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Cooperative Education
in
Ocean Engineering
at
Florida Atlantic University
An Upper Division State University at Boca Raton



Supported by the National Science Foundation as part
of the U.S. National Sea Grant Program of 1966.

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OPPORTUNITIES IN OCEAN ENGINEERING

OCEAN ENGINEERING, the application of oceanographic knowledge and engineering skills to the development of the oceans' resources is making rapid strides as a recognized engineering discipline in today's world.

Increasing demands for oil, minerals, chemicals, food and national defense to serve and protect our nation and the world's rapidly increasing populations, and to improve their standards of living, make the development and profitable use of the oceans' resources essential. As resources of the land are used and depleted, those of the oceans become increasingly important. The ocean engineer is one who will make these ocean developments possible.

The fields of interest today for an ocean engineer include: offshore oil development, underwater mining and chemical extraction, ocean defense systems, Man-in-the-Sea, underwater structures, vehicles and communications systems, engineering associated with the development of sea food resources, desalination, and prevention of deterioration of submerged metals and materials. New fields will be developed as technology is improved.

Today there are few trained ocean engineers to meet the demand. Most have entered ocean engineering from other fields. At Florida Atlantic University the first undergraduate Ocean Engineering program started in 1965. Graduates from this upper division program in 1967 are now employed in such organizations as Ocean Systems, Inc. of Union Carbide Corp.; Pan American Petroleum Corp. (offshore oil); General Dynamics Corp. (Deep Star and Acoustics Branches); North American Rockwell Corp. (Ocean Operations Division); U. S. Naval R & D Center, San Diego (Naval Electronics Laboratory); RCA (Atlantic Undersea Test and Evaluation Center); Westinghouse Electric Corp. In addition, ocean engineering graduates of Florida Atlantic University are now enrolled in, or accepted for, Master's ocean engineering programs at the University of Rhode Island, Massachusetts Institute of Technology, the University of Washington, and the University of Hawaii. Graduates of the current senior class have offers from many of the same companies and from others engaged in similar ocean engineering work.

Ocean Engineering graduates from Florida Atlantic University are prepared for positions in offshore petroleum and mining industries, underwater defense, construction and exploration companies, governmental and private ocean laboratories doing instrumentation, underwater habitation, Man-in-the-Sea, acoustics and related systems work. They are equipped for work in Research and Development laboratories doing work

related to the exploration and exploitation of ocean resources. To date, graduates of the Ocean Engineering program who received their B. S. degrees at Florida Atlantic University have received starting salaries between \$8,700 and \$12,800 per year, with averages about \$10,500 per year. This salary average and the demand for these engineers are increasing.

A newly approved Cooperative Work/Study Program in Ocean Engineering at Florida Atlantic University supported by the National Science Foundation under the National Sea Grant Program Act will give qualified students the opportunity to divide their time between class work at Florida Atlantic University and practical on-the-job experience in ocean industries or laboratories. This program will enhance their practical education and offer the students an opportunity to earn money to meet educational costs.

Ocean engineering offers great opportunities to the qualified graduate in an exciting, rapidly expanding, important field.

FLORIDA ATLANTIC UNIVERSITY

Florida Atlantic University is the first university in the United States to give only the Junior and Senior years of undergraduate work. It is located on a 1200 acre site in Boca Raton, a few miles west of the Atlantic Ocean, midway between Palm Beach to the north and Fort Lauderdale and Miami to the south. It is easily accessible from major north-south highways and enjoys a subtropical climate with an average year-round temperature of 75 degrees. Its buildings now in use or nearing completion have a value of approximately \$30 million. The University was established in 1961 as a State University and accepted its first students in 1964. In 1965, the first undergraduate program in Ocean Engineering anywhere in the world was established.

The University is fully accredited by the Southern Association of Colleges and Schools and the State Board of Education. Its graduates are accepted for further study by other universities in the State and in the nation. Current enrollment is approximately 5,000. A student body of 10,000 is anticipated by 1975.

The University operates on a yearly basis of four quarters and is organized into Colleges of Business and Public Administration, Education, Humanities, Science and Social Science, and the newly established College of Engineering. Each division operates under University-wide policies, is granted the widest latitude, and is encouraged to develop new and unique programs which will best serve the student in the disciplines within its jurisdiction. Graduate work leading to the Master's degrees in Arts, Science, and Education are available, and programs for the Doctorate will be established in the near future.

