Crittenden

UNITED STATES NAVAL POSTGRADUATE SCHOOL

Catalogue for 1959-1960

FIFTIETH ANNIVERSARY

MONTEREY ★ CALIFORNIA

UNITED STATES NAVAL
POSTGRADUATE SCHOOL

Catalogue for 1959-1960

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MONTEREY ★ CALIFORNIA

MISSION

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

"To conduct and direct the instruction of commissioned officers by advanced education, 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."

Herrmann Hall, the Administration Building. This building contains the offices of the Superintendent, the Academic Dean, and the Administrative Command. The wings, extending toward the west, contain the General Line and Naval Science School, and the Bachelor Officers' Quarters.

U.S. NAVAL POSTGRADUATE SCHOOL

Superintendent

ELMER EUGENE YEOMANS
Rear Admiral, U. S. Navy
B.S., USNA, 1924; M.S., Univ. of California, 1933;
National War College, 1948

Chief of Staff

LOWELL WINFIELD WILLIAMS
Captain, U.S. Navy
B.S., USNA, 1931; M.S., Ohio State Univ., 1951

Academic Dean

ROY STANLEY GLASGOW
B.S., M.S., E.E.

Director, Engineering School

HAROLD MILLAR HEMING
Captain, U.S. Navy
B.S., USNA, 1930; U.S. Naval War College, 1953

Director, General Line and Naval Science School

ROBERT PARK BEEBE
Captain, U.S. Navy
B.S., USNA, 1931; U.S. Naval War College

Director, Management School

THOMAS LOUIS CONROY
Captain, U.S. Navy
B.S., Rhode Island State College, 1937;
M.B.A., George Washington Univ., 1955

Commanding Officer, Administrative Command

MAXIM WILLIAM FIRTH
Captain, U.S. Navy
B.S., USNA, 1931; U.S. Naval War College, 1952

UNITED STATES POSTGRADUATE SCHOOL CALENDAR

Academic Year 1959 - 1960

1959

Management School Summer Session Registration . . Thursday, 18 June
Management School Summer Session Begins . . . . Monday, 22 June
General Line and Naval Science School Term Ends (NS-1) Friday, 26 June
Engineering School, General Line and Naval Science School (Classes 1959B(W), 1960A, NS-3) Registration Monday, 27 July
General Line and Naval Science School Term Ends . . Friday, 31 July
Management School Summer Session Ends . . . . . Friday, 31 July
Engineering School, General Line and Naval Science School Term Begins . . . . Monday, 3 August
Management School Registration (Class 1960A) . . Monday, 10 August
Management School Classes Begin . . . . Monday, 17 August
Labor Day (Holiday) . . . . Monday, 7 September
Engineering School Term Ends . . . . Thursday, 8 October
General Line and Naval Science School Term Ends . Friday, 9 October
General Line and Naval Science School Term Begins . Monday, 12 October
Engineering School Term Begins . . . . Tuesday, 13 October
Veterans' Day (Holiday) . . . . Wednesday, 11 November
Thanksgiving Day (Holiday) . . . . Thursday, 26 November
General Line School Graduation (Classes 1959B, 1959B(W) . . . . Wednesday, 16 December
Engineering School, General Line and Naval Science School Term Ends, Christmas Holiday Begins . . . Friday, 18 December

CALENDAR FOR 1959

JANUARY

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CALENDAR FOR 1960

JANUARY

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NOVEMBER

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DECEMBER

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1960

Engineering School, General Line and Naval Science School Term Begins (Registration and Classes Begin Class 1960A (W) . . . . Monday, 4 January
Management School Graduation (Class 1960A) . Wednesday, 13 January
Management School Registration (Class 1960B) . Monday, 18 January
Management School Classes Begin (Class 1960B) . Monday, 25 January
Washington's Birthday (Holiday) . . . . . . Monday, 22 February
General Line and Naval Science School Registration (Classes 1960B and NS-4) . . . . Monday, 7 March
Engineering School Term Ends . . . . Thursday, 10 March
General Line and Naval Science School Term Ends . Friday, 11 March
General Line and Naval Science School Term Begins Monday, 14 March
Engineering School Term Begins . . . . Tuesday, 15 March
Engineering School, General Line and Naval Science School Term Ends . . . . Friday, 20 May
General Line and Naval Science School Term Begins . Monday, 23 May
Engineering School, General Line and Naval Science School (Classes NS-1, 1960A, 1960A(W) Graduation . Thursday, 26 May
Engineering School Special Weapons Orientation Begins Tuesday, 31 May
Engineering School Special Weapons Orientation Ends . Friday, 3 June
Management School Graduation (Class 1960B) . . . Tuesday, 7 June
Management School Summer Session Registration . . . Friday, 10 June
Management School Summer Session Begins . . . . Monday, 13 June
General Line and Naval Science School Summer Term Ends (Class NS-2) . . . . Friday, 24 June
Management School Summer Session Ends . . . . . Friday, 22 July
Engineering School, Management School, General Line and Naval Science School (Classes 1960A(W), 1961A, NS-5) Registration . . . . Monday, 25 July
General Line and Naval Science School Term Ends . . . Friday, 29 July
Engineering School, Management School, General Line and Naval Science School Term Begins . . . . . Monday, 1 August

U.S. NAVAL POSTGRADUATE SCHOOL

GENERAL INFORMATION

Functions

In carrying out its mission the Postgraduate School performs the following functions: (a) provides advanced engineering education through its own facilities at Monterey, and by supervision of the education of officer students at various civilian institutions throughout the country; (b) provides advanced professional education through the medium of the General Line and Naval Science School; (c) provides graduate management education through the medium of the Management School. Through the performance of these functions the Postgraduate School becomes the agent of the Bureau of Naval Personnel for graduate education.

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 threefold: technical, special and professional. The technical phase is the particular province of the Engineering School which seeks, by graduate instruction, to provide officers with the facility for intelligent technical direction of the Navy's activities in such fields as electronics, ordnance, aerology, aeronautics, naval engineering and communications. This is done through the Engineering School facilities as well as by utilization of civilian institutions known for their leadership in the fields involved. Because of this latter contact, the Engineering School is also charged with the handling of such special programs as civil engineering, naval construction and engineering at civilian institutions.

The General Line and Naval Science School, successor to the General Line School, embraces that portion of the program formerly known as the General Line curriculum, and in addition will include the pilot input of a segment of the so-called five term program. Successful completion of the latter by qualified candidates will lead to a baccalaureate degree (BS). The General Line curriculum is of 9½ months duration and is designed to broaden and enhance the mental outlook and professional knowledge of all career line officers upon the completion of five to seven years commissioned service, thereby preparing them for more responsible duties in the operating forces of the Navy. The curriculum of the five term, or bachelor of science, program will include subjects taught in the 9½ month General Line curriculum.

The Management School offers a five month program including courses in various business subjects and in the general field of management. This School provides Naval officers with graduate level instruction enabling them to be better prepared for their future assignments to management billets. It also has administrative responsibility for related curricula such as business and personnel administration offered at civilian universities.

In addition to the above, the Postgraduate School exercises general supervision over the Naval Intelligence School at Washington, D.C. Otherwise, the Intelligence School operates independently under a Rear Admiral of the line who holds the title of director.

Organization

The Postgraduate School consists of four main components: the Engineering School, The General Line and Naval Science School, the Management School, and the Administrative Command. Heading the organization is the superintendent, a rear admiral of the line of the Navy. He is assisted by captains of the line as heads of the four components. The Administrative Command is the supporting organization for the schools at Monterey and provides all the usual housekeeping services.

The three schools at Monterey, the Engineering School, the Management School, and the General Line and Naval Science School, each have a military and an academic organization. The civilian faculty of the three schools, headed by the academic dean, provides the academic instruction in fields usually found in a well-rounded technical institution. In addition, officer instructors provide education in the purely naval subjects. Because of their different functions the three schools have different proportions of officer and civilian instructors; the Engineering School teaching staff is preponderantly civilian, whereas the opposite is true in the case of the General Line and Naval Science School. The Management School staff is about equal in proportion of officer and civilian instructors.

Student Information

Detailed information on the Postgraduate School and the Monterey area is provided in a student information brochure given to all newcomers. In general, however, the living facilities approach those detailed by the many travel folders available concerning the Monterey Peninsula. The general housing facilities are adequately supported by schools, churches, and shopping facilities.

Of particular interest to the married student is La Mesa Village located within one mile of the school which provides 522 units of public quarters. An elementary school is located within the housing area.

The majority of the rooms of the old Del Monte Hotel are used as a BOQ. Within the same buildings are the usual facilities associated with the BOQ, such as closed and open messes, Navy Exchange, etc.

The Naval Air Facility, Monterey, is located about 2 miles from the school grounds. Its main mission is to provide flight facilities for the use of aviator students in maintaining their flight proficiency.

Facilities

The Naval Postgraduate School is located about one mile east of the city of Monterey. This site is in the process of development aimed at the ultimate provision of modern classroom and laboratory facilities for the Engineering School, the General Line and Naval Science School, and the Management School. When this objective is attained, the spaces now employed for classes and laboratories will revert to their primary purposes as BOQ and other supporting facilities.

During the latter part of 1954 the Engineering School moved into the first group of buildings completed as part of this development plan. These buildings provide proper laboratory space for the first time during the existence of the Engineering School. The following buildings are now in use:

The main Engineering School building, Spanagel Hall, five stories in height, which houses the departments of Electronics, Physics, Metallurgy and Chemistry, and Electrical Engineering. Because of the building's height, the top level supports special equipment for demonstrations in aerology and electronics.

Bullard Hall, the Electrical Engineering Laboratory.

Halligan Hall, the Mechanical Engineering and Aeronautical Engineering Laboratories.

Root Hall, primarily a classroom building, is a long, two-story building that also provides space for the Computer Laboratory and for the departments of Aeronautics, Mechanical Engineering, Aerology and Mathematics and Mechanics. The Management School is also located in Root Hall as is the Reference and Research Library which is occupying about one-third of the building until such time as a separate library building is constructed.

Historical

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 dis-established 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 other 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 School 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.

In December 1948 a survey was conducted by Region IV Committee on Engineering Schools of the Engineering Council for Professional Development (ECPD). As a result of this survey which was a detailed and thorough investigation of the curricula, faculty and facilities of the School, the Naval Postgraduate School was informed on 29 October 1949 by the ECPD that the Curricula in Aeronautical Engineering, Electrical Engineering (including option in Electronics) and Mechanical Engineering were accredited. In 1955 the School was accredited by the Western College Association and in the same year the ECPD reaccredited the curricula it had approved in 1949 and, in addition, accredited that in Ordnance Engineering (Special Physics).

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 the Aerology Department and

Curricular office were moved to the new location. Concurrently with this relocation, the U.S. Naval School (General Line) at Monterey was disestablished as a separate military command and its functions and facilities were assumed by the U.S. Naval Postgraduate School. At the same time, there was established the U.S. Naval Administrative Command, U.S. Naval Postgraduate School, Monterey, to provide logistic support, including supply, public works, medical and dental functions, for the Naval Postgraduate School and its components.

In Mid-1957 a series of discussions were commenced between representatives of the Bureau of Naval Personnel and the Postgraduate School looking to the possibility of establishing a bachelor of science curriculum at the General Line School. It was conceived that this curriculum would fit into the Navy's five-term college program commencing in August 1958 with semi-annual pilot inputs, and ultimately, as the faculty and facilities expanded, the entire program would be carried out at Monterey. This curriculum was planned to include subjects taught in the General Line curriculum as well as a number of new courses adequate to support a degree of bachelor of science, no major designated. The discussions resulted in a feasibility study by the staff of the Postgraduate School, and in October 1957 the Chief of Naval Personnel approved the concept of a composite Five Term/General Line School Program to be implemented with the August 1958 input. The pilot phase of this program will require that selected candidates possess advance credits in specific areas in order to compensate for courses not yet established. Transition to the ultimate program of complete course offerings will depend upon the availability of funds required for expansion of faculty and physical facilities. In the interim, each semi-annual student input will include 50 students to be enrolled in the composite program, with the remainder enrolled in the 9½ month General Line Curriculum as heretofore. The Chief of Naval Personnel further specified that the title "General Line School" be changed to "General Line and Naval Science School," effective 1 July 1958.

In June 1956, by direction of the Chief of Naval Personnel, a Management School was established as an additional component of the Postgraduate School. The mission of the school 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 toward 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. The curriculum now includes various areas of industrial management and additional material in the basic areas.

The U.S. Naval Postgraduate School, Monterey, now comprises the Engineering School under a director, the General Line and Naval Science School under a director, the Management School under a director, and the Administrative Command under a commanding officer. In command of the Naval Postgraduate School and all of its components is a line officer of flag rank in the Regular Navy with the title of superintendent.

Today, in its location at Monterey, California, approximately 1,100 officer students are enrolled in approximately forty curricula in engineering and related subjects, in the Engineering School and the General Line and Naval Science School. Facilities are being planned and implemented to accommodate a total of 1475 officer students—775 in the Engineering School, 50 in the Management School, and 650 in the General Line and Naval Science School. Since 1909 the growth and development of the U.S. Naval Postgraduate School has been in keeping with its original objective of providing the Navy with officers of advanced technical education capable of administering and directing a modern Navy.

THE LIBRARIES

Description

The Libraries of the U.S. Naval Postgraduate School, which contain various collections of published and unpublished materials for the use of students, faculty and staff of the Engineering School, the General Line and Naval Science School, and the Management School are three in number—the Reference and Research Library, the Christopher Buckley, Jr., Library, and the Textbook Service.

The Reference and Research Library, temporarily located in the east end of Root Hall, is an active collection of some 230,000 books, periodicals and research reports dealing mainly with the curricular subjects in the fields of science, engineering, management and naval studies. Its research and development report collection, including a classified section, provides up-to-date information on research being done, under government-sponsored projects, by universities and by independent researchers. The Reference and Research Library also furnishes microfilm and photostat services and will obtain, on interlibrary loan, any publications which are requested and which are not present in its own collection.

The Christopher Buckley, Jr. Library, located on the first floor of Herrmann Hall is a collection of about 5,000 books relating mainly to naval history or to subjects connected with the sea. It contains among these, many rare or otherwise valuable books, including Sir Water Raleigh's "Excellent Observations and Notes, Concerning the Royal Navy and Sea-Service," published in 1650; Samuel Pepys' "Memoires Relating to the State of the Royal Navy of England for Ten Years, Determin'd December 1688"; the first edition (1773-1784) of Capt. James Cook's "Voyages," in eight volumes; a number of manuscripts, and many other interesting items. It is a comfortably furnished library in surroundings that are conducive to reading, relaxing, browsing or study. The collection was the result of the generosity and kindness of Mr. Christopher Buckley, resident of Pebble Beach, California, who has been donating books to the School for this Library since 1949, and who has designated it to be the testamentary recipient of his estate.

The Textbook Service operated by the Supply and Fiscal Department contains approximately 90,000 textbooks, reference books and pamphlets in multiple copies, which are issued to students on a term-loan basis and to instructors for an unlimited period. Students are assigned certain specified texts for their courses but may use this Library to obtain related material to use in conjunction with them.

Staff

George Ridgely Luckett, Professor and Director of Libraries (1950); B.S., Johns Hopkins Univ., 1949; M.S., Catholic Univ., 1951.

Ljubo Lulich, Associate Professor and Associate Director of Libraries (1958); B.A., Univ. of California, 1951; M.S., Drexel Institute of Technology, 1956.

Edgar Raymond Larson, Assistant Professor and Public Services Librarian (1959); B.A., Univ. of Washington, 1939; B.S., (Librarianship) Univ. of Washington, 1950.

Janusz Ignacy Kodrebski, Assistant Professor and Head Catalog Librarian (1956); Secondary education, Torun, Poland, 1927; Diploma National War College, Warsaw, Poland, 1938; M.S., Univ. of Southern California, 1955.

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

Elsa Maria Kuswalt, Cataloger (1958); A.B., Univ. of California, 1957.

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

Mabel C. Van Vorhis, Technical Reports Cataloger (1955); A.B., Univ. of California, 1926.

UNITED STATES NAVAL

POSTGRADUATE SCHOOL

Catalogue for 1959-1960

ENGINEERING SCHOOL

MONTEREY ★ CALIFORNIA

Spanagel Hall, the Engineering School Building

ENGINEERING SCHOOL

DIRECTOR

HAROLD MILLAR HEMING
Captain, U.S. Navy
B.S., USNA, 1930;
USNPS, 1939, Marine Engineering;
U. S. Naval War College, 1950.

Assistant Director

HARRY EDSON TOWNSEND
Captain, U.S. Navy
B.S., USNA, 1932;
USNPS, 1939, Marine Engineering;
U. S. Naval War College, 1953.

Administrative Officer

JAMES LOUIS MAY
Commander, U.S. Navy
B.S., USNA, 1939.
USNPS, 1944, Applied Communications

Allotment and Material Control Officer

JACKSON MADISON RIGHTMYER
Commander, U.S. Navy

NAVAL STAFF

AERONAUTICAL CURRICULA

JAMES VICTOR ROWNEY, Commander, U.S. Navy; Officer in Charge; B.S., UNSA, 1941; Ae.E., California Institute or Technology, 1950.

DONALD LEROY IRGENS, Commander, U.S. Navy; Assistant Officer in Charge; B.S., North Dakota Agricultural College, 1940; M.S., Univ. of Minnesota, 1949.

PAUL MILLER, JR., Commander, U.S. Navy; Instructor in Aeronautics; B.S., USNA, 1943; Test Pilot Training; NATC, Patuxent River, Md., 1951.

ELECTRONICS AND COMMUNICATIONS ENGINEERING CURRICULA

LOUIS PIOLLET SPEAR, Captain, U.S. Navy; Officer in Charge; B.S., USNA, 1939; M.S., USNPS, 1947.

CLARENCE MILLER BROOKS, JR., Commander, U.S. Navy; Assistant Officer in Charge; B.S., The Citadel, 1941; USNPS, 1947, Applied Communications.

HERMAN EDWARD MEYER, Commander, U.S. Navy; Instructor in Communications; USNPS, 1945, Applied Communications.

EUGENE LATIMER REID, Lieutenant, U.S. Navy; Instructor in Communications; B.S., Georgia Institute of Technology, 1950; USNPS, 1955, Command Communications.

RICHARD LORD BROWNING, Ensign, U.S. Navy Reserve; Electronics Laboratory Officer; B.S., Case Institute of Technology, 1958.

METEOROLOGY CURRICULA

EDWIN TYLER HARDING, Captain, U.S. Navy: Officer in Charge; A.B., University of California, 1932; USNPS, 1943, Aerological Engineering.

LEO CREUSOT CLARKE, Commander, U.S. Naval Reserve; Assistant Officer in Charge; B.S., University of Miami, 1941.

MILTON BRUCE MORELAND, Commander, U.S. Navy; Instructor in Meteorology; B.S., Colorado State University, 1942; M.S., USNPS, 1952.

ROBERT GEORGE READ, Lieutenant Commander, U.S. Navy; Instructor in Meteorology; B.S., USNPS, 1953.

ROBERT JAY BRAZZELL, Lieutenant Commander, U.S. Navy; Instructor in Meteorology; B.S., Maryville State Teachers College, 1948; M.S., USNPS, 1950.

FREDRICK GUSTAVE OLSON, Lieutenant Commander, U.S. Navy; Instructor in Meteorology; A.B., University of Washington, 1943.

ROBERT ALVIE MOORE, Lieutenant Commander, U.S. Navy; Instructor in Meteorology; B.S., USNPS, 1953.

EDWARD LEONARD SNOPKOWSKI, Lieutenant Commander, U.S. Navy; Instructor in Meteorology; B.S., USNPS, 1957.

NAVAL ENGINEERING CURRICULA

William Rolston Crutcher, Captain, U.S. Navy; Officer in Charge; A.B., University of California, 1932; USNPS, 1950.

Wilbur M. M. Fowden, Jr., Commander, U.S. Navy; Assistant Officer in Charge; B.S., Polytechnic College of Engineering, 1942; M.M.E., Rensselaer Polytechnic Institute, 1948.

Laurence V. McNamara, Lieutenant Junior Grade, U.S. Navy; Reactor Officer.

Virgil R. Childers, Chief Machinist, U.S. Navy; Machine Shop Officer.

ORDNANCE ENGINEERING CURRICULA

Robert Ernest Odening, Captain, U.S. Navy; Officer in Charge; B.S., USNA, 1936; M.S., Cornell Univ., 1944; M.S., California Institute of Technology, 1951.

Harold Lee Graham, Jr., Commander, U.S. Navy; Assistant Officer in Charge and Instructor in Ordnance Engineering; B.S., USNA, 1941; USNPS, 1946; Cornell Univ., 1948.

Thomas Dominic Pfundstein, Lieutenant Commander, U.S. Navy; Instructor in Mine Warefare; B.S., USNPS, 1955.

CIVILIAN FACULTY

DEPARTMENT OF AERONAUTICS

Wendell Marois Coates, Professor of Aeronautics; Chairman (1931)*; A.B., Williams College, 1919; M.S., Univ. of Michigan, 1923; D.Sc., 1929.

Richard William Bell, Professor of Aeronautics (1951); A.B., Oberlin College, 1939; Ae.E., California Institute of Technology, 1941; Ph.D., 1958.

Theodore Henry Gawain, Professor of Aeronautics (1951); B.S., Univ. of Pennsylvania, 1940; D.Sc., Massachusetts Institute of Technology, 1944.

Ulrich Haupt, Associate Professor of Aeronautics (1954); Dipl. Ing., Institute of Technology, Darmstadt, 1934.

Richard Moore Head, Professor of Aeronautics (1949); B.S., California Institute of Technology, 1942; M.S., 1943; Ae.E., 1943; Ph.D., 1949.

George Judson Higgins, Professor of Aeronautics (1942); B.S., Univ. of Michigan, 1923; Ae.E., 1934.

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

Henry Lebrecht Kohler, Professor of Aeronautics (1943); B.S., Univ. of Illinois, 1929; M.S., Yale Univ., 1930; M.E., 1931.

Peter Barry Stuart Lissaman, Assistant Professor of Aeronautics (1958); B.S., Natal Univ., 1951; A.M., Cambridge Univ., 1954; M.S., California Institute of Technology, 1955.

Michael Hans Vavra, Professor of Aeornautics (1947); Dipl. Ing., Swiss Federal Institute of Technology, 1934; Ph.D., Univ. of Vienna, 1958.

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

DEPARTMENT OF ELECTRICAL ENGINEERING

Charles Van Orden Terwillliger, Professor of Electrical Engineering; Chairman (1925); B.E., Union College, 1916; M.S., 1919; M.S., Harvard Univ., 1922; D.Eng., Johns Hopkins Univ., 1938.

John Miller Bouldry, Associate Professor of Electrical Engineering (1946); B.S., Northeastern Univ., 1941; M.S., Brown Univ., 1956.

Joseph Daniel Bronzino, Instructor in Electrical Engineering (1959); B.S., Worchester Polytechnic Institute, 1959.

Richard Carl Dorf, Instructor in Electrical Engineering (1959); B.E.E., Clarkson College of Technology, 1955; M.S., Univ. of Colorado, 1957.

Edward Markham Gardner, Professor of Electrical Engineering (1948); B.S., Univ. of London, 1923; M.S., California Institute of Technology, 1938.

Alex Gerba, Jr., Assistant Professor of Electrical Engineering (1959); B.E.E., Univ. of Louisville, 1947; M.S., Univ. of Illinois, 1957.

Raymond Kenneth Houston, Professor of Electrical Engineering (1946); B.S., Worcester Polytechnic Institute, 1938; M.S., 1939.

Donald Evan Kirk, Instructor in Electrical Engineering (1959); B.S., Worchester Polytechnic Institute, 1959.

Jack William LaPatra, Instructor in Electrical Engineering (1958); B.E.E., Clarkson College of Technology, 1955; M.S., Univ. of Iowa, 1956.

Herbert LeRoy Myers, Assistant Professor of Electrical Engineering (1951); B.S., Univ. of Southern California, 1951.

Charles Benjamin Oler, Professor of Electrical Engineering (1946); B.S., Univ. of Pennsylvania, 1927; M.S., 1930; D.Eng., Johns Hopkins Univ., 1950.

Marvin Paul Pastel, Associate Professor of Electrical Engineering (1955); B.S., Principia College, 1947; M.S., Washington Univ., 1948; Ph.D., USNPS, 1959.

Orval Harold Polk, Professor of Electrical Engineering 1946); B.S., Univ. of Colorado, 1927; M.S., Univ. of Arizona, 1933; E.E., Univ. of Colorado, 1940.

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

William Conley Smith, Professor of Electrical Engineering (1946); B.S., Ohio Univ., 1935; M.S., 1939.

Robert Denney Strum, Assistant Professor of Electrical Engineering (1958); B.S., Rose Polytechnic Institute, 1946.

George Julius Thaler, Professor of Electrical Engineering (1951); B.E., Johns Hopkins Univ., 1940; D.Eng., 1947.

Allen Edgar Vivell, Professor of Electrical Engineering (1945); B.E., Johns Hopkins Univ., 1927; D.Eng., 1937.

Richard Carvel Hensen Wheeler, Professor of Electrical Engineering (1929); B.E., Johns Hopkins Univ., 1923; D.Eng., Rensselaer Polytechnic Institute, 1926.

Milton Ludell Wilcox, Associate Professor of Electrical Engineering (1958); B.S., Michigan State Univ., 1938; M.S. Univ. of Notre Dame, 1956.

Raymond Benjamin Yarbrough, Instructor in Electrical Engineering (1959); B.S., Univ. of California, 1958.

DEPARTMENT OF ELECTRONICS

George Robert Giet, Professor of Electronics; Chairman (1925); A.B., Columbia Univ., 1921; E.E., 1923.

William Malcolm Bauer, Professor of Electronics (1946); B.S., Northwestern Univ., 1927; E.E., 1928; M.S., Harvard Univ., 1929; D.Sc., 1940.

Stephen Breida, Jr., Assistant Professor of Electronics (1958); B.S., Drexel Institute of Technology, 1952; M.S., Purdue Univ., 1954.

Jesse Gerald Chaney, Professor of Electronics (1946); A.B., Southwestern Univ., 1924; A.M., Univ. of Texas, 1930.

Paul Eugene Cooper, Professor of Electronics (1946); B.S., Univ. of Texas, 1937; M.S., 1939.

Mitchell Lavette Cotton, Associate Professor of Electronics (1953); B.S., California Institute of Technology, 1948; M.S., Washington Univ., 1952; E.E., Univ. of California, 1954.

David Boysen Hoisington, Professor of Electrical Engineering (1947); B.S., Massachusetts Institute of Technology, 1940; M.S., Univ. of Pennsylvania, 1941.

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

Carl Ernest Menneken, Professor of Electronics (1942); B.S., Univ. of Florida, 1932; M.S. Univ. of Michigan, 1936.

Robert Lee Miller, Professor of Electronics (1946); B.Ed., Illinois State Normal Univ., 1936; M.S., Univ. of Illinois, 1942.

Raymond Patrick Murray, Associate Professor of Electrical Engineering (1947); B.S., Kansas State College, 1937; M.S., Brown Univ., 1953.

William Everett Norris, Associate Professor of Electrical Engineering (1951); B.S., Univ. of California, 1941; M.S., 1950.

Abraham Sheingold, Professor of Electronics (1946); B.S., College of the City of New York, 1936; M.S., 1937.

Donald Alan Stentz, Associate Professor of Electronics (1949); B.S., Duke Univ., 1949; M.S., USNPS, 1958.

John Benjamin Turner, Jr., Assistant Professor of Electronics (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California, 1948.

Carl Paul Wiedow, Associate Professor of Electronics (1956); A.B., Occidental College, 1933; M.S., Univ. of Southern California, 1935; M.S., (Physics), California Institute of Technology, 1945; M.S., (E.E.), California Institute of Technology, 1946; Ph.D., Oregon State College, 1956.

DEPARTMENT OF MATHEMATICS AND MECHANICS

Warren Randolph Church, Professor of Mathematics and Mechanics; Chairman (1938); A.B., Amherst, 1926; A.M., Univ. of Pennsylvania, 1930; Ph.D., Yale Univ., 1935.

Ralph Eugene Root, Professor Emeritus of Mathematics (1914); B.S., Morningside College, 1905; hon. ScD. 1942; A.M., Univ. of Iowa, 1909; Ph.D. Univ.of Chicago, 1911.

Charles Henry Rawlins, Jr., Professor Emeritus of Mathematics and Mechanics (1922); Ph.B., Dickinson College, 1910; A.M., 1913; Ph.D., Johns Hopkins Univ., 1916.

Horace Crookham Ayres, Associate Professor of Mathematics and Mechanics (1958); B.S., Univ. of Washington, 1931; M.S. 1931; Ph.D., Univ. of California, 1936.

Willard Evan Bleick, Professor of Mathematics and Mechanics (1946); M.E., Stevens Institute of Technology, 1929; Ph.D., Johns Hopkins Univ., 1933.

Jack Raymond Borsting, Assistant Professor of Mathematics (1959); A.B., Oregon State College, 1951; A.M., Univ. of Oregon 1952; Ph.D., 1959.

Richard Crowley Campbell, Professor of Mathematics and Mechanics (1948); B.S., Muhlenberg College, 1940; A.M., Univ. of Pennsylvania, 1942.

Craig Comstock, Instructor in Mathematics (1958); B.E.P., Cornell Univ., 1956.

Frank David Faulkner, Professor of Mathematics and Mechanics (1950); B.S., Kansas State Teachers College, 1940; M.S., Kansas State College, 1942.

Joseph Giarratana, Professor of Mathematics and Mechanics (1946); B.S., Univ. of Montana, 1928; Ph.D., New York Univ., 1936.

Donald Guthrie, Jr., Assistant Professor of Mathematics (1958); B.S., Stanford Univ., 1954; A.M., Columbia Univ., 1955; Ph. D., Stanford Univ., 1958.

Walter Jennings, Associate Professor of Mathematics and Mechanics (1947); A.B., Ohio State Univ., 1932; B.S., 1934; A.M., 1934.

Brooks Javins Lockhart, Professor of Mathematics and Mechanics (1948); A.B., Marshall College, 1937; M.S., West Virginia Univ., 1940; Ph.D., Univ. of Illinois, 1943.

Kenneth Robert Lucas, Assistant Professor of Mathematics (1958); B.S., Washburn Univ., 1949; Ph. D., Univ. of Kansas, 1957.

Craig A. Magwire, Associate Professor of Mathematics and Mechanics (1955); A.B., Nebraska State Teachers College, 1943; M.S., Univ. of Michigan, 1947; Ph.D., Stanford Univ., 1953.

Aladuke Boyd Mewborn, Professor of Mathematics and Mechanics (1946); B.S., Univ. of Arizona, 1927; M.S., 1933; Ph.D., California Institute of Technology, 1940.

Thomas Edmond Oberbeck, Professor of Mathematics and Mechanics (1951); A.B., Washington Univ., 1938; A.M., Univ. of Nebraska, 1940; Ph.D., California Institute of Technology, 1948.

James Roland Payne, Instructor in Mathematics (1959); A.B., Univ. of California, 1954; A.M., 1955.

John Philip Pierce, Associate Professor of Mathematics and Mechanics (1948); B.S., Worcester Polytechnic Institute, 1931; M.E.E., Polytechnic Institute of Brooklyn, 1937.

Francis McConnell Pulliam, Professor of Mathematics and Mechanics (1949); A.B., Univ. of Illinois, 1937; A.M., 1938; Ph.D., 1947.

Franklin Fryer Sheehan, Associate Professor of Mathematics (1958); B.S., Stanford Univ., 1947.

Elmo Joseph Stewart, Associate Professor of Mathematics and Mechanics (1955); B.S., Univ. of Utah, 1937; M.S. 1939; Ph.D., Rice Institute, 1953.

Charles Chapman Torrance, Professor of Mathematics and Mechanics (1946); M.E., Cornell Univ., 1922; A.M., 1927; Ph.D., 1931.

William Lloyd Wainwright, Associate Professor of Mathematics and Mechanics (1958); B.S., Purdue Univ., 1951; M.S., 1955; Ph.D., Univ. of Michigan, 1958.

Kenneth Ted Wallenius, Instructor in Mathematics and Mechanics (1958); A.B., Univ. of Southern California, 1954; A.M., 1955.

DEPARTMENT OF MECHANICAL ENGINEERING

ROBERT EUGENE NEWTON, Professor of Mechanical Engineering; Chairman (1951); B.S., Washington Univ., 1938; M.S., 1939; Ph.D., Univ. of Michigan, 1951.

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

PAUL JAMES KIEFER, Professor Emeritus of Mechanical Engineering (1920); A.B., Wittenberg College, 1908; B.S., Case Institute of Technology, 1911; M.E., 1939; D.Sc., (Hon.) Wittenberg College, 1953.

JOHN EDISON BROCK, Professor of Mechanical Engineering (1954); B.S., Purdue Univ., 1938; M.S., 1941; Ph.D., Univ. of Minnesota, 1950.

VIRGIL MORING FAIRES, Professor of Mechanical Engineering (1958); B.S., Univ. of Colorado, 1922; M.S., 1925; M.E., 1926.

ERNEST KENNETH GATCOMBE, Professor of Mechanical Engineering (1946); B.S., Univ. of Maine, 1931; M.S., Purdue Univ., 1939; Ph.D., Cornell Univ., 1944.

CHARLES PINTO HOWARD, Assistant Professor of Mechanical Engineering (1954); B.S., Texas Agricultural and Mechanical College, 1949; M.S., 1951.

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

DAVID WARREN LEWIS, Assistant Professor of Mechanical Engineering (1958); A.B., Rice Institute, 1952; B.S., 1953; M.S., 1955; Ph.D., Northwestern Univ., 1958.

ROY WALTERS PROWELL, Professor of Mechanical Engineering (1946); B.S., Lehigh Univ., 1936; M.S., Univ. of Pittsburgh, 1943.

PAUL FRANCIS PUCCI, Associate Professor of Mechanical Engineering (1956); B.S., Purdue Univ., 1949; M.S., 1950; Ph.D., Stanford Univ., 1955.

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

DEPARTMENT OF METALLURGY AND CHEMISTRY

FREDRICK LEO COONAN, Professor of Metallurgy and Chemistry; Chairman (1931); A.B., Holy Cross College, 1922; M.S., 1924; D.Sc., Massachusetts Institute of Technology, 1931.

NEWTON WEBER BUERGER, Professor of Metallurgy (1942); B.S., Massachusetts Institute of Technology, 1933; M.S., 1934; Ph.D., 1937.

JOHN ROBERT CLARK, Professor of Metallurgy (1947); B.S., Union College, 1935; D.Sc., Massachusetts Institute of Technology, 1942.

ALFRED GOLDBERG, Associate Professor of Metallurgy (1953); B.Eng., McGill Univ., 1946; M.S., Carnegie Institute of Technology, 1947; Ph.D., Univ. of California, 1955.

WILLIAM WISNER HAWES, Professor of Metallurgy and Chemistry (1952); B.S., Purdue Univ., 1924; M.S., Brown Univ., 1927; Ph.D., 1930.

CARL ADOLPH HERING, Professor of Chemical Engineering (1946); B.S., Oregon State College, 1941; M.S., Cornell Univ., 1944.

GILBERT FORD KINNEY, Professor of Chemical Engineering (1942); A.B., Arkansas College, 1928; M.S., Univ. of Tennessee, 1930; Ph.D., New York Univ., 1935.

GEORGE DANIEL MARSHALL, JR., Professor of Metallurgy (1946); B.S., Yale Univ., 1930; M.S., 1932.

GEORGE HAROLD MCFARLIN, Professor of Chemistry (1948) A.B., Indiana Univ., 1925; A.M., 1926.

RICHARD ALAN REINHARDT, Associate Professor of Chemistry (1954); B.S., Univ. of California, 1943; Ph.D., 1947.

MELVIN FERGUSON REYNOLDS, Professor of Chemistry (1946); B.S., Franklin and Marshall College, 1932; M.S., New York Univ., 1935; Ph.D., 1937.

JOHN WILFRED SCHULTZ, Assistant Professor of Chemistry (1958); B.S., Oregon State College, 1958; Ph.D., Brown Univ., 1957.

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

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

HANS W. WOHLGEMUTH, Instructor in Chemistry (1959); Technical Institute of Danzig; Technical Institue of Graz.

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); A.B., Univ. of British Columbia, 1936; A.M., 1938; Ph.D., Univ. of Chicago, 1941.

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

CHARLES LUTHER TAYLOR, Assistant Professor of Meteorology, (1954); B.S., 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.

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

DEPARTMENT OF PHYSICS

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

ALFRED WILLIAM COOPER, Assistant Professor of Physics (1957); A.B., (Mod), Univ. of Dublin, 1955; A.M., 1959.

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.

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

GUNTER ECKER, Professor of Physics (1959); Dipl., Univ. Bonn, 1946; Dr. Phil., 1948.

DANIEL H. FILSON, Assistant Professor of Physics (1959); B.S., Cornell University, 1954; M.S., Univ. of California, Los Angeles, 1955; Ph.D., 1958.

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

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

LAWRENCE EDWARD KINSLER, Professor of Physics (1946); B.S., California Institute of Technology, 1931; Ph.D., 1934.

HERMAN MEDWIN, Associate Professor of Physics (1955); B.S., Worcester Polytechnic Institute, 1941; M.S., Univ. of California at Los Angeles, 1948; Ph.D., 1953.

EDMUND ALEXANDER MILNE, Associate Professor of Physics (1954); B.A., Oregon State College, 1949; M.S., California Institute of Technology, 1950; Ph.D., 1953.

JOHN ROBERT NEIGHBOURS, 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.

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

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 as designated "Officer-in-Charge" of the curricula.

The titles of the curricular offices are:

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

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 eight 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
- 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 both 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 4 term hours.

Since the length of the term at the Engineering School is 10 weeks as compared to the normal school semester of 15-16 weeks, the term hour is the credit equivalent of two-thirds semester hours.

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 for the student's work in that course is obtained. The sum of the quality points for all courses divided by the sum of the term hour value of all courses gives a weighted numerical evaluation of the students 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 level and hours.

In evaluating a *curriculum* as meriting the award of the Masters Degree in accordance with para. 2(C) of the Regulations set forth below, no credit is allowed for undergraduate level courses, only half the term hours of credit are allowed for partial graduate level courses, but full value is assigned to full graduate level courses. For example,

Ch-221(C) QUALITATIVE ANALYSIS (3-2) is credited as 4 term hours for a BS degree but zero term hours for the MS degree.

Ch-105(B) PHYSICAL CHEMISTRY (3-2) is credited as 4 term hours for a BS degree but only 2 term hours for the MS degree.

Ch-561(A) PHYSICAL CHEMISTRY (3-2) is credited as 4 term hours for both the BS and MS degrees.

REGULATIONS GOVERNING THE AWARD OF DEGREES. In accordance with Public Law 303 of the 80th Congress, with the Regulations prescribed by the Secretary of the Navy, and with accreditation by the Engineers' Council for Professional Development, the superintendent is authorized to confer the degree of Bachelor of Science in the Mechanical Engineering, the Electrical Engineering, the Engineering Electronics and the Aeronautical Engineering curricula. The recipients of such degrees must be found qualified by the Academic Council in accordance with certain academic standards.

The superintendent is further authorized to confer Masters' and Doctors' degrees in engineering or related fields, upon the recommendation by the faculty, based upon satisfactory completion of a program of advanced study approved by the Academic Council.

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.

(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 requirements, the Academic Council will decided 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 Masters 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 three quarters of the graduate credit courses of his curriculum with a quality point rating in them 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 courses 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; the thesis grades entered by the faculty advisor are assigned on this basis. In addition, the completed

TABLE I

CURRICULA AT THE ENGINEERING SCHOOL

Curricular Officer *Curriculum*	*Group*	*Length*	*Academic Associate*
AERONAUTICAL ENGINEERING			
General (1)	A	2, 3 yrs.	Prof. Coates
Avionics (1)	AV	2, 3 yrs.	Profs. Thaler, Klamm
ELECTRONICS AND COMMUNICATIONS ENGINEERING			
Advanced Science (2)			
Chemistry	RC	3 yrs.	Prof. Coonan
Hydrodynamics	RH	3 yrs.	Prof. Howard
Mathematics (Applied)	RM	3 yrs.	Prof. Church
Metallurgy	RMT	3 yrs.	Prof. Coonan
Physics (General)	RP	3 yrs.	Prof. Frey
Physics (Nuclear)	RX	3 yrs.	Prof. Frey
Communications Engineering	CE	2 yrs.	Prof. Stentz
Engineering Electronics			
Basic	EB	2 yrs.	Prof. Klamm
Advanced Design	EA	3 yrs.	Prof. Klamm
Information and Control Systems	EC	3 yrs.	Prof. Klamm
Underwater Acoustics	EW	3 yrs.	Prof. Kinsler
Special Mathematics	S	2, 3 yrs.	Prof. Church
METEOROLOGY			
General Meteorology	MA	2 yrs.	Prof. Duthie
Advanced Meteorology	MM	2 yrs.	Prof. Duthie
NAVAL ENGINEERING			
Electrical Engineering Advanced	NLA	3 yrs.	Prof. Polk
Engineering Materials	NM	3 yrs.	Prof. Coonan
Mechanical Engineering Advanced	NHA	3 yrs.	Prof. Wright
Mechanical Engineering (Fuels & Lubricants) (3)	NC	3 yrs.	Prof. Coonan
Mechanical Engineering (Gas Turbines)	NJ	3 yrs.	Profs. Wright, Vavra
Naval Engineering General	NG	2 yrs.	Prof. Wright
(Second year Mechanical Engineering Option)	NGH		Prof. Wright
(Second year Electrical Engineering Option)	NGL		Prof. Polk
Nuclear Power	NN	2 yrs.	Profs. C. D. G. King, Handler
ORDNANCE ENGINEERING			
Nuclear Engineering (Effects)	RZ	2 yrs.	Prof. Frey
Operations Analysis	RO	2 yrs.	Prof. Cunningham
Weapons Systems (General)	WG	2 yrs.	Department Chairmen
(Electrical Engineering)	WE	3 yrs.	or Representatives
(Physics)	WP	3 yrs.	"
(Chemistry)	WC	3 yrs.	"

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

(2) The first year of Advanced Science studies, is at Monterey followed by two years at a civilian university. (Three years for doctorate).

(3) The first year is at Monterey; the second and third years at Pennsylvania State University.

thesis must indicate an ability to report on the work in a scholarly fashion. The thesis in final form is submitted via the faculty 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 to 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 Academic Dean, for final determination of the adequacy of his preparation.

(d) Upon favorable action by the Academic Council, the student will be notified that he may request the chairman of the department of his major subject to form a Doctorate Committee. 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.

(e) 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 experimental and research work in acoustics, atomic physics, electricity, nuclear physics, geometrical and physical optics, and solid state physics.

The laboratory facilities include a two-million volt Van de Graaff electrostatic accelerator, a Collins liquid helium cryostat, a large grating spectrograph, an infrared spectrophotometer, a medium size anechoic (echo-free) chamber, a small reverberation chamber, and a multiple-unit acoustics laboratory for student experimentation in airborne acoustics.

