EI	3 yrs.	Prof. Klamm
Underwater Acoustics	EW	3 yrs.	Prof. Kinsler
Special (CEC)	EY	18 mos.	Prof. P. E. Cooper
METEOROLOGY			
General Meteorology	MA	2 yrs.	Prof. Duthie
Advanced Meteorology	MM	2 yrs.	Prof. Duthie
Air-Ocean Environment	MOC	2 yrs.	Prof. Thompson
NAVAL ENGINEERING			
Electrical Engineering Advanced	NLA	3 yrs.	Prof. Polk
Mechanical Engineering Advanced	NHA	3 yrs.	Prof. Wright
Naval Engineering (General)	NG	2 yrs.	Prof. Wright
(Electrical Engineering Option—after 3 terms)	NGL		Prof. Polk
(Mechanical Engineering Option—after 3 terms)	NGH		Prof. Wright
ORDNANCE ENGINEERING			
Nuclear Engineering (Effects)	RZZ	2 yrs.	Profs. Marmont, Oleson
Operations Analysis	ROO	2 yrs.	Profs. Cunningham, Oberbeck
Weapons Systems (General)	WGG	2 yrs.	Profs. Bleick, Rothauge
(Electrical Engineering)	WEE	3 yrs.	Profs. Kinsler, Thaler
(Physics)	WPP	3 yrs.	Profs. J. N. Cooper, Sheingold
(Chemistry)	WCC	3 yrs.	Profs. Reynolds, Handler
(Special)	WSS	2 yrs.	Profs. Bleick, Rothauge
SCIENCE CURRICULA	SS	1 yr.	Prof. P. E. Cooper

(1) Usually the third year is taken at a civilian university.

ENGINEERING SCHOOL

CURRICULA

ADVANCED MATHEMATICS

Officers students may, under special conditions, be afforded 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 and Mechanics for an evaluation of his previous work to determine his potential for obtaining either degree and to consider the possibility of schedueling the necessary work. The requirements in mathematics for these degrees are given below. They provide, on the bachelor's or master's level, a working knowledge of one field of mathematics and a well-rounded background in three of the major fields of mathematics.

A. To obtain the Bachelor of Science degree with major in mathematics the student must complete a minimum of thirty-six term hours of acceptable mathematical courses above the level of elementary calculus including Ma-101, 102, 109, 110 or their equivalent. Evaluation of courses presented upon entering the Naval Postgraduate School for credit towards the degree must be completed prior to entering a program leading to this degree.

B. To obtain the Master of Science degree with major in mathematics the student must meet the following requirements: 1) He must have completed work which could qualify him for a Bachelor of Science degree with a major in mathematics; 2) He must successfully complete a minimum of 48 term hours of courses at the graduate level distributed as nearly as practicable in the following way:

a. A minimum of 15 term hours of graduate credit in courses so chosen that not less than four term hours of graduate credit will be earned in each of three of the following branches of mathematics: a. algebra, b. geometry, c. analysis, and d. applied mathematics.

b. In addition to the above, two or more courses in the general subject chosen for specialization, carrying a total of not less than six term hours of graduate credit. It is expected that the thesis will be written on a topic in the field of this subject, and these courses may be taken fairly late in the curriculum.

c. A thesis, demonstrating the student's ability to locate and master with very little assistance the subject matter directly involved in the thesis topic, to organize it, to add to it if possible, and to present it systematically in appropriate literary, scientific, and scholarly form. The work on this project will, in general, be spread over two terms and receive eight term hours of graduate credit.

d. Not less than twelve graduate credit term hours in some related field which the candidate shall present as a minor.

The thesis director, topic, and subject of specialization shall be chosen, with the consent of the chairman of the department, as early as possible (but in all events, not later than two terms prior to the time for granting the degree). Minor departures from the preceding requirements may be authorized by the Chairman of the Department of Mathematics and Mechanics. Evaluation of entrance credits must be completed prior to entering a program leading to this degree.

ADVANCED SCIENCE CURRICULA

Chemistry (Group RC)

Hydrodynamics (Group RH)

Metallurgy (Group RMT)

General Physics (Group RP)

Nuclear Physics (Group RX)

Applied Mathematics (Group RM)

OBJECTIVE—To prepare selected officer personnel to deal with the problems of fundamental and applied research in the fields of general physics, nuclear physics, hydrodynamics, chemistry, metallurgy, and applied mathematics.

CURRICULA—Officers nominated for the Advanced Science Curricula are selected from among the first-year students enrolled in the Engineering School of the U.S. Naval Postgraduate School who apply for these curricula. 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.

Officers in the Advanced Science Curricula complete the first year of their curriculum in the Engineering School at the U.S. Naval Postgraduate School. The second and third years are spent at a civilian university. These officers may spend the summer prior to entering the civilian universities on duty at the Office of Naval Research, Washington, U.C., familiarizing themselves with the work of the Office of Naval Research in the basic natural sciences, and preparing themselves for graduate school language requirements.

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 Mastre of Science degree for those officers meeting the requirements of the civilian universities for that degree and may, in exceptional cases for especially qualified officers, lead to a Doctor's degree.

AERONAUTICAL ENGINEERING CURRICULA

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

The entrance requirement to the Aeronautical Engineering curricula, General and Advanced, is a Bachelor of Science degree, Naval Academy or its equivalent. The Naval Academy coverage in the basic prerequisite sciences in semester hours is Math (20), Engineering Mechanics (11), Mechanical Engineering (11), Electrical Engineering (13), Physics (8) and Chemistry (8).

Successful completion of two years study in either the General or the Advanced Curriculum qualifies the student for the degree of Bachelor of Science in Aeronautical Engineering, or, in exceptional cases with advanced credit, for a Master's Degree. The General Curriculum terminates in two years. The Advanced Curriculum continues study towards a higher degree, usually a Master's or an Engineer's Degree at a civilian institution.

COMMON FIRST YEAR OF STUDY

FIRST YEAR (A1)

First Term (16-8)

Ae-100(C) Basic Aerodynamics (3-2)
Ae-200(C) Structural Mechanics I (3-2)
Ma-151(C) Differential Equations (4-1)
Ma-150(C) Vector Algebra and Geometry (4-1)
Mc-101(C) Engineering Mechanics (2-2)

Second Term (16-9)

Ae-121(C) Technical Aerodynamics (3-4)
Ae-211(C) Structural Mechanics II (4-2)
Ma-251(B) Elementary Infinite Series (3-0)
Ma-158(B) Topics for Automatic Control (4-0)
Mc-102(C) Engineering Mechanics II (2-2)
Ae-001(L) Aeronautical Lecture (0-1)

Third Term (18-7)

Ae-131(B) Technical Aerodynamics Performance (4-2)
Ae-212(C) Structural Components I (4-2).
Ae-409(C) Aeronautical Thermodynamics (4-2)
Ma-260(B) Vector Analysis (3-0)
EE-101(C) Basic Electrical Phenomena (3-0)
LP-101(L) Lecture Program (0-1)

Fourth Term (16-11)

Ae-141(A) Dynamics I (3-2)
Ae-213(B) Structural Components II (4-2)
Ae-410(B) Aeronautical Thermodynamics II (3-2)
Ma-126(B) Numerical Methods for Digital Computers (3-2)
EE-102(C) Basic Circuit Analysis (3-2)
LP-102(L) Lecture Program (0-1)

Summer intersessional periods—Field trips to industry and military installations and courses in Naval Management.

After completion of the First year, selection is made for the two or three year program, either in Aeronautical Engineering General or Aeronautical Engineering Advanced.

AERONAUTICAL ENGINEERING (ADVANCED)

THIRD YEAR CURRICULUM

Third year work in aeronautical engineering is usually conducted at other universities. Universities currently used and the fields in which they provide the strongest competence for advanced study are as follows:

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

MASSACHUSETTES INST. OF TECHNOLOGY, CAMBRIDGE
- Astronautics
- Airborne Weapons Systems
- Propulsion

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

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

IOWA STATE COLLEGE, AMES, IOWA
- Nuclear Propulsion

COLLEGE OF AERONAUTICS, CRANFIELD, ENG.
- Aerodynamics
- Aircraft Design
- Propulsion
- Aircraft Economics and Production
- Aircraft Electronics

STANFORD UNIVERSITY
- Aero-and Gasdynamics
- Structures
- Guidance and Control

U.S. NAVAL POSTGRADUATE SCHOOL
- Flight Vehicles:
  - Structures
  - Propulsion
  - Avionics-Guidance (E.E.)
  - Avionics-Communication (Es.)
- Advanced Science:
  - Aerophysics
  - Aeromechanics
  - Environmental Dynamics (Astronautics)

AERONAUTICAL ENGINEERING (GENERAL)
TWO YEAR CURRICULUM
SECOND YEAR (AG2)

First Term				
Ae-142(A)	(3-4)	F	P	V
Ae-501(A)	(4-0)	F	P	V
Aa-173(A)	(4-0)			
Ae-151(B)	(2-0)	F		
Ae-161(B)	(0-4)	F		
Ch-121(B)	(4-2)	F	P	
EE-103(B)	(3-4)			V
EE-221(C)	(3-4)			V
Mt-201(C)	(3-2)		P	
Second Term				
Ae-001(L)	(0-1)	F	P	V
Ae-411(B)	(4-2)	F	P	V
Ae-502(A)	(4-0)	F	P	V
Ae-174(A)	(3-2)			
Ae-412(B)	(0-3)	F	P	
Ae-221(B)	(3-2)	F	P	
Ae-152(B)	(2-0)	F		
Ae-162(B)	(0-4)	F		
EE-104(B)	(3-2)			V
EE-311(B)	(3-2)			V
Mt-202(C)	(3-2)		P	
Third Term				
Ae-421(B)	(3-2)	F	P	V
Ae-508(A)	(3-2)		P	
Ae-316(C)	(2-4)	F		V
Ae-150(B)	(3-4)		P	
Ae-801(A)	(3-3)	F		V
EE-411(B)	(3-3)			V
EE-321(C)	(3-4)	F	P	
EE-312(B)	(3-2)			V
Mt-201(C)	(3-2)	F		
LP-101(L)	(0-1)	F	P	V
Fourth Term				
Ae-508(A)	(3-2)	F		V
Ae-316(C)	(2-4)		P	
Ae-428(A)	(3-2)	F	P	
Ae-802(A)	(3-3)	F		V
Ae-124(A)	(3-2)			
Ae-153(B)	(2-0)	F		
Ae-163(B)	(0-4)	F		
CE-542(A)	(3-2)		P	
EE-431(B)	(3-4)		P	
EE-313(A)	(3-3)			V
Mc-403(A)	(3-0)			V
Mt-202(C)	(3-2)	F		
LP-102(L)	(0-1)	F	P	V

AERO COURSE Codes:

100 Series	Technical Aerodynamics
200 Series	Structures
300 Series	Design
400 Series	Propulsion
500 Series	Theoretical Aerodynamics
600 Series	Advanced Structures
700 Series	Space Technology
800 Series	Systems Engineering.

Complete course titles & descriptions are listed in the Course Description Section.

AERONAUTICAL ENGINEERING (ADVANCED)
THREE YEAR CURRICULUM
SECOND YEAR (AA2)

First Term					
Ae-142(A)	(3-4)	A	P	S	V
Ae-511(A)	(4-0)	A	P	S	V
Ae-173(A)	(4-0)				
Ae-701(A)	(4-0)				
Ch-106(C)	(3-2)		P		
Ch-121(B)	(4-2)	A	P	S	
EE-103(B)	(3-4)				V
EE-221(C)	(3-4)				V
Mt-201(C)	(3-2)	A	P	S	
Second Term					
Ae-001(L)	(0-1)	A	P	S	V
Ae-411(B)	(4-2)	A	P	S	V
Ae-512(A)	(4-0)	A	P	S	V
Ae-174(A)	(3-2)				
Ae-214(A)	(3-0)	A	P	S	
Ae-221(B)	(3-2)	A		S	
Ae-432(A)	(4-2)				
Ch-107(C)	(3-2)		P		
EE-104(B)	(3-2)				V
EE-311(B)	(3-2)				V
Mt-202(C)	(3-2)	A	P	S	
Third Term					
Ae-421(B)	(3-2)	A	P	S	V
Ae-513(A)	(4-0)	A	P		
Ae-311(C)	(2-4)	A		S	
Ae-316(C)	(2-4)		P		V
Ae-215(A)	(4-0)			S	
EE-411(B)	(3-3)				V
EE-321(C)	(3-4)	A	P	S	
EE-312(B)	(3-2)				V
LP-101(L)	(0-1)	A	P	S	V
Fourth Term					
Ae-508(A)	(3-2)			S	V
Ae-514(A)	(3-2)	A	P		
Ae-312(B)	(1-4)	A		S	
Ae-601(A)	(4-0)			S	
Ae-431(A)	(4-1)	A	P		
CE-112(A)	(3-2)		P		
CE-542(A)	(3-2)	A	P		
EE-431(B)	(3-4)	A	P		
EE-412(A)	(3-3)				V
EE-313(A)	(3-3)				V
Mc-311(A)	(3-2)			S	
Mc-403(A)	(3-0)				V
LP-102(L)	(0-1)	A	P	S	V

ELECTIVE Major Codes:

A	Aero-Space Dynamics
F	Flight Testing and Evaluation
P	Propulsion
S	Structures
V	Avionics
M	Aeromechanics
E	Aeroelectricity
Z	Aerophysics

ELECTRONICS AND COMMUNICATIONS ENGINEERING

BASIC OBJECTIVES—The objective of the two-year program is to educate officers in the basic scientific and engineering fields related to electronics and communications and their application to the art of naval warfare.

The objective of the three-year Master of Science program is to educate a selected group of academically qualified officers to develop a particular competence and ability in directing the development, evaluation, and operation of electronic devices that are required by the Navy to improve its capability in the fields of ASW, Information and Control, Air Warfare, Electronic Intelligence and Countermeasures, etc.

CURRICULA—For the first year and a half (six terms) all students pursue the Basic Curriculum covering the basic requirements in mathematics, physics and electronic fundamentals.

Two-Year Program—For the last two terms of the second year the Engineering Electronics (EB) and the Communications Engineering (CE) students in the two-year program are permitted to take approved elective courses best suited to their individual interests and naval experience. Four courses not exceeding 24 hours per week are elected for each term. For properly qualified entering students, successful completion of two years of work in the EB or CE curriculum affords the opportunity to earn the degree of Bachelor of Science in Engineering Electronics or in Communications Engineering.

Three-Year Program—Those students who meet the academic requirements to continue for a third year of graduate work may be permitted, within quota limitations established by the Chief of Naval Personnel, to select one of three options at the end of the six-term Basic Curriculum for an additional six terms of graduate work leading to the degree of Master of Science in Engineering Electronics. The three options are constructed to develop particular competence in Advanced Electronics, Underwater Acoustics, or Information and Control Systems.

BASIC CURRICULUM

FIRST YEAR—Group EB

First Term (15-7)

Es-111(C) Fund. of Electric Circuits I (4-4)
Es-211(C) Physical Electronics (4-2)
Ma-120(C) Vector Algebra & Geometry (3-1)
Ma-230(C) Calculus of Several Variables (4-0)

Second Term (19-6)

Es-112(C) Fund. of Electric Circuits II (4-3)
Es-212(C) Electronic Circuits I (4-3)
Ma-244(C) Elem. Diff. Eqs. & Inf. Series (4-0).
Ma-260(B) Vector Analysis (3-0).
Ma-271(B) Complex Variables (4-0)

Third Term (16-6)

Es-113(C) Transform Circuit Theory (4-2).
Es-213(C) Electronic Circuits II (4-3).
Ma-246(A) Partial Differential Eqs. (4-0).
Ph-113(B) Dynamics (4-0).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (16-9)

Es-214(C) Electronic Circuits III (4-3).
Es-611(C) Intro. to Dist. Constant Networks (4-3).
Ma-321(B) Probability (4-2).
Ph-620(B) Elementary Atomic Physics (4-0).
LP-102(L) NPS Lecture Program II (0-1).

Intersessional Term: Engineering Electronics students take MN-101, "Elements of Management and Industrial Engineering" and "Art of Presentation." Communications Engineering students take a field trip to West Coast naval communications facilities.

SECOND YEAR—Group EB

First Term (14-10)

EE-463(C) Special Machinery (3-2).
Es-215(C) Electronic Devices (4-2).
Es-510(C) Electronic Measurements (3-6)
Es-612(C) Intro. to Electromagnetics (4-0).

Second Term (13-12)

EE-670(A) Intro. to Servomechanisms (3-3).
Es-216(B) Transmitters and Receivers (3-6).
Es-410(B) Communication Theory (4-0).
Es-419(C) Electronic Computers (3-3).

ENGINEERING ELECTRONICS

Those students ordered to the two-year Engineering Electronics curriculum will complete the third and fourth terms of their second year by pursuing an elective program concentrated in one of the following areas: ASW, Radar, Information and Control Systems, or Communications. The elective program will be chosen by the student from a designated list of courses approved by the OinC and Academic Advisors.

Upon completion of the second year the two-year Engineering Electronics students visit various naval and industrial laboratories and facilities on a three-week field trip prior to detachment.

COMMUNICATIONS ENGINEERING

Students ordered to the two-year Communications Engineering curriculum will complete the last two terms of their second year in an elective program approved by the OinC and Academic Advisors, chosen from a list of designated courses.

ENGINEERING ELECTRONICS—MS Program

Those students who enter the MS program will select one of the three options following. Where electives are permitted, the selection must meet approval of OinC and Academic Advisors as consistent with the option major.

Upon completion of the second year all students in MS program will visit various naval and industrial laboratories and facilities on a four-week field trip.

The third term of the third year is spent in an industrial electronics laboratory. During this period the student works as a junior engineer on a selected project which may form part of or be related to his thesis.

OPTION I — ADVANCED ELECTRONICS

SECOND YEAR—Group EA

Third Term (24)

Es-621(B) Electromagnetics I (5-0).
Ph-730(A) Solid State Physics (4-2).
LP-101(L) NPS Lecture Program I (0-1).
Two electives (12 hrs. max.).

Fourth Term (22)

Es-228(A) Microwave Tubes (3-2).
Es-622(A) Electromagnetics II (4-0).
LP-102(L) NPS Lecture Program (0-1).
Two electives (12 hrs. max.).

THIRD YEAR—Group EA

First Term (19)

Es-121(A) Circuit Synthesis I (3-2).
Ma-322(A) Statistical Decision Theory (3-2).
One elective (6 hrs. max.).
Thesis (3-0).

Second Term (19)

Es-320(A) Systems Engineering (3-2).
Es-420(A) Optimum Communication Systems (3-2).
One elective (6 hrs. max.).
Thesis (3-0).

Third Term

Industrial Tour.

Fourth Term (20)

Es-920(A) Systems Seminar (3-0).
OA-121(A) Operations Analysis (4-2).
LP-102(L) NPS Lecture Program II (0-1).
One elective (6 hrs. max.).
Thesis (4-0).

OPTION II — UNDERWATER ACOUSTICS

SECOND YEAR—Group EW

Third Term (23)

Ph-431(B) Fundamental Acoustics (4-0).
Ph-730(A) Solid State Physics (4-2).
LP-101(L) NPS Lecture Program I (0-1).
Two electives (12 hrs. max.).

Fourth Term (23)

Oc-110(C) Oceanography (3-0).
Ph-432(A) Underwater Acoustics (4-3).
LP-102(L) NPS Lecture Program II (0-1).
Two electives (12 hrs. max.).

THIRD YEAR—Group EW

First Term (23)

Es-336(A) Sonar Systems I (3-3).
Ma-322(A) Statistical Decision Theory (3-2).
Ph-461(A) Transducer Theory (3-3).
One elective (6 hrs. max.)

Second Term (22)

Es-337(A) Sonar Systems II (2-3).
Es-420(A) Optimum Communication Systems (3-2).
Ph-433(A) Waves in Fluids (3-0).
One elective (6 hrs. max.)
Thesis (3-0).

Third Term

Industrial Tour.

Fourth Term (20)

Oa-121(A) Operations Analysis (4-2).
Ph-442(A) Shock Waves in Fluids (3-0).
LP-102(L) NPS Lecture Program II (0-1).
One elective (6 hrs. max.).
Thesis (4-0).

OPTION III — INFORMATION AND CONTROL SYSTEMS

SECOND YEAR—Group EI.

Third Term (21)

Es-230(A) Feedback Networks (4-0).
Es-430(A) Information Networks (3-2).
Ma-116(A) Matrices & Numerical Methods (3-2).
LP-101(L) NPS Lecture Program I (0-1).
One elective (6 hrs. max.).

Fourth Term (22).

Es-330(A) Automation & System Control (3-3).
Es-439(A) Data Processing Methods (3-2).
Ma-423(A) Advanced Programming (4-0).
LP-102(L) NPS Lecture Program II (0-1).
One elective (6 hrs. max.).

THIRD YEAR—Group EI

First Term (19)

Es-121(A) Circuit Synthesis I (3-2).
Ma-322(A) Statistical Decision Theory (3-2).
One elective (6 hrs. max.)
Thesis (3-0).

Second Term (19)

Es-320(A) Systems Engineering (3-2).
Es-420(A) Optimum Communication Systems (3-2).
One elective (6 hrs. max.).
Thesis (3-0).

Third Term

Industrial Tour

Fourth Term (20)

Es-920(A) Systems Seminar (3-0).
OA-121(A) Operations Analysis (4-2).
LP-102(L) NPS Lecture Program II (0-1).
One elective (6 hrs. max.)
Thesis (4-0).

SPECIAL ELECTRONICS CURRICULUM FOR SELECTED CEC OFFICERS

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

ENGINEERING ELECTRONICS—Group EY

Third Term (15-5)

Es-241(C) Electronics I (3-2).
Es-628(B) Distributed Constant Networks (4-3).
Ma-113(B) Vector Analysis & Partial Diff. Eqs. (4-0).
*Ph-620(B) Elementary Atomic Physics (4-0).

Fourth term (14-8)

Es-129(A) Transforms & Transients (3-2).
*Es-242(C) Electronics II (3-2).
Ma-270(B) Complex Variables (3-0).
Ma-280(B) Laplace Transformations (2-0).
Ma-321(B) Probability & Statistics (4-2).
Intersessional term: MN-101—Elements of Management and Industrial Engineering (six weeks plus participation in Workshop Seminars)

First Term (14-8)

*Es-216(B) Transmitters & Receivers (3-6).
Es-410(B) Information Theory (4-0).
*Es-612(C) Introduction to Electromagnetics (4-0).
Ma-322(A) Statistical Decision Theory (3-2).

Second Term (15-8)

EE-670(A) Introduction to Servomechanisms (3-3).
Es-320(A) Systems Engineering (3-2).
Es-421(B) Modern Communications I (3-3).
One elective (6 hrs. max.).

Third Term (14-6)

Es-422(B) Modern Communications II (3-3).
Es-620(B) Theory of Antennas (3-3).
Es-621(B) Electromagnetics I (5-0).
Thesis (3-0).

Fourth Term (16-3)

Es-622(A) Electromagnetics II (4-0).
Es-629(B) Control of Electromagnetic Environment (4-3).
Es-630(B) Theory of Propagation (4-0).
Thesis (4-0).

**Substitutions may be made for these courses depending upon previous individual preparation. Elective options are not mandatory.*

METEOROLOGY

GENERAL METEOROLOGY

(GROUP MAA)

OBJECTIVE—To prepare officers to become qualified meteorologists, with a working knowledge of Oceanography as applied to naval operations.

FIRST YEAR (MAA)

First Term (13-3)

Ma-041(C) Review of Algebra, Trigonometry and Analytic Geometry (4-0).
Mr.-200(C) Introduction to Meteorology (3-0).
Oc-110(C) Introduction to Oceanography (3-0).
Ph-190(C) Survey of Physics I (3-0).
Weather Codes (0-3).

Second Term (13-11)

Ma-071(C) Calculus I (5-0).
Mr-201(C) Elementary Weather-Map Analysis (0-9).
Mr-211(C) Elementary Weather-Map Analysis (3-0).
Mr.-410(C) Meteorological Instruments (2-2).
Ph-191(C) Survey of Physics II (3-0).

Third Term (14-12)

Ma-072(C) Calculus II (3-0).
Ma-081(B) Introduction to Vector Analysis (2-0).
Mr-202(C) Weather Map Analysis (0-9).
Mr.-212(C) Introduction to Weather Elements (3-0).
Mr.402(C) Introduction to Meteorological Thermodynamics (3-2).
Oc-240(B) Descriptive Oceanography (3-0).
LP-101(L) NPS Lecture Program II (0-1).

Fourth Term (12-14)

Ma-381(C) Elementary Probability and Statistics (4-2)
Mr-203(C) Forecasting Weather Elements (0-9).
Mr-213(C) Forecasting Weather Elements (2-0).
Mr.301(B) Elementary Dynamic Meteorology I (4-0).
Mr.-521(B) Synoptic Climatology (2-2).
LP-102(L) NPS Lecture Program II (0-1).

During intersessional period students are instructed in the meteorological aspects of ABC warfare and visit naval and civilian installations.

SECOND YEAR (MAA)

First Term (13-11)

Ma-421(B) Introduction to Digital Computers (3-2).
Mr-204(B) Upper-Air and Surface Prognosis (0-9).
Mr-214(B) Upper-Air and Surface Prognosis (3-0).
Mr-228(B) Tropical and Southern Hemisphere Meteorology (3-0).
Mr-302(B) Elementary Dynamic Meteorology II (4-0).

Second Term (13-15)

Mr-205(B) The Middle Atmosphere and Selected Topics (0-9).
Mr-215(B) The Middle Atmosphere and Extended Forecasting (3-0).
Mr-403(B) Introduction to Micrometeorology (4-0).
Mr-611(B) Wave Forecasting (3-6).
Oc-620(B) Oceanographic Factors in Underwater Sound (3-0).

Third Term (5-18)/(10-18)

Mr-206(C) Naval Weather Service Organization and Operation (1-9).
Mr-220(B) Selected Topics in Applied Meteorology (2-0).
Oc-621(B) Ocean Thermal Structure (2-2).
LP-101(L) NPS Lecture Program I (0-1).
Research Problem (0-6.
Elective
Mr-422(A) The Upper Atmosphere (5-0)

Fourth Term (10-11)

Mr-218(B) Tropical and Southern Hemisphere Meteorology (0-6).
Mr-415(B) Radar Meteorology (2-0).
Mr-810-(A) Seminar in Meteorology and Oceanography (2-0).
Oc-213(B) Shallow-Water Oceanography (3-0).
Oc-613(B) Arctic Sea Ice and Ice Forecasting (3-4).
LP-102(L) NPS Lecture Program II (0-1).

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

ADVANCED METEOROLOGY
(GROUP MMM)

OBJECTIVE — To prepare officers to become qualified meteorologists with a working knowledge of Oceanography as applied to naval operations and to enable them, through advanced study, to conduct independent research.

FIRST YEAR (MMM)

First Term (18-4)

Ma-120(C) Vector Algebra and Geometry (3-1).
Ma-230(C) Calculus of Several Variables (4-0).
Mr-200(C) Introduction to Meteorology (3-0).
Oc-110(C) Introduction to Oceanography (3-0).
Ph-196(C) Review of General Physics (5-0).
Weather Codes (0-3).

Second Term (13-13)

Ma-240(C) Elementary Differential Equations (2-0).
Ma-251(B) Elementary Infinite Series (3-0).
Mr.-201(C) Elementary Weather-Map Analysis (0-9).
Mr-211(C) Elementary Weather-Map Analysis (3-0).
Mr-410(C) Meteorological Instruments (2-2).
Mr.413(B) Thermodynamics of Meteorology (3-2).

Third Term (17-10)

Ma-261(A) Vector Mechanics (5-0).
Mr-202(C) Weather Map Analysis (0-9).
Mr-212(C) Introduction to Weather Elements (3-0).
Mr-321(A) Dynamic Meteorology I (3-0).
Mr-412(A) Physical Meteorology (3-0).
Oc-240(B) Descriptive Oceanography (3-0).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (12-14)

Ma-125(B) Numerical Methods for Digital Computers (2-2)
Ma-331(B) Statistics (5-2).
Mr-203(C) Forecasting Weather Elements (0-9).
Mr-213(C) Forecasting Weather Elements (2-0).
Mr-322(A) Dynamic Meteorology II (3-0).
LP-102(L) NPS Lecture Program II (0-1).

During intersessional period students are instructed in the meteorological aspects of ABC warfare and visit naval and civilian installations.

SECOND YEAR (MMM)

First Term (14-13)

Ma-421(B) Introduction to Digital Computers (3-2).
Mr-204(B) Upper-Air and Surface Prognosis (0-9).
Mr-214(B) Upper-Air and Surface Prognosis (3-0).
Mr-228(B) Tropical and Southern Hemisphere Meteorology (3-0).
Mr-323(A) Dynamic Meteorology III (3-0).
Mr-521(B) Synoptic Climatology (2-2).

Second Term (11-15)

Mr-205(B) The Middle Atmosphere and Selected Topics (0-9).
Mr-215(B) The Middle Atmosphere and Extended Forecasting (3-0).
Mr-325(A) Energetics of the General Circulation (2-0).
Mr-611(B) Wave Forecasting (3-6).
Oc-620(B) Oceanographic Factors in Underwater Sound (3-0)

Third Term (10-18)

Mr-206(C) Naval Weather Service Organization and Operation (1-9).
Mr-422(A) The Upper Atmosphere (5-0).
Oc-621(B) Ocean Thermal Structure (2-2).
LP-101(L) NPS Lecture Program I (0-1).
Thesis I (2-6).

Fourth Term (10-19)

Mr-218(B) Tropical and Southern Hemisphere Meteorology (0-6).
Mr-415(B) Radar Meteorology (2-0).
Mr-810(A) Seminar in Meteorology and Oceanography (2-0).
Oc-213(B) Shallow-Water Oceanography (3-0).
Oc-613(B) Arctic Sea Ice and Ice Forecasting (3-4).
LP-102(L) NPS Lecture Program II (0-1).
Thesis II (0-8).

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

ADVANCED METEOROLOGY (NUMERICAL FORECASTING) (GROUP MMS)

OBJECTIVE — To prepare officers to become qualified meteorologists with a working knowledge of oceanography as applied to naval operations and to enable them, through advanced study, to conduct independent research. This program allows for a degree of subspecialization in the field of numerical weather forecasting.

FIRST YEAR (MMS)

Same as MMM Curriculum.

SECOND YEAR (MMS)

First Term (14-13)

Ma-421(B) Introduction to Digital Computers (3-2).
Mr-204(B) Upper-Air and Surface Prognosis (0-9).
Mr-214(B) Upper-Air and Surface Prognosis (3-0).
Mr-228(B) Tropical and Southern Hemisphere Meteorology (3-0).
Mr-323(A) Dynamic Meteorology III (3-0).
Mr-521(B) Synoptic Climatology (2-2).

Second Term (12-10)

Ma-426(A) Advanced Numerical Methods for Digital Computers (4-1).
Mr-205(B) The Middle Atmosphere and Selected Topics (0-9).
Mr-215(B) The Middle Atmosphere and Extended Forecasting (3-0).
Mr-324(A) Dynamical Prediction (3-0).
Mr-325(A) Energetics of the General Circulation (2-0).

Third Term (9-17)

Ma-420(L) Computer Operation (1-1).
Mr-206(C) Naval Weather Service Organization and Operation (1-9).
Mr-422(A) The Upper Atmosphere (5-0).
LP-101(L) NPS Lecture Program I (0-1).
Thesis I (2-6).

Fourth Term (7-21)

Mr-218(B) Tropical and Southern Hemisphere Meteorology (0-6).
Mr-415(B) Radar Meteorology (2-0).
Mr-611(B) Wave Forecasting (3-6).
Mr-810(A) Seminar in Meteorology and Oceanography (2-0).
LP-102(L) NPS Lecture Program II (0-1).
Thesis II (0-8).

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

AIR-OCEAN ENVIRONMENT (GROUP MOC)

OBJECTIVE—To provide education in Oceanography and Meteorology with emphasis on interaction between the atmosphere and oceans. Special Naval applications of this curriculum include forecasting weather and sea conditions for submarine operations, antisubmarine warfare, polar operations, surface shipping, and air operations; high speed digital computer operation and techniques are included.

FIRST YEAR (MOC)

Same as MMM Curriculum.

SECOND YEAR (MOC)

First Term (15-2)

Mr-521(B) Synoptic Climatology (2-2).
Oc-211(A) Ocean Wave Theory (3-0).
Oc-243(A) Dynamic Oceanography (4-0).
Oc-620(B) Oceanographic Factors in Underwater Sound (3-0).
Oc-700(B) Oceanographic Observations (3-0).

Second Term (14-10)

Ma-421(B) Introduction to Digital Computers (3-2).
Mr-611(B) Wave Forecasting (3-6).
Oc-212(A) Tides and Tidal Currents (3-0).
Oc-310(B) Geological Oceanography (3-0).
Oc-621(B) Ocean Thermal Structure (2-2).

Third Term (14-13)

OAST Tactical Applications of Anti-submarine Warfare (3-0).
Oc-213(B) Shallow Water Oceanography (3-0).
Oc-410(B) Biological Oceanography (3-2).
Oc-610(B) Oceanographic Forecasting (3-4).
LP-101(L) NPS Lecture Program I (0-1).
Thesis I (2-6).

Fourth Term (10-16)

Mr-810(A) Seminar in Meteorology and Oceanography (2-0).
Oc-214(B) Marine Environments (3-0).
Oc-613(B) Arctic Sea Ice and Ice Forecasting (3-4).
Oc-630(C) Operational Oceanography (2-3).
LP-102(L) NPS Lecture Program II (0-1).
Thesis II (0-8).

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

NAVAL ENGINEERING CURRICULA

OBJECTIVE—To provide selected officers with advanced marine and electrical engineering education to meet the requirements of the Navy for officers with technical and administrative competence related to modern naval machinery and engineering plants. The specific areas of study are designed to include, within the various curricula, the fundamental and advanced theories of mathematics, thermodynamics, mechanics, dynamics, electrical power, circuits and feedback control, metallurgy, structures, nuclear physics and nuclear power.

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

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

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

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

*Three year curricula in Engineering Materials, Mechanical Engineering (Gas Turbines) and Mechanical Engineering (Fuels & Lubricants) are available under the Naval Engineering Curricula. Since no quotas have been assigned to these special curricula by the Chief of Naval Personnel, detailed course listings are not included in this catalogue.

NAVAL ENGINEERING (GENERAL)
(GROUP NG)

OBJECTIVE—To educate officers in the basic sciences and engineering principles as a foundation for the more advanced studies in either an Electrical or Mechanical engineering specialty.

FIRST YEAR

First Term (14-5)

EE-111(C) Basic Electrical Phenomena (3-4).
Ma-230(C) Calculus of Several Variables (4-0).
Ma-120(C) Vector Algebra & Solid Analytic Geometry (3-1).
ME-501(C) Mechanics I (4-0).

Second Term (16-6)

EE-112(C) Circuit Analysis I (3-4).
Ma-240(C) Elementary Differential Equations (2-0).
Ma-251(B) Elementary Infinite Series (3-0).
ME-502(C) Mechanics II (4-0).
Ch-103(C) General Inorganic Chemistry (4-2).

Third Term (16-5)

Mt-201(C) Introductory Physical Metallurgy (3-2).
Ma-113(B) Vector Analysis & Partial Differential Equations (4-0).
ME-510(C) Mechanics of Solids I (4-2).
ME-111(C) Engineering Thermodynamics I (5-0).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term

Mechanical or Electrical Engineering special (See Group NGH or NGL).

NAVAL ENGINEERING (MECHANICAL)
(GROUP NGH)

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

FIRST YEAR

First through Third Terms

Same as Naval Engineering (General) Group NG.

Fourth Term (15-9)

EE-221(C) Special Machinery (3-4).
Mt-202(C) Ferrous Physical Metallurgy (3-2).
ME-411(C) Mechanics of Fluids (4-2).
ME-112(C) Engineering Thermodynamics II (5-0).
LP-102(L) NPS Lecture Program II (0-1).

Intersessional period: Course MN-101 "Elements of Management and Industrial Engineering" and course in "Art of Presentation" at USNPS.

SECOND YEAR (NGH)

First Term (15-4).

ME-221(C) Gas Dynamics & Heat Transfer (4-2).
ME-504(B) Advanced Dynamics (4-0).
ME-521(C) Mechanics of Solids II (4-0).
ME-711(B) Mechanics of Machinery (3-2).

Second Term (12-6).

ME-222(C) Thermodynamics Laboratory (1-4).
ME-522(B) Mechanics of Solids III (4-0).
Ma-421(B) Introduction to Digital Computers (3-2).
Ph-620(B) Elementary Atomic Physics (4-0).

Third Term (12-9)

ME-223(B) Marine Power Plant Analysis (2-4).
ME-722(B) Mechanical Vibrations (3-2).
EE-331(C) Introduction to Electronics (3-2).
Ph-621(B) Elementary Nuclear Physics (4-0).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (11-9)

ME-217(B) Internal Combustion Engines (3-2).
ME-240(B) Nuclear Power Plants (4-0).
ME-622(B) Experimental Mechanics (2-2).
ME-820(C) Machine Design (2-4).
LP-102(L) NPS Lecture Program II (0-1).

MECHANICAL ENGINEERING (ADVANCED)
(GROUP NHA)

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

FIRST YEAR

Same as Naval Engineering (Mechanical)—Group NGH.

SECOND YEAR (NHA)

First Term (15-4)

Ma-270(B) Complex Variables (3-0).
Ma-280(B) LaPlace Transformations (2-0).
ME-211(B) Thermodynamics of Compressible Flow (3-0).
ME-711(B) Mechanics of Machinery (3-2).
ME-412(A) Advanced Mechanics of Fluids (4-2).

Second Term (17-4)

ME-222(C) Thermodynamics Laboratory (1-4).
ME-503(A) Advanced Dynamics (4-0).
ME-511(A) Mechanics of Solids II (5-0).
Mt-301(A) High Temperature Materials (3-0).
Ph-602(B) Elementary Atomic Physics (4-0).

Third Term (16-5)

Ma-421(B) Introduction to Digital Computers (3-2).
ME-212(A) Advanced Thermodynamics (3-0).
ME-217(B) Internal Combustion Engines (3-2).
ME-512(A) Mechanics of Solids III (4-0).
Ph-637(B) Nuclear Physics I (3-0).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (13-10)

ME-310(B) Heat Transfer (4-2).
ME-712(A) Mechanical Vibrations (3-2).
ME-811(B) Machine Design I (3-2).
Ph-638(B) Nuclear Physics II (3-3).
LP-102(L) NPS Lecture Program II (0-1).

Intersessional period: A four to six week field trip will be arranged to industrial or research activities.

Third Year (NHA)

First Term (12-8)

EE-331(C) Introduction to Electronics (3-2).
ME-612(A) Experimental Mechanics (3-2).
ME-812(B) Machine Design II (3-4).
Ph-651(A) Reactor Theory I (3-0).

Second Term (8-12)

EE-421(B) Transients & Feedback Control Systems (3-4).
ME-230(B) Marine Power Plant Analysis (2-4).
Ph-652(A) Reactor Theory II (3-0).
Thesis (0-4).

Third Term (4-17)

ME-241(A) Nuclear Propulsion Systems I (4-0).
Thesis (0-16).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (9-7)

ME-242(A) Nuclear Propulsion Systems II (3-2).
ME-910(A) Naval Architecture (3-0).
Thesis (0-4).
*EE-422(B) Nuclear Reactor Instrumentation & Control (3-3).
*Mt-402(B) Nuclear Reactor Materials & Effects of Radiation (3-0).
LP-102(L) NPS Lecture Program II (0-1).
**Elective*

NAVAL ENGINEERING (ELECTRICAL)

(GROUP NGL)

OBJECTIVE—To support the aim of the basic objective to the extent practicable within a 2 year period by providing officer students with a sound science-engineering basis for assuming increased technical and administrative responsibilities related to naval machinery, with primary emphasis on Electrical Engineering aspects.

First Year

First through Third Terms

Same as Naval Engineering (General) Group NG.

Fourth Term (11-10)

EE-113(B) Circuit Analysis II (3-2).
EE-131(C) Electrical Measurements (2-3).
EE-211(C) Electric Machinery I (3-4).
Ma-270(B) Complex Variables (3-0.
LP-102(L) NPS Lecture Program I (0-1)).

Intersessional period: Course MN-101 "Elements of Management & Industrial Engineering" and course in "Art of Presentation" at USNPS.

Second Year (NGL)

First Term (13-10)

ME-132(C) Engineering Thermodynamics II (4-2).
EE-212(C) Electric Machinery II (3-4).
EE-321(C) Engineering Electronics (3-4).
EE-500(A) Seminar (1-0).
Ma-280(B) LaPlace Transformations (2-0).

Second Term (14-9).

EE-114(B) Linear Systems Analysis (3-4).
EE-323(B) Electronics of Control & Measurement (3-3).
EE-500(A) Seminar (1-0).
Ph-620(B) Elementary Atomic Physics (4-0).
Mt-202(C) Ferrous Physical Metallurgy (3-2).

Third Term (11-9)

EE-411(B) Feedback Control Systems (3-3).
EE-500(A) Seminar (1-0).
ME-210(C) Applied Thermodynamics (3-2).
Ph-621(B) Elementary Nuclear Physics (4-0).
Ph-622(B) Nuclear Physics Laboratory (0-3).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (14-10)

EE-115(B) Transmission Lines & Network Synthesis (3-4).
EE-121(B) Nonlinear Magnetic Devices (3-3).
EE-500(A) Seminar (1-0).
Ma-421(B) Introduction to Digital Computers (3-2).
ME-240(B) Nuclear Power Plants (4-0).
LP-102(L) NPS Lecture Program II (0-1).

ELECTRICAL ENGINEERING (ADVANCED)

(GROUP NLA)

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

FIRST YEAR

Same as Naval Engineering (Electrical)—Group NGL.

SECOND YEAR (NLA)

First Term (12-8)

EE-212(C) Electrical Machinery II (3-4).
EE-311(B) Applied Electronics I (3-2).
EE-500(A) Seminar (1-0).
Ma-280(B) LaPlace Transformations (2-0).
Ma-421(B) Introduction to Digital Computers (3-2).

Second Term (11-8).

EE-114(B) Linear Systems Analysis (3-4).
EE-312(B) Applied Electronics II (3-2).
EE-500(A) Seminar (1-0).
ME-132(C) Engineering Thermodynamics II (4-2).

Third Term (14-9).

EE-313(A) Electronic Control & Measurement (3-3).
EE-411(B) Feedback Control Systems (3-3).
EE-500(A) Seminar (1-0).
Ph-365(B) Electricity & Magnetism (4-0).
ME-210(C) Applied Thermodynamics (3-2).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (14-10)

EE-115(B) Transmission Lines & Network Synthesis (3-4).
EE-121(B) Nonlinear Magnetic Devices (3-3).
EE-500(A) Seminar (1-0).
Mt-202(C) Ferrous Physical Metallurgy (3-2).
Ph-366(B) Electromagnetism (4-0).
LP-102(L) NPS Lecture Program II (0-1).

Interessional period: A four to six week field trip will be arranged to industrial or research activities.

THIRD YEAR (NLA)

First Term (12-9)

EE-412(A) Nonlinear Feedback Control Systems (3-3).
or
Elective
EE-500(A) Seminar (1-0).
ME-411(C) Mechanics of Fluids (4-2).
Ph-620(B) Elementary Atomic Physics (4-0).
Thesis (0-4).

Second Term (7-13)

EE-215(A) Marine Electrical Design (2-4).
EE-500(A) Seminar (1-0).
Ph-621(B) Elementary Nuclear Physics (4-0).
Ph-622(B) Nuclear Physics Laboratory (0-3).
Thesis (0-6).

Third Term (7-13).

EE-216(A) Marine Electrical Design (2-4).
EE-500(A) Seminar (1-0).
ME-240(B) Nuclear Power Plants (4-0).
Thesis (0-8).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (6-14)

EE-217(A) Marine Electrical Design (2-4).
EE-422(B) Nuclear Reactor Instrumentation & Control (3-3).
or
Elective
EE-500(A) Seminar (1-0).
LP-102(L) NPS Lecture Program II (0-1).
Thesis (0-6).

ORDNANCE ENGINEERING CURRICULA

NUCLEAR ENGINEERING (EFFECTS) CURRICULUM

(GROUP RZZ)

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

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.

FIRST YEAR

First Term (16-4)

Ma-120(C) Vector Algebra and Solid Analytic Geometry (3-1).
Ma-230(C) Calculus of Several Variables (4-0).
Ma-250(B) Elementary Infinite Series (2-0).
Ph-151(C) Mechanics I (4-0).
Ph-240(C) Optics and Spectra (3-3).

Second Term (18-2)

Es-140(C) Electronics I (3-2).
Ma-241(C) Elementary Differential Equations (3-0).
Ma-260(B) Vector Analysis (3-0).
Ph-152(B) Mechanics II (4-0).
Ph-635(B) Atomic Physics I (5-0).

Third Term (19-4)

Ma-246(A) Partial Differential Equations (4-0).
Ph-153(A) Mechanics III (4-0).
Ph-365(B) Electricity and Magnetism (4-0).
Ph-530(B) Thermodynamics (3-0).
Ph-636(B) Atomic Physics II (4-3).
LP-101(L) Lecture (0-1).

Fourth Term (14-7)

Ch-106(C) Principles of Chemistry I (3-2).
Es-240(C) Electronics II (3-3).
Ph-366(B) Electromagnetism (4-0).
Ph-541(B) Kinetic Theory and Statistical Mechanics (4-0).
Ph-750(L) Physics Seminar (0-1).
LP-102(L) Lecture (0-1).

Intersessional period: Field Trip to Sandia Base for specially tailored Weapons Employment Course given by the Special Weapons Training Group of the Field Command, DASA.

SECOND YEAR (RZZ)

First Term (15-8)

Ch-107(C) Principles of Chemistry II (3-2).
ME-547(C) Statics and Strength of Materials (5-0).
Ph-367(A) Special Topics in Electromagnetism (4-0).
Ph-637(B) Nuclear Physics I (3-0).
Ph-750(L) Physics Seminar (0-1).
Ph-911(A) Thesis (0-5).

Second Term (12-12)

Bi-800(C) General Biology (4-2).
ME-548(B) Structural Theory (5-0).
Ph-638(B) Nuclear Physics II (3-3).
Ph-750(L) Physics Seminar (0-1).
Ph-912(A) Thesis (0-6).

Third Term (9-16)

Bi-801(B) Animal Physiology (4-2).
Ch-551(A) Radiochemistry (2-4).
Ph-441(A) Shock Waves in Fluids (4-0).
Ph-750(L) Physics Seminar (0-1).
Ph-913(A) Thesis (0-8).
LP-101(L) Lecture (0-1).

Fourth Term (9-12)

Bi-802(A) Radiation Biology (6-0).
ChE-591(A) Blast and Shock Effects (3-0).
Ph-750(L) Physics Seminar (0-1).
Ph-914(A) Thesis (0-10).
LP-102(L) Lecture (0-1).

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

OPERATIONS ANALYSIS CURRICULA

(GROUP ROO)

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

GENERAL INFORMATION—Officer students ordered for instruction in Operations Analysis will normally matriculate in a 2-year curriculum. However, a third year of advanced studies is offered to especially qualified officers. Selection will normally be made at the end of the first year of study and will be based on the expressed choice of the individual and the Superintendent's appraisal of his academic ability. The objectives of the third year of study will be to extend the student's knowledge and experience in Operations Analysis; to enhance his mathematical ability; and to broaden his knowledge in the scientific fields related to fleet operations.

FIRST YEAR

First Term (14-7)

Ma-120(C) Vector Algebra and Solid Analytic Geometry (3-1).
Ma-181(C) Partial Derivatives and Multiple Integrals (4-1).
Ma-301(C) Basic Probability and Set Theory (4-0).
OA-891(L) Seminar (0-2).
Ph-241(C) Radiation (3-3).

Second Term (17-2)

Ma-182(B) Vector Analysis and Differential Equations (5-0).
Ma-302(B) Second Course in Probability (4-0).
OA-291(B) Introduction to Operations Analysis (4-0).
OA-892(L) Seminar (0-2).
Ph-141(B) Mechanics I (4-0).

Third Term (16-5)

Ma-193(A) Set Theory and Integration (2-0).
Ma-303(B) Theory and Techniques in Statistics I (4-0).
Ma-421(B) Introduction to Digital Computers (3-2).
OA-292(B) Methods of Operations Analysis (3-0).
OA-893(L) Seminar (0-2).
Ph-142(B) Mechanics II (4-0).
LP-101(L) Lecture (0-1).

Fourth Term (17-5)

Ma-196(A) Matrix Theory (3-0).
Ma-304(A) Theory and Techniques in Statistics II (3-0).
OA-293(B) Search Theory (4-0).
OA-393(A) War Gaming (3-0).
OA-391(A) Games of Strategy (3-2).
OA-894(L) Seminar (0-2).
LP-102(L) Lecture (0-1).

Intersessional period: Students are assigned individually as working members of various industrial or military Operations Research groups engaged in military problems.

Second Year (ROO)

First Term (14-4)
Ma-183(B) Fourier Series and Complex Variables (4-0)
OA-211(A) Linear Programming (3-2).
OA-891(L) Seminar (0-2).
Ph-365(B) Electricity and Magnetism (4-0).
Elective (Required) (3-0).
Elective (Optional).

Second Term (13-3)

OA-212(A) Dynamic Programming (3-1).
OA-234(A) Introduction to Reliability and Queueing Theory (3-0).
OA-892(L) Seminar (0-2).
Ph-630(B) Elementary Atomic Physics (4-0).
Elective (Required) (3-0).
Elective (Optional).

