Stevens Institute of Technology 2006-2007 Catalog

The Charles V. Schaefer, Jr. School of Engineering

Department of Systems Engineering and Engineering Management

JOHN V. FARR, DIRECTOR

FACULTY

Professors

John V. Farr, Ph.D., P.E., (1986), University of Michigan
Bernard Gallois, Ph.D., George Meade Professor of Engineering, (1980), Carnegie-Mellon University
Donald N. Merino, Alexander Crombie Humphreys Professor, (1975), Stevens Institute of Technology
Dinesh Verma, Ph.D., Associate Dean for Outreach, (1994), Virginia Polytechnic Institute

Associate Professor

Rashmi Jain, Ph.D., (2003), Stevens Institute of Technology

Assistant Professors

Wei Jiang, Ph.D., (2000), The Hong Kong University of Science and Technology
Jose Emmanuel Ramirez-Marquez, Ph.D., (2004), Rutgers University
Brian J. Sauser, Ph.D., (2004), Stevens Institute of Technology

Distinguished Service Professors

Leon A. Bazil, Ph.D., D.Sc., (1984), St. Petersburg Technical University
Howard Berline, Ed.M., (1968), University of Illinois, Urbana
John T. Boardman, Ph.D., (1970), University of Liverpool
Carl Pavarini, Ph.D., (1973), Rensselaer Polytechnic Institute

Industry Professors

Bruce Barker, M.S., (2004), Stevens Institute of Technology
Anthony Barrese, Ph.D., (1978), Stevens Institute of Technology
Rick Dove, B.S., (1969), Carnegie Mellon University
Ralph G. Giffin, III, B.S., (1988), George Mason University
George Hudak, M.S., P.E., (1995), Stevens Institute of Technology
David Nowicki, Ph.D., (1998), University of Wisconsin, Madison
Spiros Pallas, Ph.D., (1972), University of Texas
Michael C. Pennotti, Ph.D., (1974), Polytechnic Institute of New York

Lecturers

Kathryn D. Abel, Ph.D., (2001), Stevens Institute of Technology
Eirik Hole, Diplom Ingenieur, (1995), University of Stuttgart
Alice Squires, M.B.A., (1996), George Mason University

Research Assistant Professors

Rochanak Nilchiani, Ph.D., (2005), Massachusetts Institute of Technology

UNDERGRADUATE PROGRAMS

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Engineering Management

Engineering Management (EM) is a rapidly expanding field that combines engineering, technology, management, systems, and business. High-technology companies in the telecommunications, financial services, manufacturing, pharmaceutical, consulting, information technology, and other industries utilize the concepts and tools of EM, such as project management, quality management, engineering economics, modeling and simulation, systems engineering and integration, and statistical tools. These technology-based companies recruit EM graduates for their expertise in these tools and techniques.

Recent studies show that most engineers will ultimately take on managerial positions, and that most will spend a considerable portion of their professional careers in a

management or supervisory capacity. In a recent survey conducted by the American Association of Engineering Societies, it was found that within ten years of the start of their careers, more than 50 percent of engineers were employed in technical management positions, often without the benefit of formal training in management.

The EM program combines a strong engineering core with training in accounting, cost analysis, managerial economics, quality management, project management, production and technology management, systems engineering, and engineering design. The course selection offered by this major exemplifies the Stevens interdisciplinary approach to developing strong problem-solving skills. The program prepares you for careers that involve the complex interplay of technology, people, economics, information, and organizations. The program also provides the skills and knowledge needed to enable students to assume professional positions of increasing responsibility in management or as key systems integrators.

The mission of the EM Program is to provide an education based on a strong engineering core, complemented by studies in business, technology, systems, and management, to prepare the graduate to work at the interface between technology/engineering and management, and to be able to assume positions of increasing technical and managerial responsibility. The objectives of the EM program can be summarized as follows:

- EM graduates have a strong general engineering foundation and are able to use modern technological tools while working on complex multidisciplinary problems.
- EM graduates will have assumed leadership positions in their chosen areas of work using knowledge gained from their engineering management education.
- EM graduates effectively work in teams on projects to solve real-world problems. This effort can involve information research, the use of project management tools and techniques, and the economic justification of the solution that is effectively communicated in a written or oral project report/business proposal that is presented to the client.
- EM graduates possess the ethics, knowledge, skills, and attributes to define, design, develop, and manage resources, processes, and complex systems needed to work in a multidisciplinary team environment.
- EM graduates apply the management tasks of organizing, staffing, planning, financing, and the human element and have the tools to continue sustained intellectual growth in the corporate or academic world.

The EM Program is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET). A typical course sequence for EM follows:

Freshman Year

Term I

		Hrs. Per Week		
		Class	Lab	Study
CH 115	General Chemistry IA	3	0	3
CH 117	General Chemistry Lab I	0	3	1
MA 115	Mathematical Analysis I	3	0	3
E 101	Eng Experiences I	1	0	0
E 121	Engineering Design I	0	3	2
E 120	Engineering Graphics	0	2	1
E 115	Intro. To Programming	1	1.5	2
HUM	Humanities	3	0	3
Total		11	9.5	15

Term II

		Hrs. Per Week		
		Class	Lab	Study
Science	Science Elective	3	0	3
PEP 111	Physics I	3	0	3
MA 116	Mathematical Analysis II	3	0	3
E 102	Eng. Experiences II	1	0	1
E 122	Engineering Design II	0	3	2
HUM	Humanities	3	0	3
Total		13	3	15

Sophomore Year

Term III

		Hrs. Per Week		
		Class	Lab	Study
MA 221	Differential Equations	4	0	4

PEP 112	Physics II	3	0	3
E 126	Mechanics of Solids	4	0	4
E 231	Engineering Design III	0	3	2
E 245	Circuits & Systems	2	3	3
HUM	Humanities	3	0	3
Total		16	6	19

Term IV

		Hrs. Per Week		
		Class	Lab	Study
MA 227	Multivariate Calculus	3	0	3
E 232	Engineering Design IV	2	3	3
E 234	Thermodynamics	3	0	3
Science	Science Elective II	2	3	3
EM 275	Project Management	3	0	3
EM 270	Engineering Management	3	0	3
Total		16	6	18

Junior Year

Term V

		Hrs. Per Week		
		Class	Lab	Study
CE 342	Fluid Mechanics/Transport	3	3	4
EM 321	Engineering Design V	0	3	2
EM 344	Materials Processing	3	0	3
EM 301	Engr. Cost Management	3	3	4
EM 365*	Statistics for Engr. Managers	3	1.5	4
EM 351	Management of Info Networks	3	0	3
Total		15	10.5	20

Term VI

		Hrs. Per Week		
		Class	Lab	Study
E 355	Engineering Economics	3	3	4
EM 322	Engineering Design VI	1	3	2
EM 345	Modeling & Simulation	3	0	3
EM 360	Total Quality Management	3	0	3
EM 380	Innovative System Design	3	0	3
GE	General Elective	3	0	3
Total		16	6	18

Senior Year

Term VII

		Hrs. Per Week		
		Class	Lab	Study
EM 457	Elements of Ops. Research	3	0	3
GE	General Elective	3	0	3
TG	Technogensis Core	3	0	3
EM 423	Engineering Design VII	1	7	3
EM 435	Business Process Reengineering	3	0	3
MGT 244	Microeconomics	3	0	3
Total		16	7	18

Term VIII

		Hrs. Per Week		
		Class	Lab	Study
EM 450	Logistics and Ops. Man.	3	0	3
GE	General Elective	3	0	3
EM 424	Engineering Design VIII	1	7	3
MGT 243	Macroeconomics	3	0	3
HUM	Humanities	3	0	3
Total		13	7	15

Notes:

- E 355 is a core courses for all engineers that is taught by department faculty.
- Students can take MGT 243 and 244 in any semester; these courses are part of the humanities requirements for social science.
- *Students with AP, transfer, or other credit for Statistics are still required to take the one credit EM 364 Statistics Laboratory.

Requirements for a Minor in Engineering Management

EM 270 Engineering Management
EM 275 Project Management
EM 301 Engineering Cost Estimation
EM 360 Total Quality Management

EM Minors typically take the following courses as part of the Engineering Curriculum:

Required Engineering Core

E 243 or EM 365 Statistics
E 355 Engineering Economics
E 421 Entrepreneurial Analysis of Engineering Design

Required Humanities Core

MGT 243 Macroeconomics
MGT 244 Microeconomics

Students wishing to pursue an EM minor should use any three of the EM 275, 270, 301, or 360 courses to satisfy the requirements for the three general electives. Thus, an EM minor requires a one course overload.

Engineering with a Concentration in Information Systems Engineering

The Departments of Systems Engineering and Engineering Management (SEEM) and Electrical and Computer Engineering (ECE) jointly offer an Information Systems Engineering (ISE) concentration under the Engineering Program in the undergraduate curriculum.

