Naval Architecture and Marine Engineering

Undergraduate Program

The University of Michigan
The Department of Naval Architecture and Marine Engineering

Educational Objectives

The Educational Objectives of the NA&ME Program are to produce graduates that, in 3-5 years' time, are:

- 1. designing and manufacturing vehicles and structures that operate in the marine environment
- 2. working effectively in teams
- 3. practicing professionally in the marine industries, enrolling in graduate study, and engaging in life-long learning.

Educational Outcomes

The Student Outcomes of the NA&ME Program are:

- an ability to apply knowledge of mathematics, science, and engineering within naval architecture and marine engineering;
- an ability to formulate engineering problems and develop practical solutions;
- an ability to design products and processes applicable to naval architecture and marine engineering;
- an ability to design, conduct, analyze, and interpret the results of engineering experiments in a laboratory;
- an ability to work effectively in diverse teams and provide leadership to teams and organizations;
- an ability for effective oral, graphic, and written communication;
- a broad education necessary to understand the impact of engineering decisions in a global/societal/economic/environmental context;
- an understanding of professional and ethical responsibility;
- a recognition of the need for and an ability to engage in life-long learning;
- a broad education necessary to contribute effectively beyond their professional careers;
- a sense of responsibility to make a contribution to society;
- an ability to apply probability and statistical methods to naval architecture and marine engineering problems;
- an ability to apply basic knowledge in fluid mechanics, dynamics, structural mechanics, material properties, hydrostatics, stochastic mechanics, and energy/propulsion systems in the context of marine vehicles, and/or ocean structures;
- a familiarity and experience with instrumentation appropriate to naval architecture and marine engineering including experiment design, data collection, data analysis, and formal laboratory report writing;
- an understanding of the organization, methods and techniques of marine system manufacture and the use of concurrent marine design;
- an understanding of and experience in marine system conceptual and preliminary design using industrial capability design software, including a team design experience with formal written and oral presentation.

The Department of Naval Architecture and Marine Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org/
Table of Contents

Why Naval Architecture and Marine Engineering? 4
The Department 5
Faculty 5
Naval Architecture and Marine Engineering Program of Study 6
Internships 7
Jobs 7
Facilities 7
Student Enrichment 8
Quarterdeck Society 9
Project Teams 9
  Human Powered Submarine 9
  Autonomous Surface Vehicle 10
  Concrete Canoe 10
Financial Assistance 11
College of Engineering 11
  Engineering Career Resource Center 12
  Computer Aided Engineering Network 12
Ann Arbor 12
Department History 13
Naval Architecture and Marine Engineering Major Plan 14
Naval Architecture and Marine Engineering Courses 15
Why should I pursue a career in Naval Architecture and Marine Engineering?

A career in naval architecture and marine engineering is very exciting, challenging and rewarding. As a start, you would be engaged in engineering, a profession that applies scientific knowledge to meet the needs of mankind. In today’s industrial milieu of mass production, the ship is one of the few man-made objects designed and built individually. This is one reason the marine industry attracts exceptionally creative individuals who make inspiring co-workers.

Most components of the marine industry offer rewards both through teamwork and through individual creative work. The diversity of jobs available in the industry is truly impressive. There is diversity in the kinds of boats and ships and also in professional activities such as research, design, analysis, cost estimating, sales engineering, business management and so forth. No matter what your tastes, there is a role for you to play and enjoy.

Recent statistics have indicated that today’s professionals will change careers at least three times during their working lives. A career in the maritime industry offers such diversity that you can change careers innumerable times and still stay in the same industry! Young professionals beginning their careers as naval architects, marine engineers, or ocean engineers can attain top management and leadership positions in the marine industry, where talent and dedication are recognized, encouraged and rewarded.

A career in naval architecture and marine engineering is extremely diverse. It includes:

- Shipbuilding industry (commercial, private and defense related)
- Passenger transportation
- Navy and Coast Guard activity offshore oil, gas, and mineral production
- Recreational boating and sailboat industry.

It spans many disciplines of engineering, involves economics and marketing, and has its own legal specialty: admiralty law.

The field is rich in tradition, yet modern, technologically challenging and very progressive. Diverse and demanding specifications regarding the operating capabilities of ships contribute to constant change in the way that ships are designed, configured, manned and controlled. In addition, when considering the following statistics, one realizes naval architecture and marine engineering will remain an important aspect of world commerce far into the future.

- Ninety seven percent of international trade in the world is accomplished by ship. The other 3% is done by truck, train and airplane. Nearly 20% of all worldwide trade comes to or leaves United States ports.
The United States Navy and the United States Coast Guard are essential components for providing safety and security for the American public. These ships are among the most technologically advanced engineered objects and they are exclusively designed and built in the United States.

