Management program concentrates on developing the knowledge and domination of existing ones. Core coursework in the Master of Engineering processes, and services, which, in turn, will create new markets or enable technological leadership. Vision looks to the creation of new products, management emphasizes the concept of technological leadership. 

Grounded in solid principles of systems science while exploiting the tools of engineering management program focuses on problems, design, and the necessary skills, knowledge, and abilities required to design and manage technology-intensive enterprises. The degree is directed at working professionals and traditional full-time students with technical undergraduate degrees. The degree is available on campus in a live setting as well as online through synchronous web delivery. Courses are scheduled in the evenings and can be attended from off-campus sites, including the Peninsula Higher Education Center in Hampton and the Virginia Beach Higher Education Center. The complete M.E.M. program is available through Old Dominion University’s distance learning program and through the Commonwealth Graduate Engineering Program. Both programs transmit courses to educational, industrial, and government locations throughout Virginia and via a web-based platform.

Admission Requirements
Admission to the master of Engineering Management program is in accordance with Old Dominion University and Frank Batten College of Engineering and Technology requirements for master’s programs as specified in this catalog.

Admission requirements specific to this program include the following:
1. Official transcripts from all post-secondary institutions attended.
2. Undergraduate degree from a U.S. ABET-accredited program in engineering or engineering technology with a GPA of 3.00 (out of 4.00) or better. Students who hold bachelor’s degrees in other disciplines or who do not meet the GPA requirement may be considered for admission based on transcript evidence of applicable physics and calculus courses, a résumé indicating relevant work experience in an engineering discipline, and/or satisfactory GRE quantitative scores.
3. Résumé detailing relevant work experience.
4. Personal Statement that outlines the rationale for applying to the program and how it aligns with the student's professional goals.
5. Students not meeting the above requirements may be admitted provisionally. The Graduate Program Director may request additional information, including GRE scores.
6. International students must meet University admission requirements; please refer to the website: https://www.odu.edu/admissions/proficiency

Degree Requirements
General Requirements
The Master of Engineering Management is in accordance with the general requirements for master’s degrees as specified in this Catalog. All students must have mathematics coursework through the level of integral calculus, matrix algebra or differential equations, and ENMA 420 or equivalent calculus-based probability and statistics. Students who have not had a calculus-based probability and statistics course will be required to include ENMA 420, or equivalent, as part of their plan of study in addition to the required 31 credit hours. All students are expected to communicate effectively both orally and in written documents, that are correct in grammar, style, and mechanics. Those deemed insufficient may be required to take remedial speech or writing courses. The engineering management curriculum has been designed around six core areas that develop the skill sets identified earlier and prepare graduates to assume positions within technology-based enterprises.

Curricular Requirements
The Master of Engineering Management (M.E.M.) program requires 31 credits of coursework (10 three-credit courses plus one three-credit capstone course). At least three-fifths (3/5) of coursework must be at the 600- or 700-level for the M.E.M. degree. Students must maintain a 3.00 GPA or better. Students must meet all University continuance requirements.

M.E.M. Courses:

<table>
<thead>
<tr>
<th>Prerequisite *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
</tr>
<tr>
<td>ENMA 600</td>
</tr>
</tbody>
</table>
ENMA 601  Analysis of Organizational Systems
ENMA 603  Operations Research
ENMA 604  Project Management
ENMA 646  Information Science for Systems and Engineering Management

Select one of the following: 3
  ENMA 614  Quality Systems Design
  ENMA 715  Systems Analysis
  ENMA 724  Risk Analysis
Electives * 12
Capstone 1
  ENMA 605  Program Capstone (required final semester)

Total Hours 31

* Students must select twelve credit hours of elective coursework for the M.E.M. These electives may be selected from the available graduate-level ENMA courses.

Requirements for Graduation
In addition to completing all the required courses, all graduate students must complete the Collaborative Institutional Training Initiative (CITI) basic course, Responsible Conduct of Research for Engineers. The basic course includes the following modules: Misconduct (falsification, fabrication, and plagiarism); Data acquisition, management, sharing and ownership; Mentor/ trainee relationships; Publication practice and responsible authorship; Peer review; Conflicts of interest; and Collaborative research. The RCR modules must be completed prior to completion of 12 semester hours. Students who fail to complete this requirement will have a registration hold placed on their records.

Master of Science in Engineering Management

Degree Description
The Master of Science in Engineering Management (MSEM) provides the foundation and the necessary skills, knowledge, and abilities required to design and manage the technology-based, project-driven enterprise. The Master of Science (M.S.) program requires thesis research, and the student is expected to identify an advisor and work with him/her starting from the first semester. Fundamentally, the engineering management program focuses on problems, design, and management of projects and complex operations. The program is grounded in solid principles of systems science while exploiting the tools of management science and project management. The coursework is designed to produce graduates capable of addressing issues related to the design, operation, analysis, and transformation of complex problems. Core coursework in the Master of Science in Engineering Management program concentrates on developing the knowledge and skills required by graduates to provide the project and program leadership and management necessary for an organization to develop and manage technologies.

The degree is directed at working professionals and traditional full-time students. The degree is available on campus in a live setting as well as online through synchronous web delivery. Courses are scheduled in the evenings and can be attended from off-campus sites, including the Peninsula Higher Education Center in Hampton and the Virginia Beach Higher Education Center. The complete MSEM program is available through Old Dominion University’s distance learning program and through the Commonwealth Graduate Engineering Program. Both programs transmit courses to educational, industrial, and government locations throughout Virginia and via a web-based platform.

Admission Requirements
Admission to the Master of Science in Engineering Management program is in accordance with Old Dominion University and Frank Batten College of Engineering and Technology requirements for master’s programs as specified in this catalog.

Admission requirements specific to this program include the following:
1. Official transcripts from all post-secondary institutions attended.
2. Undergraduate degree from a U.S. ABET-accredited program in engineering or engineering technology with a GPA of 3.00 (out of 4.00) or better. Students who hold bachelor’s degrees in other disciplines or who do not meet the GPA requirement may be considered for admission based on transcript evidence of applicable physics and calculus courses, a résumé indicating relevant work experience in an engineering discipline, and/or satisfactory GRE quantitative scores.
3. Résumé detailing relevant work experience.
4. Personal Statement that outlines the rationale for applying to the program and how it aligns with the student's professional goals.
5. Students not meeting the above requirements may be admitted provisionally. The Graduate Program Director may request additional information, including GRE scores.
6. International students must meet University admission requirements; please refer to the website: https://www.odu.edu/admissions/proficiency/ (https://www.odu.edu/admissions/proficiency/).

Degree Requirements

General Requirements
The Master of Science in Engineering Management (MSEM) is in accordance with the general requirements for master’s degrees as specified in this Catalog. Students are required to identify an advisor as part of the program requirements. All students are expected to communicate effectively both orally and in written documents, that are correct in grammar, style, and mechanics. Those deemed insufficient may be required to take remedial speech or writing courses. All students must have mathematics coursework through the level of integral calculus, matrix algebra or differential equations, and ENMA 420 or equivalent calculus-based probability and statistics. Students who have not had a calculus-based probability and statistics course will be required to include ENMA 420, or equivalent, as part of their plan of study in addition to the required 30 credits.