The faculty consists of a distinguished group of 300 scholars who hold a balanced dedication to both teaching and research; the majority of them hold the doctorate or a professional degree.

OCEAN ENGINEERING EDUCATION AT FLORIDA ATLANTIC UNIVERSITY

The Department of Ocean Engineering offers a comprehensive and practical curriculum in science and engineering which will prepare the student for graduate study and for professional positions in industry, government, and science. The Department is presently a part of the newly authorized College of Engineering at Florida Atlantic University. Expansion to the Master's Program is planned for 1970 and to the Doctorate level at a later date.

The program of study requires a firm foundation in English, mathematics, and science at the lower division level; and courses in the social sciences and the humanities for a balanced background for the engineering profession. These are provided in the pre-engineering (University Parallel) programs of the junior colleges in Florida and the lower division pre-engineering programs of most four-year colleges.

The Ocean Engineering Program covers integrated classroom and laboratory work units encompassing basic engineering sciences and mathematics; study of the oceans and their environment in relation to other sciences and engineering; and instrumentation and processing of data for applications to problems connected with work in, on, or under the ocean to develop its resources. Emphasis is placed upon the solution of problems related to and associated with working in the ocean in areas such as underwater acoustics, fluid mechanics, structures, electronics, materials, desalination and corrosion. Other courses are included to insure a broad and comprehensive education. A summer quarter devoted to practical work is required in the Regular program. This is not required in the Cooperative Work/Study Program.

Facilities are being expanded rapidly. Equipment is continually being secured to expand and improve laboratories in materials science, electricity, electronics, mechanics, ocean processes, and corrosion. Shore facilities and oceanographic ships on charter are available for departmental projects and related research and development work. The Department presently has two small boats available for student projects. Other boats are leased or borrowed when needed for sea operations.

Students preparing for the Bachelor of Science degree in Ocean Engineering will follow the program on pages 4 - 6. Modifications of this program must be approved by the Chairman of the Department. The degree of Bachelor of Science will be awarded to students who meet all requirements for graduation. Students will be eligible to receive the degree 'with honor' upon completion of all required residence work with a 3.2 grade point average (based on a 4 point system).

REQUIREMENTS FOR ADMISSION TO THE
OCEAN ENGINEERING PROGRAM

<u>Subject</u>	<u>Quarter Hour Credits</u>
English composition and grammar	9
Social Sciences	9
Humanities	9
Chemistry including chemistry laboratory work	12
Mathematics (through 1 year of Calculus)	12 - 21
Engineering Physics (Physics with Calculus)	12
*Electives	<u>27 - 18</u>
	90

*At least one course in engineering drawing or descriptive geometry should be included in elective selections. Additional studies in the humanities or the social sciences, pursuing an area in depth, are encouraged at the lower level since this additional work is required at FAU if not completed prior to entry.

Selected students with grade point averages above the overall minimum average of 2.0 (C) in all work may be accepted for a special three year program if they have met all entrance requirements except prerequisites in physics and calculus. These students complete physics, calculus and courses not requiring these prerequisites during the first year at FAU. If attendance has been at an institution which is a member of the State of Florida University or Junior College System, completion of the General Education Program of that institution is required.

DEGREE REQUIREMENTS

The degree of Bachelor of Science in Engineering will be awarded to students who meet the following requirements for graduation in the Department of Ocean Engineering:

1. All general degree requirements of the University.
2. Maintain a 2.0 grade point average in all professional (OCEN) courses.
3. Complete satisfactorily each of the engineering core courses listed below:

	Quarter Credits
OCEN 401 Materials I	3
OCEN 402 Materials II	3
OCEN 404 Physical Oceanography	3
OCEN 405 Chemical Oceanography	3
OCEN 406 Geological Oceanography	3
OCEN 412 Mechanical Vibrations	3
OCEN 414 Electrical Circuit Analysis	4