Third Term (14-7)

OA-235(A) Decision Criteria (3-0).
OA-893(L) Seminar (0-2).
Ph-431(B) Fundamental Acoustics (4-0).
Ph-621(B) Elementary Nuclear Physics (4-0).
Thesis (0-4).
Elective (Required) (3-0).
Elective (Optional).
LP-101(L) Lecture (0-1).

Fourth Term (6-13)

Ph-435(B) Underwater Acoustics (3-2).
OA-894(L) Seminar (0-2).
Elective (Required) (3-0).
Thesis (0-8).
Elective (Optional).
Elective (Optional).
LP-102(L) Lecture (0-1).

Electives for
Operations Analysis Curriculum

Operations Analysis:
OA-213(A) Inventory Control (3-0).
OA-214(A) Graph Theory (3-0).
OA-202(A) Econometrics (3-0).
OA-236(A) Utility Theory (3-0).
OA-225(A) Air Warfare (3-0).
OA-296(A) Development of Weapons Systems (3-0).
OA-392(A) Decision Theory (3-0).

Mathematics:
Ma-247(B) Difference Equations (3-0).
Ma-305(A) Design of Experiments (3-0).
Ma-306(A) Selected Topics in Advanced Statistics (3-0).
Ma-307(A) Introduction to Stochastic Processes (3-0).
Ma-308(A) Introduction to Time Series Analysis (3-0).
Ma-397(A) Theory of Information Communications (3-0).
Ma-423(A) Advanced Digital Computer Programming (4-0).
Ma-424(A) Boolean Algebra and Digital Computers (3-0).
Ma-425(A) Applications of Digital Computers (3-2).
Ma-426(A) Advanced Numerical Methods for Digital Computers (4-1).

Modern Physics:
Ph-366(B) Electromagnetism (4-0).
Ph-670(B) Atomic Physics I (3-0).
Ph-671(B) Atomic Physics II (3-3).
Ph-621(B) Elementary Nuclear Physics (4-0).
Ph-622(B) Nuclear Physics Laboratory (0-3).
Note 1: If the option above is elected, delete Ph-630 (B) from the second year.
Note 2: If justified by sufficient interest a Physics option could be offered in Acoustics, Optics, or Electromagnetism as an alternative to the above option in Modern Physics.

These curricula afford the opportunity to qualify for the degree of Master of Science.

WEAPONS SYSTEMS CURRICULA

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

General Information—All officers ordered for instruction in Weapons Systems initially matriculate in the 2-year General Curriculum. At the end of the first year, officer students will be selected for the 3-year Advanced Weapons Systems Curricula within the quotas assigned by the Chief of Naval Personnel. This selection is based on the expressed choice of the individual and the Superintendent's appraisal of his academic ability. For properly qualified entering students, the 2-year General Curriculum leads to the award of a Bachelor's degree and the 3-year Curricula lead to the award of a Master's degree in a scientific or engineering field. A 2-year Special Curriculum is offered to selected foreign officer students.

WEAPONS SYSTEMS (GENERAL) GROUP (WGG)

OBJECTIVE: To support the aims of the basic objective to the extent practicable within the 2-year period by equalizing the time allocated to studies in the principle science-engineering fields of Electrical Engineering, Physics and Chemistry underlying space, air and underwater weapons systems.

FIRST YEAR (Common to All)

First Term (13-7)

Ch-106(C) Principles of Chemistry I (3-2).
EE-111(C) Basic Electrical Phenomena (3-4).
Ma-120(C) Vector Algebra and Solid Analytic Geometry (3-1).
Ma-230(C) Calculus of Several Variables (4-0).

Second Term (14-6)

Ch-107(C) Principles of Chemistry II (3-2).
EE-112(C) Circuit Analysis I (3-4).
Ma-240(C) Elementary Differential Equations (2-0).
Ma-251(B) Elementary Infinite Series (3-0).
Ma-260(B) Vector Analysis (3-0).

Third Term (13-7)

ChE-611(B) General Thermodynamics (3-2).
Es-241(C) Electronics I (3-2).
Ma-270(B) Complex Variables (3-0).
Or-241(L) Ordnance Seminar (0-2).
Ph-151(C) Mechanics I (4-0).
LP-101(L) Lecture (0-1).

Fourth Term (15-9).

EE-221(C) Special Machinery (3-4).
Es-242(C) Electronics II (3-2).
Ma-245(A) Partial Differential Equations (3-0).
Ma-280(B) Laplace Transformations (2-0).
Or-242(L) Ordnance Seminar (0-2).
Ph-152(B) Mechanics II (4-0).
LP-102(L) Lecture (0-1).

Intersessional period: Enrollment in the "Elements of Management and Industrial Engineering" Course, MN-101, and a course in the "Art of Presentation" at the U.S. Naval Postgraduate School.

SECOND YEAR (WGG)

First Term (13-8)

Ch-407(A) Physical Chemistry (3-2).
Ma-116(A) Matrices and Numerical Methods (3-2).
Ph-260(C) Physical Optics (3-2).
Ph-365(B) Electricity and Magnetism (4-0).
Or-243(L) Ordnance Seminar (0-2).

Second Term (12-10)

Ch-571(A) Explosives (3-2).
EE-114(B) Linear Systems Analysis (3-4).
Es-258(B) Introduction to Microwaves (3-2).
Ma-421(B) Introduction to Digital Computers (3-2).

Third Term (13-10)

ChE-591(A) Blast and Shock Effects (3-0).
EE-411(A) Feedback Control Systems (3-3).
Es-351(B) Pulse Techniques and Radar Fundamentals (3-3)
Ph-630(B) Elementary Atomic Physics (4-0).
Ph-631(B) Atomic Physics Laboratory (0-3).
LP-101(L) Lecture (0-1).

Fourth Term (13-11)

ChE542(A) Reaction Motors (3-2).
Es-352(B) Radar Systems (3-3).
Ph-450(B) Underwater Acoustics (3-2).
Ph-621(B) Elementary Nuclear Physics (4-0).
Ph-622(B) Nuclear Physics Laboratory (0-3).
LP-102(L) Lecture (0-1).

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

ADVANCED WEAPONS SYSTEMS CHEMISTRY CURRICULUM

(GROUP WCC)

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

FIRST YEAR (Common to All)

First Term (13-7)

Ch-106(C) Principles of Chemistry I (3-2).
EE-111(C) Basic Electrical Phenomena (3-4).
Ma-120(C) Vector Algebra and Solid Analytic Geometry (3-1).
Ma-230(C) Calculus of Several Variables (4-0).

Second Term (14-6)

Ch-107(C) Principles of Chemistry II (3-2).
EE-112(C) Circuit Analysis I (3-4).
Ma-240(C) Elementary Differential Equations (2-0).
Ma-251(B) Elementary Infinite Series (3-0).
Ma-260(B Vector Analysis (3-0.

Third Term (13-7)

ChE-611(B) General Thermodynamics (3-2).
Es-241(C) Electronics I (3-2).
Ma-270(B) Complex Variables (3-0).
Or-241(L) Ordnance Seminar (0-2).
Ph-151(C) Mechanics I (4-0).
LP-101(L) Lecture (0-1).

Fourth Term (15-9)

EE-221(C) Special Machinery (3-4).
Es-242(C) Electronics II (3-2).
Ma-245(A) Partial Differential Equations (3-0).
Ma-280(B) Laplace Transformations (2-0).
Or-242(L) Ordnance Seminar (0-2).
Ph-152(B) Mechanics II (4-0).
LP-102(L) Lecture (0-1).

Intersessional period: Enrollment in the "Elements of Management and Industrial Engineering" Course, MN-101, and a course in the "Art of Presentation" at the U.S. Naval Postgraduate School.

SECOND YEAR (WCC)

First Term (13-12

Ch-108(C) Intermediate Inorganic Chemistry (3-4).
Ch-231(C) Quantitative Analysis (2-4).
Or-243(L) Ordnance Seminar (0-2).
Ph-270(B) Physical Optics and Spectra (4-2).
Ph-365(B) Electricity and Magnetism (4-0).

Second Term (13-9)

Ch-311(C) Organic Chemistry I (3-2).
Ch-443(C) Physical Chemistry I (4-3).
EE-114(B) Linear Systems Analysis (3-4).
Ph-670(B) Atomic Physics I (3-0).

Third Term (12-12)

Ch-312(C) Organic Chemistry II (3-2).
Ch-444(B) Physical Chemistry II (3-3).
EE-411(B) Feedback Control Systems (3-3).
Ph-671(B) Atomic Physics II (3-3).
LP-101(L) Lecture (0-1).

Fourth Term (13-8)

Ch-150(A) Inorganic Chemistry, Advanced (4-3).
Ch-452(A) Physical Chemistry, Advanced (3-0).
Ch-470(A) Chemical Thermodynamics (3-0).
ChE-721(B) Unit Operations (3-2).
Ch-800(A) Seminar (0-2).
LP-102(L) Lecture (0-1).

Intersessional period: Field Assignment at a representative ordnance or industrial installation.

THIRD YEAR (WCC)

First Term (9-11)

Ch-454(B) Instrumental Methods of Analysis (3-3).
ChE-632(A) Chemical Engineering Thermodynamics (3-2)
Cr-271(B) Crystallography and X-Ray Techniques (3-2).
Thesis (0-4).

Second Term (10-11)

Ch-322(A) Organic Chemistry, Advanced (3-2).
ChE-571(A) Explosives (3-2).
Ph-621(B) Elementary Nuclear Physics (4-0).
Thesis (0-7).
Chemistry Options (3-6 hours)

Third Term (6-9)

ChE-591(A) Blast and Shock Effects (3-0).
ChE-542(A) Reaction Motors (3-2).
LP-101(L Lecture (0-1).
Thesis (0-6).
Chemistry Options (7-9 hours)

Fourth Term (3-11)

ChE-113(A) Special Topics in Propellants and Fuels (3-2).
Ch-800(A) Seminar (0-2).
LP-102(L) Lecture (0-1).
Thesis (0-6.
Chemistry Options (7 hours).

OPTIONAL CHEMISTRY COURSES

Physical Chemistry:

Ch-456(A) Infrared Spectroscopy (2-0).
Ch-458(A) Structure of Molecules (3-0).
Ch-460(A) Chemical Bond (3-0).
Ch-462(A) Quantum Mechanics (3-0).

High Polymer Chemistry:

Ch-323(A) High Polymers (3-0).
Ch-324(A) Qualitative Organic Chemistry (2-4).
ChE-522(A) Plastics (3-2).

Chemical Engineering:

ChE-711(B) Chemical Engineering Calculations (3-2).
ChE-722(B) Unit Operations (3-2).
ChE-741(B) Heat Transfer (3-2).
ChE-750(A) Advanced Chemical Engineering (3-0).

Metallurgy:

Mt-201(C) Physical Metallurgy (3-2).
Mt-202(C) Ferrous Metallurgy (3-2).
Mt-301(A) High Temperature Materials (3-0).

Radiochemistry:

Ch-458(A) Structure of Molecules (3-0).
Ch-551(A) Radiochemistry (2-4).
Ch-552(A) Radiochemistry (3-4).

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

ADVANCED WEAPONS SYSTEMS ELECTRICAL ENGINEERING CURRICULUM

(GROUP WEE)

OBJECTIVE—To further the aims of the basic objective by providing officer students with a broad background of selected science-engineering studies oriented toward underwater weapon systems, with Electrical Engineering as the major field of study and Physics as the principal minor field.

FIRST YEAR (Common to All)

First Term (13-7)

Ch-106(C) Principles of Chemistry I (3-2).
EE-111(C) Basic Electrical Phenomena (3-4).
Ma-120(C) Vector Algebra and Solid Analytic Geometry (3-1).
Ma-230(C) Calculus of Several Variables (4-0).

Second Term (14-6)

Ch-107(C) Principles of Chemistry II (3-2).
EE-112(C) Circuit Analysis I (3-4).
Ma-240(C) Elementary Differential Equations (2-0).
Ma-251(B) Elementary Infinite Series (3-0).
Ma-260(B) Vector Analysis (3-0).

Third Term (13-7)

ChE-611(B) General Thermodynamics (3-2).
Es-241(C) Electronics I (3-2).
Ma-270(B) Complex Variables (3-0).
Or-241(L) Ordnance Seminar (0-2).
Ph-151(C) Mechanics I (4-0).
LP-101(L) Lecture (0-1).

Fourth Term (15-9)

EE-221(C) Special Machinery (3-4).
Es-242(C) Electronics II (3-2).
Ma-245(A) Partial Differential Equations (3-0).
Ma-280(B) Laplace Transformations (2-0).
Or-242(L) Ordnance Seminar (0-2).
Ph-152(B) Mechanics II (4-0).
LP-102(L) Lecture (0-1).

Intersessional period: Enrollment in the "Elements of Management and Industrial Engineering" Course, MN-101, and a course in the "Art of Presentation" at the U.S. Naval Postgraduate School.

Second Year (WEE)

First Term (14-11)

Ae-102(C) Aerodynamics (4-3).
EE-114(B) Linear Systems Analysis (3-4).
Ma-116(A) Matrices and Numerical Methods (3-2).
Ph-365(B) Electricity and Magnetism (4-0).
Or-243(L) Ordnance Seminar (0-2).

Second Term (13-7)

Ch-407(A) Physical Chemistry (3-2).
EE-141(A) Electrical Measurement of Nonelectrical Quantities (3-3).
Ma-421(B) Introduction to Digital Computers (3-2).
Ph-366(B) Electromagnetism (4-0).

Third Term (14-8)

ChE-542(A) Reaction Motors (3-2).
EE-411(B) Feedback Control Systems (3-3).
Ma-321(B) Probability (4-2).
Ph-367(A) Special Topics in Electromagnetism (4-0).
LP-101(L) Lecture (0-1).

Fourth Term (12-8)

EE-412(A) Nonlinear Feedback Control Systems (3-3).
EE-414(A) Sampled Data Feedback Control Systems (3-2).
Ma-322(A) Statistical Decision Theory (3-2).
Oc-110(C) Introduction to Oceanography (3-0).
LP-102(L) Lecture (0-1).

Intersessional period: Field assignment at a representative military or industrial installation.

Third Year (WEE)

First Term (14-8)

EE-413(A) Advanced Linear Feedback Control Theory (3-3).
EE-116(A) Advanced Circuit Analysis (3-2).
Ph-431(B) Fundamental Acoustics (4-0).
OA-121(A) Survey of Operations Analysis (4-2).
Thesis (0-1).

Second Term (10-13)

EE-118(A) Network Synthesis (3-2).
EE-415(A) Linear and Nonlinear Feedback Control Compensation Theory (3-2).
Ph-432(A) Underwater Acoustics (4-3).
Thesis (0-6).

Third Term (10-10)

Oc-330(A) Marine Geology and Geophysics (3-0).
Ph-442(A) Shock Waves in Fluids (3-0).
Ph-620(B) Elementary Atomic Physics (4-0).
Ph-631(B) Atomic Physics Laboratory (0-3).
LP-101(L) Lecture (0-1).
Thesis (0-6).

Fourth Term (8-12)

Ch-580(A) Electrochemistry (3-2).
Oc-230(A) Special Topics in Oceanography (3-0).
EE-121(B) Nonlinear Magnetic Devices (3-3).
LP-102(L) Lecture (0-1).
Thesis (0-6).

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

ADVANCED WEAPONS SYSTEMS PHYSICS CURRICULUM

(GROUP WPP)

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

First Year (Common to All)

First Term (13-7)

Ch-106(C) Principles of Chemistry I (3-2).
EE-111(C) Basic Electrical Phenomena (3-4).
Ma-120(C) Vector Algebra and Solid Analytic Geometry (3-1).
Ma-230(C) Calculus of Several Variables (4-0).

Second Term (14-6)

Ch-107(C) Principles of Chemistry II (3-2).
EE-112(C) Circuit Analysis I (3-4).
Ma-240(C) Elementary Differential Equations (2-0).
Ma-251(B) Elementary Infinite Series (3-0).
Ma-260(B) Vector Analysis (3-0).

Third Term (13-7)

ChE-611(B) General Thermodynamics (3-2).
Es-241(C) Electronics I (3-2).
Ma-270(B) Complex Variables (3-0).
Or-241(L) Ordnance Seminar (0-2).
Ph-151(C) Mechanics I (4-0).
LP-101(L) Lecture (0-1).

Fourth Term (15-9)

EE-221(C) Special Machinery (3-4).
Es-242(C) Electronics II (3-2).
Ma-245(A) Partial Differential Equations (3-0).
Ma-280(B) Laplace Transfarmations (2-0).
Or-242(L) Ordnance Seminar (0-2).
Ph-152(B) Mechanics II (4-0).
LP-102(L) Lecture (0-1).

Intersessional period: Enrollment in the "Elements of Management and Industrial Engineering" Course, MN-101, and a course in the "Art of Presentation" at the U.S. Naval Postgraduate School.

SECOND YEAR (WPP)

First Term (15-8)

Ch-407(A) Physical Chemistry (3-2).
Ma-321(B) Probability and Statistics (4-2).
Or-243(L) Ordnance Seminar (0-2).
Ph-154(A) Celestial Mechanics (4-0).
Ph-270(B) Physical Optics and Spectra (4-2).

Second Term (16-6)

Ae-171(A) Aerodynamics (3-2).
ChE-542(A) Reaction Motors (3-2).
Ma-322(A) Statistical Decision Theory (3-2).
Ph-365(B) Electricity and Magnetism (4-0).
Ph-670(B) Atomic Physics I (3-0).

Third Term (13-11)

Ae-172(A) Aerodynamics (3-2).
EE-114(B) Linear Systems Analysis (3-4).
Ph-366(B) Electromagnetism (4-0).
Ph-671(B) Atomic Physics II (3-3).
Ph-750(L) Physics Seminar (0-1).
LP-01(L) Lecture (0-1).

Fourth Term (13-7)

EE-411(B) Feedback Control Systems (3-3).
Es-258(B) Introduction to Microwaves (3-2).
Ph-541(B) Kinetic Theory and Statistical Mechanics (4-0).
Ph-637(B) Nuclear Physics I (3-0).
Ph-750(L) Physics Seminar (0-1).
LP-102(L) Lecture (0-1).

Intersessional period: Field assignment at a representative ordnance or industrial installation.

THIRD YEAR (WPP)

First Term (14-9)

Ae-173(A) Compressible Fluids (4-0).
Es-351(B) Pulse Techniques and Radar Fundamentals (3-3).
Ph-638(B) Nuclear Physics II (3-3).
Ph-730(A) Physics of the Solid State (4-2).
Ph-750(L) Physics Seminar (0-1).

Second Term (10-12)

Ae-174(A) Compressible Fluids (3-2).
Es-352(B) Radar Systems (3-3).
Ph-654(A) Plasma Physics (4-0).
Ph-750(L) Physics Seminar (0-1).
Thesis (0-6).

Third Term (10-13)

Es-540(B) Radio Telemetering and Simulation (3-3).
Ma-116(A) Matrices and Numerical Methods (3-2).
Mr-420(B) Upper Atmosphere Physics (4-0).
Ph-750(L) Physics Seminar (0-1).
LP-101(L) Lecture (0-1).
Thesis (0-6).

Fourth Term (9-15)

Ae-701(A) Magneto-aerodynamics (4-0).
Es-347(B) Missile Guidance (3-3).
Ma-421(B) Introduction to Digital Computers (3-2).
Ph-750(L) Physics Seminar (0-1).
LP-102(L) Lecture (0-1).
Thesis (0-6).

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

WEAPONS SYSTEMS (SPECIAL)

(GROUP WSS)

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

FIRST YEAR

First Term (13-7)

Ch-106(C) Principles of Chemistry I (3-2).
EE-111(C) Basic Electrical Phenomena (3-4).
Ma-120(C) Vector Algebra and Solid Analytical Geometry (3-1).
Ma-230(C) Calculus of Several Variables (4-0).

Second Term (14-6)

Ch-107(C) Principles of Chemistry II (3-2).
EE-112(C) Circuit Analysis I (3-4).
Ma-240(C) Elementary Differential Equations (2-0).
Ma-251(B) Elementary Infinite Series (3-0).
Ma-260(B) Vector Analysis (3-0).

Third Term (13-5)

ChE-611 (B) General Thermodynamics (3-2).
Es-241 (C) Electronics I (3-2).
Ma-270 (B) Complex Variables (3-0).
Ph-151 (C) Mechanics I (4-0).
LP-101 (L) Lecture (0-1).

Fourth Term (17-7)

EE-221 (C) Special Machinery (3-4).
Es-242 (C) Electronics II (3-2).
Ma-245 (A) Partial Differential Equations (3-0).
Ma-280 (B) Laplace Transformations (2-0).
Ph-152 (B) Mechanics II (4-0).
LP-102 (L) Lecture (0-1).

Intersessional period: Enrollment in the "Elements of Management and Industrial Engineering" Course, MN-101, and a course in the "Art of Presentation" at the U.S. Naval Postgraduate School.

Second Year (WSS)

First Term (13-6)

Ch-407 (A) Physical Chemistry (3-2).
Ma-116 (A) Matrices and Numerical Methods (3-2).
Ph-260 (C) Physical Optics (3-2).
Ph-365 (B) Electricity and Magnetism (4-0).

Second Term (12-11)

EE-114 (B) Linear Systems Analysis (3-4).
EE-141 (A) Electrical Measurement of Nonelectric Quantities (3-3).
Es-258 (B) Introduction to Microwaves (3-2).
Ma-421 (B) Introduction to Digital Computers (3-2).

Third Term (13-12)

EE-411 (B) Feedback Control Systems (3-3).
Es-351 (B) Pulse Techniques and Radar Fundamentals (3-3).
Ma-351 (B) Industrial Statistics I (3-2).
Ph-630 (B) Elementary Atomic Physics (4-0).
Ph-631 (B) Atomic Physics Laboratory (0-3).
LP-101 (L) Lecture (0-1).

Fourth Term (13-8)

ChE-521 (A) Plastics (3-2).
Es-630 (B) Theory of Propagation (4-0).
Ma-352 (B) Industrial Statistics II (2-2).
Ph-621 (B) Elementary Nuclear Physics (4-0).
Ph-622 (B) Nuclear Physics Laboratory (0-3).
LP-102 (L) Lecture (0-1).

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

ONE-YEAR SCIENCE CURRICULUM

The objective of this program is to provide post-commissioning education in the fields of Mathematics, Physics and Engineering, designed to up-date and build on undergraduate education and to prepare students for advanced functional training such as Naval Tactical Data System, Polaris and other missile instructor duty on school staffs, test pilot schools.

(GROUP SS)

First Term

Ma-230 (C) Calculus of several Variables (4-0).
Ph-151 (C) Mechanics I (4-0).
EE-171 (C) Electrical Circuits and Fields (3-4).
Ma-120 (C) Vector Algebra and Solid Analytic Geometry (4-0).

Second Term

Management
Special Weapons Orientation
Space and Astronautics
Art of Presentation

Third Term

Ma-073 (B) Differential Equations (5-0).
Ph-152 (B) Mechanics II (4-0).
EE-251 (C) A.C. Circuits (3-4).
Ma-311 (B) Introduction to Probability and Statistics (4-0).

Fourth Term

Ma-126 (B) Numerical Methods for Digital Computers (3-2).
Es-612 (C) Introduction to Electromagnetics (4-0).
Ph-620 (B) Elementary Atomic Physics (4-0).
Es-241 (C) Electronics I (3-2).

Fifth Term

Ma-421 (B) Introduction to Digital Computers (3-2).
Ph-621 (B) Elementary Nuclear Physics (4-0).
Oa-141 (B) Fundamentals of Operations Analysis (4-0).
Es-242 (C) Electronics II (3-3).

Variations in the above curriculum will be made for those students whose academic backgrounds are not appropriate to the level of work required.

From those SCIENCE students who have an "availability" of two or more years, a limited number will be transferred into advanced technical curricula at the end of Term II. Such transfer will be based upon academic performance, availability of openings in the technical curricula, and application by the student.

ENGINEERING SCHOOL

COURSE DESCRIPTIONS

AERONAUTICS

Ae-001(L) AERONAUTICAL LECTURE SERIES (0-1). Lectures on general aeronautical engineering subjects by prominent authorities from the Navy Department, research laboratories and the industry.

Ae-100(C) BASIC AERODYNAMICS (3-2). Properties of fluids; statics; velocity and pressure; Bernoulli's theorem; cavitation; theory of lift; blade screws and propellers; viscous flows; vortices; laminar and turbulent boundary layer flows; separation phenomena; surface friction; resistance of floating bodies; dynamics of compressible fluids. The laboratory periods include experimental work in the wind tunnel, allied to the topics above; technical analysis and report writing. TEXTS: D*odge and* THOMPSON, *Fluid Mechanics;* ROUSE, *Elementary Fluid Mechanics.*

Ae-102(C) AERODYNAMICS (4-3). Basic aerodynamics for ordnance application. Properties of fluids; equations of basic hydro-aerodynamics flow; viscous fluids and boundary layers; dynamic lift and drag of bodies; elementary study of compressible flows. Laboratory is in subsonic wind tunnel. TEXTS: Same as Ae-100. PREREQUISITES: Engineering Mechanics.

Ae-121(C) TECHNICAL AERODYNAMICS (3-4). Characteristic flows and pressures about bodies; surface friction; wake drag; aerodynamic characteristic of airfoil sections; three-dimensional airfoil theory; induced drag; interference drag; high lift devices; velocity polar. The laboratory periods include wind tunnel experiments, analysis and technical report writing on topics allied to the above class work. TEXTS: DWINNELL, *Principles of Aerodynamics;* POPE, *Wind Tunnel Testing.* PREREQUISITE: Ae-100(C).

Ae-131(B) TECHNICAL AERODYNAMICS PERFORMANCE (4-2). The aerodynamics characteristics of the airplane; propeller and jet engine characteristics; sea level performance; performance at altitudes; range and endurance; special performance problems; charts. The laboratory periods are devoted to computations and performance analysis. TEXTS: DWINNELL, *Principles of Aerodynamics;* PERKINS. *and* HAGE, *Airplane Performance, Stability and Control;* POPE, *Wind Tunnel Testing.* PREREQUISITE: Ae-121(C).

Ae-141(A) DYNAMICS I (3-2). Fundamental definitions; the forces and moments on the entire airplane; the equations of motion; the moments of the wing, tail and other parts of the airplane; G.C. location, effect on static stability; neutral points; maneuver points; fixed control and free control stability; elevator, aileron, rudder effectiveness; control design features; maneuverability and controllability; turns and loops. The laboratory work consists of wind tunnel experimentation and analysis of the above topics on models. TEXTS: HIGGINS, *USNPGS Notes;* PERKINS, *Aircrat Stability and Controllability;* HAMLIN, *Flight Testing;* ETKIN, *Dynamics of Flight.* PREREQUISITE: Ae-131(B).

Ae-142(A) DYNAMICS II (3-4). The Euler equations of motion; the moments of inertia of aircraft; the aerodynamic reactions and derivatives; the symmetrical or longitudinal motion analysis; the asymmetrical or lateral motion analysis; effect of control freedom, of controls and response; spins. The laboratory work consists of wind tunnel experimentation on models to study some of the above problems. TEXTS: Same as Ae-141(A). PREREQUISITE: Ae-141(A).

Ae-150(B) FLIGHT TEST PROCEDURES (3-4). Technical aerodynamics of airplanes including performance, longitudinal stability, lateral-directional stability and flight test methods and aircraft evaluation. Test flying by students in naval aircraft, data reduction and flight test report writing. TEXTS: DOMMASCH, SHERBY *and* CONNOLLY, *Airplane Aerodynamics;* NATC PATUXENT, *Flight Test Manual;* NavAer publications.

Ae-151(B) FLIGHT TESTING AND EVALUATION I (2-0). Theoretical longitudinal stability and control of aircraft, related test methods and aircraft evaluation. TEXTS: Same as Ae150(B). PREREQUISITE: Ae-141(A) or Ae-146(A).

Ae-152(B) FLIGHT TESTING AND EVALUATION II (2-0). Theoretical lateral-directional control of aircraft, relataed test methods and aircraft evaluation. TEXTS: Same as Ae-150(B). PREREQUISITE: Ae-142(A) or A-146(A).

Ae-153(B) FLIGHT TESTING AND EVALUATION III (2-0). The technical aerodynamics of airplanes, especially performance and test methods. TEXTS: Same as Ae-150(B). PREREQUISITE: Ae-421(B).

Ae-161(B) FLIGHT TESTING AND EVALUATION LABORATORY I (0-4). Flight program accompanying A-151 (B). Test flying in naval aircraft by aviator students; stalls; static and dynamics longitudinal stability; static and maneuvering neutral points; control effectiveness; trim changes; Mach effects.

Ae-162(B) FLIGHT TESTING AND EVALUATION LABORATORY II (0-4). Flight program accompanying Ae-152 (B). Test flying in naval aircraft by aviator students: rate of roll; adverse yaw; control effectiveness with asymmetric power, static and dynamics later-directional stability; over-all qualitative evaluation of aircraft.

Ae-163(B) FLIGHT TESTING AND EVALUATION LABORATORY III (0-4). Flight program accompanying Ae-153(B). Test flying in naval aircraft by aviator students and reduction of resulting data; airspeed calibration; level flight performance and fuel consumption; climb performance.

Ae-171(A) AERODYNAMICS I (3-2). Edited to the interests of ordnance curricula. Properties of gases from viewpoint of kinetc theory; dynamic equations for real fluids in vector form; circulation; potential flow, perfect fluid equations, two-dimensional flows, theory of lift, vortices, viscous fluids; dimentional analysis, incompressible laminar boundary layer; TEXT: Class notes. PREREQUISITES: Required Ma and Ph.

Ae-172(A) AERODYNAMICS II (3-2). Continuation of Ae-171. Karman integral relation, turbulent boundary-layer, transition, separation; airfoil section characteristics; laws of vortex motion, finite wing span theory, induced drag; engineering consequences and applications. TEXT: Class notes. PREREQUISITE: Ae-171.

Ae-173(A) COMPRESSIBLE FLUIDS (4-0). Essentially the coverage in Ae-513, edited to the interests of ordnance curricula. TEXTS: Same as Ae-513. PREREQUISITE: Ae-172.

Ae-174(A) COMPRESSIBLE FLUIDS (3-2). A continuation of Ae-173, edited from the same viewpoint, with coverage similar to Ae-514. TEXTS: Same as Ae-514. PREREQUISITE: Ae-173.

Ae-175(A) MISSILE DYNAMICS (3-2). Generalized force fields on flight vehicles, in continuation of this sequence. Equations of motion, trim, performance, range, static and dynamic stability, controllability, practical design problems and analysis of a particular missile. TEXTS: Same as Ae-141. PREREQUISITE: Ae-174.

Ae-200(C) STRUCTURAL MECHANICS I (3-2). This survey basic mechanics for application to the structure of flight vehicles. Topics are: Force systems, deformations, truss analysis, section properties, shear and bending moment diagrams, graphical and diagrammatic methods. Problem work supplements theory. TEXTS: BEER *and* JOHNSTON, *Statics;* NILES *and* NEWELL, *Airplane Structures;* TIMOSHENKO, *Strength of Materials, Vol. I.* PREREQUISITE: Engineering Mechanics (Statics).

Ae-211(C) STRUCTURAL MECHANICS II (4-2). A continuation of Ae-200. The two-dimensional state of stress, stress-strain relations; design of struts, circular shafts, thin cylinders, beams; load distribution; energy principles, impact; bending deflections by diagrammatic methods. Problem work and laboratory tests supplement theory. TEXTS: TIMOSHENKO, *Strength of Materials;* PEERY, *Aircraft Structures;* NILES *and* NEWELL, *Airplane Structures;* SHANLEY, *Strength of Materials.* PREREQUISITE: Ae-200(C).

Ae-212(C) STRUCTURAL COMPONENTS I (4-2). Stress and structural analysis of frame or engine components used in flight vehicles. Extended discussion of statically indeterminate systems under transverse or avial loads, bending, torsion; thermal effects; curved bars and frames; columns. Problem work and laboratory tests supplement theory. TEXTS: Same as Ae-211, and TIMOSHENKO, *Strength of Materials, Part II.* PREREQUISITE: Ae-211(C).

Ae-213(B) STRUCTURAL COMPONENTS II (4-2). A continuation of Ae-212. Flight framework is analyzed under characteristic loading, unsymmetrical bending, shear flow in open and closed sections, shear resistant webs, diagonal tension fields. Torsion of non-circular sections, membrane analogy. Problem work and laboratory tests supplement theory. TEXTS: Same as Ae-212. PREREQUISITE: Ae-212.

Ae-214(A) STRUCTURAL COMPONENTS III (3-0). A continuation of Ae-213. Topics include: Beam columns, stability, axially symmetric parts, thin shells under inner pressure, discontinuity stresses, plates under transverse loads, discs in rotation, thick cylinders and spheres under pressure: TEXTS: SECHLER, *Elasticity in Engineering;* TIMOSHENKO, *Strength of Materials, Vol. II.* PREREQUISITE: Ae-213.

Ae-215(A) ADVANCED STRUCTURES (4-0). Selected topics from the three-dimensional state of stress and strain in elastic media, in solids or fluids; plasticity, stability, vibration, flutter. TEXTS: Same as Ae-214; others depend upon topics. PREREQUISITE: Ae-214.

Ae-221(B) STRUCTURAL PERFORMANCE (3-2). Static and dynamic tests of aircraft and missile components in the Aeronautical Structures Laboratory. Electronic and optical instrumentation methods, evaluation of strain measurements, demonstration of stress distribution in various structures. TEXTS: LEE, *An Introduction to Experimental Stress Analysis;* PERRY *and* LISSNER, *Strain Gage Primer; Notes.* PREREQUISITE: Ae-213.

Ae-311(C) STRUCTURAL DESIGN I (2-4). Detail methods of design and analysis of a flight vehicle. Preliminary layout, three-view drawing, weight and balance; aerodynamic characteristics and basic performance; flight loads from V-n diagram; dynamic balancing; wing shear and moment curves; detail structural design of wing. TEXTS: Same as A-213 (B); also CORNING, *Airplane Design; MIL-A-*8629 *(Aer).* PREREQUISITE: Ae-213(B).

Ae-312(B) STRUCTURAL DESIGN II (1-4). A continuation of Ae-311(C). Stress analysis of wing including stringer stresses; shear flows; skin stresses and skin buckling check; semi-tension field analysis of front spar web, spar cap, stiffeners. Analysis of riveted, bolted, welded fittings. TEXTS: Same as Ae-311(C). PREREQUISITE: Ae-311(C).

Ae-316(C) STRUCTURAL DESIGN (2-4). Detail methods of airplane or missile design and analysis. Preliminary layout; three view drawing; weight and balance; aerodynamic characteristic and basic performance; design criteria; inertia loads, shear and moment curves; detail structural design and stress analysis of a major component. TEXTS: PEERY, *Aircraft Structures;* BONNEY, *Principles of Guided Missile Design;* CHIN, *Missile Configuration Design;* CORNING, *Airplane design.* PREREQUISITE: Ae-213(B).

Ae-409(C) THERMODYNAMICS I (AERONAUTICAL) (4-2). Fundamentals of thermodynamics edited especially for application to aerothermodynamics and aircraft propulsion. Topics include fundamental laws, energy concepts, terminology and symbolism, properties of ideal and real gases, vapors, property relationships, theoretical cycles and elementary compressible flow. TEXTS: KEENAN *and* KEYS, *Thermodynamic Properties of Steam;* KEENAN *and* KAYE, *Gas Tables;* DOOLITTLE, *Thermodynamics for Engineers; USNPS Notes.* PREREQUISITE: Ae-100(C).

Ae-410(B) THERMODYNAMICS II (AERONAUTICAL) (3-2). A continuation of Ae-409. The latter half of the course includes an introduction to heat transfer by conduction, radiation and convection. TEXTS: KEENAN *and* KAYE, *Gas Tables;* DOOLITTEL, *Thermodynamics for Engineers.* PREREQUISITE: Ae-409(C).

Ae-411(B) AIRCRAFT ENGINES (4-2). Combustion of liquid fuels in air. Chemical and physical aspects of ignition, flame propagation and stabilization in steady flow. Piston engine performance as affected by environment and mechanical design. Propeller design, performance and operation. TEXTS: LICHTY, *Internal Combustion Engines;* TAYLOR *and* TAYLOR, *Internal Combustion Engines;* NELSON, *Airplane Propeller Princples;* FRAAS, *Aircraft Power Plants:USNPS Notes.* PREREQUISITE: Ae-410(B).

Ae-412(B) THERMODYNAMICS LABORATORY (0-3). Laboratory experiments and computations involving air flow, combustion, gas analysis and heat transfer as applied to aircraft propulsion machinery. Familiarization with and use of specialized instrumentation. PREREQUISITE: To be accompanied by Ae-411(B).

Ae-421(B) AIRCRAFT PROPULSION (3-2). Steady flow machinery as applied to aircraft propulsion cycles, compression and turbine performance characteristics and matching for off-design operation. Turbojet, turboprop and turbo-fan performance in flight. Ramjet engine performance analysis. TEXTS: HESSE, *Jet Propulsion; USNPS notes.* PREREQUISITE: Ae-411(B).

Ae-422(A) PERFORMANCE OF PROPULSION SYSTEMS (4-2). Application of air-breathing and rocket engines to the propulsion of manned aircraft and missiles. Theory and performance of advanced systems to space propulsion. TEXT: To be specified. PREREQUISITE: Ae-421-(B).

Ae-428(A) OPERATING PRINCIPLES OF TURBO-MACHINES (3-2). General relations for flows with energy changes, relative and absolute motions, momentum theorem. Operating principles of axial-flow and centrifugal machines, compressors and turbines. Operating characteristics to establish relations between theoretical and actual performance in special compressor test rig. TEXT: SHEPHERD, *Principles of Turbo-Machinery;* VAVRA *and* GAWAIN, *Compressor Test Rig;* VAVRA, *Aerothermodynamics.* PREREQUISITE: Ae-41(B), and accompanied by Ae-508(A).

Ae-431(A) AEROTHERMODYNAMICS OF TURBO-MACHINES (4-1). Fundamental course in the study of flows of elastic fluids in turbo-machines. Rational methods are used for the evaluating of flow phenomena in rotating and stationary passages and for the predicting of the performance of turbomachines for present and future applications. The laboratory periods are devoted to measurements and analysis of flows in a special compressor test rig. TEXTS: VAVRA, *Aerothermodynimacis;* VAVRA *and* GAWAIN, *Compressor Test Rig.* PREREQUISITE: Ae-503(A).

Ae-432(A) ADVANCED PROPULSION SYSTEMS I (4-2). Survey and analysis of propulsion systems for different flight vehicles covering thermal, chemical and nuclear energy conversions. TEXT: USNP Notes. PREREQUISITE: Ae-431.

Ae-433(A) ADVANCED PROPULSION SYSTEMS II (4-2). Continuation of Ae-452 with special emphasis on part-load operating characteristics and control. TEXT: USNPS Notes. PREREQUISITE: Ae-432.

Ae-434(A) SPACE POWER PLANTS (3-1). Power plants for propulsion and for production of electrical power for space vehicles. Plasma, nuclear and ion propulsion. Electromechanical, electrochemical, thermoelectric and thermionic conversion methods using chemical, solar and nuclear energy sources. TEXT: USPNS Notes. PREREQUISITE: Ae-433.

Ae-441(A) DESIGN OF TURBOMACHINES (3-1). Analysis and design of turbomachines with special reference to design of bladings and other mechanical elements. Vibratory characteristics, stress analysis and general design concepts and procedures. TEXTS: USPNS Notes. PREREQUISITE: Ae-431.

Ae-501(A) HYDRO-AERO MECHANICS I (4-0). Dynamic equations for real fluids in vector and tensor form. circulation, rotational flow, potential flow, perfect fluid equations, complex variables and conformal mapping, two-dimensional airfoil theory. TEXTS: KUETHE *and* SCHETZER, *Foundations of Aerodynamics;* ABBOTT *and* VON DOENHOFF, *Theory of Wing Sections;* Instructor's Notes. PREREQUISITES: Ma-153(B) and Ae-121(C).

Ae-502(A) HYDRO-AERO MECHANICS II (4-0). Continuation of Ae-501(A). Laws of vortex motion, finite span wing theory, hydrodynamics of viscous fluids, pipe flow, moundray-layer equations, Blasius solution, Karman integral relation, turbulent boundary-layer, transition. TEXTS: Same as Ae-501(A). PREREQUISITE: Ae-501(A).

Ae-511(A) HYDRO-AERO MECHANICS ADVANCED I (4-0). This course provides a more advanced coverage of the material in Ae-501. TEXTS: Same as Ae-501(A), also VAVRA, *Aerothermodynamics.*

Ae-512(A) HYDRO-AERO MECHANICS ADVANCED II (4-0). This course provides a more advanced coverage of the material in Ae-502. TEXTS: Same as Ae-511.

Ae-513(A) COMPRESSIBILITY I (410). One dimensional gas dynamics; channel flow, normal and oblique shock waves, Prandtl-Meyer expansion, three-dimensional flow equations, Crocco's theorem, linearized potential flow of characteristics. TEXTS: LIEPMANN *and* ROSHKO, *Elements of Gasdynamics;* Instructor's Notes. PREREQUISITES: Ae-410(B) and Ae-502(A).

Ae-514(A) COMPRESSIBILITY II (3-2). Similarity laws for transonic and hypersonic flows, viscous shear and heat transfer, continuum magneto-aerodynamics: basic equations including Maxwell's relations, applications to plasmas, ionized boundary layers and magnetic nozzles. Wind tunnel and shock tube tests are conducted in conjunction with class discussion. TEXTS: Same as Ae-513(A). PREREQUISITE: Ae-513 (A).

Ae-508(A) COMPRESSIBILITY (3-2). One dimensional gas dynamics; channel flow, normal and oblique shock waves, Prandtl-Meyer expansion, three-dimensional flow equations; Crocco's theorem, linearized potential flow and application to air foils and bodies of revolution, method of characteristics, equations of magnetoaerodynamics and specific applications. Wind tunnel and shock tube tests are conducted in conjunction with class discussion. TEXTS: Same as Ae-503(A). PREREQUISITES: Ae-502(A) and Ae-410(B).

Ae-601(A) METHODS IN ELASTICITY (4-0). Formal systems in stress and strain, the generalized Hooke's Law and compatibility. Classical boundary value problems. Plane stress and strain; Airy stress function. Variational concepts: minimum potential and complementary energies. Eigenvalue solutions. Problems in elastic stability. TEXTS: R. S. SOKOLNI KOFF, *Mathematical Theory of Plasticity;* Class lecture notes. PREREQPUISITE: Ae-215(A).

Ae-602(A) STATIC AEROELASTICITY (3-0). Problems involving the coupling of aerodynamic and elastic forces without inertia coupling: the divergence of lifting surfaces and control reversal. Two-dimensional examples, related integral and differential equations, solutions for finite wings including the effect of sweep, semi-rigid solutions, iterative methods, matrix forms. Spanwise lift distribution of an elastic wing. TEXTS: BROADBENT, *The Elementary Theory of Aeroelasticity;* FUNG, *The Theory of Aeroelasticity;* BISPLINGHOFF, ASHLEY, .HALFMAN, *Areoelasticity.* PREREQUISITE: Ae-601(A).

Ae-603(A) AEROELASTICITY (FLUTTER) AND VIBRATION (4-0). Problems involving coupling of inertia forces with elastic and/or aerodynamic forces. Free and forced vibrations, effect of damping, several degrees of freedom. Torsional vibration, critical speeds. Impact. Fundamental non-stationary wing theory. Flutter of a two-dimensional airfoil and of a cantilever wing. TEXTS: Same as Ae-602(A). PREREQUISITE: Ae-602(A).

Ae-604(A) THERMOELASTICITY (3-1). Analysis and design of structures at elevated temperatures. Temperature distribution, elastic and inelastic thermal stresses in aeronautical structures, thermal effects on deflections, stiffness and flutter. TEXT. GATEWOOD, *Thermal Stresses.* PREREQUISITE: Ae-601.

Ae-605(A) PLATES AND SHELLS (4-0). Analysis of thin, stiff plates and shells from viewpoint of application to flight vehicles. Topics are: flat plates in simple bending or under transverse load, curvature and twist of middle surface, bending and twisting moments, shearing forces, equations of equilibrium, solution for stresses; strain energy stored under lateral loading, under loads in middle surface, stability considerations, crippling stress; axially symmetrical problems in shells, shell geometry, equilibrium under load, analysis for critical stresses; effects of discontinuities, flanges, cutouts; selected design applications. TEXTS: TIMOSHENKO, *Theory of Plates and Shells;* NACA and NASA Technical Notes; USNPS Notes. PREREQUISITES: Ae-601.

Ae-610(A) AERONAUTICAL STRUCTURES SEMINAR (3-0). Selected topics in advanced structural design of flight vehicles from; aeroelasticity, thermoelasticity, dynamic loading and vibration, plasticity, stability, non-linear problems, structural systems. TEXTS: Depend upon topic. PREREQUISITES: Some coursework in Ae-600 sequence.

Ae-701(A) MAGNETOAERODYNAMICS (4-0). Dynamic equations for continuous media and classical equations for electromagnetic fields as applied to ionized gases moving in a magnetic field; propagation of small disturbances, Alfven waves, fast and slow waves, shock waves; particular solutions of the magnetoaerodynamic equations; motion of charged particles, drift, anisotropic Ohm's law, applications. TEXTS: Instructor's notes. PREREQUISITE: Ae-506(A) or Ae-508(A).

Ae-801(A) AERONAUTICAL SYSTEMS ENGINEERING (3-3). Advanced manual control systems, requirements for power operation and stability augmentation; block diagram concept, transfer function, systems engineering viewpoint; basic control-reference systems for automation; single axis and multi-axis systems, inter-axis maneuver coupling; time modulated control; command flight, remote-controlled reference systems; systems concepts, applications to weapons and their sub-systems. TEXTS: ETKIN, *Dynamics of Flight.* PERKINS *and* HAGE, *Airplane Performance, Stability and Control.*

Ae-802(A) ADVANCED DYNAMICS (3-3). Effects of aeroelasticity on static longitudinal stability including trim data, neutral and maneuver points, control reversal, dynamic motion of vehicle, and interaction with stability augmentation devices and automatic controls. Automatic power plant control including turbine control for deck-recovery, ramjet phugoid coupling, precision velocity control by cut-off in ballistic vehicles, vector jet attitude stabilization. TEXTS: PERKINS *and* HAGE, *Airplane Performance, Stability and Control;* ETKIN, *Dynamics of Flight;* Instrúctors notes. PREREQUISITE: Ae-801 and Ae-142.

BIOLOGY

Bi-800(C) FUNDAMENTALS OF BIOLOGY (4-2). The fundamental principles of the living cell covered from a biochemical and bio-physical standpoint. Specialization of cell function, as exemplified in certain animal and plant tissues and organ systems. Genetics and its relation to properties of the cell nucleus. Related topics, including the evolutionary progress. TEXT: MARSLAND, *Principles of Modern Biology.*

Bi-801(B) ANIMAL PHYSIOLOGY (4-2). A general course in animal physiology, emphasizing human fuctional aspects. TEXT: BEST *and* TAYLOR, *The Living Body.* PREREQUISITE: Bi-800(C).

Bi-802(A) RADIATION BIOLOGY (4-2). Fundamental processes of energy transfer from radiation to living matter. Bio-chemical, physiological and genetic effects of radiation. Methods of experimental radiation biology. TEXTS: BACQ *and* ALEXANDER, *Fundamentals of Radiobiology;* CLAUS, *Radiation Biology and Medicine.* PREREQUISITES: Ph-642 (B), Bi-800(C), Bi-801(B).

Bi-822(A) SPECIAL TOPICS IN RADIATION BIOLOGY (2-0). Study of important current topics in radiation biology. TEXTS: Current literature in the field. PREREQUISITES: Appropriate biological background.

CHEMISTRY

Ch-001 GENERAL INORGANIC CHEMISTRY (4-3). The first term of a two-term course in elementary chemistry for students in the School of Naval Science will consist of a study of the principles governing the physical and chemical behavior of matter with sufficient descriptive chemistry to illustrate these principles. Laboratory experiments will be related to the lecture material. TEXTS: SIENKO *and* PLANE, *Chemistry;* RITTER, *An Introductory Course in Chemistry;* PIERCE *and* SMITH, *General Chemistry Workbook.*

Ch-002 GENERAL INORGANIC CHEMISTRY. (3-3). A continuation of Ch-001. The chemical properties of the elements and their compounds will be studied from the viewpoint of the periodic table. Special emphasis will be given to the compounds. TEXTS: SIENKO *and* PLANE, *Chemistry;* RITTER, *An Introductory Laboratory Course in Chemistry;* PIERCE *and* SMITH, *General Chemistry Workbook.* PREREQUISITE: Ch-001.

Ch-103(C) GENERAL CHEMISTRY (4-2). A study of the principles governing the chemical behavior of matter. Includes topics such as chemical stoichiometry, kinetic theory, atomic structure, chemical equilibria and descriptive chemistry limited almost entirely to the compounds of carbon. The laboratory work will supplement the lectures. TEXT: SIENKO *and* PLANE, *Chemistry.*

Ch-106(C) PRINCIPLES OF CHEMISTRY I (3-2). The first course of a two-term sequence. A study of the fundamental principles of chemistry governing the physical and chemical behavior of matter. Current theories of atomic structure and chemical bonding are particularly emphasized. Also studied are the states of matter, chemical kinetics, and chemical equilibria. Elementary physical chemistry experiments are performed in the laboratory. TEXT: SIENKO *and* PLANE, *Chemistry.* PREREQUISITE: College Chemistry.

Ch-107(C) PRINCIPLES OF CHEMISTRY II (3-2). A continuation of Ch-106. The principles of chemistry are applied to the study of the chemical properties of the elements and their compounds. Special attention is given to the compounds of carbon. Laboratory experiments are used to illustrate the chemical behavior of matter. TEXT: SIENKO *and* PLANE, *Chemistry.* PREREQUISITE: Ch-106(C).

