Preface

This handbook is based on the policies and procedures of the University at Buffalo (SUNY), the School of Engineering and Applied Sciences, and the Department of Industrial and Systems Engineering as of Sept. 1, 2015. These policies are subject to change.

No person, in whatever relationship with the University at Buffalo (UB), shall be subject to discrimination on the basis of age, creed, handicap, national origin, race, religion, sex, marital or veteran status.
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INTRODUCTION

This Handbook represents an effort to address in a single place some of the questions most frequently asked of advisors by graduate students in the Department of Industrial and Systems Engineering at the University at Buffalo, SUNY. It also contains answers to a number of questions that are not so frequently asked, but that should be.

Some of the information provided here also appears in other publications. Other booklets that should be consulted by graduate students include the following and are also available online at www.grad.buffalo.edu:

- Graduate Student Manual: Policies and Procedures for Graduate Students, Graduate School, University at Buffalo (SUNY).
- Handbook for Graduate Assistants and Fellowship Recipients, Graduate School, University at Buffalo (SUNY).
- Student Rules and Regulations, Division of Student Affairs, University at Buffalo (SUNY).

Regulations for Industrial Engineering Graduate Students originate from a variety of sources including the Department of Industrial and Systems Engineering, the School of Engineering and Applied Sciences (SEAS), the Graduate School, and the University as a whole. SEAS and the Department of Industrial and Systems Engineering may have degree requirements in addition to those listed in booklets published by the Graduate School and the University. With so many different offices promulgating rules which affect your academic life, there is apt to be the rare occasion when two different regulations exist for the same situation. The general rule is: In those cases where there appears to be a conflict in requirements listed in various publications, the student must satisfy the most rigorous of those requirements.

If you have any questions about your program which cannot be adequately answered by university publications or your advisor, please contact the Director of Graduate Studies or the Department Chair. They should be able to provide the answers, or direct you to someone in the university who can handle your problem.

In due time, you will be assigned office space, if you have assistantship duties. If you have been offered financial aid, you will also learn before the end of the first week of classes what your teaching or research assistantship duties are, and you will need to complete some payroll forms. The Department Secretary (room 438 Bell) will provide you with the paperwork and can answer questions related to payroll.

You should also obtain an e-mail account. The department, your advisor and your colleagues will regularly use this method for communicating with you. This is the preferred method of communication at the university, so please regularly check your UB email account.
PLANNING YOUR PROGRAM

The Department of Industrial and Systems Engineering offers the following graduate degree programs:

- **Doctor of Philosophy (Ph.D.)**
  - Human Factors Engineering/Ergonomics Specialization
  - Operations Research Specialization
  - Production Systems Engineering Specializations

- **Master of Science (M.S.) in Industrial Engineering**
  - Human Factors Engineering/Ergonomics Specialization
  - Operations Research Specialization
  - Production Systems Engineering Specialization
  - Industrial Engineering

- **Master of Engineering (ME.) in Industrial Engineering** *(PROGRAM NOT OFFERED TO NEW STUDENTS)*
  - Production Management Concentration
  - Five-Year B.S./M.Eng. in Industrial Engineering concentration in Production Management

Each of the Industrial Engineering graduate programs has its own set of requirements. Since the graduate student is ultimately responsible for ensuring that all requirements are met, you should familiarize yourself with the rules for your particular degree program.

New students will receive initial academic advisement during the Graduate Student Orientation before fall courses begin. Later, graduate students in the M.S. and Ph.D. programs choose an academic advisor consistent with the field of specialization. The Director of Graduate Studies serves as academic advisor for the remaining programs.

Your letter of admission specified whether you were admitted to the Master of Engineering, Master of Science, or Doctor of Philosophy program. Within each program, you may switch from field to field with the consent of your advisor and the Director of Graduate Studies. However, in order to change degree programs (e.g., Master of Science to Doctor of Philosophy), you will need to make a formal application using forms available from the Department.

2.1 YOUR ADVISORY COMMITTEE

Some students will complete a M.S. thesis or Ph.D. dissertation. Once a student has decided the topic for the MS thesis or Ph.D. dissertation, he/she must select, with mutual agreement, an academic advisor. In the parlance of the Graduate School, the academic advisor serves as the chair of the student’s committee and is the student’s major professor. The chair of the committee must be a member of the Graduate Faculty. It should be stressed that there is no linkage between the initial academic advisor and the major professor. While the initial academic advisor for a student could become the student’s major professor, this is not necessarily the case. A student should feel free to select (with mutual consent) any faculty member in the department as their major professor.

The following describes committee requirements for graduate students:

- **M.S. thesis student**: One faculty member (committee chair) from the department who is also a member of the Graduate Faculty.
- **M.S. non-thesis student**: One faculty member (committee chair) from the department who is also a member of the Graduate Faculty.
- **Ph.D. student**: The chair of the committee must be a faculty member from the department who is also a member of the Graduate Faculty. In addition, there needs to be two faculty members from the university who are also members of the Graduate Faculty.

Note: A student can always elect to have more faculty members on their committee than specified. These additional committee members do not have to be members of the Graduate Faculty or even faculty at UB.

When you initially form your advisory committee or make a change in its membership, you need to inform the department and all of the members of your old and new committees. In order for the change to become effective, a Change of Committee Form, available from the department, must be signed by all of the old and new committee members, and submitted to the Director of Graduate Studies.
2.2 PREPARING YOUR PROGRAM

Students are required to see academic advisors at the beginning of every semester. Prepare for your appointment by familiarizing yourself with the degree requirements for your program and with the course offerings for the upcoming semester. Degree requirements are described later in this handbook for each degree program. Course offerings are published by the university each semester on its website.

