Morgan State University

School of Graduate Studies Catalog
2014-2015

School and College Sections

CLARENCE M. MITCHELL, JR. SCHOOL OF ENGINEERING

Provisions of this publication are not to be regarded as a contract between the student and Morgan State University.

Changes are effected from time to time in the general regulations and in the academic requirements. There are established procedures for making changes and procedures which protect the institution's integrity and welfare. A curriculum or graduation requirement, when altered, is not made retroactive unless the alteration can be accommodated within the span of years required for graduation. Additionally, because of space limitations in limited enrollment programs, Morgan State University may not be able to offer admission to all qualified students applying to these programs and/or class-sections.

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DOCTOR OF ENGINEERING (D.Eng.)

Purpose

The purpose of the Doctor of Engineering program is to prepare students beyond the application of advanced engineering principles to the ability to perform independent research, problem definition and problem solving. The goal of this program is to produce engineering professionals who are leaders in their fields of stated and demonstrated expertise.

The program leading to the degree of Doctor of Engineering is formally affiliated with the department where activities are most closely related to an applicant's advanced study goals. However, the range of inquiry may (and is encouraged to) cross traditional departmental and school lines such that research and practical experience opportunities are extremely broad, and, that highly individualized programs can be pursued.

Objective

The Doctor of Engineering program is designed to provide advanced engineering education and experience that is professionally oriented and which will afford graduate degree engineers the opportunity to develop into strong engineering professionals, applied researchers, managers of technology, technologically trained educators, and technological advocates. The Doctor of Engineering program is characterized, in large part, by the special nature of the dissertation. As part of the dissertation development process, the student may be required to work with industry, a governmental agency, or a consulting engineering firm to develop a dissertation topic that is tailored individually to the student. The planning of content for this experience is done in conjunction with the faculty and corporate (government) advisor(s). All parties (student, faculty advisor, corporate advisor) will work together to meet the needs of the student, the academic and professional standards of the university, and the competitive posture of the involved corporation (government agency) respectively.

Admission

Admission to the doctoral program will be considered for those persons who, in addition to meeting admission requirements of the School of Graduate Studies, also possess the following qualifications:

- Preference for admission to the Doctor of Engineering program is given to those persons who hold a Master's Degree from an accredited graduate engineering degree program. Applicants holding master's degrees in computer science, physics, and other science and mathematics-related fields and who are currently pursuing careers closely aligned with engineering will be considered for admission to the Doctoral Program on a case by case basis.

- Exceptional students, upon the recommendation of a faculty committee, who are graduates with a Baccalaureate Degree from ABET accredited Engineering programs, may apply and be considered for admission to the Doctoral Program. Students, with Baccalaureate Degrees, who have completed 18 credit hours of Master's Degree work with a Grade Point Average (GPA) of 3.5 or greater, may apply to the Doctoral program.

General Requirements

- All candidates for the Doctor of Engineering degree must complete the required program of coursework, seminars, and research described in this catalog.
- All candidates must pass an Admission to Candidacy examination. In addition, when required by the student's Advisory/Doctoral committee, the student must take and pass a Preliminary examination.
- All candidates must submit a doctoral dissertation. When the dissertation has been completed to the satisfaction of the committee chairperson, a dissertation defense will be scheduled at which time the student must orally defend his or her work before the entire Doctoral Advisory Committee.
- All requirements for the doctoral degree in Engineering must be completed within a period of seven consecutive years from the date of admission.
- All candidates are expected to participate in experiences in academia, industry or a government agency, as required by the candidate's Advisory or Doctoral Committee.
- All candidates must satisfy residency requirements.

Residency Requirements

All candidates must satisfy 18 credit hours of residency requirements in one of the following ways:

- Full-time candidates for the Doctor of Engineering degree must satisfy residency requirements by enrolling in nine (9) credit hours per semester, for two (2) consecutive semesters.
- Part-time candidates for the Doctor of Engineering degree must satisfy residency requirements by enrolling in six (6) credit hours per semester, for three (3) consecutive semesters.
- Upon completion of course requirements and all required examinations, the candidate must continue to register for "Dissertation Guidance" each semester until the dissertation is successfully completed.

Program of Study

The program of study for a doctoral student is prescribed on an individual basis. The student's undergraduate degree concentration, master's degree concentration, professional engineering related experience, and future goals are taken into consideration in creating a program of study.

The program of study is directed toward building doctoral level capability in an interdisciplinary, but comprehensive body of knowledge. For example, the following civil engineering-related sub-disciplines are available: applied mechanics, environmental engineering, geo-mechanics, geotechnical engineering, groundwater hydrology, hydrology, infrastructure planning and engineering, structural engineering, structural mechanics, and transportation engineering.

Notice of Intention

Students who have completed at least 12 semester hours, and have attained a cumulative grade point average of at least 3.2, may file notice with the appropriate engineering department of intention to become a candidate for the Doctor of Engineering (D.Eng.). If a student, already enrolled for the Master's degree, wishes to file notice to become a candidate for the D.Eng., the student must re-apply. The notice of intention must include a plan of study with a major and a minor specialty identified and approved by the Preliminary Advisory Committee.

Two Options are Available within the Doctoral Program

Option 1: M.S./M.E. to D.Eng.

The minimum requirement for a Doctoral Degree is 30 credit hours beyond a Master's Degree. The course credit hours must be at the 500-600 level and above, of which a minimum of 21 credits are at the 600 level and above. The 30 graduate credits include those credits students take following their matriculation as a Doctor of Engineering student, at Morgan State University. This does not include credit for the dissertation. This requirement may, however, be increased at the discretion of the student's Advisory Committee. Dissertation Research credit is determined by the student's major professor and Doctoral Advisory Committee (a minimum of 12 credit hours is required). Up to 12 graduate credit hours from a regionally accredited institution at the 500-600 equivalent level or higher may be transferred with approval by the major professor.

Option 2: B.S. to D.Eng.

The minimum requirement for the Doctoral Degree is 60 credit hours beyond a Bachelor's Degree. This does not include credit for the dissertation. This requirement may, however, be increased at the discretion of the student's advisory committee. Of the 60 credits, a maximum of 33 credits can be at the 500 level; and the remaining (excluding Seminar and Project Report courses) must be at the 600 level and above. Up to 12 graduate credits from a regionally accredited institution, with ABET accredited programs, at the 500-600 equivalent level or higher, may be transferred with approval. The Dissertation Research credit requirement is determined by the student's major professor and Advisory committee. A minimum of 12 Dissertation credit hours is required.

Under Option 2, the candidate will have the option of terminating at the Master's Degree provided the candidate has completed the requirements for the Master of Engineering program.

Plan of Study

The contents of an approved plan of study will be determined by the student and his or her Advisory Committee. The committee will consider the student's interests and suggestions in arriving at an approved preliminary plan and subsequent revisions as may be required. Normally, the student will take all of the courses offered in, at least, the sequence of specialized graduate work embracing the major specialty of interest in which he or she proposes to conduct research.

Minor Specialty

The minimal number of degree credit hours is designed to ensure depth in the candidate's field of concentration. To achieve breadth across relevant fields of study, individuals are encouraged to exceed the minimum by taking a sequence of coordinated cross-disciplinary courses from within the School of Engineering or from other schools on campus (i.e. Schools of Business, Science, Liberal Arts, or Education).

Examinations

The Doctoral student is required to take two (2) examinations: (A) the Admission to Candidacy examination; and, (B) the Dissertation Defense examination. In addition, when required by the student's Doctoral Advisory Committee, a Preliminary Examination must be passed. At the discretion of the Advisory Committee, the Admission to Candidacy examination can be written, oral, or both written and oral. The Dissertation Defense is oral. The examinations are to be taken in the following manner:

Admission to Candidacy: (A) Examination

An admission to candidacy examination will be conducted to judge the candidate's comprehension of graduate course work and the candidate's ability to propose, to present and to defend the results of independent research. At the time of this examination, the student must make a presentation of his/her proposed research, which presents the underlying engineering technologies and outlines the plan of research. This examination is to be conducted by the full Doctoral Advisory Committee. Should the student fail this Candidacy Examination, the Doctoral Advisory Committee determines the conditions to be met before a second examination is to be administered. A third examination is prohibited.

Dissertation Defense (B) Examination:

All doctoral candidates are to conduct a major research project, the result of which culminates in a dissertation. This dissertation must be a well-reasoned application of advanced knowledge of technology and must show evidence of scholarly attainment in the student's major specialty. The Doctoral Advisory Committee will conduct the dissertation defense examination. This examination will determine the candidate's ability to apply advanced engineering disciplines to problems of substance in a creative and scholarly manner. Prior to the time of the (B) examination, if the Doctoral Advisory Committee deems it a requirement, the student must have submitted a paper of his/her research to a conference or professional journal. Any deficiencies that may have been uncovered in previous examinations must have been rectified before a candidate can be permitted to take his dissertation examination.

Other Miscellaneous Considerations

If a Doctoral candidate goes to industry or government while completing his/her research, an Understanding of Agreement must be drawn up between the company, advisor, and advisee. This agreement outlines the goals and expectations concerning the overview and completion of the research dissertation before the advisee leaves. All work will continue to be conducted under the guidance and approval of the Major Advisor in absentia.

DOCTOR OF PHILOSOPHY – TRANSPORTATION AND URBAN INFRASTRUCTURE SYSTEMS (Ph.D.)

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Objectives

The Ph.D. program in Transportation and Urban Infrastructure Systems targets highly motivated students who have already obtained the master's degree and desire to pursue career paths in transportation and infrastructure related education, consulting, research, or administration.

Expected Student Learning Outcomes

Upon completion of the program, students will have gained a broad technical and interdisciplinary background that will have enhanced their skills in identifying and tackling critical transportation and urban infrastructure problems. Specifically, upon completing the doctoral program, students will be expected to:

- Examine and explain the historical and political contexts of landmark transportation policy-decisions, and contemporary local and global transportation and urban infrastructure issues and priorities;
- Apply mathematics, systems theory, principles of engineering, planning, and/or management in solving complex problems;
- Design independently and execute high-level research; and
- Communicate effectively and function on a multi-disciplinary team, particularly in scholarly settings.

Admission Requirements

The Ph.D. program in Transportation and Urban Infrastructure Systems seeks exceptional students having at least a 3.0 cumulative GPA (on a scale of 4.0) for all graduate work completed and a commitment for innovation and leadership. Other requirements include a resume or curriculum vita documenting current and previous professional activities, and planned career goals; GRE scores; and three letters of recommendation from professors or supervisors familiar with the applicant's academic/professional background. All application materials must be sent directly to the School of Graduate Studies for preliminary screening. Acceptance into the School of Graduate Studies is a prerequisite for admission into the Ph.D. program in Transportation and Urban Infrastructure Systems.

General Requirements

Students enrolled in the Ph.D. program will be required to satisfy the following requirements:

- Form a doctoral advisory committee comprising at least four tenured or tenure-track faculty members, no later than the second year of enrollment, that will approve the student's program of study and guide the student's research activities;
- Complete a minimum of 48 graduate-credit hours (including 12 hours of dissertation related research and seminars) of study beyond the master's degree;
- Fulfill the minimum residency requirement by taking at least 9 credits of coursework in two consecutive semesters or 6 credits of coursework in three consecutive semesters at Morgan State University;

- Pass the doctoral candidacy examinations, administered by the dissertation committee, on the core subjects, declared concentration, and two minor areas pertinent to transportation and urban infrastructure;
- Develop and defend a dissertation proposal; and
- Complete and successfully defend a dissertation based on timely and original research in a relevant area of transportation and/or urban infrastructure.

In order to maintain a good academic standing and remain in the program, the student may not have grades lower than B on any of the required core courses or more than 20 percent of the required minimum coursework.

Program of Study

The Department of Transportation and Urban Infrastructure Studies at Morgan State University has one of the largest inventories of transportation related courses in the country. There are currently 35 graduate transportation and infrastructure analysis, planning, and management courses offered in the Department. Thus, prospective Ph.D. students, including those that graduated from the Department's M.S. degree program in Transportation, will have the flexibility in selecting from a large pool of courses (including related courses from other departments) and build a program tailored to their specific interests.

The required minimum coursework for the Ph.D. in Transportation and Urban Infrastructure Systems is 48 graduate-credits beyond the master's degree. Up to four eligible courses (not exceeding 12 credits) taken from other accredited institutions may be accepted for transfer toward the Ph.D. program, provided the courses have not been used to satisfy the requirements for another program. Students in the Ph.D. program will be required to take 8 core courses totaling 24 credits; a minimum of four elective courses totaling 12 credits from their chosen area of concentration; and a minimum of 12 credits of dissertation-related research, including Directed Dissertation Research (TRSP 996), Doctoral Research Seminars (TRSP 988 and TRSP 989), and Dissertation Seminar (TRSP 998) courses. The required core courses are listed below. Students may consider substitute courses not included in the list upon securing the approval of their dissertation committee or program chair.

Required Core Courses

Course No.	**Course Title**	**Credits**
TRSP625	Transportation Policy	3
TRSP 701*	General Systems Theory	3
TRSP725	Advanced Policy Analysis	3
TRSP889	Contemporary Global Issues in Transportation and Urban Infrastructure	3
TRSP996	Directed Dissertation Research in Transportation and/or Urban Infrastructure	3
TRSP988	Doctoral Research Seminar I	1
TRSP989	Doctoral Research Seminar II	2
TRSP998	Dissertation Seminar	6

*****_IEGR 501 can be used as a substitute course._

MASTER OF ENGINEERING (M.Eng.)

Purpose
The primary purpose of the Master of Engineering Degree program is to prepare individuals for the practice of engineering. The program emphasizes the theory and application of advanced engineering principles utilizing the most advanced computational and analytical methods and tools. The goal of the program is to produce forward-looking engineering professionals who are capable of making significant contributions to society, while safeguarding the environment. Preference for admission to the Master of Engineering Degree program is given to those persons who hold a Baccalaureate Degree from an accredited undergraduate engineering degree program. Applicants who are graduates of computer science, mathematics, physics, and other science and mathematics related fields will be considered. The Master of Engineering Degree study program is intended for those persons who plan to practice engineering in industry, government, and academe or as entrepreneurial professionals. This degree program may also serve as the initial step towards the doctorate for those who are inclined to advance their knowledge of technological, managerial and engineering design and practice-based concepts. The program provides three distinct program options that allow the student to develop a program that suits his or her professional objectives.

Objectives
The interdisciplinary Master of Engineering Degree program is designed to:

- Support the student to be successful in his/her academic and professional objectives;
- Provide program options that can be adapted to fit student's goals and needs;
- Develop an appreciation of the importance of a closer relationship between engineering education and engineering practice;
- Develop an appreciation for engineering design and for the product/process realization contin-
- uum;
- Develop a consciousness for and commitment to the importance of life-long learning;
- Provide a complement to basic research-oriented graduate degree programs;

Develop a philosophy for the role of research, application, and the environment in the product/ process realization cycle;

- Provide an innovative path to the terminal degree; and
- Generate a cadre of well-trained engineering professionals.

Admission
Admission requirements to the M.E. degree program are commensurate with the admission requirements of the School of Graduate Studies. Exceptional students who possess a GPA of 3.5 or greater in their major area of study and 3.5 GPA or better overall may apply for unconditional admission into the program at the beginning of their senior year. Applicants holding degrees in computer science, mathematics, physics, and other science and mathematics-related fields and who are currently pursuing careers closely aligned with engineering will be considered for admission to the program. Applicants holding degrees in fields other than engineering, mathematics and science may be considered for admission to the program, given that they have the requisite mathematics and science foundation. An applicant who has deficiencies in foundation courses, as defined by an advisor or departmental committee, may be required to complete successfully a number of undergraduate courses with a goal of meeting minimum departmental requirements. Undergraduate courses, taken for this purpose, may not be used to fulfill any of the requirements for the master's degree. In addition, applicants must satisfy other requirements as specified by the School of Graduate Studies.