Ch-108(C) INTERMEDIATE INORGANIC CHEMISTRY (3-4). An intensive treatment at an intermediate level of the chemistry of the common ions in aqueous solution. The course will supplement general chemistry and will emphasize facility in the use of the concepts of equilibria, kinetics and structure in correlating the chemistry of the more familiar elements. TEXT: CLIFFORD, *Inorganic Chemistry of Qualitative Analysis.* PREREQUISITE: Ch-107(C).

Ch-121(B) GENERAL AND PETROLEUM CHEMISTRY (4-2). A terminal course combining selected topics in general inorganic chemistry with the elementary chemistry of fuels and lubricants. The laboratory illustrates principles common to both fields. TEXTS: HILDEBRAND, *Principles of Chemistry;* POPOVICH *and* HERING, *Fuels and Lubricants.* PREREQUISITE: None.

Ch-150(A) INORGANIC CHEMISTRY, ADVANCED (4-3). Applications of thermodynamics, chemical kinetics, and reaction mechanisms to inorganic systems. Structures of inorganic species. Aqueous solution chemistry of selected elements. A systematic approach to the chemistry of the halogens is studied in the laboratory. TEXT: HESLOP *and* ROBINSON, *Inorganic Chemistry.* PREREQUISITE: Ch-108(C), Ch-231(C), and Ch-444(B); or permission of the instructor.

Ch-231(C) QUANTITATIVE ANALYSIS (2-4). A study of the principles and calculations of quantitaive analysis, accompanied by typical volumetric and gravimetric determinations in the laboratory. TEXT: PIERCE *and* HAENISCH, *Quantitative Analysis.* PREREQUISITE: Ch-107(C) or equivalent.

Ch-302(C) ORGANIC CHEMISTRY (4-2). A brief study of organic substances and their reactions, accompanied by the preparation of typical organic compounds. TEXT: BREWSTER, *Organic Chemistry—A Brief Course.* PREREQUISITE: Ch-107(C) or equivalent.

Ch-311(C) ORGANIC CHEMISTY (3-2). The first half of a course in organic chemistry, consisting of the study of the properties and reactions of organic compounds. The laboratory work illustrates typical organic reactions. TEXT: BREWSTER, *Organic Chemistry — A Brief Course.* PREREQUISITE: Ch-107(C) or equivalent.

Ch-312(C) ORGANIC CHEMISTRY (3-2). A continuation of Ch-311(C). Organic synthetic methods are emphasized in the laboratory. TEXT: BREWSTER, *Organic Chemistry—A Brief Course.* PREREQUISITE: Ch-311(C).

Ch-322(A) ORGANIC CHEMISTRY, ADVANCED (3-2). A more detailed consideration of reactions used in organic syntheses, with particular attention to reaction mechanisms. TEXT: To be assigned. PREPREQUISITE: Ch-302(C) or Ch-312(C).

Ch-323(A) THE CHEMISTRY OF HIGH POLYMERS (3-0). A treatment of the principal classes of natural and synthetic high polymers, including preparation, structure and properties. TEXT: GOLDING, *Polymers and Resins.* PREREQUISITE: Ch-302 (C) or Ch-312(C).

Ch-324(A) QUALITATIVE ORGANIC ANALYSIS (2-4). Identification of organic compounds on the basis of physical properties, solubility, classification reactions and the preparation of derivatives. TEXT: SHRINER *and* FUSON, *Identification of Organic Compounds.* PREREQUISITE: Ch-302 (C) or Ch-312(C).

Ch-403(B) PHYSICAL CHEMISTRY (3-2). A terminal course in physical chemistry for selected groups. Gases, liquids, chemical thermodynamics, thermochemistry, chemical equilibria, and chemical kinetics. Laboratory experiments illustrate principles discussed in the lectures. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and* others, *Experimental Physical Chemistry.* PREREQUISITES: Ch-103(C) or Ch-107(C) or equivalent.

Ch-405(B) PHYSICAL CHEMISTRY (4-2). A short course in physical chemistry including such topics as properties of matter, thermochemistry, chemical equilibria, chemical kinetics, electrochemistry. Laboratory experiments illustrate the principles discussed in the lectures. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and* others, *Experimental* Physical Chemistry. PREREQUISITE: Ch-103(C) or Ch-107(C).

Ch-407(A) PHYSICAL CHEMISTRY (3-2). A one-term course in physical chemistry for students who have had thermodynamics. Gases, liquids, solids, solutions, thermochemistry, chemical equilibria, and chemical kinetics are studied. Laboratory experiments illustrate principles discussed in the lectures. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and* others, *Experimental Physical Chemistry.* PREREQUISITES: Ch-107(C) and one term of Thermodynamics.

Ch-443(C) PHYSICAL CHEMISTRY I (4-3). The first term of a two-term course in physical chemistry. To include such topics as properties of matter, thermochemistry, chemical thermodynamics, chemical equilibria. Laboratory experiments illustrate the principles discussed in lecture. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and* others, *Experimental Physical Chemistry.* PREREQUISITE: Ch-107 (C) and one term of Thermodynamics.

Ch-444(B) PHYSICAL CHEMISTRY II (3-3). A continuation of Ch-443(C). Chemical kinetics, electrochemistry, and related topics. Laboratory experiments will support and supplement the material covered in the lecture. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and* others, *Experimental Physical Chemistry.* PREREQUISITE: Ch-443(C).

Ch-452(A) PHYSICAL CHEMISTRY, ADVANCED (3-0). Selected advanced topics in physical chemistry such as: atomic and molecular structure; chemical kinetics, physical chemistry of electrolytes. TEXT: To be assigned. PREREQUISITE: Ch-444(B).

Ch-454(B) INSTRUMENTAL METHODS OF ANALYSIS (3-3). A course designed to familiarize the student with modern instrumental techniques of chemical analysis. Emphasis is given to the theoretical basis of the various kinds of measurements made in the laboratory and the principles involved in the design and construction of analytical instruments. Laboratory experiments will deal with representative analytical problems. TEXT: WILLARD, MERRITT *and* DEAN, *Instrumental Methods of Analysis.* PREREQUISite: Ch-444(B).

Ch-456(A) CHEMICAL APPLICATIONS OF INFRARED SPECTROSCOPY (2-0). Infrared spectroscopy presented as a laboratory tool for the study of chemical bonding and for solving problems arising in chemical research. Lectures will deal with elementary theory of molecular spectra, optics and performance of infrared spectrometers, techniques of sample preparation, and measurement and interpretation of infrared spectra. A laboratory problem will involve obtaining the infrared spectrum of some substance. TEXT: To be assigned. PREREQUISITE: Physical Chemistry.

Ch-458(A) STRUCTURE OF MOLECULES (3-0). A survey of experimental methods of determining the geometry and structure of molecules. Infrared methods will not be included. TEXT: WHEATLEY, *The Determination of Molecular Structure.* PREREQUISITE: Ch-444(B).

Ch-460(A) NATURE OF THE CHEMICAL BOND (3-0). A study of concepts involved in chemical bonding including energetics and the correlation of bond properties to permit qualitative prediction of structure and reactivity. TEXTS: PAULING, *Nature of the Chemical Bond;* COULSON, *Valence.* PREREQUISITE: Ch-444(B).

Ch-462(A) QUANTUM MECHANICS IN CHEMISTRY (3-0). The application of quantum mechanics to chemical problems. Study of modern theory of the electronic structure of atoms and molecules in their stationary states. TEXT: PAULING *and* WILSON, *Introduction to Quantum Mechanics.* PREREQUISITE: Ch-444(B).

Ch-464(A) ELECTROCHEMISTRY (3-0). A detailed treatment of modern electrochemistry and the structure of solutions. TEXT: ROBINSON *and* STOKES, *Electrolyte Solutions, 2nd Ed.* PREREQUISITE: Ch-444(B).

Ch-466(A) CHEMICAL KINETICS (3-0). Experimental methods and interpretation of data. Mechanisms of reactions. Collision theory and activated-complex theory. TEXT: FROST *and* PEARSON, *Kinetics and Mechanism.* PREREQUISITE: Ch-444(B).

Ch-470(A) CHEMICAL THERMODYNAMICS (3-0). Application of thermodynamics to real gases, non-electrolytes, electrolytic solutions, multicomponent systems. Calculation of equilibria, estimation of thermodynamic quantities and brief discussion of calculations of thermodynamic properties from spectroscopic and other molecular data. TEXT: LEWIS *and* RANDALL, *Thermodynamics, 2nd Ed.* PREREQUISITE: Ch.E-611(B).

Ch-551(A) RADIOCHEMISTRY (2-4). Discussion on important aspects of radioactivity from standpoint of the chemical transformations which accompany it and which it may induce; techniques for measurement and study of ionizing radiation; methods of separation of unstable nuclides, identification and assay. TEXT: FRIEDLANDER *and* KENNEDY, *Nuclear and Radiochemistry.* PREREQUISITE: Ch-107(C), Ph-642(B), Ph-643(B).

Ch-552(A) RADIOCHEMISTRY (3-4). A discussion of chemical properties and behaviors of unstable elements. Topics considered are the formation and decay schemes of the more important unstable nuclides, methods of isolation and purification and analysis of mixtures; exchange reactions; reactions that take place in consequence of nuclear reactions. TEXTS: FRIEDLANDER *and* KENNEDY, *Nuclear and Radiochemistry;* BRUCE *and* others, *Process Chemistry.* PREREQUISITE: Ch-551(A).

Ch-555(A) RADIOCHEMISTRY (2-3). An advanced course in radiochemical techniques and applications offered to well qualified students only. Experiments in analysis of complex mixtures of active nuclides; activation analysis. Consent of curricula office and the instructor required. PREREQUISITE: Ch-551(A).

Ch-580(A) ELECTROCHEMISTRY (3-2). Basic principles of electrochemistry. Electrolytic solutions, half-cell reactions, practical aspects of primary and secondary cells. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* VINAL, *Storage Batteries;* GARRETT, *Batteries of Today.* PREREQUISITE: Physical Chemistry.

Ch-800(A) CHEMISTRY SEMINAR. This course involves library investigations of assigned topics; reports on articles in the current technical journals, and reports on thesis work in progress.

CHEMICAL ENGINEERING

Ch.E-111(B) FUEL AND OIL CHEMISTRY (2-2). A study of fuels and lubricants from an engineering aspect. Topics discussed include combustion and lubrication theory, properties of fuels and lubricants and occurrence and refining of petroleum. Laboratory work consists of fuel and lubricant testing and the analysis of gaseous combustion products. TEXTS: POPOVICH *and* HERING, *Fuels and Lubricants.* PREREQUISITE: Ch-103(C) or Ch-107(C).

Ch.E-112(A) FUELS, COMBUSTION, HIGH ENERGY FUELS (3-2). A brief survey of the organic and physical chemistry necessary for a study of the problems associated with fuels. The nature of conventional fuels and of high-energy fuels, their limitations, and possible future developments; methods of reaction rate control. TEXTS: POPOVICH *and* HERING, *Fuels and Lubricants;* PENNER, *Chemical Probleme in Jet Propulsion.* PREREQUISITE: Physical Chemistry.

Ch.E-113(A) PROPELLENTS AND FUELS (3-2). This course deals with special topics and problems of current interest in rocket propellents, liquid fuels and nuclear fuels as related to propulsion. TEXTS: Assigned reading in current journals. PREREQUISITE: Ch.E-542(A).

Ch.E-521(A) PLASTICS (3-2). A study of the general nature of plastics, their applications and limitations as engineering materials; and correlation between properties and chemical structure. In the laboratory, plastics are made, molded, tested and identified. TEXTS: KINNEY, *Engineering Properties and Applications of Plastics.* PREREQUISITE: Ch-103(C) or Ch-107(C).

Ch.E-552(A) PLASTICS AND HIGH POLYMERS (3-2). A study of the nature of plastics and high polymers. Emphasis is placed on the correlation between properties and chemical structure; applications and limitations as engineering materials. The laboratory exercises consist of the preparation of typical plastics, molding experiments, a study of their physical properties and identification tests. TEXT: KINNEY, *Engineering Properties and Applications of Plastics.* PREREQUISITES: Organic Chemistry.

Ch.E-542(A) REACTION MOTORS (3-2). A study of the fundamentals of rocket motors. The subject matter includes the basic mechanics of jet propulsion engines, properties of solid and liquid propellents, the design and performance parameters of rocket motors. In the laboratory periods representative problems are solved. TEXT: SUTTON, *Rocket Propulsion Elements.* PREREQUISITE: Ch.E-611(B) or equivalent.

Ch.E-543(A) ROCKET PROPELLANTS (2-0). A study of solid and liquid rocket propellents and their ballistic, chemical and physical properties. TEXT: To be assigned. PREREQUISITE: Ch.E-542(A).

Ch.E-544(A) ROCKET MOTOR LABORATORY (0-3). Laboratory work in reaction motors illustrating and applying principles that were presented in Ch.E-542. Experiments include the static firing of rocket motors and the analysis of the data, combustion and burning rate studies on propellents, evaluation of propellent characteristics, the formulation of small amounts of solid propellents. TEXT: Instructor's notes. PREREQUISITE: Ch.E-542(A).

Ch-571(A) EXPLOSIVES (3-2). Modes of behavior and principles of use of explosive substances as related to their chemical and physical properties; underlying principles of explosives testing and evaluation. Trends in new developments are surveyed. Independent exploratory work is encouraged in the laboratory in such areas as manner of initiation, sensitivity, brisance, power, heats of explosion and combustion. PREREQUISITES: One term each of Thermodynamics and Physical Chemistry.

Ch.E-591(A) BLAST AND SHOCK EFFECTS (3-0). Nature of explosions, progapation of shock waves in air, scaling laws for damage from explosions, thermal radiation and incendiary effects; ionizing radiation effects; principles of protection of personnel against damage. TEXT: KINNEY, *Explosive Shocks in Air.* PREREQUISITES: Physical Chemistry and Thermodynamics.

Ch.E-592(A) BLAST AND SHOCK EFFECTS LABORATORY (0-3). Laboratory work illustrating and applying the principles that were presented in Ch.E-491. TEXT: Instructor's notes. PREREQUISITE: Ch.E-591(A).

Ch.E-611(B) GENERAL THERMODYNAMICS (3-2). A treatment of the laws of thermodynamics with emphasis on the development and use of the thermodynamic state functions. Applications are made to simple systems but the course is intended to provide a foundation for succeeding specialized courses. TEXTS: ZEMANSKY, *Heat and Thermodynamics, 4th Ed.,* KIEFER, KINNEY *and* STUART, *The Principles of Engineering Thermodynamics.* PREREQUISITE: Ch-107(C) or Ch-103(C).

Ch.E-614(A) ENGINEERING THERMODYNAMICS (3-2). Thermodynamic properties of non-ideal gases. The subject matter includes the application of the laws of thermodynamics to non-ideal gases, and the construction and use of thermodynamic diagrams. In the laboratory period, thermodynamic diagrams of gas mixtures of interest in ordnance or propulsion are constructed. TEXTS: WEBER *and* MEISSNER, *Thermodynamics for Chemical Engineers;* KIEFER, KINNEY *and* STUART, *The Principles of Engineering* Thermodynamics. PREREQUISITE: Ch.E-611(B).

Ch.E-624(A) ENGINEERING THERMODYNAMICS (3-2). The subject matter includes a thermodynamic analysis of different types of flow and shock front behavior. In the laboratory period representative flow problems are solved and a flow chart for the adiabatic shock in the flow of an ideal gas is constructed. TEXTS: WEBER *and* MEISSNER, *Thermodynamics for Chemical Engineers;* KIEFER, KINNEY *and* STUART, *The Principles of Engineering Thermodynamics.* PREREQUISITE: Ch.E-611(B).

Ch.E-625(A). HIGH TEMPERATURE THERMODYNAMICS (2-2). Thermodynamics of materials at high temperatures; the effect of chemical dissociation. Numerical computations form an integral part of the course. TEXT: PENNER, *Chemical Problems in Jet Propulsion.* PREREQUISITE: Ch.E-611(B).

Ch.E-632(A) CHEMICAL ENGINEERING THERMODYNAMICS (3-2). A course in the fundamentals of engineering thermodynamics to supply the minimum background requisite for subsequent courses in reaction motors, explosives and interior ballistics. TEXTS: WEBER *and* MEISSNER, *Thermodynamics for Chemical Engineers;* KIEFER, KINNEY *and* STUART, *The Principles of Engineering Thermodynamics.* PREREQUISITE: Ch.E-611(B).

Ch.E-711(B) CHEMICAL ENGINEERING CALCULATIONS (3-2). Engineering problems involving mass and energy relations in chemical and physical-chemical processes of special interest to naval officers. TEXT: HOUGEN, WATSON *and* RAGATZ, *Chemical Process Principles, Part I.* PREREQUISITE: Ch-107(C) or Ch-103(C).

Ch.E-721(B) 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. TEXT: BADGER *and* BANCHERO, *Introduction to Chemical Engineering.* PREREQUISITE: Physical Chemistry.

Ch.E-722(B) UNIT OPERATIONS (3-2). A continuation of Ch.E-721(B). TEXT: BADGER *and* BANCHERO, *Introduction to Chemical Engineering.* PREREQUISITE Ch.E-721 (B).

Ch.E-741(A) HEAT TRANSFER (3-2). The fundamentals of heat transfer by conduction, convection, and radiation, and their application to problems in ordnance. In the laboratory periods problems illustrating these principles are solved. TEXTS: SCHENCK, *Heat Transfer Engineering;* MCADAMS, *Heat Transmission.* PREREQUISITE: Ch.E-721(B).

Ch.E-750(A) ADVANCED CHEMICAL ENGINEERING (3-0). Special topics of interest in unit processes and unit operations. TEXT: To be assigned. PREREQUISITE: Ch.E-722(B).

COMMUNICATIONS ENGINEERING

Co-221(C) COMMUNICATIONS PLANNING I (3-2). A study of the functions and facilities of naval communications, preparation of communications-electronics plans both of a general nature and pertaining to the various specialized types of naval operations. TEXTS: Classified Naval Publications.

Co-222(C) COMMUNICATIONS PLANNING II (3-2). A continuation of Co-221(C). TEXTS: Classified Naval Publications. PREREQUISITE: Co-221(C).

Co-230(C) NAVAL COMMUNICATION ANALYSIS (3-0). A brief summary of general principles, organization and methods of communications in the Naval Establishment followed by instruction in the application of operations analysis to administration and to operational communications. TEXTS: Classified Naval Publications.

CRYSTALLOGRAPHY

Cr-271(B) CRYSTALLOGRAPHY AND X-RAY TECHNIQUES (3-2). The essential concepts of crystallography, the stereographic projection, modern x-ray diffraction and radiographic apparatus and techniques, the theory of x-ray diffraction, high temperature diffraction techniques. The laboratory work includes a study of crystal models for symmetry, forms, and combinations; the construction of sterographic projections; and actual practice in making and interpreting of x-ray diffraction photographs. TEXTS: BUERGER, *Elementary Crystallography;* AZAROFF *and* BUERGER, *The Powder Method.* PREREQUISITE: Ch-107(C).

Cr-301(B) CRYSTALLOGRAPHY AND MINERALOGY (3-4). Designed primarily for the student who will continue with courses in mineralogy, geology, and petrology. The student is introduced to the fundamental concepts of crystallography, the stereographic projection, the theory of x-ray diffraction, and the application of x-ray powder methods as applied to identification of minerals. The laboratory work includes a study of crystal models, construction of stereographic projections, and determination of minerals by x-ray powder diffraction patterns. TEXTS: ROGERS *Introduction to the Study of Minerals.* PREREQUISITE: Ch-107(C).

Cr-311(B) CRYSTALLOGRAPHY AND MINERALOGY (3-2). Subject matter similar to Cr-301, but designed for students who will continue with courses in chemistry. TEXT: ROGERS, *Introduction to the Study of Minerals.* PREREQUISITE: Ch-107(C).

ELECTRICAL ENGINEERING

EE-021(C) DIRECT CURRENT CIRCUITS AND MACHINERY (5-3). A basic presentation of direct-current circuits, direct-current machines and applications. Topics include: electric and magnetic fields; general circuit theory; basic measurements and metering; direct-current machinery. Laboratory work illustrates the basic theory and applications. TEXT: DAWES, *Electrica lEngineering, Vol. I, 4th Edition.* PREREQUISITES: PH-013(C) and Ma-053(C).

EE-022(C) ALTERNATING-CURRENT CIRCUITS AND MACHINERY (5-3). A basic presentation of alternating-current circuits and alternating-current machinery. Topics include: single-phase series and parallel circuits; resonance; vector representation; coupled circuits; balanced polyphase circuits; and an introduction to servomechanisms. TEXT: DAWES, *Electrical Engineering, Vol. II, 4th Edition.* PREREQUISITE: EE-021(C).

EE-101(C) BASIC ELECTRICAL PHENOMENA (3-0). The first of a series of four courses designed to present the fundamentals of fields and circuits as a necessary background for courses in control and guidance. An introduction to the theory of electric and magnetic fields presented in a unified manner which satisfies the prerequisites for circuits and machinery. TEXT: KRAUS, *Electromagnetics.* PREREQUISITES: Vector Analysis and Ordinary Differential Equations.

EE-102(C) BASIC CIRCUIT ANALYSIS (3-2). An extension of EE-101(C). The circuit concept is developed by the complete analysis of simple circuits. Steady-state analysis is continued for more complex circuits, and the phasor concept with ac forcing functions is introduced. Poly-loop and Polyphase circuits are analyzed and basic network theorems are presented. TEXT: VAN VALKENBURG, *Network Analysis.* PREREQUISITE: EE-101(C).

EE-103(B) CIRCUIT ANALYSIS (3-4). A continuation of EE-102(C). A general coverage of steady-state circuit analysis applicable to any problem in electrical engineering is completed. A detailed analysis of the general network is begun by considering circuits with two energy storage elements. The theory of the electronic analog computer is presented. Representative problems are solved with the computer in the laboratory. TEXT: VAN VALKENBURG, *Network Analysis;* Instructor's Notes. PREREQUISITE: EE-102(C).

EE-104(B) CIRCUIT ANALYSIS (3-2). A coordinated continuation of EE-101, EE-102 and EE-103 which stresses the universal character of electric circuits. The mathematics of circuit analysis is developed and additional network theorrems are introduced, along with concepts of transient impedance and transfer functions. Mechanical and electromechanical circuits are analyzed and electro-mechanical analogs developed. TEXTS: VAN VALKENBURG, *Network Analysis;* Instructor' Notes. PREREQUISITE: EE-103(B).

EE-111(C) BASIC ELECTRICAL PHENOMENA (3-4). An introduction to the theory of electric and magnetic fields is presented as a foundation for the study of circuits and machinery. Emphasis is placed upon the physical nature of basic circuit elements and upon the principles of energy transfer and conversion through electric and magnetic fields. Circuit theory is introduced. Laboratory exercises are coordinated with the lectures. TEXTS: CLEMENT *and* JOHNSON, *Electrical Engineering Science;* CORCORAN *and* REED, *Introductory Electrical Engineering* or KRAUS, *Electromagnetics.* PREREQUISITE: Differential and Integral Calculus and Elementary Physics.

EE-112(C) CIRCUIT ANALYSIS I (3-4). Solutions of elementary circuits with emphasis on Laplace transform methods; poles and zeros. Steady-state analysis of circuits having sinusoidal excitations are considered in detail. The phasor concept is used to analyze single and multi-loop networks. Network theorems, Fourier series, and balanced polyphase circuits are discussed. The laboratory work illustrates the basic principles and introduces the student to the measurement of voltage, current, power, resistance, inductance, capacitance, and other electrical quantities. TEXTS: CLEMENT *and* JOHNSON, *Electrical Engineering Science;* VAN VALKENBURG, *Network Analysis.* PREREQUISITE: EE-111(C).

EE-113(B) CIRCUIT ANALYSIS II (3-2). Analysis of polyphase circuits with balanced and unbalanced loading. Power and energy measurements in polyphase circuits. Analysis of polyphase circuits with unbalanced voltages using symmetrical components. Fault currents and voltages determined by the application of sequences networks. TEXTS: KERCHNER *and* CORCORAN, *Alternating Currents, 3rd Ed.;* STEVENSON, *Power System Analysis.* PREREQUISITE: EE-112(C).

EE-114(B) LINEAR SYSTEMS ANALYSIS (3-4). The basic theory of circuit analysis is continued with a thorough study of transient phenomena in linear electrical systems. The concepts of network impedance, admittance, and transfer functions are developed. Methods of analysis in the frequency and time domain are compared. Mechanical and electromchanical systems are studied. Laboratory work is designed to illustrate the principles developed in the classroom by measurement of the response of actual systems and the simulation of these systems on the analog computer. TEXTS: GARDNER *and* BARNES, *Transients in Linear Systems;* VAN VALKENBURG, *Network Analysis;* WHEELER, *Basic Theory of the Electronic Analog Computer.* PREREQUISITE: EE-112(C), Complex Variable Theory.

EE-115(B) TRANSMISSION LINES AND NETWORK SYNTHESIS (3-4). Circuit theory is extended to the analysis of systems with distributed parameters. The basic theory of impedence matching with networks and stubs is studied. Modern network synthesis is introduced, considering the driving point synthesis of two-element networks and fundamental design of filter or two-port networks. Laboratory work illustrates these principles. TEXTS: WARE *and* REED, *Communication Circuits;* VAN VALKENBERG, *Modern Network Synthesis.* PREREQUISITE: EE-114(B).

EE-116(A) ADVANCED CIRCUIT ANALYSIS. (3-2). Selected topics in circuit analysis. Network topology, analysis of circuits by use of matrix methods and additional topics chosen from the following partial list: Replacement of circuits by signal-flow graphs, advanced theorems of Laplace transformation theory, difference equations, Fourier integral, potential analog, analysis of time-varying linear systems, analysis of linear noisy networks and analysis of networks with random power signals. TEXTS: SESHU *and* BALABANIAN, *Linear Networks Analysis;* Instructor's Notes and Current Literature. PREREQUISITE: EE-114(B).

EE-118(A) NETWORK SYNTHESIS (3-2). An introduction to the design of electrical networks by modern methods. Single and multiport networks are considered. Both the realization and the approximation problems are discussed. TEXTS: TUTTLE, *Network Synthesis, Vol. I;* VAN VALKENBURG, *Modern Network Synthesis.* PREREQUISITE: EE-116(A).

EE-121(B) NONLINEAR MAGNETIC DEVICES (3-3). An introduction is presented to the use of the saturable reactor as a nonlinear circuit element. Pulse, storage, counting circuits as used in data processing and digital computer technology, as well as power modulation applications are considered. Piecewise linear analysis techniques are used to develop the theory of magnetic amplifiers. The transfer function of the amplifier with and without feedback is derived. Laboratory work illustrates the theory and develops practical circuits. TEXTS: KATZ, *Solid State Magnetic and Dielectric Devices;* STORM, *Magnetic Amplifiers;* Instructor's Notes. PREREQUISITES: EE-112(C) and EE-311(B) or EE-321(C).

EE-122(A) DESIGN OF NONLINEAR MAGNETIC DEVICS (3-3). Applications of push-pull or balanced magnetic amplifiers are considered. The three phase amplifier, pulse width modulators and amplifiers with reactive loads are analyzed. Design considerations of ampliers, pulse and TSR circuits are introduced. Z-transform methods are applied to magnetic amplifiers. Laboratory work includes the design of practical nonlinear magnetic devices and circuits. TEXTS: KATZ, *Solid State Magnetic and Dielectric Devices;* GEYGER, *Magnetic Amplifier Circuits;* STORM, *Magnetic Amplifiers;* PREREQUISITE: EE-121(B).

EE-131(C) ELECTRICAL MEASUREMENTS (2-3). An introduction to the measurement of the fundamental quantities; current, voltage, capacitance, inductance and magnetic properties of materials. Alternating current bridges, their components and accessories; measurement of circuit components at various frequencies; theory of errors and treatment of data. TEXT: FRANK, *Electrical Measurement Analysis.* PREREQUISITE: EE-112(C).

EE-141(A) ELECTRICAL MEASUREMENT OF NON-ELECTRICAL QUANTITIES (3-3). The measurement of pressure, speed, acceleration, vibration, strain, heat, sound, light, time, displacement and other non-electrical quantities by electrical means. Consideration of special measurement problems encountered in development of missiles and missile guidance systems. TEXT: KINNARD, *Applied Electrical Measurements.* PREREQUISITES: EE-321(C) or EE-312(B).

EE-211(C) ELECTRIC MACHINERY I (3-4). A study of electromagnetically coupled circuits, fixed or in relative motion. The principles common to translational and rotational electromechanical energy conversion devices are presented. These principles are applied to transformers and rotating machinery in the steady state and dynamic modes. Laboratory experiments illustrate principles and applications. TEXT: FITZGERALD *and* KINGSLEY, *Electric Machinery, 2nd Edition.* PREREQUISITE: EE-112(C) or equivalent.

EE-212(C) ELECTRIC MACHINERY II (3-4). A continuation of electric machine study. Types studied are synchronous and asynchronous motors and generators, direct current motors and generators and ac and dc control machines. Basic principles and applications are illustrated by laboratory experiments. TEXT: FITZGERALD *and* KINGSLEY, *Electric Machinery, 2nd Edition.* PREREQUISITE: EE-211(C).

EE-215(A) MARINE ELECTRICAL DESIGN (2-4). A first course in the design and analysis of an electrical system and its components. Concurrently with the synchronous generator design, synchronous machine transients and stability are studied leading to the analysis of the designed alternator. Protective devices are studied and specified. Study of types of distribution systems is begun. TEXTS: KIMBARK, *Power Systems Stability* (Vols. I, II, II); STEVENSON, *Power System Analysis;* FITZGERALD *and* KINGSLEY, *Electric Machinery;* STILL *and* SISKIND, *Elements of Electrical Machine Design.* PREREQUISITE: EE-212(C).

EE-216(A) MARINE ELECTRICAL DESIGN (2-4). A continuation of EE-215(A). Determination of type of distribution. Design and analysis of distribution transformer. Effects of unbalanced loading on the system and the method of calculation. Study and calculation of faults leading to feeder and branch circuit protection. Thermal considerations on overloads. TEXTS: Same as for EE-215(A). PREREQUISITE: EE-215(A).

EE-217(A) MARINE ELECTRICAL DESIGN (2-4). A continuation of EE-216(A). Design and analysis of an induction machine. Motor starting considerations and calculations. Analysis of motor-generator combinations. Stability studies. Effects of unbalanced voltages on induction motors and their associated loads. TEXTS: Same as for EE-215(A). PREREQUISITE: EE-216(A).

EE-218(A) MARINE ELECTRICAL DESIGN(2-4). A continuation of EE-217(A). Requirements of secondary power systems. Design and analysis of a dc machine. Specifications for electrical equipment. Additional protective devices based on considerations of the distribution system. Switching time considerations. Generalized approach. TEXTS: Same as listed for EE-215(A). PREREQUISITE: EE-217(A).

EE-221(C) SPECIAL MACHINERY (3-4). The basic theory and operating characteristics of control machines under steady state and transient conditions. Power and audio frequency transformers, synchros, induction motors, conventional dc motors, dc generators, and rotary amplifiers (amplidyne type generators) are covered in sufficient detail to develop the concepts required in control applications. Transfer functions are derived for these machines and laboratory exercises illustrate applications. TEXTS: SKILLING, *A First Course in Electromechanics;* FITZGERALD *and* KINGSLEY, *Electric Machinery, 1st Edition.* PREREQUISITE: EE-112 (C) or equivalent.

EE-231(C) SPECIAL MACHINERY (3-2). The basic theory and operating characteristics of the principal control machines are covered in as much detail as the limited time permits. Laboratory exercises illustrate applications. This course is not recommended for those curricula in which somewhat more than the minimum prerequisite for the introductory courses in feedback control systems is desired. TEXT: SKILLING, *A First Course in Electromechanics.* PREREQUISITE: EE-112(C) or equivalent.

EE-311(B) APPLIED ELECTRONICS I (3-2). Theory of electron tubes and transistors for those curricula requiring more extensive coverage. Topics included are: charge motion in vacuum, gases and solids under the influence of electric and magnetic fields, thermionic emission, gaseous discharge phenomena, principles and characteristics of diodes, transistors, vacuum and gaseous multielectrode tubes. Basic circuit applications and laboratory exercises supplement the theory. TEXTS: GRAY, *Applied Electronics, 2nd Edition;* HURLEY, *Junction Transistor Electronics.* PREREQUISITE: EE-112(C).

EE-312(B) APPLIED ELECTRONICS II (3-2). A continuation of EE-311(B) extending the theory to circuit applications of electron devices. Topics include: class A, B and C amplifiers, tuned amplifiers, feedback amplifiers and oscillators. Modulation techniques and nonlinear circuits are introduced as a preparation for a study of data transmission systems. Laboratory exercises supplement the theory. TEXTS: GRAY, *Applied Electronics, 2nd Edition;* HURLEY, *Junction Transistor Electronics.* PREREQUISITE: EE-311(B).

EE-313(A) 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, dc voltage, control, motor speed and generator voltage control systems. Laboratory exercises and projects supplement the theory. TEXTS: GRAY, *Applied Electronics, 2nd Edition;* MILLMAN *and* TAUB, *Pulse and Digital Circuits.* PREREQUISITES: EE-312(B) and EE-114(B) (may be taken concurrently).

EE-321(C) ENGINEERING ELECTRONICS (3-4). Introduction to theory and practice of engineering electronics. Topics include: charge motion in vacuum, gases and solids under the influence of electric and magnetic fields. Tube and transistor principles and characteristics are treated integrally. Circuit applications include single phase rectifiers, controlled rectifiers, broad band and narrow band amplifiers, feedback and operational ampliers. Laboratory work supplements the theory. TEXTS: RYDER, *Electronic Fundamentals and Applications, 2nd Edition.* PREREQUISITE: EE-112(C).

EE-323(B) ELECTRONICS OF CONTROL AND MEASUREMENT (3-3). Analysis of electronic circuits used in electrical measurement, data transmission and control. Topics include: Vacuum tube voltmeters, dc amplifiers, switching and pulse shaping circuits, frequency and time measurement, feedback systems as applied to motor speed and generator voltage control. Laboratory exercises supplement the theory. TEXTS: RYDER, *Electronic Fundamentals and Applications, 2nd Edition;* MILLMAN *and* TAUB, *Pulse and Digital Circuits.* PREREQUISITE: EE-231(C).

EE-331(C) INTRODUCTION TO ELECTRONICS (3-2). Introduction to theory and practice of engineering electronics. Topics include: conductivity in vacuum, gas and solids. Tube and transistor characteristics. Basic circuits and operational theory of rectifiers, amplifiers and oscillators. Theory of transistors and tubes is integrated. Laboratory work supplements the theory. TEXT: RYDER, *Electronic Fundamentals and Applications, 2nd Edition.* PREREQUISITE: EE-112(C).

EE-341(C) POWER ELECTRONICS (3-2). Theory and application of various types of electron tubes is covered with particular emphasis on the Thyratron. Principles of electronic circuitry as applied to control. Application in naval devices is stressed. The laboratory work demonstrates the theory. TEXT: CORCORAN *and* PRICE, *Electronics.* PREREQUISITE: EE-112(C).

EE-411(B) FEEDBACK CONTROL SYSTEMS (3-3). The mathematical theory of linear feedback control systems is discussed in detail. Topics include basic system equations, time and frequency domain relationships, methods for improving performance, damping, differentiation and integration and their relationship to phase concepts, polar and logarithmic plots, design calculations and analysis by the root locus method. Problems and laboratory exercises illustrate the theory. TEXTS: THALER *and* BROWN, *Analysis and Design of Feedback Control Systems, 2nd Edition;* NIXON, *Principles of Automatic Controls.* PREREQUISITES: EE-114(B), EE-321(C) and EE-231(C) or equivalent.

EE-412(A) NONLINEAR FEEDBACK CONTROL SYSTEMS (3-3). A detailed study of phase plane methods and describing function methods. Application of these methods in the analysis and design of nonlinear feedback control systems with emphasis on relay applications. TEXT: THALER *and* PASTEL, *Analysis and Design of Nonlinear Feedback Control Systems.* PREREQUISITE: EE-411(B).

EE-413(A) ADVANCED LINEAR FEEDBACK CONTROL THEORY (3-3). This course includes the following topics: system analysis in the time domain; pole-zero, and root locations, and their interpretation in terms of system performance; root loci and their uses; correlation between the time domain and the frequency domain; methods for computing the transient response from the frequency response. TEXT: THALER *and* BROWN, *Analysis and Design of Feedback Control Systems, 2nd Edition.* PREREQUISITES: EE-114(B) and EE-411(B).

EE-414(A) SAMPLED DATA FEEDBACK CONTROL SYSTEMS (3-2). A study of the response of servo systems to discontinuous information. The effect of location of the sampler and of the rate of sampling. Z-transformation theory. Data smoothing and prediction. Application of phase plane techniques. TEXT: TOU, *Digital and Sampled Data Control Systems.* PREREQUISITES: EE-412(A) and EE-413(A).

EE-415(A) LINEAR AND NONLINEAR FEEDBACK CONTROL COMPENSATION THEORY (3-2). Extension of normal compensation methods to multiple loop servos. Nonlinear compensation for otherwise linear servos. Linear and nonlinear servos. TEXT: Departmental Notes: PREREQUISITE: EE-412(A) and EE-413(A).

EE-416(A) SURVEY OF FEEDBACK CONTROL LITERATURE (1-0). An analysis of current developments in feedback control systems, as disclosed by papers in current technical journals. This course is intended only for candidates for the Doctor's Degree. TEXT: None. PREREQUISITES: EE-114(B) and EE-411(B).

EE-421(B) TRANSIENTS AND FEEDBACK CONTROL SYSTEMS (3-4). Transient analysis of electrical circuits by Laplace transform methods. Differential equations are developed for feedback control systems. Analysis of these systems is made by both time domain and frequency domain methods. The transfer function concept is used. The laboratory work illustrates the principles by measurement of the response of both actual circuits and systems and their simulation on the analog computer. TEXTS: VAN VALKENBURG, *Network Analysis;* WHEELER, *Basic Theory of the Electronic Analog Computer;* THALER *and* BROWN, *Analysis and Design of Feedback Control Systems, 2nd Ed.* PREREQUISITES: EE-231(C), Ma-280(B), EE-331(C) or equivalent.

EE-422(B) NUCLEAR REACTOR INSTRUMENTATION AND CONTROL (3-3). The basic principles and methods of nuclear reactor control are presented. The treatment of the elementary reactor with temperature and poisoning feedback is given using linear feedback control system analysis. The requirements for stable operation and accuracy of automatic neutron flux control are analyzed and demonstrated using a reactor kinetics simulator. TEXTS: SCHULTZ, *Control of Nuclear Reactors and Power Plants, 2nd Edition;* GLASSTONE, *Principles of Nuclear Reactor Engineering.* PREREQUISITES: EE-421(B) or the equivalent.

EE-423(A) NUCLEAR REACTOR POWER PLANT CONTROL (3-4). This course is a continuation of EE-422(B). The elementary thermodynamics of the plant control loop is established and the transfer functions obtained. The dynamic performance of the basic plant is analyzed under various load conditions. Automatic plant control stability and performance using external reactor control systems are investigated. TEXTS: SCHULTZ, *Control of Nuclear Reactors and Power Plants, 2nd Edition;* GLASSTONE, *Principles of Nuclear Reactor Engineering.* PREREQUISITE: EE-422(B).

EE-431(B) ELECTRIC MACHINES AND SERVOS (3-4). Elements of synchros. The two phase induction motor, operating characteristics and transfer functions. Dynamic performance of dc motors and generators. Elements of servomechanism theory. Nyquist stability criteria, correlation between transient response and frequency response. Steady state performance. Applications using electrical machines. TEXTS: THALER, *Elements of Servomechanism Theory;* SKILLING, *A First Course in Electromechanics.* PREREQUISITES: EE-103(B) or equivalent.

EE-500(A) SEMINAR (1-0). In the seminar sessions papers on research and development in the field of electrical sciences are presented to the more advanced group of students. Some appreciation for research methods is developed. In these sessions papers treating of student research in progress and matters of major importance in electrical egineering are presented by the faculty and by the students pursuing an advanced engineering curriculum. TEXT: None. PREREQUISITE: A background of advanced work in electrical engineering.

ELECTRONICS

Es-111(C) FUNDAMENTALS OF ELECTRIC CIRCUITS I (4-4). This course is the first of a sequence on electric circuit theory. The major topics are: basic concepts of electrostatic and magnetic fields; Definition of the fundamental electric circuit parameters from the field point of view; relationship between Kirchoff's law and field principles; response of R, L, and C and simple networks to singularity functions; introduction of complex quantities and the phasor solution for steady state AC excitation; power and energy relationships in networks. TEXTS: SEARS *and* ZEMANSKY, *University Physics;* SKILLING, *Electrical Engineering Circuits.* PREREQUISITE: Mathematics through calculus.

Es-112(C) FUNDAMENTALS OF ELECTRIC CIRCUITS II (4-3). A continuation of linear passive, bilateral network theory from Es-111. The major topics are: resonance and Q relationships in series, parallel, series-parallel circuits; important network theorems such as superposition, reciprocity, Thevenin's, Norton's, and maximum power transfer; loop and nodal solution of networks by use of determinants and matrices; driving point, transfer and hybrid parameters of two-port networks; magnetically coupled circuits, untuned and tuned audio and radio frequency circuits; Fourier Series analysis of periodic waveforms; introductory principles on solution of integrodifferential equations of electric circuits with introduction to s plane concept. TEXTS: SKILLING, *Electrical Engineering Circuits;* LEY, LUTZ *and* REHBERG, *Linear Circuit Analysis.* PREREQUISITE: Es-111(C), Note 1.

Es-113(C) TRANSFORM CIRCUIT THEORY (4-2). A continuation of Es-112. The complete response, both transient and steady-state, of electrical circuits is obtained with emphasis on non-periodic excitation. The topics include: Fourier Integral methods for solutions of network response and spectral analysis; Laplace transform method of solution of linear network differential equations with evaluation of the complex inversion integral both by the use of contour integration and transform tables; applications of the Laplace transform to transient studies in electrical networks with illustrations in mechanical and electromechanical networks. TEXT: LEY, LUTZ *and* Rehberg, *Linear Circuit Analysis.* PREREQUISITE: Es-112(C), Note 1.

Es-121(A) CIRCUIT SYNTHESIS I (3-2). Network synthesis is introduced and studied. The following topics are treated: Properties of positive real functions, properties of driving point and transfer functions, Hurwitz polynominals, even and odd functions, Sturm's Theorem, realizability, synthesis of LC, RL, RC, and RLC networks, ladder development of transfer functions, normalization and approximation. TEXTS: GUILLEMIN, *Synthesis of Passive Networks;* TRUXAL, *Control System Synthesis;* VAN VALKENBERG, *Modern Network Synthesis.* PREREQUISITES: Note 1.

Es-122(A) CIRCUIT SYNTHESIS II (3-2). A continuation of Es-121(A). Topics studied are: parts of network functions, series and parallel realization, lattice networks, Butterworth and Chebyshev polynomial approximations, double terminated networks, image parameter methods, filter design. TEXTS: GUILLEMIN, *Synthesis of Passive Networks;* VAN VALKENBERG, *Modern Network Synthesis.* PREREQUISITE: Es-121(A).

Es-129(B) TRANSFORMS AND TRANSIENTS (3-2). The objective of this course is to provide a rigorous foundation in the analysis of linear electric circuits. The topics are: Fourier transforms, Laplace transforms, use of contour integration for evaluation of inversion integrals, description of transient behavior in time and frequency domains. TEXT: ASELTINE, *Transform Methods in Linear System Analysis.* PREREQUISITE: DC and AC circuit theory, differential equations, previous or concurrent registration in complex variables.

Es-140(C) ELECTRONICS I (NUCLEAR) (3-3). This is the first of a series of courses designed to give the Nuclear Engineering student an appreciation of electronic equipment used in this science. The first course takes the student through the analysis of network circuits and introduces elementary transient concepts, theory of vacuum and semiconductor diodes, and elementary two-terminal pair networks. TEXTS: SKILLING, *Electrical Engineering Circuits;* RYDER, *Electronic Fundamentals and Applications, 2nd Edition.* PREREQUISITES: Mathematics through calculus.

Es-211(C) PHYSICAL ELECTRONICS (4-2). A study of the internal physical behavior of vacuum, gaseous and semiconductor electron devices. A consideration of underlying physical principles, including the fundamental particles of matter, conductors, insulators, and semiconductors, and semiconductors, and charge-carrier motion in vacuum and in

Note 1: Prerequisites for this course are the Basic Curriculum courses preceding this course, or the equivalent.

solids is followed by the study of the basic properties of vacuum diodes, gas-filled tubes, semiconductor diodes, photoelectric devices, control-type vacuum tubes and transistors. TEXTS: MILLMAN, *Vacuum Tube and Semiconductor Electronics.* PREREQUISITES: Note 1.

Es212(C) ELECTRONIC CIRCUITS I (4-3). A study of electronic devices as circuit elements. Consideration is given to the control-type vacuum tube as a linear amplifier, the transistor as a linear amplifier, untuned cascaded small-signal amplifiers and untuned power amplifiers. TEXTS: MILLMAN, *Vacuum Tube and Semicondictor Electronics.* PREREQUISITES: Note 1.

Es-213(C) ELECTRONIC CIRCUITS II (4-3). A continuation of Es-212(C). The circuits studied include electronic power supplies, feedback amplifiers, wide-band and pulse amplifiers, tuned voltage and power amplifiers and oscillators. TEXTS: MILLMAN, *Vacuum Tube and Semiconductor Electronics;* RYDER, *Electronic Fundamentals and Applications.* PREREQUISITES: Note 1.

Es-214(C) ELECTRONIC CIRCUITS III (4-3). The following topics are studied: amplitude modulation, a-m detection, frequency conversion, frequency modulation, and noise generation by electron devices. TEXTS: RIDEOUT, *Active Networks;* RYDER, *Electronic Fundamentals and Applications.* PREREQUISITES: Note 1.

Es-215(C) ELECTRON DEVICES (4-2). The study of switching, timing, and pulse circuits with tubes and transistors occupies the first part of the course. Following this is a study of microwave tubes and u.h.f. effects in conventional tubes. Where pertinent, descriptions of new electron devices with applications are included. TEXTS: PETTIT, *Electronic Switching, Timing and Pulse Circuits;* REICH, *Microwave Principles.* PREREQUISITES: Note 1.

Es-216(B) TRANSMITTERS AND RECEIVERS (3-6). The objective of this course is to give the student the opportunity to coordinate his previous theoretical background in the synthesis of increasingly complex electronic systems. The course is concerned expressly with the design of radio receivers and transmitters for the medium and high-frequency range, and with the considerations which lead to a successful system. The laboratory for this course is concerned with the special circuits peculiar to transmitters and receivers, and with the development of testing procedures for evaluation of system and equipment performance characteristics. TEXTS: GRAY *and* GRAHAM, *Radio Transmitters;* TERMAN, *Radio Engineers' Handbook;* STURLEY, *Radio Receiver Design, Part I;* EITEL-MCCULLOUGH, INC., *Power Tetrodes.* PREREQUISITES: Note 1.

Es-228(A) MICROWAVE TUBES (3-2). A study of the theory and operating principles of various microwave tubes, such as: traveling wave tubes, klystrons, plasma devices, crossed-field devices. Topics to be studied will include: formation and control of electron beams, slow-wave structures, interaction between beams and waves, and coupled mode theory. TEXTS: BECK, *Space Charge Waves;* WATKINS, *Topics in Electromagnetic Theory.* PREREQUISITES: Es-612(C), and acceptance in a three year program or approval by the instructor.

Es-229(B) TRANSISTOR CIRCUITS (3-3). Following a brief review of the transistor physics and circuit analysis, the topics include: high frequency and noise models, broadband low-pass amplifiers, bandpass amplifiers, oscillators, and negative resistance devices. TEXTS: JOYCE *and* CLARK, *Transistor Circuit Analysis; Military Standardization Handbook, Selected Semiconductor Circuits; G. E. Transistor Manual.* PREREQUISITES: Note 2.

Es-230(A) FEEDBACK NETWORKS (4-0). A study of pertinent topics in modern feedback control and network theory applicable to problems in electronic system control. Resume of dynamic stability theory. Application of signal flow methods to deterministic and stochastic system models. Sample data systems and Z-transform theory. Multiports. Application of phaseplane and describing function techniques for optimum design of non-linear systems. TEXTS: SEIFERT *and* STEEG, *Control Systems Engineering.* PREREQUISITE: Note 2.

Es-240(C) ELECTRONICS II (NUCLEAR) (3-3). This course includes the common vacuum tube and transistor circuits, such as rectifiers, voltage amplifiers, and elementary feedback circuits. Special emphasis is placed on these circuits in regard to transient response, bandwidth, stability, and pulse shaping. TEXT: RYDER, *Electronic Fundamentals and Applications, 2nd Edition;* SCHULZ, *Experiments in Electronics and Communication Engineering, 2nd Edition.* PREREQUISITE: Es-140(C).

Es-241(C) ELECTRONICS I (3-2). The first term of a two-term course in fundamentals and applications of electron devices and circuits, primarily for students in curricula other than electronics. Topics studied include: electron emission, characteristics of vacuum tubes, cathode ray tubes, voltage and power amplifiers, feedback circuits. TEXTS: TERMAN, *Electronic and Radio Engineering, 4th Edition.* RYDER, *Electronic Fundamentals and Applications, 2nd Edition.* PREREQUISITE: AC Circuits.