- The United States marine industry employs over 170,000 people.
- One in 6 jobs in the United States is marine related.
- The marine industry contributes $78.6 billion to the Gross Domestic Product.
- United States domestic shipping generates $8 billion in annual freight revenue.
- The maritime industry is the leader in moving cargo, and is recognized as the most efficient mode of transporting passengers. Marine transportation is a fuel efficient and environmentally friendly mode of transportation.

Ships have a long and fascinating history, but they also have a dramatically changing present. They are undergoing continuing changes in methods of propulsion, materials of construction, methods of operation and roles to play in national security. The industry is naturally international in scope, and that brings to the employee the stimulation of vast experience and frequently, world travel and its broadening perspective.

The Department of Naval Architecture and Marine Engineering

More than 70% of our planet is covered by water. The earth’s oceans, rivers, lakes, and their coastal margins are all part of what we call the marine environment. In the Department of Naval Architecture & Marine Engineering (NA&ME), students learn how to design ships and various systems for this demanding and often harsh environment. In addition to the more traditional disciplines of naval architecture and marine engineering, we offer courses in offshore engineering and coastal engineering. Graduates of our program have designed vessels of all types, including naval ships, ocean-going commercial ships, submersibles, high-speed vessels, and recreational craft. A number of our alumni have played leading roles in the design of America’s Cup racing yachts.

Nearly 40% of the naval architects and marine engineers in the industry have ties with the University of Michigan. Thus, our graduates are highly sought by employers and enjoy the benefits of a strong network of fellow alumni. The Department works closely with the marine industry and is able to assist graduates in obtaining positions in the field. Members of the Department are in frequent contact with the country’s marine design offices, shipyards, ship operators, government agencies and other organizations in the field of naval architecture and marine engineering.

Department Focus

To prepare engineers for professional practice in the design and manufacture of vehicles to operate in the marine environment. Primary emphasis is on the scientific, engineering and design aspects of ships, small boats, and craft, and also submersibles, platforms, and other marine systems. The program also emphasizes the ability to work effectively in teams and culminates with a major team design experience.
To prepare students for professional practice in the marine industries, for further graduate study, and for life-long learning.

Our graduates’ preparation combines the essential fundamentals of engineering, mathematics, science, humanities and inter-personal skills with the most advanced facilities possible, in order for them to succeed and lead in today’s professional environment.

This focus is consistent with the mission of the University of Michigan:

To serve the people of Michigan and the world through preeminence in creating, communicating, preserving and applying knowledge, art, and academic values, and in developing leaders and citizens who will challenge the present and enrich the future.

The study of naval architecture and marine engineering is a relatively small field. In the United States and Canada, there are fewer than 20 accredited programs that prepare students for this field of engineering. Among these accredited programs, the program at the University of Michigan has consistently been ranked number one.

Our students enjoy the benefits of studying at the top department and a top university. The Department has 12 teaching and research faculty, 5 adjunct teaching faculty, and 4 research scientists. The undergraduate program typically has about 100-120 full-time students, with an average graduating class of 30 - 40 students per year. The population is approximately 11% female. Students graduate from the Department of Naval Architecture and Marine Engineering with a Bachelor of Science in Engineering Degree. Degrees are awarded three times each year: in May, August and December.

The undergraduate program is offered on the campus of the University of Michigan, Ann Arbor. Some classes are offered in the evening but the majority of classes are offered during the daytime.

Faculty

The NA&ME faculty are a group of distinguished leaders in their fields of research that support:

- A comprehensive undergraduate education program which is continually reviewed and improved to include the most current topics and provide leadership in the field.
- Comprehensive graduate education programs at the MS/MSE and Ph.D. levels. There are two areas of focus and excellence: Marine Mechanics and Marine Systems Design.
- Master of Engineering in Marine Systems Design, a practice-oriented graduate degree.
- Service to the profession and strong leadership in technical and planning committees, and journal editorial boards.

While the NA&ME faculty are very involved in research both nationally and internationally, and have won numerous awards, they have made it clear in our mission statement that our top priority is supporting the undergraduate curriculum and making sure it remains the top program in the United States. The faculty enthusiastically introduces and incorporates new concepts and material when deemed appropriate and greater student sophistication and capabilities are the result. Faculty research and expertise are further enhanced by the numerous visiting scholars and professors from industry and peer institutions throughout the world.
The primary objective of this program is to educate students for a successful engineering career in the shipbuilding and marine industry. Since the design of a marine system encompasses many engineering fields, it is considered essential that the program include preparation in the fundamentals of the physical sciences and mathematics and a sound grounding in the engineering sciences, as well as education in the engineering aspects that constitute marine design.

To provide a breadth of education, each program in the College also requires a certain number of credit hours of elective courses (a minimum of 16) concerned with cultures and relationships—generally identified as humanities and social sciences. Students are encouraged to select a cluster theme for their humanities/social science electives. This is a unifying theme (such as psychology, economics, or history) that focuses the student's electives. With careful planning, a student can obtain a minor in one of several fields; some examples are: History, Philosophy, Mathematics, and Foreign Language.