Make a list of courses that seem appropriate for you. If you are a full-time student with teaching or research assistantship duties, a normal load is three or four courses. In the absence of such duties, taking one additional course is typical. Make an appointment and see your academic advisor to verify that your course selection is appropriate.

2.3 WAIVERS OF COURSE REQUIREMENTS

Your academic advisor has the authority to waive departmental course requirements in areas in which the student is especially well prepared. There are several things you should know about such waivers. The first is that a course waiver does not reduce the number of credit hours needed to fulfill degree requirements—it merely allows you to substitute an elective course for a required one. The second is that even if a core requirement is waived, you are nonetheless responsible for the course content if you take the B-Exam or C-Exam (see Section 4.9). If your academic advisor grants a waiver, be sure that he or she remembers to put the waiver approval into your departmental file in writing. A dated, handwritten note will suffice; the main thing is to have the waiver clearly documented for the person(s) who must eventually approve your Application to Candidacy (see Section 6.1) before your degree is conferred.

2.4 TRANSFER CREDIT

If you have completed graduate work at another institution, your academic advisor may decide to allow transfer credit for some of that work, within certain guidelines:

- A maximum of 6 transfer credits of course work may be applied toward the 30 credit-hour requirement for the Master’s degree.
- A maximum of 36 transfer credits may be applied toward the 72 credit hour requirement for the Ph.D. degree.
- Only courses applicable to the degree being sought are acceptable.
- Only those graduate courses completed with grades of B or better are eligible for consideration as transfer credit.

Your academic advisor will examine any previous transcripts on a course-by-course basis to determine which courses are appropriately applicable to a graduate degree in Industrial Engineering.

As with waivers of course requirements, be sure that your academic advisor puts any transfer credit decisions into your departmental file in writing.

2.5 INFORMAL COURSES

Graduate students may have the opportunity to take what are often called informal courses. These courses are not taught on a regular basis or are customized for the student, and thus may not appear in the University course catalog. Informal courses usually include Independent Study, Individual Problems and Special Topics courses.

If you and a member of the faculty share an interest in a topic that is not a part of the department’s formal course offerings, you may wish to investigate the possibility of completing an individual course for academic credit. If the faculty member agrees to supervise your work, you should register for IE 501 (Fall) or IE 502 (Spring) if you are an M.Eng. or M.S. student, or for IE 601 (Fall) or IE 602 (Spring) if you are a Ph.D. student. These courses are variable credit offerings, and require the written consent of the instructor. Do not sign up for such a course without first talking to the instructor.

There are several special regulations regarding the use of informal courses as a part of a student’s program:

- Informal courses require a complete narrative description on a form available from the department for this purpose. The form requires the signatures of the student, instructor and the Director of Graduate Studies. A copy of this form must be included in the student’s Application to Candidacy (see Section 6.1).
- A maximum of six credit hours of informal course work may be applied toward the minimum 30 credit-hour requirement for the Master’s Degree.
- Excluding those credits applied toward the Master’s degree, a maximum of six additional credit hours of informal course work may be applied toward the minimum 72 credit-hour requirement for the Ph.D. degree.

Credits in the following courses are not applicable toward the minimum requirements for the Master’s and Ph.D. degree programs: Supervised Teaching, Supervised Research, and Departmental Seminar.
2.6 GRADUATE CREDIT FOR UNDERGRADUATE COURSES

On rare occasion, a student will find a special undergraduate course which would be particularly beneficial to be included in his or her graduate program, but unavailable as a graduate course. In order to receive credit for such a course, the student must strictly follow these regulations:

- Students wishing to use an undergraduate course for graduate credit must file a petition during the first week of class to the Graduate School for approval. Copies of these petitions must be included in the Application to Candidacy. Retroactive approval will not be granted. Remedial courses, to make up for deficiencies in a student's undergraduate background, will not be allowed.
- Such courses must be limited to a maximum of two advanced undergraduate courses at the 400 level. This maximum limit applies to the student's entire Master's and Ph.D. degree program.
- Undergraduate courses which carry four or more semester hours of credit will receive a maximum of three semester hours of graduate credit.

2.7 THE DEPARTMENTAL SEMINAR

The Department’s seminar series meets approximately once a week. A typical seminar consists of an one-hour presentation by a visitor or faculty member, preceded by refreshments. Remember that while you are a graduate student, you are a member of a community of scholars. The participation in exchanges of ideas, even outside your area of concentration, is integral to the community's vitality.

2.8 PART-TIME STUDY

A number of required or key elective courses are offered each semester at times particularly convenient to part-time students. Such courses meet twice a week and start at 3:00 p.m. or later. Occasionally, a student will need to be on campus earlier for a specific elective course that is desired. For part-time students, completing two courses each semester is considered a normal rate of progress. The ability to take courses throughout the day is essential to the successful completion of the Ph.D. program. Although the Ph.D. program may be entered on a part-time basis, the department encourages full-time participation. A minimum of one year of study on a full-time basis is a requirement of the department and of the university for Ph.D. study.
THE DOCTOR OF PHILOSOPHY IN INDUSTRIAL ENGINEERING PROGRAM

The Ph.D. program provides an advanced level of study and training for the development of research scholars. Students graduate from the program having demonstrated, by means of their dissertations, their ability to make original and significant contributions to the fields of

- Human Factors Engineering/Ergonomics
- Operations Research, and/or
- Production Systems Engineering.

3.1 ADMISSION TO THE Ph.D. PROGRAM

Students may be admitted to the Ph.D. program if they hold a bachelor’s or master's degree in engineering or any of the mathematical, physical, behavioral, or health sciences. Admission to the Ph.D. program requires a demonstration of high levels of performance in previous academic studies and unusual promise for making significant research contributions. Those students who are admitted directly to the Ph.D. with a bachelor's degree will have the option to earn an M.S. degree during their course of study.