Es-242(C) ELECTRONICS II (3-3). A continuation of Es-241(C). Principal topics include: Semiconductors and transistors, tuned amplifiers, oscillators, modulation and detection, and communication systems. TEXTS: TERMAN, *Electronic and Radio Engineering, 4th Edition;* RYDER, *Electronic Fundementals and Applications, 2nd Edition.* PREREQUISITE: Es-241(C).

Es-250(B) MATHEMATICAL METHODS IN ELECTRONIC DEVICES (4-2). A brief survey of linear circuit analysis in the time and frequency domains for Operations

Note 2: Prerequisite for this course is the Basic Curriculum, or the equivalent.

Analysis students. Topics included are: Fourier Transforms, transfer functions for electronic amplifiers and devices, principles of feedback devices and control, modulation spectra and detection, sources of electronic interference and noise. TEXT: Instructor's notes. PREREQUISITE: Second year standing.

Es-258(B) INTRODUCTION TO MICROWAVES (3-2). The objective of this course is to serve as an introduction to radar. The principle topics are: wave solutions to the transmission line equations, characteristics of lossless lines, impedance matching via Smith's Charts, lines as resonant circuit elements, common modes in waveguides and resonators, study of the internal and external characteristics of cathode ray tubes, klystrons, magnetrons, and traveling wave tubes. TEXT: REICH, *and others, Microwave Principles.* PREREQUISITE: Es-242(C).

Es-271(C) ELECTRONICS I (4-2). The first of a series of two courses designed to give the Naval Science student an introduction to the theory and principles of electronics. Appropriate laboratory demonstrations and exercises are utilized. Topics include: vacuum tubes, rectifiers, transistors, and amplifiers. TEXTS: SHEINGOLD, *Fundamentals of Radio Communication;* HILL, *Electronics in Engineering (2nd edition).* PREREQUISITE: Es-271(C).

Es-272(C) ELECTRONICS II (4-2). A continuation of Es-271(C). Topics include: oscillators, modulators, antennas, receivers, transmitters, and other pertinent Naval electronic systems. TEXTS: SHEINGOLD, *Fundamentals of Radio Communication;* HILL, *Electronics in Engineering (2nd edition).* PREREQUISITE: Es-271(C).

Es-320(A) SYSTEMS ENGINEERING (3-2). A study of the fundamental principles underlying the modern practice of systems engineering. Detailed study of several engineering "cases" illustrating integrated practice. Salient characteristics of various typical components: servos, computers, communication links, airframes, propulsion units; from the point of view of the system analyst or designer. Resume of feedback and stability theory. Fundamental philosophy of system analysis. Formulation of system performance indices. System optimization methods; component improvement, logical design, filtering and signal processing. Statistical formulation of the system optimization problem. Simulation and partial system test. Reliability engineering and field performance monitoring. TEXT: GOODE *and* MACHOL, *System Engineering.* PREREQUISITE: Ma-322(A), Note 2.

Es-321(B) THEORY OF RADAR (3-3). A study of the fundamental principles of pulsed radar. The principal topics are: the theory of operation of radar timing circuits, indicators, modulators, transmitters, r-f systems, receivers, the radar range equation. TEXTS: RIDENOUR, *Radar System Engineering;* M.I.T. RADAR SCHOOL STAFF, *Principles of Radar (Third Edition).* PREREQUISITE: Note 2.

Es-322(B) RADAR SYSTEM ENGINEERING (3-3). A study of the fundamental principles and design considerations for all types of radar. The principal topics are: FM radar, pulse doppler radar, mono-pulse radar, moving target indication, data presentation, track while scan systems. TEXTS: RIDENOUR, *Radar System Engineering;* M.I.T. RADAR SCHOOL CTAFF, *Principles of Radar (Third Edition);* POVEJSIL, RAVEN *and* WATERMAN, *Airborne Radar.* PREREQUISITE: Es-321(B).

Es-328(B) ELECTRONIC COUNTERMEASURES (3-3). This is a study of radio frequency radiations, and the characteristics of devices used for detecting and interfering with these radiations. The course includes passive and active systems, spectrum analyzers, wideband video amplifiers, noise figure problems, antennas, direction-finding systems, frequency scanning and memory systems, data presentation. A term paper concerning some aspect of ECM is written during the term which is followed by an oral report to the class describing pertinent areas of the term paper. Course material is classied secret, thus requiring a secret clearance and a need to know for enrollment in the course. TEXT: SCHLESINGER, *Principles of Electronic Warfare.* PREREQUISITES: Note 2.

Es-329(B) SONAR SYSTEMS ENGINEERING (3-3). A study of sonar theory including the active and passive sonar equations, sonar tranducers, components of both active and passive sonar systems, characteristics of the systems including the transmission medium. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics;* Technical manuals and classified literature. PREREQUISITES: Ph-431(B), Note 1.

Es-330(A) AUTOMATION AND SYSTEM CONTROL (3-3). A study of basic techniques and problems encountered in large computer-centered information and control systems. Typical functional requirements for tactical data systems. Analysis of data input functions, data processing functions and data utilization functions. Laboratory work is devoted to solution of problems arising from the integration of electronic computers, radar and sonar displays, and communication equipment. Interaction between engineering design, programming and system analysis is stressed. TEXTS: GRABBE, RAMO, WOOLDRIDGE, *Handbook of Automation Computation and Control, Vol. 2*; Selected classified publications. PREREQUISITE: Note 2.

Es-331(B) GUIDANCE AND NAVIGATION (4-0). A study of the fundamental theoretical principles underlying systems of guidance and navigation. The principal topics are: radio, inertial, infra-red and celestial techniques available for guidance and navigation; fundamental limits on accuracy of the available techniques; kinematics and dynamics of radiolocation, flight, control characteristics; terrestrial and celestial references; sensors. TEXT: LOCKE, *Guidance.* PREREQUISITES: Note 2.

Es-332(B) GUIDANCE SYSTEM ENGINEERING (3-3). A study of the basic problem of integrating navigational information to achieve stable control of a given vehicle. In ad-

Note 1. Prerequisites for this course are the Basic Curriculum courses preceding this course, or the equivalent.

dition to theoretical study, representative missile guidance systems are studied and the problems of evaluation and testing are considered; including techniques of telemetering, computer simulation, test range instrumentation, and statistical evaluation of overall performance. TEXT: LOCKE, *Guidance.* PREREQUISITE: Es-331(B).

Es-336(A) SONAR SYSTEMS I (3-3). A study of the theory and engineering practices of active sonar systems. Emphasis is placed on the new developments in modern active sonar systems, and the trend of the future. Charcateristics and capabilities of existing active sonar systems are determined in the laboratory. TEXTS: Instructor's Notes; Equipment Instruction Books; Current Literature. PREREQUISITE: Ph-432(A); Ph-461(A), Note 2.

Es-337(A) SONAR SYSTEMS II (2-3). A study of the theory and engineering practices of passive sonar systems. Emphasis is placed on the new developments in modern passive sonar systems, and the trend of the future. Characteristics and capabilities of existing passive sonar systems are determined in the laboratory, and by a search of current research and engineering literature. TEXTS: Instructor's notes; Equipment Instruction Books; Current Literatrue. PREREQUISITE: Es-336(A).

Es-347(B) MISSILE GUIDANCE (3-3). A study of the fundamental principles of missile guidance systems. The principal topics are: radio, inertial, infra-red and celestial techniques available for guidance, reference systems, testing, and range instrumentation. TEXTS: LOCKE, *Guidance;* Classified reports. PREREQUISITES: Es-352(B), Es-540(B).

Es-351(B) PULSE TECHNIQUES AND RADAR FUNDAMENTALS (3-3). A study of clipping, differentiating, and integrating circuits, clamping, coupling circuits, relaxation oscillators, pulse amplifiers, transistor pulse techniques, and fundamental principles of radar. TEXTS: M.I.T. RADAR SCHOOL STAFF, *Principles of Radar (3rd Edition);* PETTIT, *Electronic Switching, Timing, and Pulse Circuits;* POVEJSIL, RAVEN, *and* WATERMAN, *Airborne Radar.* PREREQUISITE: Es-258(B).

Es-352(B) RADAR SYSTEMS (3-3). A continuation of Es-351(B). The course content includes a study of search, fire-control, and radar guidance systems with particular emphasis on pulse, FM, doppler and mono-pulse systems. TEXTS: M.I.T. RADAR SCHOOL STAFF, *Principles of Radar (3 Edition);* POVEJSIL, RAVEN *and* WATERMAN, *Airborne Radar;* RIDENOUR, *Radar System Engineering.* PREREQUISITE: Es-351(B).

Es-407(A) DETECTION THEORY (4-0). A study of the technical literature pertaining to the application of statistical decision theory to the problem of the detection of signals in noise. Recent developments in various fields of communication system engineering will be emphasized. TEXT: None. PREREQUISITES: Graduate standing and consent of instructor.

Es-408(A) SIGNAL PROCESSING METHODS (3-0). A study of the literature pertaining to signal processing techniques. Independent projects and student research will be encouraged. TEXT: None. PREREQUISITE: Es-407(A).

Es-410(B) COMMUNICATION THEORY (4-0). This course considers the characteristics of noise, noise handling concepts, periodic signals, random signals, stationary and ergodic random processes, correlation function, signal spectra, sampling theory, transmission of signals through linear systems, impulse response of linear transmission systems, and signal matching. The elements of information theory, including information measure, channel capacity, and coding concepts are also considered. TEXTS: Chapters 1, 5-6, SCHWARTZ, *Information Transmission, Modulation and Noise;* Chapters 6 and 7, MASON-ZIMMERMANN, *Electronic Circuits, Signals and Systems.* PREREQUISITE: Note 2.

Es-419(C) ELECTRONIC COMPUTERS (3-3). Basic principles of digital, analog, and incremental computers. Fundamentals of digital computer programming. Machine language, assembly language and compiler language. Elements of numerical analysis, Boolean algebra, logical design. Principles of system simulation. TEXT: LEDLEY, *Digital Computers and Control Engineering.* PREREQUISITES: Note 1.

Es-420(A) OPTIMUM COMMUNICATION SYSTEMS (3-2). Optimization criteria and considerations in circuits and systems subjected to signal inputs having stochastic components. Optimum linear and non-linear data processing operators for both continuous and sampled data systems. Signal detection criteria are compared, and standard engineering methods are evaluated and compared with optimum techniques. Laboratory exercises will include analog and digital computer simulation of problems of current scientific interest. TEXT: BAGHDADY, *Lectures on Communication System Analysis.* PREREQUISITES: Ma-322(A), Note 2.

Es-421(B) MODERN COMMUNICATIONS I (3-3). A statistical comparative study of information content and signal to noise properties of frequency, phase, amplitude, modulation, pulse modulation, coding, and single-sideband. Additional topics are: double-sideband and synchronous detection, FSK, Kineplex, and multiplexing. Emphasis will be placed upon system compatibility of the transmitter, medium, and receiver in the communication link. TEXTS: Chapter, 8, MASON-ZIMMERMANN, *Electronic Circuits, Signals and Systems;* NICHOLS *and* RAUCH, *Radio Telemetry.* PREREQUISITES: Note 2.

Es-422(B) MODERN COMMUNICATIONS II (3-3). A continuation of Es-421(B). Topics include: Facsimile, television, noise modulation systems, correlation and matched filter techniques, low noise detectors, space communication, and other communications topics of current interest. TEXT: Instructor's notes; Equipment Manuals, Research and Development Documents. PREREQUISITE: Es-421(B).

Es-430(A) INFORMATION NETWORKS (3-2). Adaptations of symbolic logic for the analysis of binary information networks using relays, vacuum-tubes, transistors, or magnetic cores. Abstract models for switching networks. Combinational and sequential circuits. Logical design of arithemetic and control elements. Dynamic simulation. Transfer function synthesis. Frequency domain treatment of analog and digital computer programs. TEXT: LEDLEY, *Digital Computers and Control Engineering.* PREREQUISITES: Note 2.

Es-439(A) DATA PROCESSING METHODS (3-2). A study of the characteristics of modern large scale electronic computing systems. Problem analysis, programming, and data handling procedures useful in the application of computers to system control. TEXT: RALSTON-WILF, *Mathematical Methods for Digital Computers.* PREREQUISITES: Note 2.

Es-450(A) STATISTICAL COMMUNICATION THEORY (4-0). Stochastic descriptions of signals and noise in both time and frequency domains, sampling theorems, vector representations, correlation functions and power spectra, information measure, channel capacity, and coding. Classical detection and introduction to optimum detection methods. TEXT: Instructor's notes. PREREQUISITE: Ma-307(A).

Es-510(C) ELECTRONIC MEASUREMENTS (3-6). A treatment of the principles and techniques of measurement over the entire frequency band, using lumped, transmission line and waveguide components. The areas considered are: measurement of frequency, power, phase, and impedance by means of lines, bridges, and resonance methods. The laboratory allows the student to acquire an ability to analyze new problems, and to plan and implement a method of solution. TEXTS: TERMAN *and* PETTIT, *Electronic Measurements;* HARTSHORN, *Radio Frequency Measurements.* PREREQUISITES: Note 1.

Es-520(B) AERO INSTRUMENTATION (3-2). A study of the instrumentation problem as encountered in modern high-performance aircraft. The performance characteristics and accuracy of conventional cockpit instruments such as airspeed indicators, barometric altimeters, rate-of-climb indicators, and basic gyro instrumentation are covered, as well as many advanced systems such as landing systems, ILS, GCA, Tacan, Omnirange, etc. The emphasis is toward pilot-oriented instrumentation rather than fully automatic data transducers. TEXT: SANDRETTO, *Electronic Aviation Engineering.* PREREQUISITE: Es-332(B).

Es-540(B) RADIO TELEMETERING AND SIMULATION (3-3). A study of radio telemetry theory and techniques including the consideration of time and frequency division multiplexing, pulse modulation techniques, transducers, data recording devices, analog and digital computation, and simulation of the tactical problem. TEXTS: LOCKE, *Guidance;* NICHOLS *and* RAUCH, *Radio Telemetry.* PREREQUISITES: Es-351(B).

Note 2: Prerequisite for this course is the Basic Curriculum, or the equivalent.

Es-611(C) INTRODUCTION TO DISTRIBUTED CONSTANT NETWORKS (4-3). The objective of this course is to introduce the distributed constant network and its relationship to the general iterative lumped constant network. The topics are: solution of the transmission line as an example of the wave equation; transient and steady state behavior of the transmission line; the circle diagrams and their usage; matching and impedance measurement; the lumped constant iterative transmission line equivalent; general iterative networks; constant k, m-derived filters; matching half-sections. TEXT: JOHNSON, *Transmission Lines and Networks.* PREREQUISITES: Note 1.

Es-612(C) INTRODUCTION TO ELECTROMAGNETICS (4-0). An introduction to the concepts utilized in electromagnetic theory. The material covered includes vector analysis, field theorems, the electrostatic field, dielectric materials, electric current, the magnetic field, Maxwell's hypothesis, plane waves, radiation, antennas, wave guides, and resonators. TEXT: SKILLING, *Fundamentals of Electric Waves (Second Edition).* PREREQUISITES: Note 2.

Es-620(B) THEORY OF ANTENNAS (3-3). This course is intended to make the student familiar with the more common types of antennas and feed systems. The attack is essentially an engineering approach, applying to practical systems. the mathematics and field theory presented in earlier courses. The laboratory is directed to the measurement of field intensities, antenna patterns, input impedance and feed systems. TEXT: KRAUS, *Antennas.* PREREQUISITES: Note 2.

Es-621(B) ELECTROMAGNETICS I (5-0). Phasor notation; generalized coordinates; rectangular, cylindrical, and spherical harmonics; Bessel functions; Maxwell's equation for time varying fields; displacement current density; retarded potentials; circuit concepts from fields; impedance; skin effect; Poynting's theorem, propagation of plane waves; phase velocity and Snell's law, pseudo-Brewster angle; waves in imperfect media; guided waves. TEXT: RAMO *and* WHINNERY, *Fields and Waves in Modern Radio (Second Edition).* PREREQUISITES: Note 2.

Es-622(A) ELECTROMAGNETICS II (4-0). A continuation of Es-621(B). TEM, TE, TM waves; rectangular and cylindrical wave guides; miscellaneous guiding systems; resonant cavities;fields from dipole antenna; gain; induced EMF method; pseudo-Maxwell's equations; parabolic reflector; slot antennas; horns, biconical antenna; driving point impedance of cylindrical antenna; receiving atenna. TEXT: RAMO *and* WHINNERY, *Fields and Waves in Modern Radio (Second Edition).* PREREQUISITE: Es-621(B).

Es-627(A) ANTENNA SYSTEMS THEORY (3-2). A discussion of the relationship of the antenna to the utilization of the antenna-derived information in the communication system. Topics described include: Application of communication theory to antenna design; "optimum" antennas. Data

Note 1. Prerequisites for this course are the Basic Curriculum courses preceding this course, or the equivalent.

processing antennas with particular reference to radio astronomy and airborne synthetic arrays. Antenna pattern synthesis using computer logic and time modulated antenna patterns. TEXT: Instructor's notes. PREREQUISITES: Es-620 (B), Note 2.

Es-628(B) INTRODUCTION TO DISTRIBUTED CONSTANTS CIRCUITS (4-3). The course treats distributed circuits in general. Starting with development of the wave equation properties and behavior of smooth lines are developed for steady statae and transient conditions. Also treated are principles and design of constant k, m-derived filter networks. Characteristic impedance, input impedance, surge impedance, iterative impedance, impedance matching, and propagation constants are studied. Graphical as well as mathematical solutions of the transmission line are developed and their use explored. TEXT: BROMWELL *and* BEAM, *Theory and Applications of Microwaves;* EVERITT *and* ANNER, *Communication Engineering, 3rd Edition.* PREREQUISITE: Mathematics through calculus, Basic electric circuit theory.

Es-629(B) AIRBORNE ANTENNAS AND PROPAGATION (3-3). The antenna topics are: stub antennas, L's, arrays, lenses, slots, flush mounts, driven structures, radomes, reflectors, frequency independent antennas, and others. Propagation topics include: effects of relative motion, doppler, scatter, polarization, etc.; ionospheric and atmospheric effects for space vehicle to earth links; effects of flames and hypersonic induced discontinuities; modeling and testing procedures. TEXTS: KRAUS, *Antennas;* LOCKE, *Guidance.* PREREQUISITES: Note 2.

Es-630(B) THEORY OF PROPAGATION (4-0). A study of the theory and technology concerning the transmission of radio frequency energy through space. The course includes: ground wave, sky wave, and tropospheric propagation; effects of terrain and weather on path, penetration of VLF in sea water, ionospheric layers, effects of ionospheric perturbations on transmission path, atmospheric noise, prediction of usable frequencies; ducting, and humidity effects, propagation, and transmission paths making use of the moon and artificial satellites. TEXT: Instructor's Notes, Current Literature concerning propagation. PREREQUISITES: Note 2.

Es-637(A) EXTREMAL METHODS IN MICROWAVE THEORY (5-0). The solution of selected microwave boundary value problems by means of the variational approach will be considered. After initial consideration of the basic variational theory, the method will be applied to problems illustrative of both continuous and discrete calculus types. Among topics to be considered are: waveguide discontinuities, energy minimization, antennas, and very simple coding problems. Other applications, time allowing, will be considered depending upon the general interest of the class. TEXTS: COLLIN, *Field Theory of Guided Waves;* FOX, *Calculus of Variations.* PREREQUISITES: Es-611(C), Es-612(C).

Note 2: Prerequisite for this course is the Basic Curriculum, or the equivalent.

Es-638(A) 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 of microwave circuit characteristics, equivalent circuits for obstacles in waveguides, and resonant cavities as microwave circuit elements. TEXTS: MONTGOMERY, et al, *Principles of Microwave Circuits;* GINZTON, *Microwave Measurements.* PREREQUISITE: Es-612(C) and acceptance in a three year program or approval of the instructor.

Es-639(B) CONTROL OF ELECTROMAGNETIC ENVIRONMENT (4-3). This course is designed to emphasize the requirements for system performance and capability where many radiating systems are operated in close proximity. The topics include shielding, sources of radiation, system coupling, effects of coupling, ground effects, and factors influencing choice of site, etc. TEXT: Instructor's notes. PREREQUISITES: Graduate standing and consent of instructor.

Es-911(A) INFORMATION PROCESSING SEMINAR (2-2). Discussion and reports on related topics of current interest in the field of information processing. PREREQUISITES: Note 2.

Es-912(A) INFORMATION PROCESSING SEMINAR (2-2). Discussion and reports on related topics of current interest in the field of information processing. PREREQUISITES: Note 2.

Es-920(A) SYSTEMS SEMINAR (3-0). This seminar provides an opportunity to apply the techniques and methods studied in the course in system engineering and serves to integrate the student's entire program of study. Groups of students undertake the overall specification and design of an integrated weapons, ECM, navigational, or communications system, under the instructor's consultation and guidance. Emphasis is on the integration of electronic devices and evaluation of system performance. TEXTS: Selected Technical Reports and Periodicals. PREREQUISITE: Es-320(A).

GEOLOGY

Ge-101(C) PHYSICAL GEOLOGY (3-2). The study of the various geological phenomena. Topics discussed are: rock-forming minerals; igneous, sedimentary, and metamorphic rocks; weathering and erosion; stream sculpture; glaciation; surface and sub-surface waters; volcanism, dynamic processes; structural geology; and interpretation of topographic maps. The course stresses those topics of particular interest to the petroleum engineer. TEXT: GILLULY, *Principles of Geology.* PREREQUISITE: Ge-401(C).

Ge-201(B) CRYSTALLOGRAPHY AND GEOLOGY (3-0). A course directed towards the specific needs of the Nuclear Engineering groups. About half the time is spent on modern concepts of crystallography including atomic bonding, lattices, point groups, space lattices, x-ray diffraction theory and techniques, polymorphism and isomorphism. Minerals, rocks, and physical geology are then covered with special emphasis on dynamic principles and seismology. TEXTS: DANA *and* HURLBUT, *Manual of Mineralogy;* GILLULY, *Principles of Geology.* PREREQUSITES: Ph-240(C), Ph-635(B), Ch-442(C).

Ge-241(A) GEOLOGY OF PETROLEUM (2-4). Seminars and discussion on the origin, accumulation, and structures which aid in the accumulation of petroleum, its general occurrence, and distribution. This course is supplemented by reading assignments in the current petroleum and petroleum geology journals. TEXT: LALICKER, *Principles of Petroleum Geology.* PREREQUISITE: Ge-101(C).

Ge-302(C) DETERMINATIVE MINERALOGY (1-4). The lectures are designed to familiarize the student with the principles and techniques involved in determining minerals in the laboratory. The laboratory periods are spent in the determination of some fifty of the more common minerals by blowpipe, chemical, x-ray diffraction and crystallographic methods. TEXTS: LEWIS *and* HAWKINS, *Determinative Mineralogy;* DANA *and* FORD, *Textbook of Mineralogy.* PREREQUISITE: Cr-301(B) or Cr-311(B).

Ge-401(C) PETROLOGY AND PETROGRAPHY (2-3). The various igneous rock series on the basis of physical chemical theories; the characteristics, structures and textures of igneous rocks; the metamorphic rocks, mineral alteration metamorphism and the resultant rock types. The laboratory work consists of the study of the various rocks in hand specimens, and in thin sections under the petrographic microscope. The course is supplemented by trips to nearby localities. TEXTS: PIRSSON *and* KNOPF, *Rocks and Rock Minerals;* GROUT, *Petrography and Petrology.* PREREQUISITE: Cr-301(B) or Cr-311(B).

LECTURE PROGRAM

LP-101(L) NPS LECTURE PROGRAM I (0-1). A series of weekly lectures to be delivered by authorities in education and government, designed to extend the knowledge of the officer students in the fields of world politics, international affairs and economics.

L-102(L) NPS LECTURE PROGRAM II (0-1). A series of weekly lectures to be delivered by authorities in military, scientific and engineering fields associated with new developments. Topics will be chosen from fields of general interest to military students in residence at the Postgraduate School.

MATHEMATICS

Ma-010(C) BASIC ALGEBRA AND TRIGONOMETRY I (4-0). Review of arithmetic processes. The real number system. Engineering notation and the slide rule. Algebraic operations. Linear equations. Graphs. Laws of exponents. Quadratic equations; the quadratic formula. Logarithms. Definition of trigonometric functions. Solution of the right triangle. TEXT: ANDRES, MISER *and* REINGOLD, *Basic Mathematics for Engineers.* PREREQUISITE: None.

Ma-011(C) BASIC ALGEBRA AND TRIGONOMETRY II (3-0). Vectors. Exponential and logarithmic equations. Trigonometric identities. Determinants and systems of linear equations. Quadratic and higher order equations. Straight line and conic section. TEXT: ANDRES, MISER *and* REINGOLD, *Basic Mathematics for Engineers.* PREREQUISITE: Ma-010(C).

Ma-015(C) ALGEBRA AND TRIGONOMETRY REFRESHER (4-0). Review of simple algebraic processes. Slide rule. Functional notation and graphs. Trigonometric functions and their graphs. Right triangle, and vectors. Exponents, radicals and logarithms. Linear equations. Quadratic equations. Straight line. TEXT: ANDRES, MISER *and* REINGOLD, *Basic Mathematics for Engineers.* PREREQUISITES: Previous courses in college algebra and trigonometry or equivalent.

Ma-016(C) SURVEY OF ANALYTIC GEOMETRY AND ELEMENTARY CALCULUS (4-0). Concepts of function, limit, continuity. Analytic geometry of the straight line and conic sections. Elements of the differential and integral calculus with emphasis on polynomials and the simpler transcendental functions. Applications are stressed throughout. TEXT: DENBOW *and* GOEDICKE, *Foundations of Mathematics.* PREREQUISITE: Recent course in algebra and trigonometry.

Ma-017(C) ELEMENTARY CALCULUS (3-0). A continuation of Ma-016(C). Theorem of the Mean. Differentiation and integration of transcendental functions. Polar coordinates. Differentials. Applications. TEXT: GRANVILLE, SMITH *and* LONGLEY, *Elements of Differential and Integral Calculus.* PREREQUISITE: Ma-016(C) or its equivalent.

Ma-021(C) INTRODUCTION TO ALGEBRAIC TECHNIQUES (5-0). Algebraic techniques are developed from the postulates for integers. TEXT: EULENBERG *and* SUNKO, *Introducing Algebra.* PREREQUISITE: None.

Ma-022(C) CALCULUS AND FINITE MATHEMATICS I (5-0). The concept of function is introduced with polynomials and rational functions used for examples. The basic ideas of differentiation and integration are presented. Introductory concepts of set theory are considered. TEXTS: MCBRIEN, *Introductory Analysis;* KEMENY, SNELL, THOMPSON, *Introduction to Finite Mathematics.* PREREQUISITE: Ma-021 (C).

Ma-023(C) CALCULUS AND FINITE MATHEMATICS II (5-0). Basic concepts of probability and matrix theories; elementary logic; linear programming; applications in social sciences are stressed. TEXT: KEMENY, SNELL, THOMPSON, *Introduction to Finite Mathematics.* PREREQUISITE: Ma-022(C).

Ma-024(C) CALCULUS AND FINITE MATHEMATICS III (3-0). A continuation of Ma-023(C); Markov chains; linear programming; strictly and non-strictly determined games; matrix games; applications to behavioral science problems. TEXT: KEMENY, SNELL, THOMPSON, *Introduction to Finite Mathematics.* PREREQUISITE: Ma-023(C).

Ma-031(C) COLLEGE ALGEBRA AND TRIGONOMETRY (5-0). Brief review of algebraic fundamentals. Slide rule and logarithmic methods of computation. Algebra of complex numbers, quadratic equations. Systems of equations, determinants: Cramer's rule. Binomial Theorem. Mathematical induction. Trigonometric functions of the general angle. Identities. Solution of right and oblique triangles. Elements of the theory of equations. TEXT: BETTINGER, ENGLUND, *Algebra and Trigonometry.* PREREQUISITES: Previous courses in College Algebra and Trigonometry.

Ma-041(C) REVIEW OF ALGEBRA, TRIGONOMETRY, ANALYTIC GEOMETRY (5-0). Basic alegbraic operations; Trigonometric functions; equations of lines and conics; complex numbers; theory of algebraic equations; matrix notation for linear equations, matrix algebra. TEXT: ALLENDOEFER *and* OAKLEY, *Fundamentals of Freshman Mathematics.* PREREQUISITE: Previous courses in algebra, trigonometry, analytic geometry.

Ma-051(C) CALCULUS AND ANALYTIC GEOMETRY I (5-0). Fundamentals of plane analytic geometry, concepts of function, limit, continuity. The derivative and differentiation of algebraic and trigonomeric functions with applications. Derivatives of higher order. Differentials. Formal integration of elementary functions. Rolles' theorem, areas, volumes of revolution. TEXT: THOMAS, *Calculus and Analytic Geometry.* PREREQUISITE: Ma-031(C) or its equivalent.

Ma-052(C) CALCULUS AND ANALYTIC GEOMETRY II (5-0). Selected topics from plane analytic geometry. Differentiation and integration of transcendental functions. Hyperbolic functions. Parametric equations. Formal integration. Numerical integration. Improper integrals. Polar coordinates. Plane vectors. TEXT: THOMAS, *Calculus and Analytic Geometry.* PREREQUISITE: Ma-051(C).

Ma-053(C) CALCULUS AND ANALYTIC GEOMETRY III (3-0). Partial derivatives, directional derivatives, total differential. Chain rule differentiation. Multiple integration and applications. Introduction to Infinite Series. TEXT: THOMAS, *Calculus and Analytic Geometry.* PREREQUISITE:

Ma-052(C), Ma-081(B) must be taken concurrently.

Ma-061(C) REVIEW OF CALCULUS (5-0). Concept of function, limit and continuity; differentiation, integration with applications; differentiation of function of several variables, directional derivatives. TEXT: THOMAS, *Calculus and Analytic Geometry.* PREREQUISITE: Previous courses in calculus.

Ma-071(C) CALCULUS I (5-0). The calculus of functions of a single independent variable with emphasis on basic concepts. Derivatives, differentials, applications. Rolles' theorem and the mean value theorem. Definite integral with applications. Elementary transcendental functions. Topics from plane analytic geometry to be introduced as necessary. Polar coordinates. TEXT: THOMAS, *Calculus and Analytic Geometry.* PREREQUISITES: Ma-031(C) or its equivalent, and previous work in calculus.

Ma-072(C) CALCULUS II (3-0). Advanced transcendental functions including hyperbolic functions. Methods of formal integration. Numerical methods. Improper integrals. Partial derivatives, directional derivatives. Total differential. Chain rule differentiation. Multiple integrals with applications. TEXT: THOMAS, *Calculus and Analytic Geometry.* PREREQUISITES: Ma-071(C), Ma-081(B) must be taken concurrently.

Ma-073(B) DIFFERENTIAL EQUATIONS (5-0). A continuation of Ma-072(C). Series of constants; power series; Fourier series; first order ordinary differential equations; ordinary linear differential equations with constant coefficients; simultaneous solution of ordinary differential equations; series solution of ordinary differential equations, including Bessel's Equation. TEXTS: THOMAS, *Calculus and Analytic Geometry;* KAPLAN, *Advanced Calculus;* GOLOMB *and* SHANKS, *Elements of Ordinary Differential Equations.* PREREQUISITE: Ma-072(C) or Ma-061(C).

Ma-081(B) INTRODUCTION TO VECTOR ANALYSIS (2-0). Vectors and their algebra. Solid analytic geometry using vector methods. Vector equations of motion. Differentiation and integration of vector functions. Space curves, arc length, curvature. Partial derivatives, directional derivatives and the gradient. Line integrals. TEXT: THOMAS, *Calculus and Analytic Geometry.* PREREQUISITE: Ma-052(C) or Ma-071(C), Ma-053(C) or Ma-072(C) must be taken concurrently.

Ma-101(B) LINEAR ALGEBRA I (3-0). Systems of Linear Equations. Vector Spaces. Algebra of Matrices. Determinants. TEXT: STOLL, *Linear Algebra and Matrix Theory.* PREREQUISITE: Consent of Instructor.

Ma-102(B) LINEAR ALGEBRA II (3-0). Bilinear and Quadratic Forms. Linear Transformations on a Vector Space. Canonical Representations of a Linear Transformation. TEXT: STOLL, *Linear Algebra and Matrix Theory.* PREREQUISITE: Ma-101(B).

Ma-103(B) PROJECTIVE GEOMETRY (3-0). Transformations in Euclidean geometry; invariants; perspectivities; Desargue's triangle theorem; principle of duality; homogeneous coordinates of points and lines; linear combinations of points and lines; cross ratio, a projective invariant; harmonic division, properties of complete quadrangles and complete quadrilaterals; projective transformations, the projective properties. TEXTS: ADLER, *Modern Geometry;* STRUIK, *Analytic and Projective Geometry.* PREREQUISITE: Consent of Instructor.

Ma-104(A) ALGEBRAIC CURVES (3-0). An introduction to the study of algebraic geometry is given by means of a selection of topics from the theory of curves, centering around birational transformations and linear series. TEXT: WALKER, *Algebraic Curves.* PREREQUISITES: Ma-103(A) and Ma-105(A) or consent of instructor.

Ma-105(A) FUNDAMENTALS OF MODERN ALGEBRA I (3-0). Concept of group; subgroups; composition of groups; basis theorems for Abelian groups. Rings; integral domains; ideals; polynomial rings; basis theorems for rings. TEXTS: BIRKHOFF *and* MACLANE, *A Survey of Modern Algebra (Revised Edition);* MILLER, *Elements of Modern Abstract Algebra.* PREREQUISITE: Ma-102(B) or consent of instructor.

Ma-106(A) FUNDAMENTALS OF MODERN ALGEBRA II (3-0). Continuation of Ma-105(A). Fields; field extensions; algebraic numbers; agebraic integers; root fields and their Galois groups; properties of the Galois group and its sub-groups; finite fields; insolvability of the quintic polynomial. TEXTS: BIRKHOFF *and* MACLANE, *A Survey of Modern Algebra (Revised Edition);* MILLER, *Elements of Modern Abstract Algebra.* PREREQUISITE: Ma-105(A).

Ma-107(A) INTRODUCTION TO GENERAL TOPOLOGY (3-0). Review of usual topolgy in E_n fundamentals of point set topology, e.g., compactness, connectivity, homeomorphism, etc. Hausdorff, metrizable, regular spaces, and embedding theorems. Applications. TEXT: SPENCER *and* HALL, *Elementary Topology.* PREREQUISITE: Ma-109(A) or consent of instructor.

Ma-109(A) FUNDAMENTALS OF ANALYSIS I (3-0). Elements of set theory and topology in E_n; vector valued functions, differentials and Jacobians; functions of bounded variation. TEXTS: APOSTAL, *Fundamentals of Analysis;* RUDIN, *Principles of Mathematical Analysis.* PREREQUISITE: A course in differential and integral calculus.

Ma-110(A) FUNDAMENTALS OF ANALYSIS II (3-0). Theory of Reimann-Stieljes integration, multiple integrals, sequences and series of functions. TEXTS: APOSTAL, *Fundamentals of Analysis;* RUDIN, *Principles of Mathematical Analysis.* PREREQUISITE: Ma-109(A).

Ma-113(B) VECTOR ANALYSIS and PARTIAL DIFFERENTIAL EQUATIONS (4-0). Calculus of vectors; differential operators; line and surface integrals; Green's, Stokes' and divergence theorems. Separation of variables; boundary conditions; applications to heat flow. TEXTS: WYLIE, *Advanced Engineering Mathematics;* SPIEGEL, *Vector Analysis.* PREREQUISITES: Ma-120(C), Ma-240(C) and Ma-251(B).

Ma-116(A) MATRICES AND NUMERICAL METHODS (3-2). Finite differences, interpolation, numerical differentiation and integration; numerical solution of polynomial equations; numerical methods for initial value and boundary value problems involving ordinary and partial differential equations; solution of systems of linear algebraic equations; latent roots and characteristic vectors of matrices; numerical methods for inversion of matrices. TEXTS: KUNZ, *Numerical Analysis;* MILNE, *Numerical Calculus.* PREREQUISITES: Ma-113(B), or Ma-183(B), or Ma-245(A), or Ma-246(A).

Ma-120(C) VECTOR ALGEBRA AND SOLID ANALYTIC GEOMETRY (3-1). Real number system. Algebra of complex numbers. Vectors and their algebra. Analytic geometry of space; points, lines, and planes in scalar and vector notation. Determinants, matrices and linear systems; linear dependence. Special surfaces. Laboratory periods devoted to review of essential topics in trigonometry and plane analytic geometry. TEXTS SELECTED FROM: SMITH, GALE *and* NEELLEY, *New Analytic Geometry;* WEATHERBURN, *Elementary Vector Analysis;* CHURCHILL, *Introduction to Complex Variables;* USNPS Notes; BRAND, *Vector Analysis;* SPIEGEL, *Theory and Problems of Vector Analysis.* PREREQUISITE: A course in plane and analytic geometry.

Ma-125(B) NUMERICAL METHODS FOR DIGITAL COMPUTERS (2-2). Numerical solution of systems of linear algebraic equations, polynominal equations, and systems of non-linear algebraic equations; finite differences, numerical interpolation, differentiation, integration; numerical methods for solving initial value and boundary value problems involving ordinary and partial differential equations. TEXTS: KUNZ, *Numerical Analysis;* MILNE, *Numerical Calculus.* PREREQUISITE: Ma-113(B) or Ma-183(B), or Ma-245(A), or Ma-246(A).

Ma-126(B) NUMERICAL METHODS FOR DIGITAL COMPUTERS (3-2). Lagrangian polynomial approximations to real functions. Introduction to best polynomial approximations in the sense of least squares. Minimax polynominal approximations. Numerical methods for solving equations and systems of equations. Difference calculus, numerical differentiation and integration. Selected numerical methods for solving initial value and boundary value problems involving ordinary and partial differential equations. The laboratory periods include sample problems solved on hand-operated keyboard calculators; emphasis is given to methods which are useful with large scale automatic digital computers. TEXTS: MILNE, *Numerical Calculus;* KUNZ, *Numerical Analysis.* PREREQUISITE: Ma-240(C) and Ma-250(C) or equivalent.

Ma-127(B) SCIENTIFIC COMPUTATION WITH DIGITAL COMPUTERS (3-2). Numerical methods for solution of scientific and engineering problems using a high speed digital computer; reduction of problems to mathematical language and the design of programs for their solution; computer evaluation of functions; systems of linear equations and differential equations; problem solving with a digital computer being used for demonstration. TEXTS: MILNE, *Numerical Calculus:* KUNZ, *Numerical Analysis.* PREREQUISITE: Ma-073(B) or equivalent.

Ma-150(C) VECTORS AND MATRICES WITH GEOMETRIC APPLICATIONS (4-1). Real number system. Algebra of complex numbers. Vector algebra. Analytic geometry of space, points, lines and planes in scalar and vector notation. Special surfaces. Frenet-Serret formulae, directional derivative, gradient and curl. Determinants, matrices and linear systems; linear dependance. Laboratory periods devoted to review of essential topics in algebra, trigonometry and plane analytic geometry. TEXTS: SMITH, GALE, NEELLEY, *New Analytic Geometry;* BRAND, *Vector Analysis;* CHURCHILL, *Introduction to Complex Variables.* USNPS notes. PREREQUISITE: A course in plane analytic geometry and calculus. Taken concurrently with Mc-101(C) unless specially arranged otherwise.

Ma-151(C) DIFFERENTIAL EQUATIONS (4-1). Review of calculus. Partial derivatives. Polar coordinates and change of variables. Elements of differential equations; first order; linear; total; systems of linear equations. TEXTS: GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus;* GOLOMB *and* SHANKS, *Elements of Ordinary Differential Equations.* PREREQUISITE: A course in differential and integral calculus.

Ma-158(B) SELECTED TOPICS FOR AUTOMATIC CONTROL (4-0). Analytic functions. Cauchy's theorem and formula. Taylor and Laurent series, residues, contour integration, conformal mapping. The Laplace transform and its use in solving ordinary differential equations; inversion integral. Systems of linear differential equations. Stability criteria. TEXTS: CHURCHILL, *Introduction to Complex Variables and Applications;* CHURCHILL, *Modern Operational Mathematics in Engineering.* PREREQUISITES: Ma-120(C) and Ma-151(C).

Ma-170(C) CALCULUS FOR MANAGEMENT (3-0). Review of elementary calculus. Emphasis on applications to probability, statistics, and the management sciences. TEXT: COOLEY, *First Course in Calculus.* PREREQUISITE: A previous course in integral calculus.

Ma-180(C) VECTORS, MATRICES, AND VECTOR SPACES (3-1). Real number system. Algebra of complex numbers. Vector algebra. Points, lines, and planes in scalar and Vector notation. Matrices, determinants, and linear systems. Abstract vector spaces. TEXTS: CHURCHILL, *Complex Variable;* NARAYAN, *Vector Algebra;* MIRKIL, SNELL *and* THOMPSON, *Finite Mathematical Structures;* BROWNE, *Theory of Determinants and Matrices.* PREREQUISITE: Consent of instructor.

Ma-181(C) PARTIAL DERIVATIVES AND MULTIPLE INTEGRALS (4-1). Review of elementary calculus. Hyperbolic functions. Infinite series. Partial and total derivatives. Directional derivatives and gradients and their physical interpretations. Jacobians. Leibnitz's Theorem for differentiating integrals. Line integrals. Double and triple integrals. Introduction to ordinary differential equations. TEXTS: GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus;* KAPLAN, *Advanced Calculus;* COGAN, NORMAN *and* THOMPSON, *Calculus of Functions of One Argument;* Instuctor's Notes. PREREQUISITES: A course in differential and integral calculus and Ma-120(C) to be taken concurrently.

Ma-182(B) DIFFERENTIAL EQUATIONS AND VECTOR ANALYSIS (5-0). Differential equations. Series solutions of ordinary differential equations. Systems of differential equations, including matrix methods. Vector differentiation. Vector integral relations. TEXTS: KAPLAN, *Advanced Calculus;* WYLIE, *Advanced Engineering Mathematics;* SPIEGEL, *Theory and Problems of Vector Analysis.* PREREQUISITE: Ma-181(C).

Ma-183(B) FOURIER SERIES AND COMPLEX VARIABLES (4-0). Expansion of functions. Fourier series and solution of partial differential equations. Algebra of complex numbers. Analytic functions of a complex variable, and the elementary transcendental functions. Complex integration. Residues. TEXTS: CHURCHILL, *Fourier Series and Boundary Value Problems;* CHURCHILL, *Complex Variables.* PREREQUISITE: Ma-182(B).

Ma-193(A) SET THEORY AND INTEGRATION (2-0). Set theoretic concepts. Basic concepts in the theories of Riemann, Lebesgue, and Stieltjes integrals with emphasis on applications to probability theory. TEXTS: MUNROE, *Introduction to Measure and Integration.* PREREQUISITE: Ma-181(C) or the equivalent.

Ma-196(A) MATRIX THEORY (3-0). Algebra of matrices; characteristic value of matrices; Hamilton-Cayley and Sylvester's theorems; Matrix methods in the solution of systems of differential equations. TEXTS: FRAZER, DUNCAN *and* COLLAR, *Elementary Matrices;* GASS, *Linear Programming.* PREREQUISITE: Ma-120(C), or Ma-150(C), or equivalent.

Ma-230(C) CALCULUS OF SEVERAL VARIABLES (4-0). Review calculus of one variable. Differential calculus of functions of several variables, directional derivatives, gradient vectors, geometry of tangent planes to surfaces. Double and triple integration in rectangular coordinates. TEXTS: GRANVILLE, SMITH *and* LONGLEY, *Elements of Differential and Integral Calculus;* KAPLAN, *Advanced Calculus.* PREREQUISITE: A previous course in calculus and Ma-120(C), or Ma-150(C), (may be taken concurrently).

Ma-240(C) ELEMENTARY DIFFERENTIAL EQUATIONS (2-0). Elements of differential equations including basic types of first order equations and linear equations of all orders with constant coefficients. Systems of linear equations. TEXT: LEIGHTON, *Introduction to the Theory of Differential Equations.* PREREQUISITE: Ma-230(C), (may be taken concurrently).

Ma-241(C) ELEMENTARY DIFFERENTIAL EQUATIONS (3-0). A longer version of Ma-240(C) including more emphasis on first order equations. TEXT: GOLOMB *and* SHANKS, *Elements of Ordinary Differential Equations.* PREREQUISITE: Ma-230(C). (May be taken concurrently).

Ma-244(C) ELEMENTARY DIFFERENTIAL EQUATIONS AND INFINITE SERIES (4-0). A combination of Ma-250(C) and Ma-240(C) given together in this order. TEXTS: COHEN, *Differential Equations;* KAPLAN, *Advanced Calculus.* PREREQUISITE: Ma-230(C).

Ma-245(A) PARTIAL DIFFERENTIAL EQUATIONS (3-0). Solution of boundary value problems by separation of variables; Sturm-Liouville theory; Fourier Bessel series solutions. TEXTS: CHURCHILL, *Fourier Series and Boundary Value Problems.* PREREQUISITE· Ma-251(B) and Ma-240(C).

Ma-246(A) PARTIAL DIFFERENTIAL EQUATIONS (4-0). Series solution of linear differential equations, generalized orthogonal functions; solution of boundary value problems by separation of variables; Sturm-Liouville theory; Fourier Bessel series solutions. TEXT: CHURCHILL, *Fourier Series and Boundary Value Problems.* PREREQUISITE: Ma-250(B) and Ma-240(C).

Ma-247(B) DIFFERENCE EQUATIONS (3-0). Elements of difference equations. Solutions to first order difference equations. Solutions to nth order equations with constant coefficients. Series solutions to nth order equations with variable coefficients. Solutions of Recurrence formula. Relation of difference equations to continued fractions. TEXT: SAMUEL GOLDBERG, *Introduction to Difference Equations.* PREREQUISITE: Ma-182(B) or equivalent.

Ma-248(A) DIFFERENTIAL EQUATIONS FOR OPTIMUM CONTROL (3-0). Methods in differential equations for calculating differentials based on the adjoint systems of differential equation. Applications to problems in optimum control, particularly trajectories and minimum time problems. Numerical methods for determining and correcting trajectories, particularly optimum trajectories, on a digital computer. TEXT: USNPS Notes. PREREQUISITES: Ma-240(C) or equivalent, and Ma-421(A) or consent of instructor.

Ma-250(B) ELEMENTARY INFINITE SERIES (2-0). Sequences and series, convergence tests; power series, Taylor series expansions; uniform convergence; introduction to Fourier series. TEXT: KAPLAN, *Advanced Calculus.* PREREQUISITE: Ma-230(C), (may be taken concurrently).

Ma-251(B) ELEMENTARY INFINITE SERIES (3-0). A longer version of Ma-250(B) including series solution of linear differentiation equations. Bessel and Legendre functions, generalized orthogonal functions. TEXT: KAPLAN, *Advanced Calculus.* PREREQUISITE: Ma-230(C) and Ma-240(C).

Ma-260(B) VECTOR ANALYSIS (3-0). Vector differential and integral calculus including differential geometry of lines and surfaces, line and surface integrals, change of variable formulas and curvilinear coordinates. TEXT: SPIEGEL, *Theory and Problems of Vector Analysis.* PREREQUISITE: Ma-120(C) and Ma-230(C).

Ma-261(A) VECTOR MECHANICS (5-0). Line, surface and volume integrals, Green's divergence, and Stokes' theorems. Vector differential calculus, and the vector differential operators in rectangular and curvilinear coordinates. The integral theorems in vector form. The vector equations of motion. Irrotational, solenoidal and linear vector fields with applications to fluid mechanics in meteorology. Total differential equations and systems of total differential equations. TEXTS: SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics for Engineers and Physicists;* COHEN, *Differential Equations;* SPIEGEL, *Theory and Problems of Vector Analysis;* WEATHERBURN, *Advanced Vector Analysis.* PREREQUISITES: Ma-240(C) and Ma-251(B).

Ma-270(B) COMPLEX VARIABLES (3-0). Analytic functions; series expansions; integration formulas; residue theory. TEXT: CHURCHILL, *Introduction to Complex Variables.* PREREQUISITE: Ma-120(C), Ma-230(C), Ma-250(C).

Ma-271(B) COMPLEX VARIABLES (4-0). A longer version of Ma-270(B) including more emphasis on Contour integration as required for transform theory. TEXT: CHURCHILL, *Introduction to Complex Variables.* PREREQUISITES: Ma-120(C), Ma-230(C), Ma-250(C).

Ma-280(B) LAPLACE TRANSFORMATIONS (2-0). Definitions and existence conditions; applications to systems involving linear difference, differential and integral equations; inversion integral. TEXT: CHURCHILL, *Modern Operational Mathematics in Engineering.* PREREQUISITE: Ma-240(C), Ma-250(C), and Ma-270(C), (the latter may be taken concurrently).

Ma-301(C) BASIC PROBABILITY AND SET THEORY (4-0). Elements of set theory including set algebra. Foundation of probability and basic rules of computation. Sample space, random variable, and the classical distribution functions. Chebyshev's inequality and the law of large numbers. TEXT: MOSTELLER, *Probability with Statistical Applications;* PARZEN, *Modern Probability Theory and its Application.* PREREQUISITE: A course in differential and integral calculus.

Ma-302(B) SECOND COURSE IN PROBABILITY (4-0). A continuation of Ma-301(C). Central limit Theorem. Jointly distributed random variables. Moments. Probability laws of functions of random variables and generating functions. TEXT: PARZEN, *Modern Probability Theory and its Application.* PREREQUISITE: Ma-301(C) and Ma-181(C) or equivalent.

Ma-303(B) THEORY AND TECHNIQUES IN STATISTICS I (4-0). Descriptive statistics. Point estimation; principles of choice and properties of estimators; methods for calculation. Confidence intervals; applications. Texting hypotheses; concepts of power, most powerful tests; applications. TEXTS: BRUNK, *An Introduction to Mathematical Statistics;* BOWKER *and* LIEBERMAN, *Engineering Statistics.* PREREQUISITE: Ma-302(B).