The undergraduate degree program is arranged to give the student a broad engineering mechanics education by requiring basic courses in the areas of structural mechanics, hydrodynamics, marine power systems and marine dynamics.

The first course the student is required to take in the department is NA 270 - Marine Design. This course introduces students to the field of engineering in the marine environment and develops their interest in naval architecture. In addition, it is intended to demonstrate to the student the importance of engineering analysis in good design so that the student will appreciate the material to be presented in the junior and senior level courses.

Subsequent courses cover engineering fundamentals and their application to the design and construction of marine vehicles and systems. Courses in marine structures deal with the design and analysis of marine vehicles and platforms including static strength, fatigue, dynamic response, safety, and manufacturing. Courses in marine hydrodynamics cover resistance, maneuvering, and seakeeping characteristics of bodies in the marine environment. The area of marine power systems involves all the mechanical systems on a marine vehicle with particular emphasis on the selection and arrangement of the main propulsion system. In marine dynamics, the student studies the vibrations of marine structures and engines and the rigid body responses of the vessel to wind and waves. Through the use of technical and free electives, students may decide to focus their education in areas such as:

- Marine Structures
- Ship Production and Management
- Sailing Yachts
- High Speed Craft
- Marine Environmental Fluid Mechanics
- Marine Power Systems
These and other combinations of free and technical electives are selected in consultation with the undergraduate program advisor. Students are strongly encouraged to review the possible options prior to their senior year.

The final integration of the material covered in earlier courses takes place in the two-semester, final design sequence. In the first course of this sequence, NA 470 - *Foundations of Ship Design*, the student works individually on a class design project using state-of-the-art computer-aided design tools. In the second semester, in NA 475 - *Marine Design Team Project*, the students form design teams and work on projects of their choosing. Recent final design projects included a Volvo Around the World racing yacht, high-speed ferry boats, an escort tug, a Coast Guard offshore cutter, a sport fisherman, a large cruise ship, a small deep-submergence submarine, a mega yacht, and a harbor design.

**Internships**

The Department of Naval Architecture and Marine Engineering provides its graduates with a unique set of knowledge and skills that makes them highly sought by the shipbuilding industry and by overall marine interests. A summer internship is a valuable tool for getting practical experience in the field of engineering. Our internship program typically places about 50 students at 18-20 companies throughout the United States for a paid summer experience. Co-op work experience, through the College’s Engineering Career Resource Center, is a longer work experience during the fall and/or winter terms, and can be extended into summer. When it comes time to look for permanent work, NA&ME graduates have yet another advantage over students in other departments: our department operates its own placement program by maintaining contact with employer representatives, arranging recruiter visits directly to the Department, and maintaining a jobs board with current positions in industry. In the summer of 2010, 41 undergraduate students participated in internships around the United States and the world. Of these 41 internships, 40 were paid and the average monthly salary was $2,800.

**Employment**

Students often receive multiple and rewarding job offers before graduation, and many take advantage of the intern program more than once. Through Quarterdeck Society luncheons, employer visits/job fairs, and the summer internship program, students come in contact with the industry early during their education, which helps them professionally.

**Facilities**

In addition to world-class faculty and staff, the Department of Naval Architecture and Marine Engineering features some of the finest lab space in the country, if not in the world, in the form of the *Marine Hydrodynamics Laboratories* (MHL).

The MHL investigates the various areas in which the marine environment affects our world. The laboratories encompass a number of "state of the art" testing facilities and numerical modeling capabilities with which to measure and predict the influence of physical forces on marine systems as well as ocean and coastal structures. The MHL also contains extensive field research capabilities for underwater exploration, nearshore and offshore hydrody-
dynamic investigations and monitoring, sediment and pollution transport measurement and prediction, in-situ sensor technology, renewable energy systems, as well as water quality assessment and coastal monitoring systems. The MHL is located on the first floor of West Hall on main campus. It consists of the main model basin, a low turbulence free surface water channel, a gravity-capillary water wave tank, a propeller tunnel for student use, and a two-dimensional gravity wave tank.

The Marine Renewable Energy Laboratory (MRELab) is dedicated to developing technology to harness the abundant, clean, and renewable marine energy in an environmentally sustainable way and at a competitive cost. The current focus of the MRELab is to study the underlying science of the VIVACE Converter, which was invented in the MRELab (three patents pending) to harness the hydrokinetic energy of ocean/river currents/tides.

The Ocean and Coastal Engineering Laboratory (OCEL) is equipped with an extensive array of field data acquisition devices ranging from conventional survey equipment, wave and current monitoring instrumentation, to a new state-of-the-art underwater remote-operated vehicle for education and research (M-ROVER). The OEL also houses an array of dive gear, surface supply and tether equipment.

The Perceptual Robotics Laboratory (PeRL) at the University of Michigan studies problems related to autonomous navigation and mapping for mobile robots in a priori unknown environments with a directed focus on computer vision techniques for perceptual sensing.