Curricular Requirements
The Master of Science in Engineering Management requires 30-credit hours of coursework (8 three-credit courses plus 2 three-credit thesis research courses). At least three-fifths (3/5) of coursework must be at the 600- or 700-level. Students must identify an advisor within completion of 9 credit hours. Students must maintain a GPA of 3.00 or better. Students must meet all University continuance requirements.

The following table delineates the specific course requirements for this program.

M.S. Courses:

<table>
<thead>
<tr>
<th>Required *</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENMA 711</td>
<td>Engineering Research Methodology</td>
</tr>
<tr>
<td>ENMA 720</td>
<td>Multivariate Statistics for Engineering</td>
</tr>
<tr>
<td>Core (select four of the following) 12</td>
<td></td>
</tr>
<tr>
<td>ENMA 608</td>
<td>Cost Estimating and Financial Analysis</td>
</tr>
<tr>
<td>ENMA 601</td>
<td>Analysis of Organizational Systems</td>
</tr>
<tr>
<td>ENMA 603</td>
<td>Operations Research</td>
</tr>
<tr>
<td>ENMA 604</td>
<td>Project Management</td>
</tr>
<tr>
<td>ENMA 614</td>
<td>Quality Systems Design</td>
</tr>
<tr>
<td>ENMA 715</td>
<td>Systems Analysis</td>
</tr>
<tr>
<td>Electives * 6</td>
<td></td>
</tr>
<tr>
<td>Thesis Research ** 6</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours 30

* Students must select six credit hours of elective coursework for the M.S.E.M. These electives may be selected from the available graduate level ENMA courses.

Department of Engineering Management and Systems Engineering
M.S. students take six credits of thesis research, ENMA 699, or project hours ENMA 698, which must be spread over a minimum of two semesters.

**Requirements for Graduation**

In addition to completing all the required courses, all graduate students must complete the Collaborative Institutional Training Initiative (CITI) basic course, Responsible Conduct of Research for Engineers. The basic course includes the following modules: Misconduct (falsification, fabrication, and plagiarism); Data acquisition, management, sharing and ownership; Mentor/trainee relationships; Publication practice and responsible authorship; Peer review; Conflicts of interest; and Collaborative research. The RCR modules must be completed prior to completion of 12 semester hours. Students who fail to complete this requirement will have a registration hold placed on their records. Master of Science students must also pass a final examination in front of a thesis committee approved by the graduate program director.

**Master of Engineering, Engineering – Systems Engineering**

**Degree Description**

The Master of Engineering, Engineering – Systems Engineering provides an interdisciplinary approach to support the realization, deployment, and maintenance of successful system solutions to complex problems. This program builds upon your technical background as an engineer. It is designed to provide in-depth, real-world practitioner expertise in engineering complex system solutions. In addition, this rigorous educational experience will help develop your skills in effectively addressing complex problems for both government and commercial organizations. Students in the program are introduced to core competencies for systems engineering, complex systems, modeling, systems analysis, complex problem solving needed for successful delivery of system solutions.

**Admission Requirements**

Admission to the MESE program is in accordance with Old Dominion University and Frank Batten College of Engineering and Technology requirements for masters programs as specified in this catalog.

Admission requirements specific to this program include the following:

1. Official transcripts from all post-secondary institutions attended.
2. Undergraduate degree from a U.S. ABET-accredited program in engineering or engineering technology with a GPA of 3.00 (out of 4.00) or better. Students who do not meet the requirements may be considered for admission based on transcript evidence of applicable physics and calculus courses, a résumé indicating relevant work experience in an engineering discipline, and/or satisfactory GRE quantitative scores.
3. Résumé detailing relevant work experience.
4. Personal Statement that outlines the rationale for applying to the program and how it aligns with the student's professional goals.
5. Students not meeting the above requirements may be admitted provisionally. The Graduate Program Director may request additional information, including GRE scores.
6. International students must meet University admission requirements; please refer to the website: https://www.odu.edu/admissions/proficiency (https://www.odu.edu/admissions/proficiency/).

**Degree Requirements**

**General Requirements**

The Master of Engineering - Engineering - Systems Engineering is in accordance with the general requirements for master’s degrees as specified in this Catalog. In addition, all students must have mathematics coursework through the level of integral calculus, matrix algebra or differential equations, and ENMA 420 or equivalent calculus-based probability and statistics. Students who have not had a calculus-based probability and statistics course will be required to include ENMA 420, or equivalent, as part of their plan of study as an additional requirement to the 31 credit hours. All students are expected to communicate effectively both orally and in written documents, that are correct in grammar, style, and mechanics. Those deemed insufficient may be required to take remedial speech or writing courses.

**Curricular Requirements**

The Master of Engineering - Engineering - Systems Engineering requires 31 graduate credit hours of coursework (10 courses plus a one-credit capstone course) for the degree. At least three-fifths (3/5) of coursework work must be at the 600 or 700 level for the M.E. degrees. The capstone course should be taken within the last two semesters of study. The following table delineates the specific course requirements for this program.

<table>
<thead>
<tr>
<th>Core</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENMA 515</td>
<td>Introduction to Systems Engineering</td>
</tr>
<tr>
<td>ENMA 656</td>
<td>Mathematical and Computational Modeling in Systems Engineering</td>
</tr>
<tr>
<td>ENMA 660</td>
<td>Systems Architectures</td>
</tr>
<tr>
<td>ENMA 661</td>
<td>Systems Engineering Design</td>
</tr>
<tr>
<td>ENMA 715</td>
<td>Systems Analysis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Select one of the following</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENMA 725</td>
<td>System Risk and Failure Analysis</td>
</tr>
<tr>
<td>ENMA 743</td>
<td>Reliability and Maintainability</td>
</tr>
<tr>
<td>ENMA 763</td>
<td>Robust Engineering Design</td>
</tr>
<tr>
<td>ENMA 771</td>
<td>Risk and Vulnerability Management of Complex Interdependent Systems</td>
</tr>
</tbody>
</table>

**Electives**

**12**

ENMA 690 Systems Engineering Capstone

**Total Hours**

**31**

* Required for the Master of Engineering in systems engineering, is to be taken near the final semester of study.

**Students must select twelve credit hours of elective coursework. These electives may be selected from the available graduate-level ENMA courses.**

**Requirements for Graduation**

In addition to completing all the required courses, all graduate students must complete the Collaborative Institutional Training Initiative (CITI) basic course, Responsible Conduct for Engineers. The basic course includes the following modules: Misconduct (falsification, fabrication, and plagiarism); Data acquisition, management, sharing and ownership; Mentor/trainee relationships; Publication practice and responsible authorship; Peer review; Conflicts of interest; and Collaborative research. The RCR modules must be completed prior to completion of 12 semester hours. Students who fail to complete this requirement will have a registration hold placed on their records.