Ma-304(A) THEORY AND TECHNIQUES IN STATISTICS II (3-0). A continuation of Ma-303(B). Regression and correlation; least squares. Elements of Analysis of Variance; multiple comparisons. Sequential sampling. Non-parametric procedures. TEXTS: BRUNK, *An Introduction to Mathematical Statistics;* BOWKER *and* LIEBERMAN, *Engineering Statistics.* PREREQUISITE: Ma-303(B).

Ma-305(A) DESIGN OF EXPERIMENTS (3-0). Theory of the general linear hypothesis. Planning of experiments. Analysis of variance. Components of variance. Randomized blocks and Latin squares. Factorial experiments. Analysis of covariance. Confounding. Models for determining the optimum combination of factor levels. TEXTS: DAVIES, *Design and Analysis of Industrial Experiments;* COX, *Planning of Experiments.* PREREQUISITE: Ma-304(B) or consent of instructor.

Ma-306(A) SELECTED TOPICS IN ADVANCED STATISTICS (3-0). Topic will be selected by instructor to fit the needs and background of the students. Areas of choice to include the fields of sequential analysis, non-parametric methods and multivariate analysis. The course may be repeated for credit if the topic changes. TEXT: To be announced. PREREQUISITE: Ma-304(B), or consent of instructor.

Ma-307(A) INTRODUCTION TO STOCHASTIC PROCESSES (3-0). Markov processes: discrete and continuous parameter cases. Gaussian processes. Stationary processes. Renewal processes. Applications. TEXTS: FELLER, *An Introduction to Probability Theory and Its Applications (2nd Edition);* TAKACS, *Stochastic Processes.* PREREQUISITE: Ma-304(B), or consent of instructor.

Ma-308(A) INTRODUCTION TO TIME SERIES ANALYSIS (3-0). Spectral Theory of discrete processes. Problems of inference in time series analysis. Estimation of parameters, spectral density and distribution functions. Hypothesis testing and confidence intervals. TEXT: HANNAN, *Time Series Analysis.* PREREQUISITE: Ma-304(B) or consent of Instructor.

Ma-311(B) INTRODUCTION TO PROBABILITY AND STATISTICS (4-0). Simple probability models. Sample space, random variable, discrete and continuous distribution functions. Limiting distribution. Sampling. Presentation and description of data. Elements of hypothesis testing and estimation. Applications to fields of interest of the class. TEXT: HODGES *and* LEHMANN, *Basic Concepts of Probability and Statistics.* PREREQUISITE: A course in differential and integral calculus.

Ma-321(B) PROBABILITY (4-2). Elements of set theory. Foundations of probability and basic rules of computation. Sample space, random variable, discrete and continuous distribution functions. The classical distribution functions. Joint marginal and conditional distribution functions. Limit theorems. Markov chains. Applications to fields of interest of the class. TEXT: DERMAN *and* KLEIN, *Probability and Statistical Inference for Engineers.* PREREQUISITE: Ma-230(C) or the equivalent.

Ma-322(A) STATISTICAL DECISION THEORY (3-2). The factors of the general decision problem. Utility. Bayes and minimax strategies. Relation to two-person zero-sum games. Relation to classical statistics. Application to fields of interest of the class. TEXTS: CHERNOFF *and* MOSES, *Elementary Decision Theory;* WEISS, *Statistical Decision Theory.* PREREQUISITE: Ma-321(B).

Ma-331(B) STATISTICS (5-2). Introduction to probability theory. Classical frequency functions. Treatment of observational data and fitting of empirical frequency functions. Small sampling theory. Correlation and regression methods in multivariate problems. Properties of good estimators. Statistical inference and the testing of hypotheses. Applications in the field of meteorology. TEXTS: HOEL, *Introduction to Mathematical Statistics (2nd Edition);* BEST *and* PANOFSKY, *Some Applications of Statistics to Meteorology.* PREREQUISITE: Ma-113(B) or the equivalent.

Ma-351(B) INDUSTRIAL STATISTICS I (3-2). Elements of set theory. Foundations of probability and basic rules of computation. Sample space, random variable, discrete and continuous distribution functions. The classical distribution functions. Joint, marginal and conditional distribution functions. Limit theorems. Elements of hypothesis testing and estimation. TEXTS: DERMAN *and* KLEIN, *Probability and Statistics for Engineers;* BOWKER *and* LIEBERMAN, *Engineering Statistics.* PREREQUISITE: Ma-113(B) or the equivalent.

Ma-352(B) INDUSTRIAL STATISTICS II (2-2). Tests of hypothesis and estimation. Analysis of variance. Statistical quality control, control charts. Sampling inspection by attributes and by variables, continuous sampling inspection. TEXT: BOWKER *and* LIEBERMAN, *Engineering Statistics.* PREREQUISITE: Ma-351(B).

Ma-355(A) RELIABILITY AND LIFE TESTING (3-0). Poisson processes, exponential distributions; sampling theory of order statistics, and distribution theory of extreme values with applications in systems reliability and life testing. Statistical theory of sequential and trancated testing; tests of statistical hypotheses, estimation and prediction with applications in reliability and life testing. TEXTS: FELLER, *An Introduction to Probability Theory and its Applications;* GUMBEL, *Statistics of Extremes.* Current literature in the field. PREREQUISITE: Ma-302(B) or the equivalent.

Ma-361(B) PROBABILITY AND STATISTICAL INFERENCE FOR ENGINEERS I (2-1). Basic probability theory and rules of computation. Sample space, random variables, discrete and continuous distribution functions. Elementary sampling theory. Introduction to the principles of testing hypothesis and estimation. TEXT: To be announced. PREREQUISITE: Ma-181 (C).

Ma-362(B) PROBABILITY AND STATISTICAL INFERENCE FOR ENGINEERS II (2-1). Sampling distributions. Regression and correlation. Design of experiments and analysis of variance. Acceptance sampling. TEXT: To be announced. PREREQUISITE: Ma-361 (B).

Ma-371(C) MANAGEMENT STATISTICS (3-0). Elements of probability theory. Descriptive statistics. Statistical inference as an aid to decision-making. TEXT: To be announced. PREREQUISITE: Ma-170(C), or the consent of the instructor.

Ma-381(C) ELEMENTARY PROBABILITY AND STATISTICS (4-2). Elements of the theory of probability. The classical probability distributions. Elements of statistical inference and statistical presentation. Applications in the field of the group. TEXTS: LEHMANN *and* HODGES, *Basic Concepts of Probability and Statistics;* PANOFSKY *and* BRIER, *Applications of Statistics to Meteorology* . (Meteorology groups only). PREREQUISITE: Ma-181 (C) or equivalent.

Ma-395(A) GAMES OF STRATEGY (3-2). Utility Theory. Games in normal and extensive forms. Two person zero-sum games; the minimax theorem. Relationship to linear programming. Methods of solving two person zero-sum games. Non zero-sum and cooperative games, n-person games. Applications. TEXTS: DRESHER, *Theory and Applications of Games of Strategy;* LUCE *and* RAIFA, *Games and Decisions.* PREREQUISITES: Ma-301 (C) or the equivalent.

Ma-396(A) DECISION THEORY (3-0). Basic concepts. Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluation trials. TEXTS: CHERNOFF *and* MOSES, *Elementary Decision Theory;* WALD, *Statistical Decision Functions;* TUCKER, *Introduction to Statistical Decision Functions;* (USNPS Thesis); SMITH, *Application of Statistical Methods to Naval Operational Testing* (USNPS Thesis). PREREQUISITES: Ma-304(A), Ma-193(A) and OA-391(A). (The latter may be taken concurrently.)

Ma-397(A) THEORY OF INFORMATION COMMUNICATION (3-0). Markov chains: surprisal of events and uncertainty of distributions; characterization of uncertainty; noise and rate of information transmission; limit distributions connected with sequences from an ergodic Markov chain; Shannan-Fano coding; detection. TEXTS: SHANNON *and* WEAVER, *The Mathematical Theory of Communication;* FELLER, *Probability Theory and its Applications;* FEINSTEIN, *Foundations of Information Theory;* KHINCHIN, *Mathematical Foundations of Information Theory.* PREREQUISITES: Ma-120(C) or Ma-150(C) and Ma-321 (B).

Ma-401(B) ANALOG COMPUTERS (2-2). Elementary analog devices which may be used to perform addition, multiplication, vector resolution, function generation, integration, etc. Combinations of such devices for solution of differential equations, systems of linear equations, algebraic equations, harmonic analysis, etc. Gimbal solvers. Digital differential analyzers. TEXTS: SOROKA, *Analog Methods in Computation and Simulation;* MURRAY, *Theory of Mathematical Machines;* Reprints of articles from scientific periodicals. PREREQUISITE: Ma-240(C) or equivalent.

Ma-411(B) DIGITAL COMPUTERS AND MILITARY APPLICATIONS (4-0). Description of a general purpose digital computer. Programming fundamentals. The use of subroutines, assembly routines and compilers in programming. Applications such as war gaming, simulation of systems, logistics and data processing; demonstration on a computer. TEXT: MCCRACKEN, *Digital Computer Programming.* PREREQUISITE: Ma-073(B) or equivalent.

Ma-420(L) COMPUTER OPERATION (1-1). (For 5 weeks). This is a NON-CREDIT course designed for students whose course or thesis work requires a knowledge of computer operation. In a combination of lecture and laboratory periods details of operation of computer and peripheral equipment are covered as well as input-output techniques and power-on, power-off procedures. TEXTS: Programming Manuals. PREREQUISITE: Ma-421 (B) or equivalent.

Ma-421(B) INTRODUCTION TO DIGITAL COMPUTERS (3-2). Octal and binary number systems. Fundamentals of programming for general purpose digital computers. Programming, using assembly routines and compilers. Engineering applications of digital computers. Elements of Boolean algebra with applications to information retrieval problems. A *portion* of the laboratory period is devoted to operating the computers. TEXTS: Programming Manuals; MCCRACKEN, *A Guide to Fortran Programming;* MCCRACKEN, *Digital Computer Programming.* PREREQUISITE: Ma-240(C) and Ma-250(B) or the equivalent.

Ma-423(A) ADVANCED DIGITAL COMPUTER PROGRAMMING (4-0). Theory and design of sub-routines, assembly routines and compilers. Symbol manipulation. Problem oriented language and control languages. TEXT: Selected articles from publications. PREREQUISITE: Ma-421 (B).

Ma-424(A) BOOLEAN ALGEBRA AND DIGITAL COMPUTERS (3-0). Development of Boolean Algebra and its application to problems in logic. Design of an Adder Circuit for a Digital Computer. Information retrieval and related problems. TEXT: PHISTER, *Logical Design of Digital Computers.* PREREQUISITE: Ma-421 (B).

Ma-425(A) APPLICATIONS OF DIGITAL COMPUTERS (3-2). Effective exploitation of modern digital computers in areas of system simulations and real time control, data editing and processing, engineering computations. Iterative and recursive techniques in digital computation. Efficent use of input-output equipment. The use of sub-routine and program check-out aids in program planning. Laboratory periods will be spent in programming, checking out, running and evaluating results of one or more problems in above areas. TEXTS: Selected Articles from Publications. PREREQUISITE: Ma-421 (B).

Ma-426(A) ADVANCED NUMERICAL METHODS FOR DIGITAL COMPUTERS (4-1). Representations of functions and/or data by: Chebycheff approximation, Continued Fractions, Economization of Series, Quadrature Methods and Multivariate Interpolation by least squares. Matrices and Linear Systems. Methods for Numerical Quadrature. Multiple Quadrature by Monte Carlo Methods. Numerical Solution of Differential Equations. Computer solutions to some of these problems and techniques. TEXT: RALSTON *and* WILF, *Mathematical Methods for Digital Computers;* LANCZO'S *Applied Analysis.* PREREQUISITE: Ma-116(A) and Ma-421(B).

Ma-441(B) INTRODUCTION TO DIGITAL COMPUTERS (3-0). Description of a general purpose digital computer. Command structure and commands. Flow charts and programming. Applications to problems in science, logic and data processing. TEXTS: MCCRACKEN, *Digital Computer Programming;* MCCRACKEN, *A Guide to Fortran Programming.* PREREQUISITE: Ma-071 (C) or equivalent.

Ma-471(B) ELECTRONIC DATA PROCESSING AND MANAGEMENT CONTROL (3-0). Functional description of a general purpose digital computer; its control, memory, arithmetic and input-output units. Binary number system and representation of information in a computer or on magnetic tape. Boolean Algebra and information retrieval. Use of computers to solve management problems associated with inventory control, personnel records, reports and assignment. TEXT: CANNING, *Electronic Data Processing for Business and Industry.* PREREQUISITE: Ma-371 (C).

Ma-701(B) SEMINAR IN ANALYSIS (2-0). Topics in analysis. Content of the course varies. Students will be allowed credit for taking the course more than one time. PREREQUISITE: Consent of Instructor.

Ma-711(A) INTRODUCTION TO FUNCTIONAL ANALYSIS (3-0). Fundamental notions in metric spaces and in linear spaces with an introduction to Banach and Hilbert spaces. Elementary spectral theory of compact operators with applications. TEXT: J. DIEUDONNE, *Foundations of Modern Analysis.* PREREQUISITE: Consent of Instructor.

Ma-740(A) CALCULUS OF VARIATIONS (3-0). Bliss's differential methods, adjoint differential equations, Euler equations, maximum principle. Weierstrass and Legendre conditions. Perturbation techniques, numerical procedures for determining solutions, and application to control problems. TEXTS: Selected papers and USNPS Notes. PREREQUISITES: Ma-240(C) or the equivalent and Ma-421 (B), or consent of instructor.

Ma-751(A) TENSOR ANALYSIS I (3-0). The basic concepts of differential geometry. Definition of a tensor. Physical interpretations. The metric tensor. Covariant differentiation. Geodesics. TEXTS: BURINGTON *and* TORRANCE, *Higher Mathematics;* WEATHERBURN, *Riemannian Geometry and the Tensor Calculus.* PREREQUISITES: Ma-120 (C), Ma-181 (C), Ma-182 (B) or the equivalent.

Ma-752(A) TENSOR ANALYSIS II (3-0). A continuation of Ma-751(A). Introduction to special relativity theory. Formulation of the laws of mechanics and electromagnetism in relativistic form. TEXT: BERGMANN, *Introduction to the Theory of Relativity.* PREREQUISITE: Ma-751(A) and a sound background in classical mechanics and electromagnetism.

Ma-753(A) TENSOR ANALYSIS III (3-0). A continuation of Ma-752(A). Introduction to general relativity theory. Parallel displacement and the curvature tensor. TEXT: BERGMANN, *Introduction to the Theory of Relativity.* PREREQUISITE: Ma-752(A).

MECHANICAL ENGINEERING

ME-111(C) ENGINEERING THERMODYNAMICS I (5-0). The laws and processes of transforming energy from one form to another; first law analysis; second law analysis and cycle analysis for reversible processes; transient flow; irreversible processes and available energy. Applications to ideal gas cases; internal combustion engines, gas turbines, turbojets, rockets. TEXT: FAIRES, *Thermodynamics.* PREREQUISITE: Ma-230(C).

ME-112(C) ENGINEERING THERMODYNAMICS II (5-0). Continuation of ME-111. Applications of thermodynamic principles to marine steam power plants; reversed cycles; gas-vapor mixtures; combustion with dissociation problems; general methods of handling imperfect gas problems. TEXT: FAIRES, *Thermodynamics.* PREREQUISITE: ME-111(C).

ME-122(C) ENGINEERING THERMODYNAMICS II (3-2). Continuation of ME-111. Applications of thermodynamic principles to marine power plant equipment, steam power plants and steam cycles with and without regeneration and reheating. TEXT: FAIRES, *Thermodynamics.* PREREQUISITE: ME-111(C).

ME-132(C) ENGINEERING THERMODYNAMICS II (4-2). Continuation of ME-111. Applications of thermodynamic principles to marine power plant equipment, steam power plants and steam cycles, gas mixtures. TEXT: FAIRES, *Thermodynamics.* PREREQUISITE: ME-111(C).

ME-210(C) APPLIED THERMODYNAMICS (3-2). Continuation of the application of thermodynamic principles, flow of compressible fluids, heat pumps, gas-vapor mixtures, turbine blading, elements of heat transfer. Complementary laboratory experiments. TEXT: FAIRES, *Thermodynamics.* PREREQUISITE: ME-132(C).

ME-211(B) THERMODYNAMICS OF COMPRESSIBLE FLOW (3-0). The thermodynamic and dynamic fundamentals of compressible fluid flow. One-dimensional analyses including the effects of area change, friction, and heat transfer. TEXT: SHAPIRO, *Thermodynamics and Dynamics of Compressible Fluid Flow, Vol. I.* PREREQUISITE: ME-112(C), ME-411(C), and Ma-113(B).

ME-212(A) ADVANCED THERMODYNAMICS (3-0). Imperfect gases and other advanced topics in thermodynamics; the mathematical development of property relations and their use with experimental data. TEXT: KIEFER, KINNEY *and* STUART, *Engineering Thermodynamics.* PREREQUISITE: ME-112(C), Ma-113(B).

ME-215(A) MARINE POWER PLANT ANALYSIS AND DESIGN (2-4). Preliminary planning of marine power plants. Estimation of hull, main engine and auxiliary power requirements, inter-relationship of components, heat balances and flow diagrams, computation of ship and plant performance indices. TEXTS: SEWARD, *Marine Engineering, Vols. I and II.* PREREQUISITE: ME-211(B).

ME-216(A) MARINE POWER PLANT ANALYSIS AND DESIGN (2-4). This course, in continuation of ME-215 (A), carries to completion the project work of the latter, with additional project work in preliminary investigation of main propulsion equipment and other major equipment items. TEXTS: SEWARD, *Marine Engineering, Vols. I and II;* CHURCH, *Steam Turbines, 3rd Edition.* PREREQUISITE: ME-215(A).

ME-217(B) INTERNAL COMBUSTION ENGINES (3-2). Theoretical and real-fuel cycles, combustion processes for spark-ignition and compression-ignition engines. Combustion chambers, carburetion and fuel-injection phenomena. Factors affecting engine performance and design. TEXTS: LICHTY, *Internal Combustion Engines;* TAYLOR *and* TAYLOR, *Internal Combustion Engines.* PREREQUISITE: ME-112(C).

ME-220(B) MARINE POWER PLANT ANALYSIS (2-4). Preliminary planning of marine power plants. Estimation of hull, main engine and auxiliary power requirements, inter-relationship of components, heat balances and flow diagrams, computation of ship and plant performance indices, preliminary investigation of major equipment items. TEXTS: SEWARD, *Marine Engineering, Vols. I and II;* CHURCH, *Steam Turbines, 3rd Edition.* PREREQUISITE: ME-210(C) or equivalent.

ME-221(C) GASDYNAMICS AND HEAT TRANSFER (4-2). Fundamentals of one-dimensional compressible fluid flow including effects of area change, friction, and heat addition. Fundamentals of conduction, convection, and radiation heat transfer, including heat exchanger analysis. TEXT: GIEDT, *Principles of Engineering Heat Transfer.* PREREQUISITES: ME-112(C), ME-411(C).

ME-222(C) THERMODYNAMICS LABORATORY (1-4). Laboratory experiments applying thermodynamic principles to gas turbine engine, diesel engine, refrigeration plant, air compressor, nuclear reactor, compressible flow metering and heat transfer. TEXT: FAIRES, *Thermodynamics.* PREREQUISITES: ME-112(C), ME-411(C).

ME-223(B) MARINE POWER PLANT ANALYSIS (2-4). Preliminary planning of marine power plants. Estimation of hull, main engine and auxiliary power requirements, inter-relationship of components, heat balances and flow diagrams, computation of ship and plant performance indices, preliminary investigation of major equipment items. TEXTS: SEWARD, *Marine Engineering, Vols. I and II;* CHURCH, *Steam Turbine, 3rd Edition.* PREREQUISITE: ME-221(C) or equivalent.

ME-230(B) MARINE POWER PLANT ANALYSIS (2-4). Preliminary planning of ship propulsion plants. Estimation of hull, main engine and auxiliary power requirements, inter-relationship of components, heat balances, computation of ship and plant performance indices, preliminary investigation of some major equipment items. TEXTS: SEWARD, *Marine Engineering, Vol. I and II;* CHURCH, *Steam Turbines, 3rd Edition.* PREREQUISITE: ME-211(C) or equivalent.

ME-240(B) NUCLEAR POWER PLANTS (4-0). Survey of nuclear power engineering. The reactor as a power source as affected by technical feasibility and economics. Elementary nuclear reactor physics. Engineering considerations in core design, including problems of core design, power removal and utilization and shielding. Discussion of reactor types. TEXT: STEPHENSON, *Introduction to Nuclear Engineering.* PREREQUISITES: ME-210(C) or ME-221(C); Ph-621 (B).

ME-241(A) NUCLEAR PROPULSION SYSTEMS I (4-0). The first of a two course sequence covering engineering aspects of nuclear power reactors. Reactor types, characteristics, and criteria for selection. Advanced heat transfer, fluid mechanics and thermodynamics as applied to characteristic cycles. TEXT: GLASSTONE, *Principles of Nuclear Reactor Engineering.* PREREQUISITES: ME-310(B) and Ph-652 (A).

ME-242(A) NUCLEAR PROPULSION SYSTEMS II (3-2). Reactor shielding. Elementary thermal core and plant design. Detailed study of existing reactor plants. TEXT: GLASSTONE, *Principles of Nuclear Reactor Engineering.* PREREQUISITE: ME-241(A).

ME-310(B) HEAT TRANSFER (4-2). The fundamentals of heat transfer mechanisms: one and two dimensional conduction, free and forced convection, condensation, boiling, thermal radiation, transient and periodic systems, and heat exchanger analysis. Use of the thermal circuit, analog, numerical, and graphical techniques. TEXT: KREITH, *Principles of Heat Transfer.* PREREQUISITES: ME-112(C), M-412(A), and Ma-113(B).

ME-411(C) MECHANICS OF FLUIDS (4-2). Mechanical properties of fluids, hydrostatics, buoyancy and stability analysis. Energy aspects of ideal and real fluid flow, flow metering and control. Impulse-momentum principles and analysis. Dimensional analysis and similitude. Elements of hydrodynamic lubrication. Analysis of fluid machinery and fluid systems. Laboratory experiments and problem work. TEXT: STREETER, *Fluid Mechanics*. PREREQUISITE: Ma-230(C).

ME-412(A) ADVANCED MECHANICS OF FLUIDS (4-2). Potential flow theory; use of vector notation, complex variables and conformal transformations. Navier-Stokes equations and applications for the real fluid. Elements of boundary layer theory. Elementary hydromechanics in ship design. TEXTS: STREETER, *Fluid Dynamics;* ROSSELL *and* CHAPMAN, *Principles of Naval Architecture, Vol. II*. PREREQUISITES: ME-411(C), Ma-113(B) and Ma-270(B) (may be concurrent).

ME-501(C) MECHANICS I (4-0). Laws of statics. Force systems, equilibrium, simple structures, distributed forces, friction, virtual work. Basic concepts of kinematics. TEXTS: MERIAM, *Mechanics, Part I;* YEH *and* ABRAMS, *Mechanics of Solids, Vol. I*. PREREQUISITE: Ma-120(C) (may be concurrent).

ME-502(C) MECHANICS II (4-0). Kinematics, Newton's laws, kinetics of particles. Work and energy, impulse and momentum. Inertia properties. Kinetics of rigid bodies. TEXTS: MERIAM, *Mechanics, Part II;* YEH *and* ABRAMS, *Mechanics of Solids, Vol. I*. PREREQUISITES: ME-501(C), and Ma-240(C) (may be concurrent).

ME-503(A) ADVANCED DYNAMICS (4-0). Restatement of laws of mechanics. General motion of a rigid body, gyroscopes. Celestial mechanics. Numerical procedures. Lagrange's equations. Hamilton's principle. TEXTS: YEH *and* ABRAMS, *Mechanics of Solids, Vol. I;* SYNGE *and* GRIFFITH, *Principles of Mechanics*. PREREQUISITE: ME-502(C).

ME-504(B) ADVANCED DYNAMICS (4-0). Restatement of laws of mechanics. Simple pendulum for large amplitudes, effects of earth's rotation, gyroscopes. Generalised coordinates, Lagrange's equations. Numerical procedures. TEXTS: YEH *and* ABRAMS, *Mechanics of Solids Vol. I;* TIMOSHENKO *and* YOUNG, *Advanced Dynamics*. PREREQUISITE: ME-502(C).

ME-510(C) MECHANICS OF SOLIDS I (4-2). Stress, strain, Hooke's law, tension and compression, shearing stresses, connections, thin vessels, torsion, statics of beams, stresses in beams, deflections of beams, combined loadings and combined stresses, columns. Strain energy, impact, simple indeterminate structures. Supporting laboratory work. TEXT: TIMOSHENKO *and* MACCULLOUGH, *Elements of Strength of Materials*. PREREQUISITES: Ma-230(C) and ME-501(C).

ME-511(A) MECHANICS OF SOLIDS II (5-0). Further elastic analysis of statically indeterminate structures, beam columns, curved beams, unsymmetrical bending, shear center, beams on elastic foundations, plates and shells, thick-walled cylinders, rotating discs, and elementary thermal stresses. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II*. PREREQUISITES: ME-510(C) and Ma-240(C).

ME-512(A) MECHANICS OF SOLIDS III (4-0). Stress tensor, strain tensor, theories of failure, elements of the theory of elasticity, torsion of non-circular sections, plastic behavior, brittle fracture. TEXTS: TIMOSHENKO, *Strength of Materials, Vol. II;* TIMOSHENKO *and* GOODIER, *Theory of Elasticity;* PARKER, *Brittle Behavior of Engineering Structures*. PREREQUISITES: Ma-113(B) and ME-511(A).

ME-521(C) MECHANICS OF SOLIDS II (4-0). Statically indeterminate problems in bending, symmetrical beams of variable cross section, beams of two materials, unsymmetrical bending, thick-walled cylinders, rotating disks, curved bars, beams with combined axial and lateral loads. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II*. PREREQUISITES: ME-510(C) and Ma-240(C).

ME-522(B) MECHANICS OF SOLIDS III (4-0). Stress concentration, deformations beyond the elastic limit, mechanical properties of materials, strength theories, impact, fatigue, torsion of non-circular sections, thin plates and shells. TEXT: TIMOSKENKO, *Strength of Materials, Vol. II*. PREREQUISITE: ME-521(C).

ME-547(C) STATICS AND STRENGTH OF MATERIALS (5-0). Review of principles of statics, statics of determinate structures, pin-connected trusses. Stress, strain, Hooke's law, tension and compression, shearing stresses. Connections, thin vessels, torsion. Statics of beams, flexural stresses and deformations, numerical procedures. Simple indeterminate structures. Combined loadings and combined stresses. Columns. TEXT: TIMOSHENKO *and* MACCULLOUGH, *Elements of Strength of Materials*. PREREQUISITE: Ph-151(C).

ME-548(B) STRUCTURAL THEORY (5-0). Fundamental concepts and nomenclature, graphical procedures, influence lines, plane frameworks, space frameworks, cables and suspension bridges, deflections, stress analysis of indeterminate structures, matrix methods, plastic behavior, plates and shells, buckling. TEXT: MCCORMAC, *Structural Analysis*. PREREQUISITES: ME-547(C) and Ma-240(C).

ME-561(C) MECHANICS I (4-0). Forces and force systems, moments and couples, resultants, equilibrants, free body diagrams, equilibrium of a free body, simple structures, friction, first and second moments, centroids, basic concepts of kinematics. TEXT: FAIRMAN *and* CUTSHALL, *Engineering Mechanics*. PREREQUISITE: Ma-052(C).

ME-562(C) MECHANICS II (4-0). Kinematics. Newton's laws, d'Alembert's principle, work and energy, impulse and momentum. Rocket motion. Kepler's laws. Artificial satellite of the earth. TEXT: FAIRMAN *and* CUTSHALL, *Engineering Mechanics.* PREREQUISITES: ME-561(C) and Ma-053(C).

ME-612(A) EXPERIMENTAL MECHANICS (3-2). Fundamentals of mechanical measurements, resistance strain gages, transducers and instrumentation systems, dynamic response characteristics, brittle lacquer, photoelasticity, analog methods, model theory. Complementary laboratory experiments. TEXTS: BECKWITH *and* BUCK, *Mechanical Measurements;* PERRY *and* LISSNER, *Strain Gage Primer;* LEE, *An Introduction to Experimental Stress Analysis.* PREREQUISITES: ME-512(A) and ME-712(A).

ME-622(B) EXPERIMENTAL MECHANICS (2-2). Fundamentals of mechanical measurements, resistance strain gages, transducers and instrumentation systems, dynamic response characteristics. Complementary laboratory experiments. TEXTS: BECKWITH *and* BUCK, *Mechanical Measurements;* PERRY *and* LISSNER, *Strain Gage Primer.* PREREQUISITES: ME-522(B) and ME-722(B).

ME-711(B) MECHANICS OF MACHINERY (3-2). Algebraic analysis of the motion of cam followers; design of cams. Velocities and accelerations of machine parts. Kinematics of gearing. Synthesis. Dynamic forces on machine members. TEXT: FAIRES, *Kinematics.* PREREQUISITE: ME-502(C).

ME-712(A) MECHANICAL VIBRATIONS (3-2). Undamped and damped, free and forced vibrations for one, two and many degrees of freedom. Vibration isolation and absorbers. Instrumentation. Methods of Rayleigh, Stodola, Holzer. Applications to multi-cylinder engines. Laboratory experiments illustrate basic principles of vibration and its control. TEXTS: DEN HARTOG, *Mechanical Vibrations;* THOMSON, *Mechanical Vibrations.* PREREQUISITES: Ma-280(B), ME-711(B) and ME-511(A).

ME-713(A) ADVANCED DYNAMICS OF MACHINERY (3-0). Special topics such as: shock and vibration mounts, torsional vibrations of crank shafts, vibration absorbers, special bearings gear lubrication, sleeve bearings with pulsating loads, oil film whirl, turbine blade vibration, nonlinear vibration problems. TEXTS: DEN HARTOG, *Mechanical Vibrations;* KARMAN *and* BIOT, *Mathematical Methods in Engineering.* PREREQUISITES: ME-712(A) and ME-812(B).

ME-722(B) MECHANICAL VIBRATIONS (3-2). Free and forced vibrations, with and without damping for one, two and many degrees of freedom. Vibration isolation and absorbers, torsional vibration, instrumentation. Laboratory experiments illustrate basic principles of vibration and its control. TEXTS: DEN HARTOG, *Mechanical Vibrations;* THOMSON, *Mechanical Vibrations.* PREREQUISITES: Ma-113(B), ME-711(B) and ME-521(C).

ME-811(B) MACHINE DESIGN I (3-2). First of a two-course sequence. Studies of fits, tolerances, allowances, material selection, stress concentration, bearings, shafting, screws, belts, chains, brakes, clutches and cams. TEXT: FAIRES, *Design of Machine Elements.* PREREQUISITES: ME-512(A) and ME-711(B).

ME-812(B) MACHINE DESIGN II (3-4). Continuation of ME-811; springs, gearing, and advanced design problems. Machine design projects of a comprehensive nature. TEXT: FAIRES, *Design of Machine Elements.* PREREQUISITES: ME-811(B) and ME-712(A).

ME-820(C) MACHINE DESIGN (2-3). Studies of fits, tolerances, allowances, stress concentration, material selection, bearings, gears, shafting, cams, springs, screws, brakes and clutches. TEXT: FAIRES, *Design of Machine Elements.* PREREQUISITES: ME-522(B) and ME-711(B).

ME-900(A) ADVANCED TOPICS IN MECHANICAL ENGINEERING (4-0). Investigation of selected advanced Mechanical Engineering topics. PREREQUISITE: Department approval.

ME-910(A) NAVAL ARCHITECTURE (3-0). Fundamental laws of naval architecture. Definition of hull forms and hull parameters. The elements of resistance of a ship form. The action of ship propulsion devices and the interaction of the hull, propulsion devices and appendages. Efficiencies of hulls and propulsion devices. TEXT: ROSSELL *and* CHAPMAN, *Principles of Naval Architecture, Vols. I and II.* PREREQUISITES: ME-230(B) and ME-412(A).

MECHANICS

Mc-101(C) ENGINEERING MECHANICS I (2-2). Review of statics; free-body diagrams; distributed forces; centroids; moments and products of inertia of areas; hydrostatics; friction, general principles of dynamics; dimensional analysis; kinematics of a particle; relative and absolute time rate of change of a vector; Cariolis acceleration. TEXT: HOUSNER *and* HUDSON, *Applied Mechanics;* SHAMES, *Engineering Mechanics.* PREREQUISITES: Ma-120(C) or Ma-150(C) (may be taken concurrently).

Mc-102(C) ENGINEERING MECHANICS II (2-2). Dynamics of a particle; impulse and momentum; work and energy; potential; conservation of energy; vibrating systems, free and forced, with and without damping; impact; dynamics of rigid bodies; moments and products of inertia; principal axes of inertia; the gyroscope. TEXT: HOUSNER *and* HUDSON, *Applied Mechanics;* SHAMES, *Engineering Mechanics.* PREREQUISITE: Mc-101(C).

Mc-201(A) METHODS OF DYNAMICS (2-2). The principles of linear momentum, angular momentum, work and energy, power and energy, conservation of energy, virtual work, and d'Alembert are developed and discussed in detail. This work is followed by a development and interpretation of Lagrange's equations of motion. Application of these various principles to obtain the differential equations of motion of dynamical systems is given particular attention. TEXTS: SYNGE *and* GRIFFITH, *Principles of Mechanics;* TIMOSHENKO *and* YOUNG, *Advanced Dynamics.* PREREQUISITE: Mc-102(C).

Mc-311(A) VIBRATIONS (3-2). Kinematics of vibrations; free and forced vibrations of systems with one degree of freedom; theory of vibration measuring instruments and of vibration insulation; systems with many degrees of freedom; normal modes of vibration; computation of fastest and slowest modes by matrix methods; vibrations of strings, beams, shafts and membranes; Rayleigh's method; Stodola's method; critical speeds; self-excited vibrations; effect of impact on elastic structures. TEXTS: THOMSON, *Mechanical Vibrations (2nd edition);* DEN HARTOG, *Mechanical Vibrations (3rd edition);* FRANKLAND, *Effects of Impact on Simple Elastic Structures* (TMB Report 481). PREREQUISITES: Mc-102 (C) and a course in beam deflection theory.

Mc-402(A) MECHANICS OF GYROSCOPIC INSTRUMENTS (3-0). Review of the vector kinematics and dynamics involved in the angular motion of rigid bodies; steady, free and forced precession and general motion of a gyro; stability of a free gyro; the gyrocompass and gyro pendulum; gyro angular velocity indicator; the stable platform; Shuler tuning of inertial guidance instruments. TEXTS: SYNGE *and* GRIFFITH, *Principles of Mechanics (2nd edition);* WRIGLEY, *Shuler Tuning of Navigational Instruments;* RUSSELL, *Inertial Guidance for Rocket-Propelled Missiles;* DRAPER, WRIGLEY *and* HOVORKA, *Inertial Guidance.* PREREQUISITE: Mc-102(C).

Mc-403(A) KINEMATICS OF GUIDANCE (3-0). Kinematics and geometry of guidance and interception systems; special coordinates; inertial reference frames; accelerometers; inertial guidance; Dovap; introductory study of the guidance of a ballistic missile and of an interceptor for a ballistic missile; optimum thrust programming for a rocket. TEXTS: LOCKE, *Guidance;* USNPGS Notes. PREREQUISITE: A course in differential equations and Mc-102(C).

Mc-404(A) 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 test; dynamic stability; resonance instability. TEXT: Classroom Notes. PREREQUISITE: Mc-402(A).

Mc-405(A) ORBITAL MECHANICS (3-0). Review of kinematics. Lagrange's equations of motion. The earth's gravitational field. Central force motion. The two body problem. Space orbits. The determination of orbits. The three body problem. Perturbations. TEXTS: BAKER *and* MAKEMSON, *Astrodynamics;* VINTI, *New Methods of Solution for Unretarded Satellite Orbits.* PREREQUISITE: Mc-102(C).

METALLURGY

Mt-002(C) BASIC METALLURGY (4-3). An elementary survey course in metallurgy designed for students in the Naval Science School. The subject matter includes a study of the properties and heat treatment of the commercially important metals and alloys and their engineering applications. The laboratory experiments are designed to illustrate the material taken up in class and includes microscopic examination of metal specimens in varying mechanical and heat treated conditions. TEXT: To be selected. PREREQUISITES: A course in general chemistry.

Mt-101(C) PRODUCTION METALLURGY (2-0). An introduction to the study of metallurgy including discussion of the nature of metal-bearing raw materials and the fundamental processes, materials and equipment of extractive metallurgy. TEXT: HAYWARD, *An Outline of Metallurgical Practice.* PREREQUISITE: Elementary General Chemistry (may be taken concurrently).

Mt-102(C) PRODUCTION OF STEEL (3-0). A discussion of the occurrence and composition of various iron ores, blast furnace products, the various methods of steel production, and the production of grey, white and malleable cast iron. TEXT: BRAY, *Ferrous Process Metallurgy.* PREREQUISITE: Ch-101(C) or equivalent.

Mt-103(C) PRODUCTION OF NON-FERROUS METALS (3-0). A discussion of the sources, the strategic importance of, and the methods of production of copper, zinc, lead, tin, aluminum, magnesium, and other metals of technical interest. TEXTS: BRAY, *Non-Ferrous Production Metallurgy.* PREREQUISITE: Ch-101(C) or equivalent.

Mt-104(C) PRODUCTION METALLURGY (4-0). A condensation of the material of Mt-102 and Mt-103 into a one-term course. TEXTS: BRAY, *Non-Ferrous Production Metallurgy;* BRAY, *Ferrous Process Metallurgy.* PREREQUISITE: Ch-101(C) or equivalent.

Mt-201(C) INTRODUCTORY PHYSICAL METALLURGY (3-2). An introduction to Physical Metallurgy. Topics include: (a) The nature and properties of metals, (b) a study of phase equilibria, (c) the correlation of microstructure and properties with phase diagrams, (d) mechanical properties and heat treatment, (e) descriptions of non-ferrous alloys of commercial importance. The laboratory experiments introduce methods available to the metallurgist for the study of metals and alloys. TEXTS: COONAN, *Principles of Physical Metallurgy.*

Mt-202(C) FERROUS PHYSICAL METALLURGY (3-2). A continuation of Mt-201. Topics include: (a) Iron-carbon alloys, (b) Effect of various heat treatments on the structure and properties of steel, (c) Reaction rates and hardenability, (d) The effect of alloying elements on steel, (e) Surface hardening methods, (f) Cast Irons, (g) Characteristics and properties of various steels. The laboratory experiments include heat treatment, mechanical testing, and metallographic examination of ferrous alloys. TEXTS: COONAN, *Principles of Physical Metallurgy;* CLARK *and* VARNEY, *Physical Metallurgy for Engineers.* PREREQUISITE: Mt-201(C).

Mt-212(C) PHYSICAL AND PRODUCTION METALLURGY (4-2). This course covers the same material as Mt-202 and includes in addition the production of iron and steel. One period each week is devoted to this latter topic. TEXTS: COONAN, *Principles of Metallurgy;* BRAY, *Ferrous Process Metallurgy;* CLARK *and* VARNEY, *Physical Metallurgy for Engineers.* PREREQUISITE: Mt-201(C).

Mt-203(B) PHYSICAL METALLURGY (Special Topics) (2-2). A continuation of material presented in Mt-201 and Mt-202, including a discussion of powder metallurgy, welding and casting, fatigue, properties of metals at low temperatures, and surveys of the alloys of aluminum and magnesium. TEXTS: COONAN, *Principles of Physical Metallurgy;* HEYER, *Engineering Physical Metallurgy;* CLARK *and* VARNEY, *Physical Metallurgy for Engineers;* WOLDMAN, *Metal Process Engineering.* PREREQUISITE: Mt-202(C).

Mt-204(A) NON-FERROUS METALLOGRAPHY (3-3). An expansion of material introduced in Mt-201, Mt-202 and Mt-203 with greater emphasis on the intrinsic properties of specific non-ferrous metals and alloys. TEXT: None. PREREQUISITES: Mt-201(C) and Mt-202(C).

Mt-205(A) ADVANCED PHYSICAL METALLURGY (3-4). The subject matter includes equilibrium in alloy systems, the crystallography of metals and alloys, phase transformations and diffusions. The laboratory time is devoted to x-ray techniques used in metallurgical studies. TEXTS: BARRETT, *Structure of Metals;* CULLITY, *Elements of X-ray Diffraction;* RHINES, *Phase Diagrams in Metallurgy.* PREREQUISITE: Mt-202(C), Ph-620(B) or equivalent.

Mt-206(A) ADVANCED PHYSICAL METALLURGY (3-4). The subject matter is an extension of that offered in Mt-205(A) but is primarily concerned with dislocations and other imperfections and their influences on the physical properties of metals. TEXTS: COTTRELL, *Dislocations and Plastic Flow in Crystals;* READ, *Dislocations in Crystals.*

Mt-207(B) PHYSICS OF SOLIDS (3-0). A course for engineers intended as an introduction to the physics of solids. Topics discussed include introductory statistical mechanics, atomic structure and spectra, introductory quantum mechanics, binding and energy bands, crystal structure and imperfections in crystals. TEXT: SPROULL, *Modern Physics.* PREREQUISITE: Mt-202(C).

Mt-301(A) HIGH TEMPERATURE MATERIALS (3-0). A course concerned with the effect of elevated temperatures on the properties of metals, especially as related to reaction motors, guided missiles, rockets, air frames and allied components. Methods of evaluating elevated temperature performance. Development of alloys, ceramics, cermets and refractory coatings for high temperature service. TEXTS: COONAN, *High Temperature Materials* (Instructor's Notes). PREREQUISITE: Mt-202(C).

Mt-302(A) ALLOY STEELS (3-3). A thorough study of the effects of the alloying elements, including carbon, commonly used in steel making, on the characteristics of steels in the annealed, the hardened and the hardened and tempered conditions. TEXT: E. C. BAIN, *The Alloying Elements in Steel.* PREREQUISITE: Mt-202(C).

Mt-303(A) METALLURGY SEMINAR. Hours to be arranged. Papers from current technical journals will be reported on and discussed by students. TEXT: None. PREREQUISITE: Mt-203(B) or Mt-205(A).

Mt-305(B) CORROSION AND CORROSION PROTECTION (3-0). Designed for Engineering Materials Curriculum. Corrosion theories and methods for corrosion protection. TEXT: None. PREREQUISITES: Mt-202 and Ch-101 or equivalent.

Mt-307(A) HIGH TEMPERATURE STUDIES (0-3). A laboratory course designed to familiarize the student in the study of fundamentals at high temperatures. Students working in small groups will be given an opportunity to undertake some original investigation with the purpose of developing an understanding of problems involved and methods of analysis in high temperature studies of materials. PREREQUISITE: Mt-301(A) (may be taken concurrently).

Mt-401(A) PHYSICS OF METALS (3-0). A discussion of crystal chemistry and modern theories of the solid state. TEXTS: KITTRELL, *Solid State Physics;* selected references. PREREQUISITES: Mt-205(A) and either Ph-610(B) or Ph-640(B).

Mt-402(B) NUCLEAR REACTOR MATERIALS—EFFECTS OF RADIATION (3-0). A course designed for students in nuclear engineering. Includes a study of materials of reactor construction; factors in materials selection; commercially available materials; liquid metal coolants; nature of radiation damage on materials. TEXTS: *The Reactor Handbook—General Properties Materials;* FINNISTON *and* HOWE, *Metallurgy and Fuels.* DRENES *and* VINEYARD, *Radiation Effects in Solids.* PREREQUISITE: Mt-202(C), Mt-207(B), or equivalent.

Mt-501(A) WELDING METALLURGY (3-3). A study of the various materials, equipment and processes employed for joining metals by both the plastic and the fusion welding methods, and of the mechanical, electrical, and metallurgical factors essential to successful welding. TEXTS: None. PREREQUISITE: Mt-203(B).

Mt-601(B) TECHNIQUES FOR ANALYSIS AND TESTING OF MATERIALS (2-4). An introduction to some of the more advanced experimental techniques, including X-ray and gamma ray radiography, X-ray diffraction, magnetic and sonic methods, spectrography and spectrometry, activation analysis and tracer techniques and qualitative and quantitative evaluation of various physical and chemical properties. TEXT: None. PREREQUISITES: Mt-202(C) and Physical Chemistry.

METEOROLOGY

Mr-100(C) FUNDAMENTALS OF ATMOSPHERIC CIRCULATION (2-0). Primarily designed to give non-meteorological officer students a survey of meteorology. Topics included are essentially the same as in Mr-200; however, there is greater emphasis on large-scale and small-scale circulations. TEXT: PETTERSSEN, *Introduction to Meteorology.*

Mr-120(C) INTRODUCTION TO METEOROLOGY AND OCEANOGRAPHY (3-0). Distribution of the properties of the atmosphere and the oceans; the mean pattern of the general circulation and the seasonal and short-term variations from the mean; methods of predicting atmospheric and oceanographic conditions. TEXTS: SHEPARD, *Submarine Geology;* SVERDRUP, *Oceanography for Meteorologists;* PETTERSSEN, *Introduction to Meteorology.*

Mr-200(C) INTRODUCTION TO METEOROLOGY (3-0). A general course which treats descriptively the composition and vertical structure of the atmosphere, physical processes, general circulation, air masses, fronts, cyclones and anticyclones. TEXT: PETTERSSEN, *Introduction to Meteorology.*

Mr-201(C) ELEMENTARY WEATHER-MAP ANALYSIS (0-9). Laboratory course taught in conjunction with Mr-211 (C). Practice in upper-air and surface analysis stressing history and continuity. TEXTS: Departmental notes. PREREQUISITES: Mr-200(C) and a knowledge of weather codes and observations.

Mr-202(C) WEATHER-MAP ANALYSIS (0-9). Laboratory course taught in conjunction with Mr-212(C). Extends surface and upper-air analysis to include control-line prognosis, basic extrapolation techniques, graphical arithmetic, and daily map discussions. TEXT: NavWeps 50-1P-502, *Practical Methods of Weather Analysis and Prognosis.* PREREQUISITE: Mr-201(C).

Mr-203(C) FORECASTING OF WEATHER ELEMENTS (0-9). Laboratory course taught in conjunction with Mr-213(C). Practice in analysis of time/space cross sections, objective and quantitive forecasting techniques, mesoscale synoptic analysis, and arctic analysis. TEXTS: Various NavWeps, AWS, and Weather Bureau publications; departmental notes. PREREQUISITE: Mr-202(C).

Mr-204(B) UPPER-AIR AND SURFACE PROGNOSIS (0-9). Laboratory course taught in conjunction with Mr-214(B). Practice in prognosis of upper-air and surface charts using current and classical methods, and in graphical numerical weather prediction techniques. TEXTS: Various NavWeps, AWS, and Weather Bureau publications; departmental notes. PREREQUISITE: Mr-203(C).

Mr-205(B) THE MIDDLE ATMOSPHERE AND SELECTED TOPICS (0-9). Laboratory course taught in conjunction with Mr-215(B). Practice in analysis and prognosis of middle atmosphere charts, forecasting of winds at stratospheric levels, techniques of evaluating radar propagation patterns and exercises in numerical weather prediction techniques. TEXTS: Various NavWeps, AWS Manuals; departmental notes. PREREQUISITE: Mr-204(B).

Mr-206(C) NAVAL WEATHER SERVICE ORGANIZATION AND OPERATION (1-9). Detailed descriptions of functions and responsibilities of Naval Weather Service, including operational aspects of fleet weather centrals/facilities, naval air stations and shipboard units; procedures for aviation and synoptic briefings; familiarization with communication networks and publications. Laboratory includes analysis and prognosis of all necessary data for the preparation and presentation of all types of operational forecasts including flight-clearance forms, flight cross sections, area, spot and local forecasts, plus mock briefings of operational commanders. TEXTS: Selected NavWeps, AWS and NWRW publications; departmental notes. PREREQUISITE: Mr-205(B).

Mr-211(C) ELEMENTARY WEATHER-MAP ANALYSIS (3-0). Objectives and techniques of surface and upper-air analysis, including contour, (isobar), isotherm and frontal analyses. TEXTS: BERRY, BOLLAY *and* BEERS, *Handbook of Meteorology;* departmental notes. PREREQUISITES: Mr-200(C) and a knowledge of weather codes and observations.

Mr-212(C) INTRODUCTION TO WEATHER ELEMENTS (3-0). Continuation of Mr-211(C). Structure of frontal wave cyclones; control-line methods of weather-chart prognoses. Air masses and related stability; cloud analyses; objective forecasting techniques. TEXTS: Same as Mr-211 (C) plus NavWeps 50-1P-502, Practical Methods of Weather Analysis and Prognosis; departmental notes. PREREQUISITE: Mr-211(C).

Mr-213(C) FORECASTING WEATHER ELEMENTS (2-0). Continuation of Mr-212(C). Significance of time-space cross sections; consideration of topographical effects; objective and quantitative forecasting of hydrometers, and surface/upper-air temperatures. Introduction to arctic forecasting. Meso-scale weather features. TEXTS: departmental notes. PREREQUISITE: Mr-212(C).

Mr-214(B) UPPER-AIR AND SURFACE PROGNOSIS (3-0). Continuation of Mr-213(C). Techniques of upper-air prognosis including long and short waves, movement of height-change centers, vorticity, CAVT, space mean, vertical consistency and continuity considerations. Techniques of surface prognosis using objective methods; graphical numerical prediction techniques. TEXTS: Same as Mr-213(C). PREREQUISITES: Mr-213(C), Mr-301(B) or Mr-321(A).