Finally, the Undergraduate Marine Design Laboratory (UGMDL) provides team-based work areas, computers and domain specific software resources to the department and its students. The lab also supports software workshops, design project reviews and presentations, and graduate research as well as playing an important role in the Department's research activities.

NA&ME Student Enrichment Activities

The NA&ME department is committed to interacting with students at all levels, from undergraduate recruiting and freshman advising, to mentoring and undergraduate research, to summer internships and job placement. This is a joint effort of faculty, staff and students. Faculty and staff members participate in the University's mentorship program in which they mentor small groups of students, and NA&ME upper-division students serve as mentors to lower-division students.

Students are given opportunities to voice their needs and opinions through the Department’s Student Advisory Board and the Undergraduate Marine Design Lab Advisory Committee. Faculty members hire undergraduate students to assist in research, and the Marine Hydrodynamics Laboratory hires student technicians. Students are encouraged to participate in at least one summer internship, and the Department maintains an active job postings board with the latest advertisements from industry.
Quarterdeck Society

The University of Michigan Quarterdeck Society is a student society devoted to service for the Naval Architecture and Marine Engineering Department, and to advancing the field of naval architecture in general. Membership is open to all NA&ME students in good standing.

What Quarterdeck really does is bring Naval Architecture students together in both a social and a professional setting so they can create friendships, interact together outside of class, and promote themselves professionally. Several social events, such as whirleyball games and parties, are held each semester. Luncheons and dinners throughout the year provide a forum for presentations by corporate visitors and recruiters. A group of students attend the annual Society of Naval Architects and Marine Engineers (SNAME) conference. This venue provides ideal opportunities for students to meet future employers, as well as have fun.

Quarterdeck also functions as a community service base for the NA&ME Department. Students help the department in a variety of ways, from participating in College of Engineering’s Welcome Day and TechDay to planning and hosting the Department’s annual banquet. The Quarterdeck’s mentorship program connects junior and senior students to incoming students in NA 270 who are new to the University and the Department.

Project Teams

There are many opportunities for undergraduates to learn by doing. While there is important interaction with faculty members, undergraduates also have the opportunity to form their own project teams, apply their knowledge, and learn from their own mistakes and successes. To promote this “learn-by-doing” approach, the College of Engineering has provided the 10,000 square foot Wilson Student Team Project Center to house space for design, assembly, machining, electronics, composite lay-up and painting in a single facility. Naval Architecture and Marine Engineering students can join any of the more than a dozen teams currently operating, they are generally most attracted to the Human Powered Submarine Team or the Autonomous Surface Vehicle Team.

Human Powered Submarine Team

The Human Powered Submarine Team (HPS) exists to compete in the biennial International Submarine Race (ISR) in Bethesda, Maryland at the Navy’s David Taylor Model Basin. They also compete in the ASME Submarine Competition held biennially (during the years when the ISR is not held).

HPS is an extracurricular student project team, so membership is voluntary. Students join the team because of their passion for submarines, the challenge of the design process, the prospect of winning international honors at the races, or simply for the excitement of belonging to an engineering team and working towards a common goal.

Members of the team come from a variety of engineering program backgrounds including Naval Architecture & Marine Engineering (NA&ME), Aerospace Engineering (AERO), Mechanical Engineering (ME), Industrial Operations Engineering (IOE), Chemical Engineering (CHEME), Nuclear Engineering (NERS), and Electrical Engineering (EE). Class standing ranges from freshmen through graduate students. HPS management is entirely composed of University of Michigan students. Team members design, fabricate, finance and promote the project under the guidance of a faculty advisor.
It is the mission of the Human Powered Submarine Team to provide an opportunity for students to explore their interests, apply their theoretical education and gain the hands-on experience that cannot be learned in a lecture hall in an effort to make a racing human powered submarine. In support of this mission, they have three major goals:

- Design, build and race a human powered submarine
- Educate interested persons in marine engineering and technology
- Break the world speed record for a human powered submarine.

You can learn more about HPS from their Web site, www.engin.umich.edu/hps/

**Autonomous Surface Vehicle Student Team**

The Autonomous Surface Vehicle Team was founded in the Fall of 2007. The group is advised by faculty in the Naval Architecture and Marine Engineering Department; members come from all engineering disciplines, but primarily from the departments of Naval Architecture and Marine Engineering and Electrical Engineering.

The team competes in the International Autonomous Surface Vehicle Competition, which is hosted by the Association for Unmanned Vehicle Systems International and the Office of Naval Research. The objective of the Autonomous Surface Vehicle Competition is to engage students interested in unmanned system design, through hands-on experience and challenging competition. Each team builds a water-surface vehicle capable of navigating, avoiding obstacles, and performing other mission-critical tasks without any human interaction. The entries are not remotely controlled but are programmed to sense their surroundings and respond accordingly, independent of any external control by an operator. Meeting this objective requires expertise from multiple fields for tasks such as sensor integration, control system design, hull design, and funding management. Members benefit through practical, hands-on experience, interdisciplinary exposure, professionalism, and leadership skills. For more information, visit their website at: http://robots.engin.umich.edu/asvt/.