**Doctor of Philosophy in Engineering – Engineering Management and Systems Engineering**

**Degree Description**

The Doctor of Philosophy (Ph.D.) focuses on developing the necessary skills to perform and evaluate rigorous research. Graduates are prepared for careers in teaching and research at academic institutions as well as in other public and private organizations characterized by innovation and technological leadership. The program blends highly theoretical with more applied or pragmatic research. The fields of research supported by the program are defined by the diverse specializations of the department faculty. Students in the Ph.D. program work closely with faculty to develop world-class expertise in their chosen fields of research. Advising faculty expect doctoral students to become collaborators, supporting the faculty’s research agenda, and contributing towards their research goals.
Admission Requirements

Admission to the Ph.D. program is competitive. The admission process is designed to select applicants that have a strong alignment between their own research interests and an area of specialization of one of the faculty. The best qualified applicant or applicants for an area of specialization are then selected. The number of students admitted into any faculty's area of specialization is dependent on the faculty's projected ability to advise additional doctoral students. The selected is based on the applicants' academic history, maturity in the development of research capabilities, and proficiency in specialized skills demanded by the research area.

In addition to general University admission requirements, which include English language proficiency for international students, applicants must have: (1) A master’s degree or equivalent with a grade point average of 3.50 in an appropriate field from an accredited institution of higher education. (2) Undergraduate degree from an ABET-accredited program in engineering or engineering technology with a GPA of 3.00 (out of 4.00) or better. Students who hold bachelor’s degrees in other disciplines or who do not meet the GPA requirement may be considered for admission based on transcript evidence of applicable physics and calculus courses, a resume indicating relevant work experience in an engineering discipline, and/or satisfactory GRE quantitative scores.

Each applicant is required to submit the following documentation when initially applying: (1) Transcripts from all institutions that the applicant has attended; (2) Graduate Record Examination general aptitude scores; (3) A curriculum vitae that highlights professional and research related activities; and (4) an essay of 300 words or less describing personal and academic goals, professional objectives, preparation for graduate study, and how the chosen program will help the applicant achieve these goals and objectives. The essay should clearly state the specific area in which the applicant intends to specialize.

Applicants whose interests can be supported by a faculty's specialization and demonstrate adequate preparation to meet the demands of doctoral studies will be contacted by the Graduate Program Director. The GPD may request additional information that will assist in the selection process. Additional information may include but is not restricted to: publications, samples of research reports, and documents or materials that support proficiency claims of specialized skills. If warranted, the GPD will organize an interview of the applicant by faculty that have specializations in areas that may overlap with the applicant's intended area of research.

Admission is contingent on having the support of a faculty that is willing to commit to acting as an advisor should the applicant be admitted.

Students lacking adequate academic preparation may be required to complete coursework in addition to the graduate admission requirements. Students may be admitted to the Ph.D. program deficient in these leveling courses, but as part of their plan of study, the student must take and successfully complete these courses at the earliest possible opportunity. All students must have mathematics coursework through the level of integral calculus; matrix algebra or differential equations; and a course in calculus-based statistics (ENMA 420) or equivalent. As part of masters-level coursework, all students must have completed the following engineering management leveling courses or their equivalent: ENMA 600 (http://catalog.odu.edu/search/?P=ENMA %20600), ENMA 603 (http://catalog.odu.edu/search/?P=ENMA %20603), and ENMA 604 (http://catalog.odu.edu/search/?P=ENMA %20604).

Degree Requirements

General Requirements

The Ph.D. program is intended to develop scholarship and research capabilities in the student. Graduates will be experts in their chosen field, highly skilled researchers, critical thinkers, and competent communicators and debaters. Graduates will demonstrate this in a variety of ways that will include, but is not limited to, their performance in: coursework, written and oral examinations, closed and public debates and defenses, and contribution to their field's body of knowledge. The development and assessment of such expertise and scholarship take place under the guidance, advising, and mentorship of a faculty that is an expert in the field, and appropriate guidance, dissertation, and examination committees.

Curricular Requirements

Curriculum requirements in engineering management are in accordance with the general requirements for Ph.D. degrees as specified in the Requirements for Graduate Degrees section of this catalog. The Ph.D. program is governed by a Plan of Study that is established by the student in conjunction with his/her advisor and guidance committee within the first nine credit hours of coursework and will follow the established course requirements (below) unless a substitution to one or more courses is agreed upon between the advisor and student and approved by the Graduate Program Director. The plan of study is designed to prepare the student to undertake scholarly research in the particular field and specialization of their dissertation. The coursework selected will provide the student with (1) the requisite foundational knowledge of the selected field, and (2) the necessary research skills. A high degree of flexibility is provided to customize the plan of study, taking into account the diversity in the fields of study, the multidisciplinary nature and variety of research that is undertaken, as well as the different levels of preparation that individual students have.

At least three-fifths (3/5) of formal coursework must be at the 800 level for all doctoral programs.

Subject Area Specialization (Advisor-driven) 9
Subject Area Electives (Suggested courses - minimum of 2) 6
ENMA 661 Systems Engineering Design
ENMA 815 Systems Analysis
ENMA 824 Risk Analysis
ENMA 843 Reliability and Maintainability
ENMA 854 Big Data Fundamentals
ENMA 863 Robust Engineering Design

Research Skills (required) 9
ENMA 811 Engineering Research Methodology
ENMA 820 Multivariate Statistics for Engineering
ENMA 821 Foundations of Research

Research Skills Electives 9

Total Coursework Required (minimum) 24
Dissertation Research * 24
Total Hours (minimum) 48

* Up to 6 dissertation research hours may be replaced by coursework with the approval of the advisor and GPD.

Requirements for Graduation

In addition to any University and College requirements presented in this catalog, the Ph.D. program in engineering management requires:

1. Satisfactory completion of a minimum of 48 credit hours of postmaster’s degree credit or equivalent level of performance coursework. This shall include a minimum of 24 credit hours of coursework that complies with the student's plan of study, and a minimum of 18 credit hours of dissertation research hours.

2. Passing a written and oral candidacy examination at the completion of formal coursework.

3. The completion of research representing independent original research and its formal documentation as a dissertation.

4. The successful defense of a dissertation proposal.

5. The successful final public defense of the dissertation before an audience, which includes an appropriately selected committee of faculty knowledgeable in the field of the research.

Continuance Requirements

Students may be separated for failure to comply with any policies, procedures or requirements that pertain to this Ph.D. program or student behavior. In addition to the requirements for graduation, separation from the program may be warranted for the following reasons, among others:
Coursework:

1. All students admitted to Engineering Management and Systems Engineering programs must earn a grade of “C” or better in all courses required for the degree and in all Engineering Management prerequisite courses. A student may be separated from the program if he/she receives a grade lower than a “C”. Additionally, a student may be separated from the program if he/she receives 2 (two) grades lower than a “B”.

