UNITED STATES NAVAL

POSTGRADUATE SCHOOL

Catalogue for 1960-1961

MONTEREY ★ CALIFORNIA

UNITED STATES NAVAL
POSTGRADUATE SCHOOL

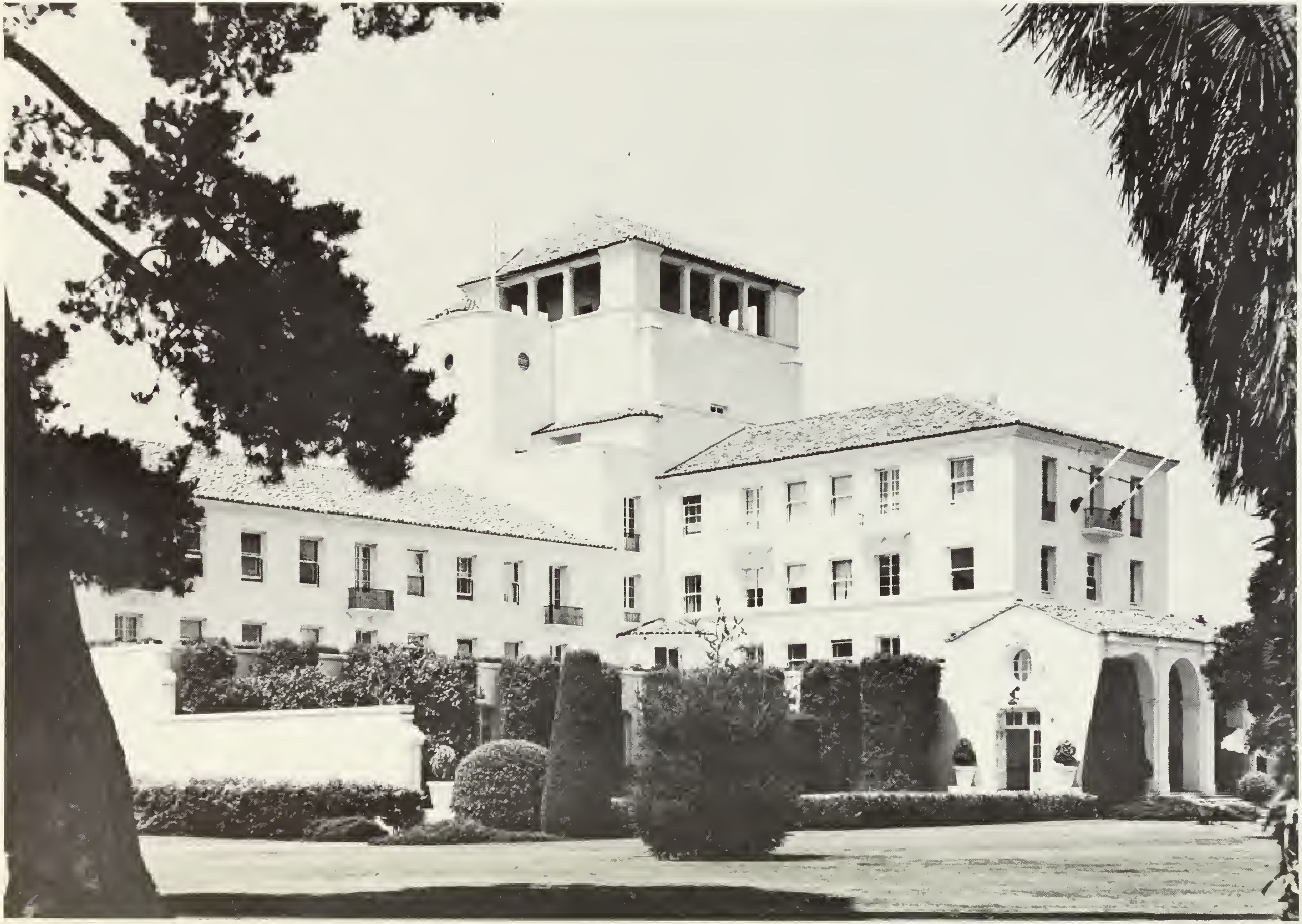
Catalogue for 1960-1961

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, which houses the Administrative Offices, 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

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

Dean Emeritus

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

Director, Engineering School

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

Director, General Line and Naval Science School

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

Director, Management School

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

Commanding Officer, Administrative Command

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

UNITED STATES NAVAL POSTGRADUATE SCHOOL
CALENDAR
Academic Year 1960 - 1961

1960

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 (Classes NS-2 and 3)	Friday, 24 June
Fourth of July (Holiday)	Monday, 4 July
Management School Summer Session Ends	Friday, 8 July
Engineering School, Management School, General Line and Naval Science School (Classes GL 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 First Term Begins	Monday, 1 August
Labor Day (Holiday)	Monday, 5 September
Engineering School Term Ends	Thursday, 6 October
Management School, General Line and Naval Science School First Term Ends	Friday, 7 October
Management School, General Line and Naval Science School Second Term Begins	Monday, 10 October
Engineering School Term Begins	Tuesday, 11 October
Veterans' Day (Holiday)	Friday, 11 November
Thanksgiving Day (Holiday)	Thursday, 24 November
General Line and Naval Science School Graduation (Class GL1960B)	Wednesday, 14 December
Engineering School, Management School, General Line and Naval Science School Second Term Ends, Christmas Holiday Begins	Friday, 16 December

CALENDAR FOR 1960

JANUARY

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

FEBRUARY

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29					

MARCH

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

APRIL

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

MAY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

JUNE

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

JULY

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

AUGUST

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

SEPTEMBER

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

OCTOBER

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

NOVEMBER

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

DECEMBER

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

CALENDAR FOR 1961

JANUARY

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

FEBRUARY

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

MARCH

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

APRIL

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

MAY

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

JUNE

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

JULY

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

AUGUST

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

SEPTEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

OCTOBER

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

NOVEMBER

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

DECEMBER

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

1961

Engineering School, Management School, General Line and Naval Science School Third Term Begins	Tuesday, 3 January
Washington's Birthday (Holiday)	Wednesday, 22 February
Engineering School, Management School, General Line and Naval Science School Third Term Ends	Friday, 10 March
General Line and Naval Science School Registration (Classes GL 1961B and NS-6)	Monday, 13 March
Engineering School, Management School, General Line and Naval Science School Fourth Term Begins	Monday, 20 March
Engineering School, Management School, General Line and Naval Science School Fourth Term Ends	Friday, 26 May
General Line and Naval Science School Fifth Term Begins	Monday, 29 May
Memorial Day (Holiday)	Tuesday, 30 May
Engineering School, Management School, General Line and Naval Science School (Class GL1961A) Graduation	Thursday, 1 June
Engineering School Special Weapons Orientation Begins	Monday, 5 June
Engineering School Special Weapons Orientation Ends	Thursday, 8 June
Management School Summer Session Registration	Friday, 9 June
Management School Summer Session Begins	Monday, 12 June
General Line and Naval Science School Summer Term Ends (Classes NS-4 and 5)	Friday, 30 June
Fourth of July (Holiday)	Tuesday, 4 July
Management School Summer Session Ends	Friday, 21 July
Engineering School, Management School, General Line and Naval Science School (Classes 1962A and NS-7) Registration	Monday, 31 July
General Line and Naval Science School Fifth Term Ends	Friday, 4 August
Engineering School, Management School, General Line and Naval Science School First Term Begins	Monday, 7 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 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 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 reasonably 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 457 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 downtown section 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, some 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, Meteorology 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.

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 7,000 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.

Paul Spinks, Assistant Professor and Chief, Technical Reports and Classified Materials Section (1959); B.A., Univ. of Oklahoma, 1958; M.S., Univ. of Oklahoma, 1959.

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

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

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 1960-1961

ENGINEERING SCHOOL

MONTEREY ⋆ CALIFORNIA

King Hall (auditorium) with Spanagel Hall (Engineering School) in the background.

ENGINEERING SCHOOL

DIRECTOR

ROBERT DUNLAP RISSER
Captain, U.S. Navy
B.S., USNA, 1934
M.S. University of Michigan 1943

ASSISTANT DIRECTOR

ROBERT ERNEST ODENING
Captain, U.S. Navy
B.S. USNA, 1936
M.S., Cornell University 1944
M.S., California Institute of Technology 1951

ADMINISTRATIVE OFFICER

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

ALLOTMENT AND MATERIAL CONTROL OFFICER

BECKUM UNDERWOOD SNEED
Lieutenant, U.S. Navy

NAVAL STAFF

AERONAUTICAL CURRICULA

JAMES VICTOR ROWNEY, Captain, U.S. Navy; Officer in Charge; B.S., USNA, 1941; Ae.E., California Institute of 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.

THOMAS LEE TABOR, Lieutenant Commander, U.S. Navy; Instructor in Communications; USNPS, 1946, Applied 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.

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.

HOWARD RODWELL SEAY, Lieutenant Commander, U.S. Navy; Instructor in Meteorology; M.S., USNPS, 1953.

LEROY ROBERT BECHELMAYR, Lieutenant, U.S. Navy; Instructor in Meteorology; B.S., USNA, 1955; M.S., USNPS, 1957.

NAVAL ENGINEERING CURRICULA

WILLIAM ROLSTON CRUTCHER, Captain, U.S. Navy; Officer in Charge; B.S., USNA, 1934; U.S. Naval War College, 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.

GERALD WILLIAM GILSTAD, Lieutenant, U.S. Navy; Reactor Officer; B.S., USNA, 1955.

JAMES H. BREHM, Ensign, U.S. Navy, Machine Shop Officer.

ORDNANCE ENGINEERING CURRICULA

SIDNEY BROOKS, Captain, U.S. Navy; Officer in Charge; M.S., Ohio State Univ.

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.

RONALD EUGENE GILL, Commander, U.S. Navy; Instructor in Mine Warfare.

5

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.

ERIC JOHN ANDREWS, Professor of Aeronautics (1959); Hons. B.S., Univ. of London, 1936.

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; 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.

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.

George Max Hahn, Associate Professor of Electronics (1960); A.B., Univ. of California, 1951; A.M., 1953.

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

Roy Martin Johnson, Jr., Assistant Professor of Electronics (1959); B.S., Univ. of California, (1951); M.S., 1959.

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

George Heinemann Marmont, Professor of Electroncs (1959); B.S., California Institute of Technology, 1934; Ph.D., 1939.

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 Electronics (1947); B.S., Kansas State College, 1937; M.S., Brown Univ., 1953.

William Everett Norris, Associate Professor of Electronics (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., Associate Professor of Electronics (1955); B.S., Univ. of Arkansas, 1941; M.S., Univ. of California, 1948.

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, 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.

Walter Jennings, 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.

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.

John Barr O'Toole, Jr., Associate Professor of Mathematics (1959); A.B., Duquesne Univ., 1948; Lit.M., Univ. of Pittsburgh, 1950; Ph.D., 1955.

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

John Philip Pierce Professor of Mathematics and Mechanics 1948; B.S., Worcester Polytechnic Institute, 1931; M.E.E., Polytechnic Institute of Brooklyin. 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.

William Bert Stuber, Instructor in Mathematics (1960); A.B., Lake Forest College, 1958.

Elmo Joseph Stewart, 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, Associate Professor of Mechanical Engineering (1954); B.S., Texas Agricultural and Mechanical College, 1949; M.S., 1951; Engr., Stanford Univ., 1960.

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

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.

* Absent on leave 1960-61.

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.

MAURICE GRIFFEL, Professor of Chemistry (1959); B.S., College of the City of New York, 1939; M.S., Univ. of Michigan, 1941; Ph.D., Univ of Chicago, 1949.

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, 1953; 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.

* Absent on leave 1960-61.

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.

ARTHUR NILES HULL, Instructor in Meteorology (1959); B.S., USNA, 1947; B.S., USNPS, 1953.

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, Associate 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.

*Absent on leave 1960-61

DEPARTMENT OF PHYSICS

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

ALFRED WILLIAM MADISON COOPER, Assistant Professor of Phyics (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.

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

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

JOHN ROBERT NEIGHBOURS, Associate Professor of Physics (1959); B.S., Case Institute of Technology, 1949; M.S., 1951; Ph.D. 1953.

NORMAN LEE OLESON, Professor of Physics (1948); B.S., Univ. of Michigan, 1935; M.S., 1937; Ph.D., 1940.

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; A.M., Univ. of California at Los Angeles, 1948; Ph.D., 1951.

*Absent on leave 1960-61

GENERAL INFORMATION

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

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

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

The titles of the curricular offices are:

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

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.

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

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

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

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

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. The degree Bachelor of Science requires a minimum of 186 term hours, including at least 36 term hours in non-technical subjects. Award of the degree in engineering or a designated specialty requires that these minima be 216 hours and 36 hours, respectively.

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

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

(d) With due regard for the above 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 pro-

TABLE I

CURRICULA AT THE ENGINEERING SCHOOL

Curricular Officer *Curriculum*	*Group*	*Length*	*Academic Associate*
Aeronautical Engineering			
General	AG	2 yrs.	Prof. Coates
Advanced (1)	AA	3 yrs.	Prof. Coates
Electronics and Communications Engineering			
Advanced Mathematics (Electronics minor)	EM	2 yrs.	Prof. Lockhart
Advanced Science (2)			
Chemistry	RC	3 yrs.	Prof. Coonan
Hydrodynamics	RH	3 yrs.	Prof. Howard
Mathematics (Applied)	RM	3 yrs.	Prof. Pulliam
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	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
Science	RS	1 yr.	Prof. P. E. Cooper
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
Mechanical Engineering Advanced	NHA	3 yrs.	Prof. Wright
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.	Prof. C. D. G. King
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.	"
(Special)	WS	2 yrs.	"

(1) Usually 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).

gram is satisfactory to the department chairman, it shall be forwarded by him to the Academic Council for final action.

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

(e) To be eligible for the Master's degree the student must attain a minimum average quality point rating of 2.0 in all the (A) and (B) level courses of his curriculum and either 1.5 in the (C) level courses or 1.75 in all 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. In addition, the completed thesis must indicate an ability to report on the work in a scholarly fashion. The thesis in final form is submitted via the 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 chairman of the department of the major subject, for determination of the adequacy of his preparation.

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

(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.

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

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

The facilities of the Compressibility Laboratory include a transonic wind tunnel having a 4″ x 16″ test section and operating in the Mach number range from 0.4 to 1.4 and a supersonic wind tunnel having a 4″ x 4″ test section and a vertical free-jet of 1″ x 1″ cross-section, both operating in the Mach number range from 1.4 to 4. Instruments associated 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 test block mounting a J-34 turbojet engine suitably instrumented for static operation tests, a combustion test rig for full scale turbojet combustor studies, and a small flame tube especially designed to study flame propogation in steady flow. 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 turbo-machines.

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

The ELECTRICAL ENGINEERING LABORATORIES, separately housed in a modern two story building 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 includes a gas or oil-fired boiler, 200 psi, and 8000 lb/hr, fully automatic controls; a 175 HP gas turbine installation, dynamometer loaded; a two-dimensional supersonic air nozzle with Schlieren equipment for analysis of shock-wise flows; a solo-shell dual-effect evaporator; a two-stage axial flow test compressor; a packaged steam power plant; an experimental single cylinder diesel engine; and a CFR diesel fuel test engine. Facilities of the mechanics laboratories include a universal fatigue tester, for testing in tension, compression, bending or torsion, a Chapman polariscope for stress determination by photoelastic method; vibration inducer units and associated equipment for inducing vibrations in mechanical systems with controlled amplitudes and frequencies from 20 to 20,000 cycles per second; dynamic balancing machines; and a linear accelerometer and calibrator unit.

THE ELECTRONICS LABORATORIES are 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.

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

THE COMPUTER CENTER functions as a service department to all Departments of the U.S. Naval Postgraduate School. The laboratory contains two general purpose digital computers: the National Cash Register-102A and the Control Data Corporation-1604. There are card, punched-paper tape, magnetic tape and printing facilities associated with each of the computers. The CDC-1604 is a completely solid state computer having 32,768 words, 48-bits per word, of core storage. This computer is capable of performing approximately 200,000 additions per second. The Computer Center has been described as the largest academic Computing Center in the United States.

Students in almost all curricula at the Postgraduate School receive course and laboratory work in the application and operation of computers. Student and Faculty research is carried on in the Computer Center on both an open-shop and closed-shop basis.

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 may, under special conditions, be afforded the opportunity to qualify for either a Bachelor of Science or Master of Science degree with major in mathematics. Any interested student should consult the Chairman of the Department of Mathematics and Mechanics for an evaluation of his previous work to determine his potential for obtaining either degree and to consider the possibility of scheduling the necessary work. The requirements in mathematics for these degrees are given below. They provide, on the bachelor's or master's level, a working knowledge of one field of mathematics and a well-rounded background in three of the major fields of mathematics.

A. To obtain the Bachelor of Science degree with major in mathematics the student must complete a minimum of thirty-six term hours of acceptable mathematical courses above the level of elementary calculus including Ma-105, 106, 109, 110 or their equivalent. Evaluation of courses presented upon entering the Naval Postgraduate School for credit towards the degree must be completed prior to entering a program leading to this degree.

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

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

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

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

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

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

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.

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

After two years study at Monterey in both the General and Advanced Curricula, the student may apply for a Bachelor of Science degree in Aeronautical Engineering. The General curriculum terminates with this two years study, while the Advanced curriculum continues study towards a Master or Professional degree usually at a civilian university.

COMMON FIRST YEAR OF STUDY

FIRST YEAR (A1)

First Term (17-7)

Ae-100(C) Basic Aerodynamics (3-2)
Ae-200(C) Rigid Body Statics (3-2)
Ma-151(C) Differential Equations (5-0)
Ma-150(C) Vector Algebra and Geometry (4-1)
Mc-101(C) Engineering Mechanics (2-2)

Second Term (16-9)

Ae-121(C) Technical Aerodynamics (3-4)
Ae-211(C) 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 (0-1)

Third Term (18-9)

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-126(B) Numerical Methods for Digital Computers (3-2)
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 periods—Field trips to industry and military installations and courses in Naval Management.

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

AERONAUTICAL ENGINEERING (GENERAL)

TWO YEAR CURRICULUM

SECOND YEAR (AG2)

First Term

Ae-142(A)	(3-4)	F	P	V
Ae-501(A)	(4-0)	F	P	V
Ae-505(A)	(4-0)			
Ae-151(B)	(2-0)	F		
Ae-161(B)	(0-4)	F		
Ch-121(B)	(4-2)	F	P	
EE-283(B)	(3-4)			V
EE-464(C)	(3-4)			V
Mt-201(C)	(3-2)		P	

Second Term

Ae-001(L)	(0-1)	F	P	V
Ae-411(B)	(4-2)	F	P	V
Ae-502(A)	(4-0)	F	P	V
Ae-506(A)	(3-2)			
Ae-412(B)	(0-3)	F	P	
Ae-316(C)	(2-4)	F		
Ae-152(B)	(2-0)	F		
Ae-162(B)	(0-4)	F		
EE-771(B)	(3-2)			V
EE-284(A)	(3-2)			V
Mt-202(C)	(3-2)		P	

Third Term

Ae-421(B)	(3-2)	F	P	V
Ae-508(A)	(3-2)		P	
Ae-316(C)	(2-4)			V
Ae-221(A)	(3-2)	F		
Ae-150(B)	(3-4)		P	
EE-670(A)	(3-3)			V
EE-752(C)	(3-2)	F	P	
EE-772(B)	(3-2)			V
LP-101(L)	(0-1)	F	P	V
Mt-201(C)	(3-2)	F		

Fourth Term

Ae-508(A)	(3-2)	F		V
Ae-316(C)	(2-4)		P	
Ae-428(A)	(3-2)	F	P	
Ae-801(A)	(3-3)			V
Ae-124(A)	(3-2)			
Ae-153(B)	(2-0)	F		
Ae-163(B)	(0-4)	F		
CE-542(A)	(3-2)		P	
EE-656(B)	(3-4)		P	
EE-745(A)	(3-3)			V
LP-102(L)	(0-1)	F	P	V
Mc-403(A)	(3-0)			V
Mt-202(B)	(3-2)	F		

AERO Codes: 100 Series Tech Aerody.
200 Series Structures
300 Series Design
400 Series Propulsion
500 Series Theor. Aerody.
800 Series Systems Eng.