General Requirements
All candidates who seek to earn the Master of Engineering degree will be required to complete one of the three options identified below:

Program Option	*Core Courses*	*Seminars*	*Electives*	*Other*	*Total Credits*
Project Report	9 credits	2 credits	18 credits	Project Report I & II	33
Thesis	9 credits	2 credits	18 credits	Thesis	34
Course Only	9 credits	2 credits	24 credits	None	35

Each student will select one of the three options in collaboration with a faculty advisor. All departments may not offer all of these options. At the time of application, the School of Engineering will notify students of the available options.

Program of Study
A core requirement of three interdisciplinary courses (9 credit hours) will be required of all students entering at the master's level. These courses are carefully designed and coordinated to stress the interdisciplinary nature of the subject matter. The content serves as the philosophical foundation on which all other materials tailored for a specific student are based. The courses are as follows:

CEGR 514 Environmental Impact and Risk Assessment	3
EEGR 505 Advanced Engineering Mathematics with Computational Methods	3
IEGR 512 Advanced Project Management	3
Total Credit Hours	**9**

Elective credits are directed toward building strength in a sub-discipline. For example, the following civil engineering-related sub-disciplines are available: applied mechanics, environmental engineering, geo-mechanics, geotechnical engineering, groundwater hydrology, hydrology, infrastructure planning and engineering, structural engineering, structural mechanics, and transportation engineering**.** For Electrical Engineering there are sub-disciplines in the areas of electro-physics, communications and signal processing, and computer engineering.

BACHELOR OF SCIENCE TO MASTER OF ENGINEERING (B.S./M.Eng.)

Purpose

The purpose of the Bachelor of Science/Masters of Engineering (B.S./M.Eng.) degree program is to enable well qualified and highly motivated undergraduates students majoring in Engineering to obtain both a bachelor's and master's degree in a minimum of five years. The B.S./M.Eng. Program is applicable to the Bachelor of Science (B.S.) degrees in the three engineering disciplines (Civil, Electrical & Computer, and Industrial Manufacturing Information) and the Master of Engineering (M.Eng.) degree within the Clarence M. Mitchell, Jr. School of Engineering. The goal of the B.S./M.Eng. Program is to accelerate the production of engineering professionals who are capable of entering into the technology workforce and making significant contributions to society, while safeguarding the environment.

Admission Criteria

The B.S./M.Eng program allows students to begin graduate study (concurrent with undergraduate work) in the second semester of their junior year. Students are allowed to apply for admission into the program upon completion of 79 credits. For consideration of admission into the B.S./M.Eng. Program, a student must:

- Complete 85 credits (a minimum of 30 credits of general education requirements, a minimum of 20 credits of Science and Math requirements, and a minimum of 23 credits of Engineering requirements).
- Have a minimum grade point average (GPA) of 3.30.
- Submission of a completed application form,
- Three (3) written recommendations from MSU faculty, one of which must be from a MSU faculty member within prospective engineering department who would serve as the candidate's primary advisor, and
- A plan of study, signed by the anticipated primary advisor, outlining the tentative courses to be pursued in the program and the anticipated major sub-discipline (and minor emphasis, if any) in the program of study.

The application is submitted in the first instance to the graduate coordinator of the prospective engineering department. Applications determined to be eligible, following consideration by the appropriate committee of the (MSU) engineering faculty, shall be forwarded through the Office of the Associate Dean of the School of Engineering to the School of Graduate Studies.

General Requirements

All students who seek candidacy into the B.S./M.Eng. Program will be required to complete the B.S. degree requirements of their respective discipline, and a total of 33 acceptable credit hours of graduate coursework inclusive of 2 credit hours of seminar and 4 credit hours of Project Report. Successful completion and oral defense of the Report Project is required in lieu of taking a comprehensive examination.

Program of Study

A core requirement of three interdisciplinary courses (9 credit hours) will be required of all students entering at the B.S./M.Eng program. These courses are carefully designed and coordinated to stress the interdisciplinary nature of the subject matter. The content serves as the philosophical foundation on which all other materials tailored for a specific student are based. The courses are as follows:

CEGR 514: Environmental Impact and Risk Assessment 3 Credits
EEGR 505: Advanced Engineering Mathematics with Computational Methods 3 Credits

IEGR 512: Advanced Project Management 3 Credits

Total Credit Hours 9

Students accepted for candidacy into the B.S./M.Eng. Program will begin taking these courses in the second semester of their junior year.

Eighteen credits (excluding the 2 credits of seminars and 4 credits of project reports) are directed toward building an interdisciplinary strength in a sub-discipline. Candidates will complete these courses during the fifth year.

Maintaining Eligibility

Candidates in the B.S./M.Eng. Program are expected to maintain a high level of scholastic achievement. The above constitutes the minimum requirements for consideration for admission into the program. Admitted students must maintain a minimum GPA of 3.00 to remain in good standing as required by the School of Graduate Studies. Candidates who fall below the minimum cumulative grade point average of 3.0 for two consecutive semesters will be removed from the program.

A student may decide to opt out of the B.S./M.Eng. Program; however, they must complete all requirements for the traditional B.S. degree program. The B.S./M.Eng. Program curriculum is designed such that candidates who successfully complete their coursework through the end of the senior year will automatically qualify them for completion of the B.S. degree requirements. Graduate courses successfully completed up to this time, may be applied to the traditional graduate program. Once a candidate has opted out of the program, the candidate is no longer eligible for the B.S./M.Eng. Program degree. In order to receive a Master's Degree at Morgan State University, the student will then have to apply to the traditional two year M.Eng. Program. Candidates who are removed from the program or otherwise opt out of the program are eligible to receive the traditional bachelor's degree in their respective engineering discipline major, on completion of the requirements for the BS degree.

Degrees Received

Upon completion of minimum requirements, students receive both the Bachelor of Science and the Master of

Engineering degrees. The Bachelors of Science degree will be awarded from the respective departments, that is,

B.S.E.E. from the Electrical & Computer Engineering department, the B.S.I.E. from the Industrial Manufacturing Information department, and the B.S.C.E. from the Civil Engineering department. The M.Eng. Degree will be awarded from the School of Graduate Studies. A student may elect to receive only a B.S. degree, but must complete the requirements for the traditional B.S. degree program.

MASTER OF SCIENCE – ELECTRICAL ENGINEERING (M.S.)

Purpose
The primary purpose of the Master of Science in electrical engineering degree program is to prepare individuals for the practice of electrical engineering. The program emphasizes the theory and application of advanced electrical engineering principles utilizing theoretical, computational and analytical methods and tools. The goal of the program is to produce forward-looking engineering professionals who are capable of making significant contributions to society.

Objectives
The M.S. in electrical engineering degree program is designed to:

- Support the student to be successful in his/her academic and professional objectives;
- Develop an appreciation for research, application, engineering design and the product/process realization continuum;
- Develop a consciousness for and commitment to the importance of life-long learning; and
- Generate a cadre of well-trained engineering professionals.

Admission
Admission requirements to the M.S.E.E. degree program are commensurate with the admission requirements of the School of Graduate Studies. Applicants should hold a Bachelors of Science in electrical engineering from an Accreditation Board for Engineering and Technology (ABET) accredited institution. Applicants holding degrees in computer science, mathematics, physics, and other science and mathematics-related fields and who are currently pursuing careers closely aligned with engineering will be considered for admission to the program. An applicant who has deficiencies in foundation courses, as defined by an advisor or departmental committee, may be required to complete successfully a number of undergraduate courses with a goal of meeting minimum departmental requirements. Undergraduate courses, taken for this purpose, may not be used to fulfill any of the requirements for the master's degree. In addition, applicants must satisfy other requirements as specified by the School of Graduate Studies.

General Requirements
The Master of Science in electrical engineering will provide two degree options in one of four areas of concentration; RADAR, signals intelligence, power and energy and communications. Both options require nine core EEGR courses related to the area of concentration and a minimum of 18 electrical engineering courses taken towards the degree. The course only option requires 33 course credits, including a scholarly project, and the thesis option requires 24 credits and two thesis courses (29 credits). Departmental permission required to substitute electives.

Program of Study
Below are the courses by area of concentration.

RADAR Concentration
<u>Core Courses</u>
EEGR 532: Microwave Transmission
EEGR 624: Detection and Estimation Theory
EEGR 635: Advanced Electromagnetic Theory

<u>Electives Courses</u>
EEGR 507: Applied Probability and Statistical Analysis

EEGR 508: Advanced Linear Systems
EEGR 524: Introduction to RADAR
EEGR 535: Active Microwave Circuit Design
EEGR 536: Antenna Theory and Design
EEGR 542: Microwave Power Devices
EEGR 543: Introduction to Microwaves
EEGR 637: Advanced Antenna Theory
EEGR 503: Communications Theory
EEGR 607: Information Theory
EEGR 610: Wireless Communications
EEGR 551: Digital Signal Processing
EEGR 622: Adaptive Signal Processing
EEGR 623: Pattern Recognition

Signals Intelligence Concentration
Core Courses
EEGR 507: Applied Probability and Statistical Analysis
EEGR 508: Advanced Linear Systems
EEGR 607: Information Theory

Electives Courses
EEGR 503: Communications Theory
EEGR 543: Introduction to Microwaves
EEGR580: Introduction to Cyber Security
EEGR581: Introduction to Network Security
EEGR582: Introduction to Communications Security
EEGR583: Introduction to Security Management
EEGR 520: Digital Image Processing
EEGR 522: Digital Signal & Speech Processing
EEGR 551: Digital Signal Processing
EEGR 620: Digital Image Processing
EEGR 622: Adaptive Signal Processing
EEGR 623: Pattern Recognition
EEGR 624: Detection and Estimation Theory
EEGR 626: Optimization/Numerical Methods
EEGR 679: Cryptography and Information Security
EEGR 722: Advanced Topics in Image Processing

Power and Energy Concentration
Core Courses
EEGR550: Fundamentals of Energy and Power Systems
EEGR555: Advanced Power Electronics
EEGR554: Renewable Energy Systems

Elective Courses
EEGR 542: Microwave Power Devices
EEGR553: Electric Drives and Machines
EEGR556: Modeling and Control Techniques in Power Electronics
EEGR557: Smart Grid and Building Energy Efficiency

EEGR 635: Advanced Electromagnetic Theory
IEGR512: Advanced Project Management
IEGR572 : Design & Analysis of Energy Systems
IEGR573: Applied Thermodynamics & combustion
IEGR571: Advanced Internal Combustion Engine
CEGR514: Environmental Engineering

Communications Concentration

Core Courses
EEGR 507: Applied Probability and Statistical Analysis
EEGR 508: Advanced Linear Systems
EEGR 607: Information Theory

Electives Courses
EEGR 503: Communications Theory
EEGR 510: Communications Networks
EEGR 605: Digital Communications
EEGR 607: Information Theory
EEGR 608: Error Control Coding
EEGR 610: Wireless Communications
EEGR 543: Introduction to Microwaves
EEGR 536: Antenna Theory and Design
EEGR 551: Digital Signal Processing
EEGR 612: Multi User Communications
EEGR 614: Queueing Networks
EEGR 615: High Speed Networks
EEGR 625: Optical Communication
EEGR 680: Switching Theory: High Speed Networks
EEGR 715: Advanced Topics in Communications

BACHELOR OF SCIENCE TO MASTER OF SCIENCE ELECTRICAL ENGINEERING (B.S./M.S.)

The purpose of the Bachelor of Science/Masters of Science (B.S./M.S.) degree program is to enable well qualified and highly motivated undergraduates students majoring in Electrical Engineering to obtain both a bachelor's and master's degree in a minimum of five years. The B.S./M.S. program is applicable to the Bachelor of Science (B.S.) degree and the Master of Science (M.S.) degree in Electrical Engineering within the Clarence M. Mitchell, Jr. School of Engineering. The goal of the B.S./M.S. program is to accelerate the production of electrical engineering professionals who are capable of entering into the technology workforce and making significant contributions to society, while safeguarding the environment.

Admission Criteria

The B.S./M.S. program allows students to begin graduate study (concurrent with undergraduate work) in the second semester of their junior year. Students are allowed to apply for admission into the program upon completion of 79 credits. For consideration of admission into the B.S./M.S. program, a student must:

- Complete 85 credits (a minimum of 30 credits of general education requirements, a minimum of 20 credits of Science and Math requirements, and a minimum of 23 credits of electrical engineering requirements).
- Have a minimum grade point average (GPA) of 3.30.
- Submit a completed application form,
- Submit three (3) written recommendations from MSU faculty, one of which must be from an MSU faculty member within the Department of Electrical and Computer Engineering who would serve as the candidate's primary advisor, and
- Submit a plan of study, signed by the anticipated primary advisor, outlining the tentative courses to be pursued in the program and the anticipated concentration in the program of study.

The application is submitted in the first instance to the graduate coordinator in the Department of Electrical and Computer Engineering. Applications determined to be eligible, following review by a committee of electrical engineering faculty, shall be forwarded to the School of Graduate Studies.

General Requirements

All students who seek candidacy into the B.S./M.S. program will be required to complete the B.S. degree requirements and the M.S. degree requirements for electrical engineering. Up to six credits of graduate coursework may count towards the undergraduate degree. For the M.S., the thesis option requires 24 credits and two thesis courses (29 credits).

Program of Study

The Master of Science in electrical engineering will provide an M.S. degree in one of four areas of concentration; RADAR, signals intelligence, power and energy and communications. The degree requires nine core EEGR courses related to the area of concentration and a minimum of 18 electives taken towards the degree. Students must complete a thesis, which requires 24 course credits and two thesis courses (29 credits). Successful completion and oral defense of the Thesis is required. Students accepted for candidacy into the B.S./M.S. program may begin taking graduate courses in their junior year. Candidates will complete these courses during the fifth year. Below are the courses by area of concentration.

RADAR Concentration

Core Courses

EEGR 532: Microwave Transmission
EEGR 624: Detection and Estimation Theory
EEGR 635: Advanced Electromagnetic Theory

Electives Courses

EEGR 507: Applied Probability and Statistical Analysis
EEGR 508: Advanced Linear Systems
EEGR 524: Introduction to RADAR
EEGR 535: Active Microwave Circuit Design
EEGR 536: Antenna Theory and Design
EEGR 542: Microwave Power Devices
EEGR 543: Introduction to Microwaves
EEGR 637: Advanced Antenna Theory
EEGR 503: Communications Theory
EEGR 607: Information Theory
EEGR 610: Wireless Communications
EEGR 551: Digital Signal Processing
EEGR 622: Adaptive Signal Processing
EEGR 623: Pattern Recognition

Signals Intelligence Concentration

Core Courses

EEGR 507: Applied Probability and Statistical Analysis
EEGR 508: Advanced Linear Systems
EEGR 607: Information Theory

Electives Courses

EEGR 503: Communications Theory
EEGR 543: Introduction to Microwaves
EEGR580: Introduction to Cyber Security
EEGR581: Introduction to Network Security
EEGR582: Introduction to Communications Security
EEGR583: Introduction to Security Management
EEGR 520: Digital Image Processing
EEGR 522: Digital Signal & Speech Processing
EEGR 551: Digital Signal Processing
EEGR 620: Digital Image Processing
EEGR 622: Adaptive Signal Processing
EEGR 623: Pattern Recognition
EEGR 624: Detection and Estimation Theory
EEGR 626: Optimization/Numerical Methods
EEGR 679: Cryptography and Information Security
EEGR 722: Advanced Topics in Image Processing

Power and Energy Concentration

Core Courses

EEGR550: Fundamentals of Energy and Power Systems
EEGR555: Advanced Power Electronics
EEGR554: Renewable Energy Systems

Elective Courses

EEGR 542: Microwave Power Devices
EEGR553: Electric Drives and Machines
EEGR556: Modeling and Control Techniques in Power Electronics
EEGR557: Smart Grid and Building Energy Efficiency
EEGR 635: Advanced Electromagnetic Theory
IEGR512: Advanced Project Management
IEGR572: Design & Analysis of Energy Systems
IEGR573: Applied Thermodynamics & combustion
IEGR571: Advanced Internal Combustion Engine
CEGR514: Environmental Engineering

Communications Concentration

Core Courses

EEGR 507: Applied Probability and Statistical Analysis
EEGR 508: Advanced Linear Systems
EEGR 607: Information Theory

Electives Courses

EEGR 503: Communications Theory
EEGR 510: Communications Networks
EEGR 605: Digital Communications
EEGR 607: Information Theory
EEGR 608: Error Control Coding
EEGR 610: Wireless Communications
EEGR 543: Introduction to Microwaves
EEGR 536: Antenna Theory and Design
EEGR 551: Digital Signal Processing
EEGR 612: Multi User Communications
EEGR 614: Queueing Networks
EEGR 615: High Speed Networks
EEGR 625: Optical Communication
EEGR 680: Switching Theory: High Speed Networks
EEGR 715: Advanced Topics in Communications

Maintaining Eligibility

Candidates in the B.S./M.S. Program are expected to maintain a high level of scholastic achievement. Admitted students must maintain a minimum GPA of 3.0 to remain in good standing as required by the School of Graduate Studies. Candidates who fall below the minimum cumulative grade point average of 3.0 for two consecutive semesters will be removed from the program.