**Concrete Canoe Team**

The Concrete Canoe Team has three major goals: learning, success and fun. On this team, Naval Architecture and Marine Engineering students find an opportunity for hands-on experience designing and building a hull. Along with fabrication of the canoe, each team must write a detailed design report and present their work in a multimedia presentation during the competition. Each team must also build a display to present their canoe, and the innovative methods used in its construction. Finally, each team must race their canoe in a regatta during which the teams go head to head in sprint and slalom races. The concrete canoe regatta is an annual competition sponsored by Master Builders, Inc. and the American Society of Civil Engineers to promote developments in concrete mix designs and encourage undergraduate involvement in advanced research, project management and intercollegiate competition. Winning the canoe competition not only takes the best thinkers, it takes the best athletes as well. For more information on the Concrete Canoe Team, visit their website at: www.engin.umich.edu/team/canoe.
Financial Assistance

The University of Michigan Financial Aid Office (www.finaid.umich.edu) is the best place to start looking for financial assistance, both merit-based and need-based. It can offer you information about how to apply for financial aid, what programs you may be eligible for and how you should handle your own specific financial situation.

The College of Engineering provides merit scholarships to qualified incoming students. A student’s application for admission is used to identify qualified recipients, who are then notified of their eligibility. Selection is made from a review of all incoming students and is based on scholastic test scores, class ranks, and grade point averages. Application is not required for consideration. The Department of Naval Architecture and Marine Engineering receives funds from several different sources for the purpose of awarding scholarships. To receive these funds, one must be a declared student in the department, and usually must have above a 3.0 grade point average. For the most part, these scholarships are awarded to deserving juniors and seniors. These scholarships come from The Society of Naval Architects and Marine Engineers, The American Bureau of Shipping, various alumnus endowments, the Loyal Crew Fund and others. In addition, the College of Engineering cooperates with the Department in making available special funds to help support students. In most cases, eligible students are asked to apply for the scholarships listed above.

The College of Engineering and the University of Michigan

The University of Michigan, one of the oldest public institutions in the country, was founded in 1817 in Detroit and moved to Ann Arbor in 1837. The University comprises 19 schools and colleges and the quality of its academic programs places it among the top 10 colleges and universities in the United States. The University has a reputation for athletic as well as academic excellence and fielding intercollegiate teams in all major sports. In addition to varsity sports, there are club teams such as sailing, soccer, water skiing, judo, crew and water polo. An outstanding intramural athletics program offers everything from team play in a variety of sports to the use of excellent recreational facilities. To learn more about the University of Michigan, browse the Web site at http://www.umich.edu/.

The University of Michigan began educating engineers in 1854. Today, the College of Engineering is consistently ranked among the top engineering schools in the United States. Most of its degree programs are rated in the top ten nationwide, and its large research portfolio is very impressive. Opportunities for study and research have expanded such that students may now choose from more than 1,000 engineering courses. For anyone excited about the potential of technology, there's no better place to learn and explore than the University of Michigan’s College of Engineering. As the oldest public engineering school in the United States (by first degree awarded), Michigan Engineering boasts more than 60,000 living alumni.

The College is located in U-M’s 850 acre “North Campus” and includes 23 buildings. The College shares North Campus with the Schools of Information, Music, Architecture and Urban Planning, and Art and Design, which makes for a vibrant and rich campus community. The College’s world class facilities include more than 150 research laboratories, and our teaching and research facilities are among the most modern in the world, with continual efforts underway to upgrade and expand them. The library collections of the College of Engineering are located in the Duderstadt Center, a 255,000 square-foot integrated technology instruction center that offers high tech resources. The Duderstadt Center offers multimedia resources and comfortable spaces to facilitate educational and social collaborations across academic boundaries. It is open 24 hours a day.

Paul White interning for the Military Sealift Command at the Norfolk Naval Base
The College’s library collections include over 500,000 volumes covering all fields of engineering. The library also uses a variety of on-line information services and provides trained staff, course-related instruction programs, and computerized reference searching to help students make effective use of information resources available from around the world.

More information about the Duderstadt Center and its amenities, including the Engineering Library, can be found at http://www.lib.umich.edu/aael/.

**Engineering Career Resource Center**

The Engineering Career Resource Center (ECRC) offers a variety of resources, services and networks to prepare you for a successful career transition. Staff members are available to meet with students to discuss career planning and job search issues. The ECRC maintains a library of current career resources for use on site. Their password-protected, online recruiting system can be accessed by students and alumni of the College of Engineering. The system integrates many of the Center’s services into a single, easy-to-use source. Using this resource, students can build their resumes, search for permanent and/or intern positions, submit resumes to specific employers and link to employer web sites. See http://career.engin.umich.edu/.