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

AERONAUTICAL ENGINEERING (ADVANCED)

THREE YEAR CURRICULUM

SECOND YEAR (AA2)

First Term

Ae-142(A)	(3-4)	A	P	S	V
Ae-511(A)	(4-0)	A	P	S	V
Ae-505(A)	(4-0)				
Ae-451(A)	(3-0)				
Ae-701(A)	(4-0)				
Ch-121(B)	(4-2)	A	P	S	
EE-283(B)	(3-4)				V
EE-464(C)	(3-4)				V
Mt-201(C)	(3-2)	A	P	S	

Second Term

Ae-001(L)	(0-1)	A	P	S	V
Ae-411(B)	(4-2)	A	P	S	V
Ae-512(A)	(4-0)	A	P	S	V
Ae-506(A)	(3-2)				
Ae-214(A)	(3-0)	A	P	S	
Ae-221(A)	(3-2)	A		S	
Ae-452(A)	(3-0)				
EE-284(A)	(3-2)				V
EE-771(B)	(3-2)				V
Mt-202(C)	(3-2)	A	P	S	
Mt-301(A)	(3-0)		P		

Third Term

Ae-421(B)	(3-2)	A	P	S	V
Ae-513(A)	(4-0)	A	P		
Ae-311(C)	(2-4)	A		S	
Ae-316(C)	(2-4)		P		V
Ae-215(A)	(4-0)			S	
Ae-124(A)	(3-2)				
EE-670(A)	(3-3)				V
EE-752(C)	(3-2)	A	P	S	
EE-772(B)	(3-2)				V
LP-101(L)	(0-1)	A	P	S	V

Fourth Term

Ae-508(A)	(3-2)			S	V
Ae-514(A)	(3-2)	A	P		
Ae-312(B)	(1-4)	A		S	
Ae-260(A)	(3-2)			S	
Ae-431(A)	(4-1)	A	P		
CE-112(A)	(3-2)		P		
CE-542(A)	(3-2)	A	P		
EE-656(B)	(3-4)	A	P		
EE-673(A)	(3-3)				V
EE-745(A)	(3-3)				V
Mc-311(A)	(3-2)			S	
Mc-403(A)	(3-0)				V
LP-102(L)	(0-1)	A	P	S	V

ELECTIVE Codes: A—Aero-Space Dynamics
F—Flight Testing & Eval.
P—Propulsion
S—Structures
V—Avionics

Other electives may be chosen depending on thesis topics, i.e. Z—Aerophysics, E—Aeroelectricity, M—Aeromaterials, etc.

AERONAUTICAL ENGINEERING (ADVANCED)

THIRD YEAR CURRICULUM

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

California Inst. of Technology, Pasadena
- Aerodynamics
- Structures
- Jet Propulsion

Massachusetts Inst. of Technology, Boston
- Astronautics
- Airborne Weapons Systems
- Propulsion

University of Michigan, Ann Arbor, Michigan
- Aerodynamics
- Aero-instrumentation
- Propulsion
- Structures
- Nuclear Engineering

Univ. of Minnesota, Minneapolis, Minn.
- Aerodynamics
- Propulsion
- Structures

Princeton University, Princeton, N. J.
- Aerodynamics (flight mechanics)
- Jet Propulsion
- Gas Dynamics

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

Stanford University
- Aero-and Gasdynamics
- Structures
- Guidance and Control

U.S. Naval Postgraduate School
- Aero—EE
- Aero—Materials
- Aero—Physics

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 program are permitted to take elective courses best suited to their individual interests and naval experience. For properly qualified entering students, successful completion of two years of work in the EB or CE curriculum affords the opportunity to earn the degree of Bachelor of Science in Engineering Electronics or in Communications Engineering.

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

BASIC CURRICULUM

First Year (All Students—Group EB1)

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. Both groups take "Art of Presentation."

Second Year (All Students — Group EB2)

(Commencing 1960)

First Term (13-11)

EE-463(C) Special Machinery (3-2).
Es-215(C) Electronic 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

The EB students will complete their second year 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

The CE students will complete their second year in an all elective program, subject to approval of the OinC and academic advisors, chosen from the listed offerings. As an example, a typical elective program in Communications Engineering might be as follows: (Four courses not exceeding 24 hours per week are elected for each term.)

Second Year (Typical Electives) (Group CE2)

Third Term (13-9)

Es-429(B) Theory of Modulation (3-3)
Es-400(A) Information Networks (3-2)
Es-620(B) Theory of Antennas (3-3)
Es-230(A) Feedback Networks (4-0)
LP-101(L) NPS Lecture Program I (0-1)

Fourth Term (14-8)

Oa-121(A) Operations Analysis (4-2)
Es-330(A) Automation and System Control (3-3)
Es-320(A) Systems Engineering (3-2)
Es-630(B) Theory of Propagation (4-0)
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 (12).

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 (12).

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).
Ma-322(A) Statistical Decision Theory (3-2).
Elective (6).
Thesis (3-0).

Second Term (19)

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

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-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).
Thesis (4-0).

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. (3-3)
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).
Elective (6).
Thesis (3-0).

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)

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).
Thesis (4-0).

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).
Ma-116(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 EC3)

(Commencing 1961)

First Term (19)

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

Second Term (19)

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

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-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).
Thesis (4-0).

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.

SCIENCE

(*Group RS*)

Objective—To provide commissioned officers with postgraduate education in the fundamentals of science and mathematics by extension of their undergraduate studies in order to prepare them for subsequent subspecialization, to stimulate a desire for maintaining and improving their basic education, and to broaden their professional knowledge through graduate education in the areas of executive leadership, management, and international relations.

First Year (Group RS1)

First Term (19-0)

HIR International Relations (3-0)
Ma-041(C) Review of Alg. Trig. & Anal. Geom. (4-0)
Ma-061(C) Review of Calculus (4-0)
Mn-441 Organization and Management (4-0)
Ph-021(C) Mechanics (4-0)

Second Term (16-0)

Ma-073(B) Differential Equations (5-0)
OOP Operational Planning (3-0)
Ph-022(C) Electromagnetism (4-0)
Ph-023(C) Radiation (4-0)

Third Term (15-2)

HGP Group Procedures & Art of Presentation (4-0)
Ma-311(B) Intro. to Probability & Statistics (4-0)
Ma-127(B) Scientific Computation with Digital Computers (3-2)
Ph-620(B) Atomic Physics (4-0)

Fourth Term (16-2)

Mn-444 Management Economics (4-0)
Ma-411(B) Digital Computers & Military Applications (4-0)
Ph-621(B) Nuclear Physics (4-0)
SLA Leadership and Administration (4-2)

METEOROLOGY

GENERAL METEOROLOGY

(*GROUP MAA*)

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

First Year (MAA)

First Term (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 (13-12)

Ma-163(C) Calculus and Vector Analysis (4-0).
Mr-202(C) Weather-Map Analysis (3-9).
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).
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 (MAA)

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).

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

A program allowing for some degree of subspecialization within the Meteorology Curricula is under study. Fields of subspecialization may include Numerical Forecasting, Oceanography, and Ice Forecasting. This program, if implemented, would concern students enrolling in the Meteorology Curricula in Fiscal Year 1961.

ADVANCED METEOROLOGY

(*GROUP MMM*)

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

First Year (MMM)

First Term (17-5)

Ma-120(C) Vector Algebra and Geometry (3-1).
Ma-131(C) Partial Derivatives and Multiple Integrals (3-1).
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 (17-10)

Ma-133(A) Differential Equations and Vector Mechanics (5-0).
Mr-202(C) Weather-Map Analysis (3-9).
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 (MMM)

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).

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

A program allowing for some degree of subspecialization within the Meteorology Curricula is under study. Fields of subspecialization may include Numerical Forecasting, Oceanography, and Ice Forecasting. This program, if implemented, would concern students enrolling in the Meteorology Curricula in Fiscal Year 1961.

NAVAL ENGINEERING CURRICULA

Objective—To provide officers with advanced marine engineering education to meet the requirements of the Navy. Specifically, these curricula are designed to cover the fundamental and advanced theories of mathematics, thermodynamics, mechanics, dynamics, electricity, metallurgy and structures within the several curricula. The curricula are Naval Engineering (General) with an option of either Mechanical or Electrical Engineering, Mechanical Engineering (Advanced), Mechanical Engineering (Gas Turbines), Electrical Engineering (Advanced) and Nuclear Power.

All students initially enter the Naval Engineering (General) curriculum. They are then selected for the various special curricula as follows:

After Second Term

Mechanical Engineering (Gas Turbines)	3 yr. curriculum
Nuclear Power	2 yr. curriculum

After First Year

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

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

NAVAL ENGINEERING (GENERAL)

(GROUP NG ENTERING 1960)

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 (13-7)

EE-371(C) D. C. Machinery (3-2)
Ma-113(B) Partial Differential Equations and Complex Variables (5-0).
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(B) 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 1960)

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 1960)

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-751(C) Electronics (3-4)
ME-132(C) Engineering Thermo II (4-2)

Second Term (10-9)

EE-273(C) Electrical Measurements I (2-3)
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 (15-8)

EE-670(A) Servomechanism (3-3)
EE-571(B) Lines and Network Synthesis (3-4)
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 1960)

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

FIRST YEAR (Entering 1960)

Same as Naval Engineering Curriculum

SECOND YEAR (NHA)

First Term (17-4)

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

Second Term (14-8)

ME-211(B) Thermodynamics of Comp. Flow (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 (10-7)

EE-453(C) Alternating-Current Machinery (3-4)
ME-310(B) Heat Transfer (4-2)
Mt-301(A) High Temperature Materials (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 (NHA3)

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.

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 (NJ1) (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 (5-0)
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 (5-0)
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 (NJ2)

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(C) 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(B) Thermo. of Comp. Flow (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(A) Adv. Thermo. (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 (NJ3)

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 engineering for technical and administrative duties connected with naval machinery and engineering plants.

First Year (Entering 1960)

Same as Naval Engineering Curriculum

Second Year (NLA2)

First Term (12-6)

EE-471(C) A. C. Machinery (3-4)
Ma-114(A) Functions of Complex Variable (5-0)
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 (11-12)

EE-273(C) Electrical Measurements I (2-3)
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 (14-6)

EE-771(B) Electronics (3-2)
EE-670(A) Servomechanisms (3-3)
EE-971(A) Seminar (1-0)
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 (NLA3)

First Term (10-12)

EE-871(A) Electrical Machine Design (4-0)
EE-772(B) Electronics (3-2)
EE-571(B) Lines and Network Synthesis (3-4)
Thesis (0-6)

Second Term (10-11)

EE-872(A) Electric Machine Design (4-0)
EE-773(A) Magnetic Amplifiers (2-3)
EE-971(A) Seminar (1-0)
Ph-362(A) Electromagnetic Waves (3-0)
Thesis (0-8)

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 (7-10)

EE-745(A) Electronic Control and Measurement (3-3)
EE-874(A) Electrical Machine Design (4-0)
EE-971(A) Seminar (1-0)
Thesis (0-6)
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.

NUCLEAR POWER

(*GROUP NN*) (*Entering 1960*)

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 (NN1)

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 (15-8)

Ma-113(B) Partial Differential Equations and Complex Variables (5-0)
EE-463(C) Special Machinery (3-2)
Mt-202(C) Ferrous Metallurgy (3-2)
Ph-660(B) Atomic Physics (4-3)
LP-101(L) NPS Lecture Program I (0-1)

Fourth Term (15-8)

Ma-114(A) Functions of Complex Variable and Vector Analysis (5-0)
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 (4-3)
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 (17-5)

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)
Ch-401(A) Physical Chemistry (3-2)
Ph-652(A) Reactor Theory II (3-0)
LP-101(L) NPS Lecture Program I (0-1)

Fourth Term (9-10)

EE-653(A) Reactor Instrumentation and Control (3-3)
ME-242(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)

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

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 their employment and defensive situations.

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

First Year (RZ1)

First Term (14-5)

Ma-120(C) Vector Algebra and Geometry (3-1)
Ma-181(C) Partial Derivatives and Multiple Integrals (4-1)
Ph-151(C) Mechanics I (4-0)
Ph-240(C) Optics and Spectra (3-3)

Second Term (18-2)

Es-140(C) Electronics I (3-2)
Ma-186(B) Vector Analysis, Series, and Differential Equations (6-0)
Ph-152(B) Mechanics II (4-0)
Ph-635(B) Atomic Physics I (5-0)

Third Term (18-4)

Ma-187(B) Partial Differential Equations and Boundary Value Problems (6-0)
Ph-153(A) Mechanics III (4-0)
Ph-365(B) Electricity (4-0)
Ph-636(B) Atomic Physics II (4-3)
LP-101(L) Lecture (0-1)

Fourth Term (15-7)

Ch-102(B) General Inorganic Chemistry (3-2)
Es-240(C) Electronics II (3-3)
Ph-366(B) Electromagnetism (4-0)
Ph-535(B) Thermodynamics, Kinetic Theory and Statistical Mechanics (5-0)
Ph-750(L) Physics Seminar (0-1)
LP-102(L) Lecture (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-367(A) Special Topics in Electromagnetism (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 (13-11)

Bi-800(C) General Biology (4-2)
ME-505(C) Statics and Strength of Materials (5-0)
Ph-638(B) Nuclear Physics II (3-3)
Ph-751(B) Physics Seminar (1-0)
Ph-912(A) Thesis (0-6)

Third Term (9-16)

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)
LP-101(L) Lecture (0-1)

Fourth Term (12-12)

Bi-802(A) Radiation Biology (4-2)
ChE-591(A) Blast and Shock Effects (3-0)
ME-550(B) Dynamic Structural Analysis (5-0)
Ph-750(L) Physics Seminar (0-1)
Ph-914(A) Thesis (0-8)
LP-102(L) Lecture (0-1)

This curriculum affords the opportunity to qualify for the degree of Master of Science in Physics. Upon completion of the curriculum, USN 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 U.S. Naval Postgraduate School prior to detachment.

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 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(B) 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 (17-5)

Ma-116(A) Matrices and Numerical Methods (3-2)
OA-292(B) Methods and Operations Analysis (4-0)
OA-391(A) Games of Strategy (3-2)
Ph-141(B) Analytical Mechanics (4-0)
Ph-321(B) Electromagnetism (3-0)
LP-101(L) Lecture (0-1)

Fourth Term (20-3)

Ma-183(B) Fourier Series and Complex Variable (4-0)
Ma-193(A) Set Theory and Integration (2-0)
Ma-196(A) Matrix Theory (3-0)
Ma-421(A) Digital Computers (3-2)
OA-293(B) Search Theory and Air Defense (4-0)
Ph-142(B) Analytical Mechanics (4-0)
LP-102(L) Lecture (0-1)

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

Second Year (RO2)

First Term (18-4)

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-431(B) Fundamental Acoustics (4-0)
Ph-541(B) Kinetic Theory and Statistical Mechanics (4-0)

Second Term (15-5)

OA-202(A) Econometrics (3-0)
Ma-394(A) Analysis and Design of Experiments (3-0)
OA-401(A) Theory of Information Communication (3-0)
Ph-435(B) Underwater Acoustics (3-2)
Ph-640(B) Atomic Physics (3-3)

Third Term (10-14)

OA-296(A) Design of Weapon Systems (3-0)
OA-392(A) Decision Theory (3-0)
Ph-642(B) Nuclear Physics (4-3)
LP-101(L) Lecture (0-1)
Thesis (0-10)

Fourth Term (11-11)

OA-295(A) Analysis of Weapon Systems (3-0)
Mr-120(C) Introduction to Meteorology and Oceanography (3-0)
Co-230(C) Naval Communication Analysis (3-0)
OA-893(A) Seminar (2-2)
LP-102(L) Lecture (0-1)
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 for such subsequent growth as may be required for the operation, maintenance, design, development or production of advanced weapons systems.

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

WEAPONS SYSTEMS (GENERAL)

(*GROUP 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 principle 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 (16-5)

ChE-611(C) Engineering Thermodynamics (3-2)
Es-241(C) Electronics I (3-2)
Ma-157(B) Complex Variable (4-0)
Or-241(C) Guided Missiles I (2-0)
Ph-151(C) Mechanics I (4-0)
LP-101(L) Lecture (0-1)

Fourth Term (16-5)

EE-463(C) Special Machinery (3-2)
Es-242(C) Electronics II (3-2)
Ma-175(B) Differential Equations of Applied Mathematics (4-0)
Or-242(B) Guided Missiles II (2-0)
Ph-152(B) Mechanics II (4-0)
LP-102(L) Lecture (0-1)

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

Second Year (WG2)

First Term (13-6)

Ch-401(A) Physical Chemistry (3-2)
Ma-116(A) Matrices and Numerical Methods (3-2)
Ph-260(C) Physical Optics (3-2)
Ph-365(B) Electricity and Magnetism (4-0)

Second Term (12-10)

Ch-571(A) Explosives (3-2)
EE-671(A) Transients (3-4)
Es-258(B) Introduction to Microwaves (3-2)
Ma-421(A) Digital Computers (3-2)

Third Term (12-10)

ChE-591(A) Blast and Shock Effects (3-0)
EE-670(A) Introduction to Servomechanisms (3-3)
Es-351(B) Pulse Techniques and Radar Fundamentals (3-3)
Ph-640(B) Atomic Physics (3-3)
LP-101(L) Lecture (0-1)

Fourth Term (13-11)

ChE-542(A) Reaction Motors (3-2)
Es-352(B) Radar Systems (3-3)
Ph-450(B) Underwater Acoustics (3-2)
Ph-642(B) Nuclear Physics (4-3)
LP-102(L) Lecture (0-1)

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.

ADVANCED WEAPONS SYSTEMS

CHEMISTRY CURRICULUM (GROUP WC)

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

FIRST YEAR (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 (16-5)

ChE-611(C) Engineering Thermodynamics (3-2)
Es-241(C) Electronics I (3-2)
Ma-157(B) Complex Variable (4-0)
Or-241(C) Guided Missiles I (2-0)
Ph-151(C) Mechanics I (4-0)
LP-101(L) Lecture (0-1)

Fourth Term (16-5)

EE-463(C) Special Machinery (3-2)
Es-242(C) Electronics II (3-2)
Ma-175(B) Differential Equations of Applied Mathematics (4-0)
Or-242(B) Guided Missiles II (2-0)
Ph-152(B) Mechanics II (4-0)
LP-102(L) Lecture (0-1)

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

SECOND YEAR (WC2)

First Term (13-8)

Ch-311(C) Organic Chemistry (3-2)
ChE-614(A) Engineering Thermodynamics (3-2)
EE-671(A) Transients (3-4)
Ph-365(B) Electricity and Magnetism (4-0)

Second Term (13-9)

Ch-231(C) Quantitative Analysis (2-4)
Ch-443(C) Physical Chemistry I (4-2)
EE-756(A) Electrical Measurement of Non-Electrical Quantities (3-3)
Ph-366(B) Electromagnetism (4-0)

Third Term (12-11)

Ch-312(C) Organic Chemistry (3-2)
Ch-571(A) Explosives (3-2)
EE-670(A) Introduction to Servomechanisms (3-3)
Ph-640(B) Atomic Physics (3-3)
LP-101(L) Lecture (0-1)

Fourth Term (9-14)

Ch-324(A) Organic Qualitative Chemistry (2-4)
Ch-444(A) Physical Chemistry II (3-4)
Ch-800(A) Chemistry Seminar (0-2)
Ph-642(B) Nuclear Physics (4-3)
LP-102(L) Lecture (0-1)

Intersessional period: Enrollment in 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.

THIRD YEAR (WC3)

First Term (7-13)

Ch-416(A) Physical Chemistry, Advanced (3-4)
Ch-551(A) Radiochemistry (2-4)
ChE-625(A) Thermodynamics (2-2)
Thesis (0-3)

Second Term (9-11)

Ch-322(A) Organic Chemistry, Advanced (3-2)
ChE-741(B) Heat Transmission (3-2)
Mt-201(C) Introductory Physical Metallurgy (3-2)
Thesis (0-5)

Third Term (9-12)

ChE-542(A) Reaction Motors (3-2)
ChE-591(A) Blast and Shock Effects (3-0)
Mt-202(C) Ferrous Physical Metallurgy (3-2)
LP-101(L) Lecture (0-1)
Thesis (0-7)

Fourth Term (9-12)

ChE-112(A) Fuels, Combustion, High Energy Fuels (3-2)
Ch-580(A) Electrochemistry (3-2)
Ch-800(A) Chemistry Seminar (0-2)
Mt-301(A) High Temperature Materials (3-0)
LP-102(L) Lecture (0-1)
Thesis (0-5)

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

ADVANCED WEAPONS SYSTEMS
ELECTRICAL ENGINEERING CURRICULUM
(GROUP WE)

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

FIRST YEAR (Common to All)

First Term (13-7)

Ch-106(C) Principles of Chemistry I (3-2)
EE-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 (16-5)

ChE-611(C) Engineering Thermodynamics (3-2)
Es-241(C) Electronics I (3-2)
Ma-157(B) Complex Variable (4-0)
Or-241(C) Guided Missiles I (2-0)
Ph-151(C) Mechanics I (4-0)
LP-101(L) Lecture (0-1)

Fourth Term (16-5)

EE-463(C) Special Machinery (3-2)
Es-242(C) Electronics II (3-2)
Ma-175(B) Differential Equations of Applied Mathematics (4-0)
Or-242(B) Guided Missiles II (2-0)
Ph-152(B) Mechanics II (4-0)
LP-102(L) Lecture (0-1)

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

SECOND YEAR (WE2)

First Term (13-8)

Ch-401(A) Physical Chemistry (3-2)
EE-671(A) Transients (3-4)
Ma-116(A) Matrices and Numerical Methods (3-2)
Ph-365(B) Electricity and Magnetism (4-0)

Second Term (15-7)

Ae-102(C) Aerodynamics (Ord) I (3-0)
Ae-103(C) Aerodynamics (Ord) I Lab (0-2)
EE-756(A) Electrical Measurement of Non-Electrical Quantities (3-3)
Ma-421(A) Digital Computers (3-2)
Or-191(C) Mines and Mine Mechanisms (2-0)
Ph-366(B) Electromagnetism (4-0)

Third Term (14-8)

ChE-542(A) Reaction Motors (3-2)
EE-672(A) Servomechanisms (3-3)
Ma-321(B) Probability and Statistics (4-2)
Ph-367(A) Special Topics in Electromagnetism (4-0)
LP-101(L) Lecture (0-1)

Fourth Term (15-6)

EE-674(A) Advanced Linear Servo Theory (3-3)
Ma-322(A) Statistical Decision Theory (3-2)
OA-152(C) Measures of Effectiveness of Mines (3-0)
Oc-110(C) Introduction to Oceanography (3-0)
Ph-161(A) Hydrodynamics (3-0)
LP-102(L) Lecture (0-1)

Intersessional period: Enrollment in 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.