The goal of the ISE concentration is to produce graduates with a broad engineering foundation who can be effective in the analysis, design, construction, implementation and management of information systems.

The program consists of a core of 6 classes taken by all students in the concentration. A student can choose either a focus area in information systems management or networked information systems. The following lists typical electives within each focus. Other appropriate electives can be chosen with the approval of a faculty advisor.

Network Information Systems (NIS)

CPE 360 Data Structures and Algorithms
CPE 491 Information Systems II
CPE xxx Wireless Network Systems

Information Systems Management (ISM)

EM 301 Engineering Cost Management (Fall of junior year)
EM 380 Innovative System Design (Spring of junior year)
EM 360 Total Quality Management (Spring of senior year)

Students taking the NIS focus will, in general, take their senior design sequence with students in the Bachelor of Engineering in Computer Engineering (CPE) program. Whereas, those students taking the ISM focus will take their senior design sequence with students in the BEEM program.

Engineering – Concentration in Information Systems Engineering

Freshman Year
Term I

Hrs. Per Week

		Class	Lab	Study
CH 115	General Chemistry I	3	0	3
CH 117	General Chemistry Lab I	0	3	1
MA 115	Math Analysis I	3	0	3
E 101	Eng Experiences I	1	0	0
E 121	Engineering Design I	0	3	2
E 120	Engineering Graphics	0	2	1
E 115	Intro. To Programming	1	1.5	2
HUM	Humanities	3	0	3
Total		11	9.5	15

Term II

		Hrs. Per Week		
		Class	Lab	Study
Science	Science Elective	3	0	3
PEP 111	Physics I	3	0	3
MA 116	Math Analysis II	3	0	3
E 102	Eng. Experiences II	1	0	1
E 122	Engineering Design II	0	3	2
HUM	Humanities	3	0	3
Total		13	3	15

Sophomore Year

Term III

		Hrs. Per Week		
		Class	Lab	Study
MA 221	Differential Equations	4	0	4
PEP 112	Physics II	3	0	3
E 126	Mechanics of Solids	4	0	4
E 231	Engineering Design III	0	3	2
E 245	Circuits & Systems	2	3	3
HUM	Humanities	3	0	3
Total		16	6	19

Term IV

		Hrs. Per Week		
		Class	Lab	Study
MA 227	Multivariate Calculus	3	0	3
E 232	Engineering Design IV	2	3	3
E 234	Thermodynamics	3	0	3
Science	Science Elective	2	3	3
EM 275	Project Management	3	0	3
CPE xxx	Intro to Network Systems	3	0	3
Total		16	6	18

Junior Year

Term V

		Hrs. Per Week		
		Class	Lab	Study
E 342	Transport/Fluid Mech. (2)	3	3	4
E 344	Materials Processing	3	0	3
E 321	Engineering Design V	0	3	2
E 243	Probability and Statistics	3	0	3
CPE 490	Information Systems I	3	0	3
TE	Technical Elective (2)	3	0	3
Total		15	6	18

Term VI

		Hrs. Per Week		
		Class	Lab	Study

E 345	Modeling & Simulation (2)	3	0	3
E 355	Engineering Economics	3	3	4
E 322	Engineering Design VI (2)	1	3	2
TE	Technical Elective I (2)	3	0	3
HUM	Humanities	3	0	3
GE	General Elective	3	0	3
Total		16	6	18

Senior Year

Term VII

		Hrs. Per Week		
		Class	Lab	Study
SYS/CPE 5xx	Database Systems and Knowledge and Data Mining	3	0	3
CPE 493	Data and Comp. Comm.	3	0	3
GE	General Elective	3	0	3
E 423	Engineering Design VII (2)	1	7	3
EM 435	Business Process Reengineering	3	0	3
HUM	Humanities	3	0	3
Total		16	7	18

Term VIII

		Hrs. Per Week		
		Class	Lab	Study
TG	Technogenesis Core	3	0	3
T.E.	Technical Elective (2)	3	0	3
GE	General Elective	3	0	3
E 424	Engineering Design VII (2)	1	7	3
HUM	Humanities	3	0	3
Total		13	7	15

(2) discipline specific courses

Four Plus One Program

The SEEM department offers a unique four plus one program designed for Stevens undergraduate engineering and science students who wish to jointly pursue a Masters of Engineering in Engineering Management (M.E.E.M.) degree concurrently with their undergraduate degree. Admission criteria to the program are junior standing, a formal interview, and a GPA of at least 3.2 in engineering or science. All undergraduates in this program are expected to take the following courses or their equivalents:

Complete all Calculus courses	by end of 3rd year - Engineering Core
MGT 243 Microeconomics	by end of 3rd year - Humanities Core
MGT 244 Macroeconomics	by end of 3rd year - Humanities Core
E 355 Engineering Economics	by end of 3rd year - Engineering Core
EM 365 Statistics for EM or equivalent	by end of 3rd year - Engineering Core
EM 301 Eng. Cost Estimation	by end of 4th year - Engineering Elective

Certificates in Systems Engineering and Architecting, Engineering Management, Financial Engineering, Pharmaceutical Manufacturing Practices, Systems Supportability and Engineering, and Project Management are approved for this program. Other certificate options must be approved by the EM Program Director and the department/program responsible for the certificate.

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GRADUATE PROGRAMS

The Department of SEEM offers the Masters' of Engineering degrees in SE and EM. In addition, the department offers the Systems Engineering master's degree through the Systems Design and Operational Effectiveness (SDOE) executive education program. The degree of Doctor of Philosophy is offered in Systems Engineering and in Engineering Management.

All of the department's programs take a multidisciplinary approach to engineering

education by providing a blend of engineering, systems, and management subjects. The traditional engineer and scientist often lack preparation in the human, financial, and systems integration skills necessary to make project teams more productive, improve product and process quality, and promote the advancement of high technology for complex systems. Our Masters' programs are unique in that we strive to create an engineer who is well-prepared for a future in the management of engineering and technology and can address systems integration and life-cycle issues.

Many engineers find themselves at a decision point about five years after graduation. They must choose between continuing their technical specialty and entering the ranks of technical management, or serve as key systems integrators. Ten years after graduation, more than 75 percent of engineers have chosen the second route, assuming managerial responsibilities or key systems integration responsibility for which they have often had little or no formal training. They must solve complex problems, requiring the integration and management of many systems across multiple disciplines in a cost-effective manner with many stakeholders. Because of the advent of technology and globalization, we believe this is engineering education for the 21st century.

The SEEM faculty is engaged in a variety of research efforts that include systems architecting, reliability of large-scale systems, engineering economic analysis, life-cycle costing, systems integration, and infrastructure systems.

Master's Programs

These programs require a minimum of 30 credit hours of course work. A thesis is optional and may be substituted for up to six credit hours of course work. The thesis option is strongly recommended for full-time students receiving financial support in the form of research assistantships or those students planning to pursue doctoral studies.

An undergraduate degree in engineering or related disciplines with a "B" average or better from an accredited college or university is generally required for graduate study in any one of the department programs. Outstanding applicants in other areas may be conditionally admitted subject to the satisfactory completion of several ramp courses or introductory courses within the specific program. The specific requirements will be determined on an individual basis depending upon the student's background. It is required that any applicants requesting research assistantship appointments and applicants to the Ph.D. program provide evidence of the ability to carry out independent work. Examples of such evidence include the master's degree thesis work and/or completed work-related projects. GRE scores are not required, but may be submitted in support of the application. International students must demonstrate their proficiency in the English language prior to admission by scoring at least 550 (210 for computer based) on the TOEFL examination. Applications for admission from qualified students are accepted at any time.

The Department of Systems Engineering and Engineering Management offers a variety of degree programs: Master of Engineering in Systems Engineering (SE), an executive SE program titled Systems Design and Operational Effectiveness (SDOE), Master of Engineering in Engineering Management (EM), and a Master of Engineering in Integrated Product Development (IPD) and a collection of Graduate Certificate programs. Each student should meet with his/her advisor to develop a study plan that matches the student's background, experience, and interests while satisfying the requirements for any of the department's programs.

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Systems Engineering

The Systems Engineering degree is a multidisciplinary program that includes a blend of engineering, systems thinking, and management subjects..

Graduates from this program will be prepared to work effectively at the interface between engineering and management and to assume professional positions of increasing responsibility. The program consists of four core courses:

ALL students must take the following two-course sequence:
SYS 625 Systems Operational Effectiveness and Life Cycle Analysis
SYS 650 System Architecture and Design

Plus, **two** of the following **four** options:
SYS 611 Modeling and Simulation or
SYS 670 Forecasting and Demand Modeling
SYS 612 Project Management for Complex Systems
SYS 660 Decision and Risk Analysis or
SYS 675 Integrated Supply Chains
SYS 605 Systems Integration

A candidate may propose a customized track of six elective courses leading to other specialties with approval from a faculty advisor. At least two of the electives must be taken from the SEEM curriculum. Students are encouraged to take an integrated four-course sequence leading to a graduate certificate for the remaining four electives or four additional courses in systems engineering or engineering management.