A student may decide to opt out of the B.S./M.S. program; however, they must complete all requirements for the traditional B.S. degree program. The B.S./M.S. program curriculum is designed such that candidates who successfully complete their coursework through the end of the senior year will automatically qualify them for completion of the B.S. degree requirements. Graduate courses successfully completed up to this time, may be applied to the traditional graduate program. Once a candidate has opted out of the program, the candidate is no longer eligible for the B.S./M.S. program degree. In order to receive a Master's degree at Morgan State University, the student will then have to apply to a traditional two year program. Candidates who are removed from the program or otherwise opt out of the program are eligible to receive the traditional bachelor's degree in electrical engineering upon completion of the requirements for the BS degree.

Degrees Received

Upon completion of minimum requirements, students receive both the Bachelor of Science and the Master of Science degrees. The Bachelors of Science degree will be awarded from the Electrical & Computer Engineering department. The M.S. degree will be awarded from the School of Graduate Studies. A student may elect to receive only a B.S. degree, but must complete the requirements for the traditional B.S. degree program.

MASTER OF SCIENCE – TRANSPORTATION (M.S.)

Objective

The Master of Science in Transportation degree program provides an interdisciplinary curriculum in transportation that prepares students to assume professional positions in transportation engineering, planning, management, and analysis. Students can concentrate their studies on traffic operations engineering, transportation planning, transportation management, or freight transportation and logistics. With the approval of the transportation faculty, students may use appropriate courses in other disciplines to supplement the requirements of their program of study.

Expected Student Outcomes

Upon completion of the program, the students are expected to:

1. Develop knowledge of local and global cross-cutting issues and challenges in transportation;
2. Apply principals of engineering, planning and management to solve complex transportation-related problems;
3. Understand the impact of solutions in a global and societal context;
4. Communicate effectively and function on multidisciplinary teams.

Admission Requirements

Prospective students for unconditional admission will have obtained a minimum GPA of 3.0 on a scale of 4.0 for all coursework completed. Students whose GPA falls between 2.5 and 3.0 may be considered for conditional admission. Additional requirements include one two page essay on the student career goals, three letters of recommendation from professors or supervisors. All application materials must be sent directly to the School of Graduate Studies for preliminary review. Acceptance into the School of Graduate Studies is a prerequisite for admission into the M.S. degree program in transportation.

General Requirements

Candidates must select a thesis or non-thesis option.

All candidates for the degree who select the thesis option must complete thirty-six (36) credit hours (including TRSP 799, Thesis Seminar) and submit an acceptable thesis.

Candidates selecting the non-thesis option must complete forty-two (42) credit hours and pass a written comprehensive examination. All students must complete the core requirements as indicated below.

Program of Study

• **Core Program** (Required of all students)		Credits
TRSP 601	Introduction to Transportation Systems	3
TRSP 602	Economics of Transportation	3
TRSP 603	Quantitative Methods in Transportation	3
TRSP 620	Transportation Systems Evaluation	3
TRSP 788/789	Supervised Research	3
TRSP 799	Thesis Seminar (Thesis option only)	3

***Repeatable for only 6 credits toward degree**

*Electives

(Thesis Students must select six credit hours and non-thesis students must select 12 credit hours)
Electives may be selected from all other I Transportation and Urban Infrastructure Studies courses (see Course descriptions following this section of the catalog), plus courses from other departments such as

City and Regional Planning, Civil Engineering, Industrial Engineering, and the Earl G. Graves School of Business and Management. The Department encourages students to take courses from other departments that complement the degree program. However, for any course taken outside of the Department, it is necessary to gain approval from the student's advisor to use a course for credit toward the degree.

CLARENCE M. MITCHELL, JR. SCHOOL OF ENGINEERING

COURSE DESCRIPTIONS

CIVIL ENGINEERING

Chairperson of Department: PROFESSOR REGINALD L. AMORY; Samuel P. Massie Chair of Excellence in the Environmental Disciplines: Professor JIANG LI; Associate Professors: IHEANYI ERONINI, MONIQUE HEAD, GBEKELOLUWA B. OGUNTIMEIN, Assistant Professors: INDRANIL GOSWAMI, JAMES HUNTER Lecturer: CHARLES O. OLUOKUN, OLLIDARE OWOLABI

CEGR 510: Principles of Environmental Engineering I
Three Hours: 3 Credits
The course covers basic concepts in environmental engineering design including environmental engineering hydrology, hydraulics, and pneumatics; water treatment; and conventional wastewater treatment. Prerequisite: Graduate standing.

CEGR 511: Principles of Environmental Engineering II
Three Hours: 3 Credits
A continuation of CEGR.510 and covers advanced wastewater treatment, solid waste management, and air pollution control. Prerequisite: CEGR.510.

CEGR 512: Principles of Environmental Engineering III
Three Hours: 3 Credits
The course covers basic concepts in environmental engineering design not covered in CEGR 510 and CEGR 511 and includes hazardous waste management and risk assessment, noise pollution and control, and environmental quality modeling (water, ground, and air). Prerequisite: Graduate standing.

CEGR 513: Environmental Chemistry and Microbiology
Three Hours: 3 Credits
Chemical laboratory work includes analyses of turgidity, color, pH, acidity, alkalinity, and hardness, etc.; and instrumental methods using high pressure liquid chromatography, gas chromatography, and atomic absorption, etc. The microbiological analyses include uses and functions of the microscope, multiple-tube and membrane filter techniques. The laboratory analyses are covered independently from the lecture. The lecture covers combustion chemistry, chemistry of the anaerobic process, and atmospheric chemistry. Prerequisite: Graduate standing.

CEGR 514: Environmental Impact and Risk Assessment
Three Hours: 3 Credits
The course covers strategies and methodologies that have been used to assess the impact of engineering projects. These include technology to assess the impact on air, surface water, and ground water quality, and on land use of transportation facilities, water supply and pollution control facilities, and industrial and community development. Prerequisite: Graduate standing.

CEGR 531: Reliability Analysis for Infrastructure and Environmental Systems
Three Hours: 3 Credits
Systems reliability and reliability analysis. Includes measures of reliability, reliability index, correlation coefficient, influence, reliability bounds, Point Estimate Method, Monte Carlo Simulation and others.

CEGR 533: Matrix Structural Analysis
Three Hours: 3 Credits
Review of statically determinate and indeterminate structures. Degrees of freedom of a structure. Force-Displacement relations for axial load, shear force and bending moment. Euler-Bernoulli beam element. Analytical basis for Force and Displacement Methods of Structural Analysis. Introduction to the Stiffness Method for structural systems. Application of Stiffness Method for trusses, beams and frames. Stepwise development of a computer program to compute nodal displacements and member forces.

CEGR 613: Physical-Chemical Treatment of Waste and Wastewater I
Three Hours: 3 Credits
This course uses object-oriented programming in conjunction with Visual C++ and MFC (Microsoft Foundation Classes) to solve problems in the physical-chemical treatment of water and wastewater. Coverage includes C++, Visual C++, objects, classes, object-oriented programming and advanced topics in unit operations of the physical-chemical treatment of water and waste water including flow measurements and flow and quality equalization; pumping; screening, settling, and flotation; mixing and flocculation; filtration and aeration, absorption, and stripping. Prerequisite: CEGR 512.

CEGR 614: Physical-Chemical Treatment of Waste and Wastewater II
Three Hours: 3 Credits
This course covers areas of the physical-chemical treatment of water and wastewater not covered in CEGR 613 and includes the unit operations of carbon absorption and membrane processes and the unit processes of water softening and removal of nitrogen and phosphorous, fluoridation and defluoridation, iron exchange, and disinfection. As in CEGR 613, this course uses object-oriented programming in conjunction with Visual C++ and MFC (Microsoft Foundation Classes) to solve problems in the physical-chemical treatment of water and wastewater. Prerequisite: CEGR 613.

CEGR 615: Open Channel Hydraulics
Three Hours: 3 Credits
This course covers basic principles and energy and momentum equations, uniform flow, gradually varied flow, and spatially and rapidly varied flow. In addition, this course emphasizes computer programming; hence, elements of C++ will be discussed. These include objects, classes, class libraries and object-oriented programming. A software project will be required for submission at the end of the course.

CEGR 616: Biochemical Processes in Environmental Engineering
Three Hours: 3 Credits
This course covers the basic fundamental principles of microbiological processes in environmental engineering systems. Basic concepts in microbiology, qualitative tools for describing stoichiometry and energetics of microbial reactions; qualitative tools for microbial and enzymatic kinetics and the principle of mass balance in the analysis of biological reactors are presented.

CEGR 617: Advanced Biochemical Processes in Environmental Engineering
Three Hours: 3 Credits
This is an advanced course in biochemical process engineering application in environmental quality control. It covers in depth application of the principles of microbiological system in the treatment of water, wastewater and biodegradation of hazardous chemicals in the environment.

CEGR 619: Modeling of Groundwater Flow
Three Hours: 3 Credits
Numerical solutions of the ground water flow equations (Partial Deferential Equations). Emphasis on learning methodology and the use of groundwater flow models such as MODELOW, FLOW PATH AND SEETRAN. Prerequisites: Hydrodynamics of Groundwater, FORTRAN Programming and Partial Differential Equations (PD).

CEGR 620: Modeling of Groundwater Pollutant Transport
Three Hours: 3 Credits
Numerical and analytical solutions of the advectiondispersion equation. Emphasis on learning methodology and the use of groundwater models in contaminant and transport such as MT3D, RT3D and MODELOW. Prerequisites: Hydrodynamics of Groundwater, FORTRAN Programming and Math (PD) applications.

CEGR 623: Hydrodynamics
Three Hours: 3 Credits
This course covers fundamental concepts of dynamics of surface water flow, analysis and characteristics of flow in open channels, flow and channel design with consideration of various types of flow, methods and application of flow measuring devices, and problem solving. Prerequisites: Groundwater Hydrology, Fluid Mechanics and Math (PD).

CEGR 624: Hydrostatistics
Three Hours: 3 Credits
Introduction to hydrostatistical data estimation using the concepts of variograms, multivariate techniques, correlation analysis, and linear multiple linear regression. Introduction to some stochastic hydrologic models.
Prerequisites: Hydrology and Math (probability and stastics)

CEGR 625: Modeling of Surface Water
Three Hours: 3 Credits
This course emphasizes fundamental concepts and theory and methods of modeling surface water flow, establishment of conceptual, physical, mechanical, mathematical models and applications of analytical and numerical solutions to solving engineering problems related to environmental issues. Prerequisites: Advanced Hydrology, FORTRAN programming and Math (ODE and PD).

CEGR 626: Surface Water Hydrology
Three Hours: 3 Credits
This course emphasizes fundamental concepts of surface water hydrology and physical processes in surface and shallow subsurface water. Through exercises and problem sets, the course introduces students to practical techniques utilized in applied surface water hydrology. Prerequisites: Fluid Mechanics and Math (PD and ODE).

CEGR 627: Introduction to Multiphase Flow
Three Hours: 3 Credits
This course emphasizes fundamental concepts of theory of multiphase flow including physical processes within multiphase flow, conservation of mass, energy and momentum, constitutive relations of multiphase flow and analytical solutions for problems related to multiphase flow through porous media.
Prerequisites: Continuum Mechanics, Advanced Groundwater Hydrology and Math (PD)

CEGR 628: Bridge Engineering
Three Hours: 3 Credits
Historical development of the modern highway bridge; materials; loads and the load path; reinforced concrete bridges; slab, T-Beam and box girders; slab-steel beam bridges, non-composite vs. composite sections; design of continuous steel beam bridges; plate girder bridges; pre-stressed concrete bridges; serviceability; inspection, maintenance and rehabilitation of highway bridges; bridge aesthetics. Prereq-uisite: CEGR 436 Elementary Structural Design or equivalent.

CEGR 630: Finite Element Analysis
Three Hours: 3 Credits
Approximation techniques; Introduction to the Finite Element Method; weighing functions; Galerkin formulation; 1-d and 2-d finite elements; coordinate systems; field problems-irrotational flow, heat transfer; structural and solid mechanics, axial force member, theory of elasticity; linear and quadratic elements, element shape functions; isoparametric elements; Software platform ANSYS 5.3. Prerequisite: Matrix Structural Analysis or consent of instructor.

CEGR 631: Structural Dynamics
Three Hours: 3 Credits
Free and forced vibrations of damped and undamped, single-degree-of-freedom and multidegree-of-freedom systems. Langrange's equations; transient and steady-state vibrations; eigenvalue analysis for natural frequencies and normal modes; analysis and stability of structural components (including beams, cables and large systems inshore, offshore, and in space). Time-domain vs. frequency domain analysis; classical approximate methods, Rayleigh method, Dunkerley's equation, RayleighRitz Method, Myklestad's Method for beams; introduction to random vibrations. Prerequisite: Matrix Methods in Structural Analysis (may be taken concurrently) or equivalent. Introduction to the Finite Element Method. Prerequisite: Matrix Structural Analysis or consent of instructor.

CEGR 635: Advanced Reinforced Concrete Design
Three Hours: 3 Credits
This course utilizes the mechanics of concrete and structural design principles to enable students to perform advanced design of reinforced concrete structures. It emphasizes the design for torsion, shear and shear friction, and teaches how to perform the design of two-way slabs, walls, reinforcement at joints, multistory columns and concrete building systems in accordance with the latest building code.

CEGR 636: Artificial Neural Networks I
Three Hours: 3 Credits
This course provides graduate students and engineering professionals with the fundamentals of Artificial Neural Networks. This course covers neural network architectures, algorithms, and applications. A wide variety of standard neural networks and training algorithms are covered in relationship to logic functions and other applications. Emphasis is on computational characteristics to illustrate similarities and differences among neural networks.

CEGR 638: Artificial Neural Networks II
Three Hours: 3 Credits
This is a computational course and applies object oriented methodology to programming artificial neural networks. Knowledge gained from this course will enable students to perform advanced application and research in Civil Engineering. Topics to be discussed include pattern class, link-list class, neural network

base classes, adaline network, back propagation neural network, self-organizing neural network, and bi-directional associative memory.

CEGR 651: Computer Aided Highway Engineering Design
Three Hours: 3 Credits
This course covers the operational, geometric and hydraulic design of highways to achieve safe and efficient vehicle operation under the conditions of uninterrupted flow.

CEGR 655: Traffic Engineering I
Three Hours: 3 Credits
The principles of traffic engineering involving the analysis, planning and design of loads, streets and highways, and their related networks. Coverage includes the dynamics of traffic flows, traffic studies, and data collection; capacity analysis of freeways and arteries; the analysis and design of traffic control systems, including signalized and unsignalized intersections.

CEGR 656: Transportation Models and Simulation Analysis I
Three Hours: 3 Credits
The theory, development, and application of modeling systems commonly used in planning, engineering and operational analysis of transportation systems. The application and calibration of an existing transportation modeling system.