Adherence to programmatic expectations:

1. Students are expected to complete their coursework according to an agreed upon plan of study. See plan of study requirements above. Failure to adhere to the plan of study may result in separation from the program.

2. Students are expected to make timely progress on their coursework and research. Persistent failure to meet deadlines and milestones or other indicators that demonstrate progress, as assessed and documented by the guidance or advisory committee may lead to separation from the program.

3. Students are expected to remain within the specialization area of their advisor and committee members. Students that deviate outside of the agreed upon research area will be notified of this deviation. The student may lose the support of their advisor and committee if the deviation persists. A student will be given a limited period of time (generally one semester) to acquire an advisor that is capable of supporting their new research direction. Separation from the program will result if the student cannot obtain a new advisor, whether this is due to the lack of a specialization in the new field, or if a faculty with a suitable specialization cannot take on additional advising responsibilities.

4. Similarly, if a student is left without an advisor for any other reason (e.g. departure of a faculty advisor from the program), it is contingent on the student to obtain a new advisor in a timely manner. This may require flexibility and willingness by the student to adjust their area of specialization. The department will assist the student and take their particular situation into consideration when the loss of an advisor is due to factors outside of the student's control. Separation from the program will, however, result if no advisor is obtained after a limited period of time (generally one semester).

Quality of Research

1. A student that persistently submits work of low quality whether it be in documented or in oral form, may be required to submit for special reviews by the committee. Records taken by the advisor, and the guidance or advisory committees, which document the quality problems and present remedial actions where appropriate will be used to help ascertain whether the problems can reasonably be expected to be resolved, or if separation from the program is warranted.

Ethical Behavior

1. Any student partaking or demonstrating behaviors that might be considered to go against the policies and conditions expected for responsible conduct in research, Old Dominion University expected codes of conduct, or ethical considerations that might be specific to an area of research, may result in separation from the program.

Doctor of Engineering – Engineering Management and Systems Engineering

Degree Description

The Department offers a Doctor of Engineering (D.Eng.) program with a concentration in Engineering Management and Systems Engineering in accordance with the D.Eng. program requirements specified for the Batten College of Engineering and Technology in this catalog. Additional information on the admission procedure and criteria can be found at https://www.odu.edu/academics/programs/doctoral/engineering-management (https://www.odu.edu/academics/programs/doctoral/engineering-management/).

Graduate Certificates

The Department of Engineering Management and Systems Engineering administers or participates in a variety of graduate certificates. These include graduate certificates or advanced engineering certificates with concentrations as follows:

- Advanced Engineering Cyber Systems Security
- Engineering Management
- Project Management
- Homeland Security
- Entrepreneurship and Innovation in Engineering
- Mission Analysis and Engineering

Please refer to Frank Batten College of Engineering and Technology (http://catalog.odu.edu/graduate/frankbattencollegeofengineeringandtechnology/) for more information.

ENGINEERING MANAGEMENT Courses

ENMA 510. Agile Project Management. 3 Credits.
This course focuses the management of projects using an agile approach to respond to the continuous changes that affect project capabilities and performance. Although any project can be manage using agile project management, projects with high degree of uncertainty obtain the most benefits from this approach (e.g., R&D projects). The course covers Scrum and expands it by articulating the human and business factors that make successful agile project management. Case studies and/or short-projects are required. Prerequisites: ENMA 401 or equivalent.

ENMA 515. Introduction to Systems Engineering. 3 Credits.
Introduces the principles, concepts and process of systems engineering. Examination of problem formulation, analysis, and interpretation as they apply to the study of complex systems. Emphasizes the design nature of systems engineering problem solving, and includes case studies stressing realistic problems. Development of system requirements, system objectives, and the evaluation of system alternatives.

ENMA 595. Topics in Engineering Management. 1-6 Credits.
Special topics with emphasis placed on the recent developments in engineering management. Prerequisites: permission of the instructor.

ENMA 600. Cost Estimating and Financial Analysis. 3 Credits.
Introduction to the monetary aspects of engineering projects, including accounting principles; financial reports and analysis; capital budgeting; cost estimation and control; inventory management; depreciation; investment decisions. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. Case studies and a term project are required. Pre- or corequisite: ENMA 420 or equivalent.

ENMA 601. Analysis of Organizational Systems. 3 Credits.
This course introduces the student to fundamental concepts in the analysis of organizations. A systems approach is taken in the examination of social, structural, procedural and environmental aspects that are of consequence to technical professionals and managers. Modules covered include: History and Systems of Organizations and Management; Basic Organizational Systems and Models emphasizing rational, natural and open systems; Organizational Behavior Models; Organizational Structure Models; Integration of Systems Perspectives.

ENMA 602. Systems Engineering Management. 3 Credits.
Students develop a comprehensive set of techniques and methods to design, maintain and evolve the systems engineering function in support of strategic enterprise objectives and operations.

ENMA 603. Operations Research. 3 Credits.
Deterministic and stochastic models for decision making. Topics include: optimization methods; linear and other programming models; network analysis; inventory analysis; queuing theory. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed.
ENMA 601. Project Management. 3 Credits.
Exploration of the systems approach to planning, scheduling, control, design, evaluation, and leadership of projects in technology-based organizations. The fundamental tools and techniques of project management; role of the project manager; project management systems; project selection; project life cycle; project monitoring and control; project management evaluation and auditing; project risk and failure analysis; contextual nature of project management; project knowledge.

ENMA 605. Program Capstone. 1 Credit.
A written, comprehensive demonstration of the candidate's competence in the fields covered by the program of study that is intended to fulfill the non-thesis master's examination requirement. Prerequisites: Completion of minimum of the 18 core credit hours in program of study.

ENMA 606. Engineering Law. 3 Credits.
Basic legal concepts and procedures for understanding the implications of engineering management decisions. Major emphasis on contracts and liability.

ENMA 607. Stochastic Decision Methods. 3 Credits.
Introduction to decision analysis and stochastic models; risk and uncertainty in decision making; probabilistic inventory problems; queuing theory; Markov processes; dynamic programming; Monte Carlo simulation of dynamic systems. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed.

ENMA 613. Logistics and Supply Chain Management. 3 Credits.
Studying how logistical decisions impact the performance of the firm and the entire supply chain. Topics include strategic planning, facilities location and analysis, distribution and transportation networks, forecasting, inventory management, and information systems for supply chains. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. The course includes case studies and/or a project. Prerequisites: ENMA 603; ENMA 420 or equivalent.

ENMA 614. Quality Systems Design. 3 Credits.
Integrated analysis of the process quality assurance and improvement function. Quality Deming's way. Scientific sampling and control charting for quality assurance and control; the quality cost concept and economic aspects of quality decisions. Organization of the quality function for process quality improvement. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. Prerequisites: ENMA 420 or equivalent.