OCEN 415	Electronics	4
OCEN 416	Electrical Energy Conversion and Control	3
OCEN 420	Acoustics	3
OCEN 421	Transducer Design	3
OCEN 425	Statics	4
OCEN 426	Dynamics	4
OCEN 429	Fluid Mechanics I	3
OCEN 430	Fluid Mechanics II	4
OCEN 434	Strength of Materials I	3
OCEN 435	Strength of Materials II	3
OCEN 437	Engineering Thermodynamics I	3
OCEN 438	Engineering Thermodynamics II	3
OCEN 440	Heat Transfer	4
OCEN 460	Ocean Engineering Seminar	1
OCEN 462	Design Planning and Engineering Practices	1
OCEN 463	Ocean Influences and Perspectives	1
MATH 370	Differential Equations	4
MATH 472	Computer Programming and Numerical Analysis	3
BIOL 315	Marine Biology for Ocean Engineers	<u>3</u>
	Total	78

4. Complete satisfactorily 9 hours of technical electives chosen from among the following course offerings:

OCEN 422	Underwater Sound Propagation	3
OCEN 423	Instrumentation	3
OCEN 431	Fluid Mechanics III	3
OCEN 432	Underwater Structures	3
OCEN 451	Communications Theory I	4
OCEN 452	Communications Theory II	2
OCEN 453	Experimental Stress Analysis	3
OCEN 454	Environmental Susceptibility of Materials	3

5. Complete an out-of-college studies program. This program must meet both of the following requirements:

- a. To meet University regulations, at least 18 quarter hours must be completed in out-of-college courses for graduation. Required core subjects include 10 of these credits. An additional 8 credit hours of elective work must be completed outside the College of Engineering.
- b. A total of 27 credit hours must be completed satisfactorily in the combined areas of the Humanities and Social Sciences at the upper and lower divisions, prior to graduation, including an in-depth study in one area of these disciplines. Entrance requirements specify a minimum of 18 credit hours in these combined subjects in the lower division. The balance of the 27 hours, if not taken in the lower division, must be completed at FAU.

6. Complete a professional development program consisting of one of the following options:

Option I - Two six month periods of work in government or industry in the Department of Ocean Engineering's Cooperative Education program. Credit for work and papers for each work/study period is covered by enrollment in courses:

OCEN 449	OCEAN ENGINEERING PRACTICAL	3 credits
OCEN 450	WORK AND INDEPENDENT STUDY	each

Option II - A final quarter of work at the University consisting of one additional technical elective and the completion of:

OCEN 490	DESIGN AND INSTRUMENTATION LABORATORY	6 credits
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Option III - One six month period of cooperative education work and completion of:

OCEN 407	OCEAN ENGINEERING LABORATORY	2 credits
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Option IV - One quarter of internship in ocean oriented industry

OCEN 449	OCEAN ENGINEERING PRACTICAL	3 credits
	WORK AND INDEPENDENT STUDY	

and completion of:

OCEN 407	OCEAN ENGINEERING LABORATORY	2 credits
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Course descriptions are found on pages 11 - 18.

COOPERATIVE OCEAN ENGINEERING EDUCATION

at

FLORIDA ATLANTIC UNIVERSITY

Cooperative education was initiated at the University of Cincinnati, Cincinnati, Ohio, in 1906. Today, nearly 100 universities and colleges in the United States include the programs in their curricula. The Program integrates classroom and practical work experiences. Modern business is so complex that it is virtually impossible for an undergraduate student to accurately visualize his professional life. Classroom instruction cannot give all the knowledge required for a successful professional career. Practical "on-the-job" work experience supplements academic study. Some minimum amount of it, and of standards of performance in it, are included in the requirements for the baccalaureate degree to assist the student to orient himself to the modern world.

In February, 1968, the Florida Atlantic University received a grant from the National Science Foundation to establish a Cooperative Work/Study Program in Ocean Engineering under the National Sea Grant College and Program Act of 1966. The award supports faculty and facilities in the new program. It does not provide direct financial assistance to students. Cooperative Program students can apply for regular student financial aid.

Classes in cooperative education begin in September and March of each year. Both the University and the Cooperating Company will have students at work at all times.

The cooperative education program integrates classroom and practical experience in industry, business, government, and service-type work situations. Its underlying philosophy is that supervised employment in the occupational field for which the student is preparing enhances comprehensive learning and vocational adaptation. The program emphasizes competency, comprehensiveness, and continuity in vocational guidance and placement.