CEGR 657: Advanced Topics in Traffic Engineering
Three Hours: 3 Credits
Theory, analysis and design of coordinated traffic signal systems, traffic information systems and traffic management emphasizing area wide optimization, intermodal coordination and incident management.

CEGR 661: Airport Planning and Engineering
Three Hours: 3 Credits
The planning and design of airports and their supportive infrastructural systems. The operational analysis of airports and the environmental considerations in their location, design, expansion, and operation.

CEGR 663: Readings in Environmental Engineering
Three Hours: 3 Credits
This course is required to prepare students in doctoral dissertation. Selected topics from the current literature will include water and waster, air pollution, solid waste, hazardous wastes, ground water hydrology, hydraulics, etc. Prerequisites: Approval of instructor.

CEGR 665: Random Vibrations and Nonlinear Dynamics
Three Hours: 3 Credits
Review of linear systems. Time Domain vs. Frequency Domain approaches. Introduction to Nonlinear Systems. Phase Plane representation. Existence and Stability using Averaging methods. Random Vibrations. Response of SDOF and MDOF systems subjected to random excitation.

CEGR 670: Special Topics in Highway Safety
Three Hours: 3 Credits
This is an elective course which discusses highway safety and design issues. The design of horizontal and vertical alignments as well as transition curves is covered. The causes of highway accidents and their relations to highway design elements such as side slope, roadway width, and sight distance, as well as to

human elements are thoroughly investigated. Analysis of high accident locations, accident reducing measures, and highway economics is also covered. Students are expected to complete a course project in the broad area of highway safety and design.

CEGR 671: Traffic Flow Theory.
Three Hours: 3 Credits
Advanced topics in traffic flow theory for noninterrupted and interrupted flows. Topics include speed flow and density; shock waves in traffic streams; gap acceptance. Queuing theory and probabilistic processes as applied in the analysis of interrupted traffic flows. Applications in highway, traffic signals and terminal systems design.

CEGR 673: Advanced Environmental Engineering Design
Three Hours: 3 Credits
Covers basic parameters and elements in design, development of design parameters, layout of design, hydraulic and/ or pneumatic profiles, cost, and financing. Possible topics included water supply and sewage systems, pumping stations and pumping systems, wastewater treatment plants, air pollution controls, sanitary landfills, etc. This course is a design course that involves real-life projects that the students have selected from the proceeding list of topics and approved by the instructor.

CEGR 680: Highway Infrastructure Management Systems
Three Hours: 3 Credits
This course deals with the development of computerized maintenance management systems for the integrated management of transportation infrastructures. It addresses the requirements of Government Accounting Standard Board (GASB) Statement 34, required to be followed on transportation maintenance projects. Modeling and management of highway maintenance, bridge maintenance, and pavement maintenance are discussed. Depreciation of highway assets over time and correlation between highway maintenance and infrastructure security are covered.

CEGR 681: Theory of Traffic Flow
Three Hours: 3 Credits
Study and evaluation of various qualitative descriptions of the complex phenomenon of traffic flow. The concept and mathematical models considered are statistical relationships, car-following analogy, queuing theory, traffic-network analysis, computing machine simulation studies, mathematical experiments, and distribution-function theories.

CEGR 684: Advanced Algorithms in Transportation I
Three Hours: 3 Credits
An introduction to graphs and networks, their properties and values in systems analysis, identification and formulation of standard problems, and basic techniques available to solve them. Spanning trees, shortest paths, traveling salesman problem, routing and scheduling, facility location problems, flow problems, covers and matchings. Applications and decision analysis. Emphasis on problem identification, use of computer packages, and the relationship of network properties to solution efforts.

CEGR 685: Advanced Algorithms in Transportation II
Three Hours: 3 Credits
This is an advanced level transportation engineering course focusing on development and applications of various algorithms in transportation problem solving. It involves modeling and analysis of transportation network problems through the design, analysis, and implementation of algorithms. Emphasis is placed on the use of quantitative techniques of operations research to model system performance.

CEGR 686: Demand Analysis and Forecasting
Three Hours: 3 Credits
Analysis and forecasting of demand for facilities and services, for use in the planning, design, and operations of transportation systems. Emphasis on the collection and analysis of survey data for demand model development. Covers alternative sample designs, individual choice theories, probabilistic discrete choice models, estimation of desegregate and aggregate models, aggregate forecasting methods and simulation. Illustrated with applications from the field of transportation planning. Hands on exercises in the use of PC statistical analysis software.

CEGR 687: Ground Water Hydrology
Three Hours: 3 Credits
Theory of ground water movement, storage exploration, and pumping tests. Design of ground water recovery and recharge systems. Prerequisite:
CEGR 510.

CEGR 688: Advanced Mechanics of Solids
Three Hours: 3 Credits
Mechanical response of materials, including elastic, plastic and viscoelastic components. Continuum mechanics; kinematics of deformation, analysis of states of stress and strain, conservation of mass, balance of momentum and energy, constitutive equations. Discussion of applications including stress concentrations at defects, metal processing, and composite materials. Prerequisite: Advanced Strength of Materials or consent of instructor.

CEGR 690: Adaptive Structures
Three Hours: 3 Credits
Behavior of engineering structures subject to induced internal deformations. Transduction devices and adaptive physical systems. Excitation and response of adaptive structures. Actuator placement and static control. Extension to the dynamic case and active vibration control.

CEGR 691: Spacecraft Dynamics and Control
Three Hours: 3 Credits
Altitude dynamics and control of spacecraft. Overview of spacecraft systems and orbit determination. Rigid body kinematics and dynamics, and linear control concepts. Active and passive stabilization of spacecraft. Altitude control subsystems and hardware components, and design technology. Illustrations with available real examples and applications.

CEGR 695: Discrete-Time Control Engineering
Three Hours: 3 Credits
Design of controllers for discrete-time systems, with emphasis on linear sampled-data control. Single-loop digital controllers. Discrete-time state space design. Discrete-time optimal control. Realization of microcomputer real-time control systems. Design problems and applications with hands-on experience. Prerequisite: A course in linear systems and control, or consent of the instructor.

CEGR 697: Geographic Information Systems Applications in Transportation
Three Hours: 3 Credits
This is a graduate level course focusing on Geographic Information Systems (GIS) application in transportation (GIS-T). GIS is an emerging technology and is widely used in real-world problem solving. The underlying concepts in GIS application as well as advantages of GIS over non-GIS methods will be

discussed and covered, extensively. Students will be introduced to two GIS softwares: ArcView GIS and MapObjects. Integration of GIS with Visual Basic and Visual C/C++ will also be covered. Finally, a number of GIS applications in real-world problem solving will be shown.

CEGR 702: Seismic Design
Three Hours: 3 Credits
This course provides for the seismic design of buildings. Dynamic analysis of single and multidegree-of-freedom elastic systems subjected to earthquake motions. Earthquake Design Spectra Analysis. Inelastic dynamic response analysis. Consideration of new building code requirements. Prerequisites: Advanced Steel Design, Structural Dynamics, CEGR 704 Innovations in Structural Steel Design (or equivalent courses) or permission of the instructor.

CEGR 703: Geometrically Nonlinear Structural Analysis
Three Hours: 3 Credits
This course provides a basic background in the theory of geometrically nonlinear structural analysis. Formation of geometric stiffness matrices. Nonlinear analysis of trusses, plane frames, space frames, membrane, and cable net structures. Development of three-dimensional beam-column theory. Prerequisites: Matrix Structural Analysis, Advanced Structural Mechanics, EEGR 505 Advanced Engineering Mathematics with Computational Methods (or equivalent courses) or permission of the instructor.

CEGR 704: Innovations in Structural Steel Design
Three Hours: 3 Credits
This course provides for the study of innovations in structural steel design. Ductile design concepts of steel structures and the systematic methods and applications of plastic analysis concepts required to describe the structural behavior associated with ductile design are presented. Design procedures and detailing requirements for ductile braced frames and ductile moment-resisting frames. Consideration of new building code requirements. Prerequisite: Advanced Steel Design (or its equivalent) or permission of the instructor.

CEGR 705: Mechanics of Composite Materials
Three Hours: 3 Credits
Basic mechanics of composite materials. StressStrain relationship of orthotropic materials. Introduction to micromechanics. Classical lamination theory. Mechanical behavior of fiber reinforced composite materials. Damage and failure criteria.

CEGR 709: Wave Propagation in Elastic Media
Three Hours: 3 Credits
Mechanical wave propagation in bounded and unbounded media. Wave reflection and transmission at interfaces and boundaries; stress waves. Additional topics of mutual interest to students and instructor.

CEGR 723: Advanced Consolidation Theory
Three Hours: 3 Credits
The fundamentals of soil consolidation theory are addressed in detail. Based on principles of continuum mechanics and constitutive relations, governing equations are derived for the deformation of the saturated skeletal frame. These in turn are tested against laboratory measurements. Unsolved problems in consolidation theory are emphasized.

CEGR 725: Aquifer Mechanics
Three Hours: 3 Credits
Emphasis on mechanical characteristics of pore flow and skeleton matrix within an aquifer system; motion of pore flow and aquifers, including vertical and horizontal movement of aquifers; interaction between pore flow and skeleton matrix of sedimentary material. Solving Environmental problems related to land subsidence and fissures due to ground fluid (gas, oil and water). Prerequisite: Soil Mechanics, Advanced Hydrology or Hydrodynamics of Groundwater, Math (PDE).

CEGR 726: Geosynthetics
Three Hours: 3 Credits
This course provides graduate students and engineering professionals with knowledge of geosynthetic materials and methods for application procedures in geotechnical and foundation engineering. Geotextiles, geogrids, geosynthetic clay liners, and geocomposites are among the geosynthetic topics of application and procedures. Designing with geosynthetics, application procedures, and specifications are topics of this course.

CEGR 730: Constitutive Laws in Geomechanics
Three Hours: 3 Credits
Fundamental concepts of stress and strain tensors, criterion of failures for geomaterials. Theory of elasticity, viscosity, and plasticity, and their combinations such as elasto-viscous, elasto-plastic models in geomechanics for clay and sand soils. Discussion of classic models in geomechanics and their applications to engineering. Prerequisites: Advanced Soil Mechanics, Continuum Mechanics, and Partial Differential Equations.

CEGR 731: Advanced Soil Mechanics I
Three Hours: 3 Credits
Mechanics of seepage and ground water flow. Effect of seepage on stability, uplift, and foundation design. Basic lateral earth pressure relationships. Stability analysis. Design of breakheads, cofferdams, retaining walls and slopes.

CEGR 737: Continuum Mechanics
Three Hours: 3 Credits
Emphasis on theoretical study of continuum mechanics including introduction to tensor analysis; analysis of stress and strain tensors; motion and deformation; conservation laws; constitutive laws. Applications to porous material or sedimentary material in geomechanics and geotechnical engineering. Prerequisite: Partial Differential Equations, Engineering Mechanics and Mechanics of Materials.

CEGR 738: Boundary Element Method in Geomechanics
Three Hours: 3 Credits
Theoretical concepts and principles of the Boundary Element Method (BEM) and applications to Geomechanics and Geotechnical Engineering. Establishment of conceptual, mathematical, numerical, and mechanical models. Time and spatial discretization. Solution of matrix equations and programming in FORTRAN and C. Applications of BEM to geomaterials which exhibit linear and nonlinear elastic, viscous, and elasto-plastic behavior. Applications of BEM to solve 2D and 3D problems in Geotechnical Engineering. Prerequisites: Mechanics of Materials, Soil Mechanics, Partial Differential Equations, Numerical Analysis, and Programming in FORTRAN or C.

CEGR 739: Discrete Element Method in Geomechanics
Three Hours: 3 Credits
Advanced concepts, principles, programming, and applications of the Discrete Element Method (DEM) in Geomechanics and Geotechnical Engineering. Parameter and determination. Contacting laws and constitutive models. Modeling of rigid block and granular materials. Modeling of deformable block and granular materials. Establishment of conceptual, physical, numerical, and mathematical models. Discretization in space and time. Programming for computation and user friendly interfaces in Visual Basic. Applications of the DEM in solving engineering problems. Prerequisites: Engineering Mechanics, Soil Mechanics, and programming in FORTRAN or C.

CEGR 740: Special Topics in Geographic Information Systems (GIS)
Three Hours: 3 Credits
Advanced concepts, principles, and applications of GIS are presented and illustrated. Project design, data acquisition, management, analyses, and display/product generation will be emphasized. Applications of GIS methodologies in real world problems from various disciplines will also be presented. Student will be required to complete a GIS project as the final examination grade for the course. ESRI's ARCINFO and Arc View will form the basic GIS software for the course. Prerequisites: Basic courses in Geographic Information Systems (GIS) and Remote Sensing or permission of the instructor.

CEGR 741: Special Course in Remote Sensing (RS)
Three Hours: 3 Credits
Advanced concepts, principles, and applications of RS are presented and illustrated. Project design, data acquisition, management, analyses, and display/product generation will be emphasized. Applications of RS methodologies in real world problems from various disciplines will also be presented. Student will be required to compete a RS project as a final examination grade for the course. ENVI and ERDAS will form the basic GIS software for the course. Prerequisites: Basic courses in Geographic Information Systems (GIS) or permission of the instructor.

CEGR 742: Geographic Information Systems (GIS) Modeling in Raster
Three Hours: 3 Credits
Advanced geographic information system (GIS) modeling concepts, principles, methodology, and applications are presented and illustrated. Map algebra, pattern recognition, model formulation, implementation and verification, and advanced raster data structures for dynamic modeling will be emphasized. Cross-disciplinary approaches of GIS modeling of real world problems will also be presented. Student will be required to complete a GIS modeling project, make an oral presentation, and submit a written report of their findings as part of the final grade for this course.

CEGR 743: Finite Element Method in Geomechanics Three Hours: 3 Credits
Theoretical concepts and principles of the Finite Element Method (FEM) as well as applications to Geomechanics and Geotechnical Engineering. Establishment of conceptual, mathematical, numerical, and mechanical models. Time and spatial discretization. Solution of matrix equations and programming in FORTRAN and C. Applications of FEM to geomaterials which exhibit linear and nonlinear elastic, viscous, elasto-plastic behavior. Applications of FEM to solve 2D and 3D problems in Geotechnical Engineering. Prerequisites: Mechanics of Materials, Soil Mechanics, Partial Differential Equations, Numerical Analysis, and Programming in FORTRAN or C.

CEGR 744: Tensor Analysis in Geomechanics
Three Hours: 3 Credits
Concepts, principles of tensors and their applications in Geomechanics. Coordinates and transformation of coordinates. Vectors and tensors, stress and strain tensors in elasticity. Gradient, divergence and rotations, derivatives of tensors and applications to Geomechanics.

CEGR 745: Advanced Analysis of Slope Stability
Three Hours: 3 Credits
Study advanced concepts and principles in limit equilibrium theory. Analyze soil and rock slope stability with theoretical approaches as well as numerical methods (e.g., FEM and FDM). Apply the limit equilibrium theory to slope stability. Back analysis and its applications to prediction of potential failure of slope. Slope design and problem solving in Geotechnical and Geological Engineering.

CEGR 746: Advanced Soil Dynamics
Three Hours: 3 Credits
Emphasis on theoretical and applied study in soil dynamics including soil stress-strain relations, strength and failure under dynamic loading, loading rate effect, small and larger deformation under repeated loading , propagation of stress wave in soils. Investigation of soil dynamic parameters through lab and field. Solving problems in engineering such as sand liquefaction due to earthquake, foundation stability analysis under vibration, wave propagation because of pile driving or earthquake, etc. Prerequisite: Soil Dynamics, Partial Differential Equations, Mechanics of Materials.

CEGR 747: Well Hydraulics
Three Hours: 3 Credits
This course emphasizes theoretical and applied well hydraulics including steady and unsteady flow toward a well within confined, semi-confined or unconfined aquifers. Analytical solutions of well draw down, analysis of aquifer parameters through aquifer testing, and applications to water resources exploitation are discussed.