ENMA 616. The Entrepreneurial Engineering Manager. 3 Credits.
Globalization has increased competition among the planet's enterprises. The quality of products and services has dramatically improved while prices have plummeted. Consumer expectations have risen to very high levels. This phenomenon has accelerated the need for large technical enterprises to become more agile, flexible and responsive to consumer demands. Government agencies are not exempt form this trend: U.S. Government agencies are now required to establish strategic plans for their enterprises and to develop business plans that illustrate the future directions of the enterprise and to define the resources required to realize the vision and strategy of the enterprise. This course introduces Engineering Management students to a wide range of approaches designed to facilitate start-up, enable growth and ensure the continued capability of emerging and mature technical enterprises.

ENMA 641. Requirements Management, Verification and Validation. 3 Credits.
Comprehensive treatment of the nature and utility of requirements, verification, and validation in systems engineering processes. Topics include: establishing user requirements; traceability; baseline and evolving requirements; governing standards; requirements management; issues in requirements for complex systems; role and methods for verification and validation in systems engineering; data treatment and analysis; standards, practices, and issues for verification and validation in systems engineering.

ENMA 645. Preparation for Systems Engineering Professional Certification. 3 Credits.
A comprehensive treatment and review of the International Council on Systems Engineering (INCOSE) Systems Engineering Handbook v4 in preparation for INCOSE Systems Engineering Professional (SEP) Certification. This course should be taken in the final semester in which the student will graduate.

ENMA 646. Information Science for Systems and Engineering Management. 3 Credits.
This course aims to prepare students with the general knowledge and skills for the on-going digital transformation. The course covers: (1) preliminaries of information and informatics; (2) information and knowledge modeling; (3) fundamental concepts, models, tools, and applications of Big Data; and (4) digital mechanisms of trust and security, including: digital asset access control, digital signature, digital certification, Public Key Infrastructures, and Blockchains.

ENMA 650. Mission Analysis and Engineering. 3 Credits.
The course provides an overview of mission engineering and the role of mission engineering and the mission engineer in government acquisitions. The course presents the theoretical foundations that enable a fuller representation of complex problem as well as the required engineering and management approaches needed to deal with the high level of complexity and uncertainty. It applies the theoretical facets to specific engineering problems/cases and explores robust approaches given the conditions of the problem. Developments, on-going research, as well as gaps in knowledge and know-how are discussed. Prerequisites: ENMA 640.

ENMA 656. Mathematical and Computational Modeling in Systems Engineering. 3 Credits.
The course introduces some of the mathematical structures and method used within systems engineering. The course will cover probability theory, scheduling, queuing theory, Markov chains, and critical path analysis. Students will implement the ideas in the course in practical computer-based laboratories including the graphical representation of quantitative outputs.

ENMA 660. Systems Architectures. 3 Credits.
Students learn the essential aspects of the systems architecture paradigm through development and analysis of multiple architecture frameworks and enterprise engineering. Emphasis is placed on systems modeling and enterprise engineering.

ENMA 661. Systems Engineering Design. 3 Credits.
This course covers modern modeling paradigms for deterministic and stochastic complex and dynamic systems. This includes, but is not limited to, Discrete Simulation, Queuing Systems, and Agent-based models among others. Focus will be on system analysis using different developed models in different domains such as production, logistics, security, and service, military and social. Prerequisites: ENMA 420 or equivalent.

ENMA 667. Cooperative Education. 1-3 Credits.
Available for pass/fail grading only. Student participation for credit based on academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and the Cooperative Education program prior to the semester in which the work experience is to take place.

ENMA 668. Internship. 1-3 Credits.
Academic requirements will be established by the graduate program director and will vary with the amount of credit desired. Allows students an opportunity to gain short-duration career-related experience. Meant to be used for one-time experience. Work may or may not be paid. Project is completed during the term.

ENMA 669. Practicum. 1-3 Credits.
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career related experience. Student is usually already employed - this is an additional project in the organization. Prerequisites: Approval by department and Career Development Services.
ENMA 670. Cyber Systems Engineering. 3 Credits.
This course provides an overview of functioning of cyber systems including how a computer interacts with the outside world. The composition of critical infrastructure and functioning of different engineered systems that form critical infrastructure are discussed. Mutual dependence and interactions between cyber systems and other engineered and the resulting security risks are also explored. Prerequisites: Undergraduate students in STEM fields or graduate students of STEM degree or instructor’s approval.

ENMA 690. Systems Engineering Capstone. 1 Credit.
A written, comprehensive demonstration of the candidate’s competence in the fields covered by the systems engineering program that is intended to fulfill the non-thesis master’s examination requirement.

ENMA 695. Topics in Engineering Management. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management. Prerequisites: Permission of the instructor.

ENMA 696. Topics in Engineering Management. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management. Prerequisites: Permission of the instructor.

ENMA 697. Independent Study in Engineering Management. 3 Credits.
Individual study selected by the student. Supervised and approved by a faculty member with the approval of the Graduate Program Director. Prerequisites: Permission of Graduate Program Director.

ENMA 698. Master’s Project. 1-3 Credits.
The master’s project is guided under the supervision of the course instructor. Projects must be approved by the Graduate Program Advisor. Prerequisites: Graduate Program Director permission is required.

ENMA 699. Thesis. 1-6 Credits.
Research leading to a Master of Science thesis. Prerequisites: ENMA 721 and permission of the Graduate Program Director.

ENMA 700. Economic Analysis of Capital Projects. 3 Credits.
This course is targeted at engineering managers who actively participate in the capital budgeting process and project justification. Topics include capital budgeting techniques (including multi-attribute decision making), utility theory, justification of new technologies, and current research in engineering economics. Reading and application of current research in the field is stressed. Case studies are used. Oral presentations and term project required. Prerequisites: ENMA 600.

ENMA 701. Digital Systems Engineering. 3 Credits.
Digital systems engineering applies digital technologies to the systems engineering processes and principles. This course provides students with knowledge and skills on necessary digital technologies, such as Artificial Intelligence and Machine Learning, Big Data, Blockchain, and computational modeling. The course covers: (1) preliminaries of digitalization and digital technologies; (2) data and knowledge modeling; (3) logical approach to MBSE (Model-Based Systems Engineering); (4) application of Big Data and Machine Learning in Systems Engineering; and (5) digital mechanisms of trust and security for digital engineering. Prerequisites: ENMA 646.

ENMA 702. Systemic Decision Making. 3 Credits.
As machine age problems have given way to systems age messes, the underlying complexity associated with understanding these situations has increased exponentially. Accordingly, the methods we use to address these situations must evolve as well. This course will introduce students to a method for thinking holistically about problems and messes conceptually founded in systems theory. This paradigm, known as systemic thinking, will be contrasted with traditional systematic thinking, and practical guidelines for the deployment of a systemic thinking approach will be provided. This paradigm will increase the student's ability to make rational decisions in complex environments.