Many of these certificates are offered on-line via web-based instruction. Approved four-course sequences:

Engineering Management,
Financial Engineering,
Pharmaceutical Manufacturing Practices,
Project Management,
Systems Engineering Management,
Systems and Supportability Engineering, or
Value Chain Enterprise Systems

Students are encouraged to take a 3-credit special project class (SYS 800) to serve as one of the electives for the masters programs.

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Engineering Management

An advanced degree in EM builds upon undergraduate engineering and science education with studies in business, management, and systems integration. The traditional engineer and scientist often lacks a formal education in the human, financial, and management skills necessary to advocate the use of technology for high quality, cost efficient, complex systems. Our Master's degree is unique in that we strive to create an engineer who is well prepared for a future in the management of engineering and technology integration.

Graduates from this program will be prepared to work effectively at the interface between engineering and management and to assume professional positions of increasing responsibility. The six core courses for this program are:

EM 600 Engineering Economics and Cost Analysis
EM 605 Elements of Operations Research
EM 611 Modeling and Simulation
EM 612 Project Management of Complex Systems
SYS 625 Systems Operational Effectiveness and Life Cycle Analysis
EM 680 Designing and Managing the Development System

Students lacking a strong quantitative background that includes calculus, statistics, and engineering economics may be required to take several ramp courses as defined by admission conditions listed in the acceptance letter.

Students are encouraged to take an integrated four-course sequence leading to a graduate certificate for the remaining four electives or four additional courses in systems engineering or engineering management. Many of these certificates are offered on-line via web-based instruction. Approved four-course sequences:

Financial Engineering,
Pharmaceutical Manufacturing Practices,
Project Management,
Systems Engineering and Architecting,
Systems Engineering Management,
Systems and Supportability Engineering, or
Value Chain Enterprise Systems

A faculty advisor must approve other options. Note that some of these certificates are not available to undergraduate students as part of the four plus one program.

A certificate in Engineering Management can be obtained by taking:

EM 600 Engineering Economics and Cost Analysis
EM 612 Project Management of Complex Systems
EM 605 Elements of Operations Research
EM 680 Designing and Managing the Development System

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Master's of Business Administration (M.B.A.) in Technology Management (TM) With A Concentration in Engineering Management

The Wesley J. Howe School of Technology Management (WJHSTM) in conjunction with the SEEM department offer a unique program which combines the quantitative elements of an engineering degree with the business topics typically taught in a MBA program. The program is designed so that students from various backgrounds can tailor their educational experience to meet their career objectives. The recommended study plan is shown below.

Course	Course Title	Credits
	M.B.A. Core Courses	
MGT 609	Introduction to Project Management	3.0

MGT 600	Mangerial Accounting	3.0
MGT 607	Managerial Economics	3.0
MGT 620	Statistical Models	3.0
MGT 623	Financial Management	3.0
MGT 641	Marketing Management	3.0
MGT 671	Technology and Innovation Management	3.0
MGT 680	Organizational Behavior and Theory	3.0
MGT 690	Organizational Theory and Design	3.0
MGT 725	Strategic Management	3.0
	Subtotal	**30**
	Breadth Courses	
MGT 657	Operations Management	3.0
MGT 679	Management of Information Systems	3.0
Elective		3.0
Elective*		3.0
Elective*		3.0
	*Two electives may be substituted (with approval) with a Master's Thesis (6 Credits)	
	Subtotal	**15**
	EM Major Courses	
	**Select one of these two courses	
EM 605	Elements of Operation Research	3.0
**EM 611	Modeling and Simulation	3.0
**SYS 660	Decision and Risk Analysis	3.0
SYS 650	System Architecture and Design	3.0
SYS 625	Systems Operational Effectiveness and Life-Cycle Analysis	3.0
EM Elective		3.0
	Subtotal	**15**
	Total	**60**
	Prerequisites (No credit) (or equivalent)	
EM 365	Statistics for Engineers	NC
MA 501	Introduction to Mathematical Analysis	NC
MGT 503	Microeconomics	NC

By carefully planning there curriculum, students can opt out of the program after the first four courses and obtain a Graduate Certificate in Engineering Management. If they choose to continue they will take and additional six courses and receive the MEEM degree. If they choose not to opt out of the program, they can apply to the WJHSTM for pursuit of an MBA with a concentration in Engineering Management. Students can apply to the WJHSTM at any point in the process for the MBA degree. However, we recommend that they apply as early as possible to better facilitate course scheduling. If the students decide not to opt out of the program after fulfilling the requirement for the MEEM they must take an additional 30 hours for the MBA in TM degree. Note that students who decide to pursue the MBA degree will not be awarded both the MEEM and MBA in TM. They will receive the Engineering Management certificate along with the MBA in Technology Management degree with an EM concentration..

All students should initially apply to the M.E.E.M. program within the SEEM department. They should then apply to the WJHSTM for the M.B.A. in TM degree if they plan to pursue that option. Admission to the M.E.E.M. program does not guarantee acceptance to the M.B.A. in TM program, and vice versa. To gain admission to the M.B.A. program, students must take a GMAT or GRE (see the WJHSTM section of the catalog for specific admission criteria and score standards). Current M.E.E.M. students and

alumni who wish to obtain an M.B.A. in TM must formally apply for entry to the M.B.A. in TM program and must take a GMAT or GRE test. A minimum of two years work experience will be required of all students prior to admission to this program. Students applying for this joint program are typically required to have an undergraduate degree in engineering or science.

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Graduate Certificate Programs

All graduate certificate programs require a minimum of 12 credit hours of course work. An undergraduate degree in engineering or related disciplines with a "B" average or better from an accredited college or university is generally required for graduate study in any one of our programs. Outstanding applicants in other areas may be conditionally admitted subject to the satisfactory completion of several ramp courses or introductory courses within the specific program. The specific requirements will be determined on an individual basis depending upon the student's background. International students must demonstrate their proficiency in the English language prior to admission by scoring at least 550 (210 for computer based) on the TOEFL examination. Applications for admission from qualified students are accepted at any time.

Each student should communicate with his/her advisor to develop a study plan that matches the student's background, experience, and interests while satisfying the requirements for any of the programs. Each of the graduate certificate programs is a stepping-stone towards the Master's degree in Systems Engineering.

Agile Systems Engineering and Design

SDOE 775 Systems Thinking
SDOE 780 Engineering of Agile Systems and Enterprises
SDOE 655 Robust Engineering Design
SDOE 780 Agile Development Strategy

Engineering Management

EM 600 Engineering Economics and Cost Analysis
EM 605 Elements of Operations Research
EM 612 Project Management of Complex Systems
EM 680 Designing and Managing the Development System

Systems Engineering and Architecting

SYS/SDOE 625 Systems Operational Effectiveness and Life-Cycle Analysis
SYS/SDOE 650 System Architecture and Design
SYS/SDOE 612 Project Management of Complex Systems
SYS/SDOE 605 Systems Integration ***or*** SYS/SDOE 611 Modeling and Simulation

Systems Engineering Management

EM/SYS/SDOE 612 Project Management of Complex Systems
EM/SYS/SDOE 620 Simulation-Based Costing and Acquisition ***or*** SYS/SDOE 625 Systems Operational Effectiveness and Life-Cycle Analysis
EM/SYS/SDOE 660 Decision and Risk Analysis
SYS/SDOE 680 Designing the Development System

Systems and Supportability Engineering

SYS/SDOE 625 System Operational Effectiveness and Life-Cycle Analysis
SYS/SDOE 640 System Supportability and Logistics
SYS/SDOE 645 Design for System Reliability, Maintainability and Supportability SYS/SDOE 650 System Architecture and Design

Value Chain Enterprise Systems

SYS/SDOE 640 Supportability and Logistics
SYS/SDOE 665 Integrated Supply Chains
SYS/SDOE 670 Forecasting and Demand Modeling Systems

or

SYS/SDOE 611 Modeling and Simulation
SYS/SDOE 675 Dynamic Pricing Systems ***or***
SYS/SDOE 660 Decision and Risk Analysis

The certificate in Agile Systems and Enterprises integrates four complimentary courses. One common theme throughout defines enterprise as a human activity system. Another defines agile systems as those responding effectively to unpredicted situations, at all times, within mission. These common themes facilitate a study of agility across a seemingly wide variety of interesting system types, with the lines of difference blurred as each informs the other. The frontier of systems engineering today seeks new levels of system capability and behavior, and expects to find those benefits in higher forms of systems that elude traditional control and creation concepts. This graduate certificate is relevant to engineers, managers, and decision makers in commercial, healthcare, financial and insurance, and defense domains working with systems that must thrive in a dynamic unpredictable environment - especially if they are system of systems or enterprise systems. The graduate certificate and the constituent courses first build a theoretical and philosophical basis for understanding and formulating the interactive and interdependent problem and solution spaces, and then suggest pragmatic and executable approaches to realize the enterprise potential.