CEGR 748: Design of Pile Foundations
Three Hours: 3 Credits
Study of theories and principles such as structure characteristics, load transfer mechanics, pile load tests, consolidation settlement of group piles, negative skin friction laterally loaded piles. Design of different types of pile foundations, estimate pile length and installation of piles.

CEGR 749: Earthquake Engineering
Three Hours: 3 credits
This course covers seismic wave and its propagation in porous media, analytical and numerical analysis for elastic, plastic and viscous waves, analysis of ground motion and field responses due to an earthquake, soil-structure interaction induced by earthquakes, soil liquefaction and site characterization, geotechnical designs with consideration of seismic forces.

CEGR 750: Advanced Geotechnical Experiments
Three Hours: 3 Credits
This course emphasizes advanced geotechnical experiments conducted in laboratories and fields, including designing and planning geotechnical tests, introduction to conventional and advanced laboratory and field equipment, data acquisition experiments, and stress analysis for experimental investigation.

CEGR 788: Seminar I
One Hour: 1 Credit
This is the first part of an advanced seminar course taken during the first two semesters of the Master of Engineering Program in which students from different engineering disciplines (Civil, Electrical, and Industrial Engineering) work together to identify and solve problems.

CEGR 789: Seminar II
One Hour: 1 Credit
This is the second part of an advanced seminar course taken during the first two semesters of the Master of Engineering Program in which students from different engineering disciplines (Civil, Electrical, and Industrial Engineering) work together to identify and solve problems.

CEGR 790: Research in Civil Engineering
Three Hours: 3 Credits
This course provides for independent inquiry into any civil engineering-related topic. Through a search of the appropriate literature, the student can gain depth in a particular subject area or breadth in other fields related to civil engineering. At the commencement of the semester, a student must submit an outline of the proposed work for approval. of the supervising faculty member and the chair of the department. A written report is required.

CEGR 794: Project Guidance
One Hour: 1 Credit
Project guidance provides students who have not completed their project in the assigned semester a mechanism for continuing their work under faculty supervision.

CEGR 795: Project Report I
Two Hours: 2 Credits
Project Report I provides a student with an opportunity to formulate a proposal for a professional engineering project. The student may work as a project at the University or off-site, under the supervision of a faculty advisor.

CEGR 796: Project Report II
Two Hours: 2 Credits
Project Report II follows up on the approved project proposal developed in CEGR 795. Under the supervision of a faculty advisor, the student must address advanced professional engineering issues, which may include analysis, design, synthesis, feasibility, development of alternatives, standards and codes, and other relevant issues as defined in Project Report I. This professional engineering experience culminates in a final report.

CEGR 997: Dissertation Guidance
Three Hours: 3 Credits
Dissertation guidance provides students, who have not completed their dissertation in the assigned semester, a mechanism for continuing their work under faculty supervision.

CEGR 998: Dissertation Seminar
Six Hours: 6 Credits
Dissertation seminar provides for the overall guidance of a doctoral student by the Doctoral Advisory Committee in the preparation of the dissertation. In particular, the Major Advisor, who is also Chair of

the Doctoral Advisory Committee, provides direct and continuous guidance in the development of a proposal, proposal defense, research implementation, and dissertation defense.

ELECTRICAL AND COMPUTER ENGINEERING

Chairperson of the Department: PROFESSOR CRAIG SCOTT; Professors: ARLENE COLE-RHODES, KEVIN KORNEGAY, CARL WHITE; Associate Professors: YACOB ASTATKE, JUMOKE LADEJI-OSIAS, KOFI NYARKO, MICHEL REECE; Assistant Professor: FARZAD MOAZZAMI; Lecturers: RICHARD DEAN, COREY DICKENS, PETRONELLA JAMES, LADAWN PARTLOW, PATERNE SISSINTO, GREGORY M. WILKINS.

EEGR 503: Communications Theory
Three Hours: 3 Credits
This course introduces students to the basic concepts in communication theory. It includes an introduction to analog AM and FM modulation, digital modulation, baseband and bandpass digital communication, communication link analysis, channel coding, modulation and coding trade-offs.

EEGR 505: Advanced Engineering Mathematics with Computational Methods
Three Hours: 3 Credits
Advanced math topics including matrix analysis, vector and tensor calculus and complex variables. Infinite series expansions and their use as solutions of variable coefficient differential equations. Partial differential equations, nonlinear differential equations and systems of differential equations. Integral transforms. Evaluation of infinite integrals. Elliptical integrals and functions; Green's functions; Bessel, Laguerre, and Legendre functions; Tensor analysis; Jacobians; diffusion, wave, Laplace and Poisson equations.

EEGR 507: Applied Probability and Statistical Analysis
Three Hours: 3 Credits
Modeling and analysis of random processes. Random variables, transforms and their probability laws. Probability assessment and decision analysis. Limit theorems. Applications using numerical methods.

EEGR 508: Advanced Linear Systems
Three Hours: 3 Credits
This course focuses on fundamental concepts for the analysis of linear systems in the discrete and continuous domains. A discussion of core topics in linear algebra for the analysis of systems of equations, including matrix representations of linear operators, eigenvector-eigenvalue analysis, and the Cayley-Hamilton theorem will be covered. Additionally, topics in system theory including system stability, controllability and observability will be discussed.

EEGR 510: Communications Networks
Three Hours: 3 Credits
An introduction to communication networks. Includes the OSI layering model of networks with emphasis on the physical, data link, and network layers; and network topologies. Introduction to a variety of computer, satellite, and local-area communication networks, including Ethernet, Internet, packet radio, and the telephone network.

EEGR 520: Digital Image Processing
Three Hours: 3 Credits
This course covers topics relevant to the understanding, feature extraction, and modification of images. Included in this course will be the necessary theoretical background as well as practical exercises in

image processing. Topics include 2-D system theory, image transforms, image analysis, image enhancement and restoration, image coding, automatic pattern recognition, image processing hardware and software.

EEGR 522: Digital Signal and Speech Processing
Three Hours: 3 Credits
The course covers of digital signal processing and an introduction to techniques for speech signal processing. Includes: linear predictive coding (LPC), pattern recognition, compression, speech physiology, and other topics of interest.

EEGR 524: Introduction to RADAR
Three Hours: 3 Credits
This course introduces the student to the fundamentals and basic principles of radar system engineering. The radar range equation, radar transmitters, antennas, and receivers are covered. Concepts of matched filtering, pulse compression, and fundamentals of radar target detection in a noise background are discussed.

EEGR 531: Linear Control Systems
Three Hours: 3 Credits
This course deals with the analysis of time and frequency response of closed loop systems, Routh-Hurwitz and Nyquist criteria for stability, Root locus method, and System specifications.

EEGR 532: Microwave Transmission
Three Hours: 3 Credits
This course will cover the fundamental concepts of Maxwell's equations, wave propagation, network analysis, and design principles as applied to modern microwave engineering. Topics include planar transmission lines, bipolar and field effect transistors, dielectric resonators, low-noise amplifiers, transistor oscillators, PIN diode control circuits and monolithic integrated circuits.

EEGR 534: Microwave System and Components
Three Hours: 3 Credits
This course provides the practical aspects of microwave systems and components. An overview of communication and radar systems is followed by detailed analysis of key components. Topics include linear and nonlinear characteristics of individual components and their relationship to system performance.

EEGR 535: Active Microwave Circuit Design
Three Hours: 3 Credits
This course will provide a brief overview of Smith Charts and transmission line theory, microstrip lines, and impedance matching. It will introduce power gain equations, stability considerations, and solid state microwave circuits such as amplifiers, oscillators, active mixers, attenuators, and frequency multipliers.

EEGR 536: Antenna Theory and Design
Three Hours: 3 Credits
This course deals with the analysis and design of basic antenna structures such as linear dipoles, antenna arrays, horns, and patch antennas. Computer-aided design software will be used to optimize antenna performance, placement of feeds, and gain.

EEGR537: Radio Frequency Integrated Circuit Design
Three Hours: 3 Credits
This course covers the design and analysis of radio-frequency integrated circuits at the transistor level using state-of-the-art complementary metal-oxide-semiconductor (CMOS) and bipolar technologies. It focuses on system-level trade-offs in transceiver design, practical radio-frequency circuit techniques, and a physical understanding of device parasitics.

EEGR 540: Solid State Electronics
Three Hours: 3 Credits
This course will focus on the fundamentals of solid state physics as it applies to electronic materials and devices. A discussion of core topics including three-dimensional bulk material properties and recent developments in low-dimensional semiconductor structures, such as heterostructures, superlattices and quantum wells will be covered. In addition, various material growth and device fabrication techniques will be discussed.

EEGR 542: Microwave Power Devices
Three Hours: 3 Credits
This course introduces microwave power devices and circuits including amplifiers, P-i-N and Schottky power rectifiers, power MOSFETs, conductivity-modulated high-power devices, wide band gap semiconductors, and emerging material technologies in relation to device modeling.

EEGR 543: Introduction to Microwaves
Three Hours: 3 Credits
This course deals with electromagnetic wave types, transmission lines and waveguides, Smith Chart, S-parameters, and passive components associated with microwave signals and circuits.

EEGR550: Fundamentals of Energy and Power Systems
Three Hours: 3 Credits
This course will provide a high level view of energy and power from a systems perspective. Major components of power systems and the technical specifications in relation to various industries will be explored.

EEGR 551: Digital Signal Processing
Three Hours: 3 Credits
This course provides an emphasis on applications of digital signal processing. It includes the theory and application of the discrete Fourier transform, Fast Fourier Transform, Sampling, Quantization, and Digital filter design.

EEGR553: Electric Drives and Machines
Three Hours: 3 Credits
This course provides an integrated approach to electric drives and subsystems that make up electric drives: electric machines, power electronics based converters, mechanical system requirements, feedback controller design, and the interaction of drives with the utility grid.

EEGR554: Renewable Energy Systems
Three Hours: 3 Credits
This course provides a multidisciplinary approach that encompasses economic, social, and environmental, policy, and engineering issues related to renewable energy. The renewable systems covered will be solar PV, solar thermal, geothermal, bioenergy, wind, and hydroelectric.

EEGR555: Advanced Power Electronics
Three Hours: 3 Credits
This course provides an approach to the design power electronic converters. Topics include state average modeling, inverter design, resonant converters, snubber circuits, and feedback control design.

EEGR556: Modeling and Control Techniques in Power Electronics
Three Hours: 3 Credits
The objective of this course is to provide the theory of control technology with various control strategies to effectively control power systems. Microprocessors and control algorithms based on PWM will be investigated in relation to switching devices and feedback control.

EEGR557: Smart Grid and Building Energy Efficiency
Three Hours: 3 Credits
This course provides a comprehensive approach towards smart grid that encompasses sensors, communications technologies, computational ability, control, and feedback mechanisms that effectively combined to create the smart grid system.

EEGR 560: Computer Networks
Three Hours: 3 Credits
ISO open systems reference model, protocol layers, TCP/IP, channel coding, data communication concepts, local area network (LAN) topologies and transmission media, queuing theory applied to LAN performance modeling, LAN access techniques, network interconnection, network reliability, network security, performance analysis of ring and bus topology networks, reliability of fiber optic ring networks.

EEGR 562: Computer Architecture, Networks, and Operating Systems
Three Hours: 3 Credits
Quantitative basis of modem computer architecture, processor designs memory hierarchy, and input/output methods. Layered operating system structures, process and storage management Layered network organization, network protocols, switching, local and wide area networks. Examples from Unix and the Internet.

EEGR 570: Advanced Digital System Design
Three Hours: 3 Credits
Introduces alternative means by which a logic system may be realized and the variety of technologies available. Reviews logical factors of digital systems and the architecture of FPGAs along with the options and trade-offs for diverse approaches. Small and modest sized design implementations on different FPGA architectures will be covered.

EEGR 575: Software Engineering: Systems Implementation
Three Hours: 3 Credits
Implementation aspects of software engineering; Programming languages; architectural designs; program design; structured programming; peripheral storage devices; I/O programming, debugging and evaluation.

EEGR580: Introduction to Cyber Security
Three Hours: 3 Credits

This course will provide an overview of all aspects of cyber-security including business, policy and procedures, communications security, network security, security management, legal issues, political issues, and technical issues. This serves as the introduction to the cyber security program.

EEGR581: Introduction to Network Security
Three Hours: 3 Credits
This course will provide a background in the many aspects of security associated with today's modern computer networks including local area networks and the internet. It includes the fundamentals of network architecture, vulnerabilities, and security mechanisms including firewalls, guards, intrusion detection, access control, malware scanners and biometrics.

EEGR582: Introduction to Communications Security
Three Hours: 3 Credits
This course will provide a background in the many aspects of communications security associated with today's modern communications and networks. It includes the fundamentals of cryptography, encryption, public and private key structures, digital signature and secure hash functions.

EEGR583: Introduction to Security Management
Three Hours: 3 Credits
This course will provide a background in the many aspects of security management associated with today's modern communications and networks. It includes the fundamentals of Risk Analysis, Risk Management, Security Policy, Security Operations, Legal issues, Business issues and Secure Systems Development.

EEGR 605: Digital Communications
Three Hours: 3 Credits
Digital Communications Systems is a foundation course for digital communications. It provides a brief review of signals, probability, stochastic processes and information theory followed by the development of source encoding, modulation systems, optimum receiver design, demodulation systems, and error correction coding. Special topics will be included based on time available and student interest.

EEGR 607: Information Theory
Three Hours: 3 Credits
This course presents measures of information, information sources, coding for discrete sources, the noiseless coding theorems, Huffman coding, channel capacity, the noisy-channel coding theorems and block and convolutional error-control coding and decoding techniques.

EEGR 608: Error Control Coding
Three Hours: 3 Credits
This course includes a review of information theory with the theory and design of error detection and correction schemes. Includes block and convolutional codes, interleaving, ARQ schemes, error detection schemes, and a variety of applications on wired and wireless networks.

EEGR 610: Wireless Communications
Three Hours: 3 Credits
This course presents current techniques on wireless digital communications, such as wireless channel modeling, channel distortion due to multipath and Doppler, digital modulation and demodulation (MODEM) techniques, and multiple access methods including TDMA, FDMA and CDMA systems.

EEGR 612: Multi User Communications
Three Hours: 3 Credits
Review of network architectures using OSI layering strategies. Includes Queueing theory application to various queues; and reservation, polling, and token passing systems. Protocol designs for radio multi-channel networks with various contention strategies. Local area network protocols, performance and strategies.

EEGR 614: Queueing Networks
Three Hours: 3 Credits
Addresses the fundamentals of stochastic processes and queuing theory. Includes Poisson processes, Markov chains, renewal processes, tandem queues, networks of queues, priority and bulk queues, computational methods, and simulation. Application and performance with a variety of computer and communications applications.

EEGR 615: High Speed Networks
Three Hours: 3 Credits
Introduction to the design of high data rate, integrated services protocols that designed for high speed multi-media applications such as video, voice, data and internet traffic. The TCP/IP, IEEE8O2.x LAN, and Asynchronous Transfer Mode (ATM). Introduction to Routing and Queuing Theory is included. Topics include switching architectures, network management and control.

EEGR 620: Digital Image Processing
Three Hours: 3 Credits
This is an introduction course on the fundamentals of digital image processing with an emphasis on signal processing. Topics included: image formation, images transforms, image enhancement image restoration, image reconstruction, image compression, image segmentation and image representation.

EEGR 622: Adaptive Signal Processing
Three Hours: 3 Credits
This course addresses adaptive digital signal processing for applications such as equalization and array processing. Emphasizes the theory and design of finite-impulse response adaptive filters including stochastic processes, Weiner filter theory, the method of steepest descent, adaptive filters using gradient-methods, analysis of the LMS algorithm, least--squares methods, recursive least squares, and least squares Iattice adaptive filters.

EEGR 623: Pattern Recognition
Three Hours: 3 Credits
This course addresses the general pattern classification problem. It includes: statistical decision theory, multivariate probability functions, discriminants, parametric and nonparametric techniques, Bayesian and maximum likelihood estimation, feature selection, dimensionality reduction, transformations, and clustering.