**Computer Aided Engineering Network**

The Computer Aided Engineering Network (CAEN) provides the College of Engineering with one of the world’s premiere computing environments for engineering-related research and education. CAEN maintains a fully integrated, multi-vendor network of advanced desktop workstations and high-performance servers and other specialized high-performance computers that serve the faculty, staff and students of the College. There are more than 850 workstations in 18 computing labs that are open to all College of Engineering students. Nearly all of these computers are available 24 hours a day, seven days a week. Many of them are available to engineering personnel only. A “Realtime Lab Monitor” allows students to check on line for computer availability in all labs before making the trip to the lab. The access to commercial, professional grade and open-source software applications in CAEN labs is unparalleled. In addition to the student labs, there are approximately 13,000 hosts and other devices connected to CAEN’s college-wide backbone network from offices, classrooms, research labs and other locations. The CAEN network allows people to sit at any workstation and see an integrated “single system” image of what is a heterogeneous underlying physical network. The College’s computing environment is fully integrated with those of other University of Michigan organizations, including other schools and colleges. Michigan’s gateways to the Internet extend connectivity from desktops across the country and around the world.

**The Ann Arbor Community**

Rated as one of the most livable communities in the United States, Ann Arbor is unique in combining many of the cultural advantages of a large city with the uncrowded, quiet atmosphere of a small town. The University of Michigan is located right in the middle of Ann Arbor and there are no formal boundaries between the campus and the community. The downtown area is a shopping and business district which is easily accessible on foot, by bicycle or by bus. The city has its own bus system, general aviation airport, community access television stations and radio stations. In addition, it serves as the Washtenaw County seat, and boasts an active political arena.

The diversity of people at the University makes Ann Arbor a distinctly cosmopolitan place to live. The social, cultural, intellectual and aesthetic aspects of Ann Arbor mix old and new, conservative and liberal, conventional and experimental. Entertainment and night life in Ann Arbor includes theater and music. The annual
Ann Arbor Art Fair in July draws visitors and artists from all over the world. For an evening on the town, Ann Arbor offers an incredible selection of restaurants with a variety of menus and cuisines.

You can learn more about Ann Arbor by browsing the Ann Arbor web site at http://www.annarbor.org.

**Brief History of the Department**

In 1879, Congress authorized the United States Navy to assign officers to engineering colleges. Mortimer E. Cooley, a graduate of the first four-year engineering officer program at the United States Naval Academy (1874-78) was detailed to serve as Professor of Steam Engineering and Iron Shipbuilding at the University of Michigan. Cooley arrived in Ann Arbor in August 1881 at the age of 26 and at the time, was the only mechanical engineer in the State of Michigan. With an enrollment of 25 out of a total of 1,500 students, engineering was a minor branch of the Department of Literature, Science, and the Arts. In 1885, Cooley resigned his naval commission and accepted a permanent University faculty position.

In 1899, a curriculum was established in naval architecture and marine engineering. Herbert C. Sadler arrived in 1900 to teach naval architecture while Cooley taught marine engineering. Cooley was appointed Dean of Engineering in 1904 and held that position until his retirement in 1928. Sadler became the first chair of the Department of Naval Architecture and Marine Engineering and in 1928 succeeded Mortimer Cooley as Dean of the College of Engineering. In 1903, Sadler supervised the design and construction of the towing tank in the new West Engineering Building, making Michigan the first educational institution in the world with such a research facility.

During World War II, the Department put forth a massive effort and became an important center of war-related activities, both in research and education, and provided a valuable experimental facility and a program for rapidly developing the trained engineers needed to support shipbuilding and ship repair efforts.

The Cold War and the Soviet space challenge brought about renewed interest in research and advanced technology. During this same period, the development of international commerce brought with it an extraordinary demand for merchant shipping. The Department responded with climbing enrollment and additional faculty, and graduated its first Ph.D. student in 1960.

In the mid-1970’s, the Department moved to a new building on North Campus where it currently resides. From its beginning until the present day, the Department of Naval Architecture and Marine Engineering has held a premier position in education for the marine environment and continues to explore new research and technology in preparing future engineers in its discipline.
Naval Architecture and Marine Engineering Major Requirements

Subjects Required by All Programs (55 credits)

Mathematics 115, 116, 215 and 216
Engineering 100- Introduction to Engineering
Engineering 101- Introduction to Computers
Chemistry 125/126 and 130 or Chemistry 210/211

Physics 140/141
Physics 240/241
Intellectual Breadth courses

Related Technical Core Subjects (11 credits)

ME 211- Introduction to Solid Mechanics
ME 240- Introduction to Dynamics
ME 235- Thermodynamics I

Program Subjects (45 credits)

NA 270- Marine Design
NA 260- Marine Systems Manufacturing
NA 310- Marine Structures I
NA 320- Marine Hydrodynamics I
NA 321- Marine Hydrodynamics II
NA 331- Marine Engineering I
NA 332- Marine Electrical Engineering