A student who is currently enrolled as an M.S. student can apply to the Ph.D. program at any time. Consideration for admission to the Ph.D. for M.S. students is not automatic—the student must apply. A suitable time might be during second semester of graduate study before taking the Ph.D. Breadth Exam; see Section 3.4. If the information available to the admissions committee is insufficient for an accurate appraisal of your candidacy, you may be asked to reapply.

The Ph.D. committee may solicit written comments on your application from all Departmental faculty members, check your record in all courses taken, review your performance on the Core Exam, and look for evidence of your potential for research (e.g., an M.S. thesis or other independent work).

The application to the Ph.D. program by students currently enrolled in the M.S. program should be in the form of a letter, addressed to either the Director of Graduate Studies or the Department Chair, that requests consideration for admission to the Ph.D. program. The letter should be submitted to the Departmental Graduate Secretary.

3.2 COURSE REQUIREMENTS

Each Ph.D. student must select an initial area of specialization among Human Factors Engineering, Operations Research or Production Systems Engineering. The student’s basic course requirements depend on the selected area of specialization.

These are only basic course requirements. Many Ph.D. students will take additional courses from all of the disciplines represented in the program.

Those students who enter the program with advanced degrees will be able to transfer credits for previous work and thereby reduce the number of required courses. After reviewing the student’s academic record, the academic advisor may grant transfer credits in writing and enter them into the university records.

A maximum of 30 credit hours may be transferred from an M.S. degree or other graduate work. Students may apply those credits to waive the course. However, students are still responsible for course content in those courses included on the Ph.D. core examination.

3.2.1 Specialization in Human Factors/Ergonomics

In addition to two fundamental research courses, students select at least three other 500-level core content courses at the 500-level:

**Fundamental Research Courses (6 credits):**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>IE 507</td>
<td>Design and Analysis of Experiments (3 credits)</td>
</tr>
<tr>
<td>IE 531</td>
<td>Research Methods (3 credits)</td>
</tr>
</tbody>
</table>

**Content Courses (9 credits) - 3 of the 4**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>IE 532</td>
<td>Human Informational Processing</td>
</tr>
<tr>
<td>IE 535</td>
<td>Human-Computer Interaction</td>
</tr>
<tr>
<td>IE 536</td>
<td>Physiological Foundations of Human Factors</td>
</tr>
<tr>
<td>IE 541</td>
<td>Human Factors in Safety</td>
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</tbody>
</table>
3.2.2 **Specialization in Operations Research** The following courses are required for the Ph.D. degree with a concentration in operations research:

- IE 572  Linear Programming
- IE 573  Discrete Optimization
- IE 575  Stochastic Methods
- IE 576  Applied Stochastic Processes
- IE 5XX  IE Elective (selection requires faculty approval)

3.2.3 **Specialization in Production Systems Engineering** The following courses are required for the Ph.D. degree with a concentration in production systems engineering:

- IE 504  Facilities Design
- IE 505  Production Planning and Control
- IE 506  Computer-Integrated Manufacturing
- IE 551  Simulation
- IE 5XX  IE Elective

Although not required, IE 509 (Six Sigma) and IE 508 (Quality Assurance) is strongly recommended as an elective content course for students in the Production Systems Engineering Specialization.

3.3 **CREDIT HOUR REQUIREMENTS**

Beyond the basic requirements, the courses taken in a Ph.D. program are determined by the student's objectives, interests, background and experience.

The equivalent of at least three years of full-time graduate study beyond the baccalaureate degree is required for completion of the Ph.D. program. At least one year must be in full-time residence. In general, formal coursework, including that taken for the M.S. degree, takes two or three years. The dissertation effort demands, in general, require at least one year of full-time concentration in residence. The Ph.D. program requires a minimum of 72 credit hours of work.

SEAS and the Department of Industrial and Systems Engineering impose limits on dissertation credits which are applicable toward graduate degree requirements. Additionally, a maximum of 30 credit hours from a Master's degree may be applied toward the 72 credit hour requirement for the Ph.D. degree. Of these, no more than six credit hours may be derived from a Master's Thesis.

A minimum of 12 credit hours of dissertation research is required. At most 24 hours of dissertation credit may be applied towards the degree. The variable credit dissertation exists to allow students flexibility to take additional content courses. It does not impact the expectations for the scope and effort of the dissertation. Hours earned from supervised teaching and research, and the Departmental Seminar do not count toward the 72 hours needed.

3.4 **MAJOR MILESTONES OF THE Ph.D PROGRAM**

Important milestones of the Ph.D. program include: formation of the Ph.D. committee, successful completion of the Breadth and Advanced Examination, proposal defense, and dissertation defense. An approximate timeline for the major milestones is given below.

![Figure 1](https://example.com/figure1.png)  Major Milestones of the Ph.D. Program

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<tbody>
<tr>
<td>Breadth</td>
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<td>Exam</td>
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</table>

<table>
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<tr>
<th>1-2 semesters</th>
<th>3-4 semesters</th>
<th>5-6 semesters</th>
<th>NOTE: Times are approximate and may vary for individual students</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Degree usually earned at or before this time</td>
<td>Ph.D. Committee formed</td>
<td></td>
<td></td>
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</table>

10
The Ph.D. is not a degree conferred on the basis of credit hours accumulated, tests passed, or time elapsed. Students in the program commit themselves to excellence in their fields, and to whatever amount of study and effort the attainment of excellence may require.

3.5 THE Ph.D. BREADTH EXAMINATION (the B-exam)

IMPORTANT: If a student decides not to take the exam, she or he must provide two weeks notice. If notice is not provided within 2 weeks, the exam will be a failed attempt.