ENMA 703. Optimization Methods. 3 Credits.
Covers advanced methods in Operations Research and Optimization. Focus will be on developing models and their applications in different domains including manufacturing and service. Modern optimization tools will be used to implement models for case studies, projects and research papers. The knowledge of programming and spreadsheets is expected. Contact instructor for more details.

ENMA 705. Financial Engineering. 3 Credits.
This course covers concepts in complex investments, how to deal with uncertainty in today’s global markets, and how to engineer and manage financial decisions. The main topics include: cash flows, portfolio theory, capital management, securities, hedge funds, optimal investment and financial engineering evaluations among others.

ENMA 711. Engineering Research Methodology. 3 Credits.
This course prepares engineering practitioners to produce systemic applied research or robust project solutions. In the applied research track, students will learn and apply the methods, tools, and concepts required for specifying the research purpose, proposal preparation, understanding the current state of the discipline, selecting and executing the appropriate research methodology, analyzing and synthesizing results, and preparing defensible publications. In the engineering project track, students will learn problem definition and scoping, project proposal preparation, methods for establishing the current state of the problem, analytical and experimental designs for testing proposed solutions, robust methods for solution optimization, and solution validation.

ENMA 712. Multi-Criteria Decision Analysis and Decision Support Systems. 3 Credits.
Currently, complex engineering-economic-societal decisions are made by involving numerous sometimes conflicting criteria and attributes, different decision rules and in the presence of various stakeholders with individual preferences who are willing to go into negotiation procedures. A number of multi-criteria decisions tools involving quantitative as well as qualitative methods, together with adequate decision support tools will be introduced. Case studies on a variety of engineering, environmental and security related aspects will also be considered.

ENMA 715. Systems Analysis. 3 Credits.
The course is designed to provide an understanding of the interdisciplinary aspects of systems development, operation, and support. The course focuses on the application of scientific and engineering efforts to transform an operational need into a defined system configuration through the interactive process of design, test, and evaluation.

ENMA 716. Complex Adaptive Situations Environment. 3 Credits.
The course focuses on the manner in which information, knowledge, and awareness are processed to facilitate decision making, management and engineering in complex adaptive situations. Topics include: knowledge acquisition, formation of technical and contextual awareness, and the role of understanding.

ENMA 717. Cost Engineering. 3 Credits.
Introduction to parametric cost modeling techniques and methodologies; generation and application of statistical relationships between life cycle costs and measurable attributes of complex systems; sources of supporting data; quality function deployment; technology forecasting. Special emphasis on life cycle design for cost; cost risk analysis; and design optimization on cost bases. Case studies and a semester project.

ENMA 720. Multivariate Statistics for Engineering. 3 Credits.
Introduction to modeling multivariate structural and residual variation, using exploratory data analysis, nonparametric regression, dependence regression, and factor analytic models, with a goal of producing robust, generalizable multivariate models that support research findings. Statistical analyses will be performed in the free general public licensed R statistical software with references to Minitab and SPSS.

ENMA 721. Foundations of Research. 3 Credits.
This course is intended to prepare students to undertake substantiated, rigorous, scholarly research, particularly theses or dissertations. The course will focus on the approaches necessary to integrate research intent, techniques and constraints. A variety of research approaches will be investigated. Emphasis will be placed on problem formulation, literature review, proposal preparation, oral presentation, experimentation and accepted canons of research. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. Research paper required.
ENMA 724. Risk Analysis. 3 Credits.
Approaches to the management of risk; probability assessment methods; risk modeling; use of software packages; extensions of decision analysis, including stochastic dominance and multiattribute methods; applications to project management, scheduling, and cost estimation.

ENMA 725. System Risk and Failure Analysis. 3 Credits.
This course is about the modeling of system dependencies using functional dependency network analysis to support the design of new and failure analysis of existing engineering systems. At the end of this course, students will be able to model and measure the operability and performance of today’s highly networked and richly interconnected systems.

ENMA 735. Team Performance and Decision Making in Engineering. 3 Credits.
This course explores and models the use of teams in organizations with a specific focus on the role of teams in decision making and problem solving. Key areas include team building, assessment of team outcomes, team learning, virtual teams and team decision making. Actual work on teams is required including team deliverables.

ENMA 743. Reliability and Maintainability. 3 Credits.
An introduction to the theory and practice of reliability engineering, maintainability and availability. Reliability evaluation models and techniques, failure data collection and analysis, reliability testing and modeling, maintained systems, and mechanical system reliability will be discussed, culminating in a semester-length project. Prerequisites: ENMA 420 or equivalent.

ENMA 750. System of Systems Engineering. 3 Credits.
Comprehensive treatment of System of Systems Engineering (SoSE), including: fundamental systems principles, concepts, and governing laws; complex and simple systems; underlying paradigms, methodologies and essential methods for SoSE analysis, design, and transformation; complex system transformation; current state of SoSE research and application challenges. Explores the range of technological, human/social, organizational/managerial, policy, and political dimensions of the SoSE problem domain.

ENMA 751. Complexity, Engineering and Management. 3 Credits.
This course examines management and engineering of complex systems as it is undertaken in complex situations. The student will develop an understanding of the unconditional attributes of complex systems and situations that become foundational in the development of robust methods to deal with the practical reality of working in dynamic, uncertain environments. Topics will include Complexity, Complex Systems, Complex Adaptive Systems, Complex Responsive Processes, Complex Adaptive Situations Methodology, SOSE, Reciprocity, and Sociotechnical Systems.

ENMA 754. Big Data Fundamentals. 3 Credits.
The objectives of the course are to provide fundamental knowledge and skills of Big Data for the new generation of researchers, engineers, project managers and business managers in the emerging data-driven science and engineering paradigm. Topics to be covered include data analytics, cloud platforms and tools for Big Data, and innovative applications of Big Data.

ENMA 755. Human System Engineering. 3 Credits.
This course introduces concepts of Human System Engineering, focusing on designing systems that include human components. Human System Integration and Human Factors Engineering are discussed, as well as other human centered design approaches. The role of human data in systems and systems of systems design is explored, and methods to capture and represent human data, including architecture frameworks, are presented. Modeling and analysis of human centered systems is done through hands-on projects.

ENMA 760. Advanced Architectures and Tools. 3 Credits.
This course is designed to expand on system architectures concepts through both theory and practice. Topics include the role of architectures in system engineering, alternative methods for architecture development, tools and techniques for architecture design, and various conceptual and technical issues in the architecture development process. Class periods are equally divided between traditional lectures and practice oriented exercises.

ENMA 763. Robust Engineering Design. 3 Credits.
A robust design approach based on "Taguchi Methods," including off-line quality engineering and applied design-of-experiments methods, full factorial and fractional factorial designs, and response surface methods. The course is designed to enable engineers and engineering managers from all disciplines to recognize potential applications, formulate problems, plan experiments, and analyze data. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. Students will engage in case studies, culminating in a semester-long project. Prerequisites: ENMA 420 or equivalent.