The basic strength of the cooperative plan is the diversity and flexibility of its programs. For the student, it gives reality to learning, increases motivation, develops greater human understanding, accelerates maturation, offers orientation to the world of work, provides useful employment contacts, and insures financial aid for all or a large part of academic expenses. For the University, it permits more efficient use of plant facilities, encourages greater community support, and enhances the effectiveness of its teaching faculty. For the cooperating corporation, it offers an excellent source of technically educated personnel, facilitates recruitment and retention, and permits better utilization of personnel.

The Coordinator of the Program will interview and evaluate each student's ability for both academic and practical excellence before admitting him into the program, at the University and later in industry. Thereafter, he will advise the student for optimum success both as a student and as leader in a professional career.

Every effort will be made to give the student maximum practical experience in his work assignments so that he can better visualize his future role in the industrial world.

There is no one procedure which will be effective for all students at all times. But the student can confirm his own judgement by his experiences and associates, in both the University and in business, by profiting from transfer values, and thereby see the business world in its proper perspective.

SELECTION OF STUDENTS FOR COOPERATIVE PROGRAM

Procedure - Students may be nominated by either the University or the Cooperating Organization. Applications and qualifications will be screened by the originating agency to assure eligibility. Students found eligible will be presented to the cooperating partner with documented qualifications for acceptance. Agreement on students' qualifications will permit them to apply for admission to the program.

Qualifications for Admission to Cooperative Program - The student must have satisfactorily completed all prerequisites for enrollment in the Department of Ocean Engineering; must have a grade point average of above 2.00 in his work; must submit a minimum of three favorable recommendations from former instructors, employers, or associates other than relatives; and must agree to remain in the program until completion if his accomplishments qualify him to do so.

Application - A student at the University will apply for designation as a cooperative student during the first or second quarter of his first, or junior, year. A student at the cooperating company will submit his application and qualifications to the Department of Ocean Engineering at the University in time for its review and his enrollment in September or March of the academic year.

Interviews - When desired or necessary, interviews with prospective students and the cooperating organization will be arranged.

Admission - A student must apply in adequate time for admission into the program in September or March of the entering year. Special arrangements for tuition and fees for students sponsored by a cooperating corporation may be made if desired by the corporation.

PROGRAM ADMINISTRATION

Work Plan - After a student has been accepted into the Program, and prior to his first work period, the Coordinator at the University will contact the organization supervisor, under whom the student will work, to coordinate all educational and work objectives. From this, a work plan will be prepared for each student. While it is expected and intended that the student will earn wages during the work phases of the program, the educational objectives of practical work will always receive greater emphasis.

Typical Coop Study and Work Schedule

<u>Calendar</u>	<u>Location</u>	<u>Program</u>
First 6 months	At the University	First and second quarters of the Ocean Engineering curriculum.
Second 6 months	At the cooperating corporation	On-the-job experience, first technical paper.
Third 6 months	At the University	Third quarter of the junior year and first quarter of the senior year of the Ocean Engineering curriculum.
Fourth 6 months	At the cooperating corporation	On-the-job experience, second technical paper
Fifth 6 months	At the University	Second and third quarters of the senior year of the Ocean Engineering curriculum. Graduation.

Technical Papers - Prior to the end of each work period, the student will prepare a technical paper on a subject pertinent to his assigned work; the subject must be approved by his work supervisor and the University Coordinator. The student will present the paper orally before his classmates and instructors at the University, and will receive a grade for the quality of his work, the excellence of his presentation, and his employer's evaluation. This grade will count toward his degree.

Review and Evaluation - Upon completion of each student's academic period, his grades will be sent to his work supervisor at the cooperating organization. After each work period, an evaluation of his performance will be sent to the University Coordinator. All grades will be reviewed carefully with the student. Modifications will be made when necessary to improve the quality of the program and the student's work in it.