The content of the B-exam is based on the most recent offerings of each of the courses for each of the concentrations listed in Section 3.2. It is incumbent upon the candidate to check that the material they prepare before the exam corresponds to that covered in the most recent offerings of each course.

This examination tests the candidate's ability in the broad range of subjects covered by the core courses and selected elective courses. It is required for formal acceptance into Ph.D. candidacy, and is normally taken following the candidate's coursework in core subjects and sufficient electives.

The written portion of the B-exam consists of five separate questions, one on each of the core courses and selected (and approved) electives if required to obtain five questions. The examination is closed-book and is given over a four-hour time period. The department faculty members meet after the written exam is graded and place students in three categories: (a) pass; (b) fail; or (c) undecided. For students in the undecided category only, a take-home question is given to test the ability to integrate concepts and information across core and elective courses. This take-home portion is defended orally several days later before faculty in the candidate's subject area and other departmental faculty. The candidate may prepare written materials and presentation materials for this part of the exam. The department faculty members then decide on the pass/fail status of students who were placed in the undecided category.

Students in each of the three concentrations are required to answer questions from different courses. Students concentrating in human factors/ergonomics answer questions for IE531, IE507 and three IE elective content courses. Students concentrating in operations research answer questions for IE572, IE573, IE575, IE 576 and one IE elective content course. Students concentrating in production systems answer questions for IE504, IE505, IE506 and two elective courses.

Number of Exam Attempts

Students are allowed two attempts to pass the Ph.D. Breadth Exam in order to continue in the Ph.D. program. These attempts will occur at the times specified below (Scheduling of Exam).

Outcome of the Exam

The following outcomes are possible:

a) The student passes the exam and may continue in the Ph.D. program.
b) The student fails the exam for the first time, must take the exam once again.
c) The student fails the exam for the second time and is not allowed to continue in the Ph.D. program. However, the student fulfills the requirement for an M.S. degree.
d) The student fails the exam for the second time and is not allowed to continue in the Ph.D. program.

Once the Ph.D. Breadth exam has been passed, many students will have also satisfied all of the course requirements for the M.S. degree. Hence, the student who passes the exam usually has the option of leaving at any time with an M.S. degree with little or no additional course work. A graduate student is considered to be a candidate for the Ph.D. degree only upon successful completion of the Ph.D. Breadth exam.

Scheduling of Exam

The student should take the Ph.D. Breadth exam as soon as possible after completing all core courses in the area of concentration. Since there is a "most recent offering" policy (i.e., the most recent faculty member to teach a course provides and grades the B-exam question), it is in the student's best interest to find out at an early stage whether continuing in the Ph.D. program is a viable and appropriate option. The Ph.D. B-exam will provide one indication.

More specifically, the first exam attempt occurs as soon as possible after the student has completed the core courses in his or her area, typically after either 2 semester of full-time study (i.e., in May). This means that students have the responsibility to register for all
required core courses as soon as offered. *If a student chooses not to take the exam at that point, the first attempt is lost, and only one attempt at the exam remains.*

The second exam attempt (for students who did not pass, or did not choose to take the first attempt) occurs in August after the first attempt in May.

**Further Information**

Further information and application forms for the exam are made available in March, for the May exam.

### 3.6 THE Ph.D. COMMITTEE

Soon after a student passes the Ph.D. Breadth exam she or he will form a committee of faculty members who will work with the student closely on dissertation research. By the time the student is ready for the Ph.D. Advanced Examination (Prelim) she or he should have determined, at least in approximate terms, a research area, and should have identified a faculty advisor who is willing to supervise the work. This faculty advisor, sometimes called the *Major Professor or Committee Chair*, will ordinarily head the committee that administers the advanced examination, defense of dissertation proposal, and dissertation defense. The *Major Professor* must be a member of the Graduate Faculty. This committee must include at least two other members of the university faculty who hold the rank of Assistant Professor or higher in the University Faculty. The Major Professor can help identify faculty members who share an interest in the topic, and who would be willing to review the dissertation and serve on the examining Committee. A student can always elect to have more faculty members on their Committee than specified. These additional Committee members do not have to be members of the graduate faculty or even faculty at UB. The Ph.D. Committee will play a major role in setting requirements for the successful completion of your program. A student should follow the advice of Committee members very carefully.

In addition, departmental policy allows the committee chair to elect to have an outside reader evaluate the Ph.D. dissertation. The outside reader is not part of the committee.

### 3.7 THE Ph.D. ADVANCED EXAMINATION (PRELIM)

The Ph.D. Advanced Examination, sometimes called the "Prelim" or "A-exam", is taken near the end of formal course work, before substantial dissertation research has begun.

The format of the exam consists of questions from the individual committee members to which written responses are required. Although questions do not necessarily have to pertain to the student's intended dissertation research, one of the exam's purposes is to gauge the student’s capability for pursuing research in his or her area of interest. The Ph.D. committee chair will discuss the precise format of the examination with the student, as well as inform the student of the deadline by which the written portion of the exam should be submitted. Generally, the time taken for the written component cannot exceed one month unless otherwise approved by the committee.

There are three possible outcomes associated with the Advanced Examination: Pass, Inconclusive, or Fail. Failing the Ph.D. Advanced Exam twice constitutes grounds for dismissal from the program. In the case of an Inconclusive outcome, the committee will specify the terms under which this evaluation can revert to a Pass. If the terms are not carried out satisfactorily, a failure on the exam results. In this case, the student has one more opportunity to retake the exam.

### 3.8 DEFENSE OF DISSERTATION PROPOSAL

When the student has identified a research topic, has become thoroughly acquainted with previous work in that area, and explored the topic well enough to have developed a credible research plan, the student then writes a dissertation proposal.