The work in the acoustics laboratory is particularly directed toward underwater sound applications, and a large proportion of the laboratory space is devoted to sonar equipment, test tanks, and instrumentation for investigations in underwater sound.

The Aeronautical Laboratories contain facilities for experimentation and research in aerodynamics, structural and stress analysis, aerothermodynamics and propulsion problems.

Facilities for the study of subsonic technical areodynamics are centered about 32" x 45" subsonic wind tunnel having a speed range extending from approximately 10 to 185 knots. The Structural Test Laboratory contains a testing machine of 200,000 pounds capacity, used in structural and stress analysis of aircraft 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 operating in the Mach number range from 1.4 to 4. Instruments associated with these wind tunnels include a 9" Mach-Zehnder interferometer and a 9" and two 5" Schlieren systems for flow observations. The Propulsion Laboratory contains a single test block and facilities for measurement of thrust, fuel flow, temperature, pressures and other parameters of engine operation. Present engine equipment consist of a 9½" Westinghouse Turbo-Jet and three pulse jet engines. A small flame tube, especially equipped for the study of flame propagation, is also available.

For studies of flows in turbo machines the laboratory contains the Mark I Compressor Test Rig, instrumented for conventional performance measurements, and for special problems of three-dimensional flows about the stationary vanes and the turning rotor blades. By changing the angular position of the stationary vanes, a large number of design configurations can be investigated. Further, a small Boeing turboprop engine with variable pitch propeller is available for the determination of performance data and investigations of transient control behavior. Under development is a 300 hp Cascade Test Rig for measurements of pressure distributions, and boundary layer investigations on blades of turbomachines.

The Chemical Laboratories of the Department of Metallurgy and Chemistry are well equipped for instructional purpose 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 Mettallurgy 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 specially designed for this purpose, provide facilities for instruction and research in electrical machinery; power and control electronics; servomechanisms; electrical measurements and electrical circuits. The building and equipment are designed and arranged for the most effective utilization by students and faculty, and sufficient equipment is available so that each student can take an active part in the laboratory work.

In addition to the conventional educational equipment, there are a number of special machines and instruments used for instruction and research. The Machinery Laboratory has amplidyne generators, control motors and dynamometer sets used in control system analysis. A five unit harmonic generator set is available for magnetic material studies at higher power frequencies. The High Voltage Laboratory facilities include a 100 kilo-volt, 60 cycle power transformer and a Schering bridge for high voltage insulation tests; a 30 kilovolt direct current supply and a high frequency-high voltage power supply for special high voltage studies.

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 control systems. The Computer Laboratory has seven electronic analog computers with accessories. These are used by students to solve electrical circuit and control system problems. The Electronics Control and Measurement Laboratory has many of the electronic control 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 electromagnetic oscillographs, oscilloscope cameras, and Polaroid-Land cameras. The film is processed in a completely outfitted darkroom. Brush recorders are used extensively to obtain test results in graphic form. A number of completely equipped research rooms are assigned to students and faculty while they are working on special projects or research.

The Mechanical Engineering Laboratories provide facilities for instruction and research in elastic-body mechanics and dynamics, in hydromechanics and in heat-power and related fields. Noteworthy equipment in the heat-power laboratories include a forced-circulation boiler, 3500 psi and 1000°F; a gas or oil-fired boiler, 250 psi, and 8000 lb./hr., fully automatic controls; a 150-HP Boeing turboprop gas turbine installation, dynamometer loaded; a two-dimensional supersonic air nozzle with schlieren equipment for analysis of shock-wise flows; a vapor-compression still and a solo-shell dual-effect evaporator. Facilities of the elastic-body mechanics and dynamics laboratories include a universal fatigue tester, for testing in tension, compression, bending or torsion, a Chapman polariscope for stress determination by photo-elastic 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; Gisholt and Olsen dynamic balancing machines; and a linear accelerometer and calibrator unit.

THE ELECTRONICS LABORATORIES are well equipped for carrying on a comprehensive program of experimental work in the various branches of the field. Facilities are available for investigating the operational characteristics of radio and electronic circuits at frequencies ranging from d-c to the microwave region. For precision measurements and accurate calibration of instruments, standard frequency sources and standardizing equipment are available.

To illustrate modern communications practices, representative systems are available 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. Additional systems include electronics countermeasures equipment, radio aids to navigation and a broad selection of Navy radar systems.

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.

The equipment of the Mathematics and Mechanics Department includes comprehensive computation facilities for use in the instruction and research program of the School. In addition to a general purpose automatically sequenced digital computer, the computing equipment now available includes an electronic analogue computer and 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. The digital computer is capable of magnetic storing of more than 1,000 numbers or instructions on a drum rotating at 40 r.p.s. and 200,000 numbers or instructions on two magnetic tape units. It is used in the solution of thesis and other research problems as wel! as for instruction.

THE FACILITIES IN METEOROLOGY 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 measure 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; a weather configurated aircraft equipped as a flying classroom; and a shore wave recorder for measuring wave heights and periods.

ENGINEERING SCHOOL

CURRICULA

ADVANCED MATHEMATICS

Officer students in any of the Engineering School curricula may, under special conditions, be afforded the opportunity to qualify for the degree of Master of Science with major in mathematics. This will require minor modifications, consistent with the objective of the officer's curriculum, designed to provide a working knowledge of one field of mathematics, a well-rounded background in three of the major fields of mathematics, and a well-founded study of some related field. Request for such modification should show that it is consistent with the objective of the officer student's curriculum and is of benefit to the Navy, and it must be approved by the Superintendent and the Chief of Naval Personnel.

1. To be eligible for this modification of curriculum the student should have passed one of the basic four-term engineering-mathematics sequences (e.g. Ma-120, Ma-121, Ma-122, Ma-123, Ma-124), or equivalent, with satisfactory grades (QPR of 2.0 or better). Courses in these sequences, designated as partial or whole graduate credit courses toward engineering degrees, will not be so considered in meeting the following requirements unless approved for such credit by the chairman of the department before commencing the course.

2. The required minimum of 48 term hours of courses at the graduate level will be 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 (statistics, probability, computational methods, game theory, etc.)

   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.

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

AERONAUTICAL ENGINEERING CURRICULA

OBJECTIVE—To provide officers with advanced aeronautical engineering education to meet the technical requirements of the Navy in this field. Specifically, these curricula are designed to cover the fundamental and advanced theories of mathematics, mechanics, metallurgy, structural analysis, aerodynamics, dynamics, aircraft propulsion, electricity and electronics as they concern the particular curriculum.

SUMMARY—The Aeronautical Engineering curricula offer study in two areas; Aeronautical Engineering (General) and Aeronautical Engineering (Avionics). Each of these areas of study includes both a two year and a three year curriculum.

All students will, however, be enrolled in a common first year of instruction. Upon completion of this first year a two-way split will be made: first, into two and three year curricula groups; second, into the General and Avionics curricula. Although the number of students selected in each case must be in accordance with quotas established by the Chief of Naval Personnel, individual preference as to length of course and field of study is given primary consideration.

Both two year curricula are given entirely at Monterey and normally lead to the degree of Bachelor of Science, Aeronautical Engineering, except for those qualified to study at a higher level. The third year of the three-year curricula is in most cases at a civilian university. Satisfactory completion of these curricula leads to the opportunity to qualify for advanced graduate degrees with a wide range of thesis subjects. The selection of a university for third year work is based upon educational capability, the interest of the student in a suitable aeronautical engineering sub-field for thesis work, and the availability of universities for this purpose.

COMMON FIRST YEAR OF STUDY

First Year (A1)

FIRST TERM (16-7)

Ae-100(C) Basic Aerodynamics (3-2)
Ae-200(C) Rigid Body Statics (3-2)
Ma-151(C) Differential Equations (5-0)
Ma-120(C) Vector Algebra and Geometry (3-1)
Mc-101(C) Engineering Mechanics (2-2)

SECOND TERM (16-10)

Ae-121(C) Technical Aerodynamics (3-4)
Ae-211(C) Strength of Materials (4-2)
Ma-152(B) 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 (0-2)

THIRD TERM (17-9)

Ae-131(B) Technical Aerodynamics Performance I (4-2)
Ae-212(C) Stress Analysis I (4-2)
Ae-409(C) Aeronautical Thermodynamics (4-2)
Ma-125(B) Numerical Methods for Digital Computers (2-2)
EE-281(C) Basic Electrical Phenomena (3-0)
LP-101(L) Lecture Program (0-1)

FOURTH TERM (16-9)

Ae-141(A) Dynamics I (3-2)
Ae-213(B) Stress Analysis II (4-2)
Ae-410(B) Aeronautical Thermodynamics II (3-2)
Ma-153(B) Vector Analysis (3-0)
EE-282(B) Basic Circuit Analysis (3-2)
LP-102(L) Lecture Program (0-1)

Summer intersessional period—Field trip to industry and leading military installations concerned with aeronautics.

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

AERONAUTICAL ENGINEERING (GENERAL)

TWO YEAR CURRICULUM

Second Year *Option One* *(AG2f)*

FIRST TERM (13-10)

Ae-142(A) Aircraft Dynamics II (3-4)
Ae-152(B) Flight Testing and Evaluation (2-0)
Ae-162(B) Flight Testing and Evaluation (0-4)
Ae-501(A) Hydro-Aero Mechanics I (4-0)
Ch-121(B) General and Petroleum Chemistry (4-2)

SECOND TERM (12-15)

Ae-153(B) Flight Testing and Evaluation (2-0)
Ae-163(B) Flight Testing and Evaluation (0-4)
Ae-411(B) Aircraft Engines (4-2)
Ae-412(B) Thermodynamics Laboratory (0-3)
Ae-502(A) Hydro-Aero Mechanics (4-0)
Ae-316(C) Airplane Design (2-4)
Ae-001(L) Aeronautical Lecture (0-2)

THIRD TERM (12-9)

Ae-421(B) Aircraft Propulsion (3-2)
Ae-221(A) Structures Performance (3-2)
EE-752(C) Electronics (3-2)
Mt-201(C) Introduction to Physical Metallurgy (3-2)
LP-101 Lecture Program (0-1)

FOURTH TERM (11-11)

Ae-151(B) Flight Testing and Evaluation (2-0)
Ae-161(B) Flight Testing and Evaluation (0-4)
Ae-428(A) Operating Principles of Turbomachines (3-2)
Ae-508(A) Compressibility (3-2)
Mt-202(B) Ferrous Physical Metallurgy (3-2)
LP-102 Lecture Program (0-1)

Second Year *Option Two* *(AG2p)*

FIRST TERM (14-8)

Ae-142(A) Aircraft Dynamics II (3-4)
Ae-501(A) Hydro-Aero Mechanics I (4-0)
Ch-121(B) General and Petroleum Chemistry (4-2)
Mt-201(C) Introduction to Physical Metallurgy (3-2)

SECOND TERM (14-11)

Ae-411(B) Aircraft Engines (4-2)
Ae-412(B) Thermodynamics Laboratory (0-3)
Ae-502(A) Hydro-Aero Mechanics II (4-0)
Ae-221(A) Structures Performance (3-2)
Mt-202(C) Ferrous Physical Metallurgy (3-2)
Ae-001(L) Aeronautical Lecture (0-2)

THIRD TERM (12-11)

Ae-150(B) Flight Test Procedures (3-4)
Ae-508(A) Compressibility (3-2)
Ae-421(B) Aircraft Propulsion (3-2)
EE-752(C) Electronics (3-2)
LP-101(L) Lecture Program (0-1)

FOURTH TERM (11-11)

Ae-316(C) Airplane Design (2-4)
Ae-428(A) Operating Principles of Turbomachines (3-2)
CE-542(A) Reaction Motors (3-2)
EE-652(B) Transients and Servomechanisms (3-2)
LP-102(L) Lecture Program (0-1)

After completion of this course a six-week course in Elements of Management and Industrial Engineering MN-IE-102(C) is given prior to detachment.

NOTE: Option I emphasizes flight testing and evaluation.

THREE YEAR CURRICULUM

Second Year (A2)

FIRST TERM (14-8)

Ae-142(A) Aircraft Dynamics II (3-4)
Ae-501(A) Hydro-Aero Mechanics I (4-0)
Ch-121(B) General and Petroleum Chem. (4-2)
Mt-201(C) Introductory Physical Metallurgy (3-2)

SECOND TERM (17-6)

Ae-214(A) Stress Analysis III (3-0)
Ae-411(B) Aircraft Engines (4-2)
Ae-502(A) Hydro-Aero Mechanics II (4-0)
Mt-202(C) Ferrous Physical Metallurgy (3-2)
Elective (3-0)
Ae-001(L) Aeronautical Lecture (0-2)

Electives	*Drop*	*Add*
Aerodynamics (AA2)	None	Ae-221(A)(3-2)
Propulsion (AP2)	None	Mt-301(A)(3-0)
Structures (AS2)	None	Ae-221(A)(3-2)
Nuclear-Propulsion (AN2)	Mt-202(C)(3-2)	Ph-660(B)(4-0)
Aero-Physics (AZ2)	Ae-214(A)(3-0)	Ph-361(A)(3-0)
	Ae-411(B)(4-2)	Ph-141(B)(4-0)
	Mt-202(C)(3-2)	Ph-240(C)(3-3)
		Ph-660(B)(4-0)
		Ph-661(B)(0-3)

THIRD TERM (12-9)

Ae-311(C) Airplane Design I (2-4)
Ae-421(B) Aircraft Propulsion (3-2)
Ae-503(A) Compressibility I (4-0)
EE-752(C) Electronics (3-2)
LP-101(L) Lecture Program I (0-1)

Electives	*Drop*	*Add*
Aerodynamics (AA2)	No Change	
Propulsion (AP2)	Ae-311(C)(2-4)	Ae-316(C)(2-4)
Structures (AS2)	Ae-503(A)(4-0)	AE-508(A)(3-2)
Nuclear-	Ae-503(A)(4-0)	Ph-642(B)(4-0)
Propulsion (AN2)	Ae-311(C)(2-4)	Mt-202(C)(3-2)
	EE-752(C)(3-2)	Mt-301(A)(3-0)
		Ae-316(C)(2-4)
Aero-Physics (AZ2)	Ae-311(C)(2-4)	Ae-316(C)(2-4)
	Ae-421(B)(3-2)	Mc-403(A)(3-0)
	EE-752(C)(3-2)	Ph-142(B)(4-0)
		Ph-362(A)(3-0)

FOURTH TERM (13-11)

Ae-312(B) Airplane Design II (1-4)
Ae-431(A) Aerothermodynamics of Turbomachines (3-2)
Ae-504(A) Compressibility II (3-2)
EE-652(B) Transients and Servomechanisms (3-2)
Elective (3-0)
LP-102(L) Lecture Program II (0-1)

Electives	*Drop*	*Add*
Aerodynamics (AA2)	None	ChE-542(A)(3-2)
Propulsion (AP2)	Ae-312(B)(1-4)	Ch-581(A)(2-2)
Structures (AS2)	Ae-504(A)(3-2)	Mc-311(A)(3-2)
	EE-652(B)(3-2)	Ae-215(A)(4-0)
Nuclear-Propulsion (AN2)	Ae-312(B)(1-4)	Ae-508(A)(3-2)
	Ae-504(A)(3-2)	Ch-561(A)(3-2)
	EE-652(B)(3-2)	ChE-542(A)(3-2)
Aero-Physics (AZ2)	Ae-312(B)(1-4)	ChE-542(A)(3-2)
	Ae-431(A)(3-2)	Mc-404(A)(3-0)
	EE-652(B)(3-2)	Ph-541(A)(4-0)
		Ph-650(A)(4-0)

NOTE: Electives shown for terms indicated are to provide prerequisites for different institutions, to accommodate a variety of thesis areas, or to utilize efficiently laboratory facilities available.

Thesis Groups are:

AZ—Aero-Physics
AS—Structures
AP—Propulsion
AA—Aerodynamics
AN—Nuclear Propulsion

Summer—Second Year: Elements of Management and Industrial Engineering MN-IE-102(C).

THIRD YEAR

Leading Universities in the field of aeronautics.

AERONAUTICAL ENGINEERING (AVIONICS)

TWO YEAR CURRICULUM

Second Year Electronics Option (AV2e)

FIRST TERM (17-8)

Ae-142(A) Aircraft Dynamics II(3-4)
Ae-501(A) Hydro-Aero Mechanics (4-0)
Es-241(C) Electron Tubes and Circuits I (3-2)
Es-249(C) Transistors, Transducers (3-2)
Es-450(B) Communication Theory (4-0)

SECOND TERM (14-9)

Ae-411(B) Aircraft Engines (4-2)
Ae-502(A) Hydro-Aero Mechanics II (4-0)
Es-242(C) Electron Tubes and Circuits II (3-2)
Es-620(B) Antennas and Feed Systems (3-3)
Ae-001(L) Aeronautical Lecture (0-2)

THIRD TERM (11-12)

Ae-316(C) Airplane Design (2-4)
Ae-421(B) Aircraft Propulsion (3-2)
Es-247(B) Pulse Techniques (2-3)
Es-251(B) Transmitters and Receivers (4-2)
LP-101(L) Lecture Program (0-1)

FOURTH TERM (12-12)

Ae-508(A) Compressibility (3-2)
Es-252(B) Electronic Systems (3-3)
Es-341(B) Radar Systems I (3-3)
Es-449(B) Radar Data Processing and Computer-Controlled Systems (3-3)
LP-102(L) Lecture Program (0-1)

After completion of this course a six-week course in Elements of Management and Industrial Engineering MN-IE-102(C) is given prior to detachment.

TWO AND THREE YEAR CURRICULA

Second Year Weapons System Option (AV2)

FIRST TERM (13-12)

Ae-142(A) Aircraft Dynamics II (3-4)
Ae-501(A) Hydro-Aero Mechanics (4-0)
EE-283(B) Advanced Circuit Analysis (3-4)
EE-464(C) Special Machinery (3-4)

SECOND TERM (14-8)

Ae-411(B) Aircraft Engines (4-2)
Ae-502(A) Hydro-Aero Mechanics II (4-0)
EE-771(B) Electronics (3-2)
EE-284(A) Circuit Analysis (3-2)
Ae-001(L) Aeronautical Lecture (0-2)

THIRD TERM (11-12)

Ae-316(C) Airplane Design (2-4)
Ae-421(B) Aircraft Propulsion (3-2)
EE-670(A) Servomechanisms (3-3)
EE-772(B) Electronics (3-2)
LP-101(L) Lecture Program (0-1)

FOURTH TERM (12-9)

Ae-508(A) Compressibility (3-2)
EE-673(A) Nonlinear Servomechanisms (3-3)
EE-745(A) Electronic Control and Measurement (3-3)
Mc-403(A) Kinematics of Guidance (3-0)
LP-102(L) Lecture Program (0-1)

Summer—Second Year—Elements of Management and Industrial Engineering MN-IE-102(C)

Third Year (AV3)

Weapons System Option M.I.T. (or) University of Michigan

THREE-YEAR CURRICULA

Third Year

All third year work in both aeronautical engineering general and avionics is presently 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

MASSACHUSETTS INST. OF TECHNOLOGY, BOSTON

- Avionics
- Propulsion

UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN

- Aerodynamics
- Avionics
- Propulsion
- Structures

UNIV. OF MINNESOTA, MINNEAPOLIS, MINN.

- Aerodynamics
- Propulsion
- Structures

PRINCETON UNIVERSITY, PRINCETON, N. J.

- Aerodynamics (flight performance)

STEVENS INST. OF TECHNOLOGY, HOBOKEN, N. J.

- Aero-hydrodynamics

IOWA STATE COLLEGE, AMES, IOWA

- Nuclear Propulsion

COLLEGE OF AERONAUTICS, CRANFIELD, ENG.

- Aerodynamics
- Aircraft Design
- Propulsion
- Aircraft Economics and Production
- Aircraft Electronics

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, D.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 Master 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.

ELECTRONICS AND COMMUNICATIONS ENGINEERING

BASIC OBJECTIVE—To educate officers in the basic scientific and engineering fields related to electronics and its application to the art of naval warfare. The specific aim is to develop competence and ability to direct the development, evaluation, and operation of electronic devices that are required by the Navy to improve its capability in the several areas of Communications, ASW, Combat Information and Direction, 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. For the last half year, students in the Engineering Electronics BS program are permitted to take elective courses best suited to their individual interests and naval experience. Successful completion of two years of work in the EB or CE curriculum leads to the degree of Bachelor of Science in Engineering Electronics or in Communications Engineering.

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 Underwater Acoustics, and Information and Control Systems.

BASIC CURRICULUM — BS and MS Programs

FIRST YEAR (All Students—Group EB1)

(Commencing August, 1959)

First Term (14-9)

Es-111(C) Fund. of Electric Circuits I (4-4).
Es-211(C) Physical Electronics (3-3).
Ma-120(C) Vector Algebra & Geometry (3-1).
Ma-121(C) Intro. to Engineering Math (4-1).

Second Term (17-7)

Es-112(C) Fund. of Electric Circuits II (4-3).
Es-212(C) Electronic Circuits I (4-3).
Ma-122(B) Diff. Eqs. and Vector Calculus (5-0).
Ma-124(B) Complex Variables (4-1).

Third Term (17-8)

Es-113(C) Circuit Theory (4-2).
Es-213(C) Electronic Circuits II (4-3).
Ma-123(A) Orthogonal Func. and Part. Diff. Eqs. (5-0).
Ph-113(B) Analytical Dynamics (4-2).
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) 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." Communications Engineering students take Co-211 (C) "Cryptographic Methods and Procedures" and a field trip to West Coast naval communications facilities.

SECOND YEAR (All Students—Group EB2)

(Commencing 1960)

First Term (13-11)

EE-463(C) Special Machinery (3-2).
Es-215(C) Electron Devices (3-3).
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) Information Theory (4-0).
Es-419(C) Electronic Computers (3-3).

Upon completion of the basic curriculum, students will complete their studies in one of the following programs.

ENGINEERING ELECTRONICS — BS Program

The EB students will complete their second year for the BS degree in an all elective program, subject to approval of the OinC and academic advisors, chosen from the listed offerings. The elective program of each student must develop some major area of the application of electronic engineering in a field of naval professional interest. As an example, a typical elective program in the field of ASW might be as follows: (Four courses not exceeding 24 hours per week are elected for each term.)

SECOND YEAR (Typical Electives) (Group EB2)

Third Term (14-6)

Es-321(B) Theory of Radar (3-3).
Es-331(B) Guidance & Navigation (4-0).
Ma-322(A) Statistical Decision Theory (3-2).
Ph-431(B) Fundamental Acoustics (4-0).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (14-9)

Es-320(A) Sys. Eng. (3-2) or OA-121(A) Op. Anal (4-2).
Es-329(B) Sonar Systems Engrg (3-3).
Oc-110(C) Oceanography (3-0).
Ph-432(A) Underwater Acoustics & Sonar Sys. (4-3).
ME-247(C) Nuclear Power Plant Survey (1-0).
LP-102(L) NPS Lecture Program II (0-1).

Intersessional Term: Upon completion of second year all students will visit various naval and industrial laboratories and facilities on a four week field trip prior to detachment.

COMMUNICATIONS ENGINEERING — BS Program

The CE students will complete their second year for the BS degree in the following curriculum.

SECOND YEAR (Group CE2)

Third Term (15-10)

Co-201(C) Communication Principles I (4-2).
Co-221(C) Communication Planning I (4-2).
Co-231(C) Naval Warfare Tactics & Procedures II (4-2).
Es-429(B) Theory of Modulation (3-3).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (17-7)

Co-202(C) Communication Principles II (4-2).
Co-222(C) Communication Planning II (4-2).
Co-232(C) Naval Warfare Tactics & Procedures II (4-2).
Es-630(B) Theory of Propagation (4-0).
ME-247(C) Nuclear Power Plant Survey (1-0).
LP-102(L) NPS Lecture Program II (0-1).

ENGINEERING ELECTRONICS — MS Program

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

OPTION I — ADVANCED ELECTRONICS

SECOND YEAR (Group EA2)

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).
Elective (6)

FOURTH TERM (22)

Es-220(A) Microwave Devices (3-2).
Es-622(A) Electromagnetics II (4-0).
LP-102(L) NPS Lecture Program II (0-1).
Elective (6).

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

THIRD YEAR (Group EA3)

(Commencing 1961)

FIRST TERM (19)

Es-120(A) Circuit Synthesis (3-2).
Es-921(A) Research (3-0).
Ma-322(A) Statistical Decision Theory (3-2)
Elective (6).

SECOND TERM (19)

Es320(A) Systems Engineering (3-2).
Es-420(A) Optimum Communication Systems (3-2).
Es-922(A) Research (3-0).
Elective (6).

THIRD TERM

This term 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.

FOURTH TERM (21)

Es-020(A) Thesis (4-0).
Es-920(A) Systems Seminar (3-0).
ME-217(C) Nuclear Power Plant Survey (1-0).
LP-102(L) NPS Lecture Program II (0-1).
Elective (6).

OPTION II — UNDERWATER ACOUSTICS

SECOND YEAR (Group EW2)

THIRD TERM (22)

Ma-322(A) Statistical Decision Theory (3-2).
Ph-431(B) Fundamental Acoustics (4-0).
Ph-730(A) Solid State Physics (4-2).
LP-101(L) NPS Lecture Program I (0-1).
Elective (6).

FOURTH TERM (22)

Es-220(A) Microwave Devices (3-2).
Oc-110(C) Oceanography (3-0).
Ph-432(A) Underwater Acoustics & Sonar Sys. (4-3).
LP-102(L) NPS Lecture Program II (0-1).
Elective (6).

THIRD YEAR (Group EW3)

(Commencing 1961)

FIRST TERM (22)

Es-120(A) Circuit Synthesis (3-2).
Es-336(A) Sonar Systems I (3-2).
Ph-461(A) Transducer Theory (3-3).
Elective (6).

SECOND TERM (19)

Es-337(A) Sonar Systems II (2-3).
Es-420 (A) Optimum Communications Systems (3-2).
Es-922(A) Research (3-0).
Elective (6).

THIRD TERM

This term 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.

FOURTH TERM (21)

Es-020(A) Thesis (4-0).
OA-121(A) Operations Analysis (4-2).
Ph-422(A) Shock Waves in Fluids (3-0).
ME-247(C) Nuclear Power Plant Survey (1-0).
LP-102(L) NPS LECTURE PROGRAM II (0-1).
Elective (6).

OPTION III — INFORMATION AND CONTROL SYSTEMS

SECOND YEAR (Group EC2)

THIRD TERM (21)

Es-230(A) Feedback Networks (4-0).
Es-430(A) Information Networks (3-2).
Ma116(A) Matrices and Numerical Methods (3-2).
LP-101(L) NPS Lecture Program I (0-1).
Elective (6).

FOURTH TERM (23)

Es-330(A) Automation & System Control (3-3).
Es-439(A) Data Processing Methods (3-2).
Ma-422(A) Advanced Programming (3-2).
LP-102(L) NPS Lecture Program II (0-1).
Elective (6).

THIRD YEAR (*Group EC*3)

(Commencing 1961)

FIRST TERM (19)

Es-120(A) Circuit Synthesis (3-2).
Es-921(A) Research (3-0)
Ma-322(A) Statistical Decision Theory (3-2).
Elective (6).

SECOND TERM (19)

Es-320(A) Systems Engineering (3-2).
Es-420(A) Optimum Communication Systems (3-2).
Es-922(A) Research (3-0).
Elective (6).

THIRD TERM

This term 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.

FOURTH TERM (21)

Es-020(A) Thesis (4-0).
Es-920(A) Systems Seminar (3-0).
OA-121(A) Operations Analysis (4-2).
ME-247(C) Nuclear Power Plant Survey (1-0).
LP-102(L) NPS Lecture Program II (0-1).
Elective (6).

SPECIAL MATHEMATICS

(*GROUP DESIGNATOR S*)

OBJECTIVE—A two or three-year curriculum, sponsored by the Chief of Naval Operations, to further the education of specially selected officers in higher mathematics, with emphasis on mathematical logic, mathematical statistics, and the application of digital computers.

The course has been given at the University of Illinois, and more recently at the Naval Postgraduate School. Special courses are taken to meet the requirements of the individual student.

METEOROLOGY

GENERAL METEOROLOGY

(*GROUP MA*)

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

FIRST YEAR (*MA*1)

FIRST TERM (14-3)

Ma-161(C) Algebra, Trigonometry, and Analytic Geometry (5-0).
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-162(C) Introduction to Calculus (5-0).
Mr-201(C) Elementary Weather-Map Analysis (3-9).
Mr-410(C) Meteorological Instruments (2-2).
Ph-191(C) Survey of Physics II (3-0).

THIRD TERM (12-13)

Ma-163(C) Calculus and Vector Analysis (4-0).
Mr-202(C) Weather-Map Analysis (2-9).
Mr-402(C) Introduction to Meteorological Thermodynamics (3-2).
Oc-210(B) Physical Oceanography (3-0).
LP-101(L) NPS Lecture Program I (0-1).

FOURTH TERM (13-12)

Ma-381(C) Elementary Probability and Statistics (4-2).
Mr-203(C) Upper-Air Analysis and Prognosis (2-9).
Mr-301(B) Elementary Dynamic Meteorology I (4-0).
Os-620(B) Oceanographic Factors in Underwater Sound I (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 (*MA*2)

FIRST TERM (11-13)

Mr-204(C) Weather Analysis and Forecasting (2-9).
Mr-228(B) Tropical and Southern Hemisphere Meteorology (2-0).
Mr-302(B) Elementary Dynamic Meteorology II (4-0).
Mr-612(B) Sea-Ice (3-4).

SECOND TERM (9-11)

Mr-215(B) Advanced Weather Analysis and Forecasting (2-9).
Mr-220(B) Selected Topics in Applied Meteorology (4-0).
Mr-415(B) Radar Propagation in the Atmosphere (2-0).
Oc-621(B) Oceanographic Factors in Underwater Sound II (1-2).

THIRD TERM (10-15)

Mr-403(B) Introduction to Micrometeorology (4-0).
Mr-611(B) Ocean Waves and Wave Forecasting (3-6).
Mr-521(B) Synoptic Climatology (3-2).
Research Problem (0-6).
LP-101(L) NPS Lecture Program I (0-1).

FOURTH TERM (8-17)

Mr-216(B) Advanced Weather Analysis and Forecasting (3-0).
Mr-217(B) Advanced Weather Analysis and Forecasting (0-16).
Mr-810(A) Seminar in Meteorology and Oceanography (2-0).
Oc-213(B) Shallow-Water Oceanography (3-0).
LP-102(L) NPS Lecture Program II (0-1).

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

ADVANCED METEOROLOGY

(GROUP MM)

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 (MM1)

First Term (16-5)

Ma-131(C) Topics in Engineering Mathematics (5-2).
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-132(B) Vector Analysis and Differential Equations (5-0).
Mr-201(C) Elementary Weather-Map Analysis (3-9).
Mr-410(C) Meteorological Instruments (2-2).
Mr-413(B) Thermodynamics of Meteorology (3-2).

Third Term (16-10)

Ma-133(A) Differential Equations and Vector Mechanics (5-0).
Mr-202(C) Weather-Map Analysis (2-9).
Mr-321(A) Dynamic Meteorology I (3-0).
Mr-412(A) Physical Meteorology (3-0).
Oc-210(B) Physical Oceanography (3-0).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (14-12)

Ma-125(B) Numerical Methods for Digital Computers (2-2).
Ma-330(C) Introduction to Statistics (2-0).
Mr-203(C) Upper-Air Analysis and Prognosis (2-9).
Mr-228(B) Tropical and Southern Hemisphere Meteorology (2-0).
Mr-322(A) Dynamic Meteorology II (3-0).
Oc-620(B) Oceanographic Factors in Underwater Sound I (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 (MM2)

First Term (14-13)

Ma-331(A) Statistics (4-2).
Mr-204(C) Weather Analysis and Forecasting (2-9).
Mr-229(B) Selected Topics in Meteorology (2-0).
Mr-323(A) Dynamic Meteorology III (Turbulence and Diffusion) (3-0).
Mr-521(B) Synoptic Climatology (3-2).

Second Term (12-14)

Ma-421(A) Digital and Analog Computation (3-2).
Mr-415(B) Radar Propagation in the Atmosphere (2-0).
Mr-611(B) Ocean Waves and Wave Forecasting (3-6).
Mr-612(B) Sea-Ice (3-4).
Oc-621(B) Oceanographic Factors in Underwater Sound II (1-2).

Third Term (12-16)

Mr-215(B) Advanced Weather Analysis and Forecasting (2-9).
Mr-422(A) The Upper Atmosphere (5-0).
Oc-213(B) Shallow-Water Oceanography (3-0).
Thesis I (2-6).
LP-101(L) NPS Lecture Program I (0-1).

Fourth Term (5-25)

Mr-216(B) Advanced Weather Analysis and Forecasting (3-0).
Mr-219(B) Advanced Weather Analysis and Forecasting (0-16).
Mr-810(A) Seminar in Meteorology and Oceanography (2-0).
Thesis II (0-8).
LP-102(L) NPS Lecture Program II (0-1).

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

NAVAL ENGINEERING (GENERAL)

(GROUP NG ENTERING 1959)

Objective—To educate officers in the basic sciences and engineering principles in order to solve technical problems afloat and ashore. At the end of the first year officers will continue in either Mechanical Engineering (NGH) or Electrical Engineering (NGL) option.

FIRST YEAR

First Term (16-8)

EE-171(C) Electrical Circuits and Fields (3-4)
Ma-111(C) Intro. to Engineering Math (3-1)
Ma-120(C) Vector Algebra and Geometry (3-1)
ME-501(C) Statics (4-0)
Ch-101(C) General Inorganic Chemistry (3-2)

Second Term (15-6)

EE-251(C) A. C. Circuits (3-4)
Ma-112(B) Differential Equations and Infinite Series (5-0)
ME-502(C) Dynamics (4-0)
Mt-201(C) Intro. Physical Metallurgy (3-2)

Third Term (12-7)

EE-371(C) D. C. Machinery (3-2)
Ma-113(B) Partial Differential Equations and Complex Variables (4-0)
Ma-125(B) Numerical Methods for Digital Computers (2-2)
Mt-202(C) Ferrous Metallurgy (3-2)
LP-101(L) NPS Lecture Program I (0-1)

Fourth Term (13-7)

Ma-420(A) Digital Computation (2-2)
ME-503(A) Advanced Dynamics (4-0)
ME-111(C) Engineering Thermo (4-2)
ME-500(C) Strength of Materials (3-0)
ME-601(C) Materials Testing Lab (0-2)
LP-101(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.

NAVAL ENGINEERING (MECHANICAL)

(*GROUP NGH ENTERING* 1959)

OBJECTIVE — This is the Mechanical Engineering option for the second year of Naval Engineering.

SECOND YEAR

FIRST TERM (14-6)

ME-122(C) Engineering Thermodynamics II (3-2)
ME-421(C) Fluid Mechanics I (3-2)
ME-521(C) Strength of Materials II (4-0)
ME-711(B) Mechanics of Machinery (4-2)

SECOND TERM (12-8)

EE-711(C) Electronics (3-2)
ME-221(C) Marine Power Plant Problems I (3-4)
ME-422(B) Fluid Mechanics II (2-2)
ME-522(B) Strength of Materials III (4-0)

THIRD TERM (12-9)

EE-453(C) Alternating-Current Machinery (3-4)
ME-222(C) Marine Power Plant Problems II (3-2)
ME-712(A) Mechanical Vibrations (3-2)
Ph-610(C) Survey of Atomic and Nuclear Physics (3-0)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (10-11)

ME-223(B) Marine Power Plant Analysis (2-4)
ME-240(B) Nuclear Power Plants (4-0)
ME-622(B) Experimental Stress Analysis (2-2)
ME-820(C) Machine Design (2-4)
LP-102(L) NPS Lecture Program II (0-1)

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

NAVAL ENGINEERING (ELECTRICAL)

(*GROUP NGL ENTERING* 1959)

OBJECTIVE—This is the electrical engineering option for the second year of Naval Engineering.

SECOND YEAR

FIRST TERM (10-10)

EE-453(B) Alternating Current Machinery (3-4)
EE-571(B) Lines and Network Synthesis (3-4)
ME-132(C) Engineering Thermo II (4-2)

SECOND TERM (11-10)

EE-751(C) Electronics (3-4)
EE-971(A) Seminar (1-0)
Ma-321(B) Probability and Statistics (4-2)
ME-210(C) Marine Power Plant Problems I (3-4)

THIRD TERM (9-9)

EE-671(A) Transients (3-4)
EE-971(A) Seminar (1-0)
ME-220(B) Marine Power Plant Analysis (2-4)
Ph-610(C) Survey of Atomic and Nuclear Physics (3-0)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (14-7)

EE-670(A) Servomechanism (3-3)
EE-773(A) Magnetic Amplifiers (2-3)
EE-971(A) Seminar (1-0)
ME-240 (B) Nuclear Power Plants (4-0)
OA-141(B) Fundamentals of Operations Analysis (4-0)
LP-102(L) NPS Lecture Program II (0-1)

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

MECHANICAL ENGINEERING (ADVANCED)

(*GROUP NHA ENTERING* 1959)

OBJECTIVE—To prepare officers in advanced Mechanical Engineering for technical and administrative duties connected with naval machinery and engineering plants.

FIRST YEAR (Entering 1959)

Same as Naval Engineering Curriculum

SECOND YEAR (*NHA*)

FIRST TERM (15-4)

EE-711(C) Electronics (3-2)
Ma-114(A) Functions of Complex Variable (3-0)
ME-112(C) Engineering Thermodynamics II (4-2)
ME-511(B) Strength of Materials II (5-0)

SECOND TERM (14-8)

ME-211(B) Marine Power Plant Problems (3-4)
ME-411(C) Fluid Mechanics (3-2)
ME-512(A) Topics in Elasticity (4-0)
ME-711(B) Mechanics of Machinery (4-2)

THIRD TERM (13-7)

ME-212(A) Advanced Thermodynamics (3-2)
ME-412(A) Hydromechanics (4-2)
ME-513(A) Advanced Strength of Materials (3-0)
ME-712(A) Mechanical Vibrations (3-2)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (10-9)

EE-453(C) Alternating-Current Machinery (3-4)
ME-310(B) Heat Transfer (4-2)
Mt-301(A) High Temperature Materials (3-2)
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*3)

FIRST TERM (11-12)

EE-651(B) Transients and Servos (3-4)
ME-215(A) Marine Power Plant Analysis and Design I (2-4)
ME-612(A) Experimental Stress Analysis (3-2)
ME-811(C) Machine Design I (3-2)

SECOND TERM (8-12)

ME-216(A) Marine Power Plant Analysis and Design II (2-4)
ME-713(A) Advanced Dynamics of Machinery (3-0)
ME-812(B) Machine Design II (3-4)
Thesis (0-4)

THIRD TERM (3-17)

Ph-610(C) Survey of Atomic and Nuclear Physics (3-0)
Thesis (0-16)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (10-10)

ME-217(B) Internal Combustion Engines (3-2)
ME-240(B) Nuclear Power Plants (4-0)
Mt-204(A) Non-Ferrous Metallography (3-3)
Thesis (0-4)
LP-101(L) NPS Lecture Program II (0-1)

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

MECHANICAL ENGINEERING (FUELS AND LUBRICANTS) CURRICULUM

(GROUP NC ENTERING 1959)

OBJECTIVE — To educate officers in the thorough understanding of the relationship between designed equipment performance and fuels and lubricants, and in the chemistry, properties and inspection of fuels and lubricants.

FIRST YEAR (NC1)

FIRST TERM (15-8)

Ch-121(B) General and Petroleum Chemistry (4-2)
Ma-120(C) Vector Algebra and Geometry (3-1)
Ma-111(C) Introduction to Engineering Mathematics (3-1)
ME-501(C) Statics (2-2)
Ge-101(C) Physical Geology (3-2)

SECOND TERM (16-8)

Ch-221(C) Qualitative Analysis (3-2)
Mt-201(C) Introductory Physical Metallurgy (3-2)
Ma-112(B) Differential Equations and Infinite Series (5-0)
ME-502(C) Dynamics (2-2)
Ch-701(C) Chemical Engineering Calculations (3-2)

THIRD TERM (15-11)

Ch-231(C) Quantitative Analysis (2-4)
Ch-311(C) Organic Chemistry (3-2)
Ch-411(C) Physical Chemistry (3-2)
Ma-113(B) Introduction to Partial Differential Equations and Functions of a Complex Variable (3-0)
Mt-208(C) Ferrous Physical Metallurgy (4-2)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (16-7)

Ch-312(C) Organic Chemistry (3-2)
Ch-412(C) Physical Chemistry (3-2)
Ma-114(B) Functions of a Complex Variable and Vector Analysis (3-0)
ME-500(C) Strength of Materials (3-0)
Me-111(C) Engineering Thermodynamics (4-2)
LP-102(L) NPS Lecture Program II (0-1)

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

SECOND YEAR (NC2) AT PENNSYLVANIA STATE UNIVERSITY

FALL SEMESTER (15)

Ch E 402—Chemical Engineering (4)
ME 31—Heat Power Engineering I (3)
Fuel Tech. 201—Introduction to Fuel Technology (2)
ME 409—Gas Turbines (3)
Physics 454—Atomic and Nuclear Physics (3)

SPRING SEMESTER (16)

Ch E 403—Chemical Engineering (4)
ME 32—Heat Power Engineering II (3)
Fuel Tech. 408—Combustion Technology (3)
ME 413—Internal Combustion Engines (3)
ME 410—Power Plants (3)

Intersessional period: Field trip.

THIRD YEAR (NC3) AT PENNSYLVANIA STATE UNIVERSITY

FALL SEMESTER (14)

Ch-E 422—Mótor Fuels (2)
ME 453—Bearing Design and Lubrication (3)
ME 510—Mixture Preparation and Combustion in Internal Combustion Engines (3)
Fuel Tech 406—Gaseous Combustion (3)
ME 504—Advanced Engineering Thermodynamics (3)
Fuel Tech. 511—Fuel Technology Seminar (audit) (0)

SPRING SEMESTER (16)

ME 553—Friction and Lubrication (3)
ME 41—Heat Power Engineering III (3)
Min. Ec. 486—Petroleum and Natural Gas Economics (3)
ME 600—Thesis (6)
ME 506—Mechanical Engineering Seminar (1)

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

GAS TURBINES
(*GROUP NJ*)

Objective—To prepare officers in advanced Mechanical engineering with special emphasis on gas turbine application and development, for technical and administrative duties connected with naval machinery and engineering plants. The students for the gas turbines program are normally selected, after the first term, from the Naval Engineering (General) group. This comprises substantially the same program as mechanical engineering except that selected courses are directed toward gas turbine design and control problems, and thesis work is done in the gas turbine field.