The Systems Engineering Management (SEM) certificate is designed for program managers, project managers, and lead systems engineers involved with conceiving, defining, architecting, integrating, and testing complex and multi-functional systems. Particular emphasis is placed on the modern engineering enterprise characterized by geographically dispersed and multi-cultural organizations. Accordingly, the role of e-collaboration is also examined, and the traditional project and program management concepts are re-examined in this context. The participating students are also introduced to the concept of the “extended” enterprise and the delivery of a value chain solution. Relevant subjects such as leadership, subcontracting, and partnering are also reviewed. Additionally, the human, financial, organizational, and systems integration skills necessary to make project teams more productive are addressed in this graduate certificate offering. With a common systems engineering process serving as the framework, courses in project management, costing and acquisition, decision and risk analysis, and the organization as a system are integrated to form a certificate that will bridge engineering, management, and systems integration.

The Value Chain Enterprise Systems certificate focuses on the

theory and practice of designing and analyzing supply chains. It will provide quantitative tools to identify key drivers of supply chain performance such as inventory, transportation, information, and facilities from a holistic perspective. This graduate certificate program has a "how-to" orientation and the understanding gained in the courses can be immediately applied to the solution of on-the-job problems.

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Doctoral Programs in Systems Engineering and in Engineering Management

The programs leading to the Doctor of Philosophy (Ph.D.) degree are designed to develop your ability to perform research or high-level design in systems engineering or engineering management. Admission to the doctoral program is made through the departmental graduate admissions committee and is based on review of your scholastic record. A master's degree is generally required before a student is admitted to the doctoral program. Your master's level academic performance must reflect your ability to pursue advanced studies and perform independent research. Typically a GPA of 3.5 or better is required for admission to the Ph.D. program.

Ninety credits of graduate work in an approved program of study beyond the bachelor's degree are required for completion of the doctoral program. Up to 30 credits obtained in a master's program can be included toward the doctoral degree. Of the remaining 60 credits, 15 to 30 credit hours of course work, as well as 30 to 45 credit hours of dissertation work, are required. Note that HUM 501, Foundations of Technical Communication, can be substituted for 3 credit hours of dissertation research. Within two years from the time of admission to the doctoral program, you must form a Doctoral Advisory Committee (DAC) and take a written qualifying examination that is intended to test your comprehension of undergraduate and master's level engineering fundamentals associated with your general dissertation topic area.

The candidate's graduate advisor serves as the chair of the DAC, and the student should seek the assistance of his/her advisor in identifying faculty who might serve on the committee. The graduate committee should be composed of those faculty members who can best assist the student in completing his/her graduate research. Each member is added to the student's committee after consenting to serve. For the Ph.D., the advisory committee must include a minimum of four members and its composition must be consistent with those guidelines contained in the Graduate Student Handbook. Committee members are expected to attend meetings as a collective body. Under unusual circumstances, a member of the committee may attend a meeting via video or telephone. However, a student's advisory committee must be physically present at all such meetings. Faculty participation on graduate student committees is considered to be an important part of SEEM faculty responsibilities. To this end, full-time SEEM faculty are expected to attend all committee meetings for students they advise or on the committees they serve.

All Ph.D. students must successfully complete the written and oral components of the qualification examination. The intent of the examination is to establish that the student is qualified to pursue creative, original, independent research at a level expected of Ph.D. students. The written portion of the examination requires two weeks for completion. The oral component of the examination is administered two weeks after the completion of the written portion. Students must be registered during the semester that the examination is taken. Students may not schedule the qualification examination until they have an approved Study Plan. The qualification examination is administered by the student's DAC and one negative vote by a committee member is permitted for the successful completion of the examination. All members of the student's advisory committee must attend the oral portion of the examination. If performance on the examination is unsatisfactory, one full semester must lapse (15 weeks) before the examination is administered a second time. Students failing the examination twice will be dismissed from the program. At the discretion of the committee, a candidate may be allowed to change his or her degree option from a Ph.D. to a Master's. The result of the examination is recorded on a form furnished by the Office of the Registrar on the day of the oral portion of the examination. Each member of the student's advisory committee must sign this form.

Students pursuing the Ph.D. are required to complete research in the course of graduate study. To initiate the research effort, students are required to pass a preliminary examination upon successful completion of the qualifying examination. The student is required to prepare a research proposal that describes the content of the research, the outcome anticipated, the contribution to the field of endeavor, and the creative content of the effort. This proposal must be in a written form and must be presented to his/her committee at a meeting where all committee members are present. Approval of the research effort is signified by signatures of each committee member on the cover page of the proposal. The signed research proposal must be delivered to the SEEM/SDOE student records office for inclusion in the student's academic record. A student pursuing the Ph.D. degree should demonstrate, through the dissertation, the ability to carry out original and creative research. The results of the research should be sufficiently significant to be publishable in a major technical journal. The writing style, grammar, and spelling of the dissertation should reflect a high level of skill in written communication. Between the research proposal and the final examination the student is required to provide at least one progress report to his/her advisory committee at a meeting where all committee members are present. The time of this meeting is determined by the student's DAC.

At the completion of the research, you must defend your thesis in a public presentation. Doctoral candidates are encouraged to hold a private defense with his or her committee several weeks prior to the public defense. At that time, the committee should raise issues with the candidate prior to the public defense. The final examination must be scheduled through the Office of the Registrar, at least two weeks prior to its administration. To pass the final examination, a degree candidate must have a favorable vote from a majority of the examining/advisory committee, with a maximum of one negative vote. If a student fails the final

examination, there must be a lapse of one full semester (15 weeks) before rescheduling the examination. A student is allowed no more than two opportunities to pass the final examination.

The Systems Integration Initiative – Executive Education

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The System Design and Operational Effectiveness (SDOE) Program
Dinesh Verma, Associate Dean, Charles V. Schaefer, Jr., School of Engineering

Participating Faculty

Professors
SEEM: John V. Farr, Ph.D., P.E. (1986), University of Michigan
SEEM: Dinesh Verma, Ph.D. (1994), Virginia Polytechnic Institute
ME: Costas Chassapis, Ph.D. (1988) City University of New York
ME: Souran Manoochehri, Ph.D. (1986), University of Wisconsin, Madison
ECE: Stuart K. Tewksbury, Ph.D. (1969), University of Rochester

Distinguished Service Professors
SEEM: John T. Boardman, Ph.D., (1970), University of Liverpool

Industry Professors
SEEM: Bruce Barker, M.S., (2004), Stevens Institute of Technology
SEEM: Anthony Barrese, Ph.D., (1978), Stevens Institute of Technology
SEEM: Rick Dove, B.S., (1969), Carnegie Mellon University
SEEM: Ralph G. Giffin, III, B.S., (1988), George Mason University
SEEM: David Nowicki, Ph.D., (1998), University of Wisconsin, Madison
SEEM: Spiros Pallas, Ph.D. (1972), University of Texas
SEEM: Michael C. Pennotti, Ph.D., (1974), Polytechnic Institute of New York

Associate Professors
SEEM: Rashmi Jain, Ph.D. (2003), Stevens Institute of Technology
ME: Kishore Pochiraju, Ph.D. (1993) Drexel University

Assistant Professor
SEEM: Wei Jiang, Ph.D. (2000), The Hong Kong University of Science and Technology
SEEM: Brian J. Sauser, Ph.D., (2004), Stevens Institute of Technology

Lecturer
SEEM: Eirik Hole, Diplom Ingenieur (1995), University of Stuttgart

Academic Fellows
Dr. Wolter J. Fabrycky, Lawrence Professor Emeritus, Virginia Tech
Dr. Harold Lawson, Professor and Chairman, Lawson Konsult, AB
Dr. Richard Nance, Dahlgren Professor Emeritus of Computer Science, Virginia Tech
Dr. Andrew Sage, Dean Emeritus and First American Bank Professor, George Mason
University
Dr. Caroline Smith, Associate Professor, James Madison University

Dr. Emre Veral, Associate Professor of Management, Baruch College, The City
University of New York

The System Design and Operational Effectiveness (SDOE) Program

As part of this initiative in the Charles V. Schaefer, Jr. School of Engineering participants can pursue a number of interdisciplinary graduate certificate programs leading to a Master's degree (M.E.) or a Doctoral degree in Systems Engineering (SE). All graduate programs offered through this initiative involve a multidisciplinary approach to engineering education by providing a blend of engineering, systems, and management subjects. The traditional engineer and scientist often lacks preparation in the human, financial, and systems integration skills necessary to make project teams more productive, improve product and process quality, and promote the advancement of high technology for complex systems. Our programs are unique in that we strive to create an engineer who is well-prepared for a future in the conception, definition, architecting, modeling and simulation, integration, sustenance, and management of modern complex systems in a variety of market domains.