A copy of the proposal must be submitted to each member of the Ph.D. Committee, and is defended approximately two weeks later in an oral examination that lasts approximately two hours. Failing the defense of proposal twice constitutes grounds for dismissal from the program. In the case of an Inconclusive outcome, the committee will specify the terms under which this evaluation can revert to a Pass. If the terms are not carried out satisfactorily, a failure on the exam results. In this case, the student has one more opportunity to retake the exam.

The student should schedule the defense after the major professor is satisfied that the topic is significant, research plans are sound, and the student’s qualifications are adequate to address the problem. The student should not hesitate to discuss the proposal with members of the Committee in advance. Above all, the student should not postpone the defense until after the work is substantially complete. If the Committee discovers, for example, that the methodology is flawed, the student may have wasted a great deal of time and effort.

The student should not view the defense of proposal as an adversarial process. While the Committee must necessarily ask probing questions to determine the extent of your preparedness, the soundness of the plans, and the significance of the proposed work, the Committee is also likely to provide insights and guidance that could greatly improve the dissertation.
Once the student has successfully defended the proposal, she or he should immediately prepare an *Application to Candidacy*. This form requires listing only additional courses that are planned to complete the course requirements. In addition, SEAS requires that the student submit a copy of the proposed dissertation abstract to the SEAS Graduate Divisional Committee. See Section 6.1 for more information.

**3.9 DEFENSE OF DISSERTATION**

Before the Ph.D. is conferred, the student must successfully defend the dissertation in an oral examination administered by the Committee. The usual format is a presentation of the work in seminar form, punctuated by numerous questions from the faculty.

**3.10 TIME LIMIT FOR DEGREE**

The time limit for finishing all Ph.D. degree requirements is seven years from the first registration date in the graduate program, excluding approved leaves of absence.

Petition for an extension of time limit requires Departmental approval. The student must be currently making active progress toward the degree. The SEAS Divisional Committee will consider each petition and, in certain cases, it may set a deadline for completion of the program. The extension of time limit is normally granted for a period of one year or less. The ultimate (and only) authority to grant a time limit extension is the Graduate School.
4

THE MASTER OF SCIENCE IN INDUSTRIAL ENGINEERING PROGRAM

The degree of Master of Science in Industrial Engineering provides advanced study beyond the baccalaureate degree for those with initial degrees in IE as well as for those from other disciplines who wish to enter the field. Programs comprise an appropriate academic core, and a cohesive set of advanced courses, culminating in a thesis or comprehensive examination. Both the thesis and comprehensive examination options require a total of at least thirty approved credit hours of work. This study leads to a specializations in:

- Human Factors Engineering/Ergonomics,
- Operations Research,
- Production Systems Engineering, or
- General Industrial Engineering (all course degree program)

4.1 ENTRANCE REQUIREMENTS

In addition to holding a bachelor’s degree in engineering or any of the mathematical, physical, behavioral, or health sciences, each entering student is expected to be skilled in a number of specific areas. Proficiency is required in

- mathematics through multivariate calculus,
- probability and design and analysis of experiments considered from a calculus point of view, and
- computer programming.

Generally, these requirements must be satisfied prior to the commencement of graduate studies.

A Master’s student admitted on a provisional basis must demonstrate his/her ability to perform satisfactorily at the graduate level before being admitted to degree candidacy. The department will specify the conditions of the provisional admission in a letter sent to the student.

4.2 THE PROGRAM

The student's course requirements depend on the area of specialization.

4.2.1 Specialization in Human Factors/Ergonomics. The following courses are required for the M.S. degree with a concentration in human factors/ergonomics:

Fundamental Research Courses (6 credits):
IE 531 Research Methods
IE 507 Design and Analysis of Experiments

Content Courses (9 credits) - 3 of the 4
IE 532 Human Informational Processing
IE 535 Human-Computer Interaction
IE 536 Physiological Foundations of Human Factors
IE 541 Human Factors in Safety

Research Requirement:

Research experience is required of all M.S. students whose concentration is in human factors. Completion of a formal thesis (3-6 credits*) is the usual means of fulfilling this requirement. Alternatively, the requirements can also be met by an alternative research experience such as research in an applied setting (usually an independent study), research activities completed during research assistantship work, or some other means. Students who fulfill the research requirements without completing a thesis are required to take the Comprehensive Exam (see Section 4.5).

*The 3-credit thesis option exists to allow students who complete a thesis flexibility to take an additional content course. It does not impact the expectations for the scope and effort of the thesis.

4.2.2 Specialization in Operations Research. The following courses are required for the M.S. degree with a specialization in operations research:
IE 572  Linear Programming
IE 573  Discrete Optimization
IE 575  Stochastic Methods
IE 576  Applied Stochastics

In addition, students are required to take two additional courses in Operations Research. Valid selections for these courses are IE 551, IE 504, IE 505, IE 512, IE 515, IE 603, IE 661, IE 662, IE 663, IE 664, IE 670, IE 675, IE 678, IE 681, and IE 682.

4.2.3 Specialization in Production Systems Engineering. The following courses are required for the M.S. degree with a specialization in production systems engineering:

- **IE 504** Facilities Design
- **IE 505** Production Planning and Control
- **IE 506** Computer-Integrated Manufacturing
- **IE 507** Design & Analysis of Experiments
- **IE 551** Simulation

Although not required, IE 508 (Six Sigma), IE 509 (Quality Assurance), IE 551 (Simulation) and IE 507 (Design and Analysis of Experiments) are recommended as an elective content course for students in the Production Systems Engineering Specialization.