FIRST YEAR (*NJ*1) (*Commencing* 1960)

First Term (16-8)

EE-171(C) Electrical Circuits and Fields (3-4)
Ma-120(C) Vector Algebra and Geometry (3-1)
Ma-111(C) Introduction to Engineering Math (3-1)
ME-501(C) Statics (4-0)
Ch-101(C) General Inorganic Chemistry (3-2)

Selection will be made from students enrolled in Naval Engineering (General) after the first term.

Second Term (15-6)

Ae-102(C) Aerodynamics (O,N) I (3-0)
Ae-103(C) Aerodynamics Lab I (0-2)
EE-251(C) Alternating-Current Circuits (3-4)
Ma-112(B) Differential Equations and Infinite Series (5-0)
ME-502(C) Dynamics (4-0)

Third Term (12-7)

Ae-124(C) Aerodynamics (O,N) II (3-0)
Ae-125(C) Aerodynamics Lab II (0-2)
EE-371(C) Direct-Current Machinery (3-2)
Ma-113(B) Introduction to Partial Differential Equations and Functions of a Complex Variable (3-0)
Mt-201(C) Intro. Physical Metallurgy (3-2)
LP-101(L) NPS Lecture Program I (0-1)

Fourth Term (13-7)

EE-453(C) Alternating-Current Machinery (3-4)
Ma-114(A) Functions of a Complex Variable and Vector Analysis (3-0)
ME-111(C) Engineering Thermodynamics (4-2)
ME-500(C) Strength of Materials (3-0)
LP-102(L) NPS Lecture Program II (0-1)

Intersessional Period: Course MN-101 Elements of Management and Industrial Engineering and a course in the "Art of Presentation" at UNSPS, Monterey.

SECOND YEAR (*NJ*2)

First Term (16-2)

Ae-501(A) Hydro-Aero-Mechanics I (4-0)
Ma-155(A) Differential Equations for Automatic Control (3-0)
ME-112(B) Engineering Thermodynamics (4-2)
ME-511(B) Strength of Materials II (5-0)

Second Term (15-6)

Ae-502(A) Hydro-Aero Mechanics II (4-0)
ME-211(C) Marine Power Plant Equipment (3-4)
ME-711(B) Mechanics of Machinery (4-2)
ME-512(A) Topics in Elasticity (4-0)

Third Term (12-7)

Ae-508(A) Compressibilitiy (3-2)
ME-212(C) Marine Power Plant Equipment (3-2)
ME-513(A) Adv. Strength of Materials (3-0)
ME-712(A) Mechanical Vibrations (3-2)
LP-101(L) NPS Lecture Program I (0-1)

Fourth Term (13-8)

Ae-431(A) Aerothermodynamics of Turbomachines (4-1)
Ma-125(B) Numerical Methods for Digital Computers (2-2)
ME-310(B) Heat Transfer (4-2)
Mt-202(C) Ferrous Metallurgy (3-2)
LP-102(L) NPS Lecture Program II (0-1)

Intersessional period: A field trip will be arranged in gas turbine manufacturing industry.

THIRD YEAR (*NJ*3)

First Term (12-8)

Ae-451(A) Gas Turbines I (3-0)
EE-711(C) Electronics (3-2)
ME-612(A) Experimental Stress Analysis (3-2)
ME-811(C) Machine Design I (3-2)
Thesis (0-2)

Second Term (11-10)

Ae-452(A) Gas Turbines II (3-0)
Ma-420(A) Digital Computation (2-2)
Mt-301(A) High Temperature Materials (3-0)
ME-812(B) Machine Design II (3-4)
Thesis (0-4)

Third Term (3-18)

Ph-610(C) Survey of Atomic and Nuclear Physics (3-0)
LP-101(L) NPS Lecture Program I (0-1)
Thesis (0-17)

Fourth Term (9-13)

EE-651(B) Transients and Servos (3-4)
ME-223(B) Marine Power Plant Analysis (2-4)
ME-240(B) Nuclear Power Plants (4-0)
LP-102(L) NPS Lecture Program II (0-1)
Thesis (0-3)

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

ELECTRICAL ENGINEERING (ADVANCED)
(*GROUP NLA*)

OBJECTIVE — To prepare officers in advanced electrical engineerin for technical and administrative duties connected with naval machinery and engineering plants.

FIRST YEAR (*Entering* 1959)

Same as Naval Engineering Curriculum

SECOND YEAR (*NLA*2)

FIRST TERM (10-10)

EE-471(C) A. C. Machinery (3-4)
EE-571(B) Lines and Network Synthesis (3-4)
ME-132(C) Engineering Thermodynamics II (4-2)

SECOND TERM (10-8)

EE-472(C) Alternating-Current Machinery (3-4)
EE-971(A) Seminar (1-0)
ME-411(C) Fluid Mechanics (3-2)
ME-210(C) Marine Power Plant Problems (3-2)

THIRD TERM (11-10)

EE-273(C) Electrical Measurements I (2-3)
EE-771(B) Electronics (3-2)
EE-971(A) Seminar (1-0)
ME-220(B) Marine Power Plant Analysis (2-4)
Ph-610(C) Survey of Atomic and Nuclear Physics (3-0)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (14-7)

EE-772(B) Electronics (3-2)
EE-971(A) Seminar (1-0)
EE-671(A) Transients (3-4)
ME-240(B) Nuclear Power Plants (4-0)
Ph-361(A) Electromagnetism (3-0)
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 (*NLA*3)

FIRST TERM (10-10)

EE-871(A) Electrical Machine Design (4-0)
EE-670(A) Servomechanisms (3-3)
Ph-362(A) Electromagnetic Waves (3-0)
Thesis (0-6)

SECOND TERM (7-13)

EE-872(A) Electric Machine Design (4-0)
EE-773(A) Magnetic Amplifiers (2-3)
EE-971(A) Seminar (1-0)
Thesis (0-10)

THIRD TERM (5-15)

EE-873(A) Electrical Machine Design (4-0)
EE-971(A) Seminar (1-0)
Thesis (0-14)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (11-11)

EE-745(A) Electronic Control and Measurement (3-3)
EE-874(A) Electrical Machine Design (4-0)
EE-971(A) Seminar (1-0)
Mt-302(A) Alloy Steels (3-3)
Thesis (0-4)
LP-101(L) NPS Lecture Program II (0-1)

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

ENGINEERING MATERIALS
(*GROUP NM*)

OBJECTIVE—To educate officers in the engineering sciences and the principles involved in the treatment, properties, applications and limitations of various engineering materials.

FIRST YEAR (*NMI*) *Commencing* 1959

FIRST TERM (16-8)

EE-171(C) Electrical Circuits and Fields (3-4)
Ma-111(C) Intro. to Engineering Math (3-1)
Ma-120(C) Vector Algebra and Geometry (3-1)
ME-501(C) Statics (4-0)
Ch-101(C) General Inorganic Chemistry (3-2)

SECOND TERM (15-6)

EE-251(C) Alternating Current Circuits (3-4)
Ma-112(B) Differential Equations and Infinite Series (5-0)
ME-502(C) Dynamics (4-0)
Mt-201(C) Intro. Physical Metallurgy (3-2)

THIRD TERM (13-7)

EE-371(C) Direct Current Machinery (3-2)
Ma-113(B) Intro. to Partial Differential Equations and Functions of a Complex Variable (3-0)
Ch-221(C) Qualitative Analysis (3-2)
Mt-208(C) Physical and Production Metallurgy (4-2)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (11-10)

EE-453(C) Alternating Current Machinery (3-4)
Ma-114(A) Functions of a Complex Variable and Vector Analysis (3-0)
ME-500(C) Strength of Materials (3-0)
ME-601(C) Materials Testing Lab. (0-2)
Ch-231(C) Quantitative Analysis (2-4)

Intersessional period: MN-161 E. Elements of Management and Industrial Engineering and a course in the "Art of Presentation" at UNSPS, Monterey.

SECOND YEAR (*NM*2)

FIRST TERM (14-8)

ChE-821(A) Plastics (3-2)
Mt-203(B) Physical Metallurgy (Special Topics) (2-2)
Cr-311(B) Crystallography and Minerology (3-2)
ME-511(B) Strength of Materials (4-0)
ME-611(C) Mechanical Properties of Engineering Materials (2-2)

SECOND TERM (12-10)

Ph-610(C) Survey of Atomic and Nuclear Physics (3-0)
Ph-240(C) Optics and Spectra (3-3)
Mt-302(A) Alloy Steels (3-3)
Mt-205(A) Advanced Physical Metallurgy (3-4)

THIRD TERM (11-12)

ChE-701(C) Chemical Engineering Calculations (3-2)
ChE-611(C) Thermodynamics (3-3)
ME-622(B) Experimental Stress Analysis (2-2)
Mt-206(A) Advanced Physical Metallurgy (3-4)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (14-8)

Ch-443(C) Physical Chemistry (4-2)
ChE-624(A) Thermodynamics (3-2)
ME-240(B) Nuclear Power Plants (4-0)
Mt-204(A) Non-Ferrous Metallography (3-3)
LP-102(L) NPS Lecture Program II (0-1)

THIRD YEAR

FIRST TERM (8-13)
Ch-311(C) Organic Chemistry (3-2)
Ch-444(A) Physical Chemistry (3-2)
Ch-551(A) Radio Chemistry (2-4)
Thesis (0-5)

SECOND TERM (6-14)
Mt-301(A) High Temperature Materials (3-0)
Ch-312(C) Organic Chemistry (3-2)
Thesis (0-12)

THIRD TERM (6-15)
Ch-323(A) Chemistry of High Polyners (3-0)
Mt-402(A) Reactor Materials and Radiation Damage (3-0)
Thesis (0-14)
LP-101(L) NPS Lecture Series (0-1)

FOURTH TERM (12-9)
Mt-104(C) Production Metallurgy (4-0)
Mt-207(B) Physics of Solids (3-0)
Mt-305(B) Corrosion and Corrosion Protection (3-0)
Ch-581(A) Chemistry of Special Fuels (2-2)
Thesis (0-6)
LP-102(L) NPS Lecture Series (0-1)

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

NUCLEAR POWER
(*GROUP NN*)

OBJECTIVE — To educate officers in Reactor Engineering in order to prepare them for technical and administrative duties afloat and ashore involving the development, operation and maintenance of nuclear reactors.

FIRST YEAR (NNI)

FIRST TERM (16-8)
EE-171(C) Electrical circuits and Fields (3-4)
Ma-111(C) Intro. to Engineering Math. (3-1)
Ma-120(C) Vector Algebra and Geometry (3-1)
ME-501(C) Statics (4-0)
Ch-101(C) General Inorganic Chemistry (3-2)

SECOND TERM (15-6)
EE-251(C) A. C. Circuits (3-4)
Ma-112(B) Differential Equations and Infinite Series (5-0)
ME-502(C) Dynamics (4-0)
Mt-201(C) Intro. Physical Metallurgy (3-2)

Selection will be made from students enrolled in Naval Engineering after the second term.

THIRD TERM (14-8)
Ma-113(B) Partial Differential Equations and Complex Variables (4-0)
EE-463(C) Special Machinery (3-2)
Mt-202(C) Ferrous Metallurgy (3-2)
Ph-660(B) Atomic Physics (4-0)
Ph-661(B) Atomic Physics Lab (0-3)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (13-8)
Ma-114(A) Functions of Complex Variable and Vector Analysis (3-0)
ME-111(C) Engineering Thermo (3-2)
ME-500(C) Strength of Materials (3-0)
ME-601(C) Materials Testing Lab (0-2)
Ph-642(B) Nuclear Physics (4-0)
Ph-643(B) Nuclear Physics Lab (0-3)
LP-102(L) NPS Lecture Program II (0-1)

Intersessional period: Field trip to industrial or research activities associated with the development of Nuclear Reactors.

SECOND YEAR (NN2)

FIRST TERM (15-6)
EE-711(C) Electronics (3-2)
ME-112(B) Engineering Thermo (4-2)
ME-411(C) Fluid Mechanics (3-2)
ME-511(B) Strength of Materials II (5-0)

SECOND TERM (14-6)
EE-651(B) Transients and Servo (3-4)
ME-310(B) Heat Transfer (4-2)
ME-512(A) Topics in Elasticity (4-0)
Ph-651(A) Reactor Theory I (3-0)

THIRD TERM (14-3)
ME-241(A) Reactor Engineering I (3-2)
ME-900(A) Special Problems in ME (4-0)
Mt-402(B) Nuclear Reactor Materials (4-0)
Ph-652(A) Reactor Theory II (3-0)
LP-101(L) NPS Lecture Program I (0-1)

FOURTH TERM (9-10)
EE-6XX(A) Reactor Instrumentation and Control (3-3)
ME-241(A) Reactor Engineering II (3-2)
ME-250(A) Reactor Lab (0-4)
Mt-301(A) High Temp. Materials (3-0)
LP-102(L) NPS Lecture Program II (0-1)

NUCLEAR ENGINEERING (EFFECTS)
(*GROUP RZ*)

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

This curriculum is sponsored by the Defense Atomic Support Agency as a joint-Service course for certain selected officers of the Army, Navy, Air Force, Marine Corps, Coast Guard, and U.S. Public Health Service.

FIRST YEAR (RZ1)

FIRST TERM (16-3)
Ma-120(C) Vector Algebra and Geometry (4-0)
Ma-181(C) Total Derivatives, Integrals and Differential Equations (5-0)
Ph-151(C) Mechanics I (4-0)
Ph-240(C) Optics and Spectra (3-3)

Second Term (17-2)

Es-140(C) Electronics I (3-2)

Ma-182(B) Vector Analysis and Partial Differential Equations (5-0)

Ph-152(B) Mechanics II (4-0)

Ph-635(B) Atomic Physics I (5-0)

Third Term (17-3)

Ma-321(B) Probability, Statistics, and Operations Analysis (5-0)

Ph-153(A) Mechanics III (4-0)

Ph-360(B) Electrostatics and Magnetostatics (4-0)

Ph-636(B) Atomic Physics II (4-3)

Fourth Term (15-6)

Ch-102(B) General Inorganic Chemistry (3-2)

Es-240(C) Electronics II (3-3)

Ph-363(A) Electromagnetism (4-0)

Ph-535(B) Thermodynamics, Kinetic Theory and Statistical Mechanics (5-0)

Ph-750(L) Physics Seminar (0-1)

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

SECOND YEAR (RZ2)

First Term (16-8)

Ch-442(C) Physical Chemistry (4-2).

Ph-364(A) Electromagnetic Waves (4-0).

Ph-441(A) Shock Waves in Fluids (4-0).

Ph-637(B) Nuclear Physics I (3-0).

Ph-751(B) Physics Seminar (1-0).

Ph-911(A) Thesis (0-6).

Second Term (13-10)

Bi-800(C) General Biology (4-2).

ME-505(C) Statics and Strength of Materials (5-0).

Ph-638(A) Nuclear Physics II (3-2).

Ph-751(B) Physics Seminar (1-0)

Ph-912(A) Thesis (0-6).

Third Term (9-15)

Bi-801(B) Animal Physiology (4-2).

Ch-551(A) Radiochemistry (2-4).

ME-750(B) Engineering Vibrations (3-0).

Ph-750(L) Physics Seminar (0-1).

Ph-913(A) Thesis (0-8).

Fourth Term (12-11)

Bi-802(A) Radiation Biology (4-2).

ChE-591(A) Blast and Shock Effects (3-0).

ME-550(B) Dynamics of Engineering Structures (5-0)

Ph-750(L) Physics Seminar (0-1).

Ph-914(A) Thesis (0-8).

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

OPERATIONS ANALYSIS CURRICULUM
(GROUP RO)

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 the simple problems in operations analysis which arise both in the fleet and ashore.

FIRST YEAR (RO1)

First Term (14-6)

Ma-120(C) Vector Algebra and Geometry (3-1)

Ma-181(C) Partial Derivatives and Multiple Integrals (4-1)

Ma-391(C) Basic Probability (4-0)

OA-892(L) Orientation Seminar (0-1)

Ph-241(C) Radiation (3-3)

Second Term (16-4)

Ma-182(C) Vector Analysis and Differential Equations (5-0)

Ma-392(B) Basic Statistics (3-2)

OA-291(C) Introduction to Operations Analysis (4-0)

Ph-341(C) Electricity and Magnetism (4-2)

Third Term (19-2)

Ma-116(A) Matrices and Numerical Methods (3-2)

Ma-183(B) Fourier Series and Complex Variables (5-0)

OA-292(B) Methods of Operations Analysis (4-0)

Ph-141(B) Analytical Mechanics (4-0)

Ph-321(B) Electromagnetism (3-0)

Fourth Term (18-4)

Ma-195(A) Matrix Theory and Integration Theory (4-0)

OA-293(B) Search Theory and Air Defense (4-0)

OA-391(A) Games of Strategy (3-2)

OA-491(A) Data Processing for Operations Analysis (3-2)

Ph-142(B) Analytical Mechanics (4-0)

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

SECOND YEAR (RO2)

First Term (17-4)

Ma-393(A) Design of Experiments (3-2)

OA-201(A) Logistics Analysis (3-2)

OA-294(A) Special Topics in Operations Analysis (3-0)

OA-891(B) Seminar (1-0)

Ph-421(B) Fundamental Acoustics (3-0)

Ph-541(A) Kinetic Theory and Statistical Mechanics (4-0)

Second Term (15-5)

OA-202(A) Econometrics (3-0)

OA-295(A) Analysis of Weapons Systems (3-0)

OA-401(A) Theory of Information Communication (3-0)

Ph-425(A) Underwater Acoustics (3-2)

Ph-640(B) Atomic Physics (3-0)

Ph-641(B) Atomic Physics Lab. (0-3)

THIRD TERM (10-15)

Co-230(C) Naval Communications Afloat and Ashore (3-2)

OA-296(A) Design of Weapons Systems (3-0)

Ph-642(B) Nuclear Physics (4-0)

Ph-643(B) Nuclear Physics Lab. (0-3)

Thesis (0-10)

FOURTH TERM (11-10)

Ma-394(A) Advanced Statistics (3-0)

Mr-120(C) Operational Aspects of Meteorology and Oceanography (3-0)

OA-297(A) Decision Theory (3-0)

OA-893(B) Seminar (2-2)

Thesis (0-8)

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

ORDNANCE ENGINEERING CURRICULA

BASIC OBJECTIVE—To provide selected officers with an advanced technical education based 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 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 Ordnance Engineering 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 Curricula within 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. 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. The Advanced Curricula are being revised in consonance with the basic objective of instilling in the student those principles in the fields of Electrical Engineering, Physics and Chemistry that have wide application to space, air and underwater weapons systems.

WEAPONS SYSTEMS (GENERAL) (*GROUP WG*)

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 principal science-engineering fields of Electrical Engineering, Physics and Chemistry underlying space, air and underwater weapons systems.

FIRST YEAR (WG1) (COMMON TO ALL)

FIRST TERM (13-7)

Ch-106-(C) Principles of Chemistry I (3-2).

EE-171(C) Electrical Circuits and Fields (3-4).

Ma-120(C) Vector Algebra and Geometry (3-1).

Ma-171(C) Differential Equations (4-0).

SECOND TERM (14-6)

Ch-107(C) Principles of Chemistry II (3-2).

EE-251(C) Alternating Current Circuits (3-4).

Ma-153(B) Vector Analysis (3-0).

Ma-172(B) Differential Equations and Infinite Series (5-0).

THIRD TERM (16-4)

ChE-611(C) Thermodynamics (3-2).

Es-241(C) Electron Tubes and Circuits I (3-2).

Ma-157(B) Complex Variable (4-0).

Ph-151(C) Mechanics I (4-0).

Or-241(C) Guided Missiles I (2-0).

FOURTH TERM (16-4)

EE-463(C) Special Machinery (3-2).

Es-242(C) Electron Tubes and Circuits II (3-2).

Ma-175(B) Differential Equations of Applied Mathematics (4-0).

Ph-152(B) Mechanics II (4-0).

Or-242(B) Guided Missiles II (2-0).

Intersessional period: Field trip to representative ordnance and industrial installations.

SECOND YEAR (WG2)

FIRST TERM (13-8)

Ch-401(A) Physical Chemistry (Ord) (3-2).

EE-671(A) Transients (3-4).

Ph-260(C) Physical Optics (3-2).

Ph-360(B) Electrostatics and Magnetostatics (4-0).

SECOND TERM (13-9)

Ch-571(A) Explosives (3-2).

EE-670(A) Servomechanisms (3-3).

Es-258(B) Introduction to Microwaves (3-2).

Ph-640(B) Atomic Physics (4-2).

THIRD TERM (14-7)

ChE-591(A) Blast and Shock Effects (3-0).

Es-351(B) Pulse Techniques and Radar (3-3).

Ma-116(A) Matrices and Numerical Methods (3-2).

Ph-642(B) Nuclear Physics (4-0).

Or-105(C) Underwater Ordnance (1-2).

FOURTH TERM (12-9)

ChE-542(A) Reaction Motors (3-2).

Es-352(B) Radar and Radar Systems (3-3).

Ma-421(A) Digital and Analog Computation (3-2).

Ph-450(B) Underwater Acoustics (3-2).

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

Upon completion of the curriculum, officers may expect to attend the six-week "Elements of Management and Industrial Engineering" course, MN-101, and a course in the "Art of Presentation" at the U. S. Naval Postgraduate School prior to detachment.

ENGINEERING SCHOOL

COURSE DESCRIPTIONS

AERONAUTICS

Ae-001(L) AERONAUTICAL LECTURE SERIES (0-2). Lectures on general aeronautical engineering subjects by prominent authorities from the Bureau of Aeronautics, research laboratories and the industry.

Ae-002(L) AERONAUTICAL LECTURE SERIES (0-1). Lectures on electrical engineering subjects in connection with aeronautical engineering by prominent authorities from the Bureau of Aeronautics, 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: DODGE and THOMPSON, *Fluid Mechanics;* ROUSE, *Elementary Fluid Mechanics.*

Ae-102(C) AERODYNAMICS (ORD) I (3-0). Basic aerodynamics for ordnance applications. Properties of fluids; equations of basic hydrodynamic flow; viscous fluids and boundary layers; dynamic lift and drag of bodies; elementary study of compressible flows. TEXTS: Same as Ae-100(C).

Ae-103(C) AERODYNAMICS (ORD) I LAB. (0-2). Laboratory in combination with Ae-102(C) in basic aerodynamics. Measurement of airspeed; the wind tunnel; pressure distributions about bodies; technical report writing. TEXTS: POPE, *Wind Tunnel Testing;* HIGGINS, *A General Outline for Technical Report Writing.* CO-REQUISTE: Ae-102(C).

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 Tunnnel Testing.* PREREQUISITE: Ae-100(C).

Ae-124(C) AERODYNAMICS (ORD) II (3-0). Continuation of Ae-102(C). Aerodynamics of component parts of missiles and aircraft; the optimum wing; drag of bodies; auxiliary devices; propulsion systems; aerodynamics of composite missiles and aircraft; subsonic and supersonic. TEXTS: DWINNELL, *Principles of Aerodynamics;* POPE, *Wind Tunnel Testing;* USNPS Notes. PREREQUISITE: Ae-102(C); Ae-103(C).

Ae-125(C) AERODYNAMICS (ORD) II LAB. (0-2). Laboratory in combination with Ae-124(C). Wind tunnel experiments and practical problems in aerodynamics. TEXTS: Same as Ae-124(C). PREREQUISITE: Ae-102(C); Ae-103(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-136(B) AIRCRAFT PERFORMANCE—FLIGHT ANALYSIS (3-2). Aerodynamic characteristics of composite aircraft; propeller and engine characteristics; aircraft performance; range and endurance; special performance problems; performance parameters; flight test reduction and analysis. Laboratory analysis of performance of an aircraft will be made based upon wind tunnel tests; analysis of practical problems from flight test. TEXTS: POPE, *Wind Tunnel Testing;* HAMLIN, *Flight 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; C.G. location, effect on static stability; neutral points; maneuver points; fixed control and free control stablility; 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, *Aircraft 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; solution of the symmetrical or longitudinal motion analysis; solution of 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-145(B) MISSILE DYNAMICS (3-2). Continuation of aerodynamics sequence for ordnance curricula. Missile performance and range; static and dynamics stability, controllability. Practical design problems and analysis. TEXTS: PERKINS and HAGE, *Airplane Performance, Stability and Control;* ETKIN, *Dynamics of Flight;* HIGGINS, *Notes on Dynamics of Aircraft.* PREREQUISITE: Ae-124(C); Ae-125(C).

Ae-146(A) DYNAMICS (3-2). Fundamental definitions, forces and moments of composite aircraft; equations of motion; static stability and trim; effects of CG location; static margins; free control stability; dynamic longitudinal stability; dynamic lateral stability, force and moment; derivatives; stability charts; controllability; maneuverability; three-dimensional motions; spins. Laboratory work consists of experimentation and analysis of static and dynamic stability of some particular aircraft. TEXTS: Same as Ae-141(A). PREREQUISITE: Ae-131(C) or Ae-136(B).

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). The technical aerodynamics of airplanes, especially performance and test methods. TEXTS: Same as Ae-150(B). PREREQUISITE: Ae-421(B).

Ae-152(B) FLIGHT TESTING AND EVALUATION II (2-0). Theoretical longitudinal stability and control of aircraft, related test methods and aircraft evaluation. TEXTS: Same as Ae-151(B). PREREQUISITE: Ae-141(A) or Ae-146(A).

Ae-153(B) FLIGHT TESTING AND EVALUTION III (2-0). Theoretical lateral-directional control of aircraft, related test methods and aircraft evaluation. TEXTS: Same as Ae-151(B). PREREQUISITE: Ae-142(A) or Ae-146(A).

Ae-161(B) FLIGHT TESTING AND EVALUATION LABORATORY I (0-4). Flight program accompanying Ae-151(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-162(B) FLIGHT TESTING AND EVALUATION LABORATORY II (0-4). Flight program accompanying Ae-152(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-163(B) FLIGHT TESTING AND EVALUATION LABORATORY III (0-4). Flight program accompanying Ae-153(B). Test flying in naval aircraft by aviator students: rate of roll; adverse yaw; control effectiveness with asymmetric power, static and dynamics lateral-directional stability; over-all qualitative evaluation of aircraft.

Ae-200(C) RIGID BODY STATICS (3-2). This course parallels Mc-101(C) and extends its coverage of statics to applications typical for aircraft design. Topics include: force systems, truss analysis, shear and moment diagrams, influence lines, section properties, Mohr's circle. Problem work supplements theory. TEXTS: TIMOSHENKO *and* YOUNG, *Statics;* NILES *and* NEWELL, *Airplane Structures, 3rd Ed., Vol I;* BRUHN, *Analysis and design of Airplane Structures.* PREREQUISITE: To be taken with Mc-101(C), with same prerequisites.

Ae-211(C) STRENGTH OF MATERIALS (4-2). Elastic body analysis applied to aircraft structures and machines. Topics include: elementary stresses in struts, beams, circular shafts, thin cylinders and columns; extended discussion of bending deflections; statically indeterminate beams and frames. Problem and laboratory work supplement theory. TEXTS: TIMOSHENKO, *Strength of Materials, Vol. II;* NILES *and* NEWELL, *Airplane Structures, 3rd Ed., Vols. I and II.* PREREQUISITE: Ae-200(C).

Ae-212(C) STRESS ANALYSIS I (4-2). The general two-dimensional state of stress in airframe and machine components. Topics include: principal stresses, unsymmetrical bending, shear flow in open and closed sections, center of twist; torsion of non-circular sections, membrane analogy; shear-resistant webs and diagonal tension fields. Problem and laboratory work supplement theory. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II;* NILES *and* NEWELL, *Airplane Structures, 3rd Ed., Vols. I and II.* PREREQUISITE: Ae-211(C).

Ae-213(B) STRESS ANALYSIS II (3-2). A continuation of Ae-212(C). Strain energy, curved bars and frames. Topics include: impact loading, energy methods, Castigliano theorem, virtual energy applications; curved bars; beam-columns; rotating machine parts. Problems and laboratory work supplement theory. TEXTS: Same as Ae-212(C). PREREQUISITE: Ae-212(C).

Ae214(A) STRESS ANALYSIS III (3-0). A continuation of Ae-213(B). General three dimensional elasticity equations. Axially symmetrical plates under lateral loadings. Discontinuity effects in shells. Beams on elastic foundations, application to cylinder, hemisphere, flat plate, hollow ring. Thick walled spheres and cylinder under internal or external pressure. TEXTS: Same as Ae-213(B); also SECHLER, *Elasticity in Engineering.*

Ae-215 (A) ADVANCED STRESS ANALYSIS (4-0). A continuation of Ae-214(A). Selected topics from theories of elasticity and plasticity and aircraft and missile structures. Advanced stability considerations. TEXTS: Depending on selection of topics. PREREQUISITE: Ae-214(A).

Ae-221(A) STRUCTURES PERFORMANCE (2-3). Aeronautical structures laboratory. Instability of columns, plates, shells, stringer panels. Combined loadings, interaction relations. Electronic and optical strain instrumentation methods. Static and dynamic tests of aircraft and missile components. TEXTS: Same as Ae-213(B). PREREQUISITE: Ae-213(B).

Ae-311(C) AIRPLANE DESIGN I (2-4). Detail methods of design and analysis of a jet airplane. 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 Ae-213(B); also CORNING, *Airplane Design; MIL-A-*8629 (*Aer*). PREREQUISITE: Ae-213(B).

Ae-312(B) AIRPLANE 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 caps, stiffners. Analysis of riveted, bolted, welded fittings. TEXTS: Same as Ae-311(C). PREREQUISITE: Ae-311(C).

Ae-316(C) AIRPLANE DESIGN (2-4). Detail methods of airplane or missile design and analysis. Preliminary layout; three view drawing; weight and balance; aerodynamic characteristics and basic performance; design criteria; inertia loads; shear and moment curves; detail structural design and stress analysis of a major component. TEXTS: Same as Ae-311(C). 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 gases and vapors, property relationships, theoretical cycles and elementary compressible flow. TEXTS: KIEFER, KINNEY *and* STUART, *Engineering Thermodynamics;* KEENAN *and* KEYS, *Thermodynamic properties of Steam;* KEENAN *and* KAYE, *Gas Tables;* SEARS, *Thermodynamics.* PREREQUISITE: Ae-100(C).

Ae-410(B) THERMODYNAMICS II (AERONAUTICAL) (3-2). This course extends the study of fundamental thermodynamics in preparation for advanced work in aerothermodynamics and aircraft propulsion. Topics include one-dimensional compressible flow, internal combustion engine and turbine cycles and elements of heat transfer. TEXTS: KIEFER, KINNEY *and* STUART, *Engineering Thermodynamics;* STOVER, *Applied Heat Transmission;* KEENAN *and* KAYE, *Gas Tables;* SABERSKY, *Engineering Thermodynamics.* PREREQUISITE: Ae-409(C).

Ae-411(B) AIRCRAFT ENGINES (4-2). This course extends the study of combustion with particular reference to piston engine and gas turbine applications. Topics are: fuel mixtures; ignition; flame propagation and stability; utilization, conversion and mechanical aspects; survey of current engine design and construction. TEXTS: LICHTY, *Internal Combustion Engines;* TAYLOR *and* TAYLOR, *Internal Combustion Engines;* USNPGS Notes; HESSE, *Jet Propulsion.* 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). Sea level and altitude performance characteristics of piston engines, propellers, turbo-jet and turbo-prop engines. Topics are: maximum performance; cruise control; laboratory and flight testing; test data correction methods; aircraft performance review with particular reference to the propulsion system. The practical work of this course consists of supervised analysis of test data taken at various Naval Air Test Centers. TEXTS: FRAAS, *Aircraft Power Plants;* NELSON, *Airplane Propeller Principles;* HESSE, *Jet Propulsion.* PREREQUISITE: Ae-411(B).

Ae-428(A) OPERATING PRINCIPLES OF TURBOMACHINES (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 turbine. Operating characteristics to establish relations between theoretical and actual performance in special compressor test rig. TEXT: USNPS Notes. PREREQUISITE: Ae-411(B), and accompanied by Ae-508(A).

Ae-431(A) AEROTHERMODYNAMICS OF TURBOMACHINES (4-1). Fundamental course in the study of flows of elastic fluids in turbomachines. 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: Instructor's Notes. PREREQUISITE: Ae-503(A).

Ae-451(A) GAS TURBINES I (3-0). Thermodynamic studies of gas turbine cycles; free-piston plants; part load performance; heat transfer and losses in regenerators; control problems; design features; operating experiences. TEXT: USNPGS Notes. PREREQUISITE: Ae-431(A).

Ae-452(A) GAS TURBINES II (3-0). Advanced aerothermodynamics; three-dimensional flow phenomena; analysis and design of bladings; analysis and design of turbomachines and gas turbines with emphasis on rational methods and future developments. TEXT: USNPGS Notes. PREREQUISITE: Ae-451(A).

Ae-453(A) ADVANCED PROBLEMS IN GAS TURBINES I. Discussion and solution of original problems of theoretical or experimental nature. Hours to be arranged. PREREQUISITE: Ae-452(A).

Ae-454(A) ADVANCED PROBLEMS IN GAS TURBINES II. Hours to be arranged. Continuation of Ae-453(A).

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, boundary-layer equations, Blasius solution, Karman integral relation, turbulent boundary-layer, transition. TEXTS. Same as Ae-501(A). PREREQUISITE: Ae-501(A).

Ae-503(A) COMPRESSIBILITY I (4-0). 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 airfoils and bodies of revolution, method of characteristics. TEXTS: LIEPMANN *and* ROSHKO, *Elements of Gasdynamics;* Instructor's Notes. PREREQUISITES: Ae-410(B) and Ae-502(A).

Ae-504(A) COMPRESSIBILITY II (3-2). Continuation of Ae-503(A). 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-503(A). PREREQUISITE: Ae-503(A).

Ae-505(A) HYDRO-AERO MECHANICS (ORD) (4-0). Essentially the same coverage as Ae-501(A) and Ae-502(A) combined, but in condensed form. TEXTS: Same as Ae-501 (A). PREREQUISITES: Ma-153(B), Ma-157(B), Ae-124 (C).

Ae-506(A) COMPRESSIBILITY (ORD) (3-2). Essentially the same coverage as Ae-503(A) and Ae-504(A) combined, but in condensed form. TEXTS: Same as Ae-503(A). PREREQUISITES: Ph-530(B) or equivalent, Ae-505(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).

BIOLOGY

Bi-800(C) GENERAL BIOLOGY (4-2). General botany, zoology, animal physiology, biochemistry, genetics, and ecology. TEXT: MARSLAND: *Principles of Modern Biology.*

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

Bi-802(A) RADIATION BIOLOGY (4-2). Physiological and genetic effects of radiation and blast. Calculation and measurement of dose; methods of experimental radiobiology. TEXT: CLAUS: *Radiation Biology and Medicine.* PREREQUISITES: Ph-642(B); Bi-801(B).

Bi-801(C) BIOLOGICAL EFFECTS OF RADIATION (3-0). Principles of biological dose measurement. Tolerance levels; genetic and physiological effects of ionizing radiations. TEXT: SPEAR: *Radiation and Living Cells.* PREREQUISITE: Ph-640(B).

CHEMISTRY AND CHEMICAL ENGINEERING

Ch-001 GENERAL INORGANIC CHEMISTRY (4-4). The first term of a two-term course in elementary chemistry for students in the School of Naval Science and 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: RITTER, *An Introduction to Chemistry;* RITTER, *An Introductory Laboratory Course in Chemistry;* PIERCE *and* SMITH, *General Chemistry Workbook.*

Ch-002 GENERAL INORGANIC CHEMISTRY (4-3). 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 of carbon. Experiments will illustrate the reactions of the elements and their irons and the preparation of their compounds. TEXTS: RITTER, *An Introduction to Chemistry;* RITTER, *An Introductory Laboratory Course in Chemistry;* PIERCE *and* SMITH, *General Chemistry Workbook.* PREREQUISITE: Ch-001.

Ch-101(C) GENERAL INORGANIC CHEMISTRY (3-2). A study of the principles governing the chemical behavior of matter. Includes topics such as kinetic theory, atomic structure, chemical equilibrium, introduction to organic chemistry and specialized topics (explosives, corrosion, etc.) Elementary physical chemistry experiments are performed in the laboratory. TEXT: HILDEBRAND, *Principles of Chemistry.*

Ch-102(B) GENERAL INORGANIC CHEMISTRY (3-2). A course in general inorganic chemistry with particular emphasis on the properties and behavior of the transition elements, including the rare earth and actimide series. The approach is from atomic structure, periodic and group properties. The laboratory work is quantitative analysis. TEXTS: HILDEBRAND *and* POWELL, *Principles of Chemistry (combined volume);* LATIMER *and* HILDEBRAND, *Reference Book of Inorganic Chemistry;* PIERCE *and* HAENISCH, *Quantitative Analysis.*

Ch-105(C) PHYSICAL CHEMISTRY (3-2). A course in theoretical chemistry for naval engineers. Includes such topics as atomic structure, kinetic theory, gases, liquids, thermochemistry, electrochemistry and kinetics. The laboratory work will consist of experiments which illustrate principles discussed in the lectures. TEXTS: HILDEBRAND, *Principles of Chemistry;* PRUTTON *and* MARON, *Fundamental Principles of Physical Chemistry.*

Ch.E-111(A) 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: GRUSE *and* STEVENS, *Chemical Technology of Petroleum;* PUGH *and* COURT, *Fuels and Lubricating Oils.* PREREQUISITE: Ch-101(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; etc. TEXTS: To be designated. PREREQUISITE: Physical Chemistry.

Ch-121(B) GENERAL AND PETROLEUM CHEMISTRY (4-2). A 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;* PUGH *and* COURT, *Fuels and Lubricating Oils;* GRUSE *and* STEVENS, *Chemical Technology of Petroleum.*

Ch-213(C) QUANTITATIVE ANALYSIS (2-3). Typical volumetric and gravimetric determinations in the laboratory are used as a basis for the study of the theory and calculations of quantitative analysis. TEXT: PIERCE *and* HAENISCH, *Quantitative Analysis.* PREREQUISITE: Ch-102(C).

Ch-221(C) QUALITATIVE ANALYSIS (3-2). The first part of a course in analytical chemistry, combining the separation and detection of selected cations on a semi-micro scale with a theoretical and descriptive treatment of solutions of electrolytes. TEXT: CURTMAN, *Introduction to Semi-micro Qualitative Analysis.* PREREQUISITE: Ch-101(C) or Ch-121(B).

Ch-222(C) QUALITATIVE ANALYSIS (2-2). A brief course in semi-micro qualitative analysis, accompanied by a theoretical and descriptive treatment of solutions of electrolytes. TEXT: CURTMAN, *Introduction to Semi-micro Qualitative Analysis.* PREREQUISITE: Ch-101(C) or Ch-121(B).

Ch-231(C) QUANTITATIVE ANALYSIS (2-4). A continuation of Ch-221(C), dealing with the principles and calculations of quantitative analysis, and accompanied by typical volumetric and gravimetric determinations in the laboratory. TEXT: PIERCE *and* HAENISCH, *Quantitative Analysis.* PREREQUISITES: Ch-101(C) or Ch-121(B) and Ch-221(C).

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-101(C) or equivalent.

Ch-311(C) ORGANIC CHEMISTRY (3-2). The first half of a course in organic chemistry, consisting of the study of the properties and reactions of aliphatic compounds. The laboratory work is designed to illustrate typical organic reactions. TEXT: BREWSTER, *Organic Chemistry—A Brief Course.* PREREQUISITE: Ch-101(C).

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

Ch-315(C) ORGANIC CHEMISTRY (3-2). An introduction to the properties, reactions and relationships of the principal classes of organic compounds, as a basis for work in the biological sciences. TEXT: HART *and* SCHUETZ, *A Short Course in Organic Chemistry*. PREREQUISITE: Ch-102(C).

Ch-321(A) ORGANIC QUALITATIVE ANALYSIS (2-2). Identification of organic compounds on the basis of physical properties, solubility behavior, classification reactions and the preparation of derivatives. TEXT: SHRINER *and* FUSON, *Identification of Organic Compounds*. PREREQUISITE: Ch-301(C) or Ch-312(C) or Ch-315(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 and electronic configurations. TEXT: ROYALS, *Advanced Organic Chemistry*. PREREQUISITE: Ch-301(C) or Ch-312(C) or Ch-315(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 physical properties. TEXT: RITCHIE, *Chemistry of Plastics and High Polymers*. PREREQUISITES: Ch-301(C) or Ch-312(C) or Ch-315(C) and Ch-521(A).

Ch-324(A) QUALITATIVE ORGANIC CHEMISTRY (2-4). Identification of organic compounds on the basis of physical properties, solubility behavior, classification reactions and the preparation of derivatives. TEXT: SHRINER *and* FUSON, *Identification of Organic Compounds*. PREREQUISITE: One term of Organic Chemistry.

Ch-401(A) PHYSICAL CHEMISTRY (3-2). A one-term course in physical chemistry for students who have had Thermodynamics. Gases, liquids, solids, chemical equilibria, and chemical kinetcis are studied. Laboratory experiments illustrate principles discussed in the lectures. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and others, Experimental Physical Chemistry*. PREREQUISITES: Ch-101(C) and one term of Thermodynamics.

Ch-416(A) PHYSICAL CHEMISTRY, ADVANCED (3-4). Selected advanced topics in physical chemistry such as: atomic and molecular structure; chemical kinetics; physical chemistry of electrolytes. The laboratory work supplements the lecture work and introduces the student to problems encountered in research. This course ordinarily follows Ch-444(A). TEXT: To be assigned. PREREQUISITE: A two-term course in physical chemistry.

Ch-442(B) PHYSICAL CHEMISTRY (4-2). A short course in physical chemistry including such topics as properties of matter, thermo-chemistry, chemical equilibria, chemical kinetics, electrochemistry. Laboratory experiments illustrate the principles discussed in lecture. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and others, Experimental Physical Chemistry*. PREREQUISITE: Ch-101(C) or Ch-102(C) or Ch-103(C).

Ch-443(C) PHYSICAL CHEMISTRY I (4-2). The first part of a course in physical chemistry. To include such topics as properties of matter, chemical thermodynamics, chemical kinetics. Laboratory experiments illustrate the principles discussed in lecture. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and others, Experimental Physical Chemistry*. PREREQUISITE: Ch-101(C) or Ch-102(C) or Ch-103(C).

Ch-444(A) PHYSICAL CHEMISTRY II (3-4). A continuation of Ch-443(C). Chemical equilibria, 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.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-101(C) or Ch-121(B).

Ch.E-522(A) PLASTIC 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*. PREREQUISITE: 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 and rocket motor testing. In the laboratory periods representative problems are solved. TEXT: SUTTON, *Rocket Propulsion Elements*. PREREQUISITE: Ch.E-624(A) or Ch.E-631(A).

Ch-551(A) RADIOCHEMISTRY (2-4). Discussions 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-442(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.E-553(A) NUCLEAR CHEMICAL TECHNOLOGY (4-3). The chemistry of nuclear fuels, fission products, and special materials required in nuclear reactors; chemical engineering aspects in their production, purification and recovery. TEXT: BENEDICT *and* PIGFORD, *Nuclear Chemical Engineering*. PREREQUISITE: Ch-511, Ch.E-611, Ch.E-701 or Ch.E-711.