THIRD YEAR (WE3)

First Term (16-3)

EE-673(A) Nonlinear Servomechanisms (3-3)
Oc-330(A) Marine Geology and Geophysics (3-0)
Or-291(C) Mine Countermeasures I (3-0)
Ph-162(A) Advanced Hydrodynamics (3-0)
Ph-431(B) Fundamental Acoustics (4-0)

Second Term (11-13)

EE-676(A) Linear and Nonlinear Servo Compensation Theory (3-2)
OA-153(B) Game Theory and Its Applications to Mine Fields (3-0)
Or-292(C) Mine Countermeasures II (1-2)
Ph-432(A) Underwater Acoustics and Sonar Systems (4-3)
Thesis (0-6)

Third Term (10-7)

Oc-230(A) Wave Phenomena in the Sea (3-0)
Or-294(A) Mine Warfare Seminar (2-0)
Or-392(B) Minefield Planning (2-0)
Ph-442(A) Shock Waves in Fluids (3-0)
LP-101(L) Lecture (0-1)
Thesis (0-6)

Fourth Term (8-15)

Ch-580(A) Electrochemistry (3-2)
EE-773(A) Magnetic Amplifiers (2-3)
Ph-640(B) Atomic Physics (3-3)
LP-102(L) Lecture (0-1)
Thesis (0-6)

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

ADVANCED WEAPONS SYSTEMS
PHYSICS CURRICULUM (GROUP WP)

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

FIRST YEAR (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 (16-5)

ChE-611(C) Engineering Thermodynamics (3-2)
Es-241(C) Electronics I (3-2)
Ma-157(B) Complex Variable (4-0)
Or-241(C) Guided Missiles I (2-0)
Ph-151(C) Mechanics I (4-0)
LP-101(L) Lecture (0-1)

Fourth Term (16-5)

EE-463(C) Special Machinery (3-2)
Es-242(C) Electronics II (3-2)
Ma-175(B) Differential Equations of Applied Mathematics (4-0)
Or-242(B) Guided Missiles II (2-0)
Ph-152(B) Mechanics II (4-0)
LP-102(L) Lecture (0-1)

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

SECOND YEAR (WP2)

First Term (15-6)

Ch-401(A) Physical Chemistry (3-2)
Ma-321(B) Probability and Statistics (4-2)
Ph-154(A) Celestial Mechanics (4-0)
Ph-270(B) Physical Optics and Spectra (4-2)

Second Term (16-6)

Ae-102(C) Aerodynamics (Ord) I (3-0)
Ae-103(C) Aerodynamics (Ord) I Lab (0-2)
ChE-542(A) Reaction Motors (3-2)
Ma-322(A) Statistical Decision Theory (3-2)
Ph-365(B) Electricity and Magnetism (4-0)
Ph-670(B) Atomic Physics I (3-0)

Third Term (14-8)

EE-671(A) Transients (3-4)
Ph-366(B) Electromagnetism (4-0)
Ph-541(B) Kinetic Theory and Statistical Mechanics (4-0)
Ph-671(B) Atomic Physics II (3-3)
LP-101(L) Lecture (0-1)

Fourth Term (12-8)

Ae-124(C) Aerodynamics (Ord) II (3-0)
Ae-125(C) Aerodynamics (Ord) II Lab (0-2)
EE-670(A) Introduction to Servomechanisms (3-3)
Es-258(B) Introduction to Microwaves (3-2)
Ph-637(B) Nuclear Physics I (3-0)
LP-102(L) Lecture (0-1)

Intersessional period: Enrollment in 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.

THIRD YEAR (WP3)

First Term (14-8)

Ae-505(A) Hydro-Aero Mechanics (Ord) (4-0)
Es-351(B) Pulse Techniques and Radar Fundamentals (3-3)
Ph-638(B) Nuclear Physics II (3-3)
Ph-730(A) Physics of the Solid State (4-2)

Second Term (10-11)

Ae-506(A) Compressibility (Ord) (3-2)
Es-352(B) Radar Systems (3-3)
Ph-654(A) Plasma Physics (4-0)
Thesis (0-6)

Third Term (10-12)

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

Fourth Term (9-14)

Ae-550(A) Magnetohydrodynamics (3-2)
Es-347(B) Missile Guidance (3-3)
Ma-421(A) Digital Computers (3-2)
LP-102(L) Lecture (0-1)
Thesis (0-6)

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

WEAPONS SYSTEMS (SPECIAL)

(GROUP WS)

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

FIRST YEAR (WS1)

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 (14-5)

ChE-611(C) Engineering Thermodynamics (3-2)
Es-241(C) Electronics I (3-2)
Ma-157(B) Complex Variable (4-0)
Ph-151(C) Mechanics I (4-0)
LP-101(L) Lecture (0-1)

Fourth Term (14-5)

EE-463(C) Special Machinery (3-2)
Es-242(C) Electronics II (3-2)
Ma-175(B) Differential Equations of Applied Mathematics (4-0)
Ph-152(B) Mechanics II (4-0)
LP-102(L) Lecture (0-1)

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

SECOND YEAR (WS2)

First Term (13-6)

Ch-401(A) Physical Chemistry (3-2)
Ma-116(A) Matrices and Numerical Methods (3-2)
Ph-260(C) Physical Optics (3-2)
Ph-365(B) Electricity and Magnetism (4-0)

Second Term (12-11)

EE-671(A) Transients (3-4)
EE-756(A) Electrical Measurement of Non-Electrical Quantities (3-3)
Es-258(B) Introduction to Microwaves (3-2)
Ma-421(A) Digital Computers (3-2)

Third Term (12-12)

EE-670(A) Introduction to Servomechanisms (3-3)
Es-351(B) Pulse Techniques and Radar Fundamentals (3-3)
Ma-351(B) Industrial Statistics I (3-2)
Ph-640(B) Atomic Physics (3-3)
LP-101(L) Lecture (0-1)

Fourth Term (12-11)

ChE-521(A) Plastics (3-2)
Es-352(B) Radar Systems (3-3)
Ma-352(B) Industrial Statistics II (2-2)
Ph-642(B) Nuclear Physics (4-3)
LP-102(L) Lecture (0-1)

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

ENGINEERING SCHOOL

COURSE DESCRIPTIONS

AERONAUTICS

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

Ae-100(C) BASIC AERODYNAMICS (3-2). Properties of fluids; statics; velocity and pressure; Bernoulli's theorem; cavitation; theory of lift; blade screws and propellers; viscous flows; vortices; laminar and turbulent boundary layer flows; separation phenomena; surface friction; resistance of floating bodies; dynamics of compressible fluids. The laboratory periods include experimental work in the wind tunnel, allied to the topics above; technical analysis and report writing. TEXTS: 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; air vehicle performance; range and endurance; special performance problems; performance parameters; flight test reduction and analysis. Laboratory analysis of performance of an air vehicle 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). Theoretical longitudinal stability and control of aircraft, related test methods and aircraft evaluation. TEXTS: Same as Ae-150(B). PREREQUISITE: Ae-141(A) or Ae-146(A).

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

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

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

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

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

Ae-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-260(A) AEROELASTICITY (4-0). Static aeroelastic problems in divergence and control reversal, spanwise lift distribution of an elastic wing, elementary non-stationary wing theories, phenomenological and simple theoretical treatments of flutter. TEXTS: BROADBENT, *The Elementary Theory of Aeroelasticity;* FUNG, *The Theory of Aeroelasticity;* BISPLINGHOFF, ASHLEY, HALFMAN, *Aeroelasticity*. PREREQUISITE: Ae-215(A).

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

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

Ae-513(A) COMPRESSIBILITY I (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-514(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).

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

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

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. TEXTS: BACQ *and* ALEXANDER: *Fundamentals of Radiobiology;* CLAUS: *Radiation Biology and Medicine.* PREREQUISITES: Ph-642(B); Bi-801(B).

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

CHEMISTRY AND CHEMICAL ENGINEERING

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

Ch-002 GENERAL INORGANIC CHEMISTRY (3-3). A continuation of Ch-001. The chemical properties of the elements and their compounds will be studied from the viewpoint of the periodic table. Special emphasis will be given to the compounds of carbon. Experiments will illustrate the reactions of the elements and their ions 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;* or SIENKO *and* PLANE, *Chemistry.*

Ch-102(C) GENERAL INORGANIC CHEMISTRY (3-2). A one-term course in chemical principles designed for students in the Nuclear Engineering (Effects) curriculum. Will include elementary chemical stoichiometry, the gas laws, chemical equilibria, and descriptive chemistry of selected transition metals. The laboratory work will supplement the lectures. TEXT: SIENKO *and* PLANE, *Chemistry:* or HILDEBRAND and POWELL, *Principles of Chemistry,* and LATIMER *and* HILDEBRAND, *Reference Book of Inorganic Chemistry* (combined volume).

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

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

Ch.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. TEXT: POPOVICH *and* HERING, *Fuels and Lubricants.*

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: POPOVICH *and* HERING, *Fuels and Lubricants;* PENNER, *Chemical Problems in Jet Propulsion.* 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;* POPOVICH *and* HERING, *Fuels and Lubricants.*

Ch-150(A) INORGANIC CHEMISTRY, ADVANCED (4-3). A systematic study, employing the methods of physical and analytical chemistry to inorganic systems. Types of chemical reactions; the periodic system; aqueous solution chemistry of selected metals and non-metals; high energy inorganic fuels. The laboratory will apply the principles of chemical equilibria and kinetics to inorganic reactions. TEXT: MOELLER, *Inorganic Chemistry.* PREREQUISITE: Ch-107(C), Ch-444(B) (may be taken concurrently), Quantitative Analysis; or permission of the instructor.

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 organic 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). 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. 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-403(B) PHYSICAL CHEMISTRY (3-2). A terminal course in physical chemistry for selected groups. Gases, liquids, chemical thermodynamics, thermochemistry, chemical equilibria, and chemical kinetics. Laboratory experiments illustrate principles discussed in the lectures. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS and others, *Experimental Physical Chemistry*. PREREQUISITES: Ch-101(C) or Ch-121(B) or equivalent.

Ch-405(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).

Ch-407(A) PHYSICAL CHEMISTRY (3-2). A one-term course in physical chemistry for students who have had Thermodynamics. Gases, liquids, solids, solutions, thermochemistry, chemical equilibria, and chemical kinetics are studied. Laboratory experiments illustrate principles discussed in the lectures. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and others, Experimental Physical Chemistry*. PREREQUISITES: Ch-101(C) and one term of Thermodynamics.

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, thermochemistry, chemical thermodynamics, chemical equilibria. Laboratory experiments illustrate the principles discussed in lecture. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and others, Experimental Physical Chemistry*. PREREQUISITE: Ch-107(C) and one term of Thermodynamics.

Ch-444(B) PHYSICAL CHEMISTRY II (3-4). A continuation of Ch-443(C). Chemical kinetics, electrochemistry, and related topics. Laboratory experiments will support and supplement the material covered in the lecture. TEXTS: DANIELS *and* ALBERTY, *Physical Chemistry;* DANIELS *and others, Experimental Physical Chemistry*. PREREQUISITE: Ch-443(C).

Ch-452(A) PHYSICAL CHEMISTRY, ADVANCED (3-4). 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(B). TEXT: To be assigned. PREREQUISITE: A two-term course in physical chemistry.

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

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

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

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

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

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

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

Ch-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;* GARRETT, *Batteries of Today.* PREREQUISITE: 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* STUART, *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* STUART, *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* STUART, *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 subiect 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* STUART, *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* STUART, *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-740(B) HEAT TRANSFER (2-2). The fundamentals of heat transfer by conduction, convection and radiation and their application to problems in ordnance. Representative problems are solved in the laboratory period. TEXT: SCHENCK, *Heat Transfer Engineering.* PREREQUISITE: Ch.E-624(A).

Ch-E-741(B) HEAT TRANSFER (3-2). The fundamentals of heat transfer by conduction, convection, and radiation, and their application to problems in ordnance. In the laboratory periods problems illustrating these principles are solved. TEXTS: 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 (3-2). 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-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 (3-2). 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-240(C) PUBLIC SPEAKING (0-2). Instruction and practice in the effective delivery of speech and presentation of ideas.

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. TEXT: KRAUS, *Electromagnetics*. 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. TEXTS: DAWES, *Electrical Engineering, Vol. I, 4th Edition;* FITZGERALD *and* KINGSLEY, *Electrical Machinery*. 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. TEXTS: PUCHSTEIN, LLOYD *and* CONRAD, *Alternating Current Machines, 3rd Edition;* FITZGERALD *and* KINGSLEY, *Electric Machinery*. 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. TEXTS: PUCHSTEIN, LLOYD *and* CONRAD, *Alternating Current Machines, 3rd Edition;* FITZGERALD *and* KINGSLEY, *Electric Machinery.* 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. TEXTS: PUCHSTEIN, LLOYD *and* CONRAD, *Alternating Current Machines, 3rd Edition;* FITZGERALD *and* KINGSLEY, *Electric Machinery.* 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. TEXTS: HEHRE *and* HARNESS, *Electrical Circuits and Machinery, Vol. II;* FITZGERALD *and* KINGSLEY, *Electric Machinery.* 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. TEXTS: HEHRE *and* HARNESS, *Electrical Circuits and Machinery, Vol. II;* FITZGERALD *and* KINGSLEY, *Electric Machinery.* 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; FITZGERALD *and* KINGSLEY, *Electric Machines.* 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 development 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, Vols. I and II, 4th Edition;* FITZGERALD *and* KINGSLEY, *Electrical Machinery.* 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. TEXTS: CARR, *Electric Machinery;* FITZGERALD *and* KINGSLEY, *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. TEXTS: CARR, *Electric Machinery;* FITZGERALD *and* KINGSLEY, *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. TEXTS: WARE *and* REED, *Communication Circuits, 3rd Edition;* VAN VALKENBURG, *Network Analysis.* 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;* THALER *and* BROWN, *Analysis and Design of Feedback Control Systems, 2nd Edition;* 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-653(A) NUCLEAR REACTOR INSTRUMENTATION AND CONTROL (3-4). The basic principles and methods of nuclear reactor control are presented. The treatment of the elementary reactor with temperature and poisoning feedback is given using linear feedback control system analysis. The requirements for stable operation and accuracy of automatic neutron flux control are analyzed and demonstrated using a reactor kinetics simulator. TEXTS: SCHULTZ, *Control of Nuclear Reactors and Power Plants;* GLASSTONE, *Principles of Nuclear Reactor Engineering.* PREREQUISITES: EE-651(B) or the equivalent.

EE-654(A) NUCLEAR REACTOR POWER PLANT CONTROL (3-4). This course is a continuation of EE-653(A). The elementary thermodynamics of the plant control loop is established and the transfer functions obtained. The dynamic performance of the basic plant is analyzed under various load conditions. Automatic plant control stability and performance using external reactor control systems are investigated. TEXTS: SCHULTZ, *Control of Nuclear Reactors and Power Plants;* GLASSTONE, *Principles of Nuclear Reactor Engineering.* PREREQUISITES: EE-653(A).

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, *Analysis and Design of Feedback Control Systems, 2nd Edition;* 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;* VAN VALKENBURG, *Network Analysis.* 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, *Analysis and Design of Feedback Control Systems, 2nd Edition.* 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. TEXT: THALER *and* BROWN, *Analysis and Design of Feedback Control Systems, 2nd Edition.* 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: STILL *and* SISKIND, *Elements of Electrical Machine Design*. 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: STILL *and* SISKIND, *Elements of Electrical Machine Design*. 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: STILL *and* SISKIND, *Elements of Electrical Machine Design*. 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: STILL *and* SISKIND, *Elements of Electrical Machine Design*. 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-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-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 (3-3). A study of the theory and engineering practices of active sonar systems. Emphasis is placed on the new developments in modern active sonar systems, and the trend of the future. Characteristics and capabilities of existing active sonar systems are determined in the laboratory. TEXTS: Instructor's Notes; Equipment Instruction Books; Current Literature. PREREQUISITE: Ph-432(A); Ph-461(A).

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-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-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-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-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).

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

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

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

Ge-401(C) PETROLOGY AND PETROGRAPHY (2-3). The various igneous rock series on the basis of physical chemical theories; the characteristics, structures and textures of igneous rocks; the metamorphic rocks, mineral alteration, metamorphism and the resultant rock types. The laboratory work consists of the study of the various rocks in hand specimens, and in thin sections under the petrographic 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 TRIGONOMETRY II (3-0). Vectors. Exponential and logarithmic equations. Trigonometric identities. Determinants and systems of linear equations. Quadratic and higher order equations. Straight line and conic section. TEXT: ANDRES, MISER *and* REINGOLD, *Basic Mathematics for Engineers.* PREREQUISITE: Ma-010(C).

Ma-015(C) ALGEBRA AND TRIGONOMETRY REFRESHER (3-0). Review of simple algebraic processes. Slide rule. Functional notation and graphs. Trigonometric functions and their graphs. Right triangle, and vectors. Exponents, radicals and logarithms. Linear equations. Quadratic equations. 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-041(C) REVIEW OF ALGEBRA, TRIGONOMETRY, ANALYTIC GEOMETRY (4-0). Basic algebraic operations; trigonometric functions; equations of lines and conics; complex numbers; theory of algebraic equations; matrix notation for linear equations, matrix algebra. TEXT: HART, *First Year College Mathematics*. PREREQUISITE: Previous courses in algebra, trigonometry, analytic geometry.

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 III (3-0). Partial derivatives, directional derivatives, total differential. Chain rule differentiation . Multiple integration and applications. Introduction to Infinite Series. TEXT: THOMAS, *Calculus and Analytic Geometry*. PREREQUISITE: Ma-052(C), Ma-081(B) must be taken concurrently.

Ma-061(C) REVIEW OF CALCULUS (4-0). Concept of function, limit and continuity; differentiation, intergration with applications; differentiation of function of several variables, directional derivatives. TEXT: THOMAS, *Calculus and Analytic Geometry*. PREREQUISITE: Previous courses in calculus.

Ma-071(C) CALCULUS I (5-0). The calculus of functions of a single independent variable with emphasis on basic concepts. Derivatives, differentials, applications. Rolles' theorem and the mean value theorem. Definite integral with applications. 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-073(B) DIFFERENTIAL EQUATIONS (5-0). A continuation of Ma-072(C). Series of constants; power series; Fourier series; first order ordinary differential equations; ordinary linear differential equations with constant coefficients; simultaneous solution of ordinary differential equations; series solution of ordinary differential equations, including Bessel's Equation. TEXTS: THOMAS, *Calculus and Analytic Geometry*; KAPLAN, *Advanced Calculus*; GOLOMB *and* SHANKS, *Elements of Ordinary Differential Equations*. PREREQUISITE: Ma-072(C) or Ma-061(C).

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

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

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-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*; APOSTOL, *Mathematical Analysis*. 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*; APOSTOL, *Mathematical Analysis*; 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;* KAPLAN, *Advanced Calculus.* PREREQUISITES: A course in differential and integral calculus; Ma-120(C) or Ma-150(C) to be taken concurrently.