Mr-215(B) THE MIDDLE ATMOSPHERE AND EXTENDED FORECASTING (3-0). Objectives and techniques of high-tropospheric and low stratospheric analysis and prognosis including jet stream, maximum-wind layer, tropopause, climatology of middle atmosphere and stratospheric wind extrapolations, plus mean-circulation and weather-type methods of extended forecasting. TEXTS: Various NavWeps, AWS Manuals; departmental notes. PREREQUISITE: Mr-214(B).

Mr-218(B) TROPICAL AND SOUTHERN HEMISPHERIC ANALYSIS (0-6). Laboratory course associated with Mr-228(B). Consists of southern hemispheric pressure analysis, low-latitude streamline analysis, low-latitude streamline forecasting, and tropical cyclone prognosis. Specially prepared charts covering southern hemispheric and tropical latitudes are used. TEXT: departmental notes. PREREQUISITES: Mr-215(B).

Mr-220(B) SELECTED TOPICS IN APPLIED METEOROLOGY (2-0). Polar meteorology; the general circulation; other topics as time permits. TEXTS: PETTERSSEN, JACOBS *and* HAYNES, *Meteorology of the Arctic;* NavWeps publications; departmental notes. PREREQUISITES: Mr-302(B) and Mr-402(C).

Mr-228(B) TROPICAL AND SOUTHERN HEMISPHERE METEOROLOGY (3-0). Southern hemisphere synoptic meteorology; tropical synoptic models (with emphasis on the tropical cyclone); tropical forecasting. TEXT: RIEHL, *Tropical Meteorology.* PREREQUISITE: Mr-301(B) or Mr-321(A).

Mr-301(B) ELEMENTARY DYNAMIC METEOROLOGY I (4-0). The equations of motion; trajectories and streamlines; thermal wind; mechanism of pressure changes and kinematics of pressure systems. TEXT: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology.* PREREQUISITES: Mr-200(C), Ph-191(C) and Ma-071(C).

Mr-302(B) ELEMENTARY DYNAMIC METEOROLOGY II (4-0). A continuation of Mr-301(B). Vorticity and circulation; applications of vorticity theorem; dynamical forecasting by numerical methods; selected topics including fronts and frontogenesis. TEXT: Same as Mr-301(B). PREREQUISITES: Mr-301(B), Mr-402(C), Ma-072(C) and Ma-081(B).

Mr-321(A) DYNAMIC METEOROLOGY I (3-0). The equations of motion; horizontal flow; geostrophic and gradient winds; vertical variations of wind and pressure systems; kinematics of pressure systems; continuity and tendency equations; convergence and divergence in trough-ridge systems. TEXT: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology.* PREREQUISITES: Mr-413(B), Ma-240(C) and Ma-251(B).

Mr-322(A) DYNAMIC METEOROLOGY II (3-0). A continuation of Mr-321(A). Circulation theorems; vorticity equation and applications; solution of hydrodynamic equations by (a) perturbation methods, (b) by numerical integration; barotropic and baroclinic models; fronts and frontogenesis. TEXT: Same as Mr-321(A). PREREQUISITES: Ma-125(B) concurrently, Ma-261(A) and Mr-321(A).

Mr-323(A) DYNAMIC METEOROLOGY III (TURBULENCE AND DIFFUSION) (3-0). The general effects of viscosity and turbulence; equations of motion for viscous and turbulent flows; diffusion of momentum; wind variation in the surface layer; diffusion of other properties including heat, water vapor, smoke, etc.; diurnal temperature variation; transformation of air masses; statistical properties of turbulence. TEXTS: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology;* SUTTON, *Micrometeorology.* PREREQUISITES: Mr-322(A), Ma-125(B) and Ma-331(B).

Mr-324(A) DYNAMICAL PREDICTION (3-0). The solution of the hydrodynamical equations for meteorological phenomena by analytical and numerical methods. Objective analysis. TEXT: THOMPSON, *Numerical Weather Analysis and Prediction.* PREREQUISITES: Mr-323(A), Ma-421(A) and Ma-426(A) concurrently.

Mr-325(A) ENERGETICS OF THE GENERAL CIRCULATION (2-0). The equations for energy and momentum balance in atmosphere; zonal and eddy available potential energies and their changes; diabatic heating and its conversion into kinetic energy by means of eddies. Model studies of the general circulation. Computations of transports of enthalphy, momentum, kinetic energy, etc., using Fourier Transforms in the domain of wave number. TEXTS: PFEFFER, *Dynamics of Climate;* departmental notes. PREREQUISITES: Mr-323(A), Ma-421(B).

Mr-335(A) THEORETICAL METEOROLOGY (3-0). Advanced topics in theoretical meteorology to fit the needs of the students. PREREQUISITE: Consent of the instructor.

Mr-402(C) INTRODUCTION TO METEOROLOGICAL THERMODYNAMICS (3-2). A treatment of elementary thermodynamics and its application in meteorology, with particular emphasis on thermodynamic charts and diagrams. Atmospheric stability, instability phenomena, and forecasting techniques are discussed. TEXT: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology.* PREREQUISITES: Ph-191(C) and Ma-071(C) or equivalent.

Mr-403(B) INTRODUCTION TO MICROMETEOROLOGY (4-0). Properties of radiating matter in general; solar and terrestrial radiation and their effects on the temperature distribution; the heat budget; structure of the wind (in the friction layer) and its significance in turbulent transfer; airmass modification; forecasting the micrometeorological variables and their use in diffusion from point and line sources. TEXT: Same as Mr-402(C). PREREQUISITES: Mr-302(B) and Ma-381(C) or equivalent.

Mr-410(C) METEOROLOGICAL INSTRUMENTS (2-2). Principles of design and operation of meteorological instruments used in naval meteorology with special emphasis on new developments and requirements. Application of electronic meteorological instruments used by the fleet meteorologist. TEXTS: MIDDLETON *and* SPILHAUS, *Meteorological Instruments*; selected papers and departmental notes. PREREQUISITES: Ma-071(C) or equivalent and Ph-196(C) or equivalent.

Mr-412(A) PHYSICAL METEOROLOGY (3-0). Solar and terrestrial radiation; absorption, scattering and diffuse reflection of solar radiation; terrestrial radiation and the atmospheric radiation chart; applications to air mass modification and minimum-temperature forecasting; heat budget of earth-atmosphere system. TEXTS: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology;* departmental notes. PREREQUISITE: Mr-413(B).

Mr-413(B) THERMODYNAMICS OF METEOROLOGY (3-2). The physical variables; equations of state; first law of thermodynamics; properties of gases; properties of water and moist air; thermodynamic diagrams; air mass identification indices; geopotential determinations; altimetry; instability phenomena and criteria. TEXTS: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology*; departmental notes. PREREQUISITES: Ma-230(C) and Ph-196(C).

Mr-415(B) RADAR METEOROLOGY (2-0). Characteristics of radar sets; propagation of electromagnetic waves in standard and non-standard atmospheres; scattering by hydrometeors; attenuation; quantitative precipitation estimates; applications of radar in convective clouds, mesometeorology and larger-scale weather systems. TEXT: BATTAN, *Radar Meteorology.* PREREQUISITES: Mr-321(A) or Mr-301 (B), Ma-331(B) or Ma-381(C).

Mr-420(B) UPPER-ATMOSPHERE PHYSICS (4-0). The fundamental laws of atmospheric flow; balloon and rocket research; sounding the atmosphere by acoustic and radio techniques; the ozonosphere; aerial tides and magnetic effects; solar, magnetic and ionospheric disturbances; meteors, cosmic rays and satellites. TEXT: MASSEY *and* BOYD, *The Upper Atmosphere.* PREREQUISITES: Ph-365(B), Ph-541(B) and Ph-671(B).

Mr-422(A) THE UPPER ATMOSPHERE (5-0). The composition of the upper atmosphere; temperature and wind structure as deduced from several lines of observation; variations of electron concentration in the ionosphere; terrestrial magnetic variations; solar disturbances and their effects in the upper atmosphere; the aurora. TEXTS: MASSEY *and* BOYD, *The Upper Atmosphere;* GOODY, *The Physics of the Stratosphere;* departmental notes. PREREQUISITES: Mr-323(A), Mr-415(B), and Ma-331(B) or Ma-381(C).

Mr-510(C) CLIMATOLOGY (2-0). The distribution with respect to season, geography, and orography of the major meteorological elements. Definitions of climatic zones and types according to Koppen and their meteorological descriptions; micrometeorology; regional climatology of the oceans; climatology as a tool in objective forecasting. TEXT: HAURWITZ *and* AUSTIN, *Climatology.* PREREQUISITE: Mr-200 (C).

Mr-521(B) SYNOPTIC CLIMATOLOGY (2-2). The study and statistical evaluation of meteorological elements in relation to the macro- and microclimates; the Koppen system; methods of presenting climatological data to non-meteorological personnel; construction and use of forecast registers; climatological techniques in objective forecasting. TEXTS: HAURWITZ *and* AUSTIN, *Climatology;* CONRAD *and* POLLAK, *Methods in Climatology.* PREREQUISITES: Mr-200 (C) and Ma-381(C) or Ma-331(B) concurrently.

Mr-610(B) WAVE FORECASTING (3-0). The generation and propagation of ocean waves; their spectral, statistical, and mechanical properties; interactions between waves and ships; wave observations; synoptic wave charts, methods of ship routing. TEXTS: H.O.603; departmental notes. PREREQUISITES: Ma-381(C) or equivalent and Ma-072(C) or equivalent.

Mr-611(B) WAVE FORECASTING (3-6). Lecture same as in Mr-610(B). Laboratory exercises on the mechanics, statistical properties, and forecasting of waves and on the analysis of wave records. TEXTS: H.O. 603; departmental notes. PREREQUISITES: Same as Mr-610(B), and Mr-212 (C).

Mr-810(A) SEMINAR IN METEOROLOGY AND OCEANOGRAPHY (2-0). Students present original research or prepare summaries of recent findings in the fields of meteorology or oceanography and present synopses for group discussion. PREREQUISITES: Mr-422(A) or Mr-403(B), Mr-521(A), and Ma-331(B) or Ma-381(C).

OCEANOGRAPHY

Oc-110(C) INTRODUCTION TO OCEANOGRAPHY (3-0). A survey course treating physical and chemical properties of sea water, marine biology, and submarine geology; the heat budget of the oceans; water masses and the general circulation; currents, waves, and tides. TEXTS: SVERDRUP, *Oceanography for Meteorologists;* SHEPARD, *Submarine Geology.*

Oc-211(A) OCEAN WAVE THEORY (3-0). Various solutions of the hydrodynamical equations of motion for surface and internal waves, with particular attention to short gravity waves and their properties; generation of waves by wind; empirical and theoretical wind-wave spectra. TEXTS: DEFANT, *Physical Oceanography;* selected publications. PREREQUISITES: Ma-261(A) and Ma-331(B).

Oc-212(A) TIDES AND TIDAL CURRENTS (3-0). Theories of the astronomical tides; the tide-producing forces; tidal oscillations in ocean basins; geographical variation of the tides; analysis and prediction of tides; tidal datum planes. Meteorological tides. Seiches. Tidal currents. TEXTS: DEFANT, *Physical Oceanography;* MARMER, *Tidal Datum Planes.* PREREQUISITE: Oc-211(A).

Oc-213(B) SHALLOW-WATER OCEANOGRAPHY (3-0). Types and characteristics of continental shelves, coasts and beaches; wave processes in shallow water; littoral currents and storm-tides. TEXT: KING, *Beaches and Coasts.* PREREQUISITES: Oc-110(C) and Mr-611(B) (may be taken concurrently).

Oc-214(B) MARINE ENVIRONMENTS (3-0). The oceanography of partially enclosed water bodies; of estuaries, fjords, straits, river mouths, and harbors; and of enclosed seas. TEXTS: DEFANT, *Physical Oceanography;* selected publications. PREREQUISITES: Oc-212(A), Oc-213(B), and Oc-243(A).

Oc-230(A) SPECIAL TOPICS IN OCEANOGRAPHY (3-0). The mechanics of simple water waves; ocean-wave spectra, statistical properties of ocean waves, wave forces, and wave pressures; the movement of ships in irregular seas; tides, tidal currents, and the forces associated with them; sea-water transparency and underwater visibility. TEXTS: SVERDRUP, JOHNSON *and* FLEMING, *The Oceans;* H. O. 603, *Practical Methods for Observing and Forecasting Ocean Waves;* departmental notes. PREREQUISITES: Oc-110(C), Ma-240(C), and Ma-321(B).

Oc-240(B) DESCRIPTIVE OCEANOGRAPHY (3-0). Properties of sea water; water masses, currents and three-dimensional circulation in all oceans; distribution of temperature, salinity and oxygen; temperature-salinity relationship. TEXTS: SVERDRUP, JOHNSON *and* FLEMING, *The Oceans;* selected references. PREREQUISITE: Oc-110(C).

Oc-243(A) DYNAMIC OCEANOGRAPHY (4-0). Turbulence and diffusion in the ocean; boundary layer flow; stability; dynamical models for the general circulation of the ocean and for special regions. TEXTS: DEFANT, *Physical Oceanography;* STOMMEL, *The Gulf Stream.* PREREQUISITES: Oc-110(C), Mr-322(A).

Oc-310(B) GEOLOGICAL OCEANGRAPHY (3-0). Physiography of the sea floor, especially the continental shelf and slope, coral reefs, submarine canyons, and sea-mounts; marine processes that have shaped the ocean basins and coasts; character and distribution of sediment types and rates of deposition; origin of the ocean basins. TEXT: KUENEN, *Marine Geology;* PREREQUISITES: Oc-110(C); Ge-101 (C) is desirable but not necessary.

Oc-330(A) MARINE GEOLOGY AND GEOPHYSICS (3-0). Physical and engineering properties of marine sediments; geographical distribution of marine sediments; types of continental shelves and harbors; deposition and erosion on the sea floor; current scour around objects on the bottom; biological fouling organisms, distributions of foulers, and rates of fouling. TEXTS: GILLULY, WATERS *and* WOODFORD, *Principles of Geology;* SHEPARD, *Submarine Geology;* TERZAGHI *and* PECK, *Soil Mechanics in Engineering Practice;* UNITED STATES NAVAL INSTITUTE, *Marine Fouling and its Prevention.* PREREQUISITE: Oc-110(C).

Oc-410(B) BIOLOGICAL OCEANOGRAPHY (3-2). Plant and animal groups in the oceans; character of the plankton, nekton, and benthos; marine biological environments; oceanographic factors influencing populations; the effect of organisms on the physical-chemical properties of sea water; organisms responsible for boring, fouling, sound and light production, and sound scattering. TEXT: SVERDRUP, JOHNSON *and* FLEMING, *The Oceans.* PREREQUISITE: Oc-110(C).

Oc-510(B) CHEMICAL OCEANOGRAPHY (3-2). Chemical composition of sea water and sea ice; determination and distribution of salinity, density, dissolved gases, and plant nutrients; production of fresh water from sea water. TEXTS: HARVEY, *Recent Advances in the Biological Chemistry and Physics of Sea Water;* SVERDRUP, JOHNSON *and* FLEMING, *The Oceans.* PREREQUISITES: Ch-101(C) or equivalent and Oc-110(C).

Oc-612(B) ARCTIC SEA ICE (3-0). Arctic geography and oceanography; sea-ice observations, formation, properties, growth, deformation and disintegration; ice drift in response to winds and currents. TEXT: H. O. *Sea Ice Manual* (unpublished). PREREQUISITES: Oc-240(B), Mr-302(B) or Mr-322(A), and Mr-611(B).

Oc-613(B) ARCTIC SEA ICE AND ICE FORECASTING (3-4). Lectures same as in Oc-612(B). Laboratory exercises on ice drift and ice growth. TEXT: H.O. *Sea Ice Manual* (unpublished). PREREQUISITE: Oc-240(B), Mr-302(B) or Mr-322(A), and Mr-611(B).

Oc-620(B) OCEANOGRAPHIC FACTORS IN UNDERWATER SOUND (3-0). The oceanographic factors involved in sound ranging, including thermal gradients, sound absorption properties of sea water, sound scattering and reflection characteristics of the sea surface and sea floor, scattering properties of marine organisms, and ambient noise arising in the sea. TEXTS: ALBERS, *Underwater Acoustics Handbook;* departmental notes. PREREQUISITES: Oc-110(C) and Ph-196(C) or equivalent.

Oc-621(B) OCEAN THERMAL STRUCTURE (2-2). Reviews variation of ocean temperature structure and processes involved; techniques in forecasting thermal structure illustrated by laboratory exercises; practice in developing forecast methods from actual air and sea data. TEXT: Selected publications. PREREQUISITE: Oc-240(B).

Oc-640(B) OCEANOGRAPHIC FORECASTING (3-4). Prediction of ocean transports and advective effects from the atmospheric wind field using the hydrodynamical equations and digital computations; prediction of long-term variations in oceanographic conditions using methods of cross-correlation and spectrum analysis. TEXT: Selected publications. PREREQUISITES: Oc-243(A) and Ma-331(B).

Oc-650(C) OPERATIONAL OCEANOGRAPHY (2-3). Applications of oceanography in ASWEPS, Arctic, submarine, weather, and other Navy operations; radar propagation. TEXTS: Selected references; departmental notes. PREREQUISITES: Mr-211(B), Oc-640(B), Oc-613(B) concurrently, and Oc-621(B).

Oc-700(B) OCEANOGRAPHIC OBSERVATIONS (3-0). Theory and operation of oceanographic instruments; processing and storage of data and samples; oceanographic data sources. TEXTS: H. O. 614; selected references. PREREQUISITES: Oc-240(B), Oc-310(B), and Oc-410(B).

OPERATIONS ANALYSIS

OA-121(A) SURVEY OF OPERATIONS ANALYSIS (4-2). The nature, origin, and contemporary status of operations analysis; fundamental concepts with special emphasis on applications in the field of evaluating radar and sonar; introduction to game theory, linear programming, and other advanced techniques. TEXTS: OPERATIONS EVALUATION GROUP, *Report No. 54, Methods of Operations Research;* OPERATIONS EVALUATION GROUP, *Report No. 56, Search and Screening;* MCCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* GASS, *Linear Programming;* TUCKER, *Submarine Firing Phase Decisions, USNPS Thesis.* PREREQUISITES: Ma-321(B) and Ma-322(A).

OA-141(B) FUNDAMENTALS OF OPERATIONS ANALYSIS (4-0). The role of operations analysis in the solution of military problems. Measures of effectiveness. Special techniques such as game theory and linear programming. TEXTS: MCCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* GASS, *Linear Programming;* TUCKER, *Submarine Firing Phase Decisions, USNPS Thesis;* WILLIAMS, *The Compleat Strategyst;* OPERATIONS EVALUATION GROUP, *Report No. 54, Methods of Operations Research.* PREREQUISITE: Ma-321(B).

OA-151(B) SURVEY OF WEAPONS EVALUATION (3-0). Review of probability theory with military interpretations. Sources of firing errors and their relative contributions to the overall errors. Damage probabilities. Selection of optimal weapon systems. Introduction to game theory and its applications. TEXTS: OPERATIONS EVALUATION GROUP, *Report No. 54, Methods of Operations Research;* DRESHER, *Games of Strategy;* Classified official publications. PREREQUISITES: Ma-113(B) and Ma-301(B).

OA-152(C) THEORY OF MINE WARFARE (3-0). Review of probability theory with military interpretations. Introduction to game theory and its application to mine warfare. Probability of damage. Growth and attrition of mine fields. TEXTS: DRESHER, *Games of Strategy;* Classified official publications. PREREQUISITES: Ma-381(C).

OA-153(B) COUNTER MEASURES IN MINE WARFARE (3-0). A continuation of OA-152(C). Analysis of countermeasures. Queueing theory and its application to the operation of mine fields. TEXTS: Classified official publications. PREREQUISITE: OA-152(C).

OA-202(A) ECONOMETRICS (3-0). Mathematical economic theory. Emphasis on inter-industry analysis. Review of current theoretical investigations of relations between military programs and the national economy. TEXTS: KOOPMANS, *Activity Analysis of Production and Allocation;* KARLIN, *Mathematical Methods and Theory in Games, Programming and Economics;* CONOLLY, *Interdiction Considerations in Leontieff-Type Land Logistic Networks* (USNPS Thesis). PREREQUISITES: Ma-196(A) and OA-391(A).

OA-211(A) LINEAR PROGRAMMING (3-2). Mathematical methods in logistics, with major emphasis on applications of linear programming to problems of transportation and the scheduling of inter-dependent activities. Relation of linear programming to the theory of games. Laboratory work on the computation of optimal solutions to linear programming problems, including the use of high-speed digital computers. TEXTS: KOOPMANS, *Activity Analysis of Production and Allocation;* GASS, *Linear Programming;* ACKOFF, *Progress in Operations Research;* CRANE, *A Review of Techniques in Transportation Research* (USNPS Thesis). PREREQUISITES: OA-391(A) and Ma-196(A).

OA-212(A) DYNAMIC PROGRAMMING (3-1). Elements of the theory of inventory control as an example of dynamic programming. Introduction to integral equations. Formulation of dynamic programming problems. Functional equations. Principle of optimality. Policy space. TEXTS: RAND PAPER P-189, *Optimal Inventory Policy;* BELLMAN, *Dynamic Programming.* PREREQUISITE: OA-211(A).

OA-213(A) INVENTORY CONTROL (3-0). Mathematical theory of inventory control. TEXTS: RAND PAPER P-189, *Optimal Inventory Policy;* BELLMAN, *Dynamic Programming;* ARROW, *Studies in the Mathematical Theory of Inventory and Production.* PREREQUISITE: OA-212(A).

OA-214(A) GRAPH THEORY (3-0). Elements of the theory of graphs, with emphasis on applications to the study of organizations, communication systems, and transportation networks. TEXT: BERGE, *Theorie des Graphes et Ses Applications.* PREREQUISITES: Ma-196(A) and Ma-193(A).

OA-225(A) AIR WARFARE (3-0). Analyses of fleet air defense exercises. Active and passive air defense. Potential improvements in air defense. Applications of operations analysis to the problem of continental air defense. TEXTS: Classified official publications. PREREQUISITES: OA-292 (B) and OA-293(B).

OA-234(A) INTRODUCTION TO RELIABILITY AND QUEUEING THEORY (3-0). Reliability theory and practice as applied to system maintenance, availability and safety. Reliability concepts and methods for simple through complex systems, will be developed, showing the solution of reliability problems by analysis, design and testing. The fundamental concepts of queuing theory as applied to operations involving variable arrivals and delays, and a demonstration of some of the techniques used to analyze and predict their behavior. TEXTS: BAROVSKY, *Reliability: Theory and Practice;* MORSE, *Queues, Inventories and Maintenance.* PREREQUISITES: Ma-321(B) or Ma-304(A).

OA-235(A) DECISION CRITERIA (3-0). General formulation of the decision problem. Special types of decision problems, including game theory. Military applications of game theory. General concept of utility and its measurement. Group decisions. Scales of measurement. The broad scope of operations analysis. TEXTS: LUCE *and* RAIFFA, *Game Theory and Decisions;* THRALL, *Decision Processes;* Classified official publications. PREREQUISITE: OA-292 (B).

OA-236(A) UTILITY THEORY (3-0). Survey and critique of the current literature dealing with the concept and measurement of utility. Comparison of cost and value. Applications to problems of human relations. TEXTS: DAVIDSON, SUPPES, SIEGEL, *Decision Making.* PREREQUISITES: OA-235(A).

OA-291(B) INTRODUCTION TO OPERATIONS ANALYSIS (4-0). Development of fundamental concepts and methods of operations analysis as illustrated in the fields of submarine and anti-submarine warfare. Over-all measures of effectiveness of a submarine as a weapon system. Determination of effectiveness as a product of measures of detection, attack, and kill capabilities. Lanchester's equations. TEXTS: MCCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* TUCKER, *Submarine Firing Phase Decisions* (USNPS Thesis); OPERATIONS EVALUATIONS GROUP, *Report No. 54, Methods of Operations Research.* PREREQUISITES: Ma-302(B) and Ma-182(B) (These may be taken concurrently.)

OA-292(B) METHODS OF OPERATIONS ANALYSIS (4-0). Classification of areas and problems of operations analysis. Classification of methods of attack. Analysis of measures of effectiveness. Critique of assumptions and results. Evaluation of weapons. TEXTS: Classified official publications. PREREQUISITES: Ma-301(C) and OA-291(B).

OA-293(B) SEARCH THEORY (4-0). Theory of radar detection. Evaluation of the operational performance of search radars. Search theory. The design of screen and barrier patrols. Allocation of search effort. TEXTS: MORSE *and* KIMBALL, *Methods of Operations Research;* KOOPMAN, *Search and Screening;* Classified official publications. PREREQUISITE: OA-292(B).

OA-296(A) DEVELOPMENT OF WEAPONS SYSTEMS (3-0). The areas of application of the various techniques of operations research which the student has learned are reviewed and placed in perspective relative to the procedure for evolving new weapons systems. Emphasis is placed upon the role of operations research in formulating operational requirements, developing prototype systems, and determining military specifications for selected systems and the role of operations analysis in various phases of operational testing of the system. The contributions of operations research to the coordination of the functions of those segments of the military establishment concerned with weapons systems development are analyzed. TEXTS: Classified official publications and instructor's notes. PREREQUISITE: OA-211(A).

OA-297(A) SELECTED TOPICS IN OPERATIONS RESEARCH (3-0). Presentation of a wide selection of reports from the current literature. At the end of the term an attempt will be made to summarize the philosophy and principal methodologies of operations research. TEXT: None. PREREQUISITE: A background of advanced work in operations research.

OA-391(A) GAMES OF STRATEGY (3-2). Utility theory. Games in normal and extensive forms. Two person zero-sum games; the minimax theorem. Relationship to linear programming. Methods of solving two person zero-sum games. Non zero-sum and cooperative games, n-person games. Applications. TEXTS: DRESHER, *Theory and Applications of Games of Strategy;* LUCE *and* RAIFFA, *Games and Decisions.* PREREQUISITES: Ma-301(C) or the equivalent.

OA-392(A) DECISION THEORY (3-0). Basic concepts. Bayes, admissible, minimax, and regret strategies. Principles of choice. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluation trials. TEXTS: CHERNOFF *and* MOSES, *Elementary Decision Theory;* WALD, *Statistical Decision Functions;* TUCKER, *Introduction to Statistical Decision Functions* (USNPS Thesis); SMITH, *Application of Statistical Methods to Naval Operational Testing* (USNPS Thesis). PREREQUISITES: Ma-304(A), Ma-193(A) and OA-391(A). (The latter may be taken concurrently.)

OA-393(A) WAR GAMING (3-0). Simulation, Monte Carlo method, and war gaming as techniques for the analysis of military problems. The USNPS-NELIAC compiler as a language for preparing war games for the CDC-1604 computer. Minefield simulations. Statistical analyses of digital computer games. TEXTS: Instructor's notes and classified official publications. PREREQUISITES: OA-291(B), Ma-303 (A), and Ma-421(B), or consent of instructor.

OA-471(B) OPERATIONS ANALYSIS FOR NAVY MANAGEMENT (4-0). The nature, origin and contemporary status of operations analysis. Fundamental concepts with special emphasis on applications in the fields of transportation, inventory control and personnel management. Introduction to game theory, linear programming and queueing theory. TEXTS: McCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* GASS, *Linear Programming;* WILLIAMS, *Compleat Strategyst;* CHERNOFF *and* MOSES, *Elementary Decision Theory.* PREREQUISITE: Ma-371(C).

OA-491(B) METHODS FOR COMBAT DEVELOPMENT EXPERIMENTATION (4-0). Introduction to the planning, analysis and reporting aspects of tactical field experiments. Examination of criteria from the military and statistical points of view. Discriminant analysis. TEXT: None. PREREQUISITES: OA-291(B) and Ma-303(A).

OA-891(L) SEMINAR I (0-2). Presentation, evaluation and critique of experience and results of summer field trips. TEXT: None. PREREQUISITE: None.

OA-892(L) SEMINAR II (0-2). A continuation of OA-891(L). Special lectures. TEXT: None. PREREQUISITE: None.

OA-893(L) SEMINAR III (0-2). Presentation of thesis developments. TEXT: None. PREREQUISITE: None.

OA-894(L) SEMINAR IV (0-2). A continuation of OA-893(L). TEXT: None. PREREQUISITE: None.

OA-899(L) MILITARY SCIENCE SEMINAR (0-1). Review of contemporary writings on the history and development of science in the military profession. TEXTS: MILLIS, *Arms and the State;* HUNTINGTON, *The Soldier and the State.* PREREQUISITE: None.

ORDNANCE

Or-241(L) ORDNANCE SEMINAR (0-2). Objectives of various Advanced Weapons Systems Curricula as a basis for selection. General organization of the Bureau of Weapons and its field activities. Utilization of Ordnance postgraduates under the sub-specialization concept. New developments in Weapons Systems. Principles of guided missile systems.

Or-242(L) ORDNANCE SEMINAR (0-2). General concepts of Mine Warfare, including Mines, Mine Countermeasures, and the theory of tactical and strategic mining. Torpedoes and their role in missile systems.

Or-243(L) ORDNANCE SEMINAR (0-2). Student presentation of principles and characteristics of modern and planned Weapons Systems.

PHYSICS

Ph-001 GENERAL PHYSICS I (Bachelor of Arts) (3-0). Mechanics — The purpose of this course as well as the following 3 units is to provide a knowledge of the *principles* of physics and thus to help the student understand the scientific background of modern civilization. This first unit deals with physical quantities and the concepts of motion, force, momentum and energy. TEXT: SMITH *and* COOPER, *Elements of Physics.*

Ph-002 GENERAL PHYSICS II (Bachelor of Arts) (4-0). Harmonic Motion, Sound and Heat — This is a continuation of Ph-001 and considers simple harmonic motion, oscillating systems including those producing sound, the propagation of sound and wave motion. The mechanics of gases, thermometry, transfer of heat, and thermodynamics are among other topics considered. TEXT: SMITH *and* COOPER, *Elements of Physics.* PREREQUISITE: Ph-001.

Ph-003 GENERAL PHYSICS III (Bachelor of Arts) (4-0). Electricity and Magnetism — This is a further continuation of General Physics I and II and presents the subject of electrostatics, including Coulomb's law, potential and capacitance, electric current and electric circuits, magnetism, and induced electromotive force. TEXT: SMITH *and* COOPER, *Elements of Physics.* PREREQUISITES: Ph-001 and Ph-002.

Ph-004 GENERAL PHYSICS IV (Bachelor of Arts) (4-0). Light and Modern Physics — This is the final unit of a four term sequence of General Physics and treats selected topics in light including the geometrical optics of mirrors and lenses, interference and diffraction and optical instruments. A brief introduction to modern physics is also given. This includes the topics of atomic structure, optical and X-ray spectra, radioactivity, and nuclear structure. TEXT: SMITH *and* COOPER, *Elements of Physics.* PREREQUISITES: Ph-001, Ph-002 and Ph-003.

Ph-011(C) GENERAL PHYSICS I (4-3). Mechanics—This course is designed to provide a knowledge of the principles of physics and to provide a scientific background for the study of engineering. It consists of lectures, recitations, problem sessions, and laboratory work dealing with force, motion, energy, momentum, elasticity, and hydrodynamics. TEXT: SEARS *and* ZEMANSKY, *University Physics.* PREREQUISITE: One term of calculus.

Ph-012(C) GENERAL PHYSICS II (4-3). Heat, Sound, and Light — This is a continuation of General Physics I and deals with molecular mechanics, behavior of gases, thermal expansion, calorimetry, the laws of thermodynamics, wave motion, vibrating bodies, reflection and refraction of light, dispersion, interference and diffraction, and optical instruments. TEXT: SEARS *and* ZEMANSKY, *University Physics.* PREREQUISITE: Ph-011(C).

Ph-013(C) GENERAL PHYSICS III (3-3). Electricity and Magnetism — This is a continuation of General Physics I and

II and deals with the fundamental principles of electrostatics, electromagnetism, electrochemistry, direct and alternating currents. TEXT: SEARS *and* ZEMANSKY, *University Physics*. PREREQUISITES: Ph-011(C) and Ph-012(C).

Ph-014(C) GENERAL PHYSICS IV (4-2). Modern Physics —This is a continuation of General Physics I, II and III and deals with the fundamentals of atomic and nuclear physics. Topics include: atomic and nuclear structure, optical spectra, radioactivity, nuclear processes, and particle accelerators. TEXT: WEHR-RICHARDS, *Physics of the Atom*. PREREQUISITES: Ph-011(C), Ph-012(C) and Ph-013(C).

Ph-021(C) MECHANICS (4-0). A review and extension of the mechanics portion of first-year college physics. Statics, linear, projectile, and satellite motion, work, energy, momentum, elasticity and harmonic motion, mechanics of fluids; wave motion. TEXT: RESNICK *and* HALLIDAY, *Physics for Students of Science and Engineering*. PREREQUISITES: College physics and calculus (may be taken concurrently).

Ph-022(C) ELECTROMAGNETISM (4-0). A review and extension of the electricity portion of first-year college physics. Electric and magnetic fields, potential, current, resistance, dc circuits, dielectrics and capacitance, induced electromotive force, ferromagnetism, alternating current, electrical oscillations, and electromagnetic waves. TEXT: RESNICK *and* HALLIDAY, *Physics for Students of Science and Engineering*.

Ph-023(C) RADIATION (4-0). Propagation of waves; superposition, reflection, refraction, diffraction, interference, dispersion, attenuation and polarization of waves. TEXT: RESNICK *and* HALLIDAY, *Physics for Students of Science and Engineering*.

Ph-113(B) DYNAMICS (4-0). Fundamental dynamical concepts, oscillator theory, motion of a particle in two and three dimensions, motion in central fields with emphasis on atomic structure, motion of a system of particles. TEXT: SYMON, *Mechanics*.

Ph-141(B) ANALYTICAL MECHANICS (4-0). Fundamental dynamical concepts, oscillator theory, curvilinear motion in a plane, energy concepts, statics and dynamics of a rigid body. Both analytical and vector methods are used. TEXT: SYMON, *Mechanics*. PREREQUISITE: Ma-182(B). (May be taken concurrently.)

Ph-142(B) ANALYTICAL MECHANICS (4-0). Wave motion, fluid mechanics, constrained motion, Lagrange's equations. TEXT: SYMON, *Mechanics*. PREREQUISITES: Ma-183(C) (may be taken concurrently) and Ph-141(B).

Ph-151(C) MECHANICS I (4-0). Fundamental concepts and laws of motion, statics and equilibrium, motion of a particle in a uniform field, oscillatory motion. TEXT: BECKER, *Introduction to Theoretical Mechanics*.

Ph-152(B) MECHANICS II (4-0). Motion of a system of particles, rigid body motion in a plane, motion in a central force field, accelerated reference frames. TEXT: BECKER, *Introduction to Theoretical Mechanics*. PREREQUISITES: Ph-151(C) and Ma-181(C).

Ph-153(A) MECHANICS III (4-0). Motion of a rigid body in three dimensions, generalized coordinates, Lagrange's and Hamilton's equations, canonical transformations, coupled systems and normal coordinates, elastic media. TEXT: BECKER, *Introduction to Theoretical Mechanics*. PREREQUISITES: Ph-152(B) and Ma-182(B).

Ph-154(A) CELESTIAL MECHANICS (4-0). Solar system, missile and satellite orbits, perturbation theory, mechanical problems of space flight. TEXT: Lecture Notes. PREREQUISITE: Ma-175(B).

Ph-155(A) ADVANCED MECHANICS I (3-0). Review of elementary principles, Lagrange formulations with applications. Hamilton's principle with applications to non-conservative and non-holomonic systems. The two body central force problem. Kinematics of rigid body motion. Orthogonal transformation. Formal properties of transformation matrix. Infinitesimal rotation. Coriolis force. TEXT: GOLDSTEIN, *Classical Mechanics*. PREREQUISITES: Ph-142(B) or Ph-153 (A), Ph-365(B) (may be taken concurrently).

Ph-156(A) ADVANCED MECHANICS II (3-0). Rigid body equation of motion. The inertia tensor, Euler's equations. Symmetrical top. Special relativity in classical mechanics, including Lorentz transformation and Lagrange formulation. Hamilton's equations of motion. Canonical transformations. Hamilton-Jacobi equation. Small oscillations with applications to free vibrations of simple poly-atomic molecules. TEXT: GOLDSTEIN, *Classical Mechanics*. PRE-requisite: Ph-155(A).

Ph-161(A) HYDRODYNAMICS (3-0). Euler's equation and equation of continuity; solutions to Laplace's equation and flow in potential fields. General stress-strain relations in a viscous fluid. Dimensionless constants for flow similarity. TEXT: LANDAU *and* LIFSHITZ, *Fluid Mechanics*. PREREQUISITES: Ae-100(C); Ae-121(C), Ma-175(B).

Ph-162(A) ADVANCED HYDRODYNAMICS (3-0). Sphere in viscous flow—Stokes solution, Oseen approximation. Vorticity transport equation. Prandtl boundary layer equations. Flow separation. Blasius solution for laminar boundary layer. Drag and boundary layer thickness for thin plate and for sphere. Non-steady boundary layers. Turbulent flow; Orr-Sommerfield stability equation. Transition to turbulence. Turbulent boundary layers and hydrodynamic noise. Surface waves. TEXT: SCHLICHTING, *Boundary Layer Theory*. PREREQUISITE: Ph-161(A).

Ph-190(C) SURVEY OF PHYSICS I (3-0). Elementary concepts and laws of statics and dynamics. Introduction to the statics and dynamics of fluids. Temperature, heat, radiation, kinetic theory and the gas laws. Fundamentals of vector representation and notation. TEXT: SMITH *and* COOPER, *Elements of Physics.*

Ph-191(C) SURVEY OF PHYSICS II (3-0). A continuation of Ph-190(C). A survey of wave propagation, sound, electricity and magnetism, atomic structure, the properties of light, and other electromagnetic wave phenomena. TEXT: SMITH *and* COOPER, *Elements of Physics.* PREREQUISITE: Ph-190(C) or equivalent.

Ph-196(C) REVIEW OF GENERAL PHYSICS (5-0). A review of statics and dynamics. A survey of electricity and magnetism, wave motion and sound, and selected topics in light as time permits. TEXT: SEARS *and* ZEMANSKY, *University Physics.* PREREQUISITE: Ph-191(C) or equivalent.

Ph-220(B) RADIATION (3-3). Reflection and refraction of light, optical instruments. Fundamentals of wave phenomena, interference, diffraction, dispersion, polarization. Propagation of electromagnetic waves, the radar equation. Thermal radiation, the photoelectric effect, the Bohr atom, visibility and photometry. TEXTS: SEARS, *Optics;* JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-240(C) OPTICS AND SPECTRA (3-3). Reflection and refraction of light, optical systems, dispersion, interference, diffraction, polarization. Basic atomic structure, photoelectric effect, radiation from atoms, molecules and solids. TEXTS: SEARS, *Optics;* JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-241(C) RADIATION (3-3). Fundamentals of geometric and physical optics. Wave phenomena and wave propagation. Origin of the quantum theory, photoelectric effect, radiation from atoms, molecules and solids, target detection by optical and infrared devices. TEXTS: SEARS, *Optics;* JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-260(C) PHYSICAL OPTICS (3-2). Reflection and refraction of light, optical systems, dispersion, interference, diffraction, polarization. Basic atomic structure, photoelectric effect, radiation from atoms, molecules and solids. TEXTS: SEARS, *Optics;* JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-270(B) PHYSICAL OPTICS AND SPECTRA (4-2). Wave phenomena and wave propagation, dispersion, interference, diffraction, polarization, basic atomic structure, photoelectric effect, radiation from atoms, molecules and solids. TEXT: JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-361(A) ELECTROMAGNETISM (3-0). Electromagnetic field theory; electrostatics, dielectrics, magnetic fields of currents; vector potential; magnetic materials; magneto-motive force; electromagnetic induction; Maxwell's equations. TEXT: SLATER *and* FRANK, *Electromagnetism.* PREREQUISITES: Ma-183(B) and EE-272(B), or equivalent.

Ph-362(A) ELECTROMAGNETIC WAVES (3-0). A continuation of Ph-361(A). Propagation, reflection and refraction of electromagnetic waves; wave guides, cavity resonators; electromagnetic radiation. TEXT: SLATER *and* FRANK, *Electromagnetism.* PREREQUISITE: Ph-361(A).

Ph-365(B) ELECTRICITY AND MAGNETISM (4-0). Electrostatics, dielectrics, magnetostatics, induced emf, magnetic materials. TEXT: REITZ *and* MILFORD, *Foundations of Electromagnetic Theory.* PREREQUISITE: Ma-153(B) or Ma-186(B).

Ph-366(B) ELECTROMAGNETISM (4-0). A continuation of Ph-365(B). Maxwell's equations and applications of Maxwell's equations. TEXT: REITZ *and* MILFORD, *Foundations of Electromagnetic Theory.* PREREQUISITE: Ph-365(B).

Ph-367(A) SPECIAL TOPICS IN ELECTROMAGNETISM (4-0). A continuation of Ph-366(B). Methods of solution to Laplace's equation and Poisson's equation. Hertz potential. Radiation, scattering and dispersion. TEXT: PANOFSKY *and* PHILLIPS, *Classical Electricity and Magnetism.* PREREQUISITES: Ph-366(B) and Ma-175(B) or Ma-187(B).

Ph-368(A) ADVANCED ELECTROMAGNETIC THEORY I (3-0). Problems in electromagnetic radiation, optics and dispersion from electromagnetic point of view, retarded potentials, special theory of relativity, Lagrangian and Hamiltonian formulation of classical electrodynamics. TEXT: PANOFSKY *and* PHILLIPS, *Classical Electricity and Magnetism.* PREREQUISITES: Ph-367(A), and Ph-155(A).

Ph-431(B) FUNDAMENTAL ACOUSTICS (4-0). An analytical study of the dynamics of free, forced, and damped simple harmonic oscillators, strings, bars and membranes. Development of, and solutions to, the acoustic wave equation. Propagation of plane waves through pipes and between different media. Acoustic filters. Beam patterns and directivity of acoustics radiation from a piston. Radiation reaction. Loudspeakers and microphones. TEXT: KINSLER *and* FREY, *Fundamentals of Acoustics.* PREREQUISITE: Ma-113(B) and Ph-113(B) or equivalents.

Ph-432(A) UNDERWATER ACOUSTICS (4-3). A continuation of Ph-431(B). Transmission of sound in the ocean, including problems of refraction, classical and molecular attenuation, scattering, reverberation, and channel propagation. Physical principles used in sonar systems. Experiments in acoustical measurements, transducer measurements and noise analysis. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics;* NDRC, *Technical Summary; Principles of Underwater Sound.* PREREQUISITE: Ph-431(B).

Ph-433(A) PROPAGATION OF WAVES IN FLUIDS (3-0). A theoretical treatment of the propagation of acoustic waves in fluids including both ray and wave propagation characteristics as well as second order effects. TEXT: LINDSAY, *Mechanical Radiation.* PREREQUISITE: Ph-432(A).

Ph-435(B) UNDERWATER ACOUSTICS (3-2). A continuation of Ph-431(B). An analytic survey of the propagation of underwater acoustic waves as influenced by boundary conditions, refraction, reverberation, and attenuation. Physical characteristics of sonar transducers. Sonar systems and developments, experimental measurements in underwater acoustics. Laboratory includes experiments in underwater acoustic measurements. TEXTS: KINSLER *and* FREY, *Fundamental of Acoustics;* NDRC *Technical Summary; Principles of Underwater Sound;* NDRC *Technical Summary; Physics of Sound in the Sea.* PREREQUISITE: Ph-431(B).

Ph-441(A) SHOCK WAVES IN FLUIDS (4-0). Simple oscillator. Hydrodynamics. Longitudinal wave equation. Propagation of acoustic waves in fluids. Propagation of explosive shock waves in fluids. Shock waves propagated from atomic explosions. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics;* COLE, *Underwater Explosions.* PREREQUISITES: Ma-183(B) and Ph-152(B).

Ph-442(A) SHOCK WAVES IN FLUIDS (3-0). Finite amplitude waves. Theory of propagation of explosive shock waves in fluids, Rankine-Hugoniot equation of shock front, scaling laws, experimental measurements of shock waves in water. Shock waves propagated from atomic explosions. TEXT: COLE, *Underwater Explosions.* PREREQUISITE: Ph-431(B).

Ph-450(B) UNDERWATER ACOUSTICS (3-2). A survey of the fundamentals of acoustics, with particular emphasis on sound radiation and transmission problems encountered in underwater acoustics. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics;* NDRC *Technical Summary; Principles of Underwater Sound;* NDRC *Technical Summary: Physics of Sound in the Sea.*

Ph-461(A) TRANSDUCER THEORY AND DESIGN (3-3). A theoretical treatment of the fundamental phenomena inherent to the design of crystal, magnetostrictive, and ceramic sonar transducers. Characteristics and parameters of various sonar transducer systems are studied in the laboratory. TEXTS: HUETER *and* BOLT, *Sonics;* NDRC *Technical Summary: Crystal Transducers;* instructor's notes.

Ph-471(A) ACOUSTICS RESEARCH (0-3). Advanced laboratory work in acoustics. PREREQUISITE: Ph-432(A) or equivalent.

Ph-408(A). ACOUSTICS SEMINAR (2-0). Survey of current classified and unclassified acoustic literature in preparation for the student's thesis.

Ph-530(B) THERMODYNAMICS (3-0). Fundamental theory of thermodynamics and application to physical problems. First and second laws of thermodynamics; introduction to classical phase rule. Gaseous reactions, thermodynamics of dilute solutions, specific heats of gases, the Nernst heat theorem. TEXT: SEARS, *Thermodynamics.* PREREQUISITES: Ph-113(B) or Ph-142(B), and Ma-156(A) or Ma-183(B).

Ph-541(B) KINETIC THEORY AND STATISTICAL MECHANICS (4-0). Maxwell-Boltzmann distribution, collision cross-sections, introduction to classical and quantum statistics, with application to radiant energy. TEXTS: KENNARD, *Kinetic Theory;* SEARS, *Thermodynamics.* PREREQUISITES: Ma-183(B) and Ph-142(B).

Ph-545(A) STATISTICAL PHYSICS I (3-0). Basic principles of statistical mechanics from an advanced viewpoint including the statistical explanation of the principles of thermodynamics. The Gibbs and Maxwell Distributions. Treatment of perfect gas using statistical methods. Fermi and Bose distributions. TEXT: LANDAU *and* LIFSHITZ, *Statistical Physics;* Lecture notes. PREREQUISITES: Ph-636(B) or Ph-671(B); Ph-153(A); Ph-366(B).

Ph-546(A) STATISTICAL PHYSICS II (3-0). A continuation of Ph-545(A). Statistical treatment of condensed bodies including solids and liquids, superfluidity. Real gases including completely ionized gas. Phase equilibrium. Properties of matter at high temperatures and densities. Theory of fluctuations. TEXT: LANDAU *and* LIFSHITZ, *Statistical Physics;* Lecture notes. PREREQUISITES: Ph-545(A).

Ph-620(B) ELEMENTARY ATOMIC PHYSICS (4-0). Fundamental particles, forces on particles, kinetic theory. photons as waves and particles, electrons as particles and waves, elementary quantum physics, binding energies in atoms and nuclei, atomic structure and spectra, X-rays, molecular structure, atoms in solids. TEXT: WEIDNER *and* SELLS, *Elementary Modern Physics.* PREREQUISITE: Ph-113(B) or equivalent.

Ph-621(B) ELEMENTARY NUCLEAR PHYSICS (4-0). A descriptive and phenomenological course including properties of nucleons, nuclear structure, radioactivity, nuclear reactions, fission, and fusion. TEXT: KAPLAN, *Nuclear Physics.* PREREQUISITE: Ph-620(B) or Ph-630(B).

Ph-622(B) NUCLEAR PHYSICS LABORATORY (0-3). Discussions and experiments on the interactions of nuclear radiations with matter and detection techniques. PREREQUISITE: Ph-621(B) (may be taken concurrently).

Ph-630(B) ELEMENTARY ATOMIC PHYSICS (4-0). Elementary particles, interactions of particles, photoelectric effect, electron diffraction, the nuclear atom, Bohr model of the atom, energy levels in atoms, optical and X-ray spectra, Pauli exclusion principle, Zeeman effect, Schroedinger's equation. TEXT: WEIDNER *and* SELLS, *Elementary Modern Physics.* PREREQUISITES: Ph-152(B) and Ph-240(C) or equivalents.

Ph-631(B) ATOMIC PHYSICS LABORATORY (0-3). Quantitative laboratory exercises in atomic physics. PREREQUISITE: Ph-620(B) or Ph-630(B) (must be taken concurrently).

Ph-635(B) ATOMIC PHYSICS I (5-0). Fundamental particles, interactions of particles, photoelectric effect, wave-particle duality, Rutherford scattering, elementary quantum mechanics, Schroedinger equation, quantum mechanical operators, Bohr theory of the atom, quantum mechanical solution for the hydrogen atom, vector model of the atom, quantum numbers, Pauli exclusion principle, periodic table of the elements. TEXT: RICHTMYER, KENNARD, *and* LAURITSEN, *Modern Physics.* PREREQUISITES: Ma-230(C) and Ph-240(C).

Ph-636(B) ATOMIC PHYSICS II (4-3). Fine structure in the hydrogen atom, Zeeman effect, selection rules in atomic spectra, X-rays, binding energies in molecules, molecular structure, band theory of solids, semiconductors, electron and nuclear spin resonance, special theory of relativity. Laboratory: Quantitative experiments related to the lecture material of Ph-635(B) and Ph-636(B). TEXTS: RICHTMYER, KENNARD, *and* LAURITSEN, *Modern Physics;* SPROULL, *Modern Physics.* PREREQUISITE: Ph-635(B).