Ch-555(A) RADIOCHEMISTRY (0-3). A laboratory course in advanced measurement techniques and applications; analysis of complex mixtures of active nuclides; activation analysis. PREREQUISITE: Ch-551(A).

Ch-561(A) PHYSICAL CHEMISTRY (3-2). A short course on physical chemistry consisting of a study of chemical thermodynamics, gases, liquids, 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-101(C) or Ch-121(C) or equivalent.

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-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;* Vinal, *Primary Batteries.* PREREQUISITE: Physical Chemistry.

Ch-581(A) CHEMISTRY OF SPECIAL FUELS (2-2). A brief survey of the organic and physical chemistry necessary for a study of the problems associated with special fuels. The nature of high-energy fuels, their limitations, and possible future developments; adiabatic flame, temperature computations. PREREQUISITE: Ch.E-111 and Physical Chemistry.

Ch.E-591(A) BLAST AND SHOCK EFFECTS (3-0). Nature of explosions, propagation 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: Hirschfelder, *The Effects of Atomic Weapons.* PREREQUISITES: Physical Chemistry and Thermodynamics.

Ch.E-611(C) ENGINEERING THERMODYNAMICS (3-2). The fundamentals of engineering thermodynamics. The subject matter includes the concepts of energy and entropy, the first and second laws of thermodynamics, and the thermodynamic properties of substances with emphasis on ideal gases. In the laboratory period representative problems are solved. TEXT: Kiefer, Kinney *and* Stewart, *The Principles of Engineering Thermodynamics.* PREREQUISITE: Ch-101(C).

Ch.E-612(C) ENGINEERING THERMODYNAMICS (3-2) Thermodynamic properties of non-ideal gases and the thermodynamics of the flow of compressible fluids. The subject matter includes the application of the laws of thermodynamics to non-ideal gases, the flow of compressible fluids. TEXT: Kiefer, Kinney *and* Stewart, *The Principles of Engineering Thermodynamics.* PREREQUISITE: Ch.E-611.

Ch.E-613(A) CHEMICAL ENGINEERING THERMODYNAMICS (3-2). Application of engineering thermodynamics to the analysis and solution of problems in chemical engineering and chemistry. The subject matter includes equilibria effects and criteria of equilibria for systems undergoing changes in composition. In the laboratory period representative problems are analyzed and solved. TEXT: Weber *and* Meissner, *Thermodynamics for Chemical Engineers.* PREREQUISITE: Engineering Thermodynamics.

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. TEXT: Kiefer, Kinney *and* Stewart, *The Principles of Engineering Thermodynamics.* PREREQUISITE: Ch.E-611(C).

Ch.E-624(A) ENGINEERING THERMODYNAMICS (3-2). The flow of incompressible and of compressible fluids. The subject matter includes a thermodynamic analysis of different types of flow and shock front behavior. In the laboratory period representative flow problems in engineering are solved and a flow chart for the adiabatic flow of an ideal gas is constructed. TEXTS: Weber *and* Meissner, *Thermodynamics for Chemical Engineers;* Kiefer, Kinney *and* Stewart, *The Principles of Engineering Thermodynamics.* PREREQUISITE: Ch.E-614(A).

Ch.E-625(A) THERMODYNAMICS (2-2). Thermodynamics of materials at high temperatures; the effect of chemical dissociation. Numerial computations form an integral part of the course. TEXT: National Bureau of Standards, *Circular #564.* PREREQUISITE: Physical Chemistry Ch.E-614 or Ch.E-631.

Ch.E-631(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: Smith, *Introduction to Chemical Engineering Thermodynamics;* Kiefer, Kinney *and* Stewart. *Principles of Engineering Thermodynamics.* PREREQUISITE: Ch-561(A).

Ch.E-701(C) CHEMICAL ENGINEERING CALCULATIONS (3-2). Engineering problems involving mass and energy relationships in chemical and physical-chemical reactions; stoichiometric treatment of the combustion of fuels; reacting materials at high temperature; gaseous and liquid-vapor equilibria. TEXTS: Williams *and* Johnson, *Stoichiometry for Chemical Engineers;* Hougen *and* Watson, *Chemical Process Principles, Part I.* PREREQUISITE. Ch-101(C).

Ch.E-711(C) CHEMICAL ENGINEERING CALCULATIONS (3-2). An introductory course in chemical engineering, with ordnance applications of especial interest, material and energy balances in various chemical and physical-chemical processes in addition to unit operations. TEXTS: Kammermeyer *and* Osburn, *Process Calculations;* Hougen *and* Watson, *Chemical Process Principles, Part I.* PREREQUISITE: Ch-101(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; e.g., Petroleum Engineering. Among the unit operations, treatment will be given to flow of fluids, filtration, agitation, mixing, sedimentation, heat transmission, evaporation, and drying. TEXTS: Brown, *Unit Operations;* Perry, *Chemical Engineers' Handbook.* PREREQUISITE: Ch.E-701(C).

Ch.E-722(A) UNIT OPERATIONS (3-2). A continuation of Ch.E-721(B). Size reduction, sizing, crystallization, gas absorption, liquid-liquid extraction, batch and continuous distillation; fractionation columns. TEXTS: Brown, *Unit Operations;* Perry, *Chemical Engineers' Handbook.* PREREQUISITE: Ch.E-721(B).

Ch.E-731(A) PETROLEUM REFINERY ENGINEERING (3-0). A study of the chemistry and chemical engineering aspects of the production of fuels and lubricants from crude oil. TEXT: Instructor's Notes. PREREQUISITE: Ch.E-722 (A) (Unit Operations).

Ch.E-732(A) PETROLEUM REFINERY ENGINEERING (3-2). A continuation of Ch.E-731(A). In the laboratory period representative problems are solved. TEXT: Instructor's Notes. PREREQUISITE: Ch.E-731(A).

Ch.E-741(B) HEAT TRANSMISSION (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: ECKERT *and* DRAKE, *Introduction to the Transfer of Heat and Mass;* JAKOB, *Heat Transfer*. PREREQUISITE: Ch.E-624.

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.

COMMUNICATIONS ENGINEERING

Co-201(C) COMMUNICATION PRINCIPLES AND PROCEDURES I (3-2). An introduction to the principles of naval communication procedures, with a study of the basic communication publications relating to the various procedures; a study of the Naval Communications System. TEXTS: *DNC* 5; Various Classified Naval Publications. PREREQUISITE: Co-261(C).

Co-202(C) COMMUNICATION PRINCIPLES AND PROCEDURES II (3-2). A continuation of Co-201(C). TEXTS: *DNC* 5; Various classified Naval Publications. PREREQUISITE: Co-201(C).

Co-211(C) CRYPTOGRAPHIC METHODS AND PROCEDURES (3-3). A survey of administrative and operating procedures used in U.S. Naval Cryptography. TEXTS: Classified Naval Publications.

Co-221(C) COMMUNICATIONS PLANNING I (2-0). A study of the functions and facilities of naval communications, including details of tactical communciations and preparation of communications-electronics plans and orders 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-223(C) COMMUNICATIONS PLANNING III (3-2). A continuation of Co-221(C) and Co-222(C). TEXTS: Classified Naval Publications. PREREQUISITE: Co-222(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: *DNC* 5; *NWIP* 16-1; *JANAP* 195.

Co-231(C) NAVAL WARFARE TACTICS AND PROCEDURES I (2-0). To provide a basic practical working knowledge of naval tactics and procedures, and the fundamental principles underlying the successful prosecution of naval warfare. TEXTS: Classified Naval Warfare Publications.

Co-232(C) NAVAL WARFARE TACTICS AND PROCEDURES II (4-3). A continuation of Co-231(C) through a study of the operational planning processes and its applications to the specific operations in naval warfare. TEXTS: Classified Naval Warfare Publications. PREREQUISITE: Co-231(C).

Co-233(C) NAVAL WARFARE TACTICS AND PROCEDURES III (4-3). A continuation of Co-231(C) and Co-232(C). TEXTS: Classified Naval Warfare Publications. PREREQUISITE: Co-232(C).

Co-240(C) PUBLIC SPEAKING (0-2). Instruction and practice in the effective delivery of speech and presentation of ideas.

Co-261(C) COMMUNICATION SECURITY AND ADMINISTRATION (3-1). A study of physical, administrative, and transmission security in the Navy, followed by a study of administrative matters related to communications including naval correspondence and censorship. TEXTS: *DNC* 5; *RPS* 4; *U.S. Navy Security Manual;* and other 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 stereographic projections; and actual practice in making and interpreting of x-ray diffraction photographs. TEXTS: BUERGER, *Elementary Crystallography:* AZAROFF *and* BUERGER, *The Powder Method*. PREREQUISITE: Ch-101(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-101(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-101(C).

ELECTRICAL ENGINEERING

EE-011(C) ELECTRICAL FUNDAMENTALS (4-0). A basic presentation of electrical phenomena. Topics include: resistance, voltage, current, magnetism, inductance, capacitance, resonance, three-phase systems, power relations, instruments, and transformers. Pertinent laboratory exercises are performed. TEXTS: DAWES, *Industrial Electricity, Parts I and II*. PREREQUISITE: Ma-011(C) or equivalent.

EE-012(C) ELECTRICAL MACHINERY (4-1). The fundamentals and important applications of machinery. Topics include: external characteristics of shunt and compound generators; shunt, series, and compound motors; alternators; synchronous and induction motors. Laboratory exercises and demonstrations are utilized. TEXTS: DAWES, *Industrial Electricity, Parts I and II*. PREREQUISITE: EE-011(C).

EE-021(C) DIRECT-CURRENT CIRCUITS AND MACHINERY (5-3). A basic presentation of the direct-current circuits, and of direct-current machines and applications. Topics include: electrical and magnetic fields, general circuit theory, basic measurement and metering; shunt series and compound motors. Laboratory work illustrates the basic theory and provides experience. TEXT: DAWES, *Electrical Engineering, 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 of 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-111(C) FUNDAMENTALS OF ELECTRICAL ENGINEERING (3-2). Basic concepts of direct-current circuits and static electric and magnetic fields are considered. Electrical units, resistivity, electromotive forces, basic measurements and metering equipment, Kirchhoff's laws, magnetism, typical magnetic circuits and simple electrostatic fields are studied. TEXT: DAWES, *Electrical Engineering, Vol. I, 4th Edition*. PREREQUISITES: Differential and Integral Calculus and Elementary Physics.

EE-151(C) DIRECT CURRENT CIRCUITS AND FIELDS (3-2). An intermediate level course for those curricula that do not require a thorough background in circuits and fields. Basic electrostatic and electromagnetic field theory is presented at a level that requires no mathematics beyond the calculus. The most commonly used theorems and methods are developed for electric and magnetic circuit analysis. TEXT: CORCORAN *and* REED, *Introductory Electrical Engineering*. PREREQUISITES: Differential and Integral Calculus and Elementary Physics.

EE-171(C) ELECTRICAL CIRCUITS AND FIELDS (3-4). A basic course in electricity and magnetism for those curricula majoring in electrical science. Direct current circuits, electrostatic and electromagnetic fields and ferromagnetism are studied in considerable detail at a level requiring no mathematics beyond the calculus. TEXT: CORCORAN *and* REED, *Introductory Electrical Engineering*. PREREQUISITES: Differential and Integral Calculus and Elementary Physics.

EE-231(C) CIRCUITS AND MACHINES (3-2). General principles of DC machines, their control and application. The characteristics of machines are developed from basic principles, then a study of the theory of alternating currents is begun. Experiments are performed to demonstrate machine characteristics and the use of control devices. TEXT: DAWES, *Electrical Engineering, Vols. I and II, 4th Edition*. PREREQUISITE: EE-111(C).

EE-241(C) ALTERNATING CURRENT CIRCUITS (3-2). A short course for those curricula that do not require an extensive coverage of the subject. Single phase and balanced polyphase circuits are analyzed by using the conventional network theorems and methods. Coupled circuit theory and non-sinusoidal wave analysis are included along with a limited amount of laboratory work. TEXTS: KERCHNER *and* CORCORAN, *Alternating Current Circuits, 3rd Edition;* SKRODER *and* HELM, *Circuit Analysis by Laboratory Methods, 2nd Edition*. PREREQUISITE: EE-151(C).

EE-251(C) ALTERNATING CURRENT CIRCUITS (3-4). An intermediate level course which covers the essentials of alternating current circuit theory. Single phase and polyphase circuits are analyzed by using the conventional network theorems and methods. Coupled circuit theory, non-sinusoidal wave analysis, metering and elementary bridge methods are included. Laboratory experiments illustrate the basic principles. TEXTS: KERCHNER *and* CORCORAN, *Alternating Current Circuits, 3rd Edition:* SKRODER *and* HELM, *Circuit Analysis by Laboratory Methods, 2nd Edition*. PREREQUISITE: EE-151(C).

EE-271(C) ALTERNATING CURRENT CIRCUITS I (3-2). A basic course in alternating current circuit analysis for those curricula that require a thorough treatment of the subject. This course is followed by EE-272 Alternating Current Circuits for the coverage required for those curricula majoring in electrical science. Single phase and balanced polyphase circuit steady-state analysis, wave analysis and power measurements are covered in detail. Laboratory requirements illustrate the basic principles. TEXTS: KERCHNER *and* CORCORAN, *Alternating Current Circuits, 3rd Edition;* SKRODER *and* HELM, *Circuit Analysis by Laboratory Methods, 2nd Edition*. PREREQUISITE: EE-171(C).

EE-272(B) ALTERNATING CURRENT CIRCUITS II (3-2). A continuation of EE-271. Topics covered include unbalanced polyphase circuits, power measurements, coupled circuits and symmetrical components. Laboratory experiments illustrate the basic principles. TEXTS: KERCHNER *and* CORCORAN, *Alternating Current Circuits, 3rd Edition;* SKRODER *and* HELM, *Circuit Analysis by Laboratory Methods, 2nd Edition*. PREREQUISITE: EE-271(C).

EE-273(C) ELECTRICAL MEASUREMENTS I (2-3). An introduction to the measurement of the fundamental quantities: current, voltage, capacitance, inductance, and the magnetic properties of materials. TEXT: STOUT, *Basic Electrical Measurements*. PREREQUISITE: EE-251(C).

EE-274(B) ELECTRICAL MEASUREMENTS II (2-3). A continuation of EE-273(C). Alternating-current bridge circuits, components, and accessories; measurement of the properties of dielectrics. TEXT: STOUT, *Basic Electrical Measurements*. PREREQUISITE: EE-273(C).

EE-281(C) BASIC ELECTRICAL PHENOMENA (3-0). The first of a series of four courses designed to present an advanced treatment of the fundamentals of fields and circuits as a necessary background for advanced 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. TEXTS: HARNWELL, *Principles of Electricity and Electromagnetism;* Instructor's Notes. PREREQUISITES: Vector Analysis and Ordinary Differential Equations.

EE-282(B) BASIC CIRCUIT ANALYSIS (3-2). An extension of EE-281. 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 poly-phase circuits are analyzed and basic network theorems are presented. TEXTS: VAN VALKENBURG, *Networks Analysis;* Instructor's Notes. PREREQUISITE: EE-281(C).

EE-283(B) ADVANCED CIRCUIT ANALYSIS (3-4). A continuation of EE-282. A universal 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. TEXT: VAN VALKENBURG, *Network Analysis;* Instructor's Notes. PREREQUISITE: EE-282(B).

EE-284(A) CIRCUIT ANALYSIS (3-2). A coordinated continuation of EE-281, EE-282 and EE-283 which stresses the universal character of electric circuits. The mathematics of circuit anlysis is developed and additional network theorems are introduced, along with concepts of transient impedance and transfer functions. Mechanical and electro-mechanical circuits are analyzed and electro-mechanical analogs developed. TEXTS: VAN VALKENBURG, *Network Analysis;* Instructor's Notes. PREREQUISITE: EE-283(B).

EE-314(C) ELECTRICAL MACHINERY (3-4). The fundamentals of direct-current and alternating-current machines are studied and supplemented with laboratory experiments. The theory, construction, and the performance of direct-current machines and alternating-current machines are briefly covered. TEXT: DAWES, *Electrical Engineering, Vols, I and II, 4th Edition.* PREREQUISITE: EE-251(C).

EE-351(C) DIRECT-CURRENT MACHINERY (2-2). Fundamentals of direct-current machinery with emphasis upon operating characteristics and applications. The external characteristics are developed from basic relations. Problems and laboratory work. TEXT: DAWES, *Electrical Engineering, Vol. I.* PREREQUISITE: EE-151(C) or EE-171(C).

EE-371(C) DIRECT-CURRENT MACHINERY (3-2). A thorough presentation of the theory of direct-current machines and control devices. Armature windings, armature reaction and commutation are fully covered. The characteristics of generators and motors are developed from basic relations. Laboratory work supplements the work of the classroom. TEXT: LANGSDORF, *Principles of Direct-Current Machines.* PREREQUISITE: EE-171(C).

EE-451(C) TRANSFORMERS AND SYNCHROS (2-2). This course followed by EE-452(C) provides a general study of alternating current machinery for those curricula that do not require an extensive coverage of the subject. Topics covered include the theory and performance characteristics of single and polyphase transformers and synchro devices for control circuits. Laboratory experiments illustrate the basic principles. TEXT: PUCHSTEIN, LLOYD *and* CONRAD, *Alternating Current Machines, 3rd Edition.* PREREQUISITE: EE-251(C).

EE-452(C) ALTERNATING CURRENT MACHINERY (3-4). A continuation of EE-451. Basic principles and performance characteristics of alternators, synchronous motors, single and polyphase induction motors are covered in considerable detail at an intermediate level. Laboratory experiments illustrate the basic principles. TEXT: PUCHSTEIN, LLOYD *and* CONRAD, *Alternating Current Machines. 3rd Edition.* PREREQUISITE: EE-451(C).

EE-453(B) ALTERNATING CURRENT MACHINERY (3-4). A combined alternating current machinery course for those curricula not majoring in electrical science. The topics covered include the theory and performance of single and polyphase transformers, single and polyphase induction motors, alternators, synchronous motors and synchros for control circuits. Laboratory experiments illustrate the basic principles. TEXT: PUCHSTEIN, LLOYD *and* CONRAD, *Alternating Current Machines, 3rd Edition.* PREREQUISITE: EE-251(C).

EE-455(C) ASYNCHRONOUS MOTORS (2-2). An elementary presentation of the principles and operating characteristics of the induction motor and of single-phase commutator motors. Emphasis is placed upon the unbalanced operation of the two-phase symmetrical induction motor. Laboratory and problem work supplement the theory. TEXT: HEHRE *and* HARNESS, *Electrical Circuits and Machinery, Vol II.* PREREQUISITE: EE-451(C).

EE-461(C) TRANSFORMERS AND SYNCHROS (3-2). Single-phase transformer principles, constructional features and operating characteristics. Special transformers. Synchro and induction motor windings. Single-phase and polyphase synchro constructional features. Mathematical analysis of synchros operating under normal and fault conditions. Synchros in control circuits. Laboratory and problem work illustrate the basic principles. TEXT: HEHRE *and* HARNESS, *Electrical Circuits and Machinery, Vol. II; Ordnance Pamphlet* 1303. PREREQUISITE: EE-241(C) or EE-251(C).

EE-462(B) SPECIAL MACHINERY (4-2) Basic principles of induction motors and single-phase commutator motors. Operation of two-phase induction motors with unbalanced voltages. Theory and operating characteristics of amplidyne and rototrol generators, and direct-current motors. Calculation of the transfer function for motors and generators. TEXT: HEHRE *and* HARNESS, *Electrical Circuits and Machinery, Vol. II.* PREREQUISITE: EE-461(C).

EE-463(C) SPECIAL MACHINERY (3-2) The theory and performance of transformers at power and audio frequencies, synchros under normal operating conditions, induction motor principles and operating characteristics in control applications. A brief treatment of DC machinery and special machinery theory (amplidyne, etc.) is included, using transfer functions and concepts important in control applications. TEXTS: DAWES, *Electrical Engineering, Vols. I and II, 4th Edition; Ordnance Pamphlet* 1303; Departmental Notes. PREREQUISITE: EE-251(C).

EE-464(C) SPECIAL MACHINERY (3-4). The electrical machines required for air and space craft electric power and control systems are covered in such a fundamental manner that future developments will be anticipated as far as their theoretical background is concerned. Extensive problems and laboratory work cover the operational behavior and circuit characteristics of the machines studied. TEXTS: DAWES, *Electrical Engineering Vol I and II, 4th Edition.* PREREQUISITE: EE-251(C) or equivalent.

EE-471(C) ALTERNATING CURRENT MACHINERY I (3-4). The basic alternating current machinery course for those curricula majoring in electrical engineering. Topics covered include the basic theory and operating characteristics of single and polyphase transformers, single and polyphase induction motors and special induction machines. Laboratory experiments illustrate the basic principles. TEXT: CARR, *Electric Machinery* PREREQUISITE: EE-272(B).

EE-472(C) ALTERNATING CURRENT MACHINERY II (3-4). A continuation of EE-471(C). Topics covered include the basic principle and operating characteristics of alternators and synchronous motors based on cylindrical rotor and the two-reaction theories. There is also included a mathematical analysis of synchro control devices and their operating characteristics under normal and fault conditions. Laboratory experiments illustrate the principles. TEXT: CARR, *Electric Machinery.* PREREQUISITE: EE-471(C).

EE-473(B) SYNCHROS (2-2) Basic theory and mathematical analysis of single-phase and polyphase synchros. Voltage, current and torque relations under normal and fault conditions. Equivalent circuits and vector diagrams, control circuits using synchros. Laboratory and problem work supplement the study. TEXT: None. PREREQUISITE: EE-251(C) or EE-271(C).

EE-474(C) SYNCHROS AND SPECIAL MACHINES (2-0). An introduction to the theory of transformers with application to synchros. Special emphasis on the synchro generator-control transformer combination. Elements of induction motor theory with emphasis on the two phases servo motor, its time constants and transfer function representation. TEXTS: *Ordnance Phamphlet* 1303; Departmental Notes.

EE-551(B) LINES AND NETWORK SYNTHESIS (3-2). An intermediate level course for those curricula that do not major in electrical science. Transmission line equations, impedance matching with networks and stubs, and network synthesis to provide frequency discrimination are covered at a lower level than in EE-571(B). A limited amount of laboratory work illustrates the basic principles. TEXT: WARE *and* REED, *Communication Circuits, 3rd Edition.* PREREQUISITE: EE-251(C).

EE-571(B) LINES AND NETWORK SYNTHESIS (3-4). A comprehensive course for those curricula majoring in electrical science. Alternating current circuit theory is extended to lines with distributed constants. The topics covered include transmission line equations, impedance matching with networks and stubs and network synthesis to provide frequency discrimination. Laboratory work illustrates the basic theory. TEXT: WARE *and* REED, *Communication Circuits, 3rd Edition.* PREREQUISITE: EE-271(C).

EE-651(B) TRANSIENTS AND SERVOMECHANISMS (3-4). Basic principles of electric transients and servomechanisms. DC and AC transients in series, parallel, series-parallel and coupled circuits. The solution of the differential equations by classical and Laplace operational methods. Servomechanisms with viscous damping and differential and integral control. TEXTS: KURTZ *and* CORCORAN, *Introduction to Electric Transients;* CHESTNUT *and* MAYER, *Servomechanism and Regulating System Design, Vol. II;* WHEELER, *Basic Theory of the Electronic Analog Computer.* PREREQUISITES: EE-451(C) and EE-711(C) or EE-751(C).

EE-652(B) TRANSIENTS AND SERVOMECHANISMS (3-2). Covers the same field as EE-651(B) with emphasis on the performance features of particular interest in air craft applications. TEXTS: SKILLING, *Electrical Engineering Circuits;* THALER, *Elements of Servomechanisms.* PREREQUISITES: EE-282(B), EE-752(C).

EE-655(B) FILTERS AND TRANSIENTS (3-2). Basic principles of filters and electrical transients. T and Pi section filters and composite filters. DC and AC transients in series, parallel, series-parallel and coupled circuits. The solution of the differential equations by classical methods and Laplace operational methods. TEXTS: KERCHNER *and* CORCORAN, *Alternating Current Circuits;* KURTZ *and* CORCORAN, *Introduction to Electrical Transients.* PREREQUISITE: EE-251 (C).

EE-656(B) MACHINES AND SERVOS (3-4). Elements of synchros. The two phase induction motor, operating characteristics and transfer function. 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. TEXT: THALER, *Elements of Servomechanism Theory.* PREREQUISITES: Courses in Circuits and Transients.

EE-660(A) CIRCUIT ANALYSIS (3-2). The study of electric networks utilizing the pole and zero approach. Concepts of sinusoidal steady state response and transient response are unified using this method. The Cauer and Foster forms of reactive networks are studied along with filter circuits. TEXT: VAN VALKENBURG, *Network Analysis.* PREREQUISITE: EE-251(C) or equivalent.

EE-661(A) CIRCUIT SYNTHESIS (3-2). The concepts studied in EE-660(A) are extended to form a foundation for the design of electrical networks. TEXT BALABANIAN, *Network Synthesis.* PREREQUISITE: EE-660(A).

EE-670(A) INTRODUCTION TO SERVOMECHANISMS (3-3). The mathematical theory of linear feedback control systems is presented in detail. This is a terminal course. Both frequency domain and time domain methods are covered. Topics include the Nyquist stability criterion, the Bode diagram and its uses, the root locus method and pole and zero configurations. TEXTS: THALER *and* BROWN, *Servomechanism Analysis;* NIXON, *Principles of Automatic Controls.* PREREQUISITE: EE-671(A).

EE-671(A) TRANSIENTS (3-4). The basic theory and practical applications of transient phenomena are treated in detail. Emphasis is on electric circuits and electromechanical system transients. The Laplace transform method is used. TEXTS: GARDNER *and* BARNES, *Transients in Linear Systems;* WHEELER, *Basic Theory of the Electronic Analog Computer;* Departmental Notes. PREREQUISITE: EE-251 (C) or EE-272(C).

EE-672(A) SERVOMECHANISMS (3-3). The mathematical theory of linear feedback-control systems is discussed in detail. Topics are: basic system equations, time domain and frequency domain relationships, methods for improving performance, damping, differentiation and integration and their relationship to phase concepts, polar and logarithmic plots, design calculations, introduction to the root locus method. Problems and laboratory work illustrate the theory. TEXT: THALER *and* BROWN, *Servomechanisms Analysis.* PREREQUISITES: EE-671(A), EE-452(C), or EE-473(B) and EE-751(C) or equivalent.

EE-673(A) NONLINEAR SERVOMECHANISMS (3-3). A detailed study of phase plane methods and describing function methods. Application of these methods in the analysis and design of nonlinear servos, with emphasis on relay servos. TEXTS: CHESTNUT *and* MAYER, *Servomechanism and Regulating System Design, Vol I;* Departmental Notes. PREREQUISITE: EE-672(A).

EE-674(A) ADVANCED LINEAR SERVO 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; correlations between the time domain and the frequency domain; methods for computing the transient response from the frequency response. TEXTS: TRUXAL, *Automatic Feedback Control System Synthesis;* Departmental Notes. PREREQUISITES: EE-671(A) and EE-672(A).

EE-675(A) SAMPLED DATA SERVO 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. TEXTS: TRUXAL, *Automatic Feedback Control System Synthesis;* Departmental Notes. PREREQUISITES: EE-673(A) and EE-674(A).

EE-676(A) LINEAR AND NONLINEAR SERVO 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. PREREQUISITES EE-673(A) and EE-674(A).

EE-677(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-671(A) and EE-672(A).

EE-711(C) ELECTRONICS (3-2). Elementary theory of the control of electron motion by electric and magnetic fields in vacuum, gaseous conduction phenomena and electron tube characteristics are presented. Principles of the amplifier, rectifier and oscillator circuits. Laboratory work serves to integrate the principles of practical applications and circuits. TEXT: CORCORAN *and* PRICE, *Electronics*. PREREQUISITE: EE-251(C).

EE-731(C) POWER ELECTRONICS (3-2). Theory and application of various types of electron tubes is covered with particular emphasis on the thyratron. Principles of electronics circuitry as applied to control. Application in naval devices is stressed. The laboratory work demonstrates the theory. TEXT: CORCORAN *and* PRICE, *Electronics*. PREREQUISITE: EE-231(C).

EE-745(A) ELECTRONIC CONTROL AND MEASUREMENT(3-3). This course presents the principles and practice of electronic control and measurement. It includes the theory of vacuum tube volt-meters, direct coupled amplifiers, oscillators, timing circuits and frequency sensitive circuits with particular attention to their application in the measurement and control of current, voltage, frequency, speed, pressure, temperature, and illumination. Applications are studied in the laboratory. TEXT: GRAY, *Applied Electronics, 2nd Ed.* PREREQUISITE: EE-751(C) or EE-772(B).

EE-751(C) ELECTRONICS (3-4). This is an introduction to the theory and practice of engineering electronics. Topics treated are: electron motion in electric and magnetic fields, thermionic emission, vacuum tube characteristics, gaseous discharge phenomena, gas tube characteristics, transistor theory and applications. TEXT: RYDER, *Electronic Engineering Principles, 2nd Edition*. PREREQUISITE: EE-251(C) or equivalent.

EE-752(C) ELECTRONICS (3-2) Covers the same field as EE-751(C) with emphasis on avionic rather than laboratory technique. TEXT: RYDER, *Electronic Engineering Principles, 2nd Edition*. PREREQUISITE: EE-282(B) or equivalent.

EE-755(A) ELECTRONIC CONTROL AND MEASUREMENT (3-4). The principles and practice of electronic control and measurement. Includes the theory of such basic circuits as vacuum tube voltmeters, direct coupled amplifiers, oscillators, timing circuits and frequency sensitive circuits with particular attention to their application in the measurement and control of current, voltage, frequency, speed, pressure, temperature and illumination. TEXT: GRAY, *Applied Electronics, 2nd Edition*. PREREQUISITE: EE-751(C) or EE-772(B).

EE-756(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 problems of measurement encountered in development of missiles and missile guidance systems. TEXT: KINNARD, *Applied Electrical Measurement*. PREREQUISITE: EE-751 or EE-772(B).

EE-771(B) ELECTRONICS (3-2). The theory of electron tubes and circuits for those curricula requiring advanced treatment. Topics covered include: electron motion in electric and magnetic fields, thermionic emission, gaseous discharge phenomena, vacuum and gas tube characteristics and the principles of such tubes as the ignitron, glow tube, cathode-ray tube, the photo-tube, and circuit applications. TEXT: GRAY, *Applied Electronics, 2nd Edition*. PREREQUISITE: EE-251 (C) or equivalent.

EE-772(B) ELECTRONICS (3-2). A continuation of EE-771(B). Topics covered include tuned amplifier circuit theory, class B power amplifiers, class C amplifiers and oscillators. Feedback amplifier theory is given as a basis for analog computer and electronic control applications. Transsistor theory and transistor circuitry is presented. TEXT: GRAY, *Applied Electronics, 2nd Edition*. PREREQUISITE: EE-771(B).

EE-773(A) MAGNETIC AMPLIFIERS (2-3). Basic principles of magnetic amplifiers and magnetic amplifier circuits, including feedback and biasing. Emphasis placed on circuits useful in industrial control and military applications. TEXTS: STORM, *Magnetic Amplifiers;* Instructor's Notes. PREREQUISITE: EE-251(C).

EE-791(A) MAGNETOHYDRODYNAMICS (3-2) The application of electromagnetic theory to the problems of ionized gases and space technology. TEXT: COWLING, *Magnetohydrodynamics*. PREREQUISITE: Course in Electromagnetism.

EE-851(B) MAGNETIC DESIGN (4-0). Selected topics, in electromagnetic design principles to satisfy the requirements of a particular curriculum. Typical topics are synchros, transformers, relays, magnetic amplifiers, solenoids, and instruments. TEXT *None*. PREREQUISITES: EE-111 and EE-251.

EE-871(A) ELECTRICAL MACHINE DESIGN (4-0). A quantitative analysis of machine characteristics using the design approach. Presents the limitations and possibilities in electrical machine construction for naval applications, and the merits of present designs. This course consists of the study and design of a transformer. Later the analysis of the DC machine is begun. TEXT: SLICHTER, *Principles Underlying the Design of Electrical Machinery.* PREREQUISITE: EE-472(C).

EE-872(A) ELECTRICAL MACHINE DESIGN (4-0). A continuation of EE-871(A). The completion of the quantitative analysis and design of a DC machine and the beginning of a similar analysis of the synchronous machine. TEXT: SLICHTER, *Principles Underlying the Design of Electrical Machinery.* PREREQUISITE: EE-871(A).

EE-873(A) ELECTRICAL MACHINE DESIGN (4-0). A continuation of EE-872(A). The completion of the quantitative analysis and design of a synchronous machine and a similar analysis and design of the induction machine. TEXT: SLICHTER, *Principles Underlying the Design of Electrical Machinery.* PREREQUISITE: EE-872(A).

EE-874(A) ELECTRICAL MACHINE DESIGN (4-0). A continuation of EE-873(A). The design of the induction machine is analyzed quantitatively and its operating characteristics, both as a motor and as an induction generator, are determined. TEXT: SLICHTER, *Principles Underlying the Design of Electrical Machinery.* PREREQUISITE: EE-873(A).

EE-971(A) SEMINAR (1-0). In the seminar sessions, papers on research and developments in the field of electrical science 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 engineering 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 laws and field principles; the planar network as a linear graph; development of network theroems; solution of the planar network from nodal and loop methods; introduction of complex quantities and the phasor solution for steady state alternating current excitation. TEXTS: SEARS *and* ZEMANSKY, *University Physics;* GUILLEMIN, *Introductory Circuit Analysis;* SKILLING, *Electrical Engineering Circuits.* PREREQUISITE: Mathematics through calculus.

Es-112(C) FUNDAMENTALS OF ELECTRIC CIRCUITS II (4-3). This course is a continuation of the study of planar networks. The topics are: power relationships in A.C. circuits; mutual inductance; resonance; normalized resonance curves; Q relationships; coupled circuits; Fourier series and periodic driving functions; the complex frequency concept; "natural" and "driven" response of circuits; elementary use of pole-zero method for describing circuit behavior; matrix formulation and solution of the general planar network including Z, Y, transfer and hybrid matrices. TEXTS: GUILLEMIN, *Introductory Circuit Analysis;* SKILLING, *Electrical Engineering Circuits.* PREREQUISITE: Es-111(C).

Es-113(C) CIRCUIT THEORY (4-2). The objective of this course is to develop facility in the complete solution of electrical circuits with emphasis on transient behavior. The topics are: the Laplace transform method of solution of linear differential equation; use of contour integration for the evaluation of the inversion integral; application to transient studies in electrical networks with illustrations in mechanical and electro-mechanical networks. The laboratory will include introductory work on the use of analog computing elements to simulate transient problems and to solve linear differential equations. TEXT: ASELTINE, *Transform Method in Linear System Analysis.* PREREQUISITE: Es-112(C).

Es-120(A) CIRCUIT SYNTHESIS (3-3). Network synthesis is introduced and illustrated. The following are treated: realizability, properties of driving point and transfer functions, synthesis of LC, RC, RL and RLC driving point impedances, approximation, normalization, lattice networks and their transformation, synthesis of transfer functions with emphasis on RC networks. TEXTS: STEWART, *Circuit Theory and Design;* TRUXAL, *Control System Synthesis;* GUILLEMIN, *Synthesis of Passive Networks.* PREREQUISITES: Electronics common core.

Es-140(C) ELECTRONICS I (3-2). This is a series of three 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. TEXT: SKILLLING, *Electrical Engineering Circuits.* PREREQUISITE: Mathematics through calculus.

Es-191(B) ADVANCED CIRCUIT THEORY I (4-2). Advanced circuit theory with transient analysis. Basic circuit relations, philosophy of circuit behavior. The Laplace transform treated as a tool and used in circuit analysis and study of circuit properties. Normalized networks. Harmonic analysis, the Fourier integral and Fourier transform and their use in further study of circuit properties. Superposition formulae, indicial admittance, impulse functions. Translation, repeated action circuit analysis. TEXTS: Notes by GIET, GARDNER *and* BARNES, *Transients in Linear Systems;* GOLDMAN, *Frequency Analysis, Modulation, and Noise.* Not available after F-Y 59-60.

Es-192(A) ADVANCED CIRCUIT THEORY II (4-2). A continuation of Es-191(B). Two terminal pair networks, matrix algebra applied to the analysis of two terminal pair networks both passive and active, including tube and transistor circuits. Transient analysis of distributed constant circuits, long lines. Introduction to circuit synthesis given a driving point impedance. Foster's Reactance theorem. Synthesis of LC, RL, RC and RLC networks. TEXTS: Notes by GIET; GARDNER *and* BARNES, *Transients in Linear Systems;* GOLDMAN, *Frequency Analysis, Modulation, and Noise.* Not available after F-Y 59-60.

Es-211(C) PHYSICAL ELECTRONICS (3-3). 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 charge-carrier motion in vacuum and in 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. TEXT: MILLMAN, *Vacuum Tube and Semiconductor Electronics.*

Es-212(C) ELECTRONIC CIRCUITS I (4-3). A study of electronic devices as linear or piece-wise linear circuit elements. The treatment of practical diode circuits is preceded by the consideration of the ideal diode as a circuit element. Secondary consideration is given to the ideal amplifier followed by the study of practical small-signal vacuum tube and transistor amplifiers. TEXT: ANGELO, *Electronic Circuits*.

Es-213(C) ELECTRONIC CIRCUITS II (4-3). A study of applications of electronic circuit analytical techniques to various basic circuits, including feedback amplifiers, wide-band amplifiers, wave-shaping circuits, tuned voltage amplifiers, power amplifiers, and regulated power supplies. TEXT: ANGELO, *Electronic Circuits*.

Es-214(C) ELECTRONIC CIRCUITS III (4-3). The following circuits are studied with the objective of providing an engineering grasp of their performance characterisitcs: sine-wave oscillators, astable multivibrators, amplitude modulation, a-m detection and frequency conversion, and frequency modulation. TEXT: RIDEOUT, *Active Networks*.

Es-215(C) ELECTRON DEVICES (3-3). The objective is to provide an understanding of switching circuits, high-frequency techniques and devices, and, on a survey basis, a description of new electron devices and their applications. Topics studied include monostable and bistable multivibrators, u-h-f effects in tubes and transistor circuits, and microwave tubes. TEXT: MILLMAN *and* TAUB, *Pulse and Digital circuits;* M.I.T. RADAR SCHOOL STAFF, *Principles of Radar* (*3rd Edition.*)

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 sythesis of increasingly complex electronic systems. The course concerns itself 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 primarily with the development of testing procedures for evaluation of system and equipment performance characteristics. TEXTS: RCA, *Radiotron Designers Handbook*. PREREQUISITE: Es-214(C).

Es-220(A) MICROWAVE DEVICES (3-2). The principal topics presented are: circuit components; coupling methods between beams and circuits; matrix formulation of microwave circuit characteristics; analysis of gaseous, solid-state and beam-type microwave devices. TEXTS: MONTGOMERY, *and others*, *Principles of Microwave Circuits;* WATKINS, *Topics in Electromagnetic Theory*.

Es-229(B) TRANSISTOR CIRCUITS (3-3). This course is to be a brief review, elaboration, and extension of transistor physics and circuits. Topics included are: high frequency equivalent circuits and parameters, high frequency amplification, video amplifiers, switching, class C amplifiers, oscillators, modulation and detection, d-c regulators, transistor-saturable core reactor circuits. TEXT: HURLEY, *Junction Transistor Electronics*.

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 phase-plane and describing function techniques for optimum design of non-linear systems. TEXT: TRUXAL, *Control System Synthesis*.

Es-240(C) ELECTRONICS II (3-3). This course includes the common vacuum tube 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. Also included is semi-conductor diode and transistor theory. TEXT: CORCORAN *and* PRICE, *Electronics*. 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, voltage and power amplifiers, feedback circuits. TEXT: CORCORAN *and* PRICE, *Electronics*. PREREQUISITE: A C Circuits.

Es-242(C) ELECTRONICS II (3-2). A continuation of Es-241(C). Principal topics include: tuned amplifiers, oscillators, modulation and detection, gas-filled tubes, cathode-ray tubes, transistors, special circuits. TEXT: CORCORAN *and* PRICE, *Electronics*. PREREQUISITE: Es-241(C).

Es-243(B) TRANSMITTERS AND RECEIVERS (3-3). This is a study of the design and characteristics of radio transmitters and receivers. Although double sideband AM systems are emphasized, single sideband AM systems and frequency modulation is also covered. TEXT: TERMAN, *Radio Engineering*. PREREQUISITE: Es-242(C).

Es-247(B) PULSE TECHNIQUES (2-3). The principles and underlying problems of pulse techniques. Principal topics are: pulse-shaping, switching, clipping, differentiating and integrating circuits; sweep-circuit generators; pulse transformers; delay lines; transistors. TEXT: M.I.T. RADAR SCHOOL STAFF, *Principles of Radar* (*Third Edition*). PREREQUISITE: EE-771(B).

Es-248(A) PULSE TECHNIQUES (3-3). A study of clipping, differentiating and integrating circuits, clamping, coupling circuits, relaxation oscillators, pulse amplifiers, and transistor pulse techniques. TEXTS: M.I.T. RADAR SCHOOL STAFF, *Principles of Radar* (*Third Edition*); MILLMAN *and* TAUB, *Pulse and Digital Circuits*. PREREQUISITE: Es-242(C).

Es-249(C) TRANSISTORS AND TRANSDUCERS (3-2). A study of the theory and circuits of transistors and other solid state devices. Included in this course is a study of the theory and use of certain transducers associated with airplanes such as the sonar dipping transducer. This course is designed to acquaint the air officer with those devices which affect the design, operation, and effectiveness of the airplane and its mission. TEXTS: RIDDLE *and* RISTENBATT, *Transistor Physics and Circuits*; Instructor's Notes.

Es-251(B) TRANSMITTERS AND RECEIVERS (4-2). A study of radio transmitter and receiver communications systems. This course concerns itself with the design of AM radio transmitters and receivers, single sideband generation and reception, frequency modulation. TEXTS: Navy instruction manuals; Current technical literature.

Es-252(B) ELECTRONIC SYSTEMS (3-3). A continuation of Es-251(B). This course concerns itself with specialized electronic techniques. Topics covered are: FSK teletype, image systems, pulse modulation systems, time-division multiplexing. TEXTS: Navy instruction manuals; Current technical literature. PREREQUISITE: Es-251(B).

Es-258(B) INTRODUCTION TO MICROWAVES (3-2). The objective of this course is to serve as an introduction to radar. The principal 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-259(A) ELECTRON TUBES AND ULTRA-HIGH FREQUENCY TECHNIQUES (3-2). The principal topics are: electron ballistics, noise in electron-tube circuits, ultra-high frequency effects, microwave techniques, i.e., cavity resonators, the klystron, the cavity magnetron and the traveling-wave tube. TEXT: REICH, *and others, Microwave Principles*. PREREQUISITES: Es-242(C); Ph-362(A).