Ma-112(B) DIFFERENTIAL EQUATIONS and INFINITE SERIES (5-0). A continuation of Ma-111(C). Constant term series; series of functions, convergence concepts; Taylor's formula; Fourier series and integral; orthogonal functions, ordinary differential equations of first order, elementary solutions; linear equations with constant coefficients; systems of linear equations; power series solution of linear equations. TEXT: KAPLAN, *Advanced Calculus.* PREREQUISITE: Ma-111(C).

Ma-113(B) VECTOR ANALYSIS AND PARTIAL DIFFERENTIAL EQUATIONS (4-0). Vector differentiation; differential operators; line, surface and volume integrals; integral theorems. Partial differential equations; separation of variables; boundary conditions; applications to flow of heat. TEXTS: SPEIGEL, *Vector Analysis;* WYLIE, *Advanced Engineering Mathematics.*

Ma-114(A) FUNCTIONS OF A COMPLEX VARIABLE AND VECTOR ANALYSIS (3-0). A continuation of Ma-113(B) as offered in 1959-60. 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. TEXTS: 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;* KUNZ, *Numerical Analysis;* MILNE, *Numerical Calculus.* PREREQUISITE: Ma-113(B), or Ma-156(B), or Ma-123(B), or Ma-183(B), or Ma-175(B).

Ma-120(C) VECTOR ALGEBRA AND SOLID ANALYTIC GEOMETRY (3-1). Real number system. Algebra of complex numbers. Vectors and their algebra. Analytic geometry of space; points, lines, and planes in scalar and vector notation. Determinants, matrices and linear systems; linear dependence. Special surfaces. Laboratory periods devoted to reveiw 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 (4-1). 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 and Ma-120(C) or Ma-150(C) to be taken concurrently.

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 (4-1). 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 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. TEXTS: BOOTH, *Numerical Methods;* KUNZ, *Numerical Analysis;* MILNE, *Numerical Calculus.* PREREQUISITE: Ma-113(B) or Ma-123(A) or Ma-156(B) or Ma-175(B) or Ma-183(B).

Ma-126(B) NUMERICAL METHODS FOR DIGITAL COMPUTERS (3-2). Lagrangian polynomial approximations to real functions. Introduction to best polynomial approximations in the sense of least squares. Minimax polynomial approximations. Numerical methods for solving equations and systems of equations. Difference calculus, numerical differentiation and integration. Selected numerical methods for solving initial value and boundary value problems involving ordinary and partial differential equations. The laboratory periods include sample problems solved on hand-operated keyboard calculators; emphasis is given to methods which are useful with large scale automatic digital computers. TEXTS: MILNE, *Numerical Calculus;* KUNZ, *Numerical Analysis.* PREREQUISITE: Ma-152(B) or equivalent.

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

Ma-131(C) PARTIAL DERIVATIVES AND MULTIPLE INTEGRALS (3-1). Concepts of function and limit. Fundamentals of sequences and series. Elementary properties of power series and Fourier series. Derivatives and partial derivatives of scalar and vector functions. Leibnitz' Formula. Partial and multiple integrals. Laboratory period will be used for review of elementary calculus. TEXTS: SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics;* GRANVILLE, SMITH *and* LONGLEY, *Elements of Differential and Integral Calculus.* PREREQUISITE: A course in differential and Integral Calculus and Ma-120(C) or Ma-150(C) to be taken concurrently.

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 Stokes' 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). Total differential equations and systems of differential equations. The vector equations of motion. Irrotational, solenoidal and linear vector fields. Gamma, Beta, Bessel and Legendre functions. Solution of differential equations in series. TEXTS: COHEN, *Differential Equations;* SOKOLNIKOFF *and* SOKOLNIKOFF, *Higher Mathematics;* WEATHERBURN, *Advanced Vector Analysis.* PREREQUISITE: Ma-132(B).

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

Ma-151(C) DIFFERENTIAL EQUATIONS (4-1). Review of calculus. Partial derivatives. Polar coordinates and change of variables. Elements of differential equations; first order; linear; 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 applications. Curvilinear coordinates. TEXTS: SPIEGEL, *Vector Analysis.* PREREQUISITE: Ma-120(C) or Ma-150(C).

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.* 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. TEXTS: LEIGHTON, *Introduction to the Theory of Differential Equations;* GRANVILLE, SMITH *and* LONGLEY, *Elements of the Differential and Integral Calculus;* CHURCHILL, *Fourier Series and Boundary Value Problems.* 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. Solution of partial differential equations by separation of variables and Fourier Series. 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;* THOMAS, *Calculus and Analytic Geometry.* PREREQUISITES: A course in differential and integral calculus, and Ma-120(C) or Ma-150(C) to be taken concurrently.

Ma-182(B) VECTOR ANALYSIS AND DIFFERENTIAL EQUATIONS (5-0). Vector differentiation. Vector integral relations. Ordinary first order differential equations. Higher order linear differential equations. Systems of differential equations. Series solutions of differential equations. Infinite series. TEXTS: PHILLIPS, *Vector Analysis;* KAPLAN, *Advanced Calculus;* WYLIE, *Advanced Engineering Mathematics.* PREREQUISITE: Ma-181(C).

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

Ma-186(B) VECTOR ANALYSIS, SERIES, AND DIFFERENTIAL EQUATIONS (6-0). Vector differentiation. Vector integral relations. Physical applications. Infinite series. Ordinary first order differential equations. Higher order linear differential equations. Series solutions of differential equations. Systems of differential equations. TEXTS: PHILLIPS, *Vector Analysis;* KAPLAN, *Advanced Calculus;* WYLIE, *Advanced Engineering Mathematics.* PREREQUISITES: Ma-120(C) and Ma-181(C).

Ma-187(B) PARTIAL DIFFERENTIAL EQUATIONS AND BOUNDARY VALUE PROBLEMS (6-0). Physical applications of partial differential equations. D'Alembert Solution of the wave equation. Separation of variables method. Boundary value problems. Fourier series. Bessel functions. Legendre polynomials. Orthogonal functions and Sturm-Liouville theory. TEXT: WYLIE, *Advanced Engineering Mathematics.* PREREQUISITE: Ma-186(B).

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

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

Ma-311(B) INTRODUCTION TO PROBABILITY AND STATISTICS (4-0). Simple probability models. Sample space, random variable, discrete and continuous distribution functions. Limiting distribution. Sampling. Presentation and description of data. Elements of hypothesis testing and estimation. TEXT: LINDGREN *and* MCELRATH. *Introduction to Probability and Statistics.* PREREQUISITE: Ma-061(C) or equivalent.

Ma-321(B) PROBABILITY AND STATISTICS (4-2). Elements of set theory. Foundations of probability and basic rules of computation. Sample space, random variable, discrete and continuous distribution functions. The classical distribution functions. Joint, marginal and conditional distribution functions. Limit theorems. Elements of hypothesis testing and estimation. TEXT: DERMAN *and* KLEIN, *Probability and Statistical Inference for Engineers.* 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);* PANOFSKY *and* BRIER, *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. Elements of hypothesis testing and estimation. TEXTS: WILKS, *Elementary Statistical Analysis;* FRASER, *Statistics, An Introduction.* PREREQUISITE: Ma-071(C) or equivalent.

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

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

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-392(B) or the equivalent.

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

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

Ma-371(C) MANAGEMENT STATISTICS (3-0). Review of elementary calculus with particular emphasis on basic concepts. Elements of probability theory. Descriptive statistics. Statistical inference as an aid to decision-making. TEXTS: CHERNOFF *and* MOSES, *Elementary Decision Theory;* SHERWOOD *and* TAYLOR, *Calculus.* PREREQUISITE: A previous course in the differential and integral calculus.

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 in the field of the group. TEXTS: DERMAN *and* KLEIN, *Probability and Statistical Inference for Engineers;* PANOFSKY *and* BRIER, *Applications of Statistics to Meteorology* (Meteorology groups only). PREREQUISITE: Ma-163(C) or Ma-181(C).

Ma-391(C) BASIC PROBABILITY (4-0). Elements of Set Theory. Foundations of probability and basic rules of computation. Sample space, random variable, discrete and continuous distribution functions. The classical distribution functions. Joint, marginal and conditional distribution functions. Limit theorems. TEXTS: KEMENY, MIRKIL, SNELL, THOMPSON, *Finite Mathematical Structures.* PREREQUISITE: A previous course in differential and integral calculus.

Ma-392(B) BASIC STATISTICS (3-2). A continuation of Ma-391(C). Some sampling distributions. Theory of point and interval estimation. Theory of hypothesis testing. Applications, including linear models. TEXT: FRASER, *Statistics, An Introduction.* PREREQUISITE: Ma-391(C) or the equivalent.

Ma-393(A) DESIGN OF EXPERIMENTS (3-2). Theory of the general linear hypothesis. Planning of experiments. 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. TEXT: DAVIES, *Design and Analysis of Industrial Experiments.* PREREQUISITE: Ma-392(B).

Ma-394(A) ADVANCED STATISTICS (3-0). Selected topics in statistics, to include the theory and applications of sequential analysis and nonparametric inference. TEXTS: WALD, *Sequential Analysis;* FRAZER, *Nonparametric Methods in Statistics;* MOOD, *Introduction to The Theory of Statistics.* PREREQUISITE: Ma-392(B).

Ma-411(B) DIGITAL COMPUTERS AND MILITARY APPLICATIONS (4-0). Description of a general purpose digital computer, command structure and commands, flow charts and preparation of problems for programming; applications such as war gaming, simulation of systems, logistics and data processing; demonstrations on a computer. TEXT: MCCRACKEN, *Digital Computer Programming.* PREREQUISITE. Ma-073(B) or equivalent.

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. TEXTS: Programming Manuals; MCCRACKEN, *Digital Computer Programming.* PREREQUISITES: 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-423(A) ADVANCED PROGRAMMING (4-0). General Service, assembly and compiler programs for digital computers. Particular emphasis given to the AR-assembly routine for the CDC-1604. Applications to scientific, data processing, logic and war gaming problems. TEXT: CDC-1604 *Characteristics Manuals.* PREREQUISITE: Ma-421(A).

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

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

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

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

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

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

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, turbines; combustion; reversed cycles; 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-210(C) APPLIED THERMODYNAMICS (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) THERMODYNAMICS OF COMPRESSIBLE FLOW (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: SHAPIRO, *Thermodynamics of Compressible Flow, Vol. I*. PREREQUISITE: ME-112(C).

ME-212(A) ADVANCED THERMODYNAMICS (3-2). Imperfect gases and other advanced topics in thermodynamics; the mathematical development of property relations and their use with experimental data. TEXT: KIEFER, KINNEY *and* STUART, *Engineering Thermodynamics*. PREREQUISITE: ME-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 211(B).

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

ME-217(B) INTERNAL COMBUSTION ENGINES (3-2). Theoretical and real-fuel cycles, combustion processes for spark-ignition and compression-ignition engines. Combustion chambers, carburetion and fuel-injection phenomena. Factors affecting engine performance and design. TEXTS: LICHTY, *Internal Combustion Engines;* TAYLOR *and* TAYLOR, *Internal Combustion Engines*. PREREQUISITE: ME-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, inter-relationship of components, heat balances and flow diagrams, computation of ship and plant performance indices, preliminary investigation of major equipment items. TEXTS: SEWARD, *Marine Engineering, Vols. I and II;* CHURCH, *Steam Turbines, 3rd Edition*. PREREQUISITE: ME-210 (C) or equivalent.

ME-221(C) APPLIED THERMODYNAMICS (3-4). Continuation of power cycles: reheat, regenerative and reversed cycle. Gas vapor mixtures. Compressible fluid flow. Fundamentals of heat transfer. TEXT: FAIRES, *Thermodynamics*. PREREQUISITE: ME 122(C).

ME-222(C) THERMODYNAMICS LABORATORY (1-4). Laboratory experiments applying thermodynamic principles to gas turbine engine, diesel engine, refrigeration plant, air compressor, nuclear reactor, compressible flow metering and heat transfer. TEXT: FAIRES, *Thermodynamics*. 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 course sequence covering engineering aspects of nuclear power reactors. Reactor types, characteristics, and criteria for selection. Advanced heat transfer, fluid mechanics and thermodynamics as applied to characteristic cycles. TEXT: GLASSTONE, *Principles of Nuclear Reactor Engineering*. PREREQUISITES: ME-310(B) and Ph-642(B).

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

ME-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 buoyancy. 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(B) 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-505(C) STATICS AND STRENGTH OF MATERIALS (5-0). Review of principles of statics, statics of determinate structures, pin-connected trusses. Stress, strain, Hooke's law, tension and compression, shearing stresses. Connections, thin vessels, torsion. Statics of beams, flexural stresses and deformations, numerical procedures. Simple indeterminate structures. Combined loadings and combined stresses. Columns. TEXT: TIMOSHENKO *and* MACCULLOUGH, *Elements of Strength of Materials.* PREREQUISITE: Ph-151(C).

ME-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.;* PARKER, *Brittle Behavior of Engineering Structures.* PREREQUISITE: ME-512(A).

ME-521(C) STRENGTH OF MATERIALS II (4-0). Statically indeterminate problems in bending, symmetrical beams of variable cross section, beams of two materials, unsymmetrical bending, strain energy and impact, curved bars, beams with combined axial and lateral loads. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II.* PREREQUISITE: ME-500(C).

ME-522(B) STRENGTH OF MATERIALS III (4-0). Stress concentration, deformations beyond the elastic limit, mechanical properties of materials, strength theories, impact, fatigue, thick walled cylinders, torsion of non-circular sections, thin plates and shells. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II.* PREREQUISITE: ME-521(C).

ME-550(B) DYNAMICS OF ENGINEERING STRUCTURES (5-0). Structural types and nomenclature. Structural elements: beams, columns, beam columns, plates, reinforced concrete, structural steel. Methods of analyzing statically indeterminate structures, applications of slope deflection analysis. Plastic behavior of materials, of structural elements, of structures. Dynamic response of linear structures. Dynamic response of idealized structures loaded in inelastic regime. Analog and digital computer treatments. TEXTS: TIMOSHENKO, *Strength of Materials, Vols. I and II.* PREREQUISITES: ME-505(C) and ME-750(B).

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, rotation, Newton's laws, d'Alembert's principle, work and energy, impulse and momentum, applications to satellites and space vehicles. TEXT: MERIAM, *Mechanics, Part II.* PREREQUISITES: ME-561(C) and Ma-053(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(C).

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: DAVIS, and others, *Testing and Inspection of Engineering Materials;* TIMOSHENKO, *Strength of Materials, Vols. I and II.* 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-512(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;* LEE, *An Introduction to Experimental Stress Analysis.* 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, non-linear 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-750(B) ENGINEERING VIBRATIONS (3-0). The single degree of freedom system from an engineering viewpoint. Instrumentation. Vibration isolation. Many degrees of freedom. Methods of Rayleigh, Holzer, Stodola. Simple nonlinear cases. Methods of Newmark and phase-plane-delta. TEXT: DEN HARTOG, *Mechanical Vibrations.* PREREQUISITE: Ph-153(A).

ME-811(B) MACHINE DESIGN I (3-2). First of a two-course sequence. Studies of fits, tolerances, allowances, material selection, stress concentration, bearings, shafting, screws, belts, chains, brakes, clutches and cams. TEXT: FAIRES, *Design of Machine Elements.* PREREQUISITES: ME-512(A) and ME-711(B).

ME-812(B) MACHINE DESIGN II (3-4). Continuation of ME-811; springs, gearing, and advanced design problems. Machine design projects of a comprehensive nature. TEXT: FAIRES, *Design of Machine Elements.* PREREQUISITES: ME-811(B) and ME-712(A).

ME-820(C) MACHINE DESIGN (2-4). 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-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-120(C) or Ma-150(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*)*;* WRIGLEY, *Shuler Tuning of Navigational Instruments;* RUSSELL, *Inertial Guidance for Rocket-Propelled Missiles.* 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. TEXT: Classroom Notes. PREREQUISITE: Mc-402(A).

METALLURGY

Mt-002(C) BASIC METALLURGY (4-3). An elementary and survey course in metallurgy designed for students in the Naval Science School. The subject matter includes a study of the properties and heat treatment of the commercially important metals and alloys and their engineering applications. The laboratory experiments are designed to illustrate the material taken up in class and includes microscopic examination of metal specimens in varying mechanical and heat treated conditions. TEXT: To be selected. PREREQUISITES: A course in general chemistry.

Mt-101(C) PRODUCTION METALLURGY (2-0). An introduction to the study of metallurgy including discussion of the nature of metal-bearing raw materials and the fundamental processes, materials and equipment of extractive metallurgy. TEXT: HAYWARD, *an Outline of Metallurgical Practice*. PREREQUISITE: Elementary General Chemistry (may be taken concurrently).

Mt-102(C) PRODUCTION OF STEEL (3-0). A discussion of the occurrence and composition of various iron ores, blast furnace products, the various methods of steel production, and the production of grey, white and malleable cast iron. TEXT: BRAY, *Ferrous Process Metallurgy*. PREREQUISITE: Ch-101(C) or equivalent.

Mt-103(C) PRODUCTION OF NON-FERROUS METALS (3-0). A discussion of the sources. the strategic importance of, and the methods of production of copper, zinc, lead, tin, aluminum, magnesium, and other metals of technical interest. TEXTS: BRAY, *Non-Ferrous Production Metallurgy*. PREREQUISITE: Ch-101(C) or equivalent.

Mt-104(C) PRODUCTION METALLURGY (4-0). A condensation of the material of Mt-102 and Mt-103 into a one-term course. TEXTS: BRAY, *Non-Ferrous Production Metallurgy;* BRAY, *Ferrous Process Metallurgy*. PREREQUISITE: Ch-101(C) or equivalent.

Mt-201(C) INTRODUCTORY PHYSICAL METALLURGY (3-2). An introduction to Physical Metallurgy. Topics include: (a) The nature and properties of metals, (b) a study of phase equilibria, (c) the correlation of microstructure and properties with phase diagrams, (d) mechanical properties and heat treatment, (e) descriptions of non-ferrous alloys of commercial importance. The laboratory experiments introduce methods available to the metallurgist for the study of metals and alloys. TEXTS: COONAN, *Principles of Physical Metallurgy*.

Mt-202(C) FERROUS PHYSICAL METALLURGY (3-2). A continuation of Mt-201. Topics include: (a) Iron- carbon alloys, (b) Effect of various heat treatments on the structure and properties of steel, (c) Reaction rates and hardenability, (d) The effect of alloying elements on steel, (e) Surface hardening methods, (f) Cast Irons, (g) Characteristics and properties of various steels. The laboratory experiments include heat treatment, mechanical testing, and metallographic examination of ferrous alloys. TEXTS: COONAN, *Principles of Physical Metallurgy;* CLARK *and* VARNEY, *Physical Metallurgy for Engineers*. PREREQUISITE: Mt-201(C).

Mt-212(C) PHYSICAL AND PRODUCTION METALLURGY (4-2). This course covers the same material as Mt-202 and includes in addition the production of iron and steel. One period each week is devoted to this latter topic. TEXTS: COONAN, *Principles of Metallurgy*. BRAY, *Ferrous Process Metallurgy;* CLARK *and* VARNEY, *Physical Metallurgy for Engineers*. PREREQUISITE: Mt-201(C).

Mt-203(B) PHYSICAL METALLURGY (Special Topics) (2-2). A continuation of material presented in Mt-201 and Mt-202, including a discussion of powder metallurgy, welding and casting, fatigue, properties of metals at low temperatures, and surveys of the alloys of aluminum and magnesium. TEXTS: COONAN, *Principles of Physical Metallurgy;* HEYER, *Engineering Physical Metallurgy;* CLARK *and* VARNEY, *Physical Metallurgy for Engineers;* WOLDMAN, *Metal Process Engineering*. PREREQUISITE: Mt-202(C).

Mt-204(A) NON-FERROUS METALLOGRAPHY (3-3). An expansion of material introduced in Mt-201, Mt-202 and Mt-203 with greater emphasis on the 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 equilibrium in alloy systems, the crystallography of metals and alloys, phase transformations and diffusion. The laboratory time is devoted to X-ray techniques used in metallurgical studies. TEXTS: BARRETT, *Structure of Metals;* CULLITY, *Elements of X-ray Diffraction;* RHINES, *Phase Diagrams in Metallurgy*. PREREQUISITE: Mt-202(C).

Mt-206(A) ADVANCED PHYSICAL METALLURGY (3-4). The subject matter is an extension of that offered in Mt-205(A) but is primarily concerned with dislocations and other imperfections and their influence on the physical properties of metals. TEXTS: COTTRELL, *Dislocations and Plastic Flow in Crystals;* READ, *Dislocations in Crystals*.

Mt-207(B) PHYSICS OF SOLIDS (3-0). A course for engineers intended as an introduction to the physics of solids. Topics discussed include introductory statistical mechanics, atomic structure and spectra, introductory quantum mechanics, binding and energy bands, crystal structure and imperfections in crystals. TEXT: SPROULL, *Modern Physics*. PREREQUISITE: Mt-202(C).