ENMA 771. Risk and Vulnerability Management of Complex Interdependent Systems. 3 Credits.
Seminar discussions and team projects. A systematic approach to basic principles of design, economics and management of critical infrastructure systems, including issues of risk, vulnerability and risk governance. Development of advanced methodologies, e.g. system of systems, by use of complexity analysis, dynamic/chaotic behavior, threat analysis, resilient design and management under normal and stress conditions. Adopting an agent based modeling approach under conditions of uncertainty, dysfunctionality, malicious attacks and/or presence of natural perils.

ENMA 777. Complex System Governance. 3 Credits.
Students will be prepared to better design, execute, evaluate, and evolve governance for complex systems. This preparation includes development of marketable capabilities to more effectively deal with governance systems and their emergent problems through: (1) development of capabilities to effectively design, analyze, and execute complex system governance, (2) identification and development of more effective intervention strategies to address underlying governance problems in operational systems, (3) employment of a range of methods, tools, and techniques, and (4) development of capabilities for generating novel insights and improvements to address systemic deficiencies in governance systems.

ENMA 780. Leadership for Engineering Managers. 3 Credits.
Seminar discussions and team projects. This course is designed to expose students to the concepts, skills, characteristics and emotional composition of effective and successful leaders in the 21st century. The course is intensive and requires students to immerse themselves in the course material and classroom discussion to derive meaning and value from the topics. The course objectives will be achieved by classroom discussion of the assigned material, candid self-assessment, experimental exercises and analysis of the actions of leaders, as described in case studies and literature. Areas of exploration include the fundamentals of leadership, ethical leadership, social capital, emotional intelligence and three-dimensional leadership. Prerequisites: ENMA 601 or Ph.D. status.

ENMA 795. Topics in Engineering Management. 3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management.

ENMA 796. Topics in Engineering Management. 3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management.

ENMA 797. Independent Study in Engineering Management. 1-3 Credits.
Designed for advanced individualized study into an engineering management topic area. Independent study projects will be related to engineering management and completed under the supervision of a certified faculty member. Prerequisites: Permission of the instructor and Graduate Program Director.

ENMA 800. Economic Analysis of Capital Projects. 3 Credits.
It is targeted at engineering managers who actively participate in the capital budgeting process and project justification. Topics include capital budgeting techniques (including multi-attribute decision making), utility theory, justification of new technologies, and current research in engineering economics. Reading and application of current research in the field is stressed. Case studies are used. Oral presentations and term project required. Prerequisites: ENMA 600.
ENMA 801. Digital Systems Engineering. 3 Credits.
Digital systems engineering applies digital technologies to the systems engineering processes and principles. This course provides students with knowledge and skills on necessary digital technologies, such as Artificial Intelligence and Machine Learning, Big Data, Blockchain, and computational modeling. The course covers: (1) preliminaries of digitalization and digital technologies; (2) data and knowledge modeling; (3) logical approach to MBSE (Model-Based Systems Engineering); (4) application of Big Data and Machine Learning in Systems Engineering; and (5) digital mechanisms of trust and security for digital engineering. Prerequisites: ENMA 646.

ENMA 802. Systemic Decision Making. 3 Credits.
As machine age problems have given way to systems age messes, the underlying complexity associated with understanding these situations has increased exponentially. Accordingly, the methods we use to address these situations must evolve as well. This course will introduce students to a method for thinking holistically about problems and messes conceptually founded in systems theory. This paradigm, known as systemic thinking, will be contrasted with traditional systematic thinking, and practical guidelines for the deployment of a systemic thinking approach will be provided. This paradigm will increase the student's ability to make rational decisions in complex environments.

ENMA 803. Optimization Methods. 3 Credits.
Covers advanced methods in Operations Research and Optimization. Focus will be on developing models and their applications in different domains including manufacturing and service. Modern optimization tools will be used to implement models for case studies, projects and research papers. The knowledge of programming and spreadsheets is expected. Contact instructor for more details.

ENMA 805. Financial Engineering. 3 Credits.
This course covers concepts in complex investments, how to deal with uncertainty in today's global markets, and how to engineer and manage financial decisions. The main topics include: cash flows, portfolio theory, capital management, securities, hedge funds, optimal investment and financial engineering evaluations among others.

ENMA 811. Engineering Research Methodology. 3 Credits.
This course prepares engineering practitioners to produce systemic applied research or robust project solutions. In the applied research track, students will learn and apply the methods, tools, and concepts required for specifying the research purpose, proposal preparation, understanding the current state of the discipline, selecting and executing the appropriate research methodology, analyzing and synthesizing results, and preparing defensible publications. In the engineering project track, students will learn problem definition and scoping, project proposal preparation, methods for establishing the current state of the problem, analytical and experimental designs for testing proposed solutions, robust methods for solution optimization, and solution validation.

ENMA 812. Multi-Criteria Decision Analysis and Decision Support Systems. 3 Credits.
Currently, complex engineering-economic-societal decisions are made by involving numerous sometimes conflicting criteria and attributes, different decision rules and in the presence of various stakeholders with individual preferences who are willing to go into negotiation procedures. A number of multi-criteria decisions tools involving quantitative as well as qualitative methods, together with adequate decision support tools will be introduced. Case studies on a variety of engineering, environmental and security related aspects will also be considered.

ENMA 815. Systems Analysis. 3 Credits.
The course is designed to provide an understanding of the interdisciplinary aspects of systems development, operation, and support. The course focuses on the application of scientific and engineering efforts to transform an operational need into a defined system configuration through the interactive process of design, test, and evaluation.

ENMA 816. Complex Adaptive Situations Environment. 3 Credits.
The course focuses on the manner in which information, knowledge, and awareness are processed to facilitate decision making, management and engineering in complex adaptive situations. Topics include: knowledge acquisition, formation of technical and contextual awareness, and the role of understanding.

ENMA 817. Cost Engineering. 3 Credits.
Introduction to parametric cost modeling techniques and methodologies; generation and application of statistical relationships between life cycle costs and measurable attributes of complex systems; sources of supporting data; quality function deployment; technology forecasting. Special emphasis on life cycle design for cost; cost risk analysis; and design optimization on cost bases. Case studies and a semester project.

ENMA 820. Multivariate Statistics for Engineering. 3 Credits.
This course covers concepts in complex investments, how to deal with uncertainty in today's global markets, and how to engineer and manage financial decisions. The main topics include: cash flows, portfolio theory, capital management, securities, hedge funds, optimal investment and financial engineering evaluations among others.

ENMA 824. Risk Analysis. 3 Credits.
Approaches to the management of risk; probability assessment methods; risk modeling; use of software packages; extensions of decision analysis, including stochastic dominance and multiattribute methods; applications to project management, scheduling, and cost estimation.