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. Applications in naval electronics systems are developed. Appropriate laboratory demonstrations and exercises are utilized. Topics include: vacuum tubes, gas tubes, transistors, rectifiers, amplifiers, oscillators, modulators, detectors, wave propagation. TEXT: HILL, *Electronics in Engineering*. PREREQUISITE: EE-002(C).

Es-272(C) ELECTRONICS II (4-2). A continuation of Es-271(C). Topics include: review of oscillators, and modulators; receivers, transmitters; oscilloscopes, cathode ray tubes; pulse circuits, timing circuits; general theory involved in certain electronic systems used by the Navy. TEXT: TERMAN, *Radio Engineering*. PREREQUISITE: Es-271(C).

Es-290(C) ELECTRON TUBES AND CIRCUITS (3-2). The principal topics are: high-frequency limitations of tube-circuit operation; microwave technique, i.e., cavity resonators, the klystron, the cavity magnetron and the traveling-wave tube; basic pulse techniques, i.e., clipping circuits, differentiating and integrating circuits, clamping circuits, relaxation oscillators, switching circuits. TEXT: M.I.T. RADAR SCHOOL STAFF, *Principles of Radar (Third Edition)*. Not available after F-Y 59-60.

Es-291(B) ELECTRON TUBES (3-3). The tubes treated are those in which operation depends on the motions of electrons under the control of electric and magnetic fields. Some of the tube types studied are picture tubes, beam deflection, storage, and photo tubes. The topic of noise is also included. TEXTS: HARMAN, *Fundamentals of Electron Motion;* SPANGENBERG, *Vacuum Tubes*. Not available after F-Y 59-60.

Es-292(A) MICROWAVE TUBES AND TECHNIQUES (3-3). The principal topics presented are: fundamentals of microwave amplifiers and oscillators, triode and tetrode microwave amplifiers and oscillators, cavity klystrons, reflex klystrons, magnetrons, traveling-wave and double-beam tubes, circuit components, coupling methods, energy transfer, and circuit concepts at microwave frequencies. TEXTS: REICH, *and others, Microwave Theory and Techniques;* SPANGENBERG, *Vacuum Tubes;* HARMAN, *Fundamentals of Electron Motion*. PREREQUISITES: Es-291(B); Es-693(A).

Es-296(A) TRANSISTOR ELECTRONICS (3-3). The principal topics are: transistors—properties of semi-conductors and P-N junctions; transistors as circuit elements; small and large signal transistor circuit characteristics and analysis. TEXTS: RCA STAFF, *Transistor Electronics;* Instructor's notes. Not available after F-Y 59-60.

Es-297(B) PULSE TECHNIQUES (3-3). Pulse Shaping: clipping, clamping, peaking coupling, integrating. Pulse-forming networks and artificial lines. Trigger and multivibrator circuits. Time-base generators. Pulse transformers and blocking oscillators. Transistor switching circuits. TEXTS: M.I.T. RADAR SCHOOL STAFF, *Principles of Radar (Third Edition)*; MILLMAN *and* TAUB, *Pulse and Digital Circuits*. PREREQUISITE: Es-296(A).

Es-298(B) ULTRA-HIGH FREQUENCY TECHNIQUES (3-2). The principles and underlying problems of high-frequency techniques. The principal topics are: limitations of conventional tubes at ultra-high frequencies, transit-time effects, noise problems, electron ballistics, wave guides, cavity resonators, klystrons, magnetrons and traveling-wave tubes. TEXTS: SPANGENBURG, *Vacuum Tubes;* M.I.T. RADAR SCHOOL STAFF, *Principles of Radar (Third Edition)*. Not available after F-Y 59-60.

Es-299(B) TRANSISTOR ELECTRONICS (3-3). The principal topics are: electrical characteristics of semi-conductors; P-N junctions and their rectification properties; basic transistor action; transistors as circuit elements; transistor circuit anlysis. TEXTS: RCA STAFF, *Transistor Electronics;* Instructor's notes. Not available after F-Y 59-60.

Es-300(B) ELECTRONIC SYSTEMS (3-3). Study in this course is directed toward the philosophy principles, and design of electronic aids to navigation, missile guidance systems and electronic counter-measures. A study of telemetering is included in support of missile guidance systems. TEXT: LOCKE, *Guidance*. Not available after F-Y 60-61.

Es-301(B) COMMUNICATION SYSTEMS II (2-3). A study of the considerations involved in the design of communication receivers for ranges from VLF to UHF. The use of propagation prediction data, and the natural division of services and frequency allocations is also covered. TEXTS: STURLEY, *Radio Receiver Design;* WALLMAN *and* VALLEY, *Vacuum Tube Amplifiers;* TERMAN, *Radio Engineering Handbook;* BLACK, *Modulation Theory*. PREREQUISITE: Es-398(B).

Es-302(B) COMMUNICATION SYSTEMS III (3-3). A continuation of the communication systems sequence directed toward the study of recent and advanced methods of establishing a communication link. Topics covered are: statistical properties of fading, diversity and scatter propagation techniques, single-sideband systems, wideband systems, e.g., frequency modulation, pulse modulation, time-division multiplexing. TEXTS: BLACK, *Modulation Theory;* GOLDMAN, *Frequency Analysis, Modulation, and Noise*. PREREQUISITE: Es-301(B).

Es-303(B) COMMUNICATION SYSTEMS IV (2-3). A continuation of Es-302(B). This course considers communication systems involving a variety of presentation techniques. Topics covered are: FSK teletype, image systems, e.g., facsimile and television. TEXTS: BLACK, *Modulation Theory;* Current technical literature. PREREQUISITE: Es-302(B).

Es-304(B) RADAR SYSTEM ENGINEERING I (3-3). A study of the fundamental principles of radar. The principal topics are: the theory of operation and design features of radar timing circuits, indicators, modulators, transmitters, r-f systems and receivers. TEXTS: RIDENOUR, *Radar System Engineering;* M.I.T. RADAR SCHOOL STAFF, *Principles of Radar (Third Edition)*. PREREQUISITE: Es-499(B).

Es-305(B) RADAR SYSTEM ENGINEERING II (3-6). A continuation of Es-304(B). The course contents include a study of representative search, fire-control and IFF systems, including airborne, with particular attention to design features; a study of current radar developments; related laboratory work on current Navy radar equipment. TEXT: RIDENOUR, *Radar System Engineering.* PREREQUISITE: Es-304 (B).

Es-309(B) SONAR SYSTEM ENGINEERING DESIGN AND DEVELOPMENTS (3-3). Classroom and laboratory study of engineering design problems met in operational and developmental sonar systems. TEXTS: Classified technical reports; Navy equipment instruction books. PREREQUISITE: Ph-423(A).

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).

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: Electronics common core.

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 STAFF, *Principles of Radar (Third Edition).* PREREQUISITE: Es-321(B).

Es-329(B) SONAR SYSTEMS ENGINEERING (3-3). A study of sonar theory including echo ranging equations, sonar transducers, sonar systems components and characteristics. This course also includes the trends and new developments in this field. TEXT: Navy Instruction Manuals; Current technical literature. PREREQUISITE: Ph-426(B).

Es-330(A) AUTOMATION AND SYSTEM CONTROL (3-3). A study of basic techniques and problems in the integration of electronic computers, data transfer links, mechanized material handling, power modulators, and display and monitor functions, to achieve automatic control of complex system functions such as machine tool control, automatic production, ballistic missile launching, target surveillance and weapon control for automatic tactical systems. Analysis of the component design, economic, and system considerations which must be met for successful application of automation methods. Basic principles of computer-control. Methods of specifying fixed system performance dynamics. Formulation of desired performance parameters. Synthesis of computer structure and programs to achieve desired overall characteristics. Integration of command, monitor, and operator functions to achieve maximum effectiveness and reliability. TEXT: GRABBE, RAMO *and* WOOLDRIDGE, *Handbook of Automation Computation, and Control, Vol. 2 Computer and Data Processing.*

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.*

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 addition 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: MERRILL, *Principles of Guided Missile Design (Series).* PREREQUISITE: Es-331(B).

Es-336(A) SONAR SYSTEMS I (3-2). 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. Characteristics and capabilities of existing passive sonar systems are determined in the laboratory. TEXTS: Instructor's Notes; Equipment Instruction Books; Current Literature. PREREQUISITE: Ph-432(A); Ph-461(A).

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 capabilitiies of existing passive sonar systems are determined in the laboratory. TEXTS: Instructor's notes; Equipment Instruction Books; Current Literature. PREREQUISITE: Es-336(A).

Es-341(B) RADAR SYSTEMS I (3-3). A study of the fundamental principles of radar. The principal topics are: the theory of operation of radar timing circuits, indicators, modulators, transmitters, r-f systems and receivers, the radar range equation. TEXTS: RIDENOUR, *Radar System Engineering;* M.I.T. RADAR SCHOOL STAFF, *Principles of Radar (Third Edition).* PREREQUISITE: Es-247(B).

Es-342(B) RADAR SYSTEMS II (3-3). A continuation of Es-341(B). The course contents include a study of representative search, fire-control and IFF systems, including airborne, with particular attention to design features; a study of current radar developments; related laboratory work on current Navy radar equipment. TEXT: RIDENOUR, *Radar Systems Engineering.* PREREQUISITE: Es-341(B).

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-350(B) INTRODUCTION TO RADAR (3-2). The course treats pulse shaping, clipping, switching, differentiating, integrating circuits, and the fundamental principles of radar such as the range equation, timing circuits, indicators, modulators, transmitters and receivers. TEXT: M.I.T. RADAR SCHOOL STAFF, *Principles of Radar.* PREREQUISITE: Es-242(C).

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: MIT RADAR SCHOOL STAFF, *Principles of Radar* (*3rd Edition*); MILLMAN *and* TAUB, *Pulse and Digital Circuits;* RIDENOUR, *Radar System Engineering.* 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: RIDENOUR, *Radar System Engineering;* Classified Documents. PREREQUISITE: Es-351(B).

Es-359(C) INTRODUCTION TO RADAR (2-2). A study of the radar range equation, i.e., effect of pulse duration, pulse repetition frequency, types of targets, etc., block diagram studies of current fire-control systems, with emphasis on operationnal limitations, propagation phenomena, types of presentation, and anti-jam techniques. TEXT: M.I.T. RADAR SCHOOL STAFF, *Principles of Radar* (*Third Edition*). PREREQUISITE: Es-242(C).

Es-390(B) RADAR SYSTEMS II (3-6). A continuation of Es-341(B). The course contents include a study of representative search, fire-control and IFF systems, including airborne, with particular attention to design features; a study of current radar developments; related laboratory work on current Navy radar equipment. TEXT: RIDENOUR, *Radar System Engineering.* PREREQUISITE: Es-341(B).

Es-391(C) SYSTEMS I (3-3). This course is a study of the theory, characteristics, and design of communication transmitters and receivers. Emphasis is placed on those considerations which lead to a successful communication system. Principal topics are transmitters and receivers, amplitude and frequency modulation, single sideband systems, automatic frequency control and selection. TEXTS: TERMAN, *Radio Engineering Handbook;* FEDERAL TELEPHONE AND TELEGRAPH CORP., *Reference Data for Radio Engineers.* Not available after F-Y 59-60.

Es-392(C) SYSTEMS II (3-3). The second course of a series concerned with the principles and design of systems using coded information. Of particular interest is the effect on information rates and bandwidth when pulse modulation techniques are used. Principles and characteristics of these systems are studied through the application to frequency shift keying, image systems, and multiplexing. TEXTS: Navy Equipment Manuals; Instructor's notes. PREREQUISITES: Es-391(C); Es-440(B).

Es-393(C) SYSTEMS III (3-0). The third of a series the aim of which is to consider the principles, characteristics, capabilities, and limitations of certain non-communication systems. These include radar, loran, direction finder, NTDS, and ECM systems. TEXTS: Naval equipment manuals; Selected reading; Instructor's notes. PREREQUISITE: Es-392(C).

Es-398(B) COMMUNICATION SYSTEM I (3-3). The first of a series of five courses designed to give the student the opportunity to coordinate his previous theoretical background in the philosophy, requirements and synthesis of increasingly complex electronic systems. The first course concerns itself primarily with the design of radio transmitters for the medium and high frequency range, together with considerations which lead to a successful system, such as reliability, consideration in human engineering, etc. TEXTS: TERMAN, *Radio Engineering Handbook;* FEDERAL TELEPHONE AND TELEGRAPH CORP., *Reference Data for Radio Engineers;* BLACK, *Modulation Theory.* PREREQUISITES: Es-291(B); Ma-104(A).

Es-399(B) MISSILE GUIDANCE SYSTEM (3-0). A study of missile guidance systems. The principal topics are: fundamental problems of missile guidance, prior and present day missile guidance systems, missile guidance servo requirements, launching transients, simulation and computation of the missile guidance system, radio telemetry. TEXT: LOCKE, *Principles of Guided Missile Design.* PREREQUISITE: Es-252(B).

Es-400(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 arithmetic and control elements. Dynamic simulation. Transfer function synthesis. Sampled-data control systems. Frequency domain treatment of analog and digital computer programs. Weighting functions for smoothing, prediction and tracking. Digital and analog techniques for the detection of small signals in noise. TEXTS: Instructor's notes; Selected references from the periodical literature. PREREQUISITES: Es-499(B); Es-498(A).

Es-409(A) INFORMATION THEORY II (3-0). A continuation of Es-450(B). The primary emphasis is on the optimization of circuits and systems subjected to stochastic inputs. The optimization of both linear and non-linear data processing operators is considered. The optimization of sampled data systems is discussed. Optimum signal detection criteria are compared, and standard engineering methods are evaluated and compared with optimum techniques. TEXTS: Selected technical reports and references from scientific periodicals. PREREQUISITE: Es-400(A).

Es-410(B) INFORMATION THEORY (4-0). Statistical methods in communications engineering are studied. These include information measure, channel capactiy, coding, signal spectra, signal space, and an introduction to correlation techniques with applications to noise analysis and signal detection. TEXTS: SHANNON *and* WEAVER, *Mathematical Theory of Communication;* DAVENPORT *and* ROOT, *Random Signals and Noise;* Selected technical reports and references from scientific periodicals.

Es-419(C) ELECTRONIC COMPUTERS (3-3). Basic principles of digital, analog, and incremental computers. Elements of numerical analysis, Boolean algebra, logical design. Basic computer programming. Principles of simulation. The laboratory is devoted to applications practice on the three types of computers. TEXT: Instructor's notes.

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. TEXTS: Selected technical reports and references from scientific periodicals. PREREQUISITE: Electronics common core.

Es-429(B) THEORY OF MODULATION (3-3). A theoretical comparative study of modern modulation techniques based on communications theory. Specialized aspects of circuitry employed in the modulation and detection process is considered. The material and level of presentation will be comparable with Black. TEXT: BLACK, *Modulation Theory.*

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 arithmetic and control elements. Dynamic simulation. Transfer function synthesis. Frequency domain treatment of analog and digital computer programs. TEXT: CALDWELL, *Switching Circuit and Logical Design.*

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: GRABBE, RAMO *and* WOOLDRIDGE, *Handbook of Automation Computation and Control, Vol. 2 Computers and Data Processing.*

Es-440(B) COMPUTERS AND DATA PROCESSORS (3-3). A study of component engineering, logical design and systems engineering considerations in the application of electronic computer methods to data processing and automatic control programs. Principles of digital, analog, and incremental information processing systems, logical design, simulation, methods for prediction, smoothing, and tracking. TEXTS: RICHARDS, *Arithmetic Operations in Digital Computers;* WASS, *Introduction to Electronic Analog Computers.*

Es-449(B) RADAR DATA PROCESSING AND COMPUTER-CONTROLLED SYSTEMS (3-3). A study of advanced applications of computer techniques in systems of importance to the Naval service. Subjects include coding and transmission of radar range data, reliable digital communication links, programming, and computer techniques applicable to missile guidance systems. TEXTS: Selected references; Instructor's notes.

Es-450(B) COMMUNICATION THEORY (4-0). Elementary treatment of concepts from probability and statistics. Application of these concepts to an introductory discussion of selected problems arising in electronics engineering. These problems may include: sampling and quality control in electranics manufacturing; noise in electronic components; filtration and detection in the presence of noise; information theory, channel capactiy, and coding. TEXT: Instructor's notes.

Es-490(B) COMMUNICATION THEORY (4-0). Application of statistical methods to problems arising in electronics engineering. These problems will include: noise in electronic components; filtration and detection in the presence of noise; information theory—information measure, channel capacity, and coding. TEXT: Instructor's notes. Not available after F-Y 59-60.

Es-498(A) INFORMATION THEORY I (3-0). Statistical methods in communications engineering are studied. These include information measure, channel capacity, coding, signal spectra, signal space, and an introduction to correlation techniques. TEXTS: SHANNON *and* WEAVER, *Mathematical Theory of Communication;* DAVENPORT *and* ROOT, *Random Signals and Noise.* PREREQUISITES: Es-192(A); Ma-321(B).

Es-499(B) PULSE AND DIGITAL TECHNIQUES (3-3). Study of circuit methods applicable to radar, television, digital computers, pulse communication, data-processing, digital control, and similar systems. Voltage and current time base generators, blocking oscillators, frequency division and multiplication, bit storage elements, AND OR gates, transmission gates, comparators, time modulation, ANDIG and DIGAN converters. TEXT: MILLMAN *and* TAUB, *Pulse and Digital Circuits.* Not available after F-Y 59-60.

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.*

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 air-speed indicators, barometric altimeters, rate-of-climb indicators, and basic gryo instrumentation are covered, as well as more 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 Avigation Engineering.* PREREQUISITE: Es-332(B).

Es-540(B) RADIO TELEMETERING AND SIMULATION (3-3). A survey of telemetering and missile guidance methods including consideration of time and frequency division multiplexing, pulse modulation techniques, FM/FM telemetry, transducers, data recording devices, analog and digital computation, simulation of the tactical problem. TEXT: LOCKE, *Guidance.*

Es-548(C) ELECTRONICS III (3-2). This course emphasizes systems of vacuum tube circuits used by the nuclear engineer, such as the cathode-ray oscilloscope, scalers, counters, pulse height analyzers, Geiger counters, and other nuclear energy detecting devices such as Radiac. Detection and measurement of nuclear energy by making use of telemetering systems is also included. TEXTS: SEELY, *Electron Tube Circuits;* HOISINGTON, *Nucleonics Fundamentals.* PREREQUISITE: Es-240(C).

Es-549(A) ELECTRONIC INSTRUMENTATION (3-3). The principal topics are: pulseamplitude analysis circuits, scaling circuits, electronic counter systems, counting-rate meters, coincidence and anti-coincidence circuits, electrometers, special power-supply considerations. TEXTS: ELMORE *and* SANDS, *Electronics;* MILLMAN *and* TAUB, *Pulse Digital Circuits.* PREREQUISITE: Es-248(A).

Es-590(C) RADIO FREQUENCY MEASUREMENTS (2-3). This is a continuing study of the problems involved in the measurement of the quantities of interest in electronic circuits. The principles and techniques of measurement of power, inpedance and phase over an extended frequency range are studied. The laboratory work will be devoted to drill on the use of these techniques with particular emphasis on the capabilities and limitations of the more commonly used methods and test equipments. TEXT: TERMIN *and* PETTIT, *Electronic Measurements.* Not available after F-Y 59-60.

Es-599(C) RADIO-FREQUENCY MEASUREMENT AND MICROWAVE TECHNIQUES (2-6). An advanced treatment of the principles and techniques of measurement over the entire frequency band, using lumped, transmission line and waveguide components. The areas considered are those of the measurement of frequency, power, phase, and impedance. TEXTS: TERMAN *and* PETTIT, *Electronic Measurements;* HARTSHORN, *Radio Frequency Measurements.* Not available after F-Y 59-60.

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: STEWART, *Circuit Analysis of Transmission Lines.*

Es-612(C) INTRODUCTION TO ELECTROMAGNETICS (4-0). An introduction to the concepts utlized 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).*

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 impedances and feed systems. TEXT: KRAUS, *Antennas.*

Es-621(B) ELECTROMAGNETICS I (5-0). Phasor notation; generalized coordinates; rectangular, cylindrical, and spherical harmonics; Bessel functions; Maxwell's equations for time varying fields; displacement current density; retarded potentials; circuit concepts from fields; impendance; 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).*

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; image antenna; field from rhombic antenna; antenna arrays; induced EMF method; pseudo-Maxwell's equations; parabolic reflector; slot antennas; horns, biconical antenna; driving point impedance of cylindrical antenna; receiving antenna. TEXT: RAMO *and* WHINNERY, *Fields and Waves in Modern Radio (Second Edition).* PREREQUISITE: Es-621(B).

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; modelling and testing procedures. TEXTS: KRAUS, *Antennas;* LOCKE, *Guidance.*

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 into polar regions, forward and back scatter, meteor burst propagation, and transmission paths making use of the moon and artificial satellites. TEXT: MENZEL, *Elementary Manual of Radio Propagation.*

Es-648(B) ANTENNAS AND FEED SYSTEMS (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 laboratory work is directed to the measurement of field intensities, antenna patterns, input impedances and feed systems. TEXT: KRAUS, *Antennas.*

Es-690(B) ANTENNAS AND PROPAGATION (3-2). This course is an anlytical study of certain elementary antennas used in transmission and reception of radio communications. Emphasis is placed on those antenna systems found aboard ship. Propagation characteristics throughout the communications spectrum are studied with emphasis on proper choice of frequency, power, and time of transmission. Propagation anomalies are studied with the object of maintaining reliable communications. New techniques of transmission are studied such as scatter communications. TEXTS: MENZEL, *Elementary Manual of Radio Propagation;* KRAUS, *Antennas.* Not available after F-Y 59-60.

Es-691(C) ELECTROMAGNETICS I (4-0). An introduction to the concepts utilized in electromagnetic theory. The material covered includes vector analysis, field theorems, the electrostatic field dieletric materials, electric current, the magnetic field, Maxwell's hypothesis, plane waves, radiation, antennas, wave guides. TEXT: SKILLING, *Fundamentals of Electric Waves (Second Edition).* Not available after F-Y 59-60.

Es-692(B) ELECTROMAGNETICS II (5-0). Phasor notation; generalized coordinates; rectangular, cylindrical, and spherical harmonics; Bessel functions; Maxwell's equations for time varying fields; displacement current density; retarded potentials; circuit concepts from fields; impedance; skin effect; inductance; 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).* PREREQUISITE: Es-691(C).

Es-693(A) ELECTROMAGNETICS III (4-0). A continuation of Es-692(B). TEM, TE, TM waves; rectangular and cylindrical wave guides; miscellaneous guiding systems; resonant cavities; fields from dipole antenna; gain; image antenna; field from rhombic antenna; antenna arrays; induced EMF method; pseudo-Maxwell's equations; parabolic reflector; slot antenna; electromagnetic horns; biconical antenna; driving point impedance of cylindrical antenna; receiving antenna. TEXT: RAMO *and* WHINNERY, *Fields and Waves in Modern Radio (Second Edition)*. PREREQUISITE: Es-692(B).

Es-698(B) ANTENNAS, TRANSMISSION LINES (3-3). The engineering problems associated with the practical design of antennas, antenna systems, and transmission lines. TEXT: KRAUS, *Antennas*. PREREQUISITE: Es-693(A).

Es-699(C) GUIDED WAVES AND RESONATORS (2-0). Application of Maxwell's equations to TEM propagation on open wire and coaxial lines, and TE and TM waves in the rectangular guide. Discussion of TE and TM modes in the circular guide and the coaxial line. Cavity resonance and equivalent circuits for resonators. TEXTS: SKILLING, *Fundamentals of Electric Waves (Second Edition)*. Instructor's notes. Not available after F-Y 59-60.

Es-900(A) PROJECT SEMINAR (0-2). In this seminar an oral report is made to the class by each student on his individual development work on a project at an industrial laboratory in electronics. A written engineering report is also required of each student covering his term project in industry. For third year electronics students only.

Es-920(A) SYSTEMS SEMINAR (3-0). This seminar provides an apportunity 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).

Es-921(A) RESEARCH (3-0). Research under guidance of faculty adviser.

Es-922(A) RESEARCH (3-0). Research under guidance of faculty adviser.

Es-990(B) SYSTEMS SEMINAR (3-0). Groups of students undertake the overall specification and design of an integrated weapons, countermeasures, navigational, or communications system, under the instructor's consultation and guidance. Emphasis is on the integration of electronic devices and evaluation of system performance. PREREQUISITE: Es-252(B).

Es-991(C) SYSTEMS LECTURES I (0-1). A series of informational lectures covering recent developments, new publications, and faculty visits to industrial and military research and development laboratories. Not available after F-Y 59-60.

Es-992(C) SYSTEMS LECTURES II (0-1). A continuation of Es-990 (C). PREREQUISITE: Es-991(C).

Es-029(A) THESIS (2-0). Thesis under guidance of faculty adviser.

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; steam 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(C) PHYSICAL GEOLOGY (3-0). Course content similar to Ge-101, but directed towards the specific needs of the Nuclear Engineering Groups. TEXT: GILLULY, *Principles of Geology*.

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 miscroscope. 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.

LP-102(L) NPS LECTURE PROGRAM II (Space Technology) (0-1). A series of weekly lectures to be delivered by authorities in the scientific fields associated with Space Technology. Topics will be chosen from among the new developments most prominent or promising in the advancing field of outer space exploration for delivery at an appropriate level of technical sophistication.

MATHEMATICS

Ma-010(C) BASIC ALGEBRA AND TRIGONOMETRY I (3-0). 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.*

Ma-011(C) BASIC ALGEBRA AND TRIG 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. TEXTS: DAVIS, *College Algebra;* HART, *First Year College Mathematics.* PREREQUISITE: Ma-010(C).

Ma-015(C) ALGEBRA AND TRIGONOMETRY REFRESHER (3-0). Review of simple algebraic processes. Slide rule. Functional notation and graphs. Trigonometric functions and their graphs. Right triangle, complex numbers and vectors. Exponents, radicals and logarithms. Linear equations. Quadratic equations. Introduction to analytic geometry. TEXT: ANDRES, MISER *and* REINGOLD, *Basic Mathematics for Engineers.* PREREQUISITES: Previous courses in college algebra and trigonometry or equivalent.

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. Combinations and permutations. Mathematical induction. Trigonometric functions of the general angle. Identities. Solution of right and oblique triangles. TEXT: ANDRES, MISER *and* REINGOLD, *Basic Mathematics for Engineers.* PREREQUISITES: Previous courses in College Algebra and Trigonometry.

Ma-050(C) SURVEY OF ANALYTIC GEOMETRY AND ELEMENTARY CALCULUS (4-0). Concepts of function, limit, continuity. Analytic geometry of a straight line. Graphs. The derivative. Differentiation of algebraic and transcendental functions. Higher derivatives. Applications of the derivative. Differentials. Formal integration. The definite integral with applications. TEXTS: GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus;* SMITH, GALE *and* NEELLEY, *New Analytic Geometry.* PREREQUISITE: Recent course in algebra and trigonometry.

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

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

Ma-053(C) CALCULUS AND ANALYTIC GEOMETRY (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-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. Transcendental functions. Topics from Plane Analytic Geometry to be introduced as necessary. TEXT: THOMAS, *Calculus and Analytic Geometry.* PREREQUISITE: Ma-031(C) or its equivalent.

Ma-072(C) CALCULUS II (3-0). 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-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-071(C). Ma-072(C) must be taken concurrently.

Ma-100(C) VECTOR ALGEBRA AND GEOMETRY (2-1). Outline of real number system. Vectors and their algebra. Analytic geometry of space; points, lines, and planes in scalar and vector notation. Determinants and linear systems. Special surfaces. The laboratory periods are devoted to review. TEXTS: SMITH, GALE *and* NEELLEY, *New Analytic Geometry;* WEATHERBURN, *Elementary Vector Analysis;* USNPS Notes; BRAND, *Vector Analysis.* PREREQUISITE: A course in plane analytic geometry.

Ma-109(A) FUNDAMENTALS OF ANALYSIS I (3-0). Development of natural number system and extension to real and complex number systems; the elements of point set theory; basic limit theory; sequences, series; uniform convergence of infinite sequences and series of functions; continuity and differential properties of functions; Riemann integration. TEXTS: LANDAU, *Foundations of Analysis;* COURANT, *Differential and Integral Calculus, Volume I;* OSGOOD, *Functions of Real Variables;* HARDY, *Pure Mathematics;* BRAND, *Advanced Calculus.* PREREQUISITE: A course in differential and integral calculus.

Ma-110(A) FUNDAMENTALS OF ANALYSIS II (3-0). A continuation of Ma-109(A). Rigorous development of infinite series. Functions of a real variable. Riemann integral. TEXTS: COURANT, *Differential and Integral Calculus, Volume I;* OSGOOD, *Functions of Real Variables;* HARDY, *Pure Mathematics;* BRAND, *Advanced Calculus;* Periodicals. PREREQUISITE: Ma-109(A).

Ma-111(C) INTRODUCTION TO ENGINEERING MATHEMATICS (3-1). Partial differentiation; multiple integrals; hyperbolic functions. The laboratory periods are devoted to a review of selected topics in basic calculus. TEXTS: GRANVILLE, SMITH *and* LONGLEY, *Elements of the*

Differential and Integral Calculus; WYLIE, *Advanced Engineering Mathematics.* PREREQUISITES: A course in differential and integral calculus and Ma-100(C) or Ma-120 (C) to be taken concurrently.

Ma-112(B) DIFFERENTIAL EQUATIONS AND INFINITE SERIES (5-0). A continuation of Ma-111(C). First order ordinary differential equations; ordinary linear differential equations with constant coefficients; power series and power series expansion of functions; power series solution of ordinary differential equations; Fourier series. TEXTS: GOLOMB *and* SHANKS, *Elements of Ordinary Differential Equations;* GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus;* WYLIE, *Advanced Engineering Mathematics.* PREREQUISITE: Ma-111(C).

Ma-113(B) INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS AND FUNCTIONS OF A COMPLEX VARIABLE (4-0). A continuation of Ma-112(B). Solution of partial differential equations by means of series of orthogonal functions; analytic functions of a complex variable; line integrals in the complex plane; infinite series of complex variables; theory of residues. TEXT: WYLIE, *Advanced Engineering Mathematics.* PREREQUISITE: Ma-112(B).

Ma-114(A) FUNCTIONS OF A COMPLEX VARIABLE AND VECTOR ANALYSIS (3-0). A continuation of Ma-113(B). Conformal mapping and applications; calculus of vectors with geometric applications; differential operators; line, surface and volume integrals involving vector fields; applications to heat flow and potential problems. TEXT: WYLIE, *Advanced Engineering Mathematics.* PREREQUISITE: Ma-113(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; elementary properties and types of matrices; matrix algebra; latent roots and characteristic vectors of matrices; numerical methods for inversion of matrices. TEXTS: BOOTH, *Numerical Methods;* SALVADORI *and* BARON, *Numerical Methods in Engineering;* KUNZ, *Numerical Analysis.* PREREQUISITE: Ma-114(A), or Ma-153(B), or Ma-122(B), or Ma-182(B).

Ma-120(C) VECTOR ALGEBRA AND 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: SMITH, GALE, *and* NEELLEY, *New Analytic Geometry;* WEATHERBURN, *Elementary Vector Analysis;* CHURCHILL, *Introduction to Complex Variables;* USNPS Notes; BRAND, *Vector Analysis.* PREREQUISITE: A course in plane analytic geometry.

Ma-121(C) INTRODUCTION TO ENGINEERING MATHEMATICS (3-1). Review of elementary calculus with particular emphasis on basic concepts. Power series. Fourier series. Differential calculus for functions of several variables. TEXTS: FRANKLIN, *Methods of Advanced Calculus;* GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus.* Instructor's notes. PREREQUISITE: A course in differential and integral calculus.

Ma-122(B) DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS (5-0). A continuation of Ma-121(C). Elementary differential equations. Line, surface and multiple integrals. Vector calculus. Theorems of Gauss, Green and Stokes. Applications. TEXTS: SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics;* BRAND, *Vector Analysis;* COHEN, *Differential Equations.* PREREQUISITE: Ma-121(C).

Ma-123(A) ORTHOGONAL FUNCTIONS AND PARTIAL DIFFERENTIAL EQUATIONS (5-0). A continuation of Ma-122(B). Elliptic integrals, Gamma and Beta functions. Series solution of differential equations. Elements of Sturm-Liouville Theory. Bessel functions. Legendre polynomials. Partial differential equations and solution of boundary value problems. TEXTS: CHURCHILL, *Fourier Series and Boundary Value Problems;* FRANKLIN, *Methods of Advanced Calculus.* PREREQUISITE: Ma-122(B).

Ma-124(B) COMPLEX VARIABLE (3-0). A continuation of Ma-123(A). Analytic functions. Cauchy's theorem and formula. Taylor and Laurent series. Theory of residues. Contour integration. Conformal mapping. Applications. TEXT: CHURCHILL, *Introduction to Complex Variable.* PREREQUISITE: Ma-122(B) or the equivalent (may be taken concurrently).

Ma-125(B) NUMERICAL METHODS FOR DIGITAL COMPUTERS (2-2). Numerical methods for solution of systems of linear algebraic equations, polynomial equations, and systems of non-linear algebraic equations; finite differences, numerical interpolation, differentiation, integration; numerical methods for solving initial value and boundary value problems involving ordinary and partial differential equations. The laboratory periods cover sample problems solved on hand-operated keyboard calculators; emphasis is given to the methods which are most useful in large scale automatic digital computers. TEXTS: SALVADORI *and* BARON, *Numerical Methods in Engineering;* BOOTH, *Numerical Methods;* KUNZ, *Numerical Analysis.* PREREQUISITE: Ma-113(B) or Ma-123(A) or Ma-183(B).

Ma-131(C) TOPICS IN ENGINEERING MATHEMATICS (5-2). Concepts of function and limit. Fundamentals of sequences and series. Taylor and Maclaurin series. Solution of algebraic equations. Determinants, matrices and systems of linear equations. Analytic geometry of space and the definition and algebra of vectors. Partial derivatives and multiple integrals. Laboratory periods will be devoted to essential reveiw in analytic geometry and elementary calculus. TEXTS: SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics;* WEATHERBURN, *Elementary Vector Analysis;* GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus.* PREREQUISITE: A course in differential and integral calculus.

Ma-132(B) VECTOR ANALYSIS AND DIFFERENTIAL EQUATIONS (5-0). A continuation of Ma-131(C). Line, surface and volume integrals. Green's theorem and the divergence and Stoke's theorems. Introduction to differential calculus of vectors. The integral theorems in vector form. Ordinary differential equations of first order. Linear differential equations with constant coefficients. TEXTS: SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics;* WEATHERBURN, *Advanced Vector Analysis.* PREREQUISITE: Ma-131(C).

Ma-133(A) DIFFERENTIAL EQUATIONS AND VECTOR MECHANICS (5-0). A continuation of Ma-132(B). Stability criteria. Total differential equations and systems of differential equations. The vector equations of motion.

Irrotational, solenoidal and linear vector fields. Fourier series. Solution of differential equations in series. TEXTS: SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics;* WEATHERBURN, *Advanced Vector Analysis.* PREREQUISITE: Ma-132(B).

Ma-151(C) DIFFERENTIAL EQUATIONS (5-0). Review of calculus. Partial derivatives. Polar coordinates and change of variables. Elements of differential equations; first order; linear; and total, with condition of integrability. 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-152(B) INFINITE SERIES (3-0). Convergence of a series, uniform convergence. Taylor series in one and two variables; associated approximation methods. Expansion of function in Fourier series; even and odd functions. Series solution of differential equations, introducing method of Frobenius. TEXTS: GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus;* SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics for Engineers and Physicists.* PREREQUISITE: Ma-151(C) or equivalent. (May be taken concurrently.)

Ma-153(B) VECTOR ANALYSIS (3-0). Differential and integral relations involving vectors. Gradients, divergence and curl. Normals and tangents to lines and surfaces. Line and surface integrals. Theorems of Gauss, Green, and Stokes, and related integral formulas. TEXTS: PHILLIPS, *Vector Analysis;* WEATHERBURN, *Elementary Vector Analysis;* WEATHERBURN, *Advanced Vector Analysis.* PREREQUISITE: Ma-120(C).

Ma-154(B) DIFFERENTIAL EQUATIONS FOR AUTOMATIC CONTROL (3-0). Systems of linear differential equations. Operational mathematics for solving differential and elementary integral equations. Phase-plane relations for non-linear second-order differential equations. TEXTS: GOLOMB *and* SHANKS, *Elements of Ordinary Differential Equations;* CHURCHILL, *Modern Operational Mathematics.* PREREQUISITES: Ma-120(C) and Ma-151(C) or equivalent.

Ma-155(A) DIFFERENTIAL EQUATIONS FOR AUTOMATIC CONTROL (3-0). Systems of linear differential equations. Laplace transforms for solving ordinary differential equations. Inversion integral. Phase-plane relations for non-linear differential equations. Stability criteria. TEXTS: GOLOMB *and* SHANKS, *Elements of Ordinary Differential Equations;* CHURCHILL, *Modern Operational Mathematics;* STOKER, *Non-linear Vibrations;* MINORSKY, *Introduction to Non-linear Mechanics.* PREREQUISITE: Ma-157(B), or equivalent.

Ma-156(A) PARTIAL DIFFERENTIAL EQUATIONS (3-0). Solution of boundary value problems by separation of variables. Orthogonal functions and introduction to Sturm-Liouville theory. Problems involving expansions in Bessel functions and Legendre polynomials. TEXT: CHURCHILL, *Fourier Series and Boundary Value Problems.* PREREQUISITE: Ma-152(B).

Ma-157(B) COMPLEX VARIABLE (4-0). Analytic functions. Cauchy's Theorem and formula. Taylor and Laurent series. Theory of residues. Contour integration. Conformal mapping. Applications. TEXT: CHURCHILL, *Introduction to Complex Variable.* PREREQUISITES: Ma-151(C) and Ma-152(B).

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-161(C) ALGEBRA, TRIGONOMETRY AND ANALYTIC GEOMETRY (5-0). Review of elementary algebraic operations. Exponent laws and logarithms. Variables and functions of variables. Coordinate representation of functions; graphs. The trigonometric functions. The straight line and its slope. Simultaneous linear equations. The quadratic equation. Elementary equations of the conics. TEXT: BRINK, *A First Year of College Mathematics.*

Ma-162(C) INTRODUCTION TO CALCULUS (5-0). The limit concept. The derivatives of elementary functions. Elementary applications of derivatives. Differentials, higher order derivatives and curvature. The integral as an antiderivative and as an area. Elementary applications of integration. TEXT: GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus.* PREREQUISITE: Ma-161(C) or satisfactory evidence of competence in analytic geometry.

Ma-163(C) CALCULUS AND VECTOR ANALYSIS (4-0). Elementary vector operations. Partial derivatives, total derivatives and total differentials with applications. Partial and multiple integrals. Differentiation of vectors; gradient, divergence and curl. Introduction to line integrals. TEXTS: PHILLIPS, *Vector Analysis;* GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus.* PREREQUISITE: Ma-162(C) or a recent course in differential and integral calculus.

Ma-171(C) DIFFERENTIAL EQUATIONS (4-0). Review of calculus. Partial differentiation. Elements of differential equations; first order and linear. TEXTS: GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus;* LEIGHTON, *Introduction to the Theory of Differential Equations.* PREREQUISITE: A course in differential and integral calculus.

Ma-172(B) DIFFERENTIAL EQUATIONS AND INFINITE SERIES (5-0). Operator methods for solution of systems of linear differential equations; use of matrix algebra. Convergence of a series, uniform convergence. Taylor series and expansion of functions in series. Series solution of linear ordinary differential equations. Expansion of functions in Fourier Series. Solution of partial differential equations using Fourier Series. TEXTS: LEIGHTON, *Introduction to the Theory of Differential Equations;* SOKOLNIKOFF *and* REDHEFFER, *Mathematics of Physics and Modern Engineering.* PREREQUISITE: Ma-171(C) or equivalent.

Ma-175(B) DIFFERENTIAL EQUATIONS OF APPLIED MATHEMATICS (4-0). The Laplace transform and its use in solving ordinary differential equations; applications to partial differential equations. Orthogonal functions and their use in solving boundary value problems. Phase plane solutions of certain non-linear differential equations. TEXTS: CHURCHILL, *Modern Operational Mathematics in Engineering;* CHURCHILL, *Fourier Series and Boundary Value Problems;* STOKER, *Nonlinear Vibrations.* PREREQUISITE: Ma-172(B) and Ma-157(B).

Ma-181(C) PARTIAL DERIVATIVES AND MULTIPLE INTEGRALS (4-1). Review of elementary calculus. Partial and total derivatives. Gradients and their physical interpretations. Line integrals. Double and triple integrals. Introduction to ordinary differential equations. Physical applications. TEXTS: GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus;* KAPLAN, *Advanced Calculus.* PREREQUISITES: A course in differential and integral calculus, and Ma-100(C) or Ma-120(C) to be taken concurrently.

Ma-182(B) VECTOR ANALYSIS AND DIFFERENTIAL EQUATIONS (5-0). Vector differentiation. Vector integral relations. Physical applications. Ordinary first order differential equations. Higher order linear differential equations. Systems of differential equations. Physical interpretations. Infinite series. TEXTS: PHILLIPS, *Vector Analysis;* KAPLAN, *Advanced Calculus.* PREREQUISITES: Ma-100(C) and Ma-181(C).

Ma-183(B) FOURIER SERIES AND COMPLEX VARIABLES (5-0). Expansion of Functions. Series solution of differential equations. Fourier series and solution of partial differential equations. Algebra of complex numbers. Analytic functions of a complex variable, and the elementary transcendental functions. Conformal maps. Cauchy's Theorem. Residues. TEXTS: CHURCHILL, *Fourier Series and Boundary Value Problems;* CHURCHILL, *Complex Variables.* PREREQUISITE: Ma-182(B).

Ma-184(A) MATRICES AND NUMERICAL METHODS (3-0). Algebra of matrices. Characteristic values of matrices. Application of matrices. Notation of finite differences. Numerical differentiation and numerical integration. TEXTS: SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics;* MARGENAU *and* MURPHY, *Mathematics of Physics and Chemistry;* SALVADORI *and* BARON, *Numerical Methods in Engineering.* PREREQUISITE: Ma-183(B).

Ma-194(A) LAPLACE TRANSFORMS, MATRICES AND VARIATIONS (5-0). Definition and properties of Laplace transforms. Solution of ordinary and partial differential equations by Laplace transforms. Algebra of matrices. Characteristic values of matrices and differential operators. Introduction to calculus of variations. TEXTS: CHURCHILL, *Modern Operational Mathematics;* MARGENAU *and* MURPHY, *Mathematics of Physics and Chemistry;* BURINGTON *and* TORRANCE, *Higher Mathematics.* PREREQUISITE: Ma-183(B).