NA 340- Marine Dynamics I
NA 387- Probability and Statistics for Marine Engineers
NA 470- Foundations of Ship Design
NA 475- Marine Design Team Project
NA 491- Marine Engineering Laboratory I
NA 492- Marine Engineering Laboratory II

Technical Electives (6-8 credits)

Choose at least 2 courses from List 1 and/or List 2. **One course MUST come from List 1.**

List 1

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>NA 410- Marine Structure II</td>
<td>NA 401- Small Craft Design</td>
</tr>
<tr>
<td>NA 420- Environ. Ocean Dynamics</td>
<td>NA 403- Sailing Craft Design Principles</td>
</tr>
<tr>
<td>NA 431- Marine Engineering II</td>
<td>NA 416- Theory of Plates and Shells</td>
</tr>
<tr>
<td>NA 440- Marine Dynamics II</td>
<td>NA 455- Nearshore Environmental Dynamics</td>
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List 2

Advanced Mathematics: Math 450- Math 454- or Math 471

General Electives (9 – 11credits)

Total credits required for graduation - 128

Notes:

1. If you have a satisfactory score or grade in Chemistry AP, A-Level, IB Exams or transfer credit from another institution for Chemistry 125/126/130 you will have met the Chemistry Core Requirement for the College of Engineering.

2. If you have a satisfactory score or grade in Physics AP, A-Level, IB Exams or transfer credit from another institution for Physics 140/141 and Physics 240/241 you will have met the Physics Core Requirement for the College of Engineering.

3. At least 16 credits of Humanities, Liberal Arts and Professional or Creative Development courses required. See Engineering Bulletin for additional details.
Naval Architecture and Marine Engineering Course Offerings

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Prerequisites</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAVARCH 260</td>
<td>Marine Systems Manufacturing</td>
<td>NAVARCH 270 or concurrent with NAVARCH 270. II (3 credits)</td>
<td>3</td>
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<tr>
<td></td>
<td>Overview of the marine industry and its environment as it relates to all aspects of naval architecture and engineering, including industry characteristics; organization; product types and components; materials used; joining methods; design; production engineering; planning; contracts and specifications; cost estimating; production and material control.</td>
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<tr>
<td>NAVARCH 270</td>
<td>Marine Design</td>
<td>Prerequisite: NAVARCH 270. II (4 credits)</td>
<td>4</td>
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<td></td>
<td>Introduction to the marine industries, ships, and platforms. Engineering economics as applied in marine design decision making. Overview of preliminary ship design with brief team design project. Hydrostatics, stability, and trim of ships, boats, and marine platforms.</td>
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<tr>
<td>NAVARCH 310</td>
<td>Marine Structures I</td>
<td>MECHENG 211, NAVARCH 270. I (4 credits)</td>
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<tr>
<td>NAVARCH 320</td>
<td>Marine Hydrodynamics I</td>
<td>Math 215 and MECHENG 211 or MECHENG 240, or permission of instructor. I (4 credits)</td>
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<td>Concepts and basic equations of marine hydrodynamics. Similarity and dimensional analysis, basic equations in integral form, continuity, and Navier-Stokes equations. Ideal fluid flow, Euler's equations, Bernoulli equation, free surface boundary value problems. Laminar and turbulent flows in pipes and around bodies.</td>
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<tr>
<td>NAVARCH 321</td>
<td>Marine Hydrodynamics II</td>
<td>NAVARCH 320. II (4 credits)</td>
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<tr>
<td>NAVARCH 331</td>
<td>Marine Engineering I</td>
<td>MECHENG 235, co-requisite NAVARCH 320. I (4 credits)</td>
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<tr>
<td>NAVARCH 332</td>
<td>Marine Electrical Engineering</td>
<td>NAVARCH 331, Phys 240. II (3 credits)</td>
<td>3</td>
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<tr>
<td>NAVARCH 340</td>
<td>Marine Dynamics I</td>
<td>MECHENG 240. Co-requisites: NAVARCH 321, NAVARCH 387. II (4 credits)</td>
<td>4</td>
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<tr>
<td>NAVARCH 387</td>
<td>Introduction to Probability and Statistics for Marine Engineers</td>
<td>MATH 116. II (3 credits)</td>
<td>3</td>
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<td>Fundamentals of probability theory, with marine engineering applications. An introduction to statistics, estimation, goodness of fit, regression, correlation, engineering applications.</td>
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<tr>
<td>NAVARCH 401</td>
<td>Small Craft Design</td>
<td>preceded or accompanied by NAVARCH 321 and NAVARCH 340. I (4 credits)</td>
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<tr>
<td>NAVARCH 403</td>
<td>Sailing Craft Design Principles</td>
<td>preceded or accompanied by NAVARCH 321. II (4 credits)</td>
<td>4</td>
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<tr>
<td>NAVARCH 410</td>
<td>Marine Structures II</td>
<td>NAVARCH 310. I (4 credits)</td>
<td>4</td>
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<tr>
<td></td>
<td>Structural modeling and analysis techniques applied to ship and marine structure components. Equilibrium and energy methods applied to elastic beam theory; static bending, torsion and buckling. Shear flow and warping of multicell cross sections. Stiffened and composite plates. Plastic analysis of beams. Thick walled pressure vessels. Course project using finite element analysis.</td>
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</table>
NAVARCH 416 (AEROSP 416). Theory of Plates and Shells  
**Prerequisite: NAVARCH 310 or AEROSP 315. II (3 credits)**  