As technology advances, systems tend to become more complex. Complexity can greatly increase the cost of a system over its life cycle. Short-term costs including research, design, test, and production are only part of the life-cycle cost. Post-production costs associated with system operation, maintenance, and support is often 70% to 80% of the total cost. The traditional approach to system design focuses on key performance characteristics plus cost and schedule. Only near the end of design is it determined exactly how the system-as-already-designed is to be supported. This approach for complex systems compromises their reliability, maintainability, and supportability, thus greatly increasing total ownership costs. At the same time, users are demanding more quality. That is, users want more reliability and availability at a lower total cost.

An integrated approach to system design and development can result in an improved balance between system effectiveness and total ownership cost. Such an approach must concurrently consider all aspects of the entire life cycle of the system/product from design to manufacture, maintenance, repair, and disposal; and bring potential cost drivers to the attention of decision-makers early and in compelling ways.

The Charles V. Schaefer, Jr. School of Engineering, as a leader in engineering education, is offering a graduate degree in SE and a variety of certificate programs that stress system design, modeling, analysis, operations, and life-cycle support. The program objective is to provide an innovative view of the landscape of system design to practitioners from different engineering disciplines, to enhance their practice of engineering today, and to position them for career growth in the global economy.

Uniqueness of the Curriculum and Delivery Format in the System Design and Operational Effectiveness Program

The curriculum in the SDOE Program is focused on the requirements of system integrators across a multitude of domains

in the commercial and aerospace sectors. A synopsis of the topical clusters is reflected in the figure. These topical clusters were identified in collaboration with our partners in the aerospace and defense, telecommunications, IT, and automotive industries. Courses within the program address all these functional clusters. A more detailed description of these clusters can be obtained from the **SDOE Program Web site**.

The delivery mechanism of our courses is also unique. All courses in our program are offered in a unique weeklong modular format or offered in a completely web-based format. Modes of instruction of the SDOE program have been structured to allow flexibility. The week-long modular format minimizes time away from “home base,” while live and intensive weeklong courses, and associated group exercises, ensure development of team building skills, leadership development, and the real-time negotiation and tradeoffs that characterize reality. Students are normally given reading assignments prior to the instructional week. Further, participants pursing a degree or graduate certificate have ten weeks subsequent to the instructional week to complete their homework assignments and projects.

Systems Engineering Master’s Degree in the SDOE Executive Education Program

The Systems Engineering degree is a multidisciplinary program that includes a blend of engineering, systems thinking, and management subjects. The increasing complexity of systems, the pervasive realities of global competitiveness, the enhanced focus on cost and profitability, and ever more challenging customer expectations have led a number of premiere organizations in the defense and commercial sectors to assume the role of system integrators. These organizations are increasingly adopting an evolving business model that emphasizes the selling of functionality, a solution, or a capability, instead of focusing on selling and providing systems, system elements, and products. The curriculum emphasizes the development of large-scale, complex, and multifunctional systems in a number of domains, while also addressing the requirements of time-to-market focused organizations in the commercial sector. Core courses in the SDOE Program have a strong case study and project orientation to facilitate understanding of the concepts discussed.

Admission to the SDOE program generally requires an undergraduate degree in engineering or related disciplines with a "B" average or better from an accredited college or university. Outstanding applicants in other areas may be conditionally admitted subject to the satisfactory completion of several introductory courses within the program. Specific requirements are determined on an individual basis depending upon the student’s background. It is required that any applicants requesting research assistantship appointments and applicants to the Ph.D. program provide evidence of the ability to carry out independent work. Examples of such evidence include the master's degree thesis work and/or completed work-related projects. GRE scores are not required, but may be submitted in support of the application. International students must demonstrate their proficiency in the English language prior to admission by scoring at least 550 (210 for computer-based) on the TOEFL examination. Applications for admission from qualified students are accepted at any time.

Graduates from this program will be prepared to work effectively at the interface between engineering and management and to assume professional positions of increasing responsibility. The program consists of four core courses that must be completed if the applicant is pursuing a Master's or Doctoral degree:

ALL students must take the following two-course sequence:
SDOE 625 Operational Effectiveness and Life-Cycle Analysis
SDOE 650 System Architecture and Design

Plus, two of the following four options:
SDOE 611 Modeling and Simulation ***or***
SDOE 670 Forecasting and Demand Modeling
SDOE 612 Project Management for Complex Systems
SDOE 660 Decision and Risk Analysis ***or***
SDOE 675 Integrated Supply Chains
SDOE 605 Systems Integration

A candidate may propose a customized track of six elective courses leading to other specialties with approval from a faculty advisor. At least two of the electives must be taken from the SEEM/SDOE curriculum. Students should review other sections of the graduate catalog for certificate options. Students are encouraged to take an integrated four-course sequence leading to a graduate certificate for the remaining four electives or four additional courses in systems engineering. Many certificates are offered online via web-based instruction.

Students in the SDOE program are required to take either a 3-credit special project class (SDOE 800) or a 6-credit hour thesis (SDOE 900). Students should communicate with their academic advisor to develop a study plan to coordinate the thesis versus the project options and to match the student's background, experience, and interests while satisfying the requirements for any of the programs.

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UNDERGRADUATE COURSES

EM 270 Engineering Management
(3-0-3)
This course deals with the problems associated with the management of engineering personnel, projects, and organizations. The applications of the functions of management to engineering related operations, including the engineering aspects of products and process development, are reviewed. The course requires students to apply their knowledge of human behavior, economic analysis, and science to solve problems in the management of technologically-oriented organizations. The capstone of the course is a term paper analyzing an engineering management problem taken from actual practice.

EM 275 Project Management
(3-0-3)
This course presents the tools and techniques for project definition, work breakdown, estimating, resource planning, critical path development, scheduling, project monitoring and control, and

scope management. Students will use Project Management software to accomplish these tasks. In addition, the student will become familiar with the responsibilities, skills, and effective leadership styles of a good project manager. The role organization design plays in project management will also be addressed. Corequisite: EM 270

EM 301 Engineering Cost Management
(3-3-4)
This course introduces students to the fundamental concepts of financial and managerial accounting, with an emphasis on actions managers can take to more effectively address the goals of the firm. Key topics covered include the preparation and analysis of financial statements, particularly creating cash flow statements needed for engineering economic analysis; consideration of variable costs, fixed costs, cost of goods sold, operating costs, product costs, period costs; job costing and process costing; application of accounting information for decision-making: marketing decisions, production decisions; capital budgeting: depreciation, taxation; budgeting process, master budgets, flexible budgets, analysis of budget variances; asset valuation, and inventory costing. The laboratory portion of the course provides the student opportunity to use the personal computer for solving problems related to the major topics of the course, such as spreadsheet analysis, and in addition covers managerial topics, including sessions focused on group dynamics and teamwork, research using the Internet and business ethics/corporate governance (Sarbanes-Oxley).

EM 322 Engineering Design VI
(1-3-2)
Provides students with "hands-on" experience of management of New Product (Process) Development, which they can use in their senior design projects. Students will study the stages of product (technology) life-cycle from concept to discharge of a product. Study includes systems consisting of hardware and software design, manufacturing, testing, and installation based on Integrated Product and Process Development (IPPD) model. Different tools for forecasting, optimization, and simulation are provided for students to identify the problem, select the project, form the team, and prepare proposals suitable for submission to a potential sponsor for the senior design capstone project. Proposal documented according to ISO 9000 Quality Management and ISO 14000 Environment Management Standards. Corequisites: EM 345, EM 380, and E 355.

EM 345 Modeling and Simulation
(3-0-3)
This course covers contemporary decision support models of forecasting, optimization, and simulation for management. Students will learn how to identify the problem situation, choose the appropriate methods, collect the data, and find the solution. The course also covers handling the information and generating alternative decisions based upon operations research optimization, statistical simulation, and systems dynamic forecasting. Computer simulations will be performed on PCs by user-friendly graphical interface with multimedia report generation for visualization and animation. Students will also be trained in management simulations for group decision support. Prerequisite: EM 365.

EM 351 Management of Information Networks
(3-0-3)
This course will provide students with a sound foundation in the field of data communications, networking, and distributed processing systems, so that they can better understand and manage the information technology and systems that they will encounter in their careers. A comprehensive survey of communication protocols, hardware, and software required to deliver information from a source through a medium to a destination. Digital, analog, security solutions and network management requirements for data communication are introduced. Emphasis will be on the managerial aspects of data communications.