4.2.4 Specialization in Industrial Engineering (all course option)

The MS with specialization in Industrial Engineering is intended to allow students to take a broad range of IE courses. It requires student to take a minimum of 7 IE courses of choice, plus 3 additional courses which can be either IE or from other departments, with advisor approval, such as Mathematics or Management. This program allows the student to customize course selection to meet his or her professional needs. For example, with two operations research courses and electives in supply chain management and economics, the resulting degree is well-suited to the needs of e-commerce. Alternatively, electives in safety, biomechanics and work physiology provide the student with more depth in industrial ergonomics. Finally, electives from the production systems area provide a sound basis for modern manufacturing. A major feature of this program is the ability for a student to complete a degree in two semesters by taking 5 courses per semester. This minimizes time away from an existing job as well as provides a concentrated immersion experience in the graduate program. The culminating experience of this specialization comes from passing a comprehensive examination based on a degree program consisting of at least thirty hours of course work.

Many of the above described courses may also be taken via the UB Distance Learning program (EngiNet). Completing courses via this program is particularly convenient to students who are not able to attend courses on campus, because of job, family, geography and other constraints. Interested students should seek admissions from the department and register with the UB’s EngiNet Office enginet@eng.buffalo.edu for selected graduate courses offered each semester. Fewer than half of a student’s courses can be taken via Enginet towards the M.S. degree.

4.3 CULMINATING EXPERIENCE

The M.S. program may be completed in one of two ways:

1. By a formal research thesis representing 3 or 6 credits, satisfactory performance in an oral defense-of-thesis examination, and completion of 24 or 27 credits of non-thesis course work.
2. By passing a written comprehensive examination (C-exam) based on a degree program consisting of at least thirty hours of course work.

The M.S. Thesis

If a student wishes to fulfill the M.S. degree requirements by means of a thesis, the student must first find a faculty member who shares your interest in a topic and is willing to supervise your efforts. This person will constitute the committee that must ultimately read and approve your work. Each thesis must be successfully defended in an oral examination. Note that students in the MS IE concentration cannot complete a master’s thesis.

A limit is imposed by the School of Engineering and Applied Sciences (SEAS) on the number of thesis credits which are applicable toward graduate degree requirements. For the M.S. degree with a thesis, a maximum of six credit hours for thesis (plus at least 24 credit hours of course work) may be applied. A minimum of 3 credit hours of thesis work is required.

Students should register for **IE 559** (Fall) or **IE 560** (Spring) while working on an M.S. thesis.

Instructions governing the preparation of theses appear in several University publications, including one (aptly) entitled Instructions for
Preparing Theses and Dissertations. Students should consult these guidelines before preparing the final manuscript.

The typing of a thesis is the responsibility of the student. There are editors and typesetting programs available on the university computer system which can be used for manuscript preparation.

The Comprehensive Exam (the C-exam)

The content of the C-exam is based on the most recent offerings of each of the courses. It is incumbent upon the candidate to check that the material they prepare before the exam corresponds to that covered in the most recent offerings of each course.

The Comprehensive Exam is offered twice a year, once in December and again in May. It is an integrative experience in the form of a written examination of 90 minutes duration. Questions will be of an integrative nature, largely focusing on the core subjects of the major. That is, the minimal answer to pass will be drawn from the core courses. The emphasis will be on the integration of the tools/methods that were covered in the core courses. Students are not allowed to bring in any course material (formulae, books, etc.) to the exam. Any such material, if needed, will be provided at the exam.

Number of Attempts

Students are allowed two attempts to pass the MS Comprehensive Exam as the culminating experience for graduation. Failing the Comprehensive Exam twice constitutes grounds for dismissal from the program. These attempts will occur at the times specified below. **NOTE: A student must give two weeks notice if she/he decides not to take the exam. Failure to do so will be considered a FAILING attempt.**

Scheduling of the Exam

The first exam attempt occurs after one year of full time study (2 semesters). This means that students have the responsibility to register for all required core courses in HF, PS, OR, or IE, so that the core courses are completed at the end of two semesters of full time student. Part-time students should register for core courses first; the first exam attempt for part-time students will be as soon as the core is completed. **If a student chooses not to take the exam when the first attempt is scheduled, the first attempt is lost, and only one attempt at the exam remains.**

The second exam attempt (for students who did not pass, or did not choose to take the first attempt) occurs one (1) semester after the first attempt. For example, the typical full-time student would register for core courses in the Fall and Spring semesters of his/her first year of study, and attempt the exam in May, at the end of the Spring semester. If the student did not pass the exam, he or she would be given a second attempt in December.

Further Information

Further information and application forms for the exam are made available in October, for the December exam, and March, for the May exam.

How to Apply

Students should pick up an application form from the Comprehensive Exam Coordinator or from the Departmental Office and submit the completed form by the date indicated on the form.

4.4 TIME LIMIT FOR DEGREE

The time limit for finishing all M.S. degree requirements is two years from the first registration date in the graduate program, excluding approved leaves of absence.

A petition for an extension of time limit requires Departmental approval. The student must be currently making active progress toward the degree. The SEAS Divisional Committee will consider each petition and, in certain cases, it may set a deadline for completion of the program. The extension of time limit is normally granted for a period of one year or less.

4.5 NONAPPLICABLE CREDITS

Credits in the following courses are not applicable toward the minimum requirements for the Master’s degree programs: Supervised Teaching, Supervised Research, and Departmental Seminar.
THE MASTER OF ENGINEERING PROGRAM

***NOTE - (CURRENTLY THIS PROGRAM IS NOT OFFERED TO NEW STUDENTS)***

The Master of Engineering (M.Eng.) degree with a concentration in Production Management provides graduate study for those engineers who desire to advance to leadership positions in their organizations. This course of study prepares students to become effective engineering managers by enhancing their technical competence, exposing them to critical engineering management issues, and training them to deal with these issues confidently.