Ma-195(A) MATRIX THEORY AND INTEGRATION THEORY (4-0). Algebra of matrices; characteristic value of matrices; Hamilton-Cayley and Sylvester's theorems; Matrix methods in the solution of systems of differential equations. Basic concepts in the theories of Riemann, Lebesgue, and Stieltjes integrals with emphasis on the applications of these theories to probability theory. TEXTS: FRAZER, DUNCAN *and* COLLAR, *Elementary Matrices;* MUNROE, *Introduction to Measure and Integration.* PREREQUISITE: Ma-183(B).

Ma-105(A) FUNDAMENTALS OF MODERN ALGEBRA I (3-0). Concepts of integral domain and field based on real integers and rational numbers; concept of ring based on polynomials; groups of transformations, cyclic and permutation groups; concepts of isomorphism, automorphism, homomorphism, equivalence. Vectors and vector spaces. TEXT: BIRKHOFF *and* MACLANE, *A Survey of Modern Algebra (Revised edition).* PREREQUISITE: Consent of instructor.

Ma-106(A) FUNDAMENTALS OF MODERN ALGEBRA II (3-0). Continuation of Ma-105(A). Algebra of matrices; algebra of classes, Boolean algebra, lattices; theory of rings and ideals with applications to geometry and linear algebras; algebraic number fields; introduction to Galois Theory. TEXT: BIRKHOFF *and* MACLANE, *A Survey of Modern Algebra (Revised Edition).* PREREQUISITE: Ma-105(A).

Ma-320(C) INTRODUCTION TO STATISTICS AND OPERATIONS ANALYSIS (4-0). Frequency distributions. Mean value and standard deviation. Basic probability theory for discrete and continuous variables. Basic probability distributions. Applications to kill probability, target analysis, and communication networks. Correlation with applications. TEXTS: CLARK, *Introduction to Statistics;* WILKS, *Elementary Statistical Analysis;* GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus.* PREREQUISITE: A course in differential and integral calculus.

Ma-321(B) PROBABILITY AND STATISTICS (4-2). Definitions 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. Correlation. Limit theorems. TEXT: PARZEN, *Modern Probability Theory and its Applications.* PREREQUISITE: Ma-121(C) or the equivalent.

Ma-322(A) STATISTICAL DECISION THEORY (3-2). Introduction to two-person zero-sum games. Decision problems viewed as two-person games. Bayes and minimax solutions. Theory of testing hypotheses and estimation as special cases. Applications. TEXT: To be announced. PREREQUISITE: Ma-321(B) or equivalent.

Ma-330(C) INTRODUCTION TO STATISTICS (2-0). Preliminary considerations in the analysis of observations. Measures of central tendency and dispersion. Elementary probability. The Poisson, Bernoulli and normal distributions. Some applications to sampling. TEXT: WILKS, *Elementary Statistical Analysis.* PREREQUISITE: Ma-131(C) or equivalent.

Ma-331(A) STATISTICS (4-2). A continuation of Ma-330(C). Definition and laws of probability over an event space. Joint frequency functions. Tests of statistical hypotheses. Large and small sampling theory. Correlation and regression methods in multivariate problems. Applications to problems in meteorology. TEXTS: HOEL, *Introduction to Mathematical Statistics (Second Edition);* BEST *and* PANOFSKY, *Some Applications of Statistics to Meteorology* PREREQUISITE: Ma-330(C).

Ma-341(C) ELEMENTS OF PROBABILITY AND STATISTICS FOR MILITARY APPLICATIONS (3-0). Basic probability calculations for discrete and continuous chance variables with emphasis on bionomial, Poisson, and normal distributions. Applications to computation of detection probabilities and hit probabilities. Properties of estimates of mean and standard deviation. Correlation and curve fitting. Elements of statistical decisions. TEXTS: WILKS, *Elementary Statistical Analysis;* FRASER, *Statistics, An Introduction.* PREREQUISITE: Ma-071(C) or its equivalent.

Ma-351(B) INDUSTRIAL STATISTICS I (3-2). Frequency distributions. Elements of the theory of probability. The hypergeometric, binomial, Poisson, and normal probability distributions. Sampling distributions of the mean, variance, and range. Acceptance sampling by attributes. TEXTS: DUNCAN, *Quality Control and Industrial Statistics;* BOWKER *and* LIEBERMAN, *Handbook of Industrial Statistics.* PREREQUISITE: Ma-113(B).

Ma-352(B) INDUSTRIAL STATISTICS II (2-2). Double and sequential acceptance sampling by attributes. Acceptance sampling by variables. Control charts. Statistical tests. Analysis of variance and design of experiments. Regression and correlation. Illustrations from selected ordnance publications. TEXTS: Same as Ma-351(B). 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.* EPSTEIN, SOBEL *and others, Publications on Life Testing;* AERONAUTICAL RADIO *and others, Publications on Statistical Techniques for Evaluation and Prediction of Equipment Reliability.* PREREQUISITE: Ma-301(B) or the equivalent.

Ma-361(B) PROBABILITY AND STATISTICAL INFERENCE FOR ENGINEERS I (2-1). Definitions of probability and basic rules of computation. Sample space, random variables, discrete and continuous distribution functions. Elementary sampling theory. Introduction to the principles of testing hypotheses and estimation. TEXTS: PARZEN, *Modern Probability Theory and its Applications.* 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. TEXTS: PARZEN, *Modern Probability Theory and its Applications;* MOOD, *Introduction to the Theory of Statistics.* PREREQUISITE: Ma-361(B).

Ma-371(C) MANAGEMENT STATISTICS (2-0). The development of intuitive concepts of probability, probability distribution, central tendency, and correlation. Some indications of the general manner in which these concepts permeate all the management sciences. TEXT: SPROWLS, *Elementary Statistics.* PREREQUISITE: Ma-161(C) or equivalent.

Ma-381(C) ELEMENTARY PROBABILITY AND STATISTICS (4-2). Elements of the theory of probability. The classical probability distributions. Elements of statistical inference with applications. Regression and correlation. Applications in the field of the group. TEXTS: WILKS, *Elementary Statistical Analysis;* PANOFSKY *and* BRIER, *Applications of Statistics to Meteorology* (*Meteorology groups only*); CRAMER, *The Elements of Probability Theory.* PREREQUISITE: Ma-163(C) or Ma-181(C).

Ma-391(C) BASIC PROBABILITY (4-0). Definitions 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. TEXTS: PARZEN, *Modern Probability Theory and its Applications;* FELLER, *An Introduction to Probability Theory and its Applications, Vol. I, Second Edition.* PREREQUISITE: Ma-181(C) (May be taken concurrently).

Ma-392(B) BASIC STATISTICS (3-2). Sampling distributions. Point estimation, properties of point estimators, the theory of testing simple hypotheses, interval estimation, application to the common distributions. Procedures for testing composite hypotheses, power functions. Regression analysis. TEXT: MOOD, *Introduction to the Theory of Statistics.* PREREQUISITE: Ma-391(C) or the equivalent.

Ma-393(A) SEQUENTIAL ANALYSIS AND NONPARAMETRIC INFERENCE (3-2). Sequential method of statistical decisions, probability ratio test, the fundamental identity, simple hypotheses. Estimation and testing when the functional form of the population distribution is unknown, rank order statistics. Tests based on permutations of observations. Nonparametric confidence intervals and tolerance limits. TEXTS: WALD, *Sequential Analysis;* FRASER, *Nonparametric Methods in Statistics;* MOOD, *Introduction to the Theory of Statistics.* PREREQUISITE: Ma-392(B) or the equivalent.

Ma-394(A) ANALYSIS AND DESIGN OF EXPERIMENTS(3-0). Theory of the general linear hypothesis. Analysis of variance. Randomized blocks and Latin squares. Factorial experiments. Analysis of covariance; confounding and fractional replication. Methods for determining the optimum combination of factor levels. TEXTS: MANN, *Analysis and Design of Experiments;* DAVIES, *Design and Analysis of Industrial Experiments.* PREREQUISITE: Ma-392(B).

Ma-401(A) ANALOG COMPUTERS (2-2). Elementary analog devices which may be used to perform addition, multiplication, function generation, integration, etc. Combinations of such devices for solution of differential equations, systems of linear equations, algebraic equations, harmonic analysis, etc. Digital differential analyzers. TEXTS: W. W. SOROKA, *Analog Methods in Computation and Simulation;* MURRAY, *Theory of Mathematical Machines;* Reprints of articles from scientific periodicals. PREREQUISITE: Ma-113(B) or Ma-123(A) or equivalent.

Ma-420(A) DIGITAL COMPUTATION (2-2). Logical design of digital computers. Programming and coding for general-purpose digital and differential analyzer computers. Laboratory operation of computing machines. Applications. TEXTS: Programming Manuals; BOOTH *and* BOOTH, *Automatic Digital Calculators;* MCCRACKEN, *Digital Computer Programming.* PREREQUISITE: Ma-116(B) or Ma-125(B).

Ma-421(A) DIGITAL COMPUTERS (3-2). Programming and coding for general-purpose digital computers. Boolean algebra. Logical design of digital computers. Laboratory operation of computers. Applications to problems in engineering, logic and data processing. Operation of differential analyzer and analog computer will be covered if time permits. TEXTS: Programming Manuals; MCCRACKEN, *Digital Computer Programming.* PREREQUISITES: Ma-111(C) and Ma-112(B) or the equivalent.

Ma-422(A) APPLICATIONS OF DIGITAL COMPUTERS (3-2). This course considers the application of digital computers to the solution of: Problems in Science (eg. Solutions to Differential Equations, Monte Carlo Methods, etc.); Problems in Logic (eg. Assigning Men and Machines to Jobs, etc.); Data Processing Problems (eg. Inventory Control, Personnel Records, etc); System Control Problems (eg. War Gaming Problems) and System Design Problems (eg. Simulation of Systems under Varying Conditions, etc.) TEXTS: Articles from scientific periodicals and literature of government and industrial users of computers. PREREQUISITES: Ma-114(A) or equivalent and Ma-421(A).

Ma-441(C) INTRODUCTION TO DIGITAL COMPUTERS (2-0). Description of a general purpose digital computer. Command structure and commands. Flow charts and programming. Applications to problems in science, logic and data processing. TEXT: McCRACKEN, *Digital Computer Programming*. PREREQUISITE: Ma-071(C) or equivalent.

Ma-471(B) ELECTRONIC DATA-PROCESSING AND MANAGEMENT CONTROL (3-2). Study and analysis of intermediate and large-scale electronic digital data-processing machines in the solution of management problems. Scientific approach to management problems. Case studies in inventory control, material accounting, personnel accounting or applications of immediate interest to the group. TEXTS: KOZMETSKY *and* KIRCHER, *Electronic Computers and Management Control*. Periodicals and literature of government and industrial users of electronic data-processing equipment.

MECHANICAL ENGINEERING

ME-111(C) ENGINEERING THERMODYNAMICS I (4-2). The laws and processes of transforming energy from one form to another, first law analysis, second law analysis and cycle analysis for reversible processes. Irreversible processes and available energy. TEXT: FAIRES, *Thermodynamics*. PREREQUISITE: Ma-112(B).

ME-112(C) ENGINEERING THERMODYNAMICS II (4-2). Continuation of ME-111. Applications of thermodynamic principles to marine power plant equipment, combustion engines and steam turbines, combustion, with use of charts and tables, low-pressure gas-vapor mixtures. 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-vapor mixtures. TEXT: FAIRES, *Thermodynamics*. PREREQUISITE: ME-111(C).

ME-160(C) THERMODYNAMICS (4-3). Laws of theoretical thermodynamics with applications to naval machines of the reciprocating and steady-flow types, power generation and refrigeration. Experiments related to performance analysis. TEXT: FAIRES, *Thermodynamics of Heat Power*. PREREQUISITES: Ph-012(C) and Ma-053(C).

ME-210(C) MARINE POWER PLANT PROBLEMS (3-2). Continuation of the applications of thermodynamic principles, flow of compressible fluids, elements of heat transfer. Complementary laboratory experiments. TEXT: FAIRES, *Thermodynamics*. PREREQUISITE: ME-132(C).

ME-211(B) MARINE POWER PLANT PROBLEMS (3-4). Continuation of applications of thermodynamic principles, compressible flow, including flow through turbines, thermodynamic experiments on power generating naval machinery and compressible flow. TEXT: FAIRES, *Thermodynamics*. PREREQUISITE: ME-112(C).

ME-212(A) ADVANCED THERMODYNAMICS (3-2). Imperfect gases and other advanced topics in thermodynamics. Continuation of experiments on thermodynamic devices. TEXT: FAIRES, *Thermodynamics*. PREREQUISITE: ME-211(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-212(A).

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-211(B).

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

ME-221(C) MARINE POWER PLANT PROBLEMS I (3-4). Continuation of the applications of thermodynamic principles, flow through nozzles, principles of measuring the rate of flow, flow through turbines, gas-vapor mixtures. Complementary laboratory experiments. TEXT: FAIRES, *Thermodynamics*. PREREQUISITE: ME 122(C).

ME-222(C) MARINE POWER PLANT PROBLEMS II (3-2). Continuation of applications of thermodynamic principles, refrigeration cycles and equipment, elements of heat transfer. Complementary laboratory experiments. TEXT: FAIRES, Thermodynamics. PREREQUISITE: ME-221(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, interrelationship of components, heat balances and flow diagrams, computation of ship and plant performance indices, preliminary investigation of major equipment items. TEXTS: SEWARD, *Marine Engineering, Vols. I and II;* CHURCH, *Steam Turbines, 3rd Edition*. PREREQUISITE: ME-210 (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 equivalent; and Ph-610(B).

ME-241(A) REACTOR ENGINEERING I (3-2). The first of a two-term series, covering engineering aspects of nuclear power reactors. Reactor types, properties, and criteria for selection. Advanced heat transfer and thermodynamics of characteristic cycles. Elementary thermal core and plant design. Economics of nuclear plants. Shielding. TEXT: GLASSTONE, *Principles of Nuclear Reactor Engineering*. PREREQUISITES: ME-310(B) and Ph-642(B).

ME-242(A) REACTOR ENGINEERING II (3-2). Reactor control methods and programs. Plant stability, kinetic behavior, poisoning. Detailed studies of existing reactor plants. TEXT: GLASSTONE, *Principles of Nuclear Reactor Engineering*. PREREQUISITE: ME-241(A).

ME-247(C) NUCLEAR POWER SURVEY (1-0). A general survey of nuclear power plants for students in fields other than mechanical engineering. Familiarization with basic concepts in nuclear reactor physics, shielding, and materials. General description of types of plants and equipment peculiar to nuclear plants.

ME-250(A) NUCLEAR REACTOR LABORATORY (0-4). Laboratory experiments using the AGN-201 Reactor covering reactor operation and the measurement of nuclear reactor characteristics. Experiments on a reactor simulator investigating reactor behavior and control. TEXTS: AEROJET-GENERAL, *Elementary Reactor Experimentation;* HUGHES, *Pile Neutron Research*. 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: Ma-113(B) and ME-112(C).

ME-320(B) HEAT TRANSFER (3-2). Fundamentals of heat transfer with emphasis on conduction and convection, steady and unsteady state, radiation, change of phase, heat exchangers, analogical, numerical and graphical methods. TEXT: KREITH, *Principles of Heat Transfer*. PREREQUISITES: Ma-113(B) and ME-132(C).

ME-350(B) HEAT TRANSFER (2-2). Basic concepts of the mechanisms of heat transfer; conduction, convection, and radiation. Emphasis on radiant heat transfer and transient systems. Numerical, graphical, and analog techniques. TEXT: GIEDT, *Principles of Engineering Heat Transfer*. PREREQUISITE: Ma-182(C).

ME-411(C) FLUID MECHANICS (3-2). Mechanical properties of fluids, hydrostatics, and bouyancy. Energy aspects of fluid flow, flow metering and control. Impulse-momentum principles and analysis. Dimensional analysis and similitude, fluid machinery. Laboratory experiments and problem work. TEXT: STREETER, *Fluid Mechanics*. PREREQUISITE: Ma-111(C).

ME-412(A) HYDROMECHANICS (4-2). Potential flow theory; use of vector notation, complex variables and conformal transformations. Linearized subsonic and supersonic flows. Navier-Stokes equations and applications for the real fluid. Elements of boundary layer theory. TEXT: STREETER, *Fluid Dynamics*. PREREQUISITES: ME-411(C) and Ma-114(A).

ME-421(C) FLUID MECHANICS I (3-2) First course in a sequence of two. A study of fluid properties, hydrostatics, buoyancy, energy concepts of ideal and real fluid flow, dynamic analysis, fluid metering and control, dimensional analysis and similitude. TEXT: VENNARD, *Elementary Fluid Mechanics*. PREREQUISITE: Ma-111(C).

ME-422(B) FLUID MECHANICS II (2-2). Detailed analysis of fluid machinery and fluid systems. Elements of hydrodynamic lubrication. Laboratory experiments and problem work. TEXT: SHEPHERD, *Principles of Turbomachinery*. PREREQUISITES: ME-421(C) and Ma-113(B).

ME-460(C) ELEMENTARY FLUID MECHANICS (4-0). A brief study of the basic relations and applications in fluid mechanics. TEXT: BINDER, *Fluid Mechanics*. PREREQUISITE: Recent course in differential and integral calculus.

ME-500(C) STRENGTH OF MATERIALS (3-0). 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. TEXT: TIMOSHENKO *and* MACCULLOUGH, *Elements of Strength of Materials*. PREREQUISITES: Ma-111(C), and Mc-101(C) or ME-501(C).

ME-501(C) STATICS (4-0). Laws of statics. Force systems, equilibrium. Simple structures, distributed forces, friction, virtual work. TEXT: MERIAM, *Mechanics, Part I*. PREREQUISITE: Ma-100(C) or Ma-120(C) (may be taken concurrently).

ME-502(C) DYNAMICS (4-0). Kinematics, Newton's laws, kinetics of particles. Work and energy, impulse and momentum. Kinetics of rigid bodies in plane motion, periodic motion, moments of inertia. TEXT: MERIAM, *Mechanics, Part II*. PREREQUISITES: ME-501(C), and differential equations (may be taken concurrently).

ME-503(A) ADVANCED DYNAMICS (4-0). Restatement of laws of mechanics. Simple pendulum for large amplitudes, effects of earth's rotation. The inertia tensor, general motion of a rigid body, spinning tops, gyroscopes. Numerical procedures. Lagrange's equations. TEXT: SYNGE *and* GRIFFITH, *Principles of Mechanics*. PREREQUISITE: ME-502(C).

ME-511(B) STRENGTH OF MATERIALS II (5-0). Methods of elastic analysis of statically indeterminate structures, strain energy and slope deflection analysis, beam columns, curved beams, unsymmetrical bending, shear center, beams on elastic foundations, applications of these topics to ship structures. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II*. PREREQUISITE: ME-500(C).

ME-512(A) TOPICS IN ELASTICITY (4-0). Stress tensor, strain tensor, theories of failure, fundamentals of the theory of elasticity, torsion of noncircular sections, thick walled cylinders, rotating disks, stresses due to localized loading, thermal stresses, stress concentration, use of the literature on theory of elasticity. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II;* TIMOSHENKO *and* GOODIER, *Theory of Elasticity*. PREREQUISITE: ME-511(B).

ME-513(A) ADVANCED STRENGTH OF MATERIALS (3-0). Plates and shells, ship plating, buckling of plates and shells, plastic behavior of engineering materials, of structural and machine elements, limit analysis, brittle and ductile failures. Impact, fatigue, creep and other high temperature phenomena. Theories for working stresses, codes and standards, new materials, high strength materials, special materials. TEXTS: LESSELS, *Strength and Resistance of Materials;* TIMOSHENKO, *Strength of Materials, Vol. II.* PREREQUISITE: ME-512(A).

ME-521(C) STRENGTH OF MATERIALS II (4-0). Slope-deflection analysis, beam columns, curved beams, unsymmetrical bending, shear center, applications of these topics to ship structures. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II.* PREREQUISITE: ME-500(C).

ME-522(B) STRENGTH OF MATERIALS III (4-0). Thick walled cylinders, thermal stresses, theories of failure, stress concentrations, torsion of noncircular sections, plastic behavior of materials and parts, plastic analysis of structures, brittle and ductile failures, impact, fatigue, creep and other high temperature phenomena. TEXT: TIMOSHENKO, *Strength of Materials, Vol. II.* PREREQUISITE: ME-521 (C).

ME-550(B) DYNAMIC STRUCTURAL ANALYSIS (5-0). Elastic and plastic analysis of principal structural elements and of determinate and indeterminate structures, suddenly applied loads, dynamic response of simple linear and nonlinear systems, response of idealized structures to large suddenly applied loads, numerical and computer solutions. TEXTS: TIMOSHENKO *and* MACCULLOUGH, *Elements of Strength of Materials;* TIMOSHENKO, *Strength of Materials, 3rd Edition, Vols. I and II.* PREREQUISITE: ME-500(C) or ME-511(A).

ME-561(C) ENGINEERING MECHANICS I (STATICS) (4-0). Forces and force systems, moments and couples, resultants, equilibrants, free body diagrams, equilibrium of a free body, two force members, trusses, many force members, friction, cables, first and second moments, centroids. TEXT: MERIAM, *Mechanics, Part I.* PREREQUISITE: Ma-052(C).

ME-562(C) ENGINEERING MECHANICS II (DYNAMICS) (4-0). Kinematics of a particle, force, mass and acceleration, Newton's laws of motion, d'Alembert's principle for a particle, systems of particles, motion of the mass center, translation and rotation, plane motion, work and energy, impulse and momentum. TEXT: MERIAM, *Mechanics, Part II.* PREREQUISITES: ME-561(C) and Ma-053(C).

ME-570(C) STRENGTH OF MATERIALS (4-0). 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, indeterminate structures. TEXT: TIMOSHENKO *and* MACCULLOUGH, *Elements of Strength of Materials.* PREREQUISITE: ME-562(C).

ME-601(C) MATERIALS TESTING LABORATORY (0-2). Performance and analysis of standard tests used in determining the mechanical properties of engineering materials, including tests in tension, compression, torsion, shear, transverse bending, impact and hardness. TEXTS: MUHLENBRUCH, *Testing of Engineering Materials;* A.S.T.M., *Student Standards.* PREREQUISITE: Subsequent to or concurrent with ME-500(C) or Ae-211.

ME-611(C) MECHANICAL PROPERTIES OF ENGINEERING MATERIALS (2-2). Study of the theories of failure, the evaluation of experimental error and experiments in the determination of the mechanical properties of engineering materials. These tests include: tension, compression, torsion, shear, transverse bending, impact, hardness, fatigue and column action. TEXTS: SEELY *and* SMITH, *Advanced Mechanics of Materials;* DAVIS, *and others, Testing and Inspection of Engineering Materials.* PREREQUISITE: ME-500(C).

ME-612(A) EXPERIMENTAL STRESS ANALYSIS (3-2). Theory and applications of resistance strain gages for static and dynamic analyses. Instrumentation systems and transducer applications. Brittle lacquer, model theory, photoelastic and analogue methods. Complementary laboratory experiments. TEXTS: PERRY *and* LISSNER, *Strain Gage Primer;* LEE, *An Introduction to Experimental Stress Analysis.* PREREQUISITE: ME-513(A).

ME-622(B) EXPERIMENTAL STRESS ANALYSIS (2-2). Theory and applications of resistance strain gages for static and dynamic analyses. Instrumentation systems and transducer applications. Elements of photoelasticity and brittle lacquer techniques. Complementary laboratory experiments. TEXT: PERRY *and* LISSNER, *Strain Gage Primer.* PREREQUISITE: ME-522(B) or equivalent.

ME-710(B) MECHANICS OF MACHINERY (4-2). Velocity and acceleration of machine parts, static and dynamic forces on machine members. Kinematic analysis of cams and gears. Balancing of solid rotors. Basic principles of vibration, undamped and damped, free and forced vibrations, vibration isolation, instrumentation. TEXTS: HAM *and* CRANE, *Mechanics of Machinery;* THOMSON, *Mechanical Vibrations.* PREREQUISITE: ME-502(C).

ME-711(B) MECHANICS OF MACHINERY (4-2). Velocity and acceleration of machine parts, static and dynamic forces on machine members. Kinematic analysis of cams and gears. This course is the first of a coordinated sequence of ME-711 and ME-712. TEXTS: HAM *and* CRANE, *Mechanics of Machinery;* FAIRES, *Kinematics.* PREREQUISITE: ME-502(C).

ME-712(A) MECHANICAL VIBRATIONS (3-2). Balancing of solid rotors and reciprocating machines. Undamped and damped, free and forced vibrations for one, two and many degrees of freedom, vibration isolation and absorbers, instrumentation. Laboratory experiments illustrate basic principles of vibration and its control. TEXTS: DEN HARTOG, *Mechanical Vibrations;* THOMSON, *Mechanical Vibrations.* PREREQUISITES: Ma-114(A), ME-711(B) and ME-500(C).

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-730(A) 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 non-linear systems. Laboratory experiments illustrate basic principles of vibration and its control. TEXTS: DEN HARTOG, *Mechanical Vibrations;* THOMSON, *Mechanical Vibrations.* PREREQUISITES: Ma-114(A), ME-500(C) and ME-502(C).

ME-811(C) 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(C) and ME-712(A).

ME-820(C) MACHINE DESIGN (2-4). Review of strength of materials. Studies of fits, tolerances, allowances, stress concentration, material selection, bearing, gears, shafting, cams, springs, screws, brakes and clutches. TEXT: FAIRES, *Design of Machine Elements.* PREREQUISITES: ME-522 (B) and ME-711(B).

ME-840(C) MANUFACTURING ENGINEERING (3-2). The following topics are studied: the principles of interchangeable manufacture, the selection of and use of the proper machine tools to fulfill a specific requirement, the details of gage design and inspection methods with reference to proper fits and tolerances. Several industrial plants will be visited, where lectures on the use of machines will be provided. TEXT: BUCKINGHAM, *Interchangeable Manufacturing.* PREREQUISITE: ME-811(C).

ME-900(A) SPECIAL PROBLEMS IN MECHANICAL ENGINEERING (4-0). Advanced topics to meet special entrance requirements at other institutions. Analytic theory of heat conduction. Thermal stresses in plates, rods, and pressure vessels. TEXTS: JAKOB, *Heat Transfer;* TIMOSHENKO *and* GOODIER, *Theory of Elasticity.* PREREQUISITES: ME-310 (B) and ME-512(A) or equivalent.

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; Coriolis acceleration. TEXT: HOUSNER *and* HUDSON, *Applied Mechanics.* PREREQUISITE: A previous course in mechanics is desirable. Ma-100 (C) or Ma-120(C) to 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.* PREREQUISITE: Mc-101(C).

Mc-201(A) METHODS IN DYNAMICS (2-2). The principles of linear momentum, angular momentum, work and energy, power and energy, conservation of energy, virtual work, and d'Alembert are developed and discussed in detail. This work is followed by a development and interpretation of Lagrange's equations of motion. Application of these various principles to obtain the differential equations of motion of dynamical systems is given particular attention. Numerous exercises in the writing of differential equations of motion are assigned; some of these are designed to furnish practice in the formulation of the differential equations for systems of variable mass. 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 (Second Edition);* TIMOSHENKO *and* YOUNG, *Advanced Dynamics;* SCARBOROUGH, *The Gyroscope;* KLASS, *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; introduction to optimum rocket trajectories; Dovap; Introductory study of errors in prediction from regular observation. TEXTS: LOCKE, *Guidance;* USNPS Notes. PREREQUISITE: Mc-402(A).

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 tests; dynamic stability; resonance instability. TEXTS: Classroom Notes; DAVIS, FOLLIN, *and* BLITZER, *Exterior Ballistics of Rockets.* PREREQUISITE: Mc-402(A).

METALLURGY

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 Production 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 Production 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;* GUY, *Elements 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-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 inntrinsic 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 a discussion of equilibrium in alloy systems, structure of metals and alloys, phase transformations and diffusion. TEXTS: BARRETT, *Structure of Metals;* RHINES, *Phase Diagrams in Metallurgy;* SMOLUCHOWSKI, *Phase Transformations in Solids.* PREREQUISITE: Mt-202(C).

Mt-206(A) ADVANCED PHYSICAL METALLURGY (3-4). The subject matter is an extension of that offered in Mt-205(A) and includes such topics as plastic deformation, theories of slip, recrystallization, preferred orientation, age hardening, etc. TEXTS: BARRETT, *Structures of Metals;* CHALMERS, *Progress in Metal Physics;* COTTRELL, *Dislocations and Plastic Flow in Crystals;* SHOCKLEY, *Imperfections in Nearly Perfect Crystals.* PREREQUISITE: Mt-205(A).

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-208(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-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-304(C) NON-DESTRUCTIVE TESTING (2-2). An introduction to the methods and procedures available for the non-destructive determination of quality characteristics of metals and metal objects. Types of procedures to be discussed may include x-ray and gamma ray radiography, magnetic and electro-magnetic methods, sonic methods, fluorescent liquid and powder methods, spot tests, spark tests, etc. TEXT None. PREREQUISITE: Mt-202(C).

Mt-305(B) CORROSION AND CORROSION PROTECTION (3-0). Designed for Engineering Materials Curriculum. Corrosion theories and methods of corrosion protection. TEXT: None. PREREQUISITES: Mt-202 and Ch-101 or equivalent.

Mt-306(B) ADVANCED ANALYTICAL TECHNIQUES (3-3). Designed for Engineering Materials Curriculum. Engineering measurements, to include x-ray diffraction, concentration measurements, pH meters, etc. Density measurements and radio tracer techniques, activation analysis, infrared techniques. TEXT: None. PREREQUISITES: Mt-202 and Physical Chemistry.

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. Topics considered are the wave nature of electrons, the electron theory of metals, reaction kinetics, free energy of alloy phases, order-disorder transformations, etc. TEXTS: COTTRELL, *Theoretical Structure Metallurgy;* KITTELL, *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 (4-0). 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.* 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).

METEOROLOGY

Mr-100(C) FUNDAMENTALS OF ATMOSPHERIC CIRCULATION (2-0). Primarily designed to give nonmeteorological 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;* NAVAER 50-1R-242, *Application of Oceanography to Subsurface Warfare;* 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 (3-9). Objectives and techniques of surface and upper-air analysis, including contour (isobar), isotherm and frontal analyses. Laboratory practice in upper-air and surface analyses stressing history and continuity; weather observation flights. TEXTS: BERRY, BOLLAY *and* BEERS, *Handbook of meteorology;* departmental notes. PREREQUISITES: Mr-200 (C) and a knowledge of weather codes and observations.

Mr-202(C) WEATHER MAP ANALYSIS (2-9). Continuation of Mr-201(C). Structure of frontal-wave cyclones and occlusions; graphical analysis techniques; upper-air analysis, especially jet stream, moisture and extended analyses. Laboratory practice extends surface and upper-air analyses to include the foregoing; daily map discussions; aircraft flights continued. TEXTS: NAVAER 50-1P-502, *Practical Methods of Weather Analysis and Prognosis;* departmental notes. PREREQUISITE: Mr-201(C).

Mr-203(C) UPPER-AIR ANALYSIS AND PROGNOSIS (2-9). Continuation of Mr-202(C). Interdependence of surface weather and upper atmospheric conditions; techniques of upper-air prognosis, including long and short waves, vorticity, thickness, space-mean, 3-D consistency and continuity considerations. Laboratory practice is continued in surface and upper-air analyses; upper-air prognosis is introduced. TEXTS: Same as Mr-202(C) plus various Navy, AWS and Weather Bureau publications; departmental notes. PREREQUISITE: Mr-202(C).

Mr-204(C) WEATHER ANALYSIS AND FORECASTING (2-9). Continuation of Mr-203(C). Movement and development of surface weather systems; objective and subjective methods of forecasting weather elements; weather types; air masses. Laboratory practice in upper-air prognosis and weather forecasting is introduced. TEXTS: Same as Mr-203(C). PREREQUISITE: Mr-203(C).

Mr-215(B) ADVANCED WEATHER ANALYSIS AND FORECASTING (2-9). Lectures cover general operational weather problems, single-station, severe weather, stratospheric and extended-period forecasting. Laboratory work includes coordinated analyses and prognoses in all above subjects. TEXT: Various NavAer, AWS Manuals, and departmental notes. PREREQUISITE: Mr-204(C).

Mr-216(B) ADVANCED WEATHER ANALYSIS AND FORECASTING (3-0). A continuation of Mr-215 (B). Operational weather problems are discussed; flight forecasting and clearance, carrier strikes, amphibious operations, radar meteorology, administrative and organizational details of the Naval Weather Service. TEXTS: Same as Mr-215(B). PREREQUISITE: Mr-215(B).

Mr-217(B) ADVANCED WEATHER ANALYSIS AND FORECASTING (0-16). Students operate as a weather central and prepare analyses and prognoses as required. Tropical weather, southern and northern hemispheric series are analyzed. Flight cross-sections and clearances are prepared for selected routes. TEXTS: Selected NavAer, AWS, and NWRF publications. PREREQUISITE: Mr-215(B).

Mr-219(B) ADVANCED WEATHER ANALYSIS AND FORECASTING (0-16). Students operate as a weather central: prepare analyses and prognoses; analyze northern and southern hemispheric and tropical weather series; numerical weather prediction; prepare flight cross-sections and clearances for selected routes. TEXTS: Same as Mr-217(B). PREREQUISITE: Mr-215(B).

Mr-220(B) SELECTED TOPICS IN APPLIED METEOROLOGY (4-0). Tropical and polar meteorology; the general circulation; other topics as time permits. TEXTS: RIEHL, *Tropical Meteorology;* PETTERSSEN, JACOBS *and* HAYNES, *Meteorology of the Arctic;* NAVAER publications; departmental notes. PREREQUISITES: Mr-302(B) and Mr-402(C).

Mr-228(B) TROPICAL AND SOUTHERN HEMISPHERE METEOROLOGY (2-0). Southern hemisphere synoptic meteorology; tropical synoptic models (with emphasis on the tropical cyclone); tropical forecasting. TEXT: RIEHL, *Tropical Meteorology.* PREREQUISITE: Mr-321(A).

Mr-229(B) SELECTED TOPICS IN METEOROLOGY (2-0). General circulation of the atmosphere; arctic and antarctic meteorology; extended-range forecasting; recent developments as time permits. TEXTS: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology;* selected NavAer and AWS publications. PREREQUISITES: Mr-322(A), Ma-125(B) and Ma-331(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-162(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) and Ma-163 (C).

Mr-321(A) DYNAMIC METEOROLOGY I (4-0). 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) and Ma-132(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 front-o-genesis. TEXT: Same as Mr-321(A). PREREQUISITES: Ma-125(B) and Ma-330(C) concurrently, Ma-133(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. TEXTS: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology;* SUTTON, *Micrometeorology.* PREREQUISITES: Mr-322(A), Ma-125 (B) and Ma-330(C).

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-162(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 frictional layer) and its significance in turbulent transfer; air-mass modification; forecasting the micrometeorological variables and their use in diffusion from point and line sources. TEXT: Same as Mr-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-162(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 airmass modification and minimum-temperature forecasting; heat budget of earth-atmosphere system; selected topics in atmosphere optics and electricity. TEXTS: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology;* NEUBERGER, *Introduction to Physical Meteorology.* 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 indentification indices; geopotential determinations; altimetry; instability phenomena and criteria. TEXTS: HOLMBOE, FORSYTHE *and* GUSTIN, *Dynamic Meteorology;* HALTINER *and* MARTIN, *Dynamical and Physical Meteorology;* U. S. DEPT. OF COMMERCE, *The Thunderstorm.* PREREQUISITES: Ma-131(C) and Ph-196(C).

Mr-415(B) RADAR PROPAGATION IN THE ATMOSPHERE (2-0). Propagation of microwaves; vertical profile of refractive index as a condition for ducting, superrefraction, subrefraction of microwaves; ray tracing; air-mass profiles of refractive index; scattering of microwaves by precipitation elements and detection of echoes on PPI and RHI scopes; synoptic interpretations of echoes. TEXTS: JOHNSON, *Physical Meteorology;* selected NavAer publications. PREREQUISITES: Mr-323(A) and Ma-331(A) or Mr-302 (B) and Ma-381(C).

Mr-422(A) THE UPPER ATMOSPHERE (5-0). The composition of the upper atmosphere; the nature of the upper atmosphere as determined from several lines of observation; the ionosphere and related optical and electrical activity; the sun and its effect on the atmosphere; the terrestrial magnetic variations; atmospheric oscillations of tidal origin; aurora. TEXTS: MITRA, *The Upper Atmosphere;* GOODY, *The Physics of the Stratosphere;* departmental notes and selected publications. PREREQUISITES: Ma-331(A) and Mr-323(A).

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 (3-2). 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; objective forecasting techniques and their applications to practical problems. TEXTS: HAURWITZ *and* AUSTIN, *Climatology;* CONRAD *and* POLLAK, *Methods in Climatology.* PREREQUISITES: Mr-200(C) and Ma-381(C) or Ma-331(A) concurrently.

Mr-611(B) OCEAN WAVES AND WAVE FORECASTING (3-6). The generation and propagation of ocean waves; statistical properties of waves; wave spectra; tropical-storm waves; synoptic wave charts and ship routing; movement of ships in a seaway; forecasts in the laboratory. TEXTS: H. O. 603, *Practical Methods for Observing and Forecasting Ocean Waves;* other H. O. publications. PREREQUISITES: Mr-201(C) and Ma-381(C) or equivalent.

Mr-612(B) SEA ICE (3-4). Arctic geography and oceanography; sea-ice observations and codes; ice formation, properties, growth, deformation and disintegration; ice drift and its relation to winds and currents. TEXT: H. O. SEA ICE MANUAL (unpublished). PREREQUISITES: Mr-200 (C) and Oc-210(B).

Mr-810(A) SEMINAR IN METEOROLOGY AND OCEANOGRAPHY (2-0). Students perform 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(B), Oc-621(B), and Ma-331(A) 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;* NAVAER 50-1R-242, *Application of Oceanography to Subsurface Warfare.*

Oc-210(B) PHYSICAL OCEANOGRAPHY (3-0). The physics of ocean currents, diffusion, boundary-layer flow, electromagnetic radiation and visibility in the sea; tides and seiches; the nature of estuarine circulation; interface phenomena. TEXTS: SVERDRUP, JOHNSON, *and* FLEMING, *The Oceans;* NAVAER 50-1R-242, *Application of Oceanography to Subsurface Warfare;* departmental notes. PREREQUISITES: Oc-110(C) or equivalent, Ma-163(C) or equivalent, and Ph-196(C) or Ph-191(C).

Oc-212(B) 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: MARMER, *The Tide;* MARMER, *Tidal Datum Planes.* PREREQUISITES: Ma-111(C) and Ph-142(B) or their equivalents.

Oc-213(B) SHALLOW-WATER OCEANOGRAPHY (3-0). Types and characteristics of continental shelves, coasts and beaches; surf, breaking waves, littoral currents, and other shallow-water phenomena, and their influence upon amphibious operations; storm-tides. TEXT: Departmental notes. PREREQUISITES: Oc-110(C) and Mr-611(B).

Oc-220(B) OCEAN CURRENTS AND DIFFUSION (3-0). Dynamics of ocean currents; advection and diffusion, including that of radioactive substances; the natural flushing of contaminants from harbors and estuaries; boundary-layer flow in the sea. TEXTS: SVERDRUP, JOHNSON, *and* FLEMING, *The Oceans;* SHEPARD, *Submarine Geology;* NAVAER 50-1R-242 *Application of Oceanography to Subsurface Warfare.* PREREQUISITES: Oc-110(C), and Ma-163(C) and Ph-196(C) or their equivalents.

Oc-230(A) WAVE PHENOMENA IN THE SEA (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-152(B), and Ma-321(B) or equivalent.

Oc-310(B) GEOLOGICAL OCEANOGRAPHY (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. TEXTS: KUENEN, *Marine Geology;* SHEPARD, *Submarine Geology.* PREREQUISITES: Oc-110(C) or equivalent. 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: TERZAGHI *and* PECK, *Soil Mechanics in Engineering Practice;* SHEPARD, *Submarine Geology;* UNITED STATES NAVAL INSTITUTE, *Marine Fouling and its Prevention;* selected publications. PREREQUISITE: Oc-110(C).

Oc-400(C) GENERAL OCEANOGRAPHY AND MARINE BIOLOGY (3-0). Physical and chemical properties of sea water; currents, waves, and tides; general circulation of the oceans; submarine geology; biology of the oceans; organisms responsible for noise making, sound scattering, bioluminescense, fouling, and boring. TEXTS: SVERDRUP, JOHNSON *and* FLEMING, *The Oceans;* selected publications.

Oc-410(B) BIOLOGICAL OCEANOGRAPHY (3-1). Plants 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) or equivalent.

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) or equivalent.

Oc-620(B) OCEANOGRAPHIC FACTORS IN UNDERWATER SOUND I (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: NAVAER 50-1R-242, *Application of Oceanography to Subsurface Warfare;* departmental notes. PREREQUISITES: Oc-110(C) and Ph-196(C) or equivalent.

Oc-621(B) OCEANOGRAPHIC FACTORS IN UNDERWATER SOUND II (1-2). A continuation of Oc-620(B). Diurnal and seasonal thermoclines and their variations; forecasting vertical thermal gradients, surface scattering coefficients, etc.; use of data sources for mean thermal structures, ambient noise levels, and sea floor reverberation. TEXT: Selected publications. PREREQUISITE: Oc-620(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;* classified official publications; notes from MIT Summer Course on Operations Research, 1953; MCCLOSKEY *and* TREFETHEN, *Operations Research for Management. Vols. I and II.* PREREQUISITE: Ma-321(B).

OA-141(B) FUNDAMENTALS OF OPERATIONS ANALYSIS (4-0). The role of operations analysis in the solution of military problems. Measures of effectiveness and the selection of optimal weapon systems. Special techniques such as game theory, linear programming, detection theory, and reliability theory. TEXTS: MCCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* KOOPMANS, *Activity Analysis of Production and Allocation;* classified official publications; instructor's notes. 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 over-all errors. Damage probabilities. Selection of optimal weapon systems. Introduction to game theory and its application. TEXTS: OPERATIONS EVALUATION GROUP, *Report No.* 54 *Methods of Operations Research;* classified official publications. PREREQUISITES: Ma-113 (B) and Ma-301(B).

OA-152(C) MEASURES OF EFFECTIVENESS OF MINES (3-0). Review of probability theory with military interpretations. Introduction to operations analysis. Errors in mine laying. Probability of damage. Theory of mine field operation. TEXTS: Classified official publications. PREREQUISITE: Ma-381(C).

OA-153(B) GAME THEORY AND ITS APPLICATIONS TO MINE FIELDS (3-0). A continuation of OA-152(C). Introduction to game theory. Operation of a mine field according to game theory. Analysis of countermeasures. TEXTS: Classified official publications. PREREQUISITE: OA-152(C).