EM 360 Total Quality Management
(3-0-3)
This course will provide the student with the underlying management concepts and principles of Total Quality Management (TQM) and how they apply to Engineering Management. The ideas and concepts of Frederick Winslow Taylor, Edward Deming, Joe Juran, Phil Crosby, Armand Fiegenbaum, and Karou Ishikawa will be presented and discussed in relation to how management thought has developed from Scientific Management to Quality Management. Discussion of the Baldridge and Deming awards will include how leadership, information and analysis, strategic quality planning, human resource utilization, quality assurance, and customer satisfaction relate to QM in Engineering Management. The use of concurrent engineering in research, design, and engineering will be explored. The student will learn various TQM tools explored such as quality function deployment, design for cost, and cost of quality. The students will learn the methodology and techniques of continuous process improvement and use this knowledge to analyze and correct defects as part of a team project.

EM 365 Statistics for Engineering Managers
(3-1.5-4)
Provides a working knowledge of basic statistics as it is most often applied in engineering. Topics include: fundamentals of probability theory, review of distributions of special interest in statistics, analysis and enumeration of data, linear regression and correlation, statistical design of engineering experiments, completely randomized design, randomized block design, factorial experiments, engineering applications, and use of the computer as a tool for statistical analysis. (Students with AP, transfer, or other credit for Statistics are still required to take the one credit EM 364 Statistics Lab.)

EM 380 Innovative System Design
(3-0-3)
This project-based course addresses the fundamentals of systems engineering. Principles and concepts of systems engineering within a life-cycle perspective are presented through case studies and applied throughout the course to a student-selected team project. The initial focus is on the understanding of business drivers for systems engineering and the generation of innovative ideas. Students then engage in analysis, synthesis, and evaluation activities as they progress through the conceptual and preliminary

design phases. Emphasis is placed on tools and methodologies for system evaluation during all phases of the design process with the goal of enhancing the effectiveness and efficiency of deployed systems, as well as reducing operational and support costs. Pre- or corequisite: EM 365.

EM 423-424 Engineering Management Design Project (0-8-3)
This year-long two-course sequence involves the students in a small-team Engineering Management project. The problem for the project is taken from industry, business, government, or a not-for-profit organization. Each student team works with a client and is expected to collect data, analyze it, and develop a design by the end of the first semester. In the second semester, the design solution of the problem is completed, and a written report is submitted for binding. During the year, oral and written progress reports are presented to peers and clients. The total project involves the application of the subject areas covered in the EM 380 Engineering Management Laboratory course, as well as skills learned in the other technical and non-technical courses of the Engineering Management curriculum. Prerequisites: EM 270, EM 275, E 355, EM 301, EM 322, EM 345, and EM 380.

EM 435 Business Process Reengineering (3-0-3)
This course covers the area of business analysis that includes enterprise technologies, supply chain management, engineering management, systems engineering, decision support systems, e-business, process operations and reengineering, technology consulting and analytical modeling and the relating of Business Process Reengineering to quality improvement. The course will be broken in two components with the first focusing on implementing theory into action, showing use in process discovery and definition, diagnosis and improvement, design, support and enactment. The second part of the course uses case studies to demonstrate applications of process engineering to improve efficiency. Most application and case studies are information technology focused. Prerequisite: EM 365.

EM 450 Logistics and Operations Management (3-0-3)
Students learn about planning, organizing, staffing, directing, and controlling the production of goods and providing service functions of an organization. Main stages of production cycle and components will include raw materials, personnel, machines, and buildings. Specific topics covered will include forecasting, product design and process planning, allocation of scarce resources, capacity planning and facility location, materials management, scheduling, office layout, and total quality management. Prerequisite: EM 457.

EM 457 Elements of Operations Research (3-0-3)
Application of forecasting and optimization models to typical engineering management situations and problems. Topics include: optimization theory and its special topics (linear programming, transportation models, and assignment models), dynamic programming, recasting models, decision trees, game theory, and queuing theory. Applications to resource allocation, scheduling and

routing, location of facilities, and waiting lines will be covered. Prerequisite: EM 365.

TG 401 Entrepreneurship and Business for Engineers and Scientists
(3-0-3)
Aspects of entrepreneurship and business most relevant for technical people and the practice of Technogenesis. Investigates business-related considerations in successfully commercializing new technology. Exposes technologists to five critical aspects of creating a successful new venture and/or a successful product or service business within an existing enterprise: (1) market and customer analysis, (2) beating the competition, (3) planning and managing for profitability, (4) high-tech marketing and sales, and (5) business partnerships and acquisitions. Students should take this course if they: (1) desire to maximize their effectiveness as technologists by understanding the business and customer considerations that impact the work of technologists, (2) intend to lead or participate in a technology-based new venture/start-up, or (3) contemplate an eventual transition from a technical to a business management career. It is intended for either advanced undergraduate (junior or senior) or graduate students in engineering or science curricula. Also offered as TG 501.

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GRADUATE COURSES

All Graduate courses are 3 credits except where noted.

Engineering Management

EM 600 Engineering Economics and Cost Analysis
This course presents advanced techniques and analysis designed to permit managers to estimate and use cost information in decision-making. Topics include: historical overview of the management accounting process, statistical cost estimation, cost allocation, and uses of cost information in evaluating decisions about pricing, quality, manufacturing processes (e.g., JIT, CIM), investments in new technologies, investment centers, the selection process for capital investments, both tangible and intangible, and how this process is structured and constrained by the time value of money, the source of funds, market demand, and competitive position. Also listed as Mgt 618.

EM 605 Elements of Operations Research
This course brings a strong modeling orientation to bear on the process of obtaining and utilizing resources to produce and deliver useful goods and services so as to meet the goals of the organization. Decision-oriented models, such as linear programming, inventory control, and forecasting are discussed and then implemented utilizing spreadsheets and other commercial software. A review of the fundamentals of statistical analysis oriented toward business problems will also be conducted.

EM 611 Modeling and Simulation
This course emphasizes the development of modeling and simulation concepts and analysis skills necessary to design, program, implement, and use computers to solve complex systems/products analysis problems. The key emphasis is on problem formulation, model building, data analysis, solution techniques, and evaluation of alternative designs/ processes in complex systems/products. Overview of modeling techniques and

methods used in decision analysis, including Monte Carlo and discrete event simulation is presented. Cross-listed as SYS/SDOE 611.

EM 612 Project Management of Complex Systems (Module version is SDOE 612)
This project-based course exposes students to tools and methodologies useful for the effective management of systems engineering and engineering management projects. This course presents the tools and techniques for project definition, work breakdown, estimating, resource planning, critical path development, scheduling, project monitoring and control, and scope management. These tools will be presented within the context of a life-cycle and a systems approach. Students will be exposed to advanced project management software. Reinforcing these fundamentals in project management, the course will introduce advanced concepts in project management, and establish the building blocks for the management of complex systems. Also listed SYS/SDOE 612.

EM 620 Simulation-Based Costing and Acquisition (Module version is SDOE 620)
This course will provide an understanding of both the tools and models that can be used throughout the design, development, and support phases of a system to conduct trade-offs between system performance and life-cycle cost. The students will be exposed to the cost benefit analysis process as a strategic tool during system design and development consistent with the principles of Cost as an Independent Variable (CAIV). The students will also be exposed to the formulation of cost-estimating relationships in this context. The course will focus on the use of tools and the development of models from case studies. Prerequisite: IPD 611, SYS 611, or consent of instructor. Cross-listed as SYS 620.

EM 680 Designing and Managing the Development System
This course addresses the design of the peopled-system that is responsible for designing and testing a product or operational system. The purpose of this course is to introduce the human system integration attributes associated with the development system. These attributes will be emphasized with respects to three keys to designing the development system: the design process as a discovery process, feedback and control activities, and risk management. This course will focus on the functional processes that must be performed by the development system, but will also address physical resources (people and software) and associated organizational structures, leadership, and cultural issues. Cross-listed as SYS 680.

EM 690 Selected Topics in Engineering Management
Selected topics from various areas within Engineering Management. This course is typically taught to more than one student and often takes the form of a visiting professor's course. Prerequisite: Consent of instructor.

EM 740 Dynamics of Economic Systems
The course introduces students to system dynamics models of business policy analysis and forecasting of associated management problems of complex systems. The course covers advanced techniques of policy and strategy development applications:

system thinking and modeling dynamics of growth and stability, including interaction of human factors with the technology. The tools of increasing power and complexity are offered for student's business and management applications: causal feedback diagrams, technology process graphs, information processing flowcharts, and decision scenarios. Students will get hands-on training in systems modeling by STELLA and DYNAMO software languages and perform their own case studies of real system of technology and/or business development based on the Technogenesis approach. Prerequisite: Course in statistics.