Ph-637(B) NUCLEAR PHYSICS I (3-0). Basic nuclear concepts, nuclear stability, static properties of the nucleus, and nuclear forces. TEXTS: HALLIDAY, *Introductory Nuclear Physics;* KAPLAN, *Nuclear Physics.* PREREQUISITES: Ph-635(B), Ph-636(B) or Ph-670(B), Ph-671(B), and Ph-365(B).

Ph-638(B) NUCLEAR PHYSICS II (3-3). Nuclear models, dynamic properties of the nucleus, including radioactivity, nuclear reactions, and nuclear fission. Laboratory: Discussions and experiments on the interactions of nuclear radiations with matter and detection techniques. TEXTS: HALLIDAY, *Introduction Nuclear Physics;* KAPLAN, *Nuclear Physics.* PREREQUISITE: Ph-637(B).

Ph-646(A) ADVANCED NUCLEAR PHYSICS I (3-0). Partial wave analysis of scattering, the theories of nuclear reactions, nuclear forces. TEXTS: BLATT *and* WEISSKOPF, *Theoretical Nuclear Physics;* SACKS, *Nuclear Theory;* BETHE *and* MORRISON, *Elementary Nuclear Theory;* the periodicals of nuclear physics. PREREQUISITES: Ph-638(B), Ph-367 (A), and Ph-712(A).

Ph-647(A) ADVANCED NUCLEAR PHYSICS II (3-0). Nuclear models, theory of beta-decay, theory of gamma emission, theory of alpha decay. TEXTS: BLATT *and* WEISSKOPF, *Theoretical Nuclear Physics;* SACKS, *Nuclear Theory*; BETHE *and* MORRISON, *Elementary Nuclear Theory;* the periodicals of nuclear physics. PREREQUISITE: Ph-646(A).

Ph-650(A) GASEOUS DISCHARGES (4-0). Basic phenomena in gaseous discharges and infrared spectroscopy; theory of detectors for nuclear reactions. TEXTS: VON ENGEL, *Ionized Gases;* RICHTMEYER *and* KENNARD, *Introduction to Modern Physics;* Lecture note. PREREQUISITE: Ph-630(B) or equivalent.

Ph-651(A) REACTOR THEORY I (3-0). Nuclear fission, the diffusion and slowing down of neutrons, homogenous thermal reactors. TEXT: GLASSTONE *and* EDLUND, *The Elements of Nuclear Reactor Theory;* MURRAY, *Nuclear Reactor Physics.* PREREQUISITES: Ph-637(B), Ph-638(B) and Ma-113(B) or equivalent.

Ph-652(A) REACTOR THEORY II (3-0). A continuation of Ph-651(A). Time behavior, reactor control, reflected systems, multigroup theory, heterogeneous systems, perturbation theory. TEXTS: GLASSTONE *and* EDLUND, *The Elements of Nuclear Reactor Theory;* MURRAY, *Nuclear Reactor Theory.* PREREQUISITE: Ph-651(A).

Ph-653(A) REACTOR PHYSICS LABORATORY (0-2). Experiments using the AGN-201 reactor including the measurement of basic reactor parameters and the study of its transient behavior. TEXTS: AEROJET-GENERAL, *Elementary Reactor Experimentation;* HUGHES, *Pile Neutron Research;* GLASSTONE *and* EDLUND, *The Elements of Nuclear Reactor Theory.* PREREQUISITES: Ph-651(A) and Ph-652(A). (The latter may be taken concurrently.)

Ph-654(A) PLASMA PHYSICS I (4-0). This is the first of a two term sequence concerned with the dynamics of plasmas to provide the basic concepts for application to such fields as controlled fusion and ion propulsion. Topics covered are collision phenomena, including atomic and surface effects, the Boltzmann equation, breakdown of a gas, diffusion both in the presence and absence of space charge. The general hydromagnetic macroscopic equation is derived and from this the momentum transport and energy transport equations are obtained. The hydromagnetic equations for a two particle plasma are considered. TEXT: ROSE *and* CLARK, *Plasmas and Controlled Fusion; Lecture Notes.* PREREQUISITES: Ph-636(B) or Ph-671(B), Ph-367(A), and Ph-541(B).

Ph-655(A) PLASMA PHYSICS II (4-0). A continuation of Ph-654(A). 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. Motion of individual charges in a plasma. Types of radiation from plasmas, including bremsstrahlung and cyclotron radiation. Discussion of various types of plasma instabilities. Consideration of methods that have been used in attempts to obtain a useful thermonuclear power source. TEXT: ROSE *and* CLARK, *Plasmas and Controlled Fusion; Lecture Notes.* PREREQUISITE: Ph-654(A).

Ph-670(B) ATOMIC PHYSICS I (3-0). Fundamental particles, kinetic theory, forces on particles, special theory of relativity, wave-particle duality, quantum mechanics of simple systems, quantum mechanical operators, Bohr model of the atom, quantum mechanical solution for the hydrogen atom. TEXTS: RICHTMYER, KENNARD *and* LAURITSEN, *Modern Physics;* Lecture Notes. PREREQUISITES: Ph-152 (B) or equivalent, Ma-240(C) or equivalent, and Ph-270 (B).

Ph-671(B) ATOMIC PHYSICS II (3-3). Fine structure in the hydrogen atom, vector model of the atom, spectroscopic notation, Zeeman effect, many-electron atoms, periodic table in terms of quantum numbers, X-rays, binding in molecules. Laboratory: Quantitative experiments related to lecture material of Ph-670(B) and Ph-671(B). TEXT: RICHTMYER, KENNARD *and* LAURITSEN, *Modern Physics;* Lecture Notes. PREREQUISITES: Ph-670(B).

Ph-711(A) QUANTUM MECHANICS I (3-0). The Schrodinger equation, eigenvalues and energy levels, the hydrogen atom, collision theory. TEXTS: SCHIFF, *Quantum Mechanics;* PAULING *and* WILSON, *Introduction to Quantum Mechanics.* PREREQUISITES: Ph-144(A), or Ph-156(A), Ph-367(A).

Ph-712(A) QUANTUM MECHANICS II (3-0). Matrix formulation of quantum mechanics, spin, atoms, time-dependent and time-independent perturbation theory. TEXT: SCHIFF, *Quantum Mechanics.* PREREQUISITE: Ph-711(A).

Ph-713(A) QUANTUM MECHANICS III (3-0). Semi-classical radiation theory, angular momentum and coupling, Dirac relativistic wave equation. TEXTS: SCHIFF, *Quantum Mechanics;* LANDAU *and* LIFSCHITZ, *Quantum Mechanics—Non Relativistic Theory.* PREREQUISITES: Ph-712(A), Ph-368(A).

Ph-714(A) QUANTUM MECHANICS IV (3-0). Quantum theory of radiation processes. TEXTS: HEITLER, *The Quantum Theory of Radiation.* PREREQUISITE: Ph-713 (A).

Ph-721(A) INTRODUCTORY QUANTUM MECHANICS (4-0). This course is designed to familiarize the student with the postulates and methods of Schroedinger's quantum mechanics, with application to such problems as the free particle, particle in a potential well, potential barriers, natural radioactivity, harmonic oscillator, free rotator, hydrogen atom and the one-dimensional potential lattice for the solid state. TEXT: ROJANSKY, *Introductory Quantum Mechanics;* SCHIFF, *Quantum Mechanics.* PREREQUISITES: Ph-144(A) and Ph-640(B) or equivalent.

Ph-723(A) PHYSICS OF THE SOLID STATE (4-0). Crystal classes, interference phenomena. Quantum theory of crystal lattices, binding energies. Statistics of electrons in solids, band theory of solids, Brillouin zones, Hume-Rothery rule, electron negative mass and the "hole" concept. Conductivity, insulators and semiconductors, electron trapping, fluorescence, junction rectification, transistor action. Superconductivity, properties of liquid helium II. Magnetic properties of solids. Dislocations, strength and plastic flow. TEXTS: KITTEL, *Introduction to Solid State Physics;* SEITZ, *Modern Theory of Solids;* READ, *Dislocations in Crystals.* PREREQUISITE: Ph-636(B), or Ph-671(B).

Ph-724(B) THEORY OF QUANTUM ELECTRONIC DEVICES (4-0). Theory of the operation of electronic devices depending on energy states and the quantum nature of radiation; topics in quantum mechanics, spin resonance, rotating coordinates, relaxation times, internal fields; application to specific electronic devices such as masers, microwave and optical pumping devices, paramagnetic amplifiers, magnetic instruments. TEXTS: HERZBERG, *Atomic Spectra and Atomic Structure;* TOWNES *and* SCHAWLOW, *Microwave Spectroscopy.* PREREQUISITE: Ph-620(B) or equivalent.

Ph-730(B) PHYSICS OF THE SOLID STATE (4-2). Fundamental theory and related laboratory experiments dealing with solids, with emphasis on electronic properties; crystals, binding energy, anisotropy, lattice oscillations, band theory of electrons, Brillouin zones, "hole" concept, effective mass, electrical conductivity, insulators and semiconductors, fluorescence, junction rectifiers, transistors, magnetism, and dielectrics. TEXTS: SPROULL, *Modern Physics;* SINOTT, *The Solid State for Engineers;* KITTEL, *Introduction to Solid State Physics.* PREREQUISITE: Ph-620(B).

Ph-731(A) ADVANCED SOLID STATE PHYSICS I (3-0). Fundamental studies of selected topics in solid state physics. The material selected will be chosen from: Theory of specific heats, transport properties, one electron approximations, the cohesive energy, mechanical properties, optical properties, magnetic properties, and resonance methods. TEXTS: KITTEL, *Introduction to Solid State Physics;* SEITZ, *Modern Theory of Solids;* SEITZ *and* TURNBULL, *Solid State Physics;* and current literature. PREREQUISITES: Ph-730 (A) and Ph-711(A).

Ph-732(A) ADVANCED SOLID STATE PHYSICS II (3-0). A continuation of Ph-731(A) with emphasis on the study of the current scientific literature. PREREQUISITE: Ph-731(A).

Ph-750(L) PHYSICS SEMINAR (0-1). Discussion of special topics of current interest in the field of physics and student thesis reports.

Ph-770(A) READING IN ADVANCED PHYSICS (3-0). Supervised reading from the periodicals in fields of advanced physics selected to meet the needs of the student.

NOTES and MEMORANDA

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UNITED STATES NAVAL

POSTGRADUATE SCHOOL

Catalogue for 1962-1963

THE GENERAL LINE AND NAVAL SCIENCE SCHOOL

M O N T E R E Y ★ C A L I F O R N I A

GENERAL LINE AND NAVAL SCIENCE SCHOOL

Director

ALFRED LEROY GURNEY
Captain, U. S. Navy
A.B., St. Mary's College, 1935; General Line School, 1947; Industrial College of the Armed Forces, 1956

Academic Chairman

FRANK EMILIO LA CAUZA (1929)*
B.S., Harvard Univ., 1923
M.S., 1924; A.M., 1929

Administrative Officer

CHARLOTTE L. SAFFORD
Lieutenant Commander, U.S. Navy
B.A., Barnard College, 1950

Assistant to Director for Women
and
Assistant Administrative Officer

MARY ANN GERHART
Lieutenant, U.S. Navy
B.S., Albright College, 1951

Scheduling Officer

JAMES WILLIAM AMOS
Lieutenant Commander, U.S. Navy

DEPARTMENT OF NAVAL WARFARE

WENDELL W. BEMIS, Captain, U.S. Navy; Head of Department; B.S., USNA, 1939; Naval War College, 1948; Imperial Defence College, 1959.

WILLIAM ARNOLD, Commander, U.S. Navy; Instructor in Guided Missiles and Outer Space; B.S., Univ. of Kansas, 1940.

IRA W. BLAIR, Lieutenant Commander, U.S. Navy; Instructor in Amphibious Operations; B.S., USNA, 1946; M.S., USNPS, 1961.

JOHN K. BOLES, Lieutenant Commander, U.S. Navy; Instructor in Communications.

RALPH D. BOTTEN, Commander, U.S. Navy; Instructor in Tactics and CIC; B.S., Univ. of Maryland, 1955.

ERIC B. BOWER, Commander, U.S. Navy; Instructor in Operational Planning.

ROBERT P. BREWER, Commander, U.S. Navy; Instructor in Naval Aviation; A.B., University of North Carolina, 1939.

MARVIN JAY COOPER, Lieutenant Commander, U.S. Navy; Instructor in Restricted Weapons.

JAMES J. FIMIAN, Lieutenant, U.S. Navy; Instructor in Tactics and CIC; B.S., Univ. of Vermont, 1952.

GEORGE H. GOLDSMITH, Commander, U.S. Navy; Instructor in Tactics and Aviation; A.B., Univ. of Alabama, 1939; Air Command and Staff School, 1953.

FRANK C. HEBERT, Lieutenant Commander, U.S. Navy; Instructor in Anti-Submarine Warfare.

GEORGE H. HEDRICK, Commander, U.S. Navy; Instructor in Advanced Tactics.

CHARLES F. HICKEY, Lieutenant Commander, U.S. Navy; Instructor in Mine Warfare; B.S., USNA, 1949.

ROBERT G. JACKSON, Lieutenant Commander, U.S. Navy; Instructor in Guided Missiles and Space.

DOWNING L. JEWELL, Lieutenant Commander, U.S. Navy; Instructor in Anti-Submarine Warfare; B.S., Michigan State, 1949.

DAVID B. MAHER, Commander, U.S. Navy; Instructor in Anti-Submarine Warfare; B.S., USNA, 1943.

WILLIS C. MCCLELLAND, Lieutenant Commander, U.S. Navy; Instructor in Naval Ordnance and Fire Control.

PAUL J. RAMSEY, Lieutenant Commander, U. S. Navy; Instructor in Guided Missiles and Outer Space; B.S., USNA, 1942.

JOHN W. SHONG, Commander, U.S. Navy; Instructor in Operational Planning; B.S., Michigan State University, 1942.

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

LEONARD A. SNIDER, Lieutenant Commander, U.S. Navy; Instructor in Restricted Weapons; B.S., George Washington University, 1948.

HAROLD H. STIRLING, JR., Lieutenant Colonel, U.S. Marine Corps; Instructor in Amphibious Operations; A.A., Diablo Valley College, 1961.

THOMAS L. TABOR, Lieutenant Commander, U.S. Navy; Instructor in Communications.

RICHARD LEE WARREN, Lieutenant Commander, U.S. Navy; Instructor in Naval Ordnance and Fire Control; B.S., USNA, 1944.

HAROLD J. YERLY, Lieutenant Commander, U.S. Navy; Instructor in Mine Warfare.

DEPARTMENT OF SEAMANSHIP AND ADMINISTRATION

WILLIAM H. PELLETT, Captain, U.S. Navy; Head of Department; B.S., USNA, 1942.

CARL F. BARRON, Commander, U.S. Navy; Instructor in Meteorology; B.S., St. Louis Univ., 1941; USNPS, 1947.

GEORGE A. CALDWELL, Commander, U.S. Navy; Instructor in Naval Intelligence; B.S., USNA, 1945; Naval Intelligence, USNPS, 1955.

FRED C. CULVER, Commander, U.S. Navy; Instructor in Logistics and Naval Supply and Personal Affairs; A.B., M.B.A., Univ. of Michigan, 1940; Naval War College, 1952.

CARL M. DAVIS, Lieutenant Commander, U.S. Navy; Instructor in Leadership and Administration; Management, USNPS, 1960.

ROBERT V. ECKERT, Commander, U.S. Navy; Instructor in Leadership and Administration.

WILLIAM J. GERRITY, Lieutenant, U.S. Navy; Instructor in Seamanship.

ARIEL L. LANE, Commander, U.S. Navy; Instructor in Navigation; B.S., USNPS, 1961.

FREDERICK E. LANE, Commander, U.S. Navy; Instructor in Seamanship.

FLOYD D. RICHARDS, Commander, U.S. Navy; Instructor in Leadership and Administration; B.S., Central Normal College, 1942.

RICHARD RODRIGUEZ, Commander, U.S. Navy; Instructor in Navigation.

ALLAN R. VAATVEIT, Commander, U.S. Navy; Instructor in Navigation.

DEPARTMENT OF APPLIED ENGINEERING

WILLIAM B. PAULIN, Captain, U.S. Navy; Head of Department; B.S., UCLA, 1939; USNPS, 1950.

HARRY E. CONRAD, Lieutenant Commander, U.S. Navy; Instructor in Marine Engineering.

DONALD E. CUNNINGHAM, Lieutenant, U.S. Navy, Instructor in Damage Control.

ARNOLD E. DOWNS, Commander, U.S. Navy; Instructor in Electricity-Electronics; B.S., S. Dakota State College, 1941; USNPS, 1950.

PAUL V. GUTHRIE, JR., Lieutenant, Junior Grade, U.S. Naval Reserve; Instructor in Electricity-Electronics; B.S., M.S., Univ. of Tennessee, 1959.

MALLIE B. MOORE, Lieutenant Commander, U.S. Navy; Instructor in Marine Engineering.

JOHN J. MORRISSEY, Ensign, U.S. Naval Reserve; Instructor in Physics; B.S., M.S., St. John's University, 1961.

STEPHEN J. NEMETH, Commander, U.S. Navy; Instructor in Damage Control.

JAMES ROLAND PAYNE, Lieutenant, U.S. Naval Reserve; Instructor in Mathematics; A.B., Univ. of California, 1954; A.M., 1955.

DAVID R. SLOTBOOM, Lieutenant, U.S. Naval Reserve; Instructor in Electricity; B.S., Univ. of Utah, 1958.

WILLIAM B. STAUBER, Lieutenant, Junior Grade, U.S. Naval Reserve; Instructor in Mathematics; B.A., Lake Forest College, 1958.

ERNEST W. STEFFEN, JR., Commander, U.S. Navy; Instructor in Electricity and Electronics; B.S., Univ. of Washington; M.A., USNPS, 1948.

THOMAS A. VAN SANT, Ensign, U.S. Naval Reserve; Instructor in Mathematics; B.A., St. John's, 1958; B.E.S., Johns Hopkins University, 1960.

DONALD WALTER WILKINSON, Lieutenant Commander, U.S. Navy; Instructor in Marine Nuclear Propulsion; B.S., Univ. of Michigan, 1953; Nav. Eng., Massachusetts Institute of Technology, 1952.

DEPARTMENT OF GOVERNMENT AND HUMANITIES

EMMETT FRANCIS O'NEIL, Commander, U.S. Naval Reserve; Head of Department; A.B., Harvard Univ., 1931; A.M., Univ. of Michigan, 1932; Ph.D., 1941.

FRANCES E. BIADASZ, Commander, U.S. Navy; Instructor in International Relations; B.S., Worcester State Teachers College, 1935; M.A., Georgetown Univ., 1953; Ph.D., Georgetown Univ., 1961.

LOFTUR L. BJARNASON, Professor of Literature, (1958); A.B., Univ. of Utah, 1934; A.M., 1936; A.M., Harvard Univ., 1939; Ph.D., Stanford Univ., 1951.

WILLIAM CLAYTON BOGGESS, Assistant Professor of Public Speaking (1956); B.S., Univ. of Southern California, 1953; M.S., 1954.

RUSSELL BRANSON BOMBERGER, Assistant Professor of English (1958); B.S., Temple Univ., 1955; A.M., State Univ. of Iowa, 1956, 1961; M.S., Univ. of Southern Calif., 1961.

WILLIAM F. COLE, Lieutenant Commander, U.S. Navy; Instructor in International Law. LL.B., Baylor Univ., 1950.

HUBERT C. GRIGSBY, JR., Lieutenant Commander, U.S. Navy; Instructor in International Relations; A.B., Univ. of Southern California, 1951; Naval Intelligence, USNPS, 1953.

WILLARD D. HOOT, Commander, U.S. Navy; Instructor in International Law; A.B., Penn State, 1939; LL.B., Univ. of Michigan, 1942; Army JAG School, Univ. of Virginia, 1956.

BOYD FRANCIS HUFF, Associate Professor of History (1958); A.B., Univ. of Washington, 1938; A.M., Brown Univ., 1941; Ph.D., Univ. of California, 1955.

ROBERT N. LASS, Lieutenant Commander, U.S. Naval Reserve; Instructor in English and Speech; B.A., 1935; M.A., 1937; Ph.D., 1942, Univ. of Iowa.

RICHARD V. MONTAG, Lieutenant, U.S. Navy; Instructor in Political Science; M.A., Ohio State, 1952.

THOMAS W. NAGLE, Lieutenant, U.S. Navy; Instructor in Political Science; B.A., Univ. of California, 1947; M.A., Univ. of California, 1948; Ph.D., Graduate Institute of International Studies, Geneva, Switzerland, 1957.

GORDON T. RANDALL, Lieutenant Commander, U.S. Navy; Instructor in Political Science; B.A., U.S. Naval Academy, 1944; M.A., Boston University, 1959.

DONALD E. SELBY, Lieutenant Commander, U.S., Navy; Instructor in Military Justice; A.B., Brown University, 1948; LL.B., Univ. of Virginia, 1951; Army JAG School, Univ. of Virginia, 1960.

BURTON MACLYNN SMITH, Associate Professor of Speech, (1955); A.B., Univ. of Wisconsin, 1936; A.M., 1937.

GENERAL INFORMATION

MISSION

The mission of the General Line and Naval Science School is to raise the educational level, broaden the mental outlook, and increase the professional and scientific knowledge of line officers in order that they may better perform the duties and meet the responsibilities of higher rank.

TASKS

The tasks for the General Line and Naval Science School are:

To provide instruction of about two years' duration leading to either a Bachelor of Science or Bachelor of Arts Degree, to meet the educational and career requirements of those officers who do not have a baccalaureate degree.

To provide instruction of about nine-and-one-half months duration which will prepare line officers with about 5 to 7 years commissioned service for more responsible duties in the operating forces.

To provide special programs of instruction as may be directed for women officers, legal officers, public information officers, and foreign naval officers.

ORGANIZATION

The Director of the General Line and Naval Science School is responsible to the Superintendent, U.S. Naval Postgraduate School, for all phases of administration of the General Line and Naval Science Scchool. The Director's staff includes his administrative assistants, the Academic Chairman of the General Line and Naval Science School, the four heads of academic departments, the civilian faculty, and officer instructors.

The four academic departments, each of which is headed by an appropriately qualified officer, are:

Department of Naval Warfare.
Department of Seamanship and Administration.
Department of Applied Engineering.
Department of Government and Humanities.

The Academic Chairman of the General Line and Naval Science School supervises the granting of advanced credit and the instruction given in all departments of the school.

Officer students enrolled in the General Line and Naval Science School are divided into sections for administrative purposes. The senior officer of each section is designated section leader with certain administrative responsibilities for the officers in his section. Each section has a member of the school staff assigned as its section advisor. The section advisor serves in the capacity of student counselor and provides a convenient link between the students and the school administration.

CALENDAR

The General Line and Naval Science School utilizes the Postgraduate School calendar which is based on five terms of ten weeks each and a two week Christmas leave period in a calendar year. The tenth week of each term is used as necessary for examinations and administrative transition to the next term.

NINE-AND-ONE-HALF MONTH GENERAL LINE CURRICULUM

The Nine-and-one-half Month General Line Curriculum extends over four terms and may be taken separately or as a component of the Bachelor of Science curriculum. Prescribed courses totaling 800 classroom and laboratory hours, chiefly in the Naval-Professional area, comprise the curriculum. An officer student enrolled in this program must take each of these courses or establish his qualifications for exemptions. All courses offered by the General Line and Naval Science School are available as electives if the student has the prerequisites and scheduling permits.

Exemptions for each officer student are determined on the basis of information obtained from a "Pre-Registration Questionnaire," prior college record, and personal interview by staff members. In some cases examinations are given to determine qualifications in specific areas. Students pursuing this curriculum are expected to carry an average load of 21 class and laboratory hours, some of which may be electives.

A tabulation of the courses offered by the four departments of the General Line and Naval Science School, and a description of each course, is given on pages G8-G13. Listed also are the courses given by the Engineering School which form a part of the General Line Curriculum.

BACCALAUREATE CURRICULA

The Baccalaureate Curricula include the Naval Professional courses of the General Line Curriculum (described below) and, in addition, sufficient coverage in the Humanities and Science-Engineering areas to adequately support Bachelor of Science and Bachelor of Arts degrees. From 1 to 2 calendar years are allowed for those enrolled to complete the program. Students pursuing this curriculum will carry an average load of 17 credit hours. The total of class hours and laboratory hours should average about 20 hours per week.

ELIGIBILITY

To be eligible for enrollment an officer must have acceptable advanced standing of 75 term credit hours (equivalent to 45 semester hours) which can be applied toward completion of the prescribed course of study. This must include a minimum of five term hours of college-level mathematics.

DEGREE REQUIREMENTS

The Bachelor of Science and Bachelor of Arts Degrees will be awarded by the Superintendent, U.S. Naval Postgraduate School, to those officer students who successfully complete the curriculum with a minimum average quality point rating of 1.0 (i.e., an average grade of C). A minimum of at least 215 term credit hours (equivalent to 129 semester hours), representing college level course credit earned at the General Line and Naval Science School or through accepted advanced standing, is required. For the Bachelor of Science, the 215 term hours must be distributed in the following academic areas: 118 (55%) in Science-Engineering; 54 (25%) in Naval Professional; 43 (20%) in the Humanities. For the Bachelor of Arts, the 215 term hours must be distributed in the following academic areas: 118 (55%) in the Humanities; 54 (25%) in Naval Professional; 43 (20%) in Science-Engineering. A minimum of 3 terms (equivalent to one college year) in residence at the General Line and Naval Science School is also required.

The Baccalaureate Curricula schedules are shown below. Students are required to complete the courses listed there, or equivalents, either before admission to the curriculum or as part of it. Furthermore, it will be necessary to satisfy a basic English and Grammar requirement through attainment of satisfactory scores on a standard examination administered on arrival. Those who fail the test will be enrolled in English Composition (HCA) without credit. Elective courses may be selected from any programs of the Engineering School, General Line and Naval Science School, or Management School to substitute for required courses for which advanced credit has been allowed so as to fulfill the total term credit hour requirements.

*BACHELOR OF SCIENCE CURRICULUM SCHEDULE

FIRST TERM

OFC Naval Ordnance and Fire Control	3–0
Ch001 General Chemistry I	4–3
Ma031 College Algebra and Trigonometry	5–0
**HCA Review of English Grammar	0–0
HUH U. S. History II	4–0
	16–3

SECOND TERM

OOP Operational Planning	3–0
Ch002 General Chemistry II	3–3
Ma051 Analytic Geometry and Calculus I	5–0
HCB Composition	2–0
HSY Psychology I	3–0
	16–3

THIRD TERM

Ma052 Analytic Geometry and Calculus II	5–0
Mt002 Basic Metallurgy	4–3
Ph011 General Physics I	4–3
HEH European History	4–0
	17–6

FOURTH TERM

OCM Communications	3–0
Ma053 Calculus and Analytic Geometry	3–0
Ma081 Introduction to Vector Analysis	2–0
Ph012 General Physics II	4–3
HPM International Communism	4–0
	16–3

FIFTH TERM

OAO Amphibious Operations	3–0
ORW Restricted Weapons	3–0
SMN Command Seamanship	3–0
	9–0

SIXTH TERM

EGM Marine Engineering	4–0
ME561 Mechanics I (Statics)	4–0
Ph013 General Physics III	3–3
SLO Logistics and Naval Supply	3–0
HJA Military Law I	3–0
HSP Public Speaking	2–0
	19–3

SEVENTH TERM

OTC Tactics and CIC	3–2
EE021 Electrical Circuits and Machinery I	5–3
ME562 Mechanics II (Dynamics)	4–0
HCP Conference Procedures	2–0
HJB Military Law II	3–0
	17–5

EIGHTH TERM

SLA Leadership and Administration	4–0
EE022 Electrical Circuits and Machinery II	5–3
Ph014 General Physics IV	4–2
Mn10 Introduction to Economics	4–0
	17–5

NINTH TERM

OAA/OAV Naval Aviation	3–0
SNA Marine Piloting and Radar Navigation	2–2
EDC Damage Control and ABC Warfare Defense	4–0
Es271 Electronics I	4–2
HNS Organization for National and International Security	3–0
	16–4

TENTH TERM

OAS Anti-Submarine Warfare	4–0
OMS Missiles and Space Operations	6–0
Es272 Electronics II	4–2
HIR International Relations	3–0
	17–2

*BACHELOR OF ARTS CURRICULUM SCHEDULE

FIRST TERM

Ma021 Introduction to Algebraic Technique	5–0
**HCA Review of English Grammar	0–0
HPA U. S. Government	4–0
HSP Public Speaking	2–0
HSY Introduction to Psychology	3–0
Mn10 Introduction to Economics	4–0
	18–0

SECOND TERM

Ma022 Calculus and Finite Mathematics I	5–0
EGM Marine Engineering	4–0
HCB Composition	2–0
HCP Conference Procedures	2–0
HHC European History I	3–0
HLA Appreciation of Literature I	3–0
	19–0

THIRD TERM

Ma023 Calculus and Finite Mathematics II	5–0
Ph001 General Physics I	3–0
HEH European History II	4–0
HLB Appreciation of Literature II	3–0
Mn113 Intermediate Economics	4–0
	19–0

FOURTH TERM

SLO Logistics and Supply	3–0
Ph002 General Physics II	4–0
HCC Expository Logic	3–0
HHA U. S. History I	4–0
HLC American Literature	3–0
HPT Political Thought	4–0
	21–0

FIFTH TERM

OAO Amphibious Operations	3–0
ORW Restricted Weapons	3–0
SMN Command Seamanship	3–0
	9–0

SIXTH TERM

Ph003 General Physics III	4–0
HJA Military Law I	3–0
HLD British Literature	3–0
HUH U. S. History II	4–0
Mn114 International Economics	4–0
	18–0

SEVENTH TERM

OTC Tactics and CIC	3–2
Ph004 General Physics IV	4–0
HIL International Law	4–0
HJB Military Law II	3–0
HNS Organization for National and International Security	3–0
	17–2

EIGHTH TERM

OAA/OAV Naval Aviation	3–0
OAS Anti-Submarine Warfare	4–0
OOP Operational Planning	3–0
HAD American Diplomacy	4–0
HPJ Theory and Principles of International Relations	4–0
	18–0

NINTH TERM

OMS Missiles and Space Operations	6–0
HPM International Communism	4–0
HPN American Traditions	3–0
HPO Military Warfare and Seapower	3–0
	16–0

TENTH TERM

OCM Communications	3–0
OFC Naval Ordnance and Fire Control	3–0
SLA Leadership and Administration	4–0
SNA Marine Piloting and Radar Navigation	2–2
EDC Damage Control and ABC Warfare Defense	4–0
	16–2

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

**No credit. To be taken by students who fail the English Entrance Examination and by others with permission from Head of Department.

Note 1: The above are for August input; for a March input, leave will occur during the 7th instead of the 5th term with a slight modification in the schedule.

Note 2: Courses designated by letters and numbers (e.g., Ma031 or Mn10) are given by the Engineering School or Management School. Descriptions of these courses are contained in the catalogues of the Engineering and the Management Schools.

SPECIAL PROGRAMS

The courses offered by the Generai Line and Naval Science School are also utilized in special programs individually designed to meet the needs of women officers, law officers, and foreign naval officers who are ordered to the school for instruction. In most cases special programs extend over four terms, except that women and law officers are usually limited to two terms.

READING ACCELERATION

Outside instruction is available from the Speech instructors for students who are slow readers. Early use of this assistance is urged for maximum benefit.

COURSE DESCRIPTION

COURSE DESCRIPTION, PREREQUISITES, AND EXEMPTIONS

OTC TACTICS AND COMBAT INFORMATION CENTER (3-2). Shipboard tactical doctrine and procedures, and the functions and organization of CIC. USUAL BASIS FOR EXEMPTION: Qualified Destroyer Type OOD, or CIC School of 4 weeks or longer and qualified CIC Officer.

OCM OPERATIONAL COMMUNICATIONS (3-0). Essentials of operational communications, including doctrine, organization, radio and visual procedures, command responsibilities, Registered Publications System, Technical (Code 4) Publications and Communications Plans. USUAL BASIS FOR EXEMPTION: (a) Completion of NAVPERS 10916, 10918, and 10760, or 10403, 10996, and 10760 or (b) Appropriate formal communications course or (c) Appropriate experience in communications duties.

OAA AVIATOR'S AVIATION (3-0). A study of the present-day responsibilities and problems peculiar to a squadron commander. Course includes (a) a review of applied aerodynamics, (b) responsibilities associated with personnel, material, doctrine, training, morale, public relations, and continuous education of pilots and mechanics, and (c) aviation safety. PREREQUISITE: Designation as Naval Aviator. USUAL BASIS FOR EXEMPTION: Served as Commanding Officer of a fleet squadron or a graduate of a formal Test Pilot Training Course.

OAV NAVAL AVIATION SURVEY (3-0). Organizational structure and command relationship of entire naval aviation system; research and development, procurement, testing and evaluation of naval aircraft; specific discussions based on latest material available on missions, tasks, current and projected equipment, as well as present and future employment of aircraft squadrons, carriers and seaplane tenders. USUAL BASIS FOR EXEMPTION: Extensive aviation duty.

OOP OPERATIONAL PLANNING (3-0). Purpose and procedure for the Estimate of the Situation, the Development of the Plan, and the Preparation of the Directive (OpOrder); including the preparation of each under supervision. Staff organization. The Navy Planning System. PREREQUISITE: Facility in English Composition. USUAL BASIS FOR EXEMPTION: Naval War College Correspondence course "Strategy and Tactics (Part I)" or "Operational Planning and Staff Organization."

OAO AMPHIBIOUS OPERATIONS (3-0). Basic Orientation, to include doctrine, planning and fundamentals of troop organization, helicopter operations, embarkation, ship-to-shore movement, and coordination of supporting arms. USUAL BASIS FOR EXEMPTION: Completion of a Marine Corps or Amphibious Forces School and/or a tour of duty with an amphibious staff at PhibRon level or higher.

OAS ANTI-SUBMARINE WARFARE (4-0). Surface, air, and sub-surface ASW doctrine. Submarine operating characteristics, offensive and defensive tactics, and weapons. ASW search, detection, and attack procedures, and weapons systems. Coordinated ASW operations are emphasized. Allied officer students are offered a special course. PREREQUISITE: OTC (or exempt therefrom). USUAL BASIS FOR EXEMPTION: Recent completion of: Coordinated ASW Course at NORFOLK, SAN DIEGO, LONDONDERRY, or HALIFAX, or ASW Officer or CO/XO Anti-Submarine Course at Fleet Sonar School.

OAT ADVANCED TACTICS (3-0). A survey of the status of fleet readiness and future concepts in various tactical fields, followed by student reports and seminars on selected Fleet and Intertype Exercises. PREREQUISITE: OTC (or exempt therefrom).

OFC NAVAL ORDNANCE AND FIRE CONTROL (3-0). A survey of the fields of surface and airborne ordnance including guns, bombs, rockets, and associated delivery systems. A discussion of the elements of present fire control systems, including computers, radar, and designation systems. An analysis of the capabilities and limitations of both present fire control surface and airborne, from the standpoint of weapons systems evaluation and employment. A special course, OFC(F), (3-0) is offered for Allied officer students. USUAL BASIS FOR EXEMPTION: Completion of USNA, NROTC, or equivalent courses in naval ordnance and fire control and service experience in these fields.

OMW MINE WARFARE (3-0). Fundamentals of Mining Operations including mines, mine laying agents and mining planning; Principles of Mine Countermeasures Operation and Planning; Harbor Defense, and New Developments. A special course, OMW(F) (3-0) is offered to Allied officer students.

ORW RESTRICTED WEAPONS (3-0). Characteristics, capabilities, limitations and employment of current nuclear weapons and those under development. Foreign Officers are excluded. USUAL BASIS FOR EXEMPTION: Attendance within the previous two years at a one week nuclear weapon orientation course given by DASA or Nuclear Weapons Training Center, Pacific or Atlantic; or within the previous three years at a planning or employment course given by one of the above commands.

OMS MISSILES AND SPACE OPERATIONS (6-0). Principles of guidance and propulsion, operational capabilities and limitations of guided missile systems. Orientation in space technology, problems and potentialities of operations in outer space. A special course OMS(F) (3-0) is offiered to Allied officer students. USUAL BASIS FOR EXEMPTION: Equivalent experience or educational background.

OTD INTRODUCTION TO NAVAL TACTICAL DATA SYSTEM (3-0). A brief review of number systems with concentration in octal and binary operations. An introduction to Boolean algebra and logic circuitry of modern computers. Modern high-speed digital computer principles. An introduction to operational programming for NTDS. A comprehensive coverage of the Naval Tactical Data System and its associated elements, its capabilities and limitations as planned for CVA(N), GG(N) and DLG types.

SMN COMMAND SEAMANSHIP (3-0). The fundamentals of seamanship as applicable to the responsibilities and duties assigned to the commanding officer on board ship. Included topics: shiphandling; anchoring and mooring and associated tackle; officer of the deck function at sea and inport; underway replenishment; heavy weather procedures; shipboard honors and ceremonies; marine collision laws including international and inland rules of the road with court interpretations; emergency shiphandling. Usual basis for exemption qualified OOD underway or CO Fleet Type Vessel.

SNA MARINE PILOTING AND RADAR NAVIGATION (2-2). Practical aspects of shipboard navigation, including marine piloting, radar and loran navigation. Included topics: charts; buoys; navigation lights; tides and currents; magnetic and gyro compasses; the navigator's records; voyage planning; electronic navigation devices. Practical work covers the use of hydrographic publications and performance of chart work. USUAL BASIS FOR EXEMPTION: Successful completion of USNA, NROTC, OCS or equivalent course; or previous assignment as navigator (assistant navigator of large ship) for one year.

SNB CELESTIAL NAVIGATION (3-0). The theory and practice of celestial navigation as applicable to the navigator's work at sea. Included topics: introduction to nautical astronomy; the use of the nautical almanacs and the H.O. 214; the applications of celestial navigation. Practical work covers the navigator's day's work at sea.

SME METEOROLOGY (3-0). The principles of meteorology and the effects of weather phenomena on naval operations. Included topics: structure of the atmosphere; weather elements; the station model; pressure and winds; theory of air masses and fronts; tropical storms; sources of weather information; sea and surf conditions; climatology and the principles of weather map analysis and forecasting.

SLA LEADERSHIP (4-0). The improvement of Naval Leadership by broadening the line officer's knowledge and understanding of the following topics: methods and techniques of enlisted personnel administration; applications of the principles of management to the naval unit; philosophy of authority and responsibility with major emphasis on the principles of effective naval leadership. Instruction methods emphasize individual study projects and group study discussion.

SLO LOGISTICS AND NAVAL SUPPLY (3-0). The vital importance of naval logistics to operational readiness, logistic problems at the Commanding Officer level, the fundamental steps in the logistics process, and the Navy's system for providing logistic support to the operating unit. Topics covered include: determination of requirements, procurements, and distribution as steps in the logistics process; the organization and planning aspects of logistics administration; the Navy Supply System; Joint Logistic Procedures; funding; the role of bases, mobile support, and the operating unit in naval logistics; and logistics management at the operating level. USUAL BASIS FOR EXEMPTION: Completion of the Naval War College course in Logistics.

SNI NAVAL INTELLIGENCE (3-0). An overview of intelligence functions. Included topics: nature of intelligence; development of modern intelligence; the role of intelligence in planning national policy and military strategy; the rise of Russia and Communism as international forces; the intelligence cycle, including the line officers role in intelligence collection; employment of intelligence by operational commanders; counter-intelligence.

SAF PERSONAL AFFAIRS (3-0). The fundamentals of personal estate planning. Included topics: government benefits; life insurance and general insurance; budgeting and banking; borrowing; real estaate; securities, wills and related legal matters.

EPH SURVEY OF PHYSICS (5-0). An introduction to the fundamental concepts and laws of statics and dynamics, including Newton's laws of motion, force, energy, momentum, and harmonic motion. Survey of gas laws, heat, wave propagation, sound, and the properties of light. USUAL BASIS FOR EXEMPTION: Equivalent educational background. TEXT: WHITE, *Modern College Physics, 3rd Ed.* PREREQUISITE: Ma-010 or equivalent.

EEF ELECTRICAL FUNDAMENTALS (4-0). A presentation of basic electrical phenomena. Topics include: DC circuits and components, magnetism, electromagnetism, instruments, AC circuits and components, resonance, transformers, batteries, and power sources. TEXT: HICKEY *and* VILLINES, *Elements of Electronics* and JACOBOWITZ, *Electricity Made Simple.*

ERF ELECTRONICS FUNDAMENTALS (4-0). A qualitative approach to the fundamentals of electronics. Topics include: vacuum tubes, gas-filled tubes, cathode ray tubes, transistors, rectifiers, amplifiers, oscillators, modulators, detectors, receivers, transmitters, antennas and propagation. USUAL BASIS FOR EXEMPTION: Equivalent educational background. TEXT: HICKEY *and* VILLINES, *Elements of Electronics* and JACOBOWITZ, *Electronics Made Simple.* PREREQUISITE: EEF or equivalent.

ENF NUCLEONICS FUNDAMENTALS (3-0). A study of atomic structure, natural and artificial radioactivity, nuclear structure, nuclear fission, and chain reaction. Introduction to reactor principles, reactor components, and nuclear power plants. USUAL BASIS FOR EXEMPTION: Equivalent educational background. TEXTS: HOISINGTON, *Nucleonics Fundentals and* NAVPERS 10786, *Basic Nuclear Physics.*

ENP MARINE NUCLEAR PROPULSION (2-0). An introduction to nuclear power plants of possible use in marine propulsion. Includes principles of operation, fuels and materials, limitations and economy of various reactors, and a brief description of reactor power plants currently in use. PREREQUISITES: EGM and ENF, or equivalent.

EEM ELECTRICAL MACHINERY (4-1). The fundamentals and applications of electrical machinery. Topics include: external characteristics of shunt and compound generators; shunt, series and compound motors; alternators; induction and synchronous motors; parallel operation of alternators and generators. Laboratory testing and demonstrations are utilized. TEXT: DAWES, *Electrical Engineering, Parts I and II.* PREREQUISITE: EEF or equivalent.

EMT MATERIALS OF ENGINEERING (4-0). A rapid survey of basic physical metallurgy of both ferrous and nonferrous metals with emphasis placed on their engineering application; followed by a survey of fuels, lubricants, plastics and special problems involving fiber glass reinforcing. TEXTS: COONAN, *Principles of Physical Metallurgy;* KINNEY, *Engineering Properties and Applications of Plastics.*

EGM MARINE ENGINEERING (4-0). Shipboard steam main propulsion plants and auxiliaries, Diesel engines, shipboard electrical distribution, miscellaneous naval auxiliary machinery, and organization and administration of shipboard engineering department. USUAL BASIS FOR EXEMPTION: Qualification as Engineering Officer of the Watch of a steam-propelled ship.

EDC DAMAGE CONTROL AND ATOMIC, BIOLOGICAL, CHEMICAL WARFARE DEFENSE (4-0). Fundamentals of ship construction and stability, stability calculations and analysis, damage control systems and organization, repair of damage; effects of ABC weapons, ABC detection, decontamination and personnel protection; disaster control ashore. PREREQUISITE: ENF or equivalent. USUAL BASIS FOR EXEMPTION: Completion of 10 weeks "Officers' Basic Damage Control" Course, or completion of correspondence courses "Practical Damage Control" (NAVPERS 10936), "Theoretical Damage Control" (NAVPERS 10937), and "Radiological Defense" (NAVPERS 10771).

HCA ENGLISH A REVIEW OF ENGLISH GRAMMAR. A review of the basic principles of English grammar and exercise in the writing of papers. To be taken by students who fail the English Entrance Examination or others with the permission of the Head of Department.

HCB ENGLISH 10 COMPOSITION (2-0). An analysis and application of the techniques of expository writing. Lectures, discussions, and preparation of papers by the students.

HCC ENGLISH 102 EXPOSITORY LOGIC (3-0). A study of the elementary principles of symbolic and expository logic to develop clear thinking and proof in the presentation of ideas.

HCD ENGLISH 103 SEMINAR IN RESEARCH TECHNIQUES (1-0). A study of principles and techniques of research writing.

HCE ENGLISH 120 THE ENGLISH LANGUAGE (2-0). Lectures and exercises on the English language; its history, vocabulary, and usage.

HGA GEOGRAPHY 101 POLITICAL GEOGRAPHY (3-0). A study of world areas, regions, and countries; peoples, their distribution and political organizations.

HGB GEOGRAPHY 102 ECONOMIC GEOGRAPHY (3-0). A study of the natural resources, technologies and industrial complexes of areas, regions and countries, with emphasis on strategic implications.

HHA HISTORY 101 U. S. HISTORY 1763-1865 (4-0). The development of the Federal Union from the American Revolution to the end of the Civil War.

HUH HISTORY 102 U.S. HISTORY 1865-present (4-0). The development of the American nation from the reconstruction crisis to the present.

HHC HISTORY 103 EUROPEAN HISTORY 1871-1919 (3-0). The international, internal and military development of the major European states in the period before World War I.

HEH HISTORY 104 EUROPEAN HISTORY 1919-present (4-0). The international, internal, and military development of the major European states since World War I.

HLA-HLB LITERATURE 10A-10B APPRECIATION OF LITERATURE (3-0, 3-0). An introduction to the understanding and enjoyment of literature expressing the enduring problems of mankind. Style and structure will be considered as well as content. Some attention will be paid to *genres* and periods of literature. 10A is not a prerequisite to 10B.

HLC LITERATURE 101 MASTERPIECES OF AMERICAN LITERATURE (3-0). A study of those ideas which have shaped American cultural life and reflect American thinking.

HLD LITERATURE 102 MASTERPIECES OF BRITISH LITERATURE (3-0). A study of the significant ideas of selected British thinkers as they pertain to social and cultural life.

HLE LITERATURE 103A-103B MASTERPIECES OF EUROPEAN LITERATURE (3-0, 3-0). A study of the significant ideas of European writers. Play, novels, short stories, essays, and criticisms will be read and discussed. 103A covers the period from early times to the end of the Renaissance. 103B covers the period from the Renaissance to the present time.

HLF LITERATURE 104A-104B-104C MASTERPIECES OF RUSSIAN LITERATURE (3-2-2) A study of selected Russian and Soviet writers to demonstrate the role of literature in Russian and Soviet life and culture. 104A A survey of Russian literature from the early period through the 19th century, exclusive of the novel. (3-0). 104B A study of the Russian novel of the 19th century (2-0). 104C A study of Soviet literature.

HLG LITERATURE 105 PHILOSOPHICAL TRENDS IN MODERN LITERATURE (3-0). An examination of modern literature expressing social, psychological, and cultural problems in order to show how literature reflects the aspirations and the frustrations of modern man. PREREQUISITE: Permission of head of Department.

HLH LITERATURE 106 THE LITERATURE OF NORTHERN EUROPE (2-0). A study of selected writers of Germany, Scandinavia, and the British Isles with particular reference to the dramatists such as Hauptmann, Ibsen, Strindberg, and Shaw to demonstrate their influence on the social and philosophical thinking of their times.

HLI LITERATURE 107 THE AMERICAN NOVEL (2-0). A study of the novel in the United States from Charles Brocken Brown to William Faulkner.

HPA GOVERNMENT 101 U.S. GOVERNMENT (4-0). A study of the structure and powers of the Federal Government, its relation to the individual states, and its military aspects.

HNS GOVERNMENT 102 ORGANIZATION FOR NATIONAL AND INTERNATIONAL SECURITY (3-0). The factors of power, geopolitics, national security; the evolution, structure, organization and functions of the organs and agencies for U.S. national defense, the United Nations, and regional organizations.

HAD GOVERNMENT 103 AMERICAN DIPLOMACY (4-0). An analysis of the major problems of United States foreign relations in Europe, Latin America, and the Far East from 1900 to the Korean conflict.

HAP GOVERNMENT 104 GOVERNMENT AND POLITICS OF ASIA (4-0). The international, internal, and military problems of the major Asian and Southeast Asian states, exclusive of Communist China.

HIR GOVERNMENT 105 INTERNATIONAL RELATIONS (3-0). A study of the nation-state system, the forces making for conflict, adjustment, and harmony, with emphasis on nationalism, imperialism, war, and diplomacy. PREREQUISITE: HNS GOVERNMENT 102.

HIL GOVERNMENT 106 INTERNATIONAL LAW (4-0). A survey of the basic principles of International Law with emphasis on jurisdiction and the rules of warfare. Case and problem discussions.

HME GOVERNMENT 107 THE MIDDLE EAST (3-0). A study of political, economic, social, cultural and strategic aspects of the contemporary Middle East and its role in international relations.

HPH GOVERNMENT 108 COMPARATIVE GOVERNMENT (4-0). A study of the nature, organization and operation of modern authoritarian, democratic and non-democratic governments of the major powers. PREREQUISITE: HPA GOVERNMENT 101.

HPI GOVERNMENT 109 ATLANTIC COMMUNITY (3-0). A study of the states in the Atlantic Community; their political, economic, military, ideological, and sociological relations, both regional and international.

HPJ GOVERNMENT 110 THEORY AND PRINCIPLES OF INTERNATIONAL RELATIONS (4-0). A seminar in the scope and theories of International Relations and techniques of research in the field; the analysis of problems.

HPK GOVERNMENT 111 LATIN AMERICA (3-0). A study of contemporary Latin America with emphasis on the problems and objectives of the constituent states, their regional and international relationships.

HPL GOVERNMENT 112 SINO-SOVIET BLOC (4-0). An analysis of the international relations of Communist China, Soviet Russia, and their respective satellites with emphasis on their military significance to the United States.