5.1 THE STANDARD ME PROGRAM

Graduate students who have earned their Bachelor's degree at a university other than UB will generally be enrolled in the standard M.Eng. program. This program can be taken on either a full-time or part-time basis. It is well-suited for those students who are already practicing engineers in the greater Buffalo metropolitan area.

Entrance Requirements

The entrance requirements for the concentration in Production Management are:

- A baccalaureate degree in Engineering.
- Demonstrated practical engineering experience (formal job or projects).
- A minimum grade point average of 3.0 (on a 4.0 basis) for all undergraduate work taken during the last two years of the applicant’s studies.

In exceptional cases, the department may authorize admission of an applicant who does not meet all of the above requirements. In such cases the Department will establish performance criteria which, when satisfied, will serve as the basis for continuing in the program.

The Program

Course Requirements. The Master of Engineering program in Production Management requires a total of 30 credit hours. Students must take the following six courses:

- **EAS 521** Principles of Engineering Management I
- **EAS 522** Principles of Engineering Management II
- **IE 505** Production Planning and Control
- **IE 508** Quality Assurance*
- **EAS 590** Case Studies in Engineering Management
- **EAS 580** Technical Communication*

*Note, if IE 408 or EAS 480 is taken at the undergraduate level, the requirements of IE 508 or EAS 580 respectively, will be waived and replaced with other electives.

In addition, each student must select two elective courses totaling six credit hours. These courses should be selected to further enrich the student’s educational experience in support of their respective career objectives. Examples of recommended courses are: IE 500 (Computational Integer Programming), IE 506 (Computer-Integrated Manufacturing), IE 507 (Design and Analysis of Experiments), IE 509 (Six Sigma Quality), IE 530 (Human Factor Fundamentals), IE 533 (Socio-Technical Systems), IE 504 (Facilities Design), IE 541 (Human Factors in Safety), and IE 551 (Simulation and Stochastic Models). Students seeking to enhance their knowledge outside of the traditional engineering and management fields should obtain approval from his or her advisor.

Engineering Project. To complete the 30 credit-hours requirement, the student must conduct an engineering project representing six hours of credit, document the results in a written technical report, and present the results orally in a seminar. Summer completion of the project requires permission from the advisor.

In an M.Eng. project, students are typically involved with the planning, benchmarking and implementation of certain engineering activities centering on the application of specific engineering principles and methodologies in real-world settings, leading to measurable improvements in quality, cost, efficiency, build-to-order flexibility, time-to-market, customer satisfaction, or other key performance indicators. The focus is on innovative application of engineering knowledge to add value, not on creation of new knowledge.

Instructions governing the preparation of the ME project reports should follow those contained in a University publication entitled:
Instructions for Preparing Theses and Dissertations.” Consult these guidelines before preparing your final manuscript.

The typing of a ME project report is the responsibility of the student. There are editors and typesetting programs available on the university campus system, which can be used for manuscript preparation.

A limit is imposed by the School of Engineering and Applied Sciences (SEAS) on the number of project credits which are applicable toward graduate degree requirements. For the ME degree, a maximum of six credit hours for project may be applied.

Generally, the six-hour project is divided equally between two semesters. Students need to register for IE 591 (Fall semester) and IE 592 (Spring semester), 3-credit hours each, with the M.E. Project Advisor of their choice. Each ISE faculty member has a different section number and registering under the wrong section number can cause unnecessary complications.

Students may request any other ISE faculty members to serve as their ME project advisors. Students should consult the Director of Graduate Studies who serves as the Departmental Advisor for all ME students for guidance, and seek opportunities to speak with as many ISE faculty members as possible. Doing so will allow students to benefit from the exceptionally rich experience in research and industrial practices of the ISE faculty, to optimally select the right ISE faculty advisors for themselves, and to maximize the value of their learning experience through the capstone ME projects.

Students who carry an Incomplete grade in ME project but have completed all other ME requirements are advised to register for the ME project for one credit hour until the Incomplete grade has been removed.

Nonapplicable Credits Credits in the following courses are not applicable toward the minimum requirements for the Master's degree programs: Supervised Teaching, Supervised Research, and Departmental Seminar.

Time Limit for Degree

The time limit for finishing all M.Eng. degree requirements is 2 years from the first registration date in the graduate program, excluding approved leaves of absence. For part-time students, a time limit of 6 years from the first registration date in the graduate program, excluding approved leaves of absence, is permitted.

Petition for an extension of time limit requires departmental approval. The student must be currently making active progress toward the degree. The SEAS Divisional Committee will consider each petition and, in certain cases, it may set a deadline for completion of the program. The extension of time limit is normally granted for a period of one year or less.

5.2 THE FIVE-YEAR B.S./M.E. PROGRAM

The “Five-Year” program in Production Management is a course of study which permits Industrial Engineering students at UB to obtain the Bachelor of Science degree at the end of four years, and the Master of Engineering (M.Eng.) degree after two additional semesters of graduate study.

Entrance Requirements

This special program is offered only to students obtaining their B.S. degree in Engineering at UB. A student should apply for admission to the Five-Year program early in the Fall semester of his or her senior year of study. Once admitted to the Five-Year program, a student still has the option of leaving the University after four years of undergraduate study with a Bachelor of Science degree. There is no obligation to continue with the fifth year of (graduate) study.

The Program

Course Requirements The Five-Year Bachelor of Science/Master of Engineering degree requires a total of 30 credit hours of graduate study beyond the B.S. degree. Undergraduate students in the Five-Year program must also take a specific set of courses in lieu of some of the usual senior-year technical electives.

Students who choose the B.S./M.Eng. Production Management option offered by the Industrial and Systems Engineering Department should adhere to the course of study outlined in Table 1.