EM 744 Advanced Data Analysis for Data Mining and Knowledge Discovery
This data-driven course focuses on the subjects of both traditional and modern data analysis and mining techniques. The course emphasizes the analysis of business and engineering data using a combination of theoretical techniques and commercially available software to solve problems. Topics such as data analysis and presentation, linear and nonlinear regression, analysis of variance, factor analysis, cluster analysis, neural networks, and classification trees will be presented. The course will make extensive use of the Splus software packages. However, students will be encouraged to use a wide variety of industry standard data analysis and mining tools, including SPSS, SAS, MATLAB, and BrainMaker.

EM 750 Total Quality Management
Principles and techniques of total quality management (TQM) with emphasis on their application to technical organizations. Topics include management philosophy, concepts, and critique of quality "Gurus"; TQM modeling and strategy; TQM tools and techniques; Dept. of Defense 5000.51-G TQM guides; review and critique of the Deming and Baldrige Awards; concurrent engineering; and quality function, deployment, and design for cost. Students will form teams to analyze a case study involving TQM concepts and techniques. Cross-listed as MGT 750.

EM 760 Production and Operations Management
Covers the general area of management of operations, both in manufacturing and non-manufacturing. The focus of the course is on productivity and total quality management. Topics include quality control and quality management, systems of inventory control, work and materials scheduling, and process management. Also listed as MGT 760.

EM 761 Analysis of Production Systems
Development of models useful in management of production operations under limited resources, optimization of production planning, and scheduling. Topics such as line-balancing, shop loading and sequencing, production smoothing, critical path analysis and forecasting models are covered. Cross-listed as MGT 761.

EM 796 Statistical Models
The major portion of the course covers an introduction to the probabilistic and statistical concepts and models used in day-to-day business decision-making. Topics include data analysis, correlation techniques, regression, statistical inference, and forecasting. Cross-listed as MGT 620.

EM 800 Special Problems in Engineering Management*

Three credits for the degree of Master of Engineering (Engineering Management). This course is typically conducted as a one-on-one course between a faculty member and a student. A student may take up to two special problems courses in a master's degree program. A department technical report is required as the final product for this course. Prerequisite: Consent of instructor.

EM 801 Special Problems in Engineering Management*
Three credits for the degree of Doctor of Philosophy. This course is typically conducted as a one-on-one investigation of a topic of particular interest between a faculty member and a student and is often used to explore topical areas that can serve as a dissertation. A student may take up to two special problems courses in a Ph.D. degree program. A department technical report is required as the final product for this course. Prerequisite: Consent of instructor.

EM 900 Thesis in Engineering Management*
For the degree of Master of Engineering (Engineering Management). A minimum of six credit hours is required for the thesis. Hours and credits to be arranged.

EM 960 Research in Engineering Management*
Original work, which may serve as the basis for the dissertation, required for the degree of Doctor of Philosophy. A minimum of 30 hours of EM 960 research is required for the Ph.D. degree. Hours and credits to be arranged.

*By request.

Systems Engineering

SYS 595 Design of Experiments and Optimization
This course is application-oriented with theoretical arguments approached from an intuitive level rather than from a rigorous mathematical approach. This course teaches the student how statistical analyses are performed while assuring the student an understanding of the basic mathematical concepts. The course will focus on "real world" uses of statistical analysis and reliability theory to solve real world problems. The student will use the software that is included in the textbook to solve problems. This course will demonstrate also Markov modeling techniques.

SYS 601 Probability and Statistics for Systems Engineering (Module version is SDOE 601)
This course is designed for students with a background in engineering, technology, or science that have not taken a class in statistics or need a refresher class. In this class, we will apply probability and statistics throughout a system's life cycle. Topics include the roles of probability and statistics in Systems Engineering, the nature of uncertainty, axioms and properties of probability models and statistics, hypothesis testing, design of experiments, basic performance requirements, quality assurance specification, functional decomposition, technical performance measurements, statistical verification, and simulation.

SYS 605 Systems Integration (Module version is SDOE 605)
This course is designed to provide students with an understanding of Systems Integration (SI) process, approaches, drivers, tools and techniques required for successful SI, critical success factors,

and best practices. The objective of the course is to provide the students an understanding of the technical and business process issues involved in systems integration. Systems integration process is illustrated over the life-cycle concept of projects – during design, development, implementation, testing, and production. Case studies and examples from the Information Technology (IT), defense, energy, and financial services industry will be used to illustrate the concepts discussed. The students will learn the theory and practice of business process integration, legacy integration, new systems integration, business-to-business integration, integration of commercial-off-the-shelf (COTS) products, interface control and management, testing, integrated program management, and integrated Business Continuity Planning (BCP). Specific focus will be given to issues of interface integration and interoperability of systems.

SYS 611 Modeling and Simulation (Module version is SDOE 611)
This course emphasizes the development of modeling and simulation concepts and analysis skills necessary to design, program, implement, and use computers to solve complex systems/products analysis problems. The key emphasis is on problem formulation, model building, data analysis, solution techniques, and evaluation of alternative designs/ processes in complex systems/products. Overview of modeling techniques and methods used in decision analysis, including Monte Carlo and discrete event simulation is presented. Cross-listed as EM 611.

SYS 612 Project Management of Complex Systems (Module version is SDOE 612)
This project-based course exposes students to tools and methodologies useful for the effective management of systems engineering and engineering management projects. This course presents the tools and techniques for project definition, work breakdown, estimating, resource planning, critical path development, scheduling, project monitoring and control, and scope management. These tools will be presented within the context of a life-cycle and a systems approach. Students will be exposed to advanced project management software. Advanced techniques for managing complex systems will also be presented. Cross-listed as IPD 612 and EM 612.

SYS 620 Simulation-Based Costing and Acquisition (Module version is SDOE 620)
This course will provide an understanding of both the tools and models that can be used throughout the design, development, and support phases of a system to conduct trade-offs between system performance and life-cycle cost. The students will be exposed to the cost benefit analysis process as a strategic tool during system design and development consistent with the principles of Cost as an Independent Variable (CAIV). The students will also be exposed to the formulation of cost-estimating relationships in this context. The course will focus on the use of tools and the development of models from case studies. Prerequisite: IPD 611, SYS 611, or consent of instructor. Cross-listed as EM 620.

SYS 625 Systems Operational Effectiveness and Life-Cycle Analysis (Module version is SDOE 625)
This course discusses fundamentals of systems engineering. Initial focus is on need identification and problems definition. Thereafter,

synthesis, analysis, and evaluation activities during conceptual and preliminary system design phases are discussed and articulated through examples and case studies. Emphasis is placed on enhancing the effectiveness and efficiency of deployed systems while concurrently reducing their operation and support costs. Accordingly, course participants are introduced to methods that influence system design and architecture from a long-term operation and support perspective. Cross-listed as CPE 625.

SDOE 630 DAU Level I Certification Examination [1]
This will test the knowledge of students who have achieved Level I certification through the Defense Acquisition University. Upon successful completion (graded pass/fail), students will be awarded three credits toward a Master of Engineering in Systems Engineering.

SDOE 631 DAU Level II and III Certification Examination [1]
This will test the knowledge of students who have achieved II and III certification through the Defense Acquisition University. Upon successful completion (graded pass/fail), students will be awarded between three and six credits toward a Master of Engineering in Systems Engineering.

SDOE 635 System Maintainability and Maintenance [1]
System maintainability is a design characteristic, whereas maintenance is a consequence of design, and this module focuses on both. Maintainability analysis, and the associated theory, provides a powerful tool with which engineers can gain a quantitative and qualitative description of the ability and cost of systems and products to be restored. On the other hand, and as part of the emphasis of this module on maintenance, participants will be introduced to analysis and optimization techniques to enhance the efficiency of the maintenance system through proper classification of tasks as preventive and/or corrective, and their intelligent clustering to reduce the associated maintenance manpower, cost, time, and resources.

SYS 640 System Supportability and Logistics (Module version is SDOE 640)
The supportability of a system can be defined as the ability of the system to be supported in a cost effective and timely manner, with a minimum of logistics support resources. The required resources might include test and support equipment, trained maintenance personnel, spare and repair parts, technical documentation, and special facilities. For large complex systems, supportability considerations may be significant and often have a major impact upon life-cycle cost. It is therefore particularly important that these considerations be included early during the system design trade studies and design decision-making.