HPM GOVERNMENT 113 INTERNATIONAL COMMUNISM (4-0). A study of Communism; its development, strategy and tactics, subsequent interpretations and successes and failures.

HNP GOVERNMENT 114 AMERICAN TRADITIONS AND IDEALS (3-0). The traditions, ideals and values of our civilization and the role of the military in implementing the image of America in the world. PREREQUISITE: HISTORY 101 or 102.

HPO GOVERNMENT 115 THEORY OF MILITARY WARFARE AND SEA POWER (3-0). A study of strategic concepts, their conflicts in implementation of national objectives, and development of the science of naval warfare and weaponry in relationship to national power. PREREQUISITE: Permission of Head of Department.

HPP GOVERNMENT 116 GREAT ISSUES (3-0). Seminar on the issues confronting the United States correlating the knowledge gained in previous courses in order to develop responses to the challenges facing the United States. PREREQUISITE: Permission of Head of Department.

HAF GOVERNMENT 117 SUB-SAHARA AFRICA (3-0). A study of contemporary Africa south of the Sahara with emphasis on emerging political institutions and analysis of major developing economic, social and cultural patterns.

HPT GOVERNMENT 118 DEVELOPMENT OF POLITICAL THOUGHT (4-0). An historical and analytical study of major Western political thought from Plato to the present with emphasis on the development of democratic philosophies and the development of modern totalitarian philosophies. Readings from original sources.

HJA GOVERNMENT 119 MILITARY LAW (3-0). The principles of Military Law as included in the Uniform Code of Military Justice, the Manual for Courts-Martial and the Manual of the Judge Advocate General. Topics include: jurisdiction; charges and specifications; substantive law; and the law of evidence.

HJB GOVERNMENT 120 MILITARY LAW (3-0). Procedural aspects of Military Law and relations with civil authorities in legal matters. Topics include: non-judicial punishment; courts of inquiry; investigations; summary and special courts-martial; trial techniques; civil and criminal process. PREREQUISITE: HJA GOVERNMENT 119.

HSY PSYCHOLOGY 10 INTRODUCTION TO PSYCHOLOGY (3-0). A survey of principles underlying human behavior with emphasis on the application of these principles to human relations and problems of social adjustment.

HYB PSYCHOLOGY 101 APPLIED PSYCHOLOGY (3-0). A study of group dynamics, rating procedures, criminology, and personality formation and adjustment. Individual projects are assigned. PREREQUISITES: PSYCHOLOGY I.

HSP SPEECH 10 PUBLIC SPEAKING (2-0). Practice in speaking effectively on subjects and in situations dealing with subject pertinent to Naval officers.

HCP SPEECH 11 CONFERENCE PROCEDURES (2-0). Theory and practice in group dynamics applied to conferences, emphasizing completed staff work in group problem solving.

HSB SPEECH 101 ADVANCED SPEECH (2-0). A study through practice of techniques in obtaining desired audience response. PREREQUISITE: SPEECH 10.

HDS UNDESIGNATED 199 (1-0) (3-0). Independent study in Social Science and Humanities subjects in which formal course work is not offered. PREREQUISITE: Permission of Head of Department.

GENERAL LINE CURRICULUM

TABULATION OF COURSE OFFERINGS BY DEPARTMENTS

Course Title	Short Title	Hours per Week Class	Hours per Week Lab.	Total Credit	*Scheduling Classification Men	*Scheduling Classification Women
NAVAL WARFARE DEPARTMENT						
Aviator's Aviation	OAA	3	0	3	x	o
Naval Aviation Survey	OAV	3	0	3	x	y
Amphibious Operations	OAO	3	0	3	x	o
Anti-Submarine Warfare	OAS	4	0	4	x	o
Advanced Tactics	OAT	3	0	3	y	o
Operational Communications	OCM	3	0	3	x	x
Naval Ordnance and Fire Control	OFC	3	0	3	x	o
Missiles and Space Operations	OMS	6	0	6	x	y
Mine Warfare	OMW	3	0	3	y	o
Operational Planning	OOP	3	0	3	x	y
Restricted Weapons	ORW	3	0	3	x	y
Tactics and Combat Information Center	OTC	3	2	4	x	o
Introduction to Naval Tactical Data System	OTD	3	0	3	y	o
SEAMANSHIP AND ADMINISTRATION DEPARTMENT						
Personal Affairs	SAF	3	0	3	y	y
Leadership	SLA	4	0	4	x	x
Logistics and Naval Supply	SLO	3	0	3	x	x
Meteorology	SME	3	0	3	y	y
Command Seamanship	SMN	3	0	3	x	y
Marine Piloting & Radar Navigation	SNA	2	2	3	x	o
Celestial Navigation	SNB	3	0	3	y	o
Naval Intelligence	SNI	3	0	3	y	x
APPLIED ENGINEERING DEPARTMENT						
Damage Control and ABC Warfare Defense	EDC	4	0	4	x	y
Electrical Fundamentals	EEF	4	0	4	x	o
Electrical Machinery	EEM	4	1	4½	y	o
Marine Engineering	EGM	4	0	4	x	o
Materials of Engineering	EMT	4	0	4	y	o
Nucleonics Fundamentals	ENF	3	0	3	x	y
Marine Nuclear Propulsion	ENP	2	0	2	y	o
Survey of Physics	EPH	5	0	5	x	o
Electronics Fundamentals	ERF	4	0	4	x	o
Basic Algebra and Trigonometry I	Ma010	4	0	3	x	o
Basic Algebra and Trigonometry II	Ma011	3	0	3	y	o
Algebra and Trigonometry Refresher	Ma015	4	0	3	x	o
Survey of Analytic Geometry and Calculus	Ma016	4	0	4	y	o
GOVERNMENT AND HUMANITIES DEPARTMENT						
International Law	HIL	4	0	4	y	x
International Relations	HIR	3	0	3	y	x
Organization for National and International Security	HNS	3	0	3	y	x
Military Law I	HJA	3	0	3	x	x
Military Law II	HJB	3	0	3	x	x
Public Speaking	HSP	2	0	2	x	x
Conference Procedures	HCP	2	0	2	x	x

* x—*Required course unless exemption granted*
y—*Elective*
o—*Not applicable to women students*

NOTES and MEMORANDA

NOTES and MEMORANDA

UNITED STATES NAVAL
POSTGRADUATE SCHOOL

Catalogue for 1962-1963

THE MANAGEMENT SCHOOL

MONTEREY ★ CALIFORNIA

THE NAVY MANAGEMENT SCHOOL

Director

HERBERT HENRY ANDERSON
Captain, U.S. Navy
B.S., USNA, 1941
M.B.A., Harvard Univ., 1953
National War College, 1958

Assistant Director

LESTER ALLEN REDDING
Commander, U.S. Navy
A.B., George Washington Univ., 1956
M.S., U.S. Naval Postgraduate School, 1961

Academic Coordinator

H. PAUL ECKER (1957)*
Professor of Management
A.B., Pomona College, 1948
A.M., Claremont Graduate School, 1949

Administrative Officer

RUTH MILDRED BOSIER
Lieutenant Commander, U.S. Navy
A.B., Western State Teachers College, 1935

STAFF

OSCAR RICHEY BLANTON, Commander, SC, U.S. Navy; Military Instructor; B.S., Ohio State Univ., 1942; M.B.A., Stanford Univ., 1952.

WILLIAM HOWARD CHURCH, Professor of Management (1956); A.B., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

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

J. HUGH JACKSON, JR., Professor of Management (1957); A.B., Stanford Univ., 1939; M.B.A., 1947.

LOUIS B. KAHN, Associate Professor of Operations Research and Management (1961); B.S., A.S., Illinois Institute of Technology, 1940; M.S., Univ. of Wisconsin, 1948; Ph.D., Univ. of Wisconsin, 1951.

EDWARD LESLIE MACCORDY, Lieutenant Commander, CEC, U.S. Navy; Military Instructor; B.S., Tufts College, 1947; M.S., Rensselaer Polytechnic Institute, 1957.

GEORGE JOSEPH M. MCGEE, Commander, U.S. Naval Reserve; Military Instructor; B.A., St. Joseph's College, 1937; M.S., George Washington Univ., 1961.

PATRICK J. PARKER, Associate Professor of Management (1962); A.B., M.B.A., Univ. of Chicago, 1955.

JAMES EDWARD RAYNES, Commander SC, U.S. Navy; Military Instructor; A.B., Stanford Univ., 1939; A.M., 1947.

JOHN DAVID SENGER, Assoc. Professor of Management (1957); B.S., Univ. of Illinois, 1945; M.S., 1948.

TORE TJERSLAND, Assoc. Professor of Management (1961); B.S., Univ. of Colorado, 1950; M.B.A., Syracuse Univ., 1953; Ph.D., Stanford Univ., 1961.

**Date in parenthesis indicates year of joining the Postgraduate School faculty.*

MISSION

The mission of the Navy Management School is to provide graduate education for naval officers in the theories, philosophies, and application of scientific methods of management specifically oriented to the Navy in order to advance efficiency and economy of operation, afloat and ashore.

TASKS

The tasks assigned the Navy Management School are:

1. To conduct an educational program in management at the graduate level for naval officers.
2. To provide courses of instruction in management for curricula in other schools of the Postgraduate School.
3. To conduct for naval officers a basic survey course of four weeks duration in the summer term in the "Elements of Management."
4. To act as host for Bureau and Office sponsored workshop seminars in management in conjunction with the "Elements of Management."

PROGRAMS

The Navy Management Course

The Navy Management Course is a ten months' course at the graduate level which leads to the degree, Master of Science in Management. The course convenes once yearly, commencing in August. The curriculum is under the direction of a faculty composed of civilian and naval officer instructors selected to represent the optimum combination of specialized knowledge and diversity of management experience.

The purpose of education in management is to broaden the officer's scope of learning, in order that he may enhance his ability to organize, plan, direct, coordinate, and control activity in which he, through the leadership of people, combines the resources of money and materials to accomplish the Navy's objectives. The naval officer, commander or executive, is continuously concerned with promoting his organization and determining its objectives, with the consideration of the means to these ends, and with the implementation of his decisions through appropriate delegation of duties and the effective motivation of personnel.

In fulfillment of these demands upon the naval officer, the Navy Management Course has the following objectives:

1. To develop comprehensive understanding by the officer of management in the operating forces and the shore establishment of the Navy.

2. To develop a sound appreciation by the officer for the interaction of the Navy's mission with public and defense policies.

3. To cultivate the habits of analysis for determination of pertinent facts, of reasoned decision making, and of imaginative thinking in the development of alternative courses of action.

4. To provide the officer with the quantitative tools of analysis and to foster the use of scientific method in management functions.

5. To encourage the officer in the development of ethical standards for professional and personal use.

6. To develop an appreciation for the human factor in the realization of organizational objectives.

The curriculum is structured to require all officers, regardless of code designator, to participate in the required "core" courses. These courses provide the foundation and tools of management and lead into the electives. The elective system offers moderate flexibility to meet the interests of the individual officer and provides limited specialization in fields of interest to the various supporting agencies. Elective courses are offered in the third and fourth terms.

Instruction is conducted by classroom lecture, case study, and seminar discussion. Throughout, the course stresses development of the officer's ability in problem solving and in expressing his thoughts concisely and meaningfully in oral and written work.

The classroom instruction program is supplemented by a special lecture series wherein the officer has the opportunity to hear discussion of management topics by Flag Officers of the military services, business executives, and educators of comparable rank from the civilian community. Additionally speakers from civilian and military activities are scheduled at appropriate times to augment the classroom instruction in various technical and specialized areas.

Through the medium of a field trip to visit industrial concerns, usually of two or three days duration, the officer is afforded the opportunity of discussing management philosophy and problems with leading executives in their own environment. The field trip takes place during the latter part of the academic year.

Entrance Standards

Officers assigned to the Navy Management Course should have demonstrated previously a high degree of potential for growth and executive responsibility.

Officers entering the Navy Management Curriculum must possess a baccalaureate degree or the equivalent from an accredited institution or institutions. The equivalency of the degree shall be interpreted as the successful completion of 120 semester hours of work from an accredited institution of higher learning, excluding those courses in which a grade below C was received.

There is a wide range of undergraduate majors which provide adequate preparation for the Navy Management Curriculum. It is required, however, that officers entering the Navy Management School have completed a basic course in college algebra. Review of this subject is strongly encouraged in the period between receipt of orders and reporting for instruction.

Degree Candidacy

An officer possessing a baccalaureate degree from an accredited institution normally shall be admitted to candidacy for the Master's degree upon enrollment. Officers lacking the baccalaureate degree, but having the equivalency as described above, shall be required to demonstrate quality of work at the B grade level for the first academic term before being admitted to candidacy for the Master's degree.

Requirements for the Master of Science

Degree in Management

The degree Master of Science in Management is conferred by the Superintendent upon the successful completion of a curriculum which has been approved by the Academic Council of the Navy Management School as meriting a degree, provided the specific requirements are met as stated in the paragraphs which follow:

a. The student shall remain in residence a minimum of one academic year (four terms).

b. The student shall complete not less than sixty term hours (forty semester hours) of course work which must include all the required or "core" courses.

c. To be eligible for the Master's Degree, the student must attain a minimum average quality point rating of 2.0. In special cases and under very extenuating circumstances, minor deficiencies may be waived at the discretion of the Academic Council.

d. The student shall be required to demonstrate proficiency in oral and written presentation, and to demonstrate the qualities of scholarly investigation and analysis.

e. The student must be recommended to the Superintendent by the Academic Council as meriting the award of the Master's Degree in Management and as having fulfilled requirements of a., b., c., and d., above.

Requirements for the Bachelor of Science Degree in Management

1. The degree Bachelor of Science in Management is offered for a few highly selected officers who have completed the equivalent of three or more years of college, and have satisfied the general education requirement for a Bachelor's degree.

2. The degree Bachelor of Science in Management is also offered for those officers who have Bachelor's degrees in other areas but who lack the necessary prerequisites for fulfilling the requirement set forth for the Master of Science degree in Management.

3. The degree Bachelor of Science in Management is conferred by the Superintendent upon the successful completion of a curriculum which has been approved by the Academic Council of the Navy Management School as meriting a degree subject to the following specific requirements:

a. The student shall remain in residence a minimum of one academic year (four terms).

b. The student shall complete not less than 60 term hours (40 semester hours) of course work which must include all the required or "core" courses.

c. To be eligible for the Bachelor's degree, the student must attain a minimum average quality point rating of 1.0.

d. The student must be recommended to the Superintendent by the Academic Council of the Navy Management School as meriting the award of the Bachelor's degree in Management and as having fulfilled requirement (a), (b), and (c) above.

Certificate of Course Work Completed

1. Students who do not qualify for either the Master's degree or the Bachelor's degree in Management shall be awarded a Certificate of Completion upon the conclusion of an approved course of study.

Grading Standards

To evaluate the performance of each student, a quality point number is assigned for each letter grade achieved by the student in his courses as follows:

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

When the term hour value of a course is multiplied by the quality point number of the student's grade, a quality point value of the student's work in that course is obtained. The sum of the quality points for all courses divided by the sum of the term hour value of all courses gives a weighted numerical evaluation of the student's performance termed the Quality Point Rating (QPR). A student achieving a QPR of 2.0 has maintained a B average in all courses.

The Course "Elements of Management"

This course is of four weeks' duration, presented once a year in the summer. It is a basic survey course in management, designed for officers attending the Engineering School of the U. S. Naval Postgraduate School. It is also of value for selected officers who may be sponsored by Bureaus and Offices of the Naval Establishment, and who will be attending the workshop seminars.

The curriculum is designed to:

1. Acquaint the officer with the principles of management and administration.
2. Examine current problems of management within the Naval Establishment and general approaches to the solution of these problems.
3. Familiarize the officer with the modern practice and method of management in civilian activities with emphasis on relationship to their applications within the Naval Establishment.

No special preparation or qualification for this course is required.

Workshop Seminars

In conjunction with the aforementioned program, the Navy Management School acts as host to Bureaus and Offices which desire to sponsor special programs and workshop seminars. The classroom program may be expected to form an excellent base for further discussion of special problems.

TABLE I

NAVY MANAGEMENT CURRICULUM (TEN MONTHS)
REQUIRED COURSES

No.	*Course Title*	*Hours*
Mn-400	Individual Research	(4-0)
Mn-410	Management Economics	(5-0)
Mn-420	Financial Management I	(4-0)
Mn-421	Financial Management II	(4-0)
Mn-440	Industrial Management	(4-0)
Mn-452	Management Psychology	(3-0)
Mn-453	Personnel Administration and Industrial Relations	(4-0)
Mn-463	Material Management	(3-0)
**Mn-470	Quantitative Methods	(5-0)
Mn-490	Organizational Theory and Administration	(5-0)
Mn-491	Management Policy	(3-0)
Mn-492	Government and Business	(3-0)

ELECTIVE COURSES

Mn-401	Individual Study	(3-0)
Mn-413	Economic Analysis	(3-0)
Mn-414	Seminar in International Economics	(3-0)
Mn-423	Advanced Cost Accounting	(3-0)
Mn-424	Auditing	(3-0)
Mn-425	Military Comptrollership Seminar	(4-0)
Mn-455	Personnel Administration Seminar	(3-0)
Mn-461	Procurement and Contract Administration	(3-0)
Mn-462	Scientific Inventory Management	(3-0)
Mn-473	Decision Making Techniques	(3-0)
Mn-480	Facilities Planning	(4-0)
Mn-481	Logistics	(3-0)
Mn-482	Military Planning	(3-0)
Mn-495	Organization and Management Seminar	(3-0)
*Ma-170	Calculus for Management	(3-0)
*Ma-371	Management Statistics	(3-0)
*Ma-471	Electronic Data-Processing and Management Control	(3-0)
*OA-471	Operations Analysis for Navy Management	(4-0)

COURSES GIVEN UNDER OTHER CURRICULA

Mn-10	Introduction to Economics	(4-0)
Mn-113	Intermediate Economics	(4-0)
Mn-114	International Economics	(4-0)
Mn-190	Organization and Management	(4-0)

*Officers with requisite preparation in mathematics through calculus are encouraged to elect this sequence of courses. Courses are described in the Engineering School section and presented by the Mathematics and Operations Research Departments.

**Ma-170 and Ma-371 exempt the student from the required course Mn-470, Quantitative Methods.

TABLE II

COURSE "ELEMENTS OF MANAGEMENT" (FOUR WEEKS)

Course Title	*Hours*
Principles of Organization and Management	15
Personnel Management	15
Production Management	15
Financial Management	15

COURSE DESCRIPTIONS

Mn-10 INTRODUCTION TO ECONOMICS (4-0)

A study of the operation of the American economy, its structural and institutional aspects, resources, technology, financial and monetary institutions, labor organizations and the role of government.

Mn-113 INTERMEDIATE ECONOMICS (4-0)

An analysis is made of demand, supply, the pricing of commodities, the theory of national income determination, pricing of productive services and economic dynamics.

Mn-114 INTERNATIONAL ECONOMICS (4-0)

Discussion of theories of international trade, tariff policy, exchange rates and trade control. Analysis of international economic problems and international economic organizations.

Mn-190 ORGANIZATION AND MANAGEMENT (4-0)

Study and evaluation of various management principles and practices that contribute to effective achievement of managerial goals. Emphasis is placed on human factors, as well as the "mechanics" of organization. The study of formal organization includes such topics as organization structure, span of control, methods of organizing and techniques of management control. A study of informal organization is made to increase the awareness of the officer of his responsibility to motivate through informal, as well as formal, organizational patterns. Case studies are used to illustrate typical problems encountered by both military and civilian administrators and to increase skill in problem solving and use of the scientific method.

Mn-400 INDIVIDUAL RESEARCH (4-0)

The student is expected to formulate a problem or select a topic considered by the staff of the School to be of interest and importance to Navy or Defense Management. The investigation will be undertaken independently under the supervision of one or more staff members. From his readings and observations, the student is expected to analyze the problem or topic and present his findings in a written report. The selection of the problem or topic is made early in the academic year, and the final report is submitted near the end of the course.

Mn-401 INDIVIDUAL STUDY (1-3)

Designed to give the student an opportunity to continue advanced study in some aspect of management. Consent of advisor must be secured.

Mn-410 MANAGEMENT ECONOMICS (5-0)

The nature of a capitalistic society and American modifications are studied. The necessity for efficient resource use and expanding productivity in relation to the defense effort is considered. The role of money, the determination of income and national product, the value of money and the price level, government fiscal and monetary policy are explored. International economics and economics of war and defense are evaluated. Studies are made of social goals and economic institutions of communism, capitalism, and socialism.

Mn-413 ECONOMIC ANALYSIS (3-0)

This course is designed to provide more intensive study in economic analysis with principle emphasis on value and distribution theory. Analysis is made of the behavior of business firms in their pricing, production, purchasing, and employment policies, and the relationship of the individual firm to the general pricing process.

Mn-414 SEMINAR IN INTERNATIONAL ECONOMICS (3-0)

The first half of the course is devoted to partial, general, and equilibrium theories of international trade, the advantages of trade, tariff policy, commercial policies of various countries, international agreements and international monetary institutions. The second half is devoted to an understanding of the concern of the more economically advanced nations for the well-being of the underdeveloped areas and an appreciation for the humanitarian, political, and international specialization aspects of the problem.

Mn-420 FINANCIAL MANAGEMENT I (4-0)

The course develops commercial-industrial accounting concepts; such as, accrual accounting and cost accounting, including cost budgeting and variance analysis.

Mn-421 FINANCIAL MANAGEMENT II (4-0)

Covers the concept and application of the Navy Industrial Fund; surveys accounting for appropriated funds in the Navy; develops the budget formulation and execution processes of the Navy; considers current programs for the improvement of financial management in the Department of Defense; introduces the Navy internal audit program; presents the concepts of military comptrollership.

Mn-423 ADVANCED COST ACCOUNTING (3-0)

Develops the concepts and allocation of cost, fixed versus variable cost, cost and operating budget, flexible budgets, standard cost accounting and variance analysis, applications of cost accounting for control, and utilization of cost accounting by the military organizations.

Mn-424 AUDITING (3-0)

Develops the concepts of and organization for audit, audit programs and reports, comprehensive and functional audits, utilization of audit for control, and the military applications of audit.

Mn-425 MILITARY COMPTROLLERSHIP SEMINAR (4-0)

Consists of lectures, directed reading, presentations by practicing experts, student seminar discussion, and a term report (consistent with the needs and interest of the individual student) on an approved topic related to military comptrollership.

Mn-440 INDUSTRIAL MANAGEMENT (4-0)

The student is expected to develop the ability to apply basic quantitative techniques; such as, statistics, operations research, and industrial engineering tools to business and economic problems. The course is taught with reference to a series of problems developing the role of quantitative data and techniques in management planning and control, production, financial and cost control, military logistic problems and general administration. Emphasis is placed on the study of complex systems and decision making, using both the deterministic and probabalistic approach.

Mn-452 MANAGEMENT PSYCHOLOGY (3-0)

The scope and methods of both psychology and social psychology are discussed. The individual's behavior as a lone human being and as a member of a group are examined, and individual differences considered. The adjustment process and the maladjusted individual are studied with emphasis placed on the techniques available in aiding such individuals where necessary. Communication and motivation are discussed in connection with the differing methods appropriate for small and large groups. Attention is given to aiding the manager in the development of a sound interpersonal relationship in his organization and in achieving the maximum utilization of available talent in that organization.

Mn-453 PERSONNEL ADMINISTRATION AND INDUSTRIAL RELATIONS (4-0)

The procurement, classification and utilization of personnel are examined. Motivation, group dynamics, evaluation, and training are discussed. Both the philosophy and background of Civil Service and the regulations covering the administration of its personnel are examined. Throughout the course, comparisons are made between the personnel management techniques of the Federal Government and of civilian industrial organizations.

Mn-455 PERSONNEL ADMINISTRATION SEMINAR (3-0)

A combination of case method and individual student presentation in specialized study areas is utilized. Officer students participate in discussions and presentations on such facets of personnel administration as: promotions; evaluation of performance; supervisory development; incentive programs; utilization of personnel; conditions leading to turnover of personnel; testing and classification; military-civilian relationships.

Mn-461 PROCUREMENT AND CONTRACT ADMINISTRATION (3-0)

The elements of the procurement cycle are discussed, beginning with the impact of requirements determination on procuring activities with the legal, fiscal, technical, business, production, security, facilities, inspection, and termination factors involved. The various procurement laws and regulations are analyzed with the purpose of understanding how the system of military procurement causes a rearrangement of economic and legal procedures to meet demands that cannot be satisfied by normal methods. The effects on the financial and legal aspects of the national economy are reviewed and discussed.

Mn-462 SCIENTIFIC INVENTORY MANAGEMENT (3-0)

This course covers basic concepts and formulae used in arriving at Economic Order Quantities, Reorder Points, Reorder Frequencies, and Variable Safety Levels. The course provides a basis for understanding the more scientific determination of the two decisions that create inventory: "How much" of the item is to be purchased, and "when" it is to be purchased. Basic accounting considerations for developing costs to order and hold are examined, as well as factors considered to be important in establishing safety levels of stocks. Opportunities are provided to study and analyze several research projects which introduce the use of mathematical inventory theory and their application to the inventories of the Navy Supply System.

Mn-463 MATERIAL MANAGEMENT (3-0)

This course presents the broad functions of material planning, requirements determination, procurement, distribution and control applied to the introduction, development and supply support of major military programs. A broad overview is given of the organizations of the Department of Defense, the three Departments, and the four services in the materiel management field.

Mn-470 QUANTITATIVE METHODS (5-0)

A knowledge of statistical methods and theory as applied to numerical data or observations is provided with the objective of preparing the officer to make rational decisions. In addition, this course equips the student with analytical tools required in the study of subsequent courses involving the use of scientific methods. The course includes problem formulation, data collection methods, and techniques of statistical analysis; such as, probability theory, correlation and regression, control charts, sampling distributions, and time series. The application of these mathematical techniques in areas of military management is presented as a foundation upon which intuitive decision making can be improved by the application of the tools of statistical analysis.

Mn-473 DECISION MAKING TECHNIQUES (3-0)

The course explores the application of science to decision making involving a survey of applicable tools of quantitative analysis. The instruction treats management decision making problems from over-all system point-of-view—primary emphasis on interaction of separate elements of an enterprise, examining flows of information, money, materials, manpower, and capital equipment. Study of behavior of military organizations and industries by simulation of feedback models representing organizational structure of firm and its basic policies and decision criteria. Application of system-dynamics approach to study of various current problem areas in industry and military including inventory policies, ordering rules, cash flows, hiring and firing policies, and research and development management. Application of principles of elementary feedback systems to industrial problems.

Mn-480 FACILITIES PLANNING (4-0)

The course includes analysis of the basic problems involved in development of requirements and programming and procurement of long lead-time support facilities. The complexity of the process brought about by technological change, modification of strategic and tactical concepts, limited budgets and their structure, the executive-legislative relationship, and internal organization are examined to determine basic problem areas and feasible solutions. The consideration of resources in site selection, standardization, compatibility of facilities and operations, and replacement and disposal of obsolete facilities are examined in relation to the problem of providing a shore establishment which effectively supports naval operations.

Mn-481 LOGISTICS (3-0)

The role of logistics is emphasized and related to economic and management considerations under both cold and hot war conditions. Logistics planning and programming, requirements, procurement, maintenance, transportation, and distribution are discussed. The philosophy of the seminar is a "generalist" approach to the area of logistics by employing all of the relevant management philosophies, principles, and skills developed in required "core" management courses.

Mn-482 MILITARY PLANNING (3-0)

The course concerns itself with the planning functions of the Department of the Navy at the seat of government. The steps in military planning from the highest levels of government through the Department of Defense are examined. The student studies the roles of various bureaus and agencies in planning with the objective of gaining an understanding of the points of correlation and coordination of policy and program planning. In the study of the levels of military planning, the techniques of control of operations are studied as measures of progress toward program objectives.

Mn-490 ORGANIZATION THEORY AND ADMINISTRATION (5-0)

The various approaches to management theory are studied. Contributions to a management theory by public administrators, business managers, sociologists and psychologists are evaluated with a view toward determining aspects of group behavior and elements of leadership. The military organization is analyzed, and the role of the military manager is appraised. The goal is to stimulate a lasting interest on the part of the officer in a philosophy of management and in the development of management skills.

Mn-491 MANAGEMENT POLICY (3-0)

The course is directed at the viewpoint of the higher levels of management and is designed as the coordination point of all offerings in Navy Management. The officer, throughout the course, is encouraged in the decision process to the end that he will achieve reasoned and responsible decisions. The emphasis will be on typical management problem analysis and policy formulation. In this action process the officer will be expected to appraise situational problems, define objectives, and develop realistic plans with control devices suitable to measure progress as plans are implemented. The dynamics of organizational structure and the human element under changing conditions and environment are considered, as well as the short- and long-term implications of planning on operations. The course will make use of topical problems and case studies drawn from Navy, Defense, and civilian sources.

Mn-492 GOVERNMENT AND BUSINESS (3-0)

The course will cover the public policies of the national government as they affect the economic, political, and social order, the increasing importance of the role of government in our society, and the responsiveness of national government to competing claims of various interest groups. Careful examination will be given to the legislative process, including the roles of committee hearings and investigations, and the role of interest groups and lobbies. Study will be made particularly of defense policy, its effect upon the Navy, and the budgetary process in the formulation of the National Strategy. The roles of the various regulatory agencies and commissions will be examined for their interactions with the Defense and other executive departments of the government. Students will be expected to analyze legislative, administrative, judicial, and executive aspects of current political and economic questions; such as, defense mobilization, conservation, labor-management relations, public housing, health, security, and government organization.

Mn-495 ORGANIZATION AND MANAGEMENT SEMINAR (3-0)

Studies are made of organizations and organizational units of industry, Defense, and the Navy. Studies are made of activities engaged in research and development, and new advanced programs to examine the near- and long-term objectives, the planning phases, the organizational structure, the advanced managerial method, and techniques. Problems in staffing are discussed. Problems of reorganization in government and private industry are studied to develop the factors initiating change in organizational structure and management method.

NOTES and MEMORANDA

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CURRICULA AT OTHER INSTITUTIONS

The curricula in this section are conducted entirely in civilian universities but are supervised by the Superintendent, U.S. Naval Postgraduate School. Table I shows the duration and place of each curriculum and the school official at Monterey responsible for administration, including initiation of changes to curriculum, contact with students and college faculty, and related functions.

The information on courses is taken from the latest college catalogues but are subject to change from year to year. Changes depend upon the scheduling problems at the institution and the background of individual students. Further detailed information can be obtained from the catalogue of the college concerned, by writing to the responsible school official at Monterey, or to the liaison official at the college as shown in Table I.

BUSINESS ADMINISTRATION

(GROUP ZKH)

At Harvard University

Objective—A curriculum consisting generally of courses in the fields of finance, business organization, marketing, statistics, public relations, and administrative practices. The curriculum at Harvard is of two-year duration and leads to a Master's Degree in Business Administration. The summer between academic years is spent in individual assignments with industrial companies.

Typical Curriculum:

First Year (All courses required)

- Administrative Practices
- Business Responsibilities in the American Society
- Control
- Finance
- Marketing
- Production
- Written Analysis of Cases

Second Year (10 half-year courses required)

- Business Policy (Required)
- Courses in General Business Management
- Courses in Industrial and Financial Accounting
- Courses in Production/Manufacturing
- Courses in Finance/Investment
- Courses in Advanced/International Economics
- Courses in Personnel Administration/Human Relations
- Courses in Marketing/Sales/Merchandising
- Courses in Transportation
- Courses in Military Management
- Courses in Taxation
- Courses in Foreign Operations
- Courses in Probability and Statistics for Business Decisions
- Courses in Industrial Procurement

(GROUP ZKM)

At University of Michigan

Objective—A curriculum consisting generally of courses in the fields of finance, business organization, marketing, statistics, public relations, and administrative practices. The one-year curriculum at the University of Michigan is for advanced students having a major in Business Administration and leads to a Master's Degree in Business Administration.

Typical Curriculum:

- Accounting
- Statistical Methods
- Money and Banking
- Financial Principles
- Personnel Administration
- Personnel Administration Skills
- Marketing Principles and Policies
- Electronic Data Processing
- Business Law
- Economics of Enterprise
- Business Policy
- Business Games Lab
- Marketing Principles and Policies II
- Business Statistics - Accounting and Finance

(GROUP ZKS)

At Stanford University

Objective—A curriculum consisting generally of courses in the fields of finance, business organization, marketing, statistics, public relations, and administrative practices. The curriculum at Stanford University is of two-year duration and leads to a Master's Degree in Business Administration. The summer between academic years is spent in individual assignments with industrial companies.

Typical Curriculum:

Required - First Year

- Business Economics
- Management Accounting

Business Statistics
Business Organization and Management
Business Finance
Marketing Management
Psychological Aspects of Business
Manufacturing I
Human Elements in Business
Legal Process in Business
Employment Relationships

Required - Second Year

Manufacturing II
Business Policy Formulation and Administration

Electives - 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

Electrical Engineering

(GROUP ZGL)

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: One year

Degree Attainable: Master of Electrical Engineering

Mechanical Engineering

(GROUP ZGH)

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 Mechanical Engineering

Sanitary Engineering

(GROUP ZGM)

At the University of Michigan

Objective—To provide advanced technical instruction for selected CEC officers in the field of water supply and sewerage.

Course Length: One year

Degree Attainable: Master of Science in Engineering

Construction

(GROUP ZGS)

At Stanford University

Objective—To provide advanced technical instruction for selected CEC officers in the field of civil construction engineering and construction management.

Course Length: One year

Degree Attainable: Master of Science

Structures

(GROUP ZGI)

At the University of Illinois

Objective—To provide advanced technical instruction for selected CEC officers in the field of structural design.

Course Length: Seventeen months.

Degree Attainable: Master of Science.

Waterfront Facilities

(GROUP ZGP)

At Princeton University

Objective—To provide advanced technical instruction in waterfront development, including planning, design, construction, rehabilitation and maintenance of waterfront facilities.

Course Length: One year.

Degree Attainable: Master of Science.

Facilities Planning

(GROUP ZFP)

At Princeton University

Objective—To provide advanced technical instruction for selected CEC officers in the field of regional, industrial and community facilities planning.

Course Length: One year.

Degree Attainable: Master of Science.

Civil Engineering (Qualification)

(GROUP ZGQ)

Given at: Rensselaer Polytechnic Institute
Georgia Institute of Technology
Massachusetts Institute of Technology
Purdue University
University of Minnesota
University of Colorado
University of California, Berkeley
University of Washington

Objective—To qualify officers for civil engineering duties. Two major options in soil mechanics or structures will be offered. This program is for line officers transferring to the interest to, the military Departments, including claims, civil

Civil Engineer Corps (5100) who do not hold engineering degrees.

Course Length: Two years.

Degree Attainable: Bachelor or Master of Science in Civil Engineering.

Financial Management

(GROUP ZS)

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 program for the improvement of management economy and efficiency through better organization, administration and procedures and better utilization of manpower, materials, facilities, funds and time. The course is designed to give graduates a working knowledge of managerial controls adequate for assignment to financial management duties as a normal preparation for command and executive billets in the shore establishment and leads to degree Master of Business Administration.

Typical Curriculum:

Undergraduate Courses:
- General Accounting
- Business Reports and Analyses
- Industrial and Governmental Economics
- Statistical Decision Making

Graduate Courses:
- Cost Accounting
- Managerial Accounting
- Internal Control and Audit
- Financial Management
- Seminar in Marketing
- Seminar in Contract Administration
- Business Organization and Management
- Reading and Conference in Comptrollership
- Human Relations in Business
- Research Seminar in Comptrollership
- Seminar in Comptrollership
- Governmental Budgeting

GEODESY

(GROUP ZV)

At Ohio State University
and USN Hydrographic Office

Objective—A two-year course in Geodesy to prepare officers for assignment to duties at the Hydrographic Office, on Geodetic survey expeditions, or on major fleet staffs. The curriculum is divided into Phase I and Phase II. Phase I consists of 18 months' academic instruction at Ohio State University and presents a sound fundamental theoretical knowledge of geodesy, cartography, and photogrammetry, particularly as applied to hydrographic surveying, and the compilation and production of charts and maps. Phase II consists of 6 months' practical instruction at the USN Hydrographic Office under the cognizance of the Hydrographer. For students with an adequate educational background, this curriculum affords the opportunity to qualify for the degree of Master of Science in Geodesy.

INDUSTRIAL MANAGEMENT

(GROUP ZMP)

At Purdue University

Objective — A one-year curriculum for Supply Corps (3100) officers in Business Administration which fulfills a particular need and leads to a Master of Science Degree.

Typical Curriculum:

Required Courses:
- Psychological Foundation of Industrial Management I
- Economics for Management
- Financial Control I
- Marketing Management I
- Managerial Policy Reports I
- Statistics Control
- Financial Management
- Industrial Relations
- Managerial Policy Reports II
- Legal and Social Relations
- Managerial Policy

Electives:
- Production Management
- Psychological Foundations of Industrial Management II
- Financial Control II
- Marketing Management II

INTERNATIONAL RELATIONS

(GROUP ZI)

At Harvard University, American University, and the University of California (Berkeley)

Objective—A one-year curriculum to provide broad and integrated 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. Leads to a Master's Degree for officers who qualify.

JUDGE ADVOCATE OFFICERS ADVANCED COURSE

(GROUP ZHV)

At JAG's School (Army), Charlottesville, Virginia

Objective—A nine month curriculum designed to prepare more experienced officer-lawyers for advanced staff responsibilities in the various legal fields. Course encompasses all branches of military law with emphasis on the administration of justice under the Uniform Code of Military Justice; military affairs; civil affairs arising out of the operation of, or litigation, and martial law; military reservations; international law, including the law of war; procurement and contract law; and legal assistance to military personnel.

MANAGEMENT AND INDUSTRIAL ENGINEERING

(GROUP ZT)

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 and leads to the degree Master of Science in Management Engineering.

Typical Curriculum:

SUMMER

Statistical Methods
Law in Management and Engineering

FALL

Cost Finding and Control
Analytical Methods in Management
Organization Planning and Development
Personnel Tests and Measurement
Choice between: Marketing
and
Research and Design Management

SPRING

Cost Analysis
Industrial Relations
Production Planning and Control
Financial Planning and Control
Seminar in Management

METALLURGICAL ENGINEERING

(GROUP ZNM)

At Carnegie Institute of Technology

Objective—To obtain the maximum possible metallurgical background in a short program designed specifically for the graduate of the Naval Construction and Engineering Curriculum.

Course Length: Nine months.

Degree Attainable: Bachelor of Science in Metallurgy.

NAVAL ARCHITECTURE

(Advanced Hydrodynamics)

(GROUP ZNA)

At University of California

Objective—To provide advanced education in the hydrodynamic aspects of Naval Architecture.

Course Length: Nine months.

Degree Attainable: Depends on academic background of student.

NAVAL CONSTRUCTION AND ENGINEERING

(GROUP ZNB)

At Massachusetts Institute of Technology
and at
Webb Institute of Naval Architecture

Objective—To qualify officers for naval construction and engineering assignments. Successful completion of this curriculum normally leads to "Engineering Duty" designation.

Course Length: Three years.

Degree Attainable: Naval Engineer and/or Master of Science.

NUCLEAR ENGINEERING (ADVANCED)

(GROUP ZNE)

At Massachusetts Institute of Technology

Objective—To qualify officers for the technical direction of nuclear power development in the Navy. Graduates of this program can normally expect to be assigned duties within the nuclear power development program under the direction of the Bureau of Ships.

Course Length: Fourteen months.

Degree Attainable: Master of Science.

NUCLEAR POWER ENGINEERING

(GROUP ZNN)

At University of California and
University of Michigan

Objective—To provide education for Civil Engineer Corps officers in nuclear power engineering. Graduates of this curriculum will normally be assigned duties in the shore nuclear power program under the technical direction of the Bureau of Yards and Docks.

Course Length: 15 to 20 months.

Degree Attainable: Master of Science.

OCEANOGRAPHY

(GROUP ZO)

18 months at the University of Washington and
6 months at the U. S. Navy Hydrographic Office,
Washington, D.C.

Objective—A two-year course in Oceanography to prepare officers for assignment to billets requiring knowledge of this field. The curriculum is divided into two phases: *Phase I* consists of 18 months of academic instruction at the University of Washington and provides comprehensive theoretical and practical foundation in the various aspects of Oceanography, as required for naval officers. Students may specialize in physical, biological, chemical or geological oceanography. The prerequisites for applicants for this program are: College General Chemistry, College General Physics, Mathematics—Trigonometry, College Algebra, Differential and Integral Calculus. Applicants meeting these requirements with additional college background in mathematics, physics, geology, biology and chemistry may qualify for the degree of Master of Science in Oceanography during the 18 months of instruction at the University of Washington. *Phase II* consists of 6 months practical instruction at the U. S. Navy Hydrographic Office under the supervision of the Hydrographer. The military applications of oceangraphy will be stressed during this phase.

OPERATIONS RESEARCH

(GROUP ZOR)

At Case Institute

Objectives — A one-year curriculum for Supply Corps (3100) officers in Operations Research, designed to develop the ability to interpret and analyze operational procedures with view of developing improved procurement, control, and distribution procedures.

PERSONNEL ADMINISTRATION AND TRAINING

(GROUP ZP)

At Stanford University

Objective—A one-year curriculum to prepare officers for assignment in personnel administration and supervision, or administration of training activities. It includes instruction in Statistical Methods; General, Educational and Social Psychology; General and Educational Sociology; General School Supervision; Counseling Techniques; Guidance; Personnel Management; Administration; Business and Professional Speaking; Personnel Test and Measurements; and Record Studies. Leads to a Master's Degree in Education.

PETROLEUM ADMINISTRATION AND MANAGEMENT

Gas, Oil and Water Rights

(GROUP ZHS)

At Southern Methodist University

Objective—A one-year curriculum to prepare officer-lawyers for assignment to billets concerned with the administration and management of the Naval Petroleum Reserves and with the special problems in water rights. This curriculum provides the student 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 encountered. This course leads to a Master's Degree for qualified officers.

PETROLEUM ENGINEERING

(GROUP ZL)

At the University of Texas and in the petroleum industry.

Objective—To prepare officers for assignments to duty involving the administration and operation of Naval Petroleum 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 one year in the field with a major oil company.

Degree Attainable: Master of Science in Petroleum Engineering.

PETROLEUM MANAGEMENT

(GROUP ZMK)

At University of Kansas

Objective—A one-year curriculum to meet an immediate need for the graduate level education of Supply Corps (3100) officers in the functional proficiency area of petroleum management and administration. This curriculum leads to a Master of Science degree. Certain specific prerequisite courses in the engineering and business administration fields are required.

Typical Curriculum:

Graduate Engineering Courses
(15 Semester Hours Required)

- Field Practice in Natural Gas
- Theoretical Principles of Petroleum Production
- Appraisal of Oil and Gas Properties
- Thesis (Problem in Petroleum Procurement)

Graduate Business Adminstration Courses
(15 Semester Hours Required)

- Introduction to High Speed Data Processing
- Controllership
- Transportation
- Personnel Management
- Industrial Training and Supervision
- Development of Business Enterprise
- Legal Aspects of Business
- Probability
- Advanced Cost Accounting
- Industrial Procurement

PUBLIC INFORMATION

(GROUP ZBI)

At Boston University

A program of one calendar year's duration, from September through the following August, designed to advance the qualifications of a limited number of officers in public relations. The annual input is one 1100 and one 1300 officer. Those selected will be experienced naval officers with previous education and/or experience in the field of public information and public relations.

The specific curriculum for each officer will be made up of courses selected from the regular course offerings described in the Boston University Bulletin, based on the individual's background and particular interests within the curricular area. It will afford the opportunity to qualify for a master's degree in Public Relations.

RELIGION

(GROUP ZU)

At selected universities

Objective—Each officer student enrolled in this curriculum pursues courses of instruction in such subjects as psychology, theology, homiletics, counselling, hospital ministry and education.

An officer selected in this curriculum will be enrolled at Harvard University, Catholic University, University of Chicago, University of Notre Dame, Fordham University, Union Theological Seminary, or the Menninger Foundation, depending on the field of study selected.

RETAILING

(GROUP ZMG)

At Graduate School of Retailing, University of Pittsburgh

Objective—To educate the Supply Corps (3100) officer in the functional proficiency area of retailing which emphasizes consumer markets, sales promotion, merchandise and merchandising, and the management function associated therewith. This curriculum leads to a Master's Degree in Retailing.

TYPICAL CURRICULUM:

The Market for Consumer Goods
Research Methods and Analysis
Human Relations
Merchandising Management I and II
Personnel Management
Merchandise Information
Administration of the Selling Function
Management of Service Operations
Credit, Finance and Control
Sales Promotion
Merchandise Design and Fashion
Seminar in Retail Distribution
Seminar in Managerial Areas

POLITICAL SCIENCE

(GROUP ZST)

At Tufts University and Stanford University

Objective—A two-year curriculum to prepare officers of mature judgment and broad background of professional knowledge in the fields of international relations, economics, political science, sociology, geography and history. Leads to a Master's Degree for qualified officers.

ONE YEAR SCIENCE

(GROUP ZSO)

At San Diego State College

Objective—To provide a one year post-commissioning education in the fields of mathematics and physics.

TRANSPORTATION MANAGEMENT

(GROUP ZMN)

At Northwestern University

Objective—A one-year curriculum to meet an immediate need for graduate level education of Supply Corps (3100) officers in the functional proficiency area of transportation management and leads to the degree of 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
Research Seminar
Transportation Management
Problems in Business Administration
Social Problems in Administration
Marketing Management
Transportation Seminar

TABLE I

CURRICULA AT OTHER INSTITUTIONS
SUPERVISED BY U. S. NAVAL POSTGRADUATE SCHOOL

Curriculum	*Group*	*Length*	*Institution*	*Liaison Official*
Business Administration (M)	ZKH	2 yrs.	Harvard	CO, NROTC
Business Administration (M)	ZKM	1 yr.	Michigan	CO, NROTC
Business Administration (M)	ZKS	2 yrs.	Stanford	CO, NROTC
Civil Engineering Advanced (E)				
Electrical Engineering	ZGL	1 yr.	U. of Michigan	CO, NROTC
Mechanical Engineering	ZGH	1 yr.	RPI	CO, NROTC
Sanitary Engineering	ZGM	1 yr.	U. of Michigan	CO, NROTC
Construction	ZGS	1 yr.	Stanford	CO, NROTC
Structures	ZGI	17 mos.	Illinois	CO, NROTC
Waterfront Facilities	ZGP	1 yr.	Princeton	CO, NROTC
Facilities Planning	ZFP	1 yr.	Princeton	CO, NROTC
Civil Engineering, Qualification (E)	ZGQ	2 yrs.	RPI	CO, NROTC
			Georgia Tech	CO, NROTC
			MIT	CO, NavAdminUnit
			Purdue	CO, NROTC
			U. of Minn.	CO, NROTC
			U. of Colorado	CO, NROTC
			U. of California	CO, NROTC
			U. of Washington	CO, NROTC
Financial Management (M)	ZS	1 yr.	Geo. Washington	Prof. A. R. Johnson
Geodesy (E)	ZV	2 yrs.	Ohio State & USN Hydro. Off.	CO, NROTC
Industrial Management (M)	ZMP	1 yr.	Purdue	CO, NROTC
International Relations (G)	ZIA	1 yr.	American U.	Senior Student
International Relations (G)	ZIB	1 yr.	Cal. (Berkeley)	CO, NROTC
International Relations (G)	ZIH	1 yr.	Harvard	CO, NROTC
Judge Advocate Officers Advanced Course (G)	ZHV	9 mos.	U. of Virginia	CO, NROTC
Management & Industrial Engineering (M)	ZT	1 yr.	RPI	CO, NROTC
Metallurgical Engineering (E)	ZNM	9 mos.	Carnegie Tech.	RAdm. R. H. Lambert, USN, Ret.
Naval Architecture (E)	ZNA	9 mos.	U. of California	CO, NROTC
Naval Construction & Engineering (E)	ZNB	3 yrs.	MIT	CO, NavAdminUnit
			Webb Inst.	Capt. R. A. Hinners, USN, Ret.
Nuclear Engineering (Advanced) (E)	ZNE	14 mos.	MIT	CO, NavAdminUnit
Nuclear Power Engineering (E)	ZNN	15 to 20 mos.	U. of California	CO, NROTC
			U. of Michigan	CO, NROTC
Oceanography (E)	ZO	2 yrs.	U. of Wash. &	CO, NROTC
			USN Hydro. Off.	CO, NROTC
Operations Research (E)	ZOR	1 yr.	Case Inst.	Senior Student
Personnel Administration & Training (M)	ZP	1 yr.	Stanford	CO, NROTC
Petroleum Administration & Management (M)	ZHS	1 yr.	SMU	Senior Student
Petroleum Engineering (E)	ZL	2 yrs.	U. of Texas	CO, NROTC
Petroleum Management (M)	ZMK	1 yr.	Kansas	CO, NROTC
Public Information (G)	ZBI	1 yr.	Boston U.	CO, NROTC Harvard U.
Religion (E)	ZU	1 yr.	Various	———
Retailing (M)	ZMG	1 yr.	Pittsburgh	CO, NROTC
Political Science (G)	ZST	2 yrs.	Tufts	CO, NROTC
		2 yrs.	Stanford	CO, NROTC
Science (E)	ZSO	1 yr.	San Diego State U.	Senior Student
Transportation Management (M)	ZMN	1 yr.	Northwestern	CO, NROTC

The letter in parentheses indicates the school official at Monterey who is responsible for the curriculum so marked:

(E) *Director, Engineering School*
(G) *Director, General Line & Naval Science School*
(M) *Director, Management School*

NOTES and MEMORANDA

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