ENMA 825. System Risk and Failure Analysis. 3 Credits.
This course is about the modeling of system dependencies using functional dependency network analysis to support the design of new and failure analysis of existing engineering systems. At the end of this course, students will be able to model and measure the operability and performance of today's highly networked and richly interconnected systems.

ENMA 835. Team Performance and Decision Making in Engineering. 3 Credits.
This course explores and models the use of teams in organizations with a specific focus on the role of teams in decision making and problem solving. Key areas include team building, assessment of team outcomes, team learning, virtual teams and team decision making. Actual work on teams is required including team deliverables.

ENMA 843. Reliability and Maintainability. 3 Credits.
An introduction to the theory and practice of reliability engineering, maintainability and availability. Reliability evaluation models and techniques, failure data collection and analysis, reliability testing and modeling, maintained systems, and mechanical system reliability will be discussed, culminating in a semester-length project. Prerequisites: ENMA 420 or equivalent.

ENMA 850. System of Systems Engineering. 3 Credits.
Comprehensive treatment of System of Systems Engineering (SoSE), including: fundamental systems principles, concepts, and governing laws; complex and simple systems; underlying paradigms, methodologies and essential methods for SoSE analysis, design, and transformation; complex system transformation; current state of SoSE research and application challenges. Explores the range of technological, human/social, organizational/managerial, policy, and political dimensions of the SoSE problem domain.
ENMA 851. Complexity, Engineering and Management. 3 Credits.
This course examines management and engineering of complex systems as it is undertaken in complex situations. The student will develop an understanding of the unconditional attributes of complex systems and situations that become foundational in the development of robust methods to deal with the practical reality of working in dynamic, uncertain environments. Topics will include Complexity, Complex Systems, Complex Adaptive Systems, Complex Responsive Processes, Complex Adaptive Situations Methodology, SOSE, Reciprocity, and Sociotechnical Systems.

ENMA 854. Big Data Fundamentals. 3 Credits.
The objectives of the course are to provide fundamental knowledge and skills of Big Data for the new generation of researchers, engineers, project managers and business managers in the emerging data-driven science and engineering paradigm. Topics to be covered include data analytics, cloud platforms and tools for Big Data, and innovative applications of Big Data.

ENMA 855. Human System Engineering. 3 Credits.
This course introduces concepts of Human System Engineering, focusing on designing systems that include human components. Human System Integration and Human Factors Engineering are discussed, as well as other human centered design approaches. The role of human data in systems and systems of systems design is explored, and methods to capture and represent human data, including architecture frameworks, are presented. Modeling and analysis of human centered systems is done through hands-on projects.

ENMA 860. Advanced Architectures and Tools. 3 Credits.
This course is designed to expand on system architectures concepts through both theory and practice. Topics include the role of architectures in system engineering, alternative methods for architecture development, tools and techniques for architecture design, and various conceptual and technical issues in the architecture development process. Class periods are equally divided between traditional lectures and practice oriented exercises.

ENMA 863. Robust Engineering Design. 3 Credits.
A robust design approach based on “Taguchi Methods,” including off-line quality engineering and applied design-of-experiments methods, full factorial and fractional factorial designs, and response surface methods. The course is designed to enable engineers and engineering managers from all disciplines to recognize potential applications, formulate problems, plan experiments, and analyze data. Knowledge of probability and statistics (ENMA 420 or equivalent) is assumed. Students will engage in case studies, culminating in a semester-long project. Prerequisites: ENMA 420 or equivalent.

ENMA 871. Risk and Vulnerability Management of Complex Interdependent Systems. 3 Credits.
Seminar discussions and team projects. A systematic approach to basic principles of design, economics and management of critical infrastructure systems, including issues of risk, vulnerability and risk governance. Development of advanced methodologies, e.g. system of systems, by use of complexity analysis, dynamic/chaotic behavior, threat analysis, resilient design and management under normal and stress conditions. Adopting an agent based modeling approach under conditions of uncertainty, dysfunctionality, malicious attacks and/or presence of natural perils. Prerequisites: Permission of the instructor.

ENMA 877. Complex System Governance. 3 Credits.
Students will be prepared to better design, execute, evaluate, and evolve governance for complex systems. This preparation includes development of marketable capabilities to more effectively deal with governance systems and their emergent problems through: (1) development of capabilities to effectively design, analyze, and execute complex system governance, (2) identification and development of more effective intervention strategies to address underlying governance problems in operational systems, (3) employment of a range of methods, tools, and techniques, and (4) development capabilities for generating novel insights and improvements to address systemic deficiencies in governance systems.

ENMA 880. Leadership for Engineering Managers. 3 Credits.
Seminar discussions and team projects. This course is designed to expose students to the concepts, skills, characteristics and emotional composition of effective and successful leaders in the 21st century. The course is intensive and requires students to immerse themselves in the course material and classroom discussion to derive meaning and value from the topics. The course objectives will be achieved by classroom discussion of the assigned material, candid self-assessment, experimental exercises and analysis of the actions of leaders, as described in case studies and literature. Areas of exploration include the fundamentals of leadership, ethical leadership, social capital, emotional intelligence and three-dimensional leadership. Prerequisites: ENMA 601 or Ph.D. standing.

ENMA 888. Ph.D. Seminar. 1 Credit.
Discussion of research projects, topics, and problems of Engineering Management faculty, researchers, and students. A weekly exchange of ideas and issues between faculty and Ph.D. students focused on doctoral research.

ENMA 892. Doctor of Engineering Project. 1-12 Credits.
Directed individual study applying advanced-level technical knowledge to identify, formulate, and solve a complex, novel problem in Engineering Management.

ENMA 895. Topics in Engineering Management. 3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management.

ENMA 896. Topics in Engineering Management. 3 Credits.
Special topics of interest with emphasis placed on recent developments in engineering management.

ENMA 897. Independent Study in Engineering Management. 1-3 Credits.
Designed for advanced individualized study into an engineering management topic area. Independent study projects will be related to engineering management and completed under the supervision of a certified faculty member. Prerequisites: Permission of the instructor and Graduate Program Director.

ENMA 898. Research in Engineering Management. 1-12 Credits.
Supervised research prior to passing Ph.D. candidacy exam. Prerequisites: ENMA 721/ENMA 821 and permission of Graduate Program Director.

ENMA 899. Doctoral Research. 1-12 Credits.
Doctoral research hours. After successfully passing the candidacy examination, all doctoral students are required to be registered for at least one graduate credit each term until the degree is complete. Prerequisites: ENMA 821 and permission of instructor.

ENMA 998. Master's Graduate Credit. 1 Credit.
This course is a pass/fail course for master's students in their final semester. It may be taken to fulfill the registration requirement necessary for graduation. All master's students are required to be registered for at least one graduate credit hour in the semester of their graduation.

ENMA 999. Doctoral Graduate Credit. 1 Credit.
This course is a pass/fail course doctoral students may take to maintain active status after successfully passing the candidacy examination. All doctoral students are required to be registered for at least one graduate credit hour every semester until their graduation.