SYS 645 Design for Reliability, Maintainability, and Supportability (Module version is SDOE 645)
This course provides the participant with the tools and techniques that can be used early in the design phase to effectively influence a design from the perspective of system reliability, maintainability, and supportability. Students will be introduced to various requirements definition and analysis tools and techniques to include Quality Function Deployment, Input-Output Matrices, and

Parameter Taxonomies. An overview of the system functional analysis and system architecture development heuristics will be provided. Further, the students will learn to exploit this phase of the system design and development process to impart enhanced reliability, maintainability, and supportability to the design configuration being developed. Given the strategic nature of early design decisions, the participants will also learn selected multiattribute design decision and risk analysis methodologies, including Analytic Hierarchy Process (AHP). As part of the emphasis on maintainability, the module addresses issues such as accessibility, standardization, modularization, testability, mobility, interchangeability and serviceability, and the relevant methods, tools, and techniques. Further, the students will learn to exploit this phase of the system design and development process to impart enhanced supportability to the design configuration being developed through an explicit focus on configuration commonality and interchangeability, use of standard parts and fasteners, adherence to open system standards and profiles, and use of standard networking and communication protocols. Examples and case studies will be used to facilitate understanding of these principles and concepts.

SYS 650 System Architecture and Design (Module version is SDOE 650)
This course discusses the fundamentals of system architecting and the architecting process, along with practical heuristics. Furthermore, the course has a strong "how-to" orientation, and numerous case studies are used to convey and discuss good architectural concepts as well as lessons learned. Adaptation of the architectural process to ensure effective application of COTS will also be discussed. In this regard, the course participants will be introduced to an architectural assessment and evaluation model. Linkages between early architectural decisions, driven by customer requirements and concept of operations, and the system operational and support costs are highlighted. Prerequisite: SYS 625.

SYS 655 Robust Engineering Design (Module version is SDOE 655)
This course is designed to enable engineers, scientists, and analysts from all disciplines to recognize potential benefits resulting from the application of robust engineering design methods within a systems engineering context. By focusing on links between sub-system requirements and hardware/software product development, robust engineering design methods can be used to improve product quality and systems architecting. Topics such as Design and Development Process and Methodology, Need Analysis and Requirements Definition, Quality Engineering, Taguchi Methods, Design of Experiments, Introduction to Response Surface Methods, and Statistical Analysis of Data will be presented.

SYS 660 Decision and Risk Analysis (Module version is SDOE 660)
This course is a study of analytic techniques for rational decision-making that addresses uncertainty, conflicting objectives, and risk attitudes. This course covers modeling uncertainty; rational decision-making principles; representing decision problems with value trees, decision trees, and influence diagrams; solving value hierarchies; defining and calculating the value of

information; incorporating risk attitudes into the analysis; and conducting sensitivity analyses. Prerequisite: Course in Probability and Statistics.

SYS 665 Integrated Supply Chain Management (Module version is SDOE 665)
This course illustrates the theory and practice of designing and analyzing supply chains. It provides tool sets to identify key drivers of supply chain performance, such as inventory, transportation, information, and facilities. Recognizing the interactions between the supply and demand components, the course provides a methodology for implementing integrated supply chains, enabling a framework to leverage these dynamics for effective product/process design, and enterprise operations.

SYS 670 Forecasting and Demand Modeling Systems (Module version is SDOE 670)
This course covers the theory and application of modeling aggregate demand, fragmented demand, and consumer behavior using statistical methods for analysis and forecasting for facilities, services, and products. It also aims to provide students with both the conceptual basis and tools necessary to conduct market segmentation studies, defining and identifying criteria for effective segmentation, along with techniques for simultaneous profiling of segments, and models for dynamic segmentation. All of this provides a window on the external environment, thereby contributing input and context to product, process, and systems design decisions and their ongoing management. Cross-listed as EM 670.

SDOE 675 Dynamic Pricing Systems [1]
Dynamic pricing is defined as the buying and selling of goods and services in free markets where the prices fluctuate in response to supply and demand and changing. This course illustrates the difference between static and dynamic pricing, and covers various dynamic pricing models and methodologies for successful pricing. This course also illustrates the fact that effective pricing optimization is based on modeling of demand and elasticity of demand at a very granular level. It will explore various dynamic pricing models and explore and identify factors relevant in choosing dynamic pricing models that best support the operational effectiveness, external environment, and business strategy of a particular firm.

SYS 680 Designing and Managing the Development System (Module version is SDOE 680)
This course addresses the design of the peopled-system that is responsible for designing and testing a product or operational system. Three keys to designing the development system are emphasized as part of this course: the fact that the design process should be a discovery process, the critical feedback and control activities that must be implemented for cost-effective success, and the design of risk management activities (with an emphasis on adaptive testing). This course will focus on the functional processes that must be performed by the development system, but will also address physical resources (people and software) and associated organizational structures. Cross-listed as EM 680.

SYS 690 Selected Topics in Systems Engineering

Selected topics from various areas within Systems Engineering. This course is typically taught to more than one student and often takes the form of a visiting professor's course. Prerequisite: Consent of instructor.

SYS 718 Multivariate Analysis (Module version is SDOE 718)
Experimental design, statistical estimation, and hypothesis testing from multivariate distributions. Topics covered will include regression models, multivariate analysis of variance, canonical correlations, classification procedures, and factor analysis. Computer applications of these techniques will be examined. Prerequisite: Statistics Class. Cross-listed as MGT 718.

SYS 775 Systems Thinking (Module version is SDOE 775)
The ability to "think" and "act" in terms of systems is a prerequisite to being able to organize and operate organizations and their enterprises so that business purpose, goals, and missions can be actively pursued. Systems thinking, also called the systemic approach, has evolved, through multiple contributions during 20th century, into a discipline that can be applied in gaining an understanding of the common denominator aspects of various types of systems, and, in particular, the dynamic and temporal relationships between multiple systems in operation. Through systems thinking, organizations and their enterprises can learn to identify system problems and opportunities and to determine the need for, as well as evaluate the potential effect of, system changes. Having decided upon the need for new systems, removal of systems and/or structural changes in one or more existing systems, it is vital to deploy a controlled means of "acting" for managing the changes in an expedient and reliable manner. In this regard, the international standard ISO/IEC 15288 (System Life-Cycle Processes) provides relevant guidance for the management of the life-cycle of any type of man-made system. This module has been developed to convey essential properties of systems, as well as to focus upon the most central activity of any organization or enterprise, namely the management of change. This is accomplished by introducing the concepts and principles of systems from the perspective of systems (systemic) thinking, as well as from the guidance provided by the ISO/IEC 15288 standard. A model for change management based upon paradigms for thinking and acting, as well as for the gathering of knowledge, provides for a unified discipline independent approach. Prerequisite: SYS 625.

SDOE 780 Agile Development Strategy [1]
Agile systems and enterprises are created and enabled by architectures, principles, and operational practices that facilitate responsive configuration and reconfiguration in the continual face of changing needs. This class introduces tools for analyzing and establishing response requirements and performance metrics; and engineering principles for synthesizing architecture and operational practices.

SDOE 785 Architecting the Extended Enterprise [1]
This course presents a systems architecting process to achieve enterprise integration both within and between corporate boundaries. The process leverages systems thinking, the antithesis of scientific reductionism, which fails to appreciate the interrelationships between components that make up a system.

Systems thinking has proven to be successful in the delivery of integrated technology products, and is now being applied to understanding the structure and dynamics of organizations for which communications and co-stuff in general is a key to business success; in other words inter-relationships are prime in managing an enterprise. The systems approach further emphasizes emergence, wider systems and the environment. These concepts are crucial to architecting an enterprise in consideration of issues of decentralization, alliance advantage, and market phenomena.

SYS 800 Special Problems in Systems Engineering*
Three credits for the degree of Master of Engineering (Systems Engineering). This course is typically conducted as a one-on-one course between a faculty member and a student. A student may take up to two special problems courses in a master's degree program. A department technical report is required as the final product for this course. Prerequisite: consent of instructor. Students enrolled in the SDOE program should enroll in course number SDOE 800.

SYS 801 Special Problems in Systems Engineering*
Three credits for the degree of Doctor of Philosophy. This course is typically conducted as a one-on-one one investigation of a topic of particular interest between a faculty member and a student and is often used to explore topical areas that can serve as a dissertation. A student may take up to two special problems courses in a Ph.D. degree program. A department technical report is required as the final product for this course. Prerequisite: consent of instructor. Students enrolled in the SDOE program should enroll in course number SDOE 801.

SYS 900 Thesis in Systems Engineering*
For the degree of Master of Engineering (Systems Engineering). A minimum of six credit hours is required for the thesis. Hours and credits to be arranged. Students enrolled in the SDOE program should enroll in course number SDOE 900.

SYS 960 Research in Systems Engineering*
Original work, which may serve as the basis for the dissertation, required for the degree of Doctor of Philosophy. A minimum of 30 hours of SYS 960 research is required for the Ph.D. degree. Hours and credits to be arranged. Students enrolled in the SDOE program should enroll in course number SDOE 960.

*By request

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[1] Courses with a SDOE only number are offered solely as part of the Systems Design and Operational Effectiveness Program, an executive program leading to an advanced degree in Systems Engineering. They are typically not taught in regular semester format.

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