NAVARCH 420 (AOSS 420). Environmental Ocean Dynamics  
**Prerequisites: NAVARCH 320 or AOSS 305 or CEE 325. I (4 credits)**  
Physical conditions and physical processes of the oceans; integration of observations into comprehensive descriptions and explanations of oceanic phenomena. Emphasis on wave and current prediction, optical and acoustical properties of sea water, currents, tides, waves and pollutant transport.

NAVARCH 421. Ship Model Testing  
**Prerequisite: undergraduates only and permission of instructor. I, II, IIIa (to be arranged)**  
Individual or team project, experimental work, research or directed study of selected advanced topics in ship model testing.

NAVARCH 431. Marine Engineering II  
**Prerequisite: NAVARCH 310, NAVARCH 331, NAVARCH 332, NAVARCH 340. II (3 credits)**  

NAVARCH 440. Marine Dynamics II  
**Prerequisite: NAVARCH 321, NAVARCH 340. II (4 credits)**  

NAVARCH 455. Environmental Nearshore Dynamics  
**Prerequisite: NAVARCH 320. offered alternate years II (4 credits)**  
Shallow water waves and currents are investigated in nearshore processes including tides and long-term sea-level changes, longshore current and prediction of sediment and pollutant transport. Beach response to these processes is examined; coastal structures and effects on the nearshore environmentally conscious coastal design is emphasized. Interpretation of aerial photography is investigated.

NAVARCH 470 (MFG 470). Foundations of Ship Design  
**Prerequisite: NAVARCH 321, NAVARCH 332, NAVARCH 340. Co-requisites: NAVARCH 310. I (4 credits)**  
Organization of ship design. Preliminary design methods for sizing and form; powering, maneuvering, seakeeping estimation; arranging; propulsion; structural synthesis; and safety and environmental risk of ships. Extensive use of design computer environment. Given owner's requirements, students individually create and report the conceptual/preliminary design for a displacement ship.

NAVARCH 475. Marine Design Team Project  
**Prerequisite: NAVARCH 470. II (4 credits)**  
Small teams of 4 or more students create, develop, and document original marine designs to contract design level. Projects typically involve a ship, yacht, submersible, or offshore system. Involves extensive project planning and weekly progress reporting. Extensive written and oral presentation of the project. Significant design CAD effort.

NAVARCH 490. Directed Study, Research and Special Problems  
**Prerequisite: undergraduate only and permission. I, II, IIIa (to be arranged)**  
Individual or team project, experimental work or study of selected topics in naval architecture or marine engineering. Intended primarily for students with senior standing.

NAVARCH 491. Marine Engineering Laboratory I  
**Prerequisite: NAVARCH 310, NAVARCH 320, NAVARCH 321, NAVARCH 331, NAVARCH 332, NAVARCH 340. I (3 credits)**  
Instruction in laboratory techniques and instrumentation. Use of computers in data analysis that includes Fast Fourier transforms. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, propeller forces, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale.

NAVARCH 492. Marine Engineering Laboratory II  
**Prerequisite: NAVARCH 310, NAVARCH 320, NAVARCH 321, NAVARCH 331, NAVARCH 332, NAVARCH 340, NAVARCH 491. II (2 credits)**  
Instruction in laboratory techniques and instrumentation. Use of computers in data analysis that includes Fast Fourier transforms. Technical report writing. Investigation of fluid concepts, hydro-elasticity, marine dynamics, propeller forces, wave mechanics, ship hydrodynamics, and extrapolation of model tests to full scale.

**Prerequisite: NAVARCH 260 or P.I. or Graduate Standing. I (4 credits)**  
Examination of business strategy development, operations management principles and methods, and design-production integration methods applied to the production of complex marine systems such as ships, offshore structures, and yachts. Addresses shipyard and boat yard business and product strategy definition, operations planning and scheduling, performance measurement, process control and improvement.
The University of Michigan
College of Engineering
Naval Architecture and Marine Engineering
Undergraduate Programs

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The Regents of the University of Michigan:
Effective January 1, 2009-December 31, 2012

Julia Donovan Darlow
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Andrew C. Richner
S. Martin Taylor
Katherine E. White

Mary Sue Coleman (ex officio)