OA-171(C) OPERATIONS ANALYSIS FOR NAVY MANAGEMENT (3-0). 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;* Notes from MIT Summer Course on Operations Research, 1953; KOOPMANS, *Activity Analysis of Production and Allocation;* Instructor's Notes. PREREQUISITE: Ma-371(C).

OA-201(A) LOGISTICS ANALYSIS (3-2). Mathematical methods in logistics, with major emphasis on applications of linear programming to problems of transportation and scheduling of interdependent activities. Theory of inventory control. Dynamic programming. Laboratory work on computation of optimal solutions of linear programs. TEXTS: KOOPMANS, *Activity Analysis of Production and Allocations;* PROJECT RAND, *Paper P*-189, *Optimal Inventory Policy;* PROJECT RAND, *Report R*-245, *An Introduction to the Theory of Dynamic Programming.* PREREQUISITES: OA-391(A) and Ma-195(A).

OA-202(A) ECONOMETRICS (3-0). A continuation of OA-201(A). Inter-industry analysis; mathematical economic theory; review of current theoretical investigations of relationships between military programs and the national economy. TEXTS: KOOPMANS, *Activity Analysis of Production and Allocation;* PROJECT RAND, *Report R*-245, *An introduction to the Theory of Dynamic Programming;* MORGENSTERN, *Economic Activity Analysis;* CONOLLY, *Interdiction Considerations in Leontieff - Type Models of Land Logistic Networks* (USNPS Thesis). PREREQUISITES: OA-201(A) and Ma-195(A).

OA-291(C) INTRODUCTION TO OPERATIONS ANALYSIS (4-0). Development of fundamental concepts and methods of operations analysis as illustrated in the field 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 measure of detection, attack, and kill capabilities. TEXTS: OPERATIONS EVALUATION GROUP, *Report No.* 54, *Methods of Operations Research;* Classified official publications; MCCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* TUCKER, *Submarine Firing Phase Decisions* (USNPS Thesis). PREREQUISITES: Ma-391(C) and Ma-182(C). (The latter 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 measurers of effectiveness. Critique of assumptions and results. Evaluation of weapons. TEXTS: MERRILL, *Operations Research;* CHURCHMAN, ACKOEF, *and* ARNOEE, *Introduction to Operations Research;* Classified official publications. PREREQUISITES: Ma-391(C) and OA-291(C).

OA-293(B) SEARCH THEORY AND AIR DEFENSE (4-0). Theory of radar detection. Evaluation of the operational performance of search radars. Search theory. The design of screens and barrier patrols. Evaluation of fleet air defense. Applications of operations analysis to the problem of continental air defense. TEXTS: Classified official publications. PREREQUISITES: OA-292(B) and Ma-392(B).

OA-294(A) SPECIAL TOPICS IN OPERATIONS ANALYSIS (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* RAIEA, *Game Theory and Decisions;* THRALL, *Decision Processes;* Classified official publications. PREREQUISITE: OA-292(B).

OA-295(A) ANALYSIS OF WEAPON SYSTEMS (3-0). Selection of optimum weapon systems. Special weapons. The effects of system complexity on system reliability. TEXTS: Classified official publications. PREREQUISITE: OA-294 (A).

OA-296(A) DESIGN OF WEAPON SYSTEMS (3-0). The areas of application of the various techniques of operations analysis 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 protootype 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 analysis 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.. PREREQUISITES: OA-295(A) and OA-392(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. 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. 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.* PREREQUISITE: Ma-391(C) or the equivalent; Ma-195(A). (The latter may be taken concurrently).

OA-392(A) DECISION THEORY (3-0). Basic concepts. Relation of statistical decision functions to the theory of games. Applications in the planning of operational evaluation trials. TEXTS: 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-392(B) and OA-391(A). (The latter may be taken concurently).

OA-401(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-195(A) and Ma-391(C) or equivalent.

OA-891(B) SEMINAR (1-0). Presentation, evaluation and critique of experiences and results of summer field trips. PREREQUISITE: Participation in summer field trip.

OA-892(L) ORIENTATION SEMINAR (0-1). Audition of OA-891(B) for guidance in later work.

OA-893(A) SEMINAR (2-2). Opportunity is given to students to prepare original material, or to choose current publications for study, and to present reports of this work as a phase of Operations Analysis. PREREQUISITE: A background of advanced work in Operations Analysis.

ORDNANCE

Or-105(C) UNDERWATER ORDNANCE (1-2). Underwater ordnance used in offensive anti-submarine or anti-surface action. Research and development programs for torpedoes, depth charges, mines and underwater rockets. Laboratory periods are devoted to the presentation of reports by students on pertinent weapons systems. TEXTS: Classified Official Publications.

Or-191(C) MINES AND MINE MECHANISMS (2-0). Present U. S. mines, mine handling, mine storage, explosives, surveillance. Foreign types. Mine firing mechanisms, representative types. Preparation and test. TEXTS: Classified official publications.

Or-241(C) GUIDED MISSILES I (2-0). General concepts and theoretical problems involved in guidance, launching, propulsion, warhead design, stabilization, and simulation of guided missiles. Tactical problems and limitations of guidance systems. Organization of guided missile program. Test ranges and instrumentation. TEXTS: Classified official publications.

Or-242(B) GUIDED MISSILES II (2-0). Continuation of Or-241(C). Concepts of FM-CW and doppler radar; types of servos; the ballistic trajectory as applied to guided missiles. Application of guided missiles principles and uses as exemplified by Terrier, Talos, Tartar, Regulus and Polaris. TEXT: Classified official publications. PREREQUISITE: Or-241(C).

Or-291(C) MINE COUNTERMEASURES I (3-0). Sweeper characteristics. Sweeping techniques. Countermeasures for specific influence mine types. Practical sweeping of influence mines. Passive countermeasures. TEXTS: Classified official publications.

Or-292(C) MINE COUNTERMEASURES II (1-2). Continuation of Or-291(C). Theory of various countermeasures techniques. Laboratory periods are devoted to problem working and student presentations of reports on advanced countermeasures theories. TEXTS: Classified official publications. PREREQUISITE: Or-291(C).

Or-293(C) MINE COUNTERMEASURES III (2-0). Continuation of Or-292(C). Mine detection and destruction. Statistical minesweeping theory. New developments. TEXTS: Classified official publications. PREREQUISITE: Or-292(C).

Or-294(A) MINE WARFARE SEMINAR (2-0). Investigation and reports by students on assigned mine warfare topics. Occasional presentations and discussions by field representatives of mine warfare activities. PREREQUISITE: Or-293(C).

Or-392(B) MINEFIELD PLANNING (2-0). Theory of tactical and strategic mining. Limitations of current planning doctrine. New approaches to minefield design. TEXTS: Classified official publications. PREREQUISITES: Or-191 (C) and a previous course in mine countermeasures.

PHYSICS

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: Semat, *Introduction to Atomic and Nuclear Physics*. PREREQUISITES; Ph-011(C), Ph-012(C) and Ph-013(C).

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, center of mass coordinates, wave motion, Lagrange's and Hamilton's methods. 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(C). (May be taken concurrently.)

Ph-142(B) ANALYTICAL MECHANICS (4-0). Wave motion, fluid mechanics, constrained motion, Hamilton's principle, Lagrange's equations. TEXT: Symon, *Mechanics*. PREREQUISITES: Ma-183(B) (may be taken concurrently) and Ph-141(B).

Ph-144(A) ANALYTICAL MECHANICS (4-0). The linear oscillator, central force motion, Lagrange's and Hamilton's equations. Kinematics of rigid bodies. Canonical transformations. Coupled systems and normal coordinates. TEXT: Goldstein, *Classical Mechanics;* lecture notes. PREREQUISITE: Ph-142(B) or equivalent.

Ph-161(A) HYDRODYNAMICS (3-0). Equilibrium conditions for liquids; liquids under gravity and Coriolis forces; Eulerian and Lagrangean motion; Bernoulli equation; two-dimensional flow; Schwarz-Christoffel transformations; three-dimensional flow; vorticity, viscous flow; analogue to magnetic-statics; hydrofoils; surface waves. TEXT: Streeter, *Fluid Dynamics;* Lecture Notes. PREREQUISITES: Ae-100 (C); Ae-121(C), Ma-114(A).

Ph-162(A) ADVANCED HYDRODYNAMICS (3-0). Navier-Stokes equation. Laws of Similarity. Sphere in non-viscous and 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 (experimental). Turbulent boundary layers and hydrodynamic noise. 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: Sears *and* Zemansky, *College 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: Sears *and* Zemansky, *College 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 temperature, heat, kinetic theory, 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, dispersing 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-421(C) RADIATION (3-3). Fundamentals of geometric and physical optics. Wave phenomena and wave propagation. Origin of the quantum theory, photoelectric effect, optics radiation from atoms, molecules and solids. TEXTS: SEARS, JENKINS, *and* WHITE, *Fundamentals of Optics.*

Ph-311(B) ELECTROSTATICS AND MAGNETOSTATICS (3-0). Coulomb's law, Gauss' law, dipoles, dielectric theory, polarization, solutions of Laplace's equation, electrical images, magnetic dipoles and shells, Ampere's law, magnetic field of current, magnetic theory. Both analytical and vector methods are used. TEXTS: SLATER *and* FRANK, *Electromagnetism;* WHITMER, *Electromagnetics.* PREREQUISITES: Ma-156(B); Es-112(C).

Ph-312(A) APPLIED ELECTROMAGNETICS (3-0). A continuation of Ph-311 with particular emphasis on magnetic fields of significance to mine warfare. Propagation of induction and radiation fields of electromagnetic waves. TEXTS: SLATER *and* FRANK, *Electromagnetism;* WHITMER, *Electromagnetics.* PREREQUISITE: Ph-311(A).

Ph-341(C) ELECTRICITY AND MAGNETISM (4-2). DC and AC circuits, elementary electrostatics, vacuum tubes, coupled circuits, filters, lines, vacuum tube circuits. The treatment emphasizes the physical aspects of these phenomena. TEXTS: WINCH, *Electricity and Magnetism;* lecture notes. PREREQUISITE: Ma-182(C). (May be taken concurrently.)

Ph-361(A) ELECTOMAGNETISM (3-0). Electromagnetic field theory; electrostatics, dielectrics, magnetic fields of currents; vector potential; magnetic materials; magnetomotive force; electromagnetic induction; Maxwell's equations. TEXT: SLATER *and* FRANK, *Electromagnetism.* PREREQUISITES: MA-183(C) 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-421(B) FUNDAMENTAL ACOUSTICS (3-0). 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. Propagation of spherical waves including acoustic output and beam patterns from a circular piston. Absorption of sound in fluids. Electro-acoustic transducers. TEXT: KINSLER *and* FREY, *Fundamentals of Acoustics.* PREREQUISITE: Ma 113(B) or equivalent.

Ph-425(A) UNDERWATER ACOUSTICS (3-2). A continuation of Ph-421(B). An analytic treatment of the propagation of underwater acoustic waves as influenced by boundary conditions, refraction, reverberation, and attenuation. Physical characteristics of sonar transducers. Psychoacoustics, shock waves, sonar systems and developments, experimental measurements in underwater acoustics. Laboratory includes experiments in underwater acoustic measurements, sonar beam pattern, and operational characteristics of sonar equipment. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics; NDRC Technical Summary: Principles of Underwater Sound; NDRC Technical Summary: Physics of Sound in the Sea.* PREREQUISITE: Ph-421(B) or Ph431(B).

Ph-428(A) UNDERWATER ACOUSTICS AND SONAR SYSTEMS (3-3). A continuation of Ph-421(B). Microphone and sonar transducer theory and design. Transmission of sound in sea water, including problems of refraction, attenuation, reverberation, and channel propagation. Physical principles, detection systems used in design and operation of current sonar equipment. New developments in sonar. Experiments in acoustical measurements, transducer measurements, sound beam and sonar equipment measurements, and noise analysis. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics; NDRC Technical Summary: Principles of Underwater sound.* PREREQUISITE: Ph-421(B).

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 acoustic radiation from a piston. Radiation reaction. Loudspeaker. Classical and molecular absorption of sound in free space and in tubes. TEXT: KINSLER *and* FREY, *Fundamentals of Acoustics.* PREREQUISITE: Ma-113(B) or equivalent.

Ph-432(A) UNDERWATER ACOUSTICS AND SONAR SYSTEMS (4-3). A continuation of Ph-431(B). Microphone and sonar transducer theory and design. Transmission of sound in sea water, including problems of refraction, attenuation, reverberation, and channel propagation. Physical principles, electronic circuits, detection systems used in design and operation of current sonar equipment. New developments in sonar. Experiments in acoustical measurements, transducer measurements, sound beam and sonar equipment 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 (2-0). 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: Instructor's notes. PREREQUISITE: Ph-421(B) or 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;* AFSWP-Hirschfeller, *The Effects of Atomic Weapons.* PREREQUISITES: Ma-183(B) and Ph-142(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-421(B) or Ph-431(B).

Ph-450(B) UNDERWATER ACOUSTICS (3-2). An analytic treatment 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*. PREREQUISITE: Ma-102(C).

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-480(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, entropy, free energy, the 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(B) or Ma-183(B).

Ph-541(B) KINETIC THEORY AND STATISTICAL MECHANICS (4-0). Maxwell-Boltzman 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-610(C) SURVEY OF ATOMIC AND NUCLEAR PHYSICS (3-0). An introductory course in atomic and nuclear physics. Elementary charged particles, photoelectricity, x-rays, radioactivity, atomic structure, nuclear reactions, nuclear fission. TEXT: SEMAT, *Atomic Physics*.

Ph-620(B) ATOMIC PHYSICS (4-0). Theory of the structure of matter; kinetic theory, electrons as particles and waves, elementary quantum physics, interaction of fundamental particles, survey of nuclear behavior, atomic structure, x-rays and spectra, molecular structure, behavior of atoms in solids. TEXT: SPROULL, *Modern Physics*. PREREQUISITES: Ph-191(C) or equivalent.

Ph-640(B) ATOMIC PHYSICS (3-3). Elementary charged particles, photoelectricity, Bohr model of the hydrogen atom, optical and x-ray spectra, Zeeman effect, Compton effect, electron diffraction, special theory of relativity, Schroedinger's wave equation. Includes laboratory. TEXTS: FINKELNBURG, *Atomic Physics;* SEMAT, *Atomic Physics*. PREREQUISITES: Ph-142(B) and Ph-240(C).

Ph-642(B) NUCLEAR PHYSICS (4-3). Nuclear structure, radioactivity, nuclear reactions and nuclear fission. Includes laboratory. TEXTS: HALLIDAY, *Introductory Nuclear Physics;* KAPLAN, *Nuclear Physics;* BLEULER *and* GOLDSMITH, *Experimental Nucleonics*. PREREQUISITE: Ph-640(B).

Ph-644(A) ADVANCED NUCLEAR PHYSICS (4-3). A continuation of Ph-642(B). Nuclear forces; general theory of nuclear reactions. Application of theory to experiments. Includes laboratory. TEXTS: BLATT *and* WEISSKOPF, *Theoretical Nuclear Physics;* lecture notes. BLEULER *and* GOLDSMITH, *Experimental Nucleonics;* laboratory notes. PREREQUISITES: Ph-642(B) or equivalent, Ph-721(A).

Ph-650(A) GASEOUS DISCHARGES AND NUCLEAR INSTRUMENTS (4-0). Basic phenomena in gaseous discharges and infrared spectroscopy; theory of particle accelerators, spectrometers and detectors for nuclear reactions. TEXTS: VON ENGEL, *Ionized Gases;* RICHTMEYER *and* KENNARD, *Introduction to Modern Physics;* HALLIDAY, *Introductory Nuclear Physics;* Lecture notes. PREREQUISITE: Ph-642(B).

Ph-651(A) REACTOR THEORY (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-640(B) or Ph-660 (B), Ph-642(B), and Ma-113(B) or equivalent.

Ph-652(A) ADVANCED REACTOR THEORY (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-660(B) ATOMIC PHYSICS (4-3). Diffraction phenomena, charged particles, Rutherford's model of the atom and scattering of alpha particles, special theory of relativity, photoelectricity, Compton effect, Bohr model of the atom, optical spectra, Zeeman effects, x-rays, Moseley's Law. TEXT: SEMAT, *Atomic Physics*. PREREQUISITE: Ph-113 (B) or equivalent.

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-722(A) QUANTUM MECHANICS (4-0). A continuation of Ph-721(A). Treats perturbation theory, the Heisenberg formalism; quantum mechanics of many particle systems; interaction of matter with radiation and relativistic quantum theory. TEXT: SCHIFF, *Quantum Mechanics*. PREREQUISITE: Ph-721(A).

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 to 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-631(B) or Ph-640 (B).

Ph-724(A) 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*. PREREQUISITES: Ph-620(B) or equivalent.

Ph-730(A) 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) THEORETICAL PHYSICS (3-0). Topics in theoretical physics selected to meet the needs of the student.

Ph-750(L) PHYSICS SEMINAR (0-1). Discussion of special topics of current interest in the field of physics and student thesis reports.

UNITED STATES NAVAL
POSTGRADUATE SCHOOL

Catalogue for 1959-1960

THE GENERAL LINE AND NAVAL SCIENCE SCHOOL

MONTEREY ⋆ CALIFORNIA

An aerial view of Herrmann Hall. The wing to the right houses the General Line and Naval Sciences School

GENERAL LINE AND NAVAL SCIENCE SCHOOL

Director
ROBERT PARK BEEBE
Captain, U.S. Navy
B.S., USNA, 1931
A.M., Boston Univ., 1957
Naval War College, 1956
Naval War College, Advanced Study in Strategy and Sea Power, 1957

Assistant Director
JEFFERSON DAVID PARKER
Captain, U.S. Navy
B.S., USNA, 1935
Armed Forces Staff College, 1952; Naval War College, 1956

Academic Chairman
FRANK EMILIO LA CAUZA (1929)*
B.S., Harvard Univ., 1923
M.S., 1924; A.M., 1929
Captain, USNR

Administrative Officer
JIMMIE RUTH FRALIC
Lieutenant, U.S. Navy
B.S., Alabama Polytechnic Institute, 1949

Assistant to Director for Women
and
Assistant Administrative Officer
MARY JANE LINDERMAN
Lieutenant, U.S. Navy
A.B., Univ. of Pennsylvania, 1947

Scheduling Officer
GEORGE HALE GOLDSMITH
Commander, U.S. Navy
A.B., Univ. of Alabama, 1939
Air Command and Staff School, 1953

DEPARTMENT OF NAVAL WARFARE

JOSEPH EDWARD HART, Captain, U.S. Navy; Head of Department; B.S., Univ. of Akron, 1936; Naval War College, 1949, 1956.

LEROY PHILIP HUNT, JR., Lieutenant Colonel, U.S. Marine Corps; Marine Corps Representative and Instructor in Amphibious Operations; A.B., Colgate Univ., 1939; Marine Corps Schools, 1955.

WILLIAM ADDISON FABRICK, Commander, U.S. Navy; Prospective Instructor in Tactics and CIC. A.B., Univ. of California at Los Angeles.

WILLIAM ARNOLD, Commander, U.S. Navy; Instructor in Guided Missiles and Outer Space; B.S. Univ. of Kansas, 1940; Guided Missile School, Ft. Bliss, 1951.

FREDERICK ERNEST FRANCIS, Commander, U.S. Navy; Instructor in Operational Planning; A.B., Whittier College, 1939; USNPS, Applied Communication, 1950; Armed Forces Staff College, 1954.

LEE GEORGE MILLS, Commander, U.S. Navy; Head, Ordnance Section.

EDWARD GOODING GRANT, Commander, U.S. Navy; Instructor in Amphibious Operations; A.B., San Jose State College, 1940.

DONALD MARCHAND MILLER, Commander, U.S. Navy; Head, Tactics Section; B.S., USNA, 1943; Naval War College, 1956.

JOHN THOMAS LYONS, Lieutenant Commander, U.S. Navy; Instructor in Communications; NS&T, Univ. of Minnesota, 1944; USNPGS, Command Communications, 1953.

RICHARD LEE WARREN, Lieutenant Commander, U.S. Navy; Instructor in Naval Ordnance and Fire Control; B.S., USNA, 1944.

MARVIN JAY COOPER, Lieutenant Commander, U.S. Navy; Instructor in Restricted Weapons.

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

Richard Harmon Wilson, Lieutenant Commander, U.S. Navy; Instructor in ASW; B.S., USNA, 1945.

Otto Darby Tiderman, Lieutenant Commander, U.S. Navy; Instructor in Tactics and CIC; USNPGS, Command Communications, 1953.

Everton Paul Vosburgh, Jr., Lieutenant Commander, U.S. Navy; Instructor in ASW; B.S., USNA, 1945; B.S., USNPGS, 1953.

Walfred Neil Pentinmaki, Lieutenant Commander, U.S. Navy; Instructor in Mine Warfare; A.B., Univ. of Michigan, 1953.

Robert Eugene Weeks, Lieutenant Commander, U.S. Navy; Instructor in Communications; B.S., Massachusetts Institute of Technology, 1949.

Harry Wayne Morgan, Jr., Lieutenant, U.S. Navy; Instructor in Mine Warfare; B.S., USNA, 1949.

Thomas Covington Stephenson, Lieutenant, U.S. Navy; Instructor in Guided Missiles; B.S., Univ. of Tennessee, 1948.

Nobert Walter O'Neill, Lieutenant, U.S. Navy; Instructor in Guided Missiles.

DEPARTMENT OF SEAMANSHIP AND ADMINISTRATION

Sam Johnston Caldwell, Captain, U.S. Navy; Head of Department; B.S., USNA, 1939.

Harold Naylor Heisel, Commander, U.S. Navy; Asst. Head of Department; A.B., Texas Western College, 1936; Air Command and Staff School, 1951.

Hartsel Dale Allen, Commander, U.S. Navy; Instructor in Navigation; B.S., West Virginia Univ., 1939.

Verne Elmer Geissinger, Commander, U.S. Navy; Instructor in Personal Affairs; A.B., Univ. of Nebraska, 1940; Naval War College, 1953.

Richard Scott Garvey, Commander, U.S. Navy; Instructor in Leadership and Administration; A.A., Univ. of Kansas City, 1938.

Richard Rodriguez, Commander, U.S. Navy; Instructor in Navigation.

Thomas Carey Farrell, Commander, Supply Corps, U.S. Navy; Instructor in Logistics and Naval Supply; A.B., Tufts College, 1939.

Alton Printess Adams, Commander, U.S. Navy; Instructor in Leadership and Administration.

Thomas Howard Hardy, Commander, U.S. Navy; Instructor in Leadership and Administration.

William Louis Balestri, Commander, U.S. Navy; Instructor in Aerology; B.S., USNPGS, 1954.

William Henry Locklin, Commander, U.S. Navy; Instructor in Navigation; A.A., San Diego Jr. College, 1942.

Joseph Ogden Collins, Lieutenant Commander, U.S. Navy; Instructor in Naval Justice; B.S., Univ. of Pennsylvania, 1931; LL.B., Temple Univ., 1939;; LL.M., St. Johns Univ., 1959.

Daniel Donald McLeod, Lieutenant Commander, U.S. Navy, Instructor in Naval Justice; LL.B., Univ. of Arkansas, 1936.

Frank Chappell Daniel, Lieutenant Commander, U. S. Navy; Instructor in Seamanship.

Gerald Chatham Edwards, Lieutenant, U.S. Navy; Instructor in Naval Intelligence; A.B., Univ. of Southern California, 1948.

DEPARTMENT OF APPLIED ENGINEERING

John Vernon Wilson, Commander, U.S. Navy; Head of Department; B.S., USNA, 1939; M.S., Univ. of California at Los Angeles, 1948.

Arthur Major, Commander, U.S. Navy; Instructor in Marine Engineering; B.S., USNA, 1944; A.M., Stanford Univ., 1958.

John Sanborn Blake, Lieutenant Commander, U.S. Navy; Instructor in Damage Control; B.S., USNA, 1946.

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.

Charles Hamlin Black, Lieutenant Commander, U.S. Navy; Instructor in Marine Engineering; B.S., Univ. of South Carolina, 1947.

John Paul Peterson, Lieutenant Commander, U.S. Navy; Instructor in Damage Control.

Kenneth Ted Wallenius, Lieutenant, Junior Grade, U.S. Navy; Instructor in Mathematics; A.B., Univ. of Southern California, 1954; A.M., 1955.

Craig Comstock, Lieutenant, Junior Grade, U.S. Navy; Instructor in Mathematics; B.E.P., Cornell Univ., 1956.

James Roland Payne, Lieutenant, Junior Grade, U.S. Naval Reserve; Instructor in Mathematics; A.B., Univ. of California, 1954; A.M., 1955.

DEPARTMENT OF HUMANITIES

Robert Edward Paige, Commander, U.S. Navy; Head of Department; B.S., USNA, 1939.

Frank Wilson Avila, Commander, U.S. Naval Reserve; Instructor in International Relations; B.S., Univ. of California at Los Angeles, 1939.

Fordyce Raymond Downs, Jr., Commander, U.S. Navy; Instructor in International Law; LL.B., Boston Univ., 1943.

Emmett Francis O'Neil, Commander, U.S. Naval Reserve; Instructor in International Relations and National Security; A.B., Harvard Univ., 1931; A.M., Univ. of Michigan, 1932; Ph.D., 1941.

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.

Burton MacLynn Smith, Associate Professor of Speech, (1955); A.B., Univ. of Wisconsin, 1936, A.M., 1937.

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.

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.

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 Scicnce School are:

To provide instruction of about two-and-one-half years' duration leading to a Bachelor of Science Degree, no major designated, to meet the educational and career requirements of "transferee" and "integrated" 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 School. The Director's staff includes his administrative assistants, the Assistant Director, 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 Humanities.

The Academic Chairman of the General Line and Naval Science School provides academic supervision of 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.

BACHELOR OF SCIENCE CURRICULUM

The Bachelor of Science Curriculum includes the Naval-Professional courses of the General Line Curriculum (described below) and, in addition, sufficent coverage in the Social-Humanistic and Scientific-Engineering areas to adequately support a Bachelor of Science degree.

To be eligible for enrollment an officer must have acceptable advance standing of 75 term credit hours (equivalent to 45 semester hours) which can be applied toward completion of the prescribed course of study. From 1 to 2½ 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. Scheduling procedures are similar to those for the General Line Curriculum.

The Bachelor of Science Degree 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 advance standing, is required. A minimum of 4 terms in residence at the General Line and Naval Science School is also required.

All officers who have applied for the Five-Term College Program are considered. Careful consideration is given to previous academic records, service experience, and apparent promotion potential in order that the best qualified officers may be enrolled.

The Bachelor of Science Curriculum schedule is shown on page G-6. Students are required to complete the course listed there, or equivalents, either before admission to the currriculum or as a part of it. 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 advance credit has been allowed so as to fulfill the total term credit hour requirements.

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 774 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.

SPECIAL PROGRAMS

The courses offered by the General 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.

EXEMPTIONS FROM PROMOTION EXAMINATIONS

Satisfactory completion (grade "C" or higher) of certain courses offered by the General Line and Naval Science School (General Line Curriculum) is the basis for promotion examination exemptions, subject to the provision of BuPers Instruction 1416.1C. In scheduling officer students, the meeting of promotion examination requirements is not, however, a governing consideration. Primary emphasis is placed on officers pursuing courses which are most essential to their professional growth. BuPers Instruction 1416.1C or its successor may be consulted for detailed information on exemptions from promotion examinations.

TABULATION OF COURSE OFFERINGS AND COURSE DESCRIPTIONS

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 page G-11. Listed also are the courses given by the Engineering School which form a part of the General Line Curriculum.

BACHELOR OF SCIENCE CURRICULUM SCHEDULE

FIRST TERM

Ma-031 College Algebra and Trigonometry	5-0
Ch-001 General Chemistry I	4-3
HCA English Composition	3-0
OFC Naval Ordnance and Fire Control	3-0
HSP Introductory Speech	2-0
	17-3

SECOND TERM

OOP Operational Planning	3-0
Ch-002 General Chemistry II	3-3
Ma-051 Analytic Geometry and Calculus I	5-0
HHE Comparative Civilization I	4-0
HGP Group Procedures and Art of Presentation	4-0
	19-3

THIRD TERM

Ma-052 Analytic Geometry and Calculus II	5-0
Ph-011 General Physics I	4-3
HHS Comparative Civilization II	3-0
Mt-002 Materials of Engineering	4-3
	16-6

FOURTH TERM

Ma-053 Analytic Geometry and Calculus III	5-0
Ph-012 General Physics II	4-3
HHA Comparative Civilization III	3-0
OCM Communications	4-0
HSY Applied Psychology	2-0
	18-3

FIFTH TERM

ME-561 Engineering Mechanics I	4-0
Ph-013 General Physics III	3-3
SMA Management and Administration	4-2
SLO Logistics and Naval Supply	2-0
EGM Marine Engineering	5-0
	18-5

SIXTH TERM

ME-562 Engineering Mechanics II	4-0
OTC Tactics and CIC	4-2
EE-021 Electrical Circuits and Machinery I	5-3
SNA Navigation I	2-2
	15-7

SEVENTH TERM

HAD American Diplomacy	3-0
OAO Amphibious Operations	3-0
ORW Restricted Weapons	3-0
	9-0

EIGHTH TERM

Ph-014 Nucleonics	4-2
EE-022 Electrical Circuits and Machinery II	5-3
HEC Economics	3-0
OMW Mine Warfare	3-0
	15-5

NINTH TERM

Es-371 Electronics I	4-2
HIR International Relations	3-0
OAV Naval Aviation	3-0
EDC Damage Control and ABCD	4-0
OAS Anti-Submarine Warfare	4-0
	18-2

TENTH TERM

Es-372 Electronics II	4-2
SNB Navigation II	2-2
OMS Missiles and Space Operations	6-0
	12-4

Note 1: The above is for March input; for an August input, leave will occur during the 5th instead of the 7th term with a slight modification in the schedule.

Note 2: Courses designated by letters and numbers (e.g. Ma-031) are given by the Engineering School. Descriptions of these courses are contained in the Catalog of the Engineering School.

COURSE DESCRIPTIONS, PREREQUISITES, AND EXEMPTIONS

OTC TACTICS AND COMBAT INFORMATION CENTER (4-0). Shipboard tactical doctrine and procedures, and the functions and organization of CIC. USUAL BASIS FOR EXEMPTION: CIC school of 4 weeks or longer, or qualified as OOD and/or CIC officer.

OCM COMMUNICATIONS (4-0). Essentials of operational communications including doctrine, organization, radio and visual procedures, command responsibilities, postal administration, Registered Publications System, and Communications plans. USUAL BASIS FOR EXEMPTION: DD Communication Officer or completion of NavPers 10916, NavPers 10918, and CIC school (15½ wks).

OCA(W) COMMUNICATIONS I (W) (2-0). Special course for women officers. Procedures of the Naval Communication System encountered in a shore communication billet. Topics included are: the communications organization; its functions, instructions and reporting systems, station organization and files, message drafting, postal affairs, security of classified matter. USUAL BASIS FOR EXEMPTION: Appropriate experience in communication duties.

OCB(W) COMMUNICATIONS II (W) (2-0). Special course for women officers. Continuation of OCA(W). Topics included are: the duties and responsibilities of a registered publications custodian, communication planner and cryptographer; and familiarization with the basic publications required in such billets. PREREQUISITE: OCA (W) or exempt therefrom. USUAL BASIS FOR EXEMPTION: Appropriate experience in communication duties.

OAV(W) NAVAL AVIATION I (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. Foreign Officers excluded from this course but similar special modified course offered. USUAL BASIS FOR EXEMPTION: Extensive aviation duty.

OAA NAVAL AVIATION II (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. Foreign Officers excluded. 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.

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: Facilitiy 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 covering doctrine, fundamentals, planning, and current trends. PREREQUISITE: OOP (or exempt therefrom.) USUAL BASIS FOR EXEMPTION: Completion of an Amphibious Force school and/or duty in an amphibious command.

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 weapon systems. Coordinated ASW operations are emphasized. Foreign students are offered a modified course. PREREQUISITE: OTC (or exempt therefrom). USUAL BASIS FOR EXEMPTION: Completion since 1955 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). Basic principles of: explosives, naval gun, bomb, and rocket ammunition, shipboard and aircraft ordnance and fire control systems including fire control radar, computers and target designation systems. Foreign officers excluded from the regular course, but modified course is offered for them. USUAL BASIS FOR EXEMPTION: Completion of USNA, NROTC, or equivalent courses in naval ordnance and fire control and broad ordnance service experience.

OMW MINE WARFARE (3-0). Fundamentals of Mining Operations including mines, mine-laying agents and mining planning; principles of Mine Countermeasures Operations and Planning; new developments. USUAL BASIS FOR EXEMPTION: Formal Mine Warfare course of more than 3 weeks duration or duty on mine warfare staff.

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 AFSWP 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, operation capabilities and limitations of guided missile systems. Orientation in space technology, problems and potentialities of operations in outer space. Foreign students excluded. USUAL BASIS FOR EXEMPTION: Equivalent experience or educational background.

OHD HARBOR DEFENSE (2-0). Concept of and planning for Harbor Defense; equipments and techniques used; practical trainer problems.

SMN SEAMANSHIP (3-0). The fundamentals of seamanship as applicable to the duties performed and the responsibilities assigned the naval officer on board ship. Included topics: duties of the officer of the deck; the deck log; conning procedures alongside and in narrow channels; man overboard procedures; anchoring and mooring; replenishment at sea; cargo handling and stowage; rules of the nautical road.

SNA NAVIGATION I (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 the performance of chart work. USUAL BASIS FOR EXEMPTION: Successful completion of USNA, NROTC or equivalent course, and some practical experience in marine piloting; or previous assignment as navigator (assistant navigator of large ship) for one year.

SNB NAVIGATION II (2-2). 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 and air almanacs and the H.O. 214 and 249 series; the applications of celestial navigation. Practical work covers the navigator's day's work at sea. PREREQUISITE: SNA (or exempt therefrom). USUAL BASIS FOR EXEMPTION: Completion of USNA, NROTC or equivalent course in celestial navigation and some practical experience in celestial navigation; or previous assignment as navigator (assistant navigator of large ship) for one year.

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 AND ADMINISTRATION (4-2). 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 and discussion.

SLO LOGISTICS AND NAVAL SUPPLY (2-0). Naval logistics and its relationship to operational readiness. Included topics: types of logistics and elements of the logistics cycle; manpower, transportation and petroleum; The Naval Support System; funding; mobile logistics support; advanced base functional components; the commanding officer's responsibility for budgeting, allotment untilization and supply. USUAL BASIS FOR EXEMPTION: Completion of the entire Naval War College Course in Logistics.

SJA NAVAL JUSTICE I (3-0). The fundamentals of Naval Justice as included in the Uniform Code of Military Justice, The Manual for Courts-Martial and the Naval Supplement. Included topics: jurisdiction; preparation of charges and specifications; the rules of evidence; offenses usually triable by special courts-martial.

SJB NAVAL JUSTICE II (3-0). Applications of the fundamentals presented in SJA. Included topics: special courts-martial. Moot court trials are used to demonstrate briefs and instructions to the court; problems and procedures at mast; investigations; courts of inquiry; summary courst-martial. Moot court trials are used to demonstrate courts-martial procedures. PREREQUISITE: Completion of SJA or "Naval School of Justice" or correspondence course "Military Justice in the Navy (NavPers 10993)" with practical experience in court-martial work.

SNI NAVAL INTELLIGENCE (3-0). An overview of naval intelligence and the setting within which it functions. Included topics: nature of intelligence; role of intelligence in national policy and military strategic planning; intelligence aspects of psychological warfare; the intelligence cycle, including the line officer's role in intelligence collection; employment of naval intelligence by operational commanders; counter-intelligence.

SAF PERSONAL AFFAIRS (3-0). The fundamentals of life estate planning. Included topics: career planning; separation and retirement; government benefits; life insurance programming; general insurance; real estate; investments; wills and related legal matters. TEXT: COHEN *and* HANSON: *Personal Finance.*

EDC DAMAGE CONTROL AND ATOMIC BIOLOGICAL, CHEMICAL WARFARE DEFENSE (5-0. 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; passive defense ashore. PREREQUISITE: ENF (or exempt therefrom). USUAL BASIS FOR EXEMPTION: Completion of 10-week "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).

EGM MARINE ENGINEERING (5-0). Shipboard steam main propulsion plans and auxiliaries; gas turbines, diesel engines; shipboard electrical distribution; miscellaneous naval auxiliary machinery; organization and administration of shipboard engineering department. USUAL BASIS FOR EXEMPTION: Qualification as Engineering Officer of the Watch of a steam-propelled ship.

ENP MARINE NUCLEAR PROPULSION (2-0). Description of marine nuclear propulsion plants now in use and under development; reactor fuels and materials; reactor operation and control; application of reactors to propulsion. PREREQUISITES: EGM and ENF (or exempt therefrom).

HRE REMEDIAL ENGLISH (No credit). A review of English essentials. The course emphasizes reading speed and comprehension; English grammar, diction, and mechanics; sentence and paragraph structure; vocabulary building.

HCA ENGLISH COMPOSITION (3-0). Principles and practice in written communication of information. The course emphasizes investigative writing, exposition, persuasion, logic, and criticism. Students will prepare and present research papers.

HHE COMPARATIVE CIVILIZATIONS I: EUROPEAN (4-0).
HHS COMPARATIVE CIVILIZATIONS II: SLAVIC AND ISLAMIC (3-0).
HHA COMPARATIVE CIVILIZATIONS III: FAR EASTERN (3-0).
Comparative Civilizations I, II, and III include examination and analysis of the geographical determinants, the major religions, the systems of political thought, the continuity and changes in institutions, the nature of economic changes, and the colonial experiences as these are reflected in the literatures, arts, and philosophies of the peoples studied.

HAD AMERICAN DIPLOMACY (4-0). A survey of the major problems of United States foreign relations in Europe, Latin America, and the Far East from 1900 to the Korean conflict. Analysis of the constitutional problems of foreign relations, of diplomatic techniques, and of the international ideals and interests of the United States.

HSY APPLIED PSYCHOLOGY (2-0). A survey of principles underlying human behavior, with emphasis on the application of these principles to human relations. Topics include the nature and methods of scientific psychology, motivation, intelligent behavior, emotional behavior, personality, the measurement of aptitudes, learning, social problems, and problems of adjustment.

HEC ECONOMICS (3-0). A survey of basic laws of economic behavior and a comparative study of major economic systems, especially capitalism, socialism, and communism. The structure of the American economy and the principles of international economic relations are examined.

HGP GROUP PROCEDURES AND ART OF PRESENTATION (4-0). The course includes two units: (1) Survey and practice in deriving essential facts and thought from detailed, lengthy materials and effective presentation of such information in concise form; (2) Survey and practice of problem-solving through group procedures, including brief student conferences devoted to assigned problems.

HSP INTRODUCTORY SPEECH (2-0). A study of effective means of planning, organizing, and delivering speeches and of obtaining desired audience responses. Standard speech situations are examined, and speech characteristics of individual students are analyzed.

HIR INTERNATIONAL RELATIONS (3-0). A survey of contemporary political, economic, social, and cultural relations among nations, with emphasis on the interplay of communist and non-communist foreign policies, and upon an analysis of contemporary world problems. The course includes examination of the formulation and conduct of the foreign policies of the United States and other leading nations.

HIL INTERNATIONAL LAW (5-0). A survey of basic principles of international law, covering the historical background, scope, and sources of international law; "international persons"; treaty-making powers of the President and his authority as Commander-in-Chief; jurisdiction over territory, marginal seas, airspaces, and territorial waters; rules of land, aerial, and maritime warfare; discussion and solution of problems.

HNS NATIONAL SECURITY AND INTERNATIONAL ORGANIZATION (3-0). A study of factors of national power, components of national strategy, formulation of national security policy, the "Organization for National Security," analysis of the functions of the Executive, the National Security Council, the Departments of Defense and State, and the roles of the military services of the United States; and an examination of the organization and functions of the United Nations and other international agencies for peace and security.

GENERAL LINE CURRICULUM
TABULATION OF COURSE OFFERINGS BY DEPARTMENTS

Course Title	Short Title	Hours per Week Class	Lab.	Total Credit	Scheduling Classification for Men	for Women
			SEAMANSHIP AND ADMINISTRATION DEPARTMENT			
Seamanship	SMN	3	0	3	Elective	Elective
Navigation I	SNA	2	2	3	Exemptive	Inapplicable
Navigation II	SNB	2	2	3	Exemptive	Inapplicable
Meteorology	SME	3	0	3	Elective	Elective
Leadership and Administration . .	SLA	4	2	5	Exemptive	Exemptive
Logistics and Naval Supply . . .	SLO	2	0	2	*Elective	Exemptive
Naval Justice I	SJA	3	0	3	Elective	Exemptive
Naval Justice II	SJB	3	0	3	Elective	Exemptive
Naval Intelligence	SNI	3	0	3	Elective	Exemptive
Personal Affairs	SAF	3	0	3	Elective	Elective
			HUMANITIES DEPARTMENT			
English Composition	HCA	3	0	3)	These are prescribed courses in the Bachelor of Science Curriculum and are not a part of the General Line Curriculum.	
Comparative Civilization I . . .	HHE	4	0	4)		
Comparative Civilization II . . .	HHS	3	0	3)		
Comparative Civilization III . . .	HHA	3	0	3)		
American Diplomacy	HAD	3	0	3)		
Applied Psychology	HSY	2	0	2)		
Economics	HEC	3	0	3)		
International Relations	HIR	3	0	3	Elective	Exemptive
Group Procedures and Art of Presentation	HGP	4	0	4	Exemptive	Exemptive
Introductory Speech	HSP	2	0	2	*Elective	Elective
International Law	HIL	5	0	5	Elective	Exemptive
National Security and International Organization	HNS	3	0	3	Elective	Elective
			APPLIED ENGINEERING DEPARTMENT			
Marine Engineering	EGM	5	0	5	Exemptive	Inapplicable
Damage Control and ABCD . . .	EDC	5	0	5	Exemptive	Elective
Marine Nuclear Propulsion . . .	ENP	2	0	2	Elective	Inapplicable
			NAVAL WARFARE DEPARTMENT			
Tactics and Combat Information Center	OTC	4	2	5	Exemptive	Inapplicable
Communications	OCM	4	0	4	Exemptive	Inapplicable
Communications I (W)	OCA(W)	2	0	2	Inapplicable	Exemptive
Communications II (W)	OCB(W)	2	0	2	Inapplicable	Exemptive
Naval Aviation I	OAV(W)	3	0	3	Exemptive	Elective
Naval Aviation II	OAA	3	0	3	Exemptive	Inapplicable
Operational Planning	OOP	3	0	3	Exemptive	Elective
Amphibious Operations	OAO	3	0	3	Exemptive	Inapplicable
Anti-Submarine Warfare	OAS	4	0	4	Exemptive	Inapplicable
Advanced Tactics	OAT	3	0	3	Elective	Inapplicable
Naval Ordnance and Fire Control .	OFC	3	0	3	Exemptive	Inapplicable
Mine Warfare	OMW	3	0	3	Exemptive	Inapplicable
Restricted Weapons	ORW	3	0	3	Exemptive	Inapplicable
Missiles and Space Operations . .	OMS	6	0	6	Exemptive	Inapplicable
Harbor Defense	OHD	2	0	2	Elective	Elective

* *Exemptive for Bachelor of Science Curriculum only.*

The following courses offered by the Engineering School are included in the General Line Curriculum but not in the Bachelor of Science Curriculum, and are described in the Engineering School section of the Catalog:

Course Title	Short Title	Hours per Week Class	Lab.	Total Credit	Scheduling Classification for Men	for Women
Basic Algebra and Trigonometry I .	Ma-010	3	0	3	Exemptive	Inapplicable
Basic Algebra and Trigonometry II .	Ma-011	3	0	3	Elective	Inapplicable
Algebra and Trigonometry Refresher	Ma-015	3	0	3	Exemptive	Inapplicable
Survey of Analytic Geometry and Calculus	Ma-050	4	0	4	Elective	Inapplicable
Survey of Physics I	Ph-192	3	0	3	Exemptive	Inapplicable
Survey of Physics II	Ph-193	3	0	3	Exemptive	Inapplicable
Materials of Engineering	Mt-001	4	0	4	Elective	Inapplicable
Electrical Fundamentals	EE-011	4	0	4	Exemptive	Inapplicable
Electrical Machinery	EE-012	4	1	4½	Elective	Inapplicable
Nucleonics Fundamentals	Ph-690	3	0	3	Exemptive	Elective
Electronics Fundamentals	Es-376	4	0	4	Exemptive	Inapplicable

UNITED STATES NAVAL

POSTGRADUATE SCHOOL

Catalogue for 1959-1960

THE MANAGEMENT SCHOOL

MONTEREY ★ CALIFORNIA

Root Hall. This building contains the Navy Management School, the Reference and Research Library, and some of the offices of the Engineering School.