EEGR 624: Detection and Estimation Theory
Three Hours: 3 Credits
This is a course on statistical decision theory, modeling of signals and noise, detection of various signals, and statistical estimation theory. Includes decision criteria, hypothesis testing, receiver operating

characteristics, detection of signals with unknown parameters, performance measures, Cramer Rao bounds, and optimum demodulation.

EEGR 625: Optical Communication
Three Hours: 3 Credits
Includes the characteristics of light as used in communications systems including propagation of rays in waveguides, scalar diffraction theory, optical information processing systems, quantum statistical communication theory, heterodyning and receivers.

EEGR 626: Optimization/Numerical Methods
Three Hours: 3 Credits
This course investigates both classical deterministic optimization techniques and stochastic optimization techniques. The classical techniques will include linear and non-linear programming, steepest descent, and Newton-Raphson methods. Stochastic methods will include Robbins-Monro gradient-based stochastic approximation and the simultaneous perturbation stochastic approximation algorithms. Application cases will be included throughout the course, including neural-network training, nonlinear control, sensor configuration, image processing, and discrete-event systems. Simulation-based optimization and computer-based homework will be given.

EEGR 633: Automated Measurements, Devices and Systems
Three Hours: 3 Credits
This course will consider microwave active circuits utilizing semiconductor devices. Circuits using unipolar (FETs), bipolar (Transistor), and diode devices will be examined. Linear amplifier analysis techniques including unilateral gain, maximum available gain, noise figure circles, and stability circles will be covered. Students will be introduced to the fundamentals of high-frequency measurements and the latest techniques for accuracy-enhanced microwave measurements. Automated network analyzers and high-speed wafer probes are used in conjunction with state-of-the-art calibration techniques. Microwave computer-aided analysis and design tools will be used to evaluate active circuits. None-linear modeling of active devices will be introduced.

EEGR 634: Computational Electromagnetics
Three Hours: 3 Credits
The finite-element method (FEM), the finite-difference (FD), the finite-difference-time-domain (FDTD), and the method of moments (MoM) are versatile tools that find important applications in electromagnetic engineering. This course will focus on several electromagnetic field equations, such as Laplace's, Poisson's, and Helmholtz's equations, and the related numerical techniques for their approximate solutions to problems for which closed-form solutions may not be obtained.

EEGR 635: Advanced Electromagnetic Theory
Three Hours: 3 Credits
This course is a first-year graduate course on electromagnetic theory and applications. Topics include Stokes parameters, Poincare sphere, gyrotropic media, uniaxial media, phase matching, layered media, dielectric waveguides, metallic waveguides and resonators, Cerenkov radiation, Hertzian dipole, equivalence principle, and reciprocity.

EEGR 636: Quantum Mechanics
Three Hours: 3 Credits

This is a survey course on quantum mechanics that covers a broad range of topics that are useful to students in electrical and computer engineering such as: Lagrangian and Hamiltonian equations, Schrodinger equation, wave packets, particle in a box, tunneling of particles, Dirac's description of quantum mechanical states and matrix formulation of quantum mechanics, and perturbation theory.

EEGR 637: Advanced Antenna Theory
Three Hours: 3 Credits
This course develops fundamental concepts used to analyze basic antenna systems. Topics include antenna patterns, optimum designs for rectangular and circular apertures, arbitrary side lobe topography, discrete arrays, mutual coupling, and feeding networks.

EEGR 640: Advanced Solid State Electronics
Three Hours: 3 Credits
This course will focus on the fundamentals of solid state physics as it applies to electronic materials and devices. A discussion of core topics including bulk material properties and recent developments in low-dimensional semiconductor structures, such as heterostructures, superlattices and quantum wells will be covered. Additionally, various material growth and device fabrication techniques will be discussed.

EEGR 642: Semiconductor Fabrication Technology
Three Hours: 3 Credits
An overview of the fundamental principles of semiconductor fabrication technology is presented. It covers both the practical and the theoretical aspects including the use of predictive engineering tools. Topics include basic material review; methods of oxidation; methods of deposition/diffusion and ion implantation, principles of epitaxial deposition/ growth, photolithographic technology, chemical vapor deposition/nitride, silicon dioxide, metallization technology, evaporation/sputtering; and electrical inline wafer testing.

EEGR 643: Advanced Semiconductor Characterization
Three Hours: 3 Credits
This course is an advanced approach to the measurement of physical principles underlying semiconductor device operation. This concept is reinforced through the application of these measurements to specific devices. Topics include measurement techniques of the critical relevant physical parameters in semiconductor material and device structures such as: impurity profiling, carrier transport, and deep and shallow level trap characterization.

EEGR 645: Optical Engineering
Three Hours: 3 Credits
This course presents the engineering concepts necessary to understand and evaluate optical systems. It begins with a brief but rigorous treatment of geometric optics, including matrix methods, aberrations, with practical examples of optical instruments and electro-optical systems. Other topics include polarization, interference, diffraction, and optical properties of crystals, thin-films, optical resonators, guided waves, modulators and detectors. The concepts are presented with examples from modern optical systems such as fiber-optical sensors, rangefinders, infrared systems, and optical communication systems.

EEGR 646: Optical Communication
Three Hours: 3 Credits

This course provides an overview of communication systems, light and electromagnetic waves, optical fibers, lasers, LED, photodetectors, receivers, optical fiber communication systems.

EEGR 660: Computer Architecture and Design
Three Hours: 3 Credits
Principles and advanced concepts and state-of-the-art developments in computer architecture: memory systems, pipelining, instruction-level parallelism, storage systems, multiprocessors, relationships between computer design and application requirements, and cost/performance tradeoffs. Additional topics include particular emphasis will be placed on architectures for DSP applications.

EEGR 662: Parallel Processing Architecture
Three Hours: 3 Credits
This course addresses fundamental issues in the design and use of large-scale multiprocessors. Both software and hardware issues are addressed. In the software area, the course will examine parallel applications and their computation requirements, including how they are expressed using parallel programming languages. The course will also look at runtime software that provides the system-level support needed in a parallel architecture. In the hardware area, the course will examine all facets of the design of multiprocessors, including processor support for parallelism, memory system design, and interconnection networks.

EEGR 664: Introduction to Parallel Computation
Three Hours: 3 Credits
Motivation for parallel processing, technological constraints, complexity, performance-characterization, communications, interconnection networks, reconfiguration and fault tolerance, systolic arrays, memory systems, large-bandwidth input/output, disk arrays, on-line visualization, coarse and fine-grain processor design, parallel FORTRAN and C, finite-difference and finite-elements, parallel optimization and transformation algorithms, selected signal and image processing applications, selected architectures: DAP, NCUBE, CM-2, and MasPar.

EEGR 666: Parallel Algorithms
Three Hours: 3 Credits
The design and analysis of efficient algorithms for parallel computers. Fundamental problem areas, such as sorting, matrix multiplication, and graph theory, are considered for a variety of parallel architectures. Simulations of one architecture by another.

EEGR 668: Topics in Networking and Network Applications
Three Hours: 3 Credits
We will discuss how existing and emerging data communication technologies can meet special application requirements. The course covers LAN and WAN Technologies, Bridging, Switching, Routing, Networking Protocols, Management, Design and Security as well as Multicast, Videoconferencing, Multimedia Collaboration Technologies and Audio/Video compression and coding. The course material is designed as an introduction to the field and a practical guide for designing and planning networks. Note that the word “topics” in the title means that the course content will vary to reflect current or interesting topics and applications in the field.

EEGR 670: **DSP VLSI Design**
Three Hours: 3 Credits
DSP VLSI architecture and algorithms; design strategies; design methodologies; system-level design; area/delay/ power trade-offs; high performance systems; multi-chip modules; low-power design; hardware/software co-design; design for testability, design for manufacturability; algorithm, architecture, and component design for adaptive computing systems; prototype system development and test, possible chip fabrication by MOSIS and subsequent chip testing.

EEGR 672: Computer Graphics
Three Hours: 3 Credits
This course gives a multi perspective overview of computer graphics with emphasis on high performance hardware and software techniques to model, render and display computer imagery. Representative topics include: geometric and raster algorithms, curves and surfaces, object hierarchy, display technologies, video controllers and processors, and input devices.

EEGR 675: Computer Vision
Three Hours: 3 Credits
Image formation and visual perception. Images, line structure, and line drawings. Preprocessing, boundary detection, texture, and region growing. Image representation in terms of boundaries, regions, and shape. Three-dimensional structures and their projections. Analysis, manipulation, and classification of image data. Knowledge-based approaches to image understanding. Applications from fields of robot vision, biomedical-image analysis, and satellite and aerial image interpretation.

EEGR 677: Object Oriented Analysis and Design: Modeling, Analysis, and Optimization of Embedded Software
Three Hours: 3 Credits
Modeling, Analysis, and Optimization of Embedded Software. Current techniques in software engineering with topics selected from economics, reusability, reliable software, program analysis, reverse engineering, CASE tools, automatic code generation, and project management techniques.

EEGR678: Network Security
Three Hours: 3 Credits
This course will provide a background in the many aspects of security associated with the protection of computer networks It includes Network attacks and advanced topics in vulnerabilities, networks security management, firewalls, guards, intrusion detection, access control, malware scanners and biometrics.

EEGR 679: Security in Network and Link Applications
Three Hours: 3 Credits
Security Architecture for open, closed and mixed network topologies. Introduction to security mechanism design and implementation.

EEGR 680: Switching Theory: High Speed Networks
Three Hours: 3 Credits
This course reviews the development and performance of state-of-the-art switching architectures of broadband networks based on the current standards. Of particular interest will be networks based on the ATM standard because of their gaining global popularity for flexibility in providing integrated transmission of sound, image and data signals.

EEGR 682: Design Patterns of Object Oriented Software Systems
Three Hours: 3 Credits
This course introduces students to the principles of design patterns applied to the design of complex systems. It covers foundational patterns, creational pattern types, structural pattern types, behavioral pattern types, and applications of design patterns.

EEGR 684: Machine Learning Algorithms
Three Hours: 3 Credits
This course introduces students to the principles of machine learning to solve complex computational engineering problems. Topics to be covered include neural networks, evolutionary algorithms, and swarm intelligence.

EEGR/CEGR 695: Discrete-Time Control Engineering
Three Hours: 3 Credits
Design of controllers for discrete-time systems, with emphasis on linear sampled-data control. Single-loop digital controllers. Discrete-time state space design. Discrete-time optimal control; dynamic programming, H-2 and H infinity optimal linear sampled-data control. Digital computer simulation of sampled-data control systems. Realization of microcomputer real-time control systems. Design problems and applications with hands-on experience.

EEGR 710: Wireless Communications II
Three Hours: 3 Credits
This is an advanced topic in wireless which encompasses advanced signal processing and communications techniques applied to wireless applications including: Spread Spectrum, adaptive equalization, rake receiver design, multiple access schemes, wireless protocols and wireless networks. Applications include cellular, satellite, wireless LAN, and wireless internet.

EEGR 715: Advanced Topics in Communications
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 720: Advanced Topics in Signal Processing
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 722: Advanced Topics in Image Processing
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 725: Advanced Topics in Control Theory
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 730: Special Topics in Microwave Engineering
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 732: Special Topics in Electromagnetics
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 740: Special Topics in Solid State and Optical Electronics
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 742: Special Topics in Microelectronics
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 760: Special Topics in Computer Engineering
Three Hours: 3 Credits
This course will address selected advanced topics on this subject that are of interest to the students and instructor.

EEGR 788: Seminar I
One Hour: 1 Credit
This is the first part of an advanced seminar course taken during the first two semesters of the master of engineering program in which students from different engineering disciplines (Civil, Electrical, and Industrial Engineering) work together to identify and solve problems.

EEGR 789: Seminar II
One Hour: 1 Credit
This is the second part of an advanced seminar course taken during the first two semesters of the master of engineering program in which students from different engineering disciplines (Civil, Electrical, and Industrial Engineering) work together to identify and solve problems.

EEGR 790: Independent Study
2 to 6 Credits
The course of Independent Study is a program of research consisting of directed reading and/or laboratory work under the direction of a graduate faculty member. The program of study will be performed in accordance with an agreed upon plan and culminate in a report or paper. This course can be taken for 2 to 6 credits consistent with the proposed effort.

EEGR 794: Scholarly Project
Two Hours: 3 Credits
This course provides the student with an opportunity to independently engage in analysis and design for an electrical engineering problem under the guidance of a faculty advisor. This course should be taken in the final semester.

EEGR 795: Project Report I
Two Hours: 2 Credits
Project report I is to let students learn how to prepare a real project. This course emphasizes the continued analysis and the design of a specific electrical engineering problem under the guidance of a faculty advisor.

EEGR 796: Project Report II
Two Hours: 2 Credits
Project report II is to let students learn how to conduct a real project. This course emphasizes the continued analysis and the design of a specific electrical engineering problem under the guidance of a faculty advisor.

EEGR 797: Thesis Guidance
Two Hours: 2 Credits
Thesis guidance provides students who have not completed their thesis in EEGR 799 a mechanism for continuing work under faculty supervision. Thesis Guidance courses earn “S” grades.

EEGR 799: Thesis Seminar
Three Hours: 3 Credits
This is the initial course for students conducting research and writing a thesis under faculty supervision. The grade is “CS” until the thesis is completed and approved. Students are required to take EEGR 799 before EEGR 797.

EEGR 997: Dissertation Guidance
Three Hours: 3 Credits
Dissertation guidance provides students who have not completed their dissertation in EEGR 998 a mechanism for continuing their work under faculty supervision. Dissertation Guidance courses earn “S” grades.

EEGR 998: Dissertation Seminar
Six Hours: 6 Credits
Dissertation seminar provides for the overall guidance of a doctoral student by the Doctoral Advisory Committee in the preparation of the dissertation. In particular, the Major Advisor, who is also Chair of the Doctoral Advisory Committee, provides direct and continuous guidance in the development of a proposal, proposal defense, research implementation, and dissertation defense. The grade is “CS” until the dissertation is completed and approved. Students are required to take EEGR 998 before EEGR 997.

INDUSTRIAL AND SYSTEMS ENGINEERING

Chairperson of the Department: TRIDIP K. BARDHAN; Professor: SEONG W. LEE, GUANGMING CHEN; Associate Professor: RICHARD A. PITTS, Jr., LEEROY BRONNER; Assistant Professor: BHEEM KATTEL; Lecturers: MASUD SALIMIAN

IEGR 500: Mathematical Programming

Three Hours: 3 Credits

Introduction to construction of deterministic mathematical models. Mathematical techniques such as linear programming, dynamic programming, integer programming, and game theory. Applications are made to production, transportation, assignment, and resource allocation problems.

IEGR 501: Introduction to Advanced Systems Engineering

Three Hours: 3 Credits

This course provides an understanding of the advanced concepts and principles of both the theory and practice of the discipline of System Engineering. In particular, students will learn the application of these principles to the design, development, and production of complex systems. The course enables the student to become familiar with System Engineering and demonstrate and understanding of inter-relationships among System Engineering artifacts.

IEGR 502: Object-Oriented Analysis and Design

Three Hours: 3 Credits

Introduction to the principles of Object-Oriented Analysis and Design (OOAD) applied to Software Engineering. Introduction to systems analysis and design theory by using object-oriented methodologies. The OQAD methodology in conjunction with use-case methods, and analysis, model and simulation of software applications.

IEGR 503: Advanced Quantitative Methods in Systems Engineering

Three Hours: 3 Credits

Systems engineering focuses on the analysis of entire systems. In this course, students will obtain a strong foundation in system analysis and design. This includes a structured problem solving approach using object-oriented and analysis techniques. Also, students will be introduced to systems methodology and management. There will be an introduction to selected techniques in systems and decision sciences, including mathematical modeling, decision analysis, risk analysis, and simulation modeling. An overview of contemporary topics will be presented such as reengineering and total quality management. Elements of systems management which includes decision styles, human information processing, organizational decision processes, and information system design for planning and decision support. The course will emphasize relating theory to practice via written analyses and oral presentations and case studies.