OCEAN ENGINEERING DEPARTMENT FACULTY

Charles R. Stephan, B. S.	- Professor and Chairman
William Tessin, Ph. D.	- Professor, Ocean Engineering
Raymond F. McAllister, Ph. D.	- Professor, Oceanography
James Blaine Davidson, M. S.	- Associate Professor, EE and Acoustics
Frederick F. Monroe, M. S.	- Assistant Professor, Oceanography and Coordinator of Cooperative Education
Robert N. Brannock, Ph. D.	- Associate Professor, Civil Engineering
Jose' Villanueva, Ph. D.	- Associate Professor, ME
Robert O. Case, Ph. D.	- Assistant Professor, ME
Peter J. Graham, Ph. D.	- Assistant Professor, EE
William H. Hartt, Ph. D.	- Assistant Professor, Materials Science
James H. Pohl, Ph. D.	- Interim Assistant Professor, ME
John W. Hartwell, M. S.	- Interim Assistant Professor, EE
	- Assistant Professor, Oceanography
	- Assistant Professor, Acoustics
Jack F. Staicer	- Leading Technician
Richard Demarest	- Electronic Technician
Louis R. Maurer	- Laboratory Technician

DIRECTION OF THE COOPERATIVE EDUCATION PROGRAM

Manager	- Professor Charles R. Stephan Chairman, Department of Ocean Engineering
Coordinator	- Frederick F. Monroe Assistant Professor of Oceanography Department of Ocean Engineering
Cooperating Corporation	- The Director of Educational Training, or another official designated by the Corporation
Advisory Committee	- An Advisory Committee consisting of selected members of the Ocean Engi- neering Industry, Education and the Scientific community will be asked to serve as advisors to the Chairman and Coordinator to insure proper direction and administration of the program.

SCHEDULE OF FEES FOR ONE QUARTER

Application Fee \$ 10.00
Registration Fee 150.00
Non-Florida Resident Fee 300.00
(In addition to Registration Fee)
Residence Hall Charge - about . . 300.00
(Includes 21 meals per week,
telephone, laundry. All air
conditioned suites.)

Fees at Florida Atlantic University are comparable to those charged at other state universities in Florida. They are subject to change by action of the State Legislature and other governing boards.

APPLICATIONS FOR ADMISSION

Application forms to enter Florida Atlantic University, and the University BULLETIN describing all courses, campus regulations, housing and student assistance, can be obtained from:

The Director of Admissions
Florida Atlantic University
Boca Raton, Florida 33432

Further information on the Ocean Engineering Cooperative and Regular Programs can be obtained from the Ocean Engineering Cooperative Program Coordinator or the Chairman of the Department of Ocean Engineering.

Students interested in applying for the Cooperative Ocean Engineering Program should apply EARLY.

DESCRIPTION OF COURSES
OCEAN ENGINEERING DEPARTMENT

OCEN 301 Introduction to Oceanography 3 credits

PREREQUISITES: None. Engineering majors may not offer this course for credit.

Survey course including: Origin of ocean basins, continents, and sea water; physical and chemical oceanography, marine biology, marine geology, meteorological oceanography. A brief introduction to Florida oceanography and ocean engineering will be included.

- OCEN 401 Engineering Materials I 3 credits
OCEN 402 Engineering Materials II 3 credits

PREREQUISITES: College Physics (with Calculus)
College Chemistry

Relations of atomic structures to properties and uses of metallic, semi-metallic, inorganic, organic, composite, and surface-coated materials at ambient, elevated and cryogenic temperatures. Sources, winning, refinement, alloying, fabrication, phases, thermal treatments, and resistance to corrosion.

- OCEN 404 Oceanography I (Physical Oceanography) 3 credits

PREREQUISITES: Engineering major or permission of Instructor

The World Ocean; physical dimensions and characteristics; distribution of salinity, temperature and pressure; density and water mass distribution; waves, tides, and currents; sound and electromagnetic radiation; heat budget of the oceans; sea-air interface studies, etc. Course stresses applications where pertinent.

- OCEN 405 Oceanography II (Chemical Oceanography) 3 credits

PREREQUISITES: Engineering major or permission of Instructor

Sea water; its chemical nature and distribution of major and minor elements, gases and nutrients in the sea; salinity and chlorinity and their measurement; principal marine chemical processes; the carbonate cycle in sea; geo-chemistry of sediments; problems in marine chemistry.

- OCEN 406 Oceanography III (Geological Oceanography) 3 credits

PREREQUISITES: Engineering major or permission of Instructor

Ocean boundaries and geological characteristics; beaches and beach phenomena; continental shelves, slopes, and deep sea floor; marine sediments, their classification, origin and history; sediment analysis; processes active in formation, transportation and deposition of marine sediments; eustatic and local sea level changes; coral reefs; problems in marine geology.