Mt-208(C) PHYSICAL AND PRODUCTION METALLURGY (4-2). This course covers the same material as Mt-212.

Mt-301(A) HIGH TEMPERATURE MATERIALS (3-0). A course concerned with the effect of elevated temperatures on the properties of metals, especially as related to reaction motors, guided missiles, rockets, air frames and allied components. Methods of evaluating elevated temperature performance. Development of alloys, ceramics, cermets and refractory coatings for high temperature service. TEXTS: COONAN, *High Temperature Materials* (Instructor's Notes). PREREQUISITE: Mt-202(C).

Mt-302(A) ALLOY STEELS (3-3). A thorough study of the effects of the alloying elements, including carbon, commonly used in steel making, on the characteristics of steels in the annealed, the hardened and the hardened and tempered conditions. TEXT: E. C. BAIN, *The Alloying Elements in Steel.* PREREQUISITE: Mt-202(C).

Mt-303(A) METALLURGY SEMINAR. Hours to be arranged. Papers from current technical journals will be reported on and discussed by students. TEXT: None. PREREQUISITE: Mt-203(B) or Mt-205(A).

Mt-305(B) CORROSION AND CORROSION PROTECTION (3-0). Designed for Engineering Materials Curriculum. Corrosion theories and methods of corrosion protection. TEXT: None. PREREQUISITES: Mt-202 and Ch--101 or equivalent.

Mt-307(A) HIGH TEMPERATURE STUDIES (0-3). A laboratory course designed to familiarize the student in the study of fundamentals at high temperatures. Students working in small groups will be given an opportunity to undertake some original investigation with the purpose of developing an understanding of problems involved and methods of analysis in high temperature studies of materials. PREREQUISITE: Mt-301(A) (may be taken concurrently).

Mt-401(A) PHYSICS OF METALS (3-0). A discussion of crystal chemistry and modern theories of the solid state. TEXTS: KITTRELL, *Solid State Physics;* selected references. PREREQUISITES: Mt-205(A) and either Ph-610(B) or Ph-640(B).

Mt-402(B) NUCLEAR REACTOR MATERIALS — EFFECTS OF RADIATION (3-0). A course designed for students in nuclear engineering. Includes a study of materials of reactor construction; factors in materials selection; commercially available materials; liquid metal coolants; nature of radiation damage on materials. TEXTS: *The Reactor Handbook—General Properties Materials;* FINNISTON *and* HOWE, *Metallurgy and Fuels;* DRENES *and* VINEYARD, *Radiation Effects in Solids.* PREREQUISITE: Mt-202(C), Mt-207(B), or equivalent.

Mt-501(A) WELDING METALLURGY (3-3). A study of the various materials, equipment and processes employed for joining metals by both the plastic and the fusion welding methods, and of the mechanical, electrical, and metallurgical factors essential to successful welding. TEXTS: None. PREREQUISITE: Mt-203(B).

Mt-601(B) TECHNIQUES FOR ANALYSIS AND TESTING OF MATERIALS (2-4). An introduction to some of the more advanced experimental techniques, including X-ray and gamma ray radiography, X-ray diffraction, magnetic and sonic methods, spectrography and spectrometry, activation analysis and tracer techniques and qualitative and quantitative evaluation of various physical and chemical properties. TEXT: None. PREREQUISITES: Mt-202(C) and Physical Chemistry.

METEOROLOGY

Mr-100(C) FUNDAMENTALS OF ATMOSPHERIC CIRCULATION (2-0). Primarily designed to give 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 (3-9). 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 (3-0). The equations of motion; horizontal flow; geostrophic and gradient winds; vertical variations of wind and pressure systems; kinematics of pressure systems; continuity and tendency equations; convergence and divergence in trough-ridge systems. TEXT: HALTINER *and* MARTIN, *Dynamical and Physical Meteorology.* PREREQUISITES: Mr-413(B) 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-ogenesis. 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-331(A) NUMERICAL WEATHER PREDICTION I (2-0). Dynamical analysis of simple atmospheric waves; barotropic and two level baroclinic models; automatic data processing; objective analysis; vertical motion, cloud and precipitation forecasting; hurricane trajectory forecasting; ship routing; quasi-empirical prediction models. TEXT: departmental notes. PREREQUISITES: Mr-322(A), Ma-125(B), Ma-133(A) or equivalent.

Mr-332(A) NUMERICAL WEATHER PREDICTION II (2-0). A continuation of Mr-331(A). Dynamical analysis of more complex atmospheric waves and vortices; non-divergent, non-geostrophic models; influence of latent heat and heat exchange between atmosphere and surface; numerical models of the general circulation. TEXT: departmental notes. PREREQUISITE: Mr-331(A).

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-420(B) UPPER-ATMOSPHERE PHYSICS (4-0). The atmosphere, balloon and rocket research; sounding the atmosphere by acoustic and radio techniques; the ozonosphere; aerial tides and magnetic effects; solar, magnetic and ionospheric disturbances; meteors, cosmic rays and satellites. TEXT: MASSEY *and* BOYD, *The Upper Atmosphere.* PREREQUISITES: Ph-360(B) and Ph-671(B).

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 seamounts; 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, bioluminescence, 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; MCCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* GASS, *Linear Programming;* TUCKER, *Submarine Firing Phase Decisions, USNPS Thesis.* PREREQUISITES: Ma-321(B) and Ma-322(A).

OA-141(B) FUNDAMENTALS OF OPERATIONS ANALYSIS (4-0). The role of operations analysis in the solution of military problems. Measures of effectiveness. Special techniques such as game theory and linear programming. TEXTS: MCCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* GASS, *Linear Programming;* TUCKER, *Submarine Firing Phase Decisions, USNPS Thesis;* WILLIAMS, *The Compleat Strategyst;* OPERATIONS EVALUATION GROUP, *Report No. 54, Methods of Operations Research.* PREREQUISITE: Ma-321(B).

OA-151(B) SURVEY OF WEAPONS EVALUATION (3-0). Review of probability theory with military interpretations. Sources of firing errors and their relative contributions to the 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-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;* GASS, *Linear Programming.* PREREQUISITES: OA-391(A) and Ma-196(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-196(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: 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: MORSE *and* KIMBALL, *Methods of Operations Research;* KOOPMAN, *Search and Screening;* OPERATIONS EVALUATION GROUP, *Report No. 56, Search and Screening.* 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* RAIFA, *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 prototoype 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-202(A) and OA-392(A). (The latter may be taken concurrently.)

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. Relationship to linear programming. Methods of solving two person zero-sum games. Non zero-sum and cooperative games, n-person games. Applications. TEXTS: DRESHER, *Theory and Applications of Games of Strategy;* LUCE *and* RAIFA, *Games and Decisions.* PREREQUISITES: Ma-391(C) or the equivalent and Ma-196(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-394(A), Ma-193(A) and OA-391(A). (The latter may be taken concurrently.)

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-196(A) and Ma-391(C) or equivalent.

OA-471(B) OPERATIONS ANALYSIS FOR NAVY MANAGEMENT (4-0). The nature, origin and contemporary status of operations analysis; fundamental concepts with special emphasis on applications in the fields of transportation, inventory control and personnel management. Introduction to game theory, linear programming and queueing theory. TEXTS: MCCLOSKEY *and* TREFETHEN, *Operations Research for Management, Vols. I and II;* Notes from MIT Summer Course on Operations Research, 1953; GASS, *Linear Programming;* WILLIAMS, *The Compleat Strategyst;* CHERNOFF *and* MOSES, *Elementary Decision Theory.* PREREQUISITE: Ma-371(C).

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-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: WEHR-RICHARDS, *Physics of the Atom*. PREREQUISITES: Ph-011(C), Ph-012(C) and Ph-013(C).

Ph-021(C) MECHANICS (4-0). A review and extension of the mechanics portion of first-year college physics. Statics, linear, rotational, projectile, and satellite motion, work, energy, momentum, elasticity and harmonic motion, mechanics of fluids; wave motion. TEXT: RESNICK *and* HALLIDAY, *Physics for Students of Science and Engineering*. PREREQUISITES: College physics and calculus (may be taken concurrently).

Ph-022(C) ELECTROMAGNETISM (4-0). A review and extension of the electricity portion of first-year college physics. Electric and magnetic fields, potential, current, resistance, dc circuits, dielectics and capacitance, induced electromotive force, ferromagnetism, alternating current, electrical oscillations and electromagnetic waves. TEXT: RESNICK *and* HALLIDAY, *Physics for Students of Science and Engineering*.

Ph-023(C) RADIATION (4-0). Propagation of waves; superposition, reflection, refraction, diffraction, interference, dispersion, attenuation and polarization of waves, radiation from atoms. TEXT: RESNICK *and* HALLIDAY, *Physics for Students of Science and Engineering*.

Ph-113(B) DYNAMICS (4-0). Fundamental dynamical concepts, oscillator theory, motion of a particle in two and three dimensions, motion in central fields with emphasis on atomic structure, motion of a system of particles. TEXT: SYMON, *Mechanics*.

Ph-141(B) ANALYTICAL MECHANICS (4-0). Fundamental dynamical concepts, oscillator theory, curvilinear motion in a plane, energy concepts, statics and dynamics of a rigid body. Both analytical and vector methods are used. TEXT: SYMON, *Mechanics*. PREREQUISITE: Ma-182(B). (May be taken concurrently.)

Ph-142(B) ANALYTICAL MECHANICS (4-0). Wave motion, fluid mechanics, constrained motion, Lagrange's equations. TEXT: SYMON, *Mechanics*. PREREQUISITES: Ma-183(C) (may be taken concurrently) and Ph-141(B).

Ph-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-151(C) MECHANICS I (4-0). Fundamental concepts and laws of motion, statics and equilibium, motion of a particle in a uniform field. TEXT: BECKER, *Introduction to Theoretical Mechanics.*

Ph-152(B) MECHANICS II (4-0). Oscillatory motion, motions of systems of particles, motions of rigid bodies, central force fields, accelerated reference frames. TEXT: BECKER, *Introduction to Theoretical Mechanics.* PREREQUISITES: Ph-151(C) and Ma-181(C).

Ph-153(A) MECHANICS III (4-0). Generalized coordinates, Lagrange's and Hamilton's equations, canonical transformations, coupled systems and normal coordinates, elastic media. TEXT: BECKER, *Introduction to Theoretical Mechanics.* PREREQUISITES: Ph-152(B) and Ma-182(B).

Ph-154(A) CELESTIAL MECHANICS (4-0). Solar system, missile and satellite orbits, perturbation theory, mechanical problems of space flight. TEXT: BECKER, *Introduction to Theoretical Mechanics.* PREREQUISITES: Ph-152(B) and Ma-175(B).

Ph-161(A) HYDRODYNAMICS (3-0). Euler's equation and equation of continuity; solutions to Laplace's equation and flow in potential fields. General stress-strain relations in a viscous fluid. Exact solutions to the Navier-Stokes equation. Dimensionless constants for flow similarity. TEXT: STREETER, *Fluid Dynamics.* PREREQUISITES: Ae-100(C); Ae-121(C), Ma-114(A).

Ph-162(A) ADVANCED HYDRODYNAMICS (3-0). Sphere in viscous flow,—Stokes solution, Oseen approximation. Vorticity transport equation. Prandtl boundary layer equations. Flow separation. Blasius solution for laminar boundary layer. Drag and boundary layer thickness for thin plate and for sphere. Non-steady boundary layers. Turbulent flow; Orr-Sommerfield stability equation. Transition to turbulence (experimental). Turbulent boundary layers and hydrodynamic noise. Surface waves. TEXT: SCHLICHTING, *Boundary Layer Theory.* PREREQUISITE: Ph-161(A).

Ph-190(C) SURVEY OF PHYSICS I (3-0). Elementary concepts and laws of statics and dynamics. Introduction to the statics and dynamics of fluids. Temperature, heat, radiation, kinetic theory and the gas laws. Fundamentals of vector representation and notation. TEXT: 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, dispersion, polarization. Propagation of electromagnetic waves, the radar equation. Thermal radiation, the photoelectric effect, the Bohr atom, visibility and photometry. TEXTS: SEARS, *Optics;* JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-240(C) OPTICS AND SPECTRA (3-3). Reflection and refraction of light, optical systems, dispersion, interference, diffraction, polarization. Basic atomic structure, photoelectric effect, radiation from atoms, molecules and solids. TEXTS: SEARS, *Optics;* JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-241(C) RADIATION (3-3). Fundamentals of geometric and physical optics. Wave phenomena and wave propagation. Origin of the quantum theory, photoelectric effect, radiation from atoms, molecules and solids. TEXTS: SEARS, *Optics,* JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-260(C) PHYSICAL OPTICS (3-2). Reflection and refraction of light, optical systems, dispersion, interference, diffraction, polarization. Basic atomic structure, photoelectric effect, radiation from atoms, molecules and solids. TEXTS: SEARS, *Optics;* JENKINS *and* WHITE, *Fundamentals of Optics.*

Ph-270(B) PHYSICAL OPTICS AND SPECTRA (4-2). Wave phenomena and wave propagation, dispersion, interference, diffraction, polarization, basic atomic structure, photoelectric effect, radiation from atoms, molecules and solids. TEXTS: STRONG, *Concepts of Classical Optics;* HERZBERG, *Atomic Spectra and Atomic Structure.*

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(B).

Ph-321(B) ELECTROMAGNETISM (3-0). Electromagnetic field theory; the electrostatic field, dielectrics, magnetic fields of currents; electromagnetic induction; Maxwell's Equations; plane waves. TEXT: SKILLING, *Fundamentals of Electric Waves.* PREREQUISITES: Ph-341(C) or equivalent.

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) ELECTROMAGNETISM (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(B) and EE-272(B), or equivalent.

Ph-362(A) ELECTROMAGNETIC WAVES (3-0). A continuation of Ph-361(A). Propagation, reflection and refraction of electromagnetic waves; wave guides, cavity resonators; electromagnetic radiation. TEXT: SLATER *and* FRANK, *Electromagnetism*. PREREQUISITE: Ph-361(A).

Ph-365(B) ELECTRICITY AND MAGNETISM (4-0). Electrostatics, dielectrics, magnetostatics, induced emf, magnetic materials, Maxwell's equations. TEXTS: WHITMER, *Electromagnetics and* KRAUS, *Electromagnetics*. PREREQUISITES: Ma-183(B) or Ma-172(B) and Ma-157(B) or equivalent.

Ph-366(B) ELECTROMAGNETISM (4-0). A continuation of Ph-365(B). Propagation and refraction of plane electromagnetic waves; wave guides, cavity resonators. TEXTS: WHITMER, *Electromagnetics* and KRAUS, *Electromagnetics*. PREREQUISITE: Ph-365(B).

Ph-367(A) SPECIAL TOPICS IN ELECTROMAGNETISM (4-0). A continuation of Ph-366(B). Methods of solution to Laplace's equation and Poisson's equation. Hertz potential. Radiation, scattering and dispersion. TEXT: PANOFSKY *and* PHILLIPS *Classical Electricity and Magnetism*. PREREQUISITE: Ph-366(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. Loudspeakers and microphones. TEXT: KINSLER *and* FREY, *Fundamentals of Acoustics*. PREREQUISITE: Ma-113(B) or equivalent.

Ph-432(A) UNDERWATER ACOUSTICS (4-3). A continuation of Ph-431(B). Transmission of sound in the ocean, including problems of refraction, classical and molecular attenuation, scattering, reverberation, and channel propagation. Physical principles used in sonar systems. Experiments in acoustical measurements, transducer measurements and noise analysis. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics;* NDRC, *Technical Summary*: *Principles of Underwater Sound;* OFFICER, *Sound Transmission*. PREREQUISITE: Ph-431(B).

Ph-433(A) PROPAGATION OF WAVES IN FLUIDS (3-0). A theoretical treatment of the propagation of acoustic waves in fluids including both ray and wave propagation characteristics as well as second order effects. TEXT: Instructor's notes. PREREQUISITE: Ph-432(A).

Ph-435(B) UNDERWATER ACOUSTICS (3-2). A continuation of Ph-431(B). An analytic survey of the propagation of underwater acoustic waves as influenced by boundary conditions, refraction, reverberation, and attenuation. Physical characteristics of sonar transducers. Sonar systems and developments, experimental measurements in underwater acoustics. Laboratory includes experiments in underwater acoustic measurements. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics;* NDRC *Technical Summary*: *Principles of Underwater Sound;* NDRC *Technical Summary*: *Physics of Sound in the Sea*. PREREQUISITE: Ph-431(B).

Ph-441(A) SHOCK WAVES IN FLUIDS (4-0). Simple oscillator. Hydrodynamics. Longitudinal wave equation. Propagation of acoustic waves in fluids. Propagation of explosive shock waves in fluids. Shock waves propagated from atomic explosions. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics;* COLE, *Underwater Explosions*. PREREQUISITES: Ma-183(B) and Ph-152(B).

Ph-442(A) SHOCK WAVES IN FLUIDS (3-0). Finite amplitude waves. Theory of propagation of explosive shock waves in fluids, Rankine-Hugoniot equation of shock front, scaling laws, experimental measurements of shock waves in water. Shock waves propagated from atomic explosions. TEXT: COLE, *Underwater Explosions*. PREREQUISITE: Ph-431(B).

Ph-450(B) UNDERWATER ACOUSTICS (3-2). A survey of the fundamentals of acoustics, with particular emphasis on sound radiation and transmission problems encountered in underwater acoustics. TEXTS: KINSLER *and* FREY, *Fundamentals of Acoustics; NDRC Technical Summary*: *Principles of Underwater Sound; NDRC Technical Summary*: *Physics of Sound in the Sea.*

Ph-461(A) TRANSDUCER THEORY AND DESIGN (3-3). A theoretical treatment of the fundamental phenomena inherent to the design of crystal, magnetostrictive, and ceramic sonar transducers. Characteristics and parameters of various sonar transducer systems are studied in the laboratory. TEXTS: HUETER *and* BOLT, *Sonics, NDRC Technical Summary*: *Crystal Transducers;* instructor's notes.

Ph-471(A) ACOUSTICS RESEARCH (0-3). Advanced laboratory work in acoustics. PREREQUISITE: Ph-432(A) or equivalent.

Ph-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(A) or Ma-183(B).

Ph-535(B) THERMODYNAMICS, KINETIC THEORY AND STATISTICAL MECHANICS (5-0). Equations of state, first and second laws of thermodynamics; introduction to classical and quantum statistics, including Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac Statistics. TEXT: ALLIS *and* HERLIN, *Thermodynamics and Statistical Mechanics;* Lecture Notes. PREREQUISITES: Ph-113(B) or Ph-142(B) or Ph-152(B) and Ma-113(B) or Ma-183(B) or equivalent.

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-621(B) NUCLEAR PHYSICS (4-0). A descriptive and phenomenological course including properties of nucleons, nuclear structure, radioactivity, nuclear reactions, fission, and fusion. TEXT: KAPLAN, *Nuclear Physics*.

Ph-635(B) ATOMIC PHYSICS I (5-0). Fundamental particles, kinetic theory of gases, particle-wave duality, Bohr model of the atom, Schroedinger equation, brief treatment of the operator approach to quantum mechanics, quantum mechanical solution for the hydrogen atom, transition probabilities, periodic table of the elements, quantum numbers as applied to many-electron atoms. TEXTS: SPROULL, *Modern Physics;* RICHTMYER, KENNARD *and* LAURITSEN, *Modern Physics;* Lecture notes on quantum mechanics. PREREQUISITES: Ma-181(C) and Ph-240(C).

Ph-636(B) ATOMIC PHYSICS II (4-3). Molecular structure, binding energies of molecules and solids, X-rays, diffraction and structure of crystals, band theory of solids, semiconductors, electron and nuclear spin resonance, crystal imperfections, plasticity, irradiation effects on materials, special theory of relativity. Laboratory: quantitative experiments related to the lecture material of Ph-635(B) and Ph-636(B). TEXTS: SPROULL, *Modern Physics;* RICHTMYER, KENNARD *and* LAURITSEN, *Modern Physics*. PREREQUISITE: Ph-635(B).

Ph-637(B) NUCLEAR PHYSICS I (3-0). Basic nuclear concepts, nuclear stability, static properties of the nucleus, and nuclear forces. TEXTS: HALLIDAY, *Introductory Nuclear Physics;* KAPLAN, *Nuclear Physics*. PREREQUISITES: Ph-635(B), Ph-636(B) or Ph-670(B), Ph-671(B), and Ph-365(B).