IEGR 505: Industrial Engineering Principles I

Three Hours: 3 Credits

Introduction to principles and concepts of Industrial Engineering for non-bachelor degreed graduate students. This is a first course to learn applied statistics and quality control, engineering economics, ergonomics/human factors, process analysis, and other advanced quantitative topics at the graduate level. This course is required for graduate students without an undergraduate degree in Industrial Engineering.

IEGR 506: Industrial Engineering Principles II
Three Hours: 3 Credits
Introduction to principles and concepts of Industrial Engineering for non-bachelor degreed graduate students. This is a second course to learn fundamentals of operations research, simulation, productions systems, and other quantitative methods in industrial engineering at the graduate level. This course is required for graduate students without an undergraduate degree in Industrial Engineering.

IEGR 510: Production Sequencing and Scheduling
Three Hours: 3 Credits
Analysis of sequencing and scheduling activities. Static and dynamic scheduling problems applied to single and multi-machine models, heuristic models, rule-based models and simulation studies of priority dispatching rules, priority queuing models.

IEGR 511: Advanced Engineering Economy
Three Hours: 3 Credits
Topics include measuring economic worth, economic optimization under constraints, analysis of economic risk and uncertainty, foundations of utility theory, and econometric models.

IEGR 512: Advanced Project Management
Three Hours: 3 Credits
This is a study of project management theory and practices, emphasizing the strategic management for engineering activities. The concept of project planning and organization project life cycle project scheduling, organizational forms and conflict resolution will be addressed. The use of cost and time value of money, schedule and technical planning and control methods such as WBS, and network models as AOA, AON, CPM/PERT will be stretched. Proposal writing and the use of project management software tools for creating a typical project plan will be explored.

IEGR 514: Risk Assessment and Systems Reliability
Three Hours: 3 Credits
This course covers risk assessment and reliability modeling/estimation when conducting system design and development. It will address the identification and quantification of the risk and its consequences, as well as reliability requirement of a system by using life cycle analysis and reliability engineering.

IEGR 515: Engineering Optimization
Three Hours: 3 Credits
Introducing and developing the practical aspects of optimization methods focusing on techniques and strategies useful in engineering design, operations and analysis. Survey of the important families of optimization methods. Topics include functions of single and several variables, constrained optimality criteria, transformation methods, constrained direct search, linearization methods for constrained problems, direction generation methods, quadratic approximation methods, structured problems, comparison of constrained optimization methods, strategies for optimization studies. Case studies include optimal design of a compressed air energy storage system, design of natural gas pipeline, and optimization of ethylene glycol-ethylene oxide process.

IEGR 516: Applied Decision Analysis
Three Hours: 3 Credits
Bayes Theorem, Bayesian estimators, utility functions, loss functions, risk analysis, minimax strategies, game theory, multiple criteria decision making. Problems in social and public decision making, values

and preferences, subjectivity measurement, and Pareto optimality, group decision analysis, social decision processes and strategy of conflicts.

IEG520: Distributed Intelligent Agent System
Three Hours: 3 Credits
Distributed Intelligent Agent Systems are the next major advancement in network computing architectures beyond Object-Oriented technology. This course is an introduction to intelligent agent-based technology that view large complex systems as societies of independent communicating agents working together to meet the goals of the system.

IEGR 530: Advance Simulation
Three Hours: 3 Credits
An up-to-date treatment of all the important aspects of simulation study, including modeling, simulation languages, validation, and output data analysis. Topics include selecting input probability distribution, random number generators, generating random variables, output data analysis, statistical techniques for comparing alternative systems, validation of simulation models, variance reduction techniques, and experimental design and optimization.

IEGR 531: Quality Management and Statistical Process Control
Three Hours: 3 Credits
This course provides useful managing tools for quality in manufacturing and service industries. The course covers quality control and statistical process control (SPC) including control charts and sampling plan design, six sigma approach and process capability analysis, total quality management (TQM), introduction to ISO 9000, quality philosophies of Deming, Juran and Taguchi. Prerequisite: Engineering statistics or equivalent.

IEGR 534: Engineering Statistics & Modeling
Three Hours: 3 Credits
Sampling distributions, estimation, maximum likelihood estimation, confidence intervals, regression, goodness of fit, correlation, tests of hypotheses, nonparametric statistics, introduction to analysis of variance (ANOVA) and design of experiments.

IEGR 535: Engineering Experimental Design
Three Hours: 3 Credits
Analysis and application of standard experimental design, including factorials, randomized block, latin square, confounding and fractional replication multiple comparisons. Fractional factorials, analysis of unbalanced data, and covariance models. Introduction to response surface methodology.

IEGR 539: Robust Design by Quality Engineering
Three Hours: 3 Credits
System design, parameter design, and tolerance design. Quality loss function, orthogonal arrays. Quality improvement by design. Making products insensitive to manufacturing variations, environmental variations and deterioration overtime. Introduction to TQM, QFD, JIT.

IEGR 550: Human Performance Engineering
Three Hours: 3 Credits
Engineering acceptable performance, human limits and differences, sensing, cognitive processing and performance, perception, problem solving and decision-making, memory, motivation. Basic design and

human factors, human-machine interface, human-human interface, human-computer interfaces. Supporting human performance and evaluating performances and preferences.

IEGR 555: Artificial Intelligence Programming
Three Hours: 3 Credits
Introduction to Lisp programming, early Al programs that use rule-based pattern matching techniques advance Al programs. Topics include building software tools, symbolic mathematics, logic programming, object-oriented programming, knowledge representation and reasoning, expert systems and natural languages.

IEGR 560: Assembly Automation & Product Design
Three Hours: 3 Credits
Analysis of the product design for ease of automatic assembly, automatic assembly transfer systems, automatic feeding and orienting-vibratory feeders, automatic feeding and orienting-mechanical feeders, feed tracks, escapements, parts-placement mechanisms, performance and economics of assembly systems, design for manual assembly, product design for high-speed automatic assembly and robot assembly, printed circuit board assembly, and feasibility study for assembly.

IEGR 562: Rapid Prototyping
Three Hours: 3 Credits
Fundamental concepts in the development of computational algorithms for the design of machine components and assemblies, and other engineering systems. Methodologies of idea generation and refinement; Computer-assisted Rapid Sketching methods; general purpose computer programs for engineering analysis and design; Solid modeling techniques and parametric modeling for manufacturing; Analysis of trajectory from idea-generation to prototype production; representation of the design process as a network of decision tables and logical flags; introduction to stereo-lithography.

IEGR 563: Nontraditional Manufacturing Processes
Three Hours: 3 Credits
This course is designed to provide an assessment of the state of the art in the design tools and techniques in the area of non-traditional manufacturing. The students will be exposed to practical applications of non-traditional manufacturing, including use of wire electro-discharge machining and computer-assisted numerical control programming.

IEGR 570: Advanced Instrumentation Techniques
Three Hours: 3 Credits
Pressure and sensors; laser holography; laser doppler velocimetry; anemometry signal conditioning, use of amplifiers with shielding and grounding techniques; digital techniques; signal multiplexing, use of microcomputers; sampling techniques, error analysis and data handling; data acquisition methods; hardware and software review.

IEGR 571: Advanced Internal Combustion Engine
Three Hours: 3 Credits
Main phases of Otto cycle, Spark-ignition internal-combustion engine, Combustion and detonation; Carburetion and fuel injection, application of reciprocating piston engine, optimal design of triangular rotor (or rotary piston), optimal arrangement of intake, exhaust, and ignition mechanisms, exhaust emissions, fuel economy, and reliability.

IEGR 572: Design & Analysis of Energy Systems
Three Hours: 3 Credits
Elements in design analysis of energy systems, system designs involving heat reservoirs and work reservoirs, selection of fluid flow equipment, heat exchanges designs options, availability analysis, system flowsheeting, economic evaluation/cost estimation, optimal design techniques, and energy systems simulation.

IEGR 573: Applied Thermodynamics & Combustion
Three Hours: 3 Credits
In-depth analysis of power and refrigeration cycles. Flow through nozzles and blade passages. Impulse and reaction turbines. Blade diagrams and efficiency. Production of thermal energy. Chemical reactions and reactive mixtures. Combustion process and analysis of the products for the fossil-fuel systems.

IEGR 574: Heating, Ventilating, Air Conditioning (HVAC), & Energy Conservation System
Three Hours: 3 Credits
Air conditioning and environmental control, heat transmission in building structure, space heat load and cooling load, room and building air distribution, Principal of psychometrics, mass transfer and measurement of humidity, direct contact heat/mass transfer, refrigeration, renewable/inexhaustible energy sources, energy conservation/legislation, cogeneration/heat reclamation, Design, installation and operation computer controlled Energy Management Systems Automation.

IEGR 575: Computer Integrated Manufacturing
Three Hours: 3 Credits
Overview of the functions, processes, and disciplines of computer-integrated manufacturing. Topic include automation and computer integrated manufacturing, computer aided process planning, group technologies, hierarchical computer control, information systems and processing, computer communications systems and software, computer networks, design, assembly, machining and control nodes. Current issues, emerging technologies, and future developments in computer integrated manufacturing.

IEGR 576: Principles of Manufacturing Information System
Three Hours: 3 Credits
Introduction to the theory and concepts of information for manufacturing organization and management of information within a manufacturing enterprise, database systems, information-based planning and management tools, electronic data interchanges. Design of manufacturing systems such as MRP, SERS, CAD/CAM, etc. Concerns of integration machine interface in manufacturing systems.

IEGR 577: Computational Heat and Fluid Engineering
Three Hours: 3 Credits
Engineering applications of computational heat and fluid engineering, computational methodology for the closed/open systems, heat balance and loss in circular pipes, variation of atmospheric by in-viscid flows are outlined and the relevant numerical methods are introduced.

IEGR 585: Occupational Safety Engineering
Three Hours: 3 Credits
Design and modification of machinery and products to eliminate or control hazards arising out of mechanical, electrical, thermal, chemical, and motion energy sources. Application of retrospective and prospective hazard analysis, systems safety performance and measurement, accident prevention philosophies, expert systems and accident reconstruction methodologies. Case studies include industrial

machinery and trucks, construction and agriculture equipment, and auto-mated manufacturing systems and processes.

IEGR 590: Advanced Topics in Industrial Engineering

Three Hours: 3 Credits

Advanced topics in industrial engineering areas will be selected and taught including manufacturing & production systems, reliability & quality engineering and ergonomics& human factors engineering, energy systems and information engineering.

IEGR 595: Engineering for Profit

Three Hours: 3 Credits

This is an interdisciplinary course in the development and application of tools, methods, and resources to provide engineering students with an entrepreneurial look at the business side of the engineering profession.

IEGR 603: Supply Chain and Logistics Management

Three Hours: 3 Credits

In-depth study on the discipline and philosophy of logistics and supply chain management with the high-level strategy design and concepts utilizing the analytical and mathematical tools to solve simultaneous cost reduction and service enhancement problems. Within the strategic framework of supply chain and logistics management, topics like inventory, transportation information and facilities oriented philosophies and techniques will be explored as knowledge integration of logistics and supply chain methodologies.

IEGR 605: Integer Programming and Network Models

Three Hours: 3 Credits

Network flow models and applications. Algorithms for the shortest path, minimum cost f low and maximum f low problems. Integer programming models and formulation. Computational complexity of integer programming problems. Lagrangean duality theory, branch and bound techniques, cutting planes and hybrid algorithms. Application of these methods to facility location and traveling salesman problems. Study of special techniques for selected topics such as vehicle routing, set covering and network design problems.

IEGR 606: STRUCT & INFO SECURITY

Three Hours: 3 Credits

This is a course suitable for students that need an understanding of information security and its critical role in business - technical and non-technical alike. Those students that might be contemplating a career in information security will find this course to be well worth their while. Topics to be covered include: Developing and implementing an information security education program, Developing and implementing information security policies and Developing procedures for assessing and controlling risk, Factors that drive the need for information security, Identifying and assessing risks, Legislative/legal aspects of information security, Risk management and Technical and administrative controls.

IEGR 610: Advanced Sequence & Scheduling

Three Hours: 3 Credits

Optimization techniques in sequencing and scheduling problems including linear, nonlinear and integer programming models; discussions on combinational nature of the problem and NP-hard type of problems; Advanced simulation techniques for real world sequencing and scheduling problems, case studies.

IEGR 615: Advanced Engineering Optimization
Three Hours: 3 Credits
Techniques and strategies useful in engineering design, operation, and analysis. This course introduces and develops the practical aspects of optimization methods at a level suitable for engineers.

IEGR 617: Topics in Computer Aided Design
Three Hours: 3 Credits
A study of advanced topics in Computer Aided Design (CAD) theory that are applied to translate and interoperate the design, manufacturing and production intents as constraints, design-history and parameterization. Advanced theories and practices of geometrical modeling will be addressed. The application and theories of tolerancing in designing, manufacturing, and inspection will be approached including ANSI Y14.5M standards on Geometric Dimensioning and Tolerancing (GD&T). Developments in the standards of interpretability between CAD systems including ISO 10303+, STEP, ENGEN as extensions of PART 42 of ISO standards will be explored.

IEGR 620: Nonlinear Programming
Three Hours: 3 Credits
Theoretical development of solution methods in nonlinear programming including manifold suboptimzation, convex simplex, reduced gradient, gradient projection, feasible direction, cutting plane, and penalty function methods. Investigation of convergence of algorithms. Methods of solution for integer programming problems including cutting plane methods, enumerative techniques, and dynamic programming methods.

IEGR 625: Stochastic Processes
Three Hours: 3 Credits
A survey course of stochastic processes with an emphasis on applications in engineering, management science, and physical sciences. Topics covered include radome walk, Markov and Poisson processes, renewal theory, and stationary processes, illustrated with examples in queuing theory, inventory control, time series and random noise.

IEGR 635: Advanced Robust Design
Three Hours: 3 Credits
This course will provide useful techniques for product and manufacturing process design. It has three basic steps: system design, parameter design, and tolerance design. Quality can be built into product into products through design. The methodology is based upon quality loss function, experimental design and orthogonal arrays, etc. Prerequisite: IEGR 535 or equivalent.

IEGR 636: Time Series Analysis and Forecasting Systems
Three Hours: 3 Credits
Time and frequency domain aspects of time series are developed in a mutually reinforcing fashion. Behavior patterns of time series are examined with a view toward model identification and forecasting. The statistical procedures for model estimation are presented and employed. Multiple time series concepts and problems are introduced. The BoxJenkins approach is emphasized.

IEGR 640: Reliability
Three Hours: 3 Credits
Probabilistic models underlying reliability and life testing analysis. Structural and reliability properties of coherent systems, exact system reliability and approximation, parametric families of life distribution and their characterizing models, homogeneous and non-homogeneous Poisson processes, mixtures of distributions, competing risk and multiple failure mode models, accelerated life testing models, regres-

sion and partial likelihood models, types of censoring, multiple failure mode analysis. Inference procedures, including graphical analysis for various parametric models and for complete and censored samples. Applications in engineering, biometry, and actuarial science.

IEGR 659: Work Physiology
Three Hours: 3 Credits
The study of cardiovascular, pulmonary and muscular responses to industrial work including aspects of endurance, strength, fatigue, recovery and energy cost of work. Utilization of physical work capacity and job demand for task design, personnel assignment and assessment of work-rest scheduling.

IEGR 660: Occupational Biomechanics
Three Hours: 3 Credits
Introduction of the mechanical behavior of the musculoskeletal system as related to physical work activities in industry. Fundamentals of human body mechanics, physical fatigue and musculoskeletal injury mechanism with application to design of physical work activities.

IEGR 662: Rapid Prototyping II
Three Hours: 3 Credits
Students, individually or in groups, develop a small-scale rapid prototyping team to address the need for a rapid prototype of a component or set of components relevant to an engineering subject. Students are given a fixed budget and a target time for completion of prototype. Problem identification, ideation and refinement; problem analysis; decision processes; advanced sketching and computer-aided design; applications of advanced solid-modeling, using a robust parametric modeler; introduction to graphical file transfer protocols for sharing design information arnung4eam members; advanced prototype production methods; production of prototypes using as stereo lithography system.