OCEN 407 Ocean Engineering Laboratory 2 credits

PREREQUISITES: OCEN 404, OCEN 405, OCEN 406,
OCEN 462, Senior Standing

Solution of practical problems related to ocean engineering. Projects are assigned in which students design, construct and install equipment in the ocean to perform designated tasks. Data is collected and from this data a report is written.

Grading: Satisfactory - Unsatisfactory

OCEN 412 Mechanical Vibrations 3 credits

PREREQUISITES: Differential Equations
OCEN 426

Equivalent springs, masses, driving systems; rigid-body dynamic analysis, steady-state response, phase-plane, normal modes, shock spectra, single and two degree of freedom systems, computer analysis, mechanical impedance methods, lumped and distributed parameter mechanical systems, dynamic behavior of foundation-like structure, vibration isolation.

OCEN 414 Electrical Circuit Analysis 4 credits

PREREQUISITES: Math through Calculus
College Physics with Calculus
COREQUISITE: Differential Equations (MATH 370)

Analysis of AC and DC electrical circuits. Kirchhoff's Laws; Thevenin and Norton Theorems; Nodal and Loop analysis; Fourier Series analysis and complex or S plane conversions.

Three hours lecture - Three hours lab

OCEN 415 Electronics 4 credits

PREREQUISITE: OCEN 414

Introduction to solid state and vacuum tube electronic circuits. Amplifiers, rectifiers, modulation, oscillators. Electronic design parameters.

Three hours lecture - Three hours lab

- OCEN 416 Electrical Energy Conversion and Control 3 credits
PREREQUISITE: OCEN 415
Magnetic circuits and transformers; Electromechanical Energy Conversion; AC and DC machines; Feedback control systems.
- OCEN 420 Acoustics 3 credits
PREREQUISITES: Differential Equations
OCEN 415
Fundamentals of acoustics, wave equation, sound propagation in solids and fluids, loudspeakers, microphones, speech hearing, noise, architectural acoustics, resonators and filters.
- OCEN 421 Transducer Design 3 credits
PREREQUISITE: OCEN 420
Principles of acoustic transducers; microphones, loudspeakers, hydrophones, projectors and arrays, are studied along with methods of construction, mounting and calibration.
- OCEN 422 Underwater Sound Propagation 3 credits
PREREQUISITE: OCEN 421
Sound propagation in the ocean utilizing ray acoustics and normal mode theory. Scattering reverberation, reflectivity, attenuation and long range propagation path. Sonar Equation. Natural and man made noise.
- OCEN 423 Instrumentation 3 credits
PREREQUISITES: Differential Equations
OCEN 416
Definition, classification of variables, measurement errors, statistical analysis, performance characteristics of instruments, comparison measurements, physical measuring devices, transducers, operational amplifiers for measurement and control; manipulation, transmission recording of data, electronic switching, timing, digital counting systems, data processing techniques, indicators, recorders, telemetry systems.

- OCEN 425 Statics 4 credits
PREREQUISITE: Mathematics through Calculus
Forces and force systems and their external effects on bodies; principally, the condition of equilibrium. Techniques of vector mathematics employed.
- OCEN 426 Dynamics 4 credits
PREREQUISITE: OCEN 425
Principles of dynamics, kinematics, kinetics of particles and rigid bodies including work and energy impulse and momentum periodic motion. Techniques of vector mathematics employed.
- OCEN 429 Fluid Mechanics I 3 credits
OCEN 430 Fluid Mechanics II 4 credits
PREREQUISITES: OCEN 426, OCEN 437
Physical properties of fluids; fluid statics and dynamics; dimensional analysis; viscous flow; potential flow; fluid measurements and control; turbomachinery; flow in closed conduits and open channels.
OCEN 430 includes a fluids laboratory.
- OCEN 431 Fluid Mechanics III 3 credits
PREREQUISITE: OCEN 430
An introduction to the hydrodynamics of the ocean. Potential flow. Theory of waves of small amplitude. Long waves in shallow water. Waves on sloping beaches, etc.
- OCEN 432 Underwater Structures 3 credits
PREREQUISITE: OCEN 435
Introduction to theory of plates and shells, thick wall pressure vessels; elements of buckling of plates, shells, and cylinders.
- OCEN 434 Strength of Materials I 3 credits
OCEN 435 Strength of Materials II 3 credits
PREREQUISITE: OCEN 425
Concepts of stress and strain, Hooke's Law, deformation of elastic materials, torsion, bending, strain energy, limit analysis, statically indeterminate elastic systems, Castigliano's Theorem, thin wall rings and shells, riveted and welded joints, columns and struts.