Ph-638(B) NUCLEAR PHYSICS II (3-3). A continuation of Ph-637(B). Nuclear models, dynamic properties of the nucleus, including radioactivity, nuclear reactions, and nuclear fission. TEXTS: HALLIDAY, *Introductory Nuclear Physics;* KAPLAN, *Nuclear Physics;* BLEULER *and* GOLDSMITH, *Experimental Nucleonics*. PREREQUISITE: Ph-637(B).

Ph-639(A) NUCLEAR THEORY (4-3). Nuclear forces; general theory of nuclear reactions. Application of theory to experiments. TEXTS: BLATT *and* WEISSKOPF, *Theoretical Nuclear Physics;* BLEULER *and* GOLDSMITH, *Experimental Nucleonics*. PREREQUISITES: Ph-638(B) and Ph-721(A).

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-650(A) GASEOUS DISCHARGES (4-0). Basic phenomena in gaseous discharges and infrared spectroscopy; theory of detectors for nuclear reactions. TEXTS: VON ENGEL, *Ionized Gases;* RICHTMEYER *and* KENNARD, *Introduction to Modern Physics;* Lecture notes. PREREQUISITE: Ph-640(B), or equivalent.

Ph-651(A) REACTOR THEORY I (3-0). Nuclear fission, the diffusion and slowing down of neutrons, homogenous thermal reactors. TEXT: GLASSTONE *and* EDLUND, *The Elements of Nuclear Reactor Theory;* MURRAY, *Nuclear Reactor Physics*. PREREQUISITES: Ph-640(B) or Ph-660(B), Ph-642(B), and Ma-113(B) or equivalent.

Ph-652(A) REACTOR THEORY II (3-0). A continuation of Ph-651(A). Time behavior, reactor control, reflected systems, multigroup theory, heterogeneous systems, perturbation theory. TEXTS: GLASSTONE *and* EDLUND, *The Elements of Nuclear Reactor Theory;* MURRAY, *Nuclear Reactor Theory*. PREREQUISITE: Ph-651(A).

Ph-654(A) PLASMA PHYSICS (4-0). This course is specifically concerned with the dynamics of plasmas. The dynamics of single particles in a vacuum under the simultaneous influence of electric and magnetic fields is considered first. To account for the particle interaction a stochastic term is added and the Langevin equation for the average motion of a single particle is obtained. For the description of the ensemble averages the transport equations are derived from the discussion of the Boltzmann fundamental equation. Finally the Fokker-Planck equation is studied. PREREQUISITES: Ph-144(A) or Ph-154(A), Ph-640(B), Ph-636(B) or Ph-671(B), Ph-366(B), and Ph-541(B) or Ph-535(B).

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-670(B) ATOMIC PHYSICS I (3-0). Fundamental particles, special theory of relativity, relationship between particles and waves, Bohr model of the atom, quantum mechanics from the operator approach, quantum mechanical solution for the hydrogen atom. TEXTS: RICHTMYER, KENNARD *and* LAURITSEN, *Modern Physics;* BOHM, *Quantum Mechanics*. PREREQUISITES: Ph-152(B) or equivalent, Ma-175(B) or equivalent, and Ph-270(B).

Ph-671(B) ATOMIC PHYSICS II (3-3). Radiative transition probabilities, periodic table of the elements in terms of one-electron quantum numbers, quantum mechanics of many-electron systems, X-rays, binding in molecules, electron and nuclear spin resonance. Laboratory: Quantitative experiments related to lecture material of Ph-670(B) and Ph-671(B). TEXT: RICHTMYER, KENNARD *and* LAURITSEN, *Modern Physics*. PREREQUISITE: Ph-670(B).

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-636(B), or Ph-671(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.

Ph-751(B) PHYSICS SEMINAR (1-0). Small-group discussions with thesis advisors on material pertaining to thesis work. Special lectures on topics of current interest in the field of physics.

UNITED STATES NAVAL

POSTGRADUATE SCHOOL

Catalogue for 1960-1961

THE GENERAL LINE AND
NAVAL SCIENCE SCHOOL

MONTEREY ★ CALIFORNIA

East Wing of Herrmann Hall which houses the General Line and Naval Science 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
Naval Warfare I, 1955; Naval Warfare II, 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 Commander, U.S. Navy
B.S., Auburn University, 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

WALFRED NEIL PENTINMAKI
Lieutenant Commander, U.S. Navy
A.B., University of Michigan, 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.

AMBROSE J. KINION, Commander, U.S. Navy; Instructor in Operational Planning; B.A., Univ. of New Hampshire, 1939.

ERNEST L. MEDFORD, JR., Lieutenant Colonel, U.S. Marine Corps; Marine Corps Representative and Instructor in Amphibious Operations; B.A., St. John's College, 1939.

WILLIAM ADDISON FABRICK, Commander, U.S. Navy; Head, Tactics Section; A.B., Univ. of California at Los Angeles.

WILLIAM ARNOLD, Commander, U.S. Navy; Head, Ordnance Section; B.S., Univ. of Kansas, 1940; Guided Missile School, Ft. Bliss, 1951.

GEORGE HALE GOLDSMITH, Commander, U.S. Navy; Head, Operations Section; A.B., Univ. of Alabama, 1939; Air Command and Staff College, 1953.

EDWARD GOODING GRANT, Commander, U.S. Navy; Instructor in Amphibious Operations; A.B., San Jose State College, 1940.

ROBERT P. BREWER, Commander, U.S. Navy; Instructor in Naval Aviation; A.B., University of North Carolina, 1939.

FREDRICK E. LANE, Commander, U.S. Navy; Instructor in Operational Planning

RICHARD LEE WARREN, Lieutenant Commander, U.S. Navy; Instructor in Naval Ordnance and Fire Control; B.S., USNA, 1944.

JOHN K. BOLES, Lieutenant Commander, U.S. Navy; Instructor in Communications.

MARVIN JAY COOPER, Lieutenant Commander, U.S. Navy; Instructor in Restricted Weapons.

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 & CIC; USNPS, Command Communications, 1953.

EVERTON PAUL VOSBURGH, JR., Lieutenant Commander, U.S. Navy; Instructor in ASW; B.S., USNA, 1945; B.S. USNPS, 1953.

ROBERT EUGENE WEEKS, Lieutenant Commander, U.S. Navy; Instructor in Communications; B.S., Massachusetts Institute of Technology, 1949.

CHARLES F. HICKEY, Lieutenant Commander, U.S. Navy; Instructor in Mine Warfare; B.S., USNA, 1949.

LEE S. HOUCHINS, Lieutenant Commander, U.S. Navy; Instructor in Restricted Weapons; B.S., Univ. of New Mexico, 1950.

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

DEPARTMENT OF SEAMANSHIP AND ADMINISTRATION

SAM JOHNSTON CALDWELL, Captain, U.S. Navy; Head of Department; B.S., USNA, 1939.

VERNE ELMER GEISSINGER, Commander, U.S. Navy; Instructor in Personal Affairs; A.B., Univ. of Nebraska, 1940; Naval War College, 1953.

RICHARD RODRIGUEZ, Commander, U.S. Navy; Instructor in Navigation.

ARIEL L. LANE, Commander, U.S. Navy; Instructor in Navigation.

FRED C. CULVER, Commander, U.S. Navy; Instructor in Logistics and Naval Supply; A.B., M.B.A., Univ. of Michigan, 1940; Naval War College, 1952.

CARL F. BARRON, Commander, U.S. Navy; Instructor in Meteorology; B.S., St. Louis Univ., 1941; USNPS, 1947.

WILLIAM HENRY LOCKLIN, Commander, U.S. Navy; Instructor in Navigation; A.A., San Diego Jr. College, 1942.

FLOYD D. RICHARDS, Commander, U.S. Navy; Instructor in Leadership and Administration; B.S., Central Normal College, 1942.

CHARLES O. ROBINSON, Commander, U.S. Navy; Instructor in Leadership and Administration; War College 1956-57; Management, USNPS, 1960.

DANIEL DONALD McLEOD, Lieutenant Commander, U.S. Navy, Instructor in Naval Justice; LL.B., Univ. of Arkansas, 1936.

DAN A. DANCY, Lieutenant Commander, U.S. Navy; Instructor in Seamanship; B.S., California Maritime Academy, 1943.

CARL M. DAVIS, Lieutenant Commander, U.S. Navy; Instructor in Leadership and Administration; Management, USNPS, 1960.

HUBERT C. GRIGSBY, JR., Lieutenant Commander, U.S. Navy; Instructor in Intelligence; A.B., Univ. of Southern California; 1951.

DEPARTMENT OF APPLIED ENGINEERING

WILLIAM B. PAULIN, Captain, U.S. Navy; Head of Department; B.S., UCLA, 1939; USNPS, 1950.

ARNOLD E. DOWNS, Commander, U.S. Navy; Instructor in Electricity-Electronics; B.S., S. Dakota State College, 1941; USNPS, 1950.

ARTHUR MAJOR, Commander, U.S. Navy; Instructor in Marine Engineering; B.S., USNA, 1944; A.M., Stanford Univ., 1958.

PAUL J. BARTKO, Commander, U.S. Navy; Instructor in Electricity-Electronics.

GEORGE F. ZIEGLER, Lieutenant Commander U.S. Navy; Instructor in Physics; B.S., Neward College of Engineering, 1942; B.S., USNPS, 1951; M.S., UCLA, 1952.

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.

JOHN PAUL PETERSON, Lieutenant Commander, U.S. Navy; Instructor in Damage Control.

JAMES ROLAND PAYNE, Lieutenant, Junior Grade, U.S. Naval Reserve; Instructor in Mathematics; A.B., Univ. of California, 1954; A.M., 1955.

LYNWOOD F. MAY, Lieutenant, Junior Grade, U.S. Naval Reserve; Instructor in Physics; B.S., Lewis & Clark College, 1955.

CRAIG COMSTOCK, Lieutenant, Junior Grade, U.S. Navy; Instructor in Mathematics; B.E.P., Cornell Univ., 1956.

PAUL V. GUTHRIE, JR., Ensign, U.S. Naval Reserve; Instructor in Electricity-Electronics; B.S., M.S., Univ. of Tennessee, 1959.

WILLIAM B. STAUBER, Ensign, U.S. Naval Reserve; Instructor in Mathematics; B.A., Lake Forest College, Illinois.

DEPARTMENT OF HUMANITIES

RICHARD S. GARVEY, Commander, U.S. Navy; Head of Department; Univ. of Kansas, 1938.

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.

WILLARD D. HOOT, Commander, U.S. Navy; Instructor in International Law; LL.B., Univ. of Michigan.

FRANK WILSON AVILA, Commander, U.S. Naval Reserve; Instructor in International Relations; B.S., Univ. of California at Los Angeles, 1939.

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 Science School are:

To provide instruction of about two-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 supervises the granting of advanced credit and the instruction given in all departments of the school.

Officer students enrolled in the General Line and Naval Science School are divided into sections for administrative purposes. The senior officer of each section is designated section leader with certain administrative responsibilities for the officers in his section. Each section has a member of the school staff assigned as its section advisor. The section advisor serves in the capacity of student counselor and provides a convenient link between the students and the school administration.

CALENDAR

The General Line and Naval Science School utilizes the Postgraduate School calendar which is based on five terms of ten weeks each and a two week Christmas leave period in a calendar year. The tenth week of each term is used as necessary for examinations and administrative transition to the next term.

BACHELOR OF SCIENCE CURRICULUM

The Bachelor of Science Curriculum includes the Naval Professional courses of the General Line Curriculum (described below) and, in addition, sufficient coverage in the Humanities and Science-Engineering areas to adequately support a Bachelor of Science degree.

To be eligible for enrollment an officer must have acceptable advanced standing of 75 term credit hours (equivalent to 45 semester hours) which can be applied toward completion of the prescribed course of study. From 1 to 2 calendar years are allowed for those enrolled to complete the program.

Students pursuing this curriculum will carry an average load of 17 credit hours. The total of class hours and laboratory hours should average about 20 hours per week. 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 advanced standing, is required. The 215 term hours must be distributed in the following academic areas: 118 (55%) in Science-Engineering; 54 (25%) in Naval Professional; 43 (20%) in the Humanities. A minimum of 3 terms (equivalent to one college year) 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 courses listed there, or equivalents, either before admission to the curriculum or as part of it. Furthermore, it will be necessary to satisfy a basic English and Grammar requirement through attainment of satisfactory scores on a standard examination administered on arrival. Those who fail the test will be enrolled in English Composition (HCA) without credit. Elective courses may be selected from any programs of the Engineering School, General Line and Naval Science School, or Management School to substitute for required courses for which advanced credit has been allowed so as to fulfill the total term credit hour requirements.

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 1416.1E. 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 1416.1E or its successor may be consulted for detailed information on exemptions from promotion examinations.

READING ACCELERATION

Outside instruction is available from the Speech insrtuctors for students who are slow readers. Early use of this assistance is urged for maximum benefit.

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 pages G7 - G10. 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

OFC Naval Ordnance and Fire Control	3-0
Ch001 General Chemistry I	4-3
Ma031 College Algebra and Trigonometry	5-0
HCA English Composition	3-0
HUH U.S. History II	4-0
	19-3

SECOND TERM

OOP Operational Planning	3-0
Ch002 General Chemistry II	3-3
Ma051 Analytic Geometry and Calculus I	5-0
HRW Research Writing	2-2
HSY Psychology I	3-0
	16-5

THIRD TERM

Ma052 Analytic Geometry and Calculus II	5-0
Mt002 Basic Metallurgy	4-3
Ph011 General Physics I	4-3
HEH European History II	4-0
	17-6

FOURTH TERM

OCM Operational Communications	4-0
Ma053 Calculus and Analytic Geometry	3-0
Ma081 Introduction to Vector Analysis	2-0
Ph012 General Physics II	4-3
HAP Asian Powers	4-0
	17-3

FIFTH TERM

EGM Marine Engineering	5-0
ME561 Engineering Mechanics I	4-0
Ph013 General Physics III	3-3
HSG Speech and Group Procedures	4-0
SLO Logistics and Naval Supply	2-0
	18-3

SIXTH TERM

OTC Tactics and CIC	4-2
EE021 Electrical Circuits and Machinery I	5-3
ME562 Engineering Mechanics II	4-0
HEC Economics I	4-0
	17-5

SEVENTH TERM

OAO Amphibious Operations	3-0
ORW Restricted Weapons	3-0
OMW Mine Warfare	3-0
	9-0

EIGHTH TERM

SLA Leadership and Administration	4-2
EE022 Electrical Circuits and Machinery II	5-3
Ph014 Nucleonics	4-2
HNS Organization for National & International Security	3-0
	16-7

NINTH TERM

OAA/OAV Naval Aviation	3-0
SNA Navigation I	2-2
EDC Damage Control and ABC	4-0
Es271 Electronics I	4-2
HIR International Relations	3-0
	16-4

TENTH TERM

OAS Anti-Submarine Warfare	4-0
OMS Missiles and Space Operations	6-0
SNB Navigation II	2-2
Es272 Electronics II	4-2
	16-4

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 Catalogue of the Engineering School.

COURSE DESCRIPTIONS, PREREQUISITES, AND EXEMPTIONS

OTC TACTICS AND COMBAT INFORMATION CENTER (4-2). 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 OPERATIONAL COMMUNICATIONS (4-0). Essentials of operational communications including doctrine, organization, radio and visual procedures, command responsibilities, Registered Publications System, Technical (Code 4) Publications and Communications plans. USUAL BASIS FOR EXEMPTION: (a) Completion of NAVPERS 10916, 10918, and 10760 or (b) Appropriate formal communications course or (c) Appropriate experience in communications duties.

OAA AVIATOR'S AVIATION (3-0). A study of the present-day responsibilities and problems peculiar to a squadron commander. Course includes (a) a review of applied aerodynamics, (b) responsibilities associated with personnel, material, doctrine, training, morale, public relations, and continuous education of pilots and mechanics, and (c) aviation safety. PREREQUISITE. Designation as Naval Aviator. USUAL BASIS FOR EXEMPTION: Served as Commanding Officer of a fleet squadron or a graduate of a formal Test Pilot Training Course.

OAV NAVAL AVIATION SURVEY (3-0). Organizational structure and command relationship of entire naval aviation system; research and development, procurement, testing and evaluation of naval aircraft; specific discussions based on latest material available on missions, tasks, current and projected equipment, as well as present and future employment of aircraft squadrons, carriers and seaplane tenders. USUAL BASIS FOR EXEMPTION: Extensive aviation duty.

OOP OPERATIONAL PLANNING (3-0). Purpose and procedure for the Estimate of the Situation, the Development of the Plan, and the Preparation of the Directive (OpOrder); including the preparation of each under supervision. Staff organization. The Navy Planning System. PREREQUISITE: 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. 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 weapons systems. Coordinated ASW operations are emphasized. Foreign students are offered a special course PREREQUISITE: OTC (or exempt therefrom). USUAL BASIS FOR EXEMPTION: Completion since 1956 of: Coordinated ASW Course at NORFOLK, SAN DIEGO, LONDONDERRY, or HALIFAX, or ASW Officer or CO/XO Anti-Submarine Course at Fleet Sonar School.

OAT ADVANCED TACTICS (3-0). A survey of the status of fleet readiness and future concepts in various tactical fields, followed by student reports and seminars on selected Fleet and Intertype Exercises. PREREQUISITE: OTC (or exempt therefrom).

OFC NAVAL ORDNANCE AND FIRE CONTROL (3-0). A survey of the fields of surface and airborne ordnance including guns, bombs, rockets, and associated delivery systems. A discussion of the elements of present fire control systems, including computers, radar, and designation systems. An analysis of the capabilities and limitations of both present fire control systems and some proposed systems, both surface and airborne, from the standpoint of weapons systems evaluation and employment. A special course, OFC(F), (3-0) is offered for foreign students. USUAL BASIS FOR EXEMPTION: Completion of USNA, NROTC, or equivalent courses in naval ordnance and fire control and service experience in these fields.

OMW MINE WARFARE (3-0). Fundamentals of Mining Operations including mines, mine laying agents and mining planning; Principles of Mine Countermeasures Operation and Planning; new developments. A special course OMW(F) (3-0), substituting Harbor Defense considerations for Mining Problems is offered to Foreign Students. 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, operational capabilities and limitations of guided missile systems. Orientation in space technology, problems and potentialities of operations in outer space. A special course OMS (F) (3-0) is offered to Foreign Students. USUAL BASIS FOR EXEMPTION: Equivalent experience or educational background.

SMN SEAMANSHIP (3-0). The fundamentals of seamanship as applicable to the responsibilities and duties assigned to the naval officer on board ship. Included topics: duties of the officer of the deck; the deck log; international and inland rules of the road including pertinent court interpretations; ship-handling in conformance with the rules to avoid collision and in anchoring, mooring, towing and emergency procedures; replenishment at sea; duties of the first lieutenant; cargo handling and stowage.

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, OCS or equivalent course; 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, OCS or equivalent course 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). The vital importance of naval logistics to operational readiness, logistic problems at the Commanding Officer level, the fundamental steps in the logistics process, and the Navy's systems for providing logistic support to the operating unit. Topics covered include: determination of requirements, procurement, and distribution as steps in the logistics process; the organization and planning aspects of logistics administration; the Navy Supply System; the Navy petroleum supply system; the Navy Personnel Distribution System; the military transportation system; funding; the role of bases, mobile support, and the operating unit in naval logistics; and logistics management at the operating unit level. USUAL BASIS FOR EXEMPTION: Completion of the 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 its Naval Supplement. Topics include: jurisdiction; preparation of charges and specifications; offenses commonly triable by special and summary courts-martial; and the rules of evidence.

SJB NAVAL JUSTICE II (3-0). Application of the fundamentals presented in SJA. Topics include: non-judicial punishment; investigations; courts of inquiry; summary and special courts-martials. Moot courts are used to demonstrate preparatory, courtroom and review procedures.

SNI NAVAL INTELLIGENCE (3-0). An overview of intelligence for naval officers and the setting within which naval intelligence functions. Included topics: nature of intelligence; development of modern intelligence; the role of intelligence in planning national policy and military strategy; the rise of Russia and Communism as international forces; the intelligence cycle, including the line officers role in intelligence collection; employment of intelligence by operational commanders; counter-intelligence.

SAF PERSONAL AFFAIRS (3-0). The fundamentals of life estate planning. Included topics: government benefits; life insurance programming; insurance; budgeting and banking; real estate; investments; wills and related legal matters. TEXT: COHEN and HANSON: *Personal Finance.*

EPA SURVEY OF PHYSICS I (3-0). An introduction to the fundamental concepts of statics and dynamics. Includes Newton's Laws of motion, force, energy, momentum and circular motion. Vector addition and resolution of forces are also presented. USUAL BASIS FOR EXEMPTION: Equivalent educational background. TEXT: WHITE: *Modern College Physics* 3rd Ed.