THE MANAGEMENT SCHOOL

Director

THOMAS LOUIS CONROY
Captain, U.S. Navy
B.S., Rhode Island State College, 1937
M.B.A., George Washington Univ., 1955

Assistant Director

HERBERT HENRY ANDERSON
Captain, U.S. Navy
B.S., USNA, 1941
M.B.A., Harvard Univ. 1953

Administrative Officer

KATHRYN DOUGHERTY
Commander, U.S. Navy
A.B., Iowa State Teachers College, 1932
A.M., Stanford Univ., 1952

Academic Chairman

WILLIAM HOWARD CHURCH
(1956)*
A.B., Whittier College, 1933
M.S.P.A., Univ. of Southern California, 1941

APPLIED MANAGEMENT DEPARTMENT

WILLIAM HOWARD CHURCH, Head of Department (1956)*; Professor of Management; A.B., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941.

HERBERT HENRY ANDERSON, Captain, U.S. Navy; Associate Professor of Management; B.S., USNA, 1941; M.B.A., Harvard Univ. 1953.

HERMAN PAUL ECKER, Professor of Management (1957); A.B., Pomona College, 1948; A.M., Claremont Graduate School, 1949.

FINANCIAL MANAGEMENT DEPARTMENT

ALFRED PAUL BOILEAU, Commander, SC, U.S. Navy; Head of Department; Associate Professor of Management; B.S., Pennsylvania State Univ., 1941; A.M., George Washington Univ., 1954.

JACOB HUGH JACKSON, JR., Professor of Management (1957); A.B., Stanford Univ., 1939; M.B.A., 1947.

INDUSTRIAL MANAGEMENT DEPARTMENT

JOHN DAVID SENGER, Head of Department; Associate Professor of Management (1957); B.S., Univ. of Illinois, 1945; M.S., 1948.

EDWARD LESLIE MACCORDY, Lieutenant Commander, CEC, U.S. Navy; Associate Professor of Management; B.S., Tufts College, 1947; M.S., Rensselaer Polytechnic Institute, 1957.

MATERIAL MANAGEMENT DEPARTMENT

HENRY SOLOMAN NISBET, JR., Commander, SC, U.S. Navy; Head of Department; Assistant Professor of Management; B.S., Univ. of California, 1941.

JAMES EDWARD RAYNES, Commander, SC, U.S. Navy; Associate Professor of Management; A.B., Stanford Univ., 1939; A.M., 1947.

WAINO W. SUOJANEN, Associate Professor of Management (1959); B.S., Univ. of Vermont, 1942; M.B.A., Harvard Univ., 1946; Ph.D., Univ. of California, 1955.

*date in parenthesis indicates year of joining the Postgraduate School faculty.

GENERAL INFORMATION

Mission

The mission of the Navy Management School is to provide executive development education at the postgraduate level for naval officers in order that they may function more effectively in the performance of their assigned duties. The broadening of the mental outlook and resultant increase in professional knowledge will enable officers to better meet the responsibilities and complexities of higher grade and thereby improve the efficiency and combat effectiveness of the Navy.

Tasks

The tasks assigned the Navy Management School are:

1. To conduct an educational program for naval officers, with from twelve to sixteen years experience, in procedures of analysis and philosophy which will lead to sound executive decisions and improved administrative achievements. Officers are to acquire a firm knowledge of the guiding principles and procedures characterizing successfully managed organizations. Individual growth, problem solving ability and initiative are to be fostered.

2. To conduct a basic course for naval officers with limited experience in the Elements of Management and Industrial Engineering which will acquaint the officers with (a) the principles of good industrial management, methods and administration; (b) the industrial problems and their general means of solution; (c) the practices of industrial activities sufficient to establish ability to provide liaison between the service and industry; (d) the ability to introduce into government installations on a limited scale the good industrial practices.

3. To act as a host for Bureau and Office sponsored executive development programs and management workshop seminars.

THE PROGRAM OF EDUCATION

The Navy Management Course

The Navy Management Course is a five month course in Executive Development offered twice a year commencing in August and January. In the conduct of this course officers, under the direction of a skilled civilian and military faculty, will:

1. Acquire a common understanding of the operation of the naval establishment, ashore and afloat, and analyze these operations in the light of sound principles and methods and thus isolate the Navy's salient executive problem areas.

2. Be educated in the methods, principles and techniques employed by successfully managed organizations in solving similar problems.

3. Be broadened, in the executive area, by "academically" improving the management of the Navy by the application of these proven methods and principles.

The course is presented in a manner designed to broaden the Naval executive's mind and intellectual curiosity, as well as his ability to present ideas. During the five month period the officer will be educated in the classroom by the faculty and by civilian and military executives of his own experience level. He will be exposed to authorities of American Management, in special lecture and discussion periods presented by civilians and military officers of the Vice-Presidential or Flag level. He will visit civilian and military installations and discuss the problems of management with executives in their own environment. Throughout this experience he will be called upon to develop his ability to express himself in oral and written presentations, and thus to prepare himself to introduce into the naval service the ideas which he has learned, through persuasion of others.

As a requirement for the certificate of completion of this course, officers are assigned to write a paper in which a salient problem facing Naval executives is analyzed and a solution evolved. These papers are transmitted to appropriate offices or activities of the Naval Establishment if, in the opinion of the faculty, they are significant as a contribution to the better administration of the Navy. Naval activities are encouraged to inform the Management School of their executive problems in order to assist in the assignment of these projects to officers under instruction.

Officers assigned to this course should possess a baccalaureate degree and be of such caliber that they have already demonstrated a high degree of professional competence and capacity for growth.

The Course "Elements of Management and Industrial Engineering"

This course is a six week course, presented once a year in June and July. It is a basic course in Executive Development, 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 afternoon workshop seminars.

The course of education is designed to acquaint the officers with:

1. The principles of good management methods and administration, with emphasis on their application to the naval establishment.

2. Problems of the naval establishment and general approaches to the solutions of these problems.

3. Organizational and management practices of naval and civilian activities, with emphasis on developing limited ability to incorporate sound and effective practices into naval activities.

No special preparation or qualification for this course is required.

Training Programs and Workshop Seminars

In conjunction with the aforementioned program, the 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 admirable base upon which to further discussion of special problems. The extent of the Postgraduate School's activity in this program is limited to providing classroom space for the program.

TABLE I

NAVY MANAGEMENT CURRICULUM (5 MONTHS)

No.	*Course Title*	*Class Contact Hours**
	Applied Management	
Mn-341	Organization and Management	27
Mn-342	Human Relations	18
Mn-343	Advanced Management Seminar	54
Mn-344	Management Economics	12
Mn-345	Personnel Administration/Industrial Relations	18
Mn-301	Management Statistics	12
Mn-472	Integrated Data Processing Systems/Operations Research	16
	FINANCIAL MANAGEMENT	
Mn-303	Managerial Accounting and Auditing	27
Mn-304	Budgeting and Comptrollership	27
	MATERIAL MANAGEMENT	
Mn-351	Material Planning, Inventory and Distribution	45
#Mn-353	Supply Management Seminar	54
Mn-354	Procurement and Contract Administration	27
	INDUSTRIAL MANAGEMENT	
Mn-346	Production Planning and Control	24
Mn-347	Work Measurement/Work Simplification	20

*This time indicates only contact time in classroom and is not indicative of total time spent by the student on the subject.

#All officers receive the same course of education with the exception that Supply Officers are required to take "Supply Management Seminar" in addition to the regular course.

TABLE II

COURSE "ELEMENTS OF MANAGEMENT AND INDUSTRIAL ENGINEERING" (Six Weeks)

Course Content	*Total Hours*
Principles of Organization and Management	15
Work Measurement, Work Simplification, Value Engineering	15
Financial Management	15
Contract Administration	15
Personnel Management	15
Production Planning and Control	15

TRAINING COURSES AND WORKSHOP SEMINARS

As prepared and presented by sponsoring Bureaus and Offices

COURSE DESCRIPTIONS

Mn-301 MANAGEMENT STATISTICS (12 hours)

Objective—To create an understanding of the strengths and weaknesses of the utilization of statistics in the Naval executive's decision making.

Description—This course develops the general concepts of probability and frequency distribution, and outlines the application of these concepts in the various fields of management. Measures of central tendency and dispersion are introduced. The technical problems of sampling are considered briefly. Practical problems involving Time Series Analysis, Correlation, and Programming are worked out. The methods of presenting ideas and facts by statistical tables and charts and their oral or written accompaniment are considered.

Mn-303 MANAGERIAL ACCOUNTING AND AUDITING (27 hours)

Objective—To present to the Naval executive the principles of sound fiscal management and their applications.

Description—Introduces fundamental accounting concepts as recognized in private enterprise; concepts of governmental accounting as they are practiced in the Navy; encourages constructive criticism of principles; examines practices of Navy Industrial Fund accounting; seeks to promote an understanding of Navy management use of accounting. Examines the basic principles of internal control, internal auditing, and the Navy audit programs.

Mn-304 BUDGETING AND COMPTROLLERSHIP (27 hours)

Objective—To create within the Naval executive an understanding of the principles of comptrollership, programming, budget formulation, justification and execution, as exemplified in government and private enterprise.

Description—Portrays the relationship of Navy budgeting to the national economy and fiscal policy, the development of the budget process, the agencies influencing the process, the terminology of budgeting, concepts of performance budgets, estimating and justifying Navy budgets, the relationship of plans to budgets, budget cycles, review levels and methods, Congressional actions and influences, nature of appropriations, apportionment, allocations, administrative control of funds, reporting, probable changes in base of appropriations and budgeting. Examines the function of a comptroller and his relations to other echelons of command.

Mn-341 ORGANIZATION AND MANAGEMENT (27 hours)

Objective—To provide the Naval executive with understanding and solution of problems faced by military executives and to educate officers in the criteria and principles of management which have characterized the most successful organizations in a competitive economy. To stimulate permanent interest in the application of scientific management techniques to effect management improvements in the economic and efficient operation of the Naval Establishment.

Description—Particular attention is paid to the type of criteria that could be used to evaluate organizational effectiveness. Emphasis is placed upon organizational purposes and objectives; policies and policy development; planning;

problems of centralization versus decentralization; work delegation and the granting of authority commensurate with responsibility; single manager concepts; work organization procedures; administrative, operational and personnel management criteria; budgetary and fiscal objectives; office methods; management problem solving techniques; public relations, internal and external. Selected case studies are used to enable officers to utilize their diversified experience backgrounds in the solution or examination of typical problems faced by executives in the Naval Establishment.

Mn-342 HUMAN RELATIONS (18 hours)

Objective—To emphasize to the Naval executive the need for observing and utilizing those management philosophies, practices, and techniques which produce high esprit de corps and leadership within any competitive working group and which are the hallmark of the successful executive leader in both business and government.

Description—Emphasis is placed on the type of information the executive needs in order to promote motivation for people to work together effectively in the achievment of worthy goals. This course focuses more on group problems and the individual in relation to a group rather than on the individual or the job. It seeks to provide basic answers to the reasons why people in organized work groups act the way they do under certain conditions so that this understanding may be used in the creation of a climate for effective management throughout the whole of Naval operations.

Mn-343 ADVANCED MANAGEMENT SEMINAR (54 hours)

Objective—To educate the Naval executive in the philosophies and principles followed by leading military and civilian authorities. To develop the executive's thought processes through written and oral presentations of problems facing the top level Naval executives and the solutions thereto.

Description—Leading military and civilian authorities address the officers and discuss their problems in an off-the-record, informal atmosphere. Officers visit military and civilian activities, view the salient operations and thereafter discuss the administration of the activity with the key executives. These experiences are discussed in oral presentations in the classroom, with the objective of analyzing the effect upon the Naval Establishment of adopting new methods and principles learned. As a requirement for completion of the course, each student is required to make a written presentation of a salient problem facing high level Naval executives, analyze this problem by sound logic in the light of principles and methods learned throughout the course of education, and arrive at a recommended solution.

Mn-344 MANAGEMENT ECONOMICS (12 hours)

Objective—To educate the Naval executive in the impact of the military expenditures on the total economy. To emphasize the reasons for conservation of our vital resources and provide a foundation for better evaluation of financial trends as related to military budget responsibilities.

Description—This course concentrates on the problems of economic growth, stability and freedom. The basic economic institutions are discussed in light of these problems. The role of the Naval executive in economic decision making is emphasized. Specific areas covered are: National Income Accounting, Money and Banking, Business Cycles, Big Business, Government Influence, Labor, International Economics, and the Economics of Mobilization and Defense.

Mn-345 PERSONNEL ADMINISTRATION/INDUSTRIAL RELATIONS (18 hours)

Objective—To provide the Naval executive with basic information on the best and most applicable personnel principles and methods in use by business and government which may be utilized under current policy and regulations; to promote harmonious interpersonal relationships in work situations which require operating under both a military personnel system and a civilian personnel system.

Description—Manpower management problems are discussed as they pertain to both Bureaus and Offices of the Navy Department and to the Fleet and Field Establishment. Sufficient detail is presented to enable the officer to utilize both civilian and military personnel systems to the best advantage of the service and the national interest.

Mn-346 PRODUCTION PLANNING AND CONTROL (24 hours)

Objective—To educate the Naval executive in the three basic elements of production: organizing, planning and control.

Description—The officer student examines the functions of production controls, production planning and the techniques involved in each of these. The process for analyzing manufacturing techniques and machine capacity are studied. Basic operating procedures for control, including orders, routing, scheduling and dispatching are discussed. The coordination process is presented, emphasizing related activities of departments in order that they might bring about the desired production results in terms of quality, quantity, time and place.

Mn-347 WORK MEASUREMENT/WORK SIMPLIFICATION (20 hours)

Objective—To educate the Naval executive in the development and application of work measurement standards, and with the concepts of work simplification so that they may more effectively administer the activity under their jurisdiction.

Description—This course will present the timing and sampling techniques by which work is measured. The application of these standard times for the purpose of evaluation and control will be studied. The analytical approach to problem solving for the purpose of simplifying work and improving methods successfully will be presented. Applications of these principles to Navy situations will be studied and problems for student solution will be included.

Mn-351 MATERIAL PLANNING, INVENTORY AND DISTRIBUTION (45 hours)

Objective—To educate Naval executives in the areas of requirements planning, inventory control and distribution management for which they will be responsible.

Description—This course educates the Naval executive in the administrative aspects of logistics planning, focuses his attention on the problems of inventory management and the distribution of material required to support the Fleet and its programs.

Mn-353 SUPPLY MANAGEMENT SEMINAR
(54 hours)

Objective—To increase the executive capacities and skills of Supply Officers through utilization of the individual officer's experiences while discussing the nature of inventory management and considering current developments and difficulties in Fleet support. An important objective of the course is to acquaint future senior Supply Officers with the administrative technical aspects of supply administration and the duties they will assume in the Bureau, Field Activities and the Fleet.

Description—The following topics are discussed in oral presentation or case study discussion:

The history of the Navy Supply Plan and its implementation—The Material Missions and the Program Support—Supply Support responsibilities (computation of requirements, distribution) of Supply Demand Control Points—The Problems of inter-SDCP Supply Support—The policy and coordiination control over the Navy Supply System as exercised by Congress, the Department of Defense, SecNav, CNO, and Bureaus of the Navy Department, Federal Cataloging Standardization Programs—The Single Purchase Service Assignments—Examination of the problems of Fleet support—The Fleet stockage and supply policy—Atlantic Fleet and Pacific Fleet Air Cargo tests—Allowance lists and load lists—Support of new construction, conversion, Ship alterations and overhauls—Determination of methods of supply; centralized vs. decentralized procurement; direct delivery to user vs. depot supply; procurement vs. redistribution; inventory stockage policy; use of formula to determine optimum operating and safety levels of supply; collection, interpretation and projection of demand date; planned requirements; Mobilization Reserve Requirements; economic order and economic retention policies; fractionation of inventories; stratification; redistribution of excess stocks and disposal of surplus stocks.

Mn-354 PROCUREMENT/CONTRACT ADMINISTRATION (27 hours)

Objective—To present the aspects of good contract administration and procurement through supervised analysis.

Description—This course directs attention to organization and policy for procurement and to the elements of effective contract administration by illustrating the close cooperation required between Bureau and field personnel. It discusses the factors affecting the above relationship, the significance of various contract types, the process of selecting and evaluating contractors and the process of evaluating and insuring the progress of the contractor. Pricing, regulations for government assistance, approval, amending or changing the contract and terminations and endings of contracts are discussed.

Mn-472 INTEGRATED DATA PROCESSING SYSTEMS/OPERATIONS RESEARCH (16 hours)

Objective—To acquaint the officer student with the potential and limitations of Integrated Data Processing Systems and Operations Research methods of analysis and their applications to management control.

Description—This course includes the study and analysis of Integrated Data Processing Systems in the solution of management problems. An analysis is made of Operations Research as an aid to decision making.

Spanagel and King Halls. The building to the left houses the Engineering School; the one on the right is the auditorium.

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

(*GROUP ZKM*)
At University of Michigan

(*GROUP ZKS*)
At Stanford University

OBJECTIVE — A curriculum consisting generally of courses in the fields of finance, business organization, marketing, statistics, public relations, administrative practices, and geography. The one-year curriculum at the University of Michigan is for advanced students. The curricula at Harvard and Stanford Universities are of two-year duration. The summer between academic years is spent in individual assignments with industrial companies.

CIVIL ENGINEERING ADVANCED

(*GROUP ZGL*)

ELECTRICAL ENGINEERING

At Rensselaer Polytechnic Institute

OBJECTIVE—To provide advanced education for selected CEC officers in Electrical Engineering with emphasis on power plants, and Electrical Utility distribution.

SUMMER TERM

11.05 Engineering Mathematics (*review*).
7.03 Circuit Theory I (*special course taken with cooperative program students, June* 10 *thru June* 26 - 7 - ½ *contact hours per week*).
7.60 Electrical Machines Theory.
or
7.40 Electronics I (*July* 29 *thru Sept.* 30, *special program with cooperative students* - 7 - ½ *contact hours per week*).

FALL TERM	CREDITS
T7.73 Motor Characteristics & Control	3
G7.15 Network Theory I	3
G7.99 Thesis	3
*G7.xx Electrical Engineering Elective (*Major*)	3
**TorG Elective	3
	15

*G7.xx Electrical Engineering Electives (*Major-Fall Term*) 3
a) G7.13 Advanced Industrial Electronics
b) G7.04 Symmetrical Components
**TorG Electives (*Fall Term*) 3
a) T11.12 Advanced Calculus (*required if not taken in summer term*)
b) TorG Mechanical Engineering Course
c) T7.13 Response of Physical Systems
d) Illumination Engineering (*no credit toward degree*)
e) Either G7.13 or G7.04 above

SPRING TERM	
G7.23 Advanced Electricity & Magnetism	3
G7.99 Thesis	3
T7.65 Power Systems	3
***G7.xx Electrical Engineering Elective (*Major*)	3
****TorG Elective	3
	15

***G7.xx Electrical Engineering Elective (Major-Spring Term) 3
a) G7.01 Power Systems Stability
b) G7.06 Advanced Electrical Machines
c) G7.08 Power Plant Design (CEC) (*concurrently with G*12.48 *Power Plant Design* (*CEC*)
d) G7.16 Network Theory II

****TorG Elective (Spring Term)
a) T7.46 Feedback Control Engineering
b) T or G Mechanical Engineering Course
c) Any one of (a), (b), (c) (d) of ***G7.xx above.

The program is to lead to a Master of Electrical Engineering Degree. Other electives compatible with degree requirements may be required to meet schedule conflicts.

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.

SUMMER TERM	CREDITS
11.05 Engineering Mathematics	
12.31 Heat Engineering (*to be extended beyond the scope of the normal graduate course*)	
FALL TERM	
T11.12 Advanced Calculus	
or	
T11.13 Differential Equations	3
T12.44 Industrial Air Conditioning	4
G12.33 Heat Engineering	3
G12.91 Selected Topics ME (Power Plant Design)	3
G12.92 Analysis of ME Problems	3
SPRING TERM	
G12.45 Air Conditioning	3
G12.31 Heat Transfer	3
G12.66 Industrial Regulators	3
G12.99 Thesis	6

The program is to lead to a Master of Mechanical Engineering degree. Electives compatible with degree requirements may be required to meet scheduling conflicts.

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 (N)				
Electrical Engineering	ZGL	1 yr.	RPI	CO, NROTC
Mechanical Engineering	ZGH	1 yr.	RPI	CO, NROTC
Sanitary Engineering	ZGM	1 yr.	Michigan	CO, NROTC
Soil Mechanics and Foundations	ZGR	1 yr.	RPI	CO, NROTC
Structures	ZGI	1 yr.	Illinois	CO, NROTC
Waterfront Facilities	ZGP	1 yr.	Princeton	CO, NROTC
Civil Engineering, Qualification (E)	ZGQ	17 mos.	RPI	CO, NROTC
Comptrollership (M)	ZS	1 yr.	Geo. Washington	Prof. A. R. Johnson
Hydrographic Engineering (R)	ZV	2 yrs.	Ohio State & USN Hydro. Off.	CO, NROTC
Industrial Management (M)	ZMP	1 yr.	Purdue	CO, NROTC
Judge Advocate Officers (E)				
Advanced Course	ZHV	9 mos.	U. of Virginia	CO, NROTC
Management & Industrial Engineering (M)	ZT	1 yr.	RPI	CO, NROTC
Metallurgical Engineering (N)	ZNM	9 mos.	Carnegie Tech.	Rear Adm. R.H. Lambert, USN, Ret.
Naval Architecture (N)	ZNA	9 mos.	U. of Calif.	CO, NROTC
Naval Construction and Engineering (N)	ZNB	3 yrs.	MIT	CO,Nav.Admin.Unit
		3 yrs.	Webb Inst.	Capt. R. A. Hinners USN, Ret.
Naval Intelligence (S)	ZI	9 mos.	USN Intel. Scol, Win, D.C.	Dir, USN Intelligence School
Nuclear Engineering (N)	ZNE	15 mos.	MIT	CO,Nav.Admin.Unit
Oceanography (R)	ZO	2 yrs.	U. of Wash. & USN Hydro. Off.	CO, NROTC
Personnel Administration & Training (E)	ZP	1 yr.	Stanford	CO, NROTC
Petroleum Administration & Management (E)	ZHS	1 yr.	SMU	Senior Student
Petroleum Engineering (N)	ZL	2 yrs.	Pittsburgh	Prof. H.G. Botset
Petroleum Management (M)	ZMK	1 yr.	Kansas	CO, NROTC
Religion (E)	ZU	1 yr.	Various	———
Retailing (M)	ZMG	1 yr.	Pittsburgh	CO, NROTC
Social Science (E)	ZST	2 yrs.	Tufts	CO, NROTC
		2 yrs.	Stanford	CO, NROTC
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) *Administrative Officer, Engineering School*
(M) *Director, Management School*
(N) *Officer-in-Charge, Naval Engineering*
(R) *Officer-in-Charge Meteorology*
(S) *Staff Secretary, Superintendents Office*

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.

SUMMER TERM

CE120 Fundamentals of Experimental Research
CE152 Water Purification and Treatment
CE131 Cost Analysis and Estimating

FALL TERM

BACT109 Bacteriology for Engineers
CE153 Sewerage and Sewage Disposal
CE155 Environmental Sanitation
EH260 Sanitary Chemistry
EH264 Stream Sanitation

SPRING TERM

CE157 Industrial Waste Treatment
CE250 Sanitary Engineering Research
CE254 Advanced Sanitary Engineering Design
CE255 Sanitary Engineering Seminar
EH265 Advanced Stream Sanitation
NE190 Elements of Nuclear Engineering
or
EH228 Radiological Health

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

Soil Mechanics and Foundations
(*GROUP ZGR*)
At Rensselaer Polytechnic Institute

Objective—To provide advanced technical education for selected CEC officers in the field of soil mechanics & foundations.

SUMMER TERM

11.25 Engineering Mathematics
10.11 Engineering Geology
Soil Mechanics & Foundations Refresher

FALL TERM

11.41 Advanced Calculus
10.12 Advanced Engineering Geology
G5.30 Soil Mechanics I
G5.32 Foundation Engineering I
G5.87 Prestressed Concrete
G5.37 Soil Mechanics III

SPRING TERM

G5.31 Soil Mechanics II
G5.33 Foundation Engineering II
T5.25 Hydrology
G5.82 Shipbuilding and Ship Repair Facilities (CEC)
G5.36 Soil Mechanics Seminar
G5.49 Thesis

This Curriculum affords the opportunity to qualify for the degree of Master of Civil Engineering.

Structures
(*GROUP ZGI*)
At the University of Illinois

Objective — To provide advanced technical instruction for selected CEC officers in the field of structural design.

FIRST SUMMER

Math 343 Advanced Calculus
CE461 Structural Theory and Design
CE493 Special Problems

FALL SEMESTER

CE481 Numerical and Approx. Methods of Structural Analysis
CE486 Investigations in Reinforced Concrete Members
CE493 Special Problems
CE461 Structural Theory and Design
CE373 Int. to Soil Mechanics
TAM421 Mechanics of Materials
TAM461 Inelastic Behavior of Eng. Materials

SPRING SEMESTER

CE482 Buckling, Vibrations and Impact
CE484 Behavior of Structures under Dynamic Load
CE467 Investigations in Reinforced Concrete Members
CE493 Special Problems
CE374 Applied Soil Mechanics
TAM462 Inelastic Behavior of Eng. Materials

The student selects courses from those tabulated above to suit his background needs and to carry the normal load of five units per term.

SECOND SUMMER

CE462 Structural Theory and Design
CE491 Thesis
TAM424 Properties of Eng. Materials

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

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.

SUMMER TERM

Mathematics
Strength of Materials
Reinforced Concrete
Fluid Mechanics
Soil Mechanics

FALL TERM

CE505 Advanced Structures
CE511 Waterfront Structures
CE513 Port and Harbor Engineering. Research preparatory to the writing of the thesis

One elective from the following group:

CE501 Soil Stablization
ME531 Applied Elasticity
ME525 Industrial Management
SOC 544 Urban Sociology

SPRING TERM

CE512 Waterfront Structures

Thesis

Two electives from the following group:

CE502 Soil Mechanics

CE504 Municipal Engineering

CE508 Soil Physics

POLITICS 512 Public Administration

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

CIVIL ENGINEERING (Qualification)

(*GROUP ZGQ*)

At Rensselaer Polytechnic Institute

OBJECTIVE — A seventeen-month curriculum, to qualify officers for civil engineering duties. Successful completion of this course normally leads to a degree of Bachelor of Science in Civil Engineering. At present this is the only program for line officers transfering to Civil Engineering Corps.

Refresher Period 8 weeks

T11.90 Numerical Methods for Engineers

17.05 Mechanics and Strength of Materials (CEC) (Refresher)

5.08 Surveying, Curves and Earthwork (CEC)

SUMMER SESSION

5.76 Structural Analysis I

5.78 Reinforced Concrete I

10.11 Engineering Geology

FALL TERM

T5.24 Construction Methods and Estimates

5.09 Contracts and Specifications

5.15 Highways and Airports (CEC)

5.75 Building Construction

5.77 Structural Design I

5.80 Structural Analysis and Design II

7.72 Utilization of Electrical Energy in Naval Establisment (CEC)

SPRING TERM

2.60 City Planning Principles

5.32 Soil Mechanics (CEC)

5.79 Reinforced Concrete II

T5.82 Indeterminate Structures I

12.42 Heating and Ventilation (CEC)

13.541 Metallurgy and Welding (CEC)

T16.60 Physics of Nuclear Reactors

SECOND SUMMER SESSION

5.59 Sanitary Engineering

7.69 Power Plants (CEC) Electrical Engineering

12.48 Power Plant (CEC) Mechanical Engineering

5.35 Foundation Engineering (CEC)

This curriculum affords the opportunity to qualify for the degree of Bachelor of Civil Engineering.

COMPTROLLERSHIP

(*GROUP ZS*)

At George Washington University

OBJECTIVE — To develop in officers of mature judgement 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 comptroller duties as a normal preparation for command and executive billets in the shore establishment.

HYDROGRAPHIC ENGINEERING

(*GROUP ZV*)

At Ohio State University and USN Hydrographic Office

OBJECTIVE — A two-year course in Hydrographic Engineering to prepare officers for assignment to duties at the Hydrographic Office, on hydrographic 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

At Purdue University

Intial input, September, 1959; descriptive data not yet available.

JUDGE ADVOCATE OFFICERS ADVANCED COURSE

(*GROUP ZHV*)

At JAG's School (Army), Charlottesville, Virginia

OBJECTIVE — A nine months' 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 interest to, the military Departments, including claims, civil 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.

METALLURGICAL ENGINEERING

(*GROUP ZNM*)

At Carnegie Institute of Technology

OBJECTIVE—To obtain the maximum possible metallurgical background in a nine-month program designed specifically for the graduate of the Naval Construction and Engineering Curriculum.

Fall Semester

E611 Physical Metallurgy
E641 Ferrous Metallurgy
E645 Metallography Lab.
E647 Non-Ferrous Metallography
E651 Mechanical Metallurgy
E661 Modern Metallurgical Practice
S125 Physical Chemistry
S291 Statistical Quality Control

Spring Semester

E612 Physical Metallurgy
E642 Ferrous Metallography
E646 Metallography Lab.
E648 Non-Ferrous Metallography
E624 Process Metallurgy
E662 Modern Metallury Practice
S126 Physical Chemistry
S292 Statistical Quality Control

Successful completion of this curriculum may lead to a B.S. degree in Metallurgy depending on the academic background of the student.

NAVAL ARCHITECTURE (ADVANCED HYDRODYNAMICS)

(*GROUP ZNA*)

At University of California

(Two Semesters)

OBJECTIVE—To provide advanced education in the hydrodynamic aspects of Naval Architecture.

Required Courses

ME298 Ship Theory (Hydrodynamics) (3) two semesters
ME298 Foil and Hydrofoil Theory (3) one semester
MA270 Technical Hydrodynamics (3) one semester

Electives as required for complete program of about 12 units per semester from:

ME298 Ship Theory (Structures) (3)
ME298 Free Surface Effects (2)
ME298 Theory of Plates and Shells (4)
PH222 Mathematical Methods of Theoretical Physics (3)
Statistics 130E Statistical Inference for Engineers (3)
ME298 Acoustics in Naval Architecture (3)
ME299 Special Study

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.

HULL DESIGN AND CONSTRUCTION SUB-SPECIALTY (XIII-A-1) at M.I.T.

FIRST SUMMER

2.046 Strength of Materials and Dynamics
8.038 Physics (Electricity)
13.20 Elementary War Ship Design
M73 Review of Mathematics

FIRST YEAR

Fall

1.612 Fluid Mechanics
2.081 Str. of Materials
2.402 Heat Engineering
13.71 History of Warships
M351 Adv. Calc. for Eng.

Spring

1.44 Struc. Eng. Elemm.
2.501 Heat Transfer
13.012 Naval Architecture
13.12 Warship Gen. arrgts.
M32 Elem. Statistics
M352 Adv. Calc. for Eng.
Intersessional Period: Field Trip

SECOND YEAR

Fall

1.63 Appl. Hydromechanics
3.391 Prop. of Metals
13.13 Warship Struc. Th. I
13.75 Warship Prop I
13.90 Warship Elec. Eng.
N101 Int. Nucl. Tech. I

Spring

1.452 Structural Analysis
3.392 Prop of Metals
13.14 Warship Struc. Th. II
13.24 Warship Struc. Des. I
13.76 Warship Prop II
22.11 Int. Nucl. Tech. II
Elective
1.683 Exp. Hydromechanics

THIRD YEAR

Fall

1.561 Exp. Stress Anal.
13.15 Warship Basic Des.
13.16 Warship Basic Des. II
13.25 Warship Struc. Des. II
13.54 Mar. Eng. Dynamics
Thesis

Spring

1.562 Adv. Struc. Mech.
13.26 Prel. Des. of War.
13.84 Ship Design Adv.
13.92 Problems in Shipyard Management
Thesis

This curriculum affords the opportunity to qualify for the degree of Naval Engineer and the degree of Master of Science in Naval Construction and Marine Engineering.

NOTE: Three other sub-specialties are offered, all of which contain basic ship design, but proportionately greater amount of other phases of marine engineering. These are:
XIII-A-2 Marine Electrical Engineering
XIII-A-3 Ship Propulsion Engineering
XIII-A-4 Nuclear Engineering

Hull Design and Construction

At Webb Institute of Naval Architecture

This three-year curriculum is basically equivalent to the Hull Design and Construction Sub-specialty at M.I.T. The schedule provides for a long winter practical work period (field trip), each year, during which the students work in a Naval shipyard or other suitable installation.

FIRST SUMMER

Practical Naval Architecture I

Calculus Review — Mechanics Review

First Year

Calculus III and IV
Differential Equations
Theoretical Fluid Mechanics I and II
Ship Model Testing
Thermodynamics I
Mechanical Processes
Mechanics of Materials I and II
Laying off
Practical Naval Architecture II and III
Theoretical Naval Architecture I and II
Naval Architecture Design I and II
Ship Resistance and Propellers I

Second Year

Engineering Economic Analysis
Industrial Organization
Metallurgy I and II
Advanced Structure I and II
Structural Laboratory
Electrical Engineering IV
Ship Resistance and Propellers II
Elementary Nuclear Physics and Reactors
Theoretical Naval Architecture III
Theory of Warship Design I and II
Warship Design I and II
Thermodynamics II
Marine Enginering III and IV

Third Year

Advanced Theoretical Fluid Mechanics
Vibrations
Machine Design
Theory of Warship Design III and IV
Warship Design III and IV
Marine Engineering V and VI
Internal Combustion Engines
Nuclear Power in Warship Design
Thesis

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

NAVAL INTELLIGENCE

(GROUP ZI)

At the U.S. Naval Intelligence School, Washington, D.C.

Objective—Nine months of instruction to train selected officers in all phases of intelligence. Following the intelligence course the students normally study a foreign language to qualify as an interpreter-translator. The length of time devoted to language study is dependent upon the language studied and the previous linguistic training of the student.

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

FIRST SUMMER

8.06N Nuclear Physics
M351 Advanced Calculus
M352 Advanced Calculus
8.051 Atomic and Nuclear Physics

FALL TERM

3.396 Nuclear Metallurgy
6.67 Prin. of Control Systems
8.531 Nuclear Physics for Engineers I
22.21 Nuclear Reactor Physics I
22.41 Nuclear Reactor Physics Lab.

SPRING TERM

8.532 Nuclear Physics for Engineers II
22.22 Nuclear Reactor Physics II
22.23 Nuclear Reactor Engineering
Thesis

ELECTIVE

22.24 Nuclear Plant Dynamics
22.42 Nuclear Reactor Lab.

SUMMER

Thesis

OCEANOGRAPHY

(GROUP ZO)

At the University of Washington and USN Hydrographic Office

Objective—A two-year course in Oceanography to prepare officers for assignment to billets requiring knowledge in this field. The curriculum is divided into Phase I and Phase II. Phase I consists of 18 months' academic instruction at the University of Washington and provides a comprehensive theoretical and practical foundation in the various aspects of oceanography, including submarine geology, physical oceanography, chemical oceanography, marine meteorology, and marine biology. A summer period of work at sea and in the laboratory is included. 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 Oceanography.

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; Counselling 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 Masters Degree for qualified officers. Appropriation restrictions may require the student to pay for his thesis expenses.

PETROLEUM ENGINEERING

(*GROUP ZL*)

At the University of Pittsburgh and in the petroleum industry

OBJECTIVE—A program consisting of two terms of academic work at the University of Pittsburgh followed by about one year in the field with a major integrated oil company. It is designed to equip naval officers with a knowledge of petroleum production engineering as well as a broad understanding of the petroleum industry. Future billet assignments may be in the Naval Petroleum Reserve system and in the higher echelons of the Defense Department concerned with petroleum logistics and where liaison with the oil industry is required.

FALL TERM

Ch.E 17 Petroleum Processes for Petroleum Engineers
Ch.E 11 Industrial Calc. for Pet. Engr.
Geology 2 Historical Geology
Pet. Engr. 101 Drilling and Development
Pet. Engr. 104 Business of Oil and Gas Prod.
Pet. Engr. 106 Pet. Production Laboratory
Pet. Engr. 110 Fundamentals of Reservoir Engr.

SPRING TERM

Ch.E 12 Industrial Calc. for Pet. Engr.
Pet. Engr. 102 Pet. Production Practice
Pet. Engr. 111 Principles of Nat. Gas Engr.
Pet. Engr. 113 Natural Gas Laboratory
Pet. Engr. 127 Valuation of Oil and Gas Prod.
Pet. Engr. 107 Gathering, Transp. and Storage
Geology 120 Geology of Oil and Gas for Engr.

The curriculum does not lead to a degree.

PETROLEUM MANAGEMENT

At University of Kansas

Intial input, September, 1959; descriptive data not yet available.

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

At University of Pittsburgh

Intial input, September, 1959; descriptive data not yet available.

SOCIAL SCIENCES

(*GROUP ZST*)

At Tufts University and Stanford University

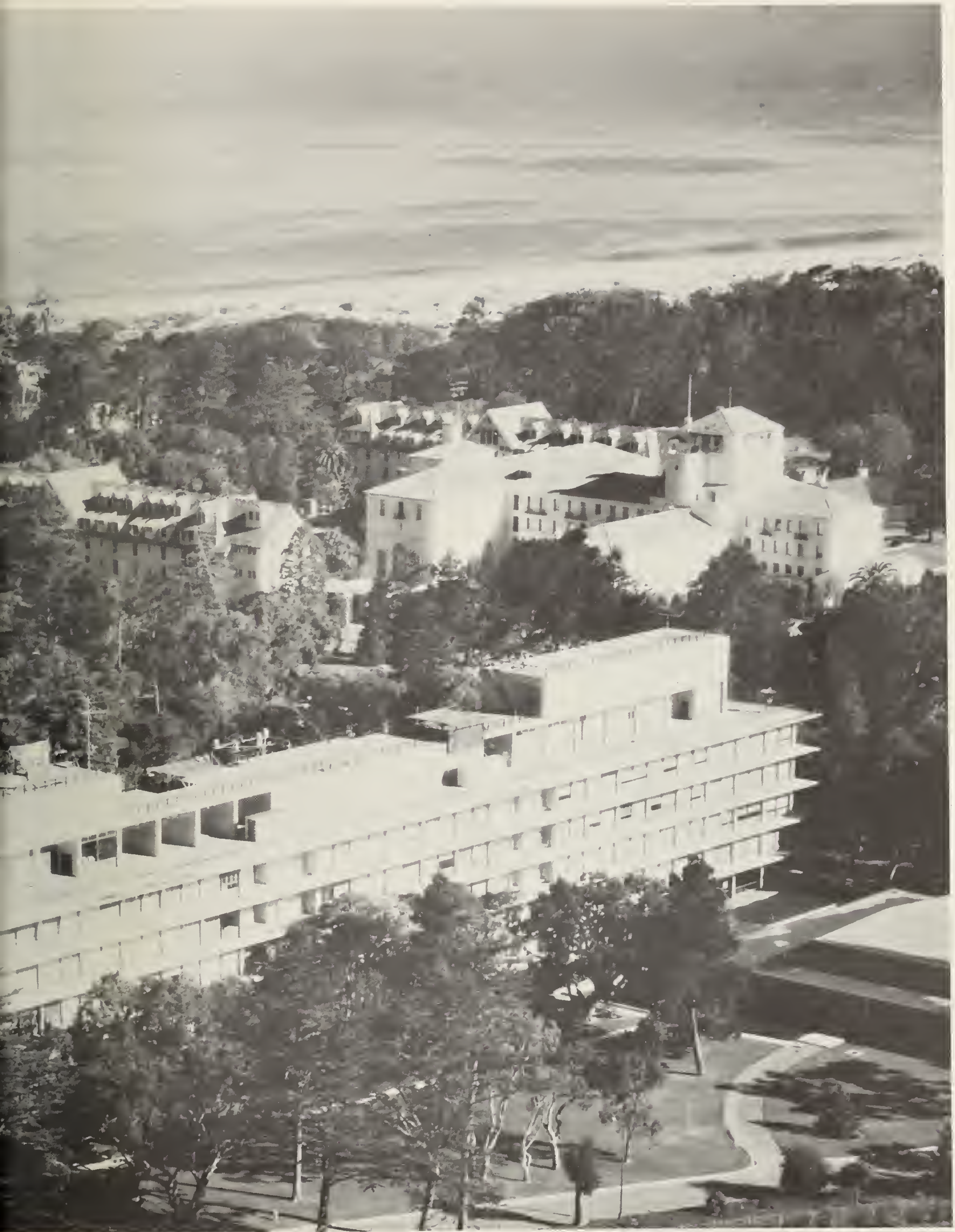
OBJECTIVE—A two year curriculum to prepare officers of mature judgement and broad background of professional knowledge in the fields of international relations, economics, political science, sociology, geography and history. Leads to a Master's Degree for qualified officers.

TRANSPORTATION MANAGEMENT

At Northwestern University

Intial input, September, 1959; descriptive data not yet available.

An aerial view of the School. Spanagel Hall is in the foreground, King Hall in the lower right, Herrmann Hall in the upper right, a
Halligan, Bullard and Root Halls in the left center.



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