IEGR 663: Nontraditional Manufacturing Processes
Three Hours: 3 Credits
Analysis of the processes, sensors, machine tools, and control systems in nontraditional manufacturing processes. Processes include abrasive jet machining, water jet machining, abrasive water jet machining, abrasive flow machining, ultrasonic machining, ultrasonic welding, high energy rate forming, electrochemical machining, electrochemical grinding, electrochemical discharge machining, electrostream drilling, shaped-tube electrolytic machining, chemical machining, electrical discharge machining, electrical discharge wire cutting, electrical discharge grinding, electron beam welding, electron beam machining, laser processing, plasma arc cutting, and thermal energy (deburring) method.

IEGR 670: Advanced Production & Operations Management
Three Hours: 3 Credits
An advanced study of production management techniques applied to control the operation of production and manufacturing systems. Advanced theories and practices of forecasting and inventory control including definitive, statistical and mixed behavior. The planning process will be approached at the aggregation of a master production schedule will be intensively explored including the unique approach of MRP. Methods of Operation sequencing and scheduling techniques under resource constraints including BHR&S. The future of production analysis and control with the use of recent developments in FMS, ASIRS, AGVS theories and applications.

IEGR 678: Engineering Design Process

Three Hours: 3 Credits

Definition of design, the design process and its considerations, managing design projects, modeling and simulation, design analysis for material selection, economic analysis in design, optimization in design, statistical decisions, design for reliability, safety and environmental protection, engineering ethics characterization.

IEGR 680: Advanced Product Design

Three Hours: 3 Credits

This course will provide determination of feasibility of design idea, and decision processes for choosing better design alternatives. Case studies will include the planning and creation of successfully engineered designs.

IEGR 686: Industrial Engineering Applications in Health Systems

Three Hours: 3 Credits

Description of the health care system and its resource components, accessibility, availability, distribution, and cost. Health system inputs, processes, and outputs. Applications of industrial engineering to health care management problem. Hospital management, forecasting, managerial control, facility planning, resource allocation and information systems.

IEGR 690: Enterprise Resource Planning

Three Hours: 3 Credits

The various topics include MRP (Material Requirements Planning), MRP II (Manufacturing Resources Planning), and Flow Manufacturing, Time as a competitive weapon (TCW) Theory, Just-In-Time Principles, Inventory Management and Theory of Constrains (TOC) philosophy. Prerequisite: IEGR 512 and EEGR 505 or consent of instructor.

IEGR 788: Seminar I

One Hour: 1 Credit

The Course is designed to provide a multidisciplinary approach to the integration of engineering disciplines and technologies. The primary objective is to demonstrate to the students how important it is, in the professional world, to work together as a team in terms of solving practical engineering problems. The students will be exposed to practical applications that focus on their academic interests but tempered by ideas coming from other disciplines. This will be accomplished by having guest speakers, special assignments, project-oriented discussions, and self-study activities.

IEGR 789: Seminar II

One Hour: 1 Credit

The course is designed to provide a multidisciplinary approach to the integration of engineering disciplines and technologies. The primary objective is to demonstrate to the students how important it is, in the professional world, to work together as a team in terms of solving practical engineering problems. The students will be exposed to practical applications that focus on their academic interests but tempered by ideas coming from other disciplines. This will be accomplished by having guest speakers, special assignments, project-oriented discussions, and self-study activities.

IEGR 790: Research in Design and Manufacturing
Three Hours: 3 Credits
Introduce the graduate students to the research topics in the important design and manufacturing area. Through this course, the students can conduct timely and topic engineering research, perform industrial design and analysis.

IEGR 791: Independent Study in Industrial Engineering
Three Hours: 3 Credits
A program of research consisting of directed reading and for laboratory work under the direction of a graduate faculty member. In accordance with an agreed upon plan and culminate in a report paper.

IEGR 792: Directed Research in Industrial Engineering
Three Hours: 3 Credits
A research topic conducted by the guidance of a graduate faculty member. In accordance with an agreed upon plan and culminate in a report paper.

IEGR 795: Project Report I
Two Hours: 2 Credits
Project report I is to let students learn how to prepare a real project. This course emphasizes the analysis and the design of a specific industrial engineering problem under the guidance of a faculty advisor.

IEGR 796: Project Report II
Two Hours: 2 Credits
Project report II is to let students learn how to conduct a real project. This course emphasizes the analysis and the design of a specific industrial engineering problem under the guidance of a faculty advisor. **Each student taking IEGR 796 is expected to have published or submitted (at least) a paper on the research project to a professional journal or a refereed conference proceedings.**

IEGR 997: Dissertation Guidance
Three Hours: 3 Credits
Dissertation guidance provides students, who have not completed their dissertation in the assigned semester, a mechanism for continuing their work under faculty supervision.

IEGR 998: Dissertation Seminar
Six Hours: 6 Credits

INSTITUTE FOR TRANSPORTATION COURSES

Chairperson of Department: PROFESSOR ANTHONY A. SAKA; Associate Professor: YOUNG-JAE LEE; Associate Professor MANSOUREH JEIHANI; and Assistant Professor: CELESTE N. CHAVIS

TRSP 513: Transportation Internship

Three Hours: 3 Credits

This course provides practical experience in the field of transportation and an opportunity to apply transportation technical skills to real-world situations by placement with a transportation agency or organization. It is designed for students selected for the MSU-MDOT Internship Program or other similar internship and co-op programs.

TRSP 514: Advanced Transportation Internship

Three Hours: 3 Credits

This course reinforces the experience gained in the first part of the internship course. Prerequisite: TRSP 513 or permission of the instructor. .

TRSP 601: Introduction to Transportation Systems

Three Hours: 3 Credits

This course is the introductory course for urban transportation systems. It will present historical, physical, economical, social, and environmental aspects of urban transportation systems. Common transportation problems in urban areas will be diagnosed, and potential solutions will be discussed in the context of policy, planning, engineering, and design.

TRSP 602: Economics of Transportation

Three Hours: 3 Credits

This course focuses on the microeconomic tools necessary for understanding, analyzing, and managing transportation firms and industries. The course is a mix of theoretical tools and applied industry studies. The major subjects covered in this course include costs, pricing behavior, regulation, intermodal competition, technological advances, and strategic decision making. Prerequisite: college algebra or equivalent.

TRSP 603: Quantitative Methods in Transportation

Three Hours: 3 Credits

This course reviews statistical analysis and probability models relevant to transportation systems analysis and modeling. Discussions include descriptive statistics, regression and correlation analysis, hypothesis testing using parametric and nonparametric statistics, probability distribution models, vehicular flow theory, and gap and queue analysis. Prerequisite: college algebra or equivalent.

TRSP 604: Operations Research Applications in Transportation

Three Hours: 3 Credits

This course will cover important optimization techniques such as linear programming, dynamic optimization and network analysis. The applications of these techniques in transportation and pertinent computer software will be discussed.

TRSP 605: Transportation and Land Use Planning

Three Hours: 3 Credits

This course deals with the basic concepts, principles, strategies, and tools of local-level urban land use planning. The focus is on the real-world planning process and implementation and its relationship with transportation planning. A land use planning software is utilized to practice transportation and land use planning.

TRSP 606: Urban Public Transportation Systems
Three Hours: 3 Credits
This course will cover the various fields of urban public transportation including technology, planning, operation, management, and policy. The application of new technology will be emphasized.

TRSP 607: Freight Transportation Systems and Logistics
Three Hours: 3 Credits
This course discusses the modes for freight transportation and their operations. The course provides the basic concepts of supply chain management, including customer service, transportation, inventory, location, etc. The relationship between components of the supply chain management is also examined.

TRSP 608: Advanced Logistics and Supply Chain Management
Three Hours: 3 Credits
This course offers analytical tools for supply chain management, including linear programming, manufacturing procedure, network analysis, inventory management, location theory, etc. This course consists of computer sessions, case studies and seminars. Prerequisite: TRSP 607

TRSP 609: Transportation in Developing Countries
Three Hours: 3 Credits
This course provides an opportunity for in-depth examination of transportation issues as they relate to developing countries. This course deals with problems, issues, policies, and solutions of transportation systems and the development process.

TRSP 610: Management of Transportation Systems
Three Hours: 3 Credits
This course is designed to familiarize the student with some of the tools and skills required for mid- level and senior managers in the transportation industries. It will focus on managerial issues and problems.

TRSP 611: Labor Relations in Transportation
Three Hours: 3 Credits
This course will examine the relationship between the transportation industry and its organized or union employees. Special attention will be given to labor-management cooperation to enhance employee productivity and, concurrently, meet employee needs of increased wages, better working conditions, etc. The major problems and issues in collective bargaining and negotiation will also be examined.

TRSP 612: Special Problems in Transportation
Three Hours: 3 Credits
This course provides the opportunity to students to examine special topics of interest in transportation. They may include: Air & Water Transportation, Transportation Safety, Highway and Traffic Systems Design and Analysis, Transportation & Environmental Issues, Transportation Policy, Transportation & Energy Conservation, Transportation & Spatial Interaction, and other emerging transportation issues.

TRSP 613: Air Quality Planning and Noise Analysis
Three Hours: 3 Credits
This course provides the fundamental understanding of air quality concepts, analytical models, and

problems encountered when complying with Federal air quality planning/analytical requirements. The main objective is to acquaint students with air quality analysis techniques used in transportation/air quality planning.

TRSP 614: Air and Sea Port Management
Three Hours: 3 Credits
This course provides students with an understanding of the planning, management and operations of transportation hubs. Master planning and its impacts on management facilities are covered from beginning to end. The course focuses on the relationship between the planning process and the needs of management in operation of the facility.

TRSP 615: Traffic and Highway Systems Design & Analysis
Three Hours; 3 Credits
This course is designed to expose the students to commonly used analytical and design techniques in transportation engineering. The course comprises two major modules: Design (including highway geometric, pavement and drainage design concepts), and Traffic operations (including traffic flow parameters, capacity analysis, safety analysis, and traffic control devices). Prerequisite: TRSP 601 or permission of the instructor.

TRSP 616: Microcomputer Applications in Transportation
Three Hours: 3 Credits
This course is designed to provide an introduction of microcomputer applications appropriate for solving problems in transportation planning and management. The course is offered as a hands-on computer course. Students will be exposed to several state-of-the-art software packages that are commonly used by transportation professionals. The emphasis of this course is on familiarization with software, computers, and analytical techniques used by transportation professionals from a wide spectrum of fields.

TRSP 617: Intelligent Transportation Systems
Three Hours: 3 Credits
This course presents fundamental knowledge on various areas of Intelligent Transportation Systems. It covers diverse areas such as traffic flow and traffic fundamentals, ITS user services and applications, regional ITS architecture, ITS planning, ITS standards, and ITS evaluation.

TRSP 618: Advanced Urban Transportation Planning
Three Hours: 3 Credits
This course discusses the traditional four-step planning process and the respective mathematical models and algorithms. Hands-on experience with state-of-the-art travel demand simulation, noise, and air quality analysis software will be emphasized. . Prerequisite: TRSP 601.

TRSP 619: Geographic Information Systems
Three Hours: 3 Credits
This course is designed to expose students to the concepts of spatial analysis using GIS tools. Students learn how to develop and use a GIS-based decision support system. State-of- the-art software is used to expose students to current tools available to produce quality GIS output.

TRSP 620: Transportation Systems Evaluation
Three Hours: 3 Credits
This course will familiarize the students with the commonly used quantitative and qualitative techniques

in transportation systems analysis and evaluation. Students will be involved in capacity analysis of transportation systems (including transit, highways, intersections, and pedestrian facilities), transportation planning process, economic analysis, multi-objective decision making, methods of evaluation, and feasibility analysis. This course will also provide computer sessions to expose students to state-of-the-art software applications

TRSP 623: Urban Infrastructure Planning and Management
Three Hours: 3 Credits
This multidisciplinary course will expose the student to the various components of critical urban infrastructure, with a primary focus in transportation infrastructure planning and management processes; and supplemental discussions in sewer, water, energy, and telecommunication distribution systems.

TRSP 625: Transportation Policy
Three Hours: 3 Credits
This course introduces students to the development, analysis and implementation of U.S. transportation policy. It focuses on how potential ideas for government action about transportation are translated from concepts into reality. It covers principal issues, programs, concepts, decision-making processes, and institutional relationships. A broad conceptual framework to understand how policy is formed at the federal, state, and local level will be analyzed.

TRSP 701: General Systems Theory
Three Hours: 3 Credits
This course introduces students to the concept and types of systems, and application of systems-based solution approach in transportation and urban infrastructure planning and management.

TRSP 717: Advanced Intelligent Transportation Systems
Three Hours: 3 Credits
This course exposes students to high-level simulation and communications tools for modeling connected vehicles, including vehicle-infrastructure interface (VII), vehicle-vehicle interface (VVI), adaptive traffic signal systems, driver response to traveler information systems, and multimodal transportation systems safety and security.

TRSP 725: Advanced Policy Analysis
Three Hours: 3 Credits
This course, built on materials discussed in TRSP 625, simulates a think-tank environment for analyzing complex issues, using landmark transportation and infrastructure policy decisions as case studies. Students will be exposed to quantitative tools for analyzing complex issues.

TRSP 788: Supervised Research
Three Hours: 3 Credits
This course is designed to enable the student to participate in meaningful and rigorous research in transportation. Under the supervision and direction of a faculty member, the student will develop a research proposal with extensive review of literature that may serve as a framework for thesis or dissertation in an area of interest. This provides an opportunity to apply quantitative methods and models to analyze specific transportation problems.

TRSP 790: Independent Study in Transportation
One to Three Hours: 1-3 Credits
This course enables the student, under the tutelage of a graduate faculty, to undertake independent study on timely and practical transportation problems/issues not directly or extensively addressed by other courses in the curriculum.

TRSP 795: Transportation Project I
Two Hours: 2 Credits
This is the first of a two-part course that enables the student, under the tutelage of a faculty member, to develop a detailed proposal for an original research on timely and practical transportation topic.

TRSP 796: Transportation Project II
Two Hours: 2 Credits
This is the second of a two-part course that enables the student, under the tutelage of a faculty member, to complete an original research on timely and practical transportation problems/issues.

TRSP 797: Thesis Guidance
Three Hours: 2 Credits
Thesis guidance provides students who have not completed their thesis in the assigned semester, a mechanism for continuing work under faculty supervision.

TRSP 799: Thesis Seminar in Transportation
Three Hours: 3 Credits
This course is for students conducting research and writing a thesis under faculty supervision.

TRSP 889: Contemporary Global Issues in Transportation and Urban Infrastructure
Three Hours: 3 Credits
This course exposes students to timely global issues and emerging paradigms in transportation and infrastructure planning, design, and management. Topics covered include adaptive and sustainable urban infrastructure systems, emergency-response transportation planning and management, transportation-energy infrastructure nexus, and innovative infrastructure financing methods.

TRSP 988: Doctoral Research Seminar I
One Hour: 1 Credit
This is the first part of a seminar sequence that provides the forum for information exchange and synergized initiatives amongst doctoral students, the faculty, and professionals, including development of dissertation proposals and presentation of research activities.

TRSP 989: Doctoral Research Seminar II
Two Hours: 2 Credits
This is the second part of a seminar sequence that provides the forum for doctoral students at the advanced stage of their dissertation research to partake in research symposium and pedagogical activities for peer and faculty evaluation.

TRSP 996: Directed Dissertation Research
Three Hours: 3 Credits
This course enables students to undertake supervised research directed towards their dissertation. Students will undertake extensive review of literature and explore available technological tools and other pertinent resources for developing their dissertation proposal.

TRSP 997: Dissertation Guidance
Three Hours: 3 Credits
This course enables students who have taken but not met all of the requirements of the Dissertation Seminar course to continue research on their doctoral dissertation and have access to the resources of the University.

TRSP 998: Dissertation Seminar
Six Hours: 6 Credits
This course requires the student to conduct high-level and original research for completing a doctoral dissertation that addresses timely transportation related issues.