EPB SURVEY OF PHYSICS II (3-0). A continuation of EPA. A survey of wave propagation, sound, temperature, heat, gas laws, the properties of light, and the science of color. USUAL BASIS FOR EXEMPTION: Equivalent educational background. TEXT: WHITE: *Modern College Physics* 3rd Ed.

EEF ELECTRICAL FUNDAMENTALS (4-0). A presentation of basic electrical phenomena. Topics include: DC circuits and components, magnetism, electromagnetism, instruments, AC circuits and components, resonance, transformers, batteries, and power sources. TEXT: HICKEY and VILLINES: *Elements of Electronics.*

ERF ELECTRONICS FUNDAMENTALS (4-0). A qualitative approach to the fundamentals of electronics. Topics include: vacuum tubes, gas-filled tubes, cathode ray tubes, transistors, rectifiers, amplifiers, oscillators, modulators, detectors, receivers, transmitters, antennas and propagation. USUAL BASIS FOR EXEMPTION: Equivalent educational background. TEXT: HICKEY and VILLINES: *Elements of Electronics.* PREREQUISITES: EEF or equivalent.

ENF NUCLEONICS FUNDAMENTALS (3-0). A study of atomic structure, natural and artificial radioactivity, nuclear structure, nuclear fission, and chain reaction. Introduction to reactor principles, reactor components, and nuclear power plants. USUAL BASIS FOR EXEMPTION: Equivalent educational background. TEXTS: HOISINGTON: *Nucleonics Fundamentals* and NAVPERS 10786: *Basic Nuclear Physics.*

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 equivalent.

EEM ELECTRICAL MACHINERY (4-1). The fundamentals and applications of electrical machinery. Topics include: external characteristics of shunt and compound generators; shunt, series and compound motors; alternators; induction and synchronous motors; parallel operation of alternators and generators. Laboratory testing and demonsstrations are utilized. TEXT: DAWES: *Industrial Electricity, Parts I and II.* PREREQUISITE: EEF or equivalent.

EMT MATERIALS OF ENGINEERING (4-0). A rapid survey of basic physical metallurgy of both ferrous and nonferrous metals, with emphasis placed on their engineering application; followed by a survey of fuels, lubricants, plastics and special problems involving fiber glass reinforcing. TEXTS: COONAN: *Principles of Physical Metallurgy,* KINNEY: *Engineering Properties and Applications of Plastics.*

EGM MARINE ENGINEERING (5-0). Shipboard steam main propulsion plants and auxiliaries, gas turbines, shipboard electrical distribution, miscellaneous naval auxiliary machinery, and organization and administration of shipboard engineering department. USUAL BASIS FOR EXEMPTION: Qualification as Engineering Officer of the Watch of a steam-propelled ship.

EDC DAMAGE CONTROL AND ATOMIC, BIOLOGICAL, CHEMICAL WARFARE DEFENSE (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; disaster control ashore. PREREQUISITE: ENF or equivalent. 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).

HEC ECONOMICS I INTRODUCTION TO ECONOMICS (4-0). An introduction to the principles of economic relationships and the functioning of an economic system.

HCB ECONOMICS 101 INTERMEDIATE ECONOMICS (4-0). The technique and principles of intermediate economic theory and analysis, including value, distribution, national income and economic dynamics. Prerequisite: ECONOMICS I.

HCA ENGLISH I COMPOSITION No Credit. A review of the basic principles of grammar and writing including student preparation of papers.

HRW ENGLISH 101 RESEARCH WRITING (3-0). An analysis and application of the techniques of research writing. A research paper will be required.

HCC ENGLISH 102 EXPOSITORY LOGIC (3-0). A study of the elementary principles of symbolic and expository logic to develop clear thinking and proof in the presentation of ideas.

HHA HISTORY 101 U. S. HISTORY 1763-1865 (4-0). The development of the Federal Union from the American Revolution to the end of the Civil War.

HUH HISTORY 102 U. S. HISTORY 1865-present (4-0). The development of the American nation from the reconstruction crisis to the present.

HEH HISTORY 104 EUROPEAN HISTORY 1919-present (4-0). The international, internal, and military development of the major European states since World War II.

HLA LITERATURE I APPRECIATION OF LITERATURE (4-0). An introduction to the understanding and enjoyment of literature expressing the enduring problems of mankind. Style and structure will be considered as well as content.

HLB LITERATURE 2 APPRECIATION OF LITERATURE (3-0). A continuation of LITERATURE I, with a brief examination of genres and periods of literature.

HLC LITERATURE 101 MASTERPIECES OF AMERICAN LITERATURE (3-0). A study of those ideas which have shaped American cultural life and reflect American thinking.

HLD LITERATURE 102 MASTERPIECES OF BRITISH LITERATURE (3-0). A study of the significant ideas of selected British thinkers as they pertain to social and cultural life.

HPA POLITICAL SCIENCE 101 U. S. GOVERNMENT (4-0). A study of the structure and powers of the Federal Government, its relation to the individual states, and its military aspects.

HNS POLITICAL SCIENCE 102 ORGANIZATION FOR NATIONAL AND INTERNATIONAL SECURITY (3-0). The factors of power, geopolitics, national security; the evolution, structure, organization and functions of the organs and agencies for U. S. national defense, the United Nations, and regional organizations.

HAD POLITICAL SCIENCE 103 AMERICAN DIPLOMACY (3-0). An analysis of the major problems of United States foreign relations in Europe, Latin America, and the Far East from 1900 to the Korean conflict.

HAP POLITICAL SCIENCE 104 ASIAN POWERS (4-0). The international, internal, and military problems of the major Asian and Southeast Asian states, exclusive of Communist China.

HIR POLITICAL SCIENCE 105 INTERNATIONAL RELATIONS (3-0). A study of the nation-state system, the forces making for conflict, adjustment, and harmony, with emphasis on nationalism, imperialism, war, and diplomacy. Prerequisite: POLITICAL SCIENCE 102.

HIL POLITICAL SCIENCE 106 INTERNATIONAL LAW (5-0). A survey of the basic principles of International Law with emphasis on jurisdiction and the rules of warfare. Case and problem discussions.

HPG POLITICAL SCIENCE 107 MIDDLE EAST AND AFRICA (3-0). A study of the states and regions of the contemporary Middle East and Africa with emphasis on the rise of nationalism and concomitant individual, regional, and international problems, aspirations and objectives.

HPJ POLITICAL SCIENCE 110 THEORY AND PRINCIPLES OF INTERNATIONAL RELATIONS (3-0). A seminar in the scope and theories of International Relations and techniques of research in the field; the analysis of problems.

HPL POLITICAL SCIENCE 112 SINO-SOVIET BLOC (4-0). An analysis of the international relations of Communist China, Soviet Russia, and their respective satellites with emphasis on their military significance to the United States.

HPN POLITICAL SCIENCE 114 AMERICAN TRADITIONS AND IDEALS (3-0). The traditions, ideals and values of our civilization and the role of the military in implementing the image of America in the world. Prerequisite: HISTORY 101 OR 102.

HSY PSYCHOLOGY I INTRODUCTION TO PSYCHOLOGY (3-0). A survey of principles underlying human behavior with emphasis on the application of these principles to human relations and problems of social adjustment.

HYB PSYCHOLOGY 101 APPLIED PSYCHOLOGY (3-0). A study of group dynamics, rating procedures, criminology, and personality formation and adjustment. Individual projects are assigned. Prerequisite: PSYCHOLOGY I.

HSG SPEECH I SPEECH AND GROUP PROCEDURES (4-0). Practice in speech fundamentals with student participation through presentations and the conference method.

HSB SPEECH 101 ADVANCED SPEECH (2-0). A study through practice of techniques in obtaining desired audience response. Prerequisite: SPEECH I.

HDS UNDESIGNATED 199 (1-0)-(3-0). Independent study in Social Science and Humanities subjects in which formal course work is not offered. Prerequisite: Permission of the Head of Department.

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
NAVAL WARFARE DEPARTMENT						
Aviator's Aviation	OAA	3	0	3	Exemptive	Inapplicable
Naval Aviation Survey	OAV	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
Operational Communications	OCM	4	0	4	Exemptive	Exemptive
Naval Ordnance and Fire Control	OFC	3	0	3	Exemptive	Inapplicable
Missiles and Space Operations	OMS	6	0	6	Exemptive	Elective
Mine Warfare	OMW	3	0	3	Exemptive	Inapplicable
Operational Planning	OOP	3	0	3	Exemptive	Elective
Restricted Weapons	ORW	3	0	3	Exemptive	Elective
Tactics and Combat Information Center	OTC	4	2	5	Exemptive	Inapplicable
SEAMANSHIP AND ADMINISTRATION DEPARTMENT						
Personal Affairs	SAF	3	0	3	Elective	Elective
Naval Justice I	SJA	3	0	3	Elective	Exemptive
Naval Justice II	SJB	3	0	3	Elective	Exemptive
Leadership and Administration	SLA	4	2	5	Exemptive	Exemptive
Logistics and Naval Supply	SLO	2	0	2	Elective	Exemptive
Meteorology	SME	3	0	3	Elective	Elective
Seamanship	SMN	3	0	3	Elective	Elective
Navigation I	SNA	2	2	3	Exemptive	Inapplicable
Navigation II	SNB	2	2	3	Exemptive	Inapplicable
Naval Intelligence	SNI	3	0	3	Elective	Exemptive
APPLIED ENGINEERING DEPARTMENT						
Damage Control and ABC Warfare Defense	EDC	5	0	5	Exemptive	Elective
Electrical Fundamentals	EEF	4	0	4	Exemptive	Inapplicable
Electrical Machinery	EEM	4	1	4½	Elective	Inapplicable
Marine Engineering	EGM	5	0	5	Exemptive	Inapplicable
Materials of Engineering	EMT	4	0	4	Elective	Inapplicable
Nucleonics Fundamentals	ENF	3	0	3	Exemptive	Elective
Marine Nuclear Propulsion	ENP	2	0	2	Elective	Inapplicable
Survey of Physics I	EPA	3	0	3	Exemptive	Inapplicable
Survey of Physics II	EPB	3	0	3	Exemptive	Inapplicable
Electronics Fundamentals	ERF	4	0	4	Exemptive	Inapplicable
Basic Algebra and Trigonometry I	Ma010	3	0	3	Exemptive	Inapplicable
Basic Algebra and Trigonometry II	Ma011	3	0	3	Elective	Inapplicable
Algebra and Trigonometry Refresher	Ma015	3	0	3	Exemptive	Inapplicable
Survey of Analytic Geometry and Calculus	Ma050	4	0	4	Elective	Inapplicable
HUMANITIES DEPARTMENT						
International Law	HIL	5	0	5	Elective	Exemptive
International Relations	HIR	3	0	3	Elective	Exemptive
Organization for National and International Security	HNS	3	0	3	Elective	Exemptive
Speech and Group Procedures	HSG	4	0	4	Exemptive	Exemptive

UNITED STATES NAVAL

POSTGRADUATE SCHOOL

Catalogue for 1960-1961

THE MANAGEMENT SCHOOL

MONTEREY ★ CALIFORNIA

Root Hall which houses the Reference and Research Library, the Management School, and some of the Engineering School offices and classrooms.

THE MANAGEMENT SCHOOL

Director
HERBERT HENRY ANDERSON
Captain, U.S. Navy
B.S., USNA, 1941
M.B.A., Harvard Univ. 1953
National War College, 1958

Administrative Officer
MABEL MARIE STOCKERT
Commander, U.S. Navy
A.B., Capital University, 1931
M.B.A., George Washington Univ., 1956

Academic Chairman
WILLIAM HOWARD CHURCH
(1956)*
A.B., Whittier College, 1933
M.S.P.A., Univ. of Southern California, 1941

FACULTY

APPLIED MANAGEMENT

WILLIAM HOWARD CHURCH, Professor of Management (1956); A.B., Whittier College, 1933; M.S.P.A., Univ. of Southern California, 1941

HERMAN PAUL ECKER, Professor of Management (1957); A.B., Pomona College, 1948; A.M., Claremont Graduate School, 1949.

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.

FINANCIAL MANAGEMENT

JACOB HUGH JACKSON, JR., Professor of Management (1957); A.B., Stanford Univ., 1939; M.B.A., 1947.

INDUSTRIAL MANAGEMENT

JOHN DAVID SENGER, 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.

MATERIEL MANAGEMENT

OSCAR RICHARD BLANTON, Commander, SC, U.S. Navy; B.S., Ohio State Univ., 1942; M.B.A., Stanford Univ., 1952.

*date in parenthesis indicates year of joining the Postgraduate School faculty.

MISSION

The mission of the Navy Management School is to provide graduate education for Naval officers in the theories, philosophies, and application of scientific methods of Management in order to advance efficiency and economy of operation in the Navy, afloat and ashore.

TASKS

The tasks assigned the Navy Management School are:

1. To conduct an educational program in Management at the graduate level for Naval officers.
2. To conduct for Naval officers a basic survey course of six weeks duration in the summer term in the Elements of Management.
3. To act as host for Bureau and Office sponsored workshop seminars in Management in conjunction with the "Elements of Management."

PROGRAMS

The Navy Management Course

The Navy Management Course is a ten months course at the graduate level which leads to the degree, Master of Science in Management. The course convenes once yearly commencing in August. The curriculum is under the direction of a faculty composed of civilian and Naval officer instructors selected to represent the optimum combination of specialized knowledge and diversity of management experience.

The purpose of education in management is to broaden the officer's scope of learning in order that he may enhance his ability to organize, plan, direct, coordinate, and control activity in which he, through the leadership of people, combines the resources of money and materials to accomplish the Navy's objectives. The Naval officer, commander or executive, is continuously concerned with promoting his organization and determining its objectives, with the consideration of the means to these ends, and with the implementation of his decisions through appropriate delegation of duties and the effective motivation of those personnel concerned.

In fulfillment of these demands upon the Naval officer, the Navy Management Course has the following objectives:

1. To develop comprehensive understanding by the officer of management of the Navy in the operating forces and the shore establishment.

2. To develop a sound appreciation by the officer for the interaction of the Navy's mission with public and defense policies.

3. To cultivate the habits of analysis for determination of pertinent facts, of reasoned decision making, and of imaginative thinking in the development of alternative courses of action.

4. To provide the officer with the quantitative tools of analysis and to foster the use of scientific method in management functions.

5. To encourage the officer in the development of ethical standards for professional and personal use.

6. To develop an appreciation for the human factor in the realization of organizational objectives.

The curriculum is structured to require all officers, regardless of code designator, to participate in the required "core" courses. These courses provide the foundation and tools of Management and lead into the electives. The elective system offers moderate flexibility to meet the interests of the individual officer and provides limited specialization in fields of interest to the various supporting agencies. Under present limitations of scheduling and course offerings, elective courses are not offered in the first and second terms.

Instruction is conducted by classroom lecture, case study, and seminar discussion. Throughout, the course stresses development of the officer's ability in problem solving and in expressing his thoughts concisely and meaningfully in oral and written work.

The classroom instruction program is supplemented by a special lecture series wherein the officer has the opportunity to hear discussion of Management topics by Flag Officers of the military services, business executives, and educators of comparable rank from the civilian community. Additionally, speakers from civilian and military activities are scheduled at appropriate times to augment the classroom instruction in various technical and specialized areas.

Through the medium of field trips, usually of two to three days duration, the officer is afforded the opportunity of discussing management philosophy and problems with leading executives in their own environment. Visits are made to military and civilian installations for this purpose.

Officers assigned to the Navy Management Course must possess a baccalaureate degree or the equivalent, and should have already demonstrated a high degree of potential for growth and executive responsibility.

Requirements for the Master of Science Degree in Management

1. The Master's Degree in Management is awarded upon the successful completion of a curriculum which complements either the general or scientific education of a student and which has been approved by the Management School Academic Council as meriting a degree, provided the student exhibits superior scholarship and meets the additional requirements stated in the following paragraphs:

a. The Management School will admit no officer to candidacy for the Master's Degree who does not possess a Bachelor's Degree, or its equivalent, from an accredited institution.

b. Since the Management Curriculum consists solely of courses at the graduate level, the minimum residence requirement of one academic year (four terms) at the Management School shall be in effect.

c. A curriculum leading to a Master's Degree shall comprise not less than 57 term hours (38 semester hours) of work that is clearly at the graduate level.

d. To be eligible for the Master's Degree, the student must attain a minimum average quality point rating of 2.0. In special cases, under very extenuating circumstances, small deficiences may be waived at the discretion of the Academic Council.

e. As a part of the academic requirements for the Master's Degree or Certificate of Completion, each candidate will be required to submit a scholarly research paper in each of the four major areas of management; namely, Financial Management, Industrial Management, Materiel Management, and Organization and Management.

f. Master's Degree candidates, upon successful completion of all course requirements, will be required to take a comprehensive written examination covering the four functional areas listed; such examination to be approximately 8 hours in length.

2. 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 student's performance termed the Quality Point Rating (QPR). A student achieving a QPR of 2.0 has maintained a B average in all courses.

3. With due regard for the requirements contained in paragraph 1 above, the Academic Council of the Management School will decide whether or not to recommend the candidate to the Superintendent of the U.S. Naval Postgraduate School for the award of the Master's Degree or a Certificate of Completion.

4. In accordance with Public Law 303 of the 79th Congress, and the regulations prescribed by the Secretary of the Navy, the Superintendent is authorized to confer Master's and Doctor's 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 Course "Elements of Management"

This course is of six weeks duration, presented once a year in June and July. It is a basic survey course in Management designed for officers attending the Engineering School of the U.S. Naval Postgraduate School. It is also of value for selected officers who may be sponsored by Bureaus and Offices of the Naval Establishment, and who will be attending the workshop seminars.

The curriculum is designed to:

1. Acquaint the officer with the principles of management and administration.

2. Examine current problems of management within the Naval Establishment and general approaches to the solution of these problems.

3. Familiarize the officer with the modern practice and method of management in civilian activities with emphasis on relationship to their applications within the Naval Establishment.

No special preparation or qualification for this course is required. A certificate is awarded upon completion of the course.

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 excellent base for further discussion of special problems.

TABLE I

NAVY MANAGEMENT CURRICULUM (10 MONTHS)

No.	*Course Title*	*Hours*
	REQUIRED COURSES	
Mn-400	*Research Methods	0
Mn-441	Organization and Management	45
Mn-442	Human Relations	30
Mn-443	Business and Government	45
Mn-444	Management Economics	45
Mn-445	Personnel Administration and Industrial Relations	45
Mn-446	Management Policy	60
Mn-447	Industrial Management	45
Mn-448	Financial Management I and II	75
Mn-449	Materiel Management I and II	45
Mn-470	Quantitative Methods and Automatic Data-Processing	45
	SUB-TOTALS	
	REQUIRED COURSES	480
	ELECTIVE COURSES	135
	TOTAL	615

*Student must demonstrate acceptable proficiency in oral and written presentation. Formal instruction consists of indoctrination lecture and printed guidance materials.

	ELECTIVE COURSES	
Mn-450	Individual Study Seminar	30-45
Mn-451	Organization and Management Seminar	30
Mn-455	Personnel Administration Seminar	30
Mn-456	Advanced Cost Accounting	30
Mn-457	Auditing	30
Mn-458	Military Comptrollership Seminar	45
Mn-460	Logistics	45
Mn-461	Procurement and Contract Administration	30
Mn-462	Scientific Inventory Management	30
Mn-464	Facilities Planning	45
Mn-465	Advanced Production Problems	45
Ma-371	**Management Statistics	30
Ma-471	**Electronic Data-Processing and Management Control	30
OA-471	**Operations Analysis for Navy Management	30-45

**Courses are described in Engineering School Catalogue and presented by Mathematics Department.

1. Students may take 135 hours of electives.

2. Term Reports — Four written reports on approved topics or problems will be required during the course — one paper in each term. Term papers will be in each of the following major areas: Financial Management, Industrial Management, Materiel Management, and Organization and Management (paper required in the 4th term).

TABLE II

COURSE "ELEMENTS OF MANAGEMENT" (Six Weeks)

Course Content	*Total Hours*
Principles of Organization and Management	15
Production Management	15
Financial Management	15
Contract Administration and Materiel Management	15
Personnel Management and Human Relations	15
Management Economics	15

COURSE DESCRIPTIONS

Mn-400 *RESEARCH METHODS (0-0)

Objective—To enhance the Naval officer's skill in the drafting and preparation of management reports. To develop familiarity with source and reference materials in the preparation of reports or studies and to develop methodical research techniques.

Description—In conjunction with a review of report writing and oral expression, officers are required to prepare reports with the view to achieving clear, concise, reasoned, and meaningful presentations. Problems on topics will be selected in the several management study areas. The reports will be critiqued on their substantive quality, logical development, and quality of the presentation. Oral presentation with opportunity for use of graphics and visual aids will be periodic and frequent in classroom and seminar discussions.