OCEN 437 Engineering Thermodynamics I 3 credits
OCEN 438 Engineering Thermodynamics II 3 credits

PREREQUISITE: Calculus

Definitions, properties and state of a pure substance, macroscopic thermodynamic processes, systems and cycles, work and heat, the first and second laws, entropy, availability, irreversibility and efficiency. Applications of concepts to ideal gases, mixtures of gases and vapors, vapor and gas cycles, combustion.

OCEN 440 Heat Transfer 4 credits

PREREQUISITES: OCEN 438, OCEN 430

Elements of steady state heat transfer; thermal conduction, convection, radiation; condensation and boiling heat transfer; thermal resistance; introduction to transient heat conduction. Includes a heat transfer laboratory.

OCEN 449 Ocean Engineering Practical Work and Independent Study 3 credits

A cooperative work/study program with ocean oriented organizations for ocean engineering students who have completed at least two quarters of Ocean Engineering. On-the-job training and instruction. A technical report is required related to cooperative work.

Grading: Satisfactory - Unsatisfactory.

OCEN 450 Ocean Engineering Practical Work and Independent Study 3 credits

PREREQUISITE: OCEN 449

A second period of cooperative work/study for students enrolled in the cooperative program who have completed one previous six month work period. Requirements are the same as for OCEN 449, but additional industrial and practical experience is provided.

Grading: Satisfactory - Unsatisfactory.

OCEN 451 Communications Theory I 4 credits
OCEN 452 Communications Theory II 2 credits

PREREQUISITE: OCEN 416

Fourier transform principles, signal transmission through electric networks; probability applications, noise in electric components and circuits, information theory, optimum linear filtering and modulation, all as applied to acoustic signal processing.

OCEN 453 Experimental Stress Analysis 3 credits

PREREQUISITES: OCEN 434, OCEN 435,
or permission of Instructor

Theory and application of strain gages; strain measurement and transducer applications. Photoelasticity. Brittle coating techniques.

OCEN 454 Environmental Susceptibility of Materials 3 credits

PREREQUISITES: OCEN 401, OCEN 402

Review of the theories of deformation in crystalline solids and the basic concepts of corrosion in metals. Application of these theories to the interpretation of the behavior of stressed materials in a corrosive environment with regard to stress corrosion, corrosion fatigue, and hydrogen embrittlement.

OCEN 460 Ocean Engineering Seminar 1 credit

Seminar session with invited leaders in the ocean engineering profession; presentation of technical papers by students on topics and projects selected with consent of instructor.

Grading: Satisfactory - Unsatisfactory.

OCEN 462 Design Planning and Engineering Practices 1 credit

PREREQUISITE: Permission of Instructor

Incorporates the elements of engineering design, ethics and the practices of engineering in industry and government. The course is a prerequisite for OCEN 407 or OCEN 490. Students plan and design a project for the follow-on laboratory course.

OCEN 463 Oceanic Influences and Perspectives 1 credit

PREREQUISITE: Permission of Instructor

Lectures and discussions on ocean science and engineering influences in local, national and international affairs; effects of laws and regulations affecting ocean operations; important national and international oceanic development programs; future trends in ocean development.

OCEN 480 Directed Independent Study 1-5 credits

PREREQUISITE: Permission of Instructor

OCEN 490 Design and Instrumentation Laboratory 6 credits

PREREQUISITES: All engineering core subjects

The practical application of engineering principles in the construction and installation of ocean oriented instrumentation or equipment. Consists of occasional lectures, laboratory experiments, project construction and practical experience at sea.

OCEN 491 Special Topics in Ocean Engineering 3 credits

PREREQUISITE: Permission of Instructor

New developments in Ocean Engineering and related areas.