Mn-441 ORGANIZATION AND MANAGEMENT (4.5-0)

Objective—This course serves as a general introduction to the study of management. The goal is to stimulate a lasting interest on the part of the officer in a philosophy of management which will make a permanent contribution toward improving the overall effectiveness, efficiency, and economy of the Naval Establishment. With this end in view, military, governmental, commercial, and philanthropic organizations are studied in order to develop generalizations aimed at improving the administration of the Navy consistent with national goals and objectives.

Description—The practice of management is a unique combination of both art and science. Both aspects of administration are studied. Primary emphasis is placed on the utilization of the results of empirical research in the social and behavioral sciences to the practical problems of organization and administration encountered by the Naval officer. In addition, the officer reviews a cross section of the literature on the art of management and studies the application of knowledge to actual situations through the use of the case method. The analysis of the role of the professional manager in the large organization is followed by a discussion of value and fact in administration. The study of formal organization includes policy, operations and control, span of control, authority and responsibility, methods of organizing, and comunication. Informal organization includes such topics as primary relations, leadership, and motivation. The basic decision making processes are analyzed and various administrative techniques are evaluated. The comparative aspects of administration are emphasized to enable the Naval officer to manage effectively, efficiently, and economically wherever he may be stationed during his military career.

Mn-442 HUMAN RELATIONS (3.0-0)

Objective—To direct attention to that area of management practice that concerns itself with the integration of people into a work situation in a way that motivates them to work together productively, cooperatively, and with economic, psychological, and social satisfaction. To develop an appreciation of the human factor in management and the leadership principles that aid in overcoming communication barriers, preventing misunderstandings, and developing the constructive side of man's nature.

Description—The development and growth of human relations practices and experiences in the military and private industry are discussed. The political, social, economic, and psychological factors involved in human relations and their relationship to our American way of life are analyzed.

Attention is given to the basic elements of human growth and development; the habits, attitudes, feelings, and emotions that affect human nature. Management's responsibility for abnormal behavior is also considered.

The importance of motivation and morale is stressed. The relationship of communication to organizational effectiveness and the elements and qualifications of effective leadership are evaluated.

Mn-443 BUSINESS AND GOVERNMENT (4.5-0)

Objective—To acquaint the Naval officer with the role of government and to discuss the scope and growth of government planning and control of industry, resources, prices, banking, and business fluctuations. To acquaint the student with the operation, administration and coordination of legislative, judicial, and executive branches of the government. To examine the interrelationships of the various executive departments and agencies and their roles in the formulation of public and defense policies.

Description—The course will cover the public policies of the national government as they affect the economic, political, and social order; the increasing importance of the role of government in our society and the responsiveness of national government to competing claims of various interest groups. Careful examination will be given to the legislative process including the roles of committee hearings and investigations, and the role of interest groups and lobbies. Study will be made particularly of defense policy, its effect upon the Navy, and the budgetary process in the formulation of the National Strategy. The roles of the various regulatory agencies and commissions will be examined for their interactions with the Defense and other executive departments of the government. Students will be expected to analyze legislative, administrative, judicial, and executive aspects of current political and economic questions such as defense mobilization, conservation, labor-management relations, public housing, health, security, and government organization.

Mn-444 MANAGEMENT ECONOMICS (4.5-0)

Objective—To analyze the nature and the prospects of the American economic system, how our private enterprise system has been able to achieve high productivity and living standards. To consider the problems of economic stability, progress, growth, and opportunity in a free society.

Description—The course concentrates on the principal problem areas in economics such as productivity, unemployment, fluctuating prices, competing economic systems, and the maintenance of the four distinguishing features of our economic system, namely; private property, freedom of enterprise, freedom of contract, and freedom of consumer choice.

The nature of a capitalistic society and American modifications are studied. The necessity for efficient resource use and expanding productivity in relation to the defense effort is considered. The role of money, the determination of income and national product, the value of money and the price level, government fiscal and monetary policy are explored. International economics and economics of war and defense are evaluated. Studies are made of social goals and economic institutions of communism, capitalism, and socialism.

Mn-445 PERSONNEL ADMINISTRATION AND INDUSTRIAL RELATIONS (4.5-0)

Objective—To provide the Naval officer with basic information on applicable personnel management principles and sound practices in use by business and government; to provide a background in statutes and regulations affecting personnel administration to the end that officers may be effective in the direction and control of civilian and military personnel, and to promote harmonious inter-personal 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 military and Civil Service personnel. The procurement, classification, and utilization of personnel are examined, with emphasis on current problem areas, e.g., problems of discipline involving demotion or dismissal together with related personnel procedures of transfer or promotion. Motivation of personnel, techniques for improvement of individual and group performance, and the evaluation of performance are discussed. The background of and the regulations covering the administration of Civil Service personnel are examined. Throughout the course comparisons are made between the personnel management techniques of the military services and of civilian industrial organizations.

Mn-446 MANAGEMENT POLICY (4.0-0)

Objective—To develop and/or increase ability of the officer to analyze and to synthesize the important factors in management situations to the end that the military executive may maximize his contribution to the successful attainment of vital military and managerial objectives.

Description—The course is directed at the viewpoint of the higher levels of management and is designed as the coordination point of all offerings in Navy Management. The officer, throughout the course, is encouraged in the decision process to the end that he will achieve reasoned and responsible decisions. The emphasis will be on typical management problem analysis and policy formulation. In this action process, the officer will be expected to appraise situational problems, define objectives, develop realistic plans with control devices suitable to measure progress as plans are implemented. The dynamics of organizational structure and the human element under changing conditions and environment are considered as well as the short and long term implications of planning on operations. The course will make use of topical problems and case studies drawn from Navy, Defense, and civilian sources.

Mn-447 INDUSTRIAL MANAGEMENT (4.5-0)

Objective—To present the planning and control techniques which will help the officer in drawing up courses of future action and aid him in maintaining intimate contact with the performance of his organization without excessive monitoring. To familiarize the officer with analytical and problem solving techniques useful in improving the effectiveness of his operation.

Description—Such concepts as standardization, performance measurement and control are studied. Techniques including production planning, scheduling and control, quality control, methods analysis, work measurement, layout, materiels handling, capital equipment replacement analysis, and facilities planning are examined. Necessary modification of these concepts and techniques for their application within the military environment is discussed.

Mn-448 FINANCIAL MANAGEMENT I and II (7.5-0)

Objective—To promote in all Naval officers a better understanding of financial management as a part of executive control and to further the utilization of financial management, method, and technique of the Navy in the administration of command.

Description—Introduces the concept of comptrollership and its utilization in the Navy; studies the application of accounting principles in industry; surveys cost accounting including cost budgeting and standard costs; covers the concept and application of the Naval Industrial Fund; surveys accounting for appropriated funds in the Navy; portrays the relationship of Navy budgeting to the national economy; develops the budget process and the estimating and justifying of Navy budgets; surveys the nature of appropriations, apportionment, allocations, and the administration of funds; introduces the concept of audit and the Navy internal audit program.

Mn-449 MATERIEL MANAGEMENT I and II (4.5-0)

Objective—To familiarize the Naval officer with the broad concepts of materiel management so that participants may relate these concepts to their future assignments and further to develop the ability of the Naval officer to solve major administrative problems in this field.

Description—This course presents the broad aspects of materiel planning, requirements determination, distribution and control, and their relation to the field of logistics. The importance of the materiel function and its influence upon military strategy is stressed. Problems of inventory management and the Navy's organization structure for managing its vast investment in materiel is critically reviewed in terms of its effectiveness for accomplishing assigned missions.

Mn-450 INDIVIDUAL STUDY SEMINAR (3-4.5-0)

Objective—To provide the officer of outstanding scholastic record with the opportunity to pursue individual study in the field of management.

Description—The Individual Study Seminar consists of individual work adapted to the needs and interests of qualified students and carried out under the direction of a faculty advisor. The officer will be expected to concentrate his research and study in an area that will be of benefit to management within the Navy.

A scholarly paper is required as evidence of proficiency in the area studied.

Mn-451 ORGANIZATION AND MANAGEMENT SEMINAR (3.0-0)

Objective—To direct attention to organizational changes necessitated by changing objectives, new concepts, and new programs. To inquire into the managerial problems associated with changing programs and to examine management approaches used in successfully adapting to change. To explore areas and opportunities for improvements in management practice, methodology, and philosophy.

Description—Studies are made of organizations and organizational units of industry, defense, and the Navy. Surveys are made of activities engaged in research and development and new advanced programs to examine the near and long term objectives, the planning phases, the organizational structure, the advanced managerial method, and techniques. Problems in staffing are discussed. Problems of reorganization in government and private industry are studied to develop the factors initiating change in organizational structure and management method. The organization of the Defense Department and Department of the Navy will be reviewed and analyzed in the light of stated objectives.

Mn-455 PERSONNEL ADMINISTRATION SEMINAR (3.0-0)

Objective—To provide the Naval officer with the opportunity for more intensive study of specific areas in the broad fields of personnel administration and industrial relations, while developing his ability to perform individual research and present his findings in a conference atmosphere.

Description—A combination of case method and individual student presentation in specialized study areas is utilized. Officer students participate in discussions and presentations on such facets of personnel administration as: promotions, evaluation of performance, supervisory development, incentive programs, utilization of personnel, conditions leading to turnover of personnel, testing and classification, and military-civilian relationships.

Mn-456 ADVANCED COST ACCOUNTING (3.0-0)

Objective—To increase the Naval officer's background in cost control through problem solving and philosophical development to the point of practical application of cost principles in any operating situation.

Description—Further develops the concepts and allocation of cost, fixed versus variable cost, cost and operating budgets, flexible budgets, standard cost accounting and variance analysis, applications of cost accounting for control, and utilization of cost accounting by the military organizations.

Mn-457 AUDITING (3.0-0)

Objective—To develop the philosophy of management control through audit and the technique of audit procedure to the point of practical application in the military services.

Description—Further develops the concepts of and organization for audit, audit programs and reports, comprehensive and functional audits, utilization of audit for control, and the military applications of audit.

Mn-458 MILITARY COMPTROLLERSHIP SEMINAR (4.5-0)

Objective—To thoroughly familiarize the Naval officer in the principles, philosophy, and methods of financial management necessary to organize for and effectively administer accounting, auditing, budgeting, and financial reporting activity in its proper relationship to command.

Description—Consists of lectures, directed reading, presentations by practicing experts, student seminar discussion, and a term report (consistent with the needs and interest of the individual student) on an approved topic related to military comptrollership.

Mn-460 LOGISTICS (4.5-0)

Objective—To develop an understanding of the relationship between strategy, tactics, and logistics.

Description—The role of logistics is emphasized and related to economic and management considerations under both cold and hot war conditions. Logistics planning and programming, requirements, procurement, maintenance, transportation, and distribution are discussed. The philosophy of the seminar is a "generalist" approach to the area of logistics by employing all of the relevant management philosophies, principles, and skills developed in required core management courses.

Mn-461 PROCUREMENT AND CONTRACT ADMINISTRATION (3.0-0)

Objective—To develop an awareness in the Naval officer of the complex procurement problem and its related aspects as it affects the defense economy.

Description—The elements of the procurement cycle are discussed beginning with the impact of requirements determination on procuring activities with the legal, fiscal, technical, business, production, security, facilities, inspection, termination factors involved.

The various procurement laws and regulations are analyzed with the purpose of understanding how the system of military procurement causes a rearrangement of economic and legal procedures to meet demands that cannot be satisfied by normal methods. The effects on the financial and legal aspects of the national economy are reviewed and discussed.

Mn-462 SCIENTIFIC INVENTORY MANAGEMENT (3.0-0)

Objective—To provide the officer with an appreciation and understanding of the scientific basis for managing inventories. To increase competence in managerial decision making and the exercise of executive judgment pertinent to inventory management.

Description—This course covers basic concepts and formulae used in arriving at Economic Order Quantities, Reorder Points, Reorder Frequencies, and Variable Safety Levels. The course provides a basis for understanding the more scientific determination of the two decisions that create inventory: "how much" of the item is to be purchased, and "when" it is to be purchased. Basic accounting considerations for developing costs to order and hold are examined, as well as factors considered to be important in establishing safety levels of stocks. Opportunities are provided to study and analyze several research projects which introduce the use of mathematical inventory theory, and their application to the Inventories of the Navy Supply System.

Mn-464 FACILITIES PLANNING (4.5-0)

Objective—To develop an appreciation by the Naval officer of the problems of planning and operating naval shore facilities in the face of changing strategic and tactical concepts, a limited budget, and current technological developments.

Description—Analysis is made of the economic, administrative, and operational aspects of the conception and planning of naval facilities. The consideration of resources in site selection, relationship between activity operations and plant requirements, analysis of activity size, internal arrangement, expansion capability, and flexibility of use necessitated by changes in technology and naval planning are discussed. Various analytical approaches to asset acquisition and replacement are considered.

Mn-465 ADVANCED PRODUCTION PROBLEMS (4.5-0)

Objective—To afford opportunity to relate the basic concepts of industrial management to special problems in production management faced by the Navy and large privately owned industrial concerns.

Description—This course approaches the manufacturing situation from the point of view of the chief manufacturing executive. Cases, problems, and simulation exercises involving the use and coordination of such techniques as quality control, production planning, work measurement, process design, methods analysis, layout, and materials handling, as well as budgets and cost controls. Such broad problems as organization for manufacture, long-range planning, standardization, and performance measurement are also considered.

Mn-470 QUANTITATIVE METHODS AND AUTOMATIC DATA-PROCESSING (4.5-0)

Objective—To provide a knowledge of statistical methods and theory as applied to numerical data or observations with the objective of preparing the officer to make rational decisions in the face of uncertainty. To provide the officer with an understanding of the capability of an automatic data-processing system to perform more efficiently many functions presently performed by human systems and functions beyond the capacity of present systems.

Description—The course includes problem formulation, data collection methods, and techniques of statistical analysis; such as, probability theory, correlation, control charts, et cetera. The application of these mathematical decision techniques to the field of military management is thoroughly explored and an appreciation is gained of the growing importance of statistical analysis and operations research to the development of scientific management. Information required for management decision and the effect of processing time on these decisions is examined as influenced by automatic data processing systems. The effect of the automatic systems upon decision areas too complex for human systems is also studied. Feasibility studies, cost comparisons, equipment capacity, and limitations of the automatic data processing systems are discussed.

Aerial view of the Engineering School with the cities of Monterey (left background) and Pacific Grove (distant center background). School buildings shown are King Hall, Spanagel Hall, Bullard Hall, Halligan Hall, and Root Hall.

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

ELECTRICAL ENGINEERING

(GROUP ZGL)

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 G12.48 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

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	13 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, Wash., 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*

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.

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
CE 460*—Structural Analysis or CE 461—Structural Theory & Design
**Physics 201—Basic Concepts of Elementary Physics—No graduate credit
or—TAM 321—Advanced Mechanics of Materials—½ unit
or—Approved Elective in Mechanics, Mathematics or Physics—½ unit

FOUR WEEKS FOLLOWING FIRST SUMMER SESSION

CE 160 Building Construction—no graduate credit
CE 290 Contracts & Specifications—No graduate credit
(or other appropriate courses)

FALL TERM

CE 464 Reinforced Concrete Design
or CE 366 Behavior of Reinforced Concrete Members
CE 471 Numerical & Approximate Methods of Structural Analysis
CE 383 Soil Mechanics
CE 461* Structural Theory & Design
or CE 462 Structural Theory & Design
Physics 383 Atomic & Solid State Physics for Engineers

SPRING TERM

CE 465 Steel Design
CE 474 Behavior of Structures under Dynamic Loads
CE 472 Advanced Numerical Methods in Engineering
CE 384 Applied Soil Mechanics
Physics 382 Nuclear Physics

SECOND SUMMER

Math 345 Differential Equations & Orthogonal Functions
CE 497 Special Problems (½ to 2 units)
Approved Elective related to purposes of curriculum

SECOND FALL

CE 477 Design of Structures for Dynamic Loads
NE 401 Fundamentals of Nuclear Engineering
CE 467 Behavior of Reinforced Concrete Structures
or CE 468 Analysis & Design of Prestressed Concrete Structures

CE 497 Special Problems
or Approved Elective (TAM 451—Theory of Elasticity with Application of Engineering Problems, TAM 461—Inelastic Behavior of Engineering Materials, NE 454 Nuclear Engineering Lab Investigations NE 458 Nuclear Reactor Engineering & others
or CE 499 Thesis

* Students having no previous background in Statically Indeterminate Structures must take CE 460 and follow it with CE 461.

** Required for Navy CEC officers with weak or remote Physics background.

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 thirteen-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.

SUMMER SESSION

5.08 Surveying, Curves and Earthwork (CEC)
5.76 Structural Analysis I
5.78 Reinforced Concrete I

FALL TERM

5.09 Contracts and Specifications
5.15 Highways & Airports
5.75 Building Construction
5.77 Structural Design I
5.80 Structural Analysis & Design II
10.11 Engineering Geology
7.22 Utilization of E. E. in Naval Establishments (CEC)

SPRING TERM

5.32 Soil Mechanics (CEC)
5.79 Reinforced Concrete II
T5.82 Indeterminate Structures I
T5.24 Construction Methods and Estimates
12.42 Heating & Ventilating (CEC)
13.54 Metallurgy & Welding
2.60 City Planning Principles

SECOND SUMMER SESSION

7.69-12.48 Power Plants (CEC) ME ½ term—EE ½ term
5.35 Foundation Engineering (CEC)
5.59 Sanitary Engineering (CEC)

COMPTROLLERSHIP

(*GROUP ZS*)

At George Washington University

Objective — To develop in officers of mature judgment and a broad background of professional experience the ability to interpret and analyze operational statistics for the purpose of developing standards of performance; to provide a periodic review of operations in order to denote areas of management which are not meeting standards; to review budget estimates; and to plan program for the improvement of management economy and efficiency through better organization, administration and procedures and better utilization of manpower, materials, facilities, funds and time. The course is designed to give graduates a working knowledge of managerial controls adequate for assignment to 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

(*GROUP ZMP*)

At Purdue University

OBJECTIVE — A one-year curriculum for Supply Corps (3100) officers in Business Administration which fulfills a particular need.

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 & Dynamics
8.00 Physics (Electricity)
13.20 Elementary Warship 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. Elemn.
2.501 Heat Transfer
13.012 Naval Architecture
13.12 Warship Gen. Arrgts.
M32 Elem. Statistics
M352 Adv. Calc. for Eng.

Second Year

Second Summer

6.251 Electronic Computational Lab
13.22 Warship Gen. Arrangements

Second Fall

1.631 Adv. Hydromechanics I
2.003 Applied Mechanics III
3.391 Properties of Metals
13.13 Warship Structure Theory I
13.75 Warship Propulsion I
22.10 Int. Nuclear Technology

Second Spring

1.452 Structural Analysis
1.632 Adv. Hydromechanics II
3.392 Properties of Metals
13.14 Warship Structure Theory II
13.24 Warship Structure Design I
2.212 Adv. Mechanics

Elective
1.683 Experimental Hydromechanics

Intersessional period: Field trip.

Third Year

Third Fall

1.561 Adv. Structural Mechanics
2.126 Experimental Stress Analysis
13.15 Warship Basic Design
13.16 Warship Basic Design II
13.25 Warship Structure Design II
13.90 Warship Electrical Engineering
Thesis

Third Spring

1.562 Adv. Structural Mechanics
13.26 Preliminary Design of Warships
13.76 Warship Propulsion II
Thesis

This curriculum affords the opportunity to qualify for the degree of Naval Engineer and the degree of Master of Science in Naval Construction & 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 (Power & Control)
XIII-A-3 Ship Propulsion Engineering
XIII-A-4 Electronics 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.

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

(*GROUP ZMK*)

At University of Kansas

Objective—A one-year curriculum to meet an immediate need for the graduate level education of Supply Corps (3100) officers in the functional proficiency area of petroleum management.

RELIGION

(*GROUP ZU*)

At selected universities

Objective—Each officer student enrolled in this curriculum pursues courses of instruction in such subjects as psychology, theology, homiletics, counselling, hospital ministry and education.

An officer selected in this curriculum will be enrolled at Harvard University, Catholic University, University of Chicago, University of Notre Dame, Fordham University, Union Theological Seminary, or the Menninger Foundation, depending on the field of study selected.

RETAILING

(*GROUP ZMG*)

At Graduate School of Retailing, University of Pittsburgh

Objective—A one-year curriculum to meet an immediate need for the graduate level education of Supply Corps (3100) officers in the functional proficiency area of retailing.

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

(*GROUP ZMN*)

At Northwestern University

Objective—A one-year curriculum to meet an immediate need for graduate level education of Supply Corps (3100) officers in the functional proficiency area of transportation management.

For Your Convenience

NOTES and MEMORANDA

Index