Engineering Project To complete the program requirements, the student must conduct an engineering project representing at least six hours of credit, resulting in a written technical report and satisfactory oral presentation in a seminar. Refer to Section 3.1 for registration procedures and content emphasis concerning the M.Eng. Project.
A limit is imposed by the School of Engineering and Applied Sciences (SEAS) on the number of project credits which are applicable toward graduate degree requirements. For the M.Eng. degree, a maximum of six credit hours for project (plus at least 24 credit hours of course work) may be applied.

**Nonapplicable Credits** Credits in the following courses are not applicable toward the minimum requirements for the Master's degree programs: *Supervised Teaching, Supervised Research, Departmental Seminar.*

**Time Limit for Degree**

The time limit for finishing all M.Eng. degree requirements is 2 years from the first registration date in the graduate program, excluding approved leaves of absence. For part-time students, a time limit of 6 years from the first registration date in the graduate program, excluding approved leaves of absence, is permitted.

Petition for an extension of time limit requires Departmental approval. The student must be currently making active progress toward the degree. The SEAS Divisional Committee will consider each petition and, in certain cases, it may set a deadline for completion of the program. The extension of time limit is normally granted for a period of one year or less.
### Table 1  Five-Year B.S./M.Eng. Program

#### Senior Year

**Fall Semester**
- IE 477  Digital Simulation  4 hrs.
- IE 491  Industrial Internship (either semester)  4 hrs.
- IE 424  Methods and Methods  4 hrs.
- IE 408  Quality Assurance  3 hrs.
- Nontechnical Elective  3 hrs.

**Spring Semester**
- IE 4xx  IE Technical Elective  3 hrs.
- Technical Elective  3 hrs.
- Technical Elective  3 hrs.
- Technical Elective  3 hrs.
- Nontechnical Elective  3 hrs.

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#### 5th Year

**Fall Semester**
- IE 591  Engineering Project/Technical  3 hrs.
- IE 505  Production Planning and Control  3 hrs.
- EAS 580  Technology Communications for Engineers  3 hrs.
- Technical Elective  3 hrs.

**Spring Semester**
- IE 592  Engineering Project/Technical  3 hrs.
- IE 509/409  Total Quality Management  3 hrs.
- Technical Elective  3 hrs.
PAPERWORK FOR DEGREE CONFERRAL

The two primary pieces of paperwork required before any graduate degree may be awarded are the Application to Candidacy (available online – www.grad.buffalo.edu), and the M-Form (Multi-purpose Form) (the M-form is filled out by the Departmental Graduate Secretary).

6.1 APPLICATION TO CANDIDACY

The Application to Candidacy only requires listing courses that remain to be completed in order to earn your degree. On it you will also list any courses taken elsewhere for which transfer credit has been approved. You must also submit a complete narrative description of all informal courses (see Section 2.5 on page 9) on a form available from the Department for this purpose. The form requires the signatures of the student, the instructor and the Director of Graduate Studies. SEAS also requires that the student provide a tentative title and abstract of the thesis, dissertation, or project.

The primary purpose of the Application to Candidacy is to serve as a useful planning document for the student. As such, it is important for the student to prepare and submit the Application to Candidacy at an early stage in her/his candidacy. Because the Application to Candidacy needs to be approved at several levels of the University hierarchy, the student must submit the form to the departmental office approximately two semesters in advance of the anticipated degree date. More precise deadlines are published by the university each year. For June 1 degree conferrals, Applications to Candidacy must be submitted to the department by November 1st. Other degree conferral dates require comparable lead times. The published dates are deadlines for receipt of the Application to Candidacy by the Office of the Graduate School. The student shall submit the Application to Candidacy early enough to allow time for departmental approval prior to these deadlines—usually one week.

Note that the stipulations above imply that students in the five-year B.S./M.Eng. program who plan to graduate after two semesters of graduate study (and for that matter, any graduate student who plans to obtain a degree within one year of entering the program) would need to submit an Application to Candidacy by approximately the end of their second month in the program.

The following additional points should be noted with regard to the Application to Candidacy:

- The Application to Candidacy must contain an abstract of the dissertation, project or thesis.
- Changes (e.g., adding and/or deleting one or two courses, changing thesis titles, changing committee members other than the major advisor) may be made by submitting a general petition form (available online at www.grad.buffalo.edu).
- The Application to Candidacy for the Ph.D. degree should be filed within one year of successfully passing the Ph.D. Breadth exam and, in no case, later than two weeks following successful passing of the Ph.D. advanced examination.

6.2 THE M-FORM

The M-Form certifies that all degree requirements have been met. From the student’s point of view, this may be the most important piece of paper among the forms required by the university. The submission of this form is the final step in certifying that the university should award you a degree. The Department Graduate Secretary will complete and submit the M-Form on your behalf.
6.3 DEADLINES

It is the responsibility of the student to meet all deadlines specified by the Graduate School. The following table provides a timetable for the receipt of paperwork. Students should consult the *Graduate School Policies and Procedures Manual* of the Graduate School for any revisions or changes to this schedule at [www.grad.buffalo.edu](http://www.grad.buffalo.edu).

<table>
<thead>
<tr>
<th>Submit Application to Candidacy</th>
<th>Other Requirements*</th>
<th>Date on Diploma</th>
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</thead>
<tbody>
<tr>
<td><strong>All Degrees</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September 1</td>
<td>Friday before Spring Classes</td>
<td>February 1</td>
</tr>
<tr>
<td>November 1</td>
<td>Last Day of Spring Exams</td>
<td>June 1</td>
</tr>
<tr>
<td>April 1</td>
<td>Friday before Fall Classes</td>
<td>September 1</td>
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*Other Requirements* include: fulfillment of the continuous registration requirement, submission of the *M-Form*, electronic Thesis & Dissertation (ETD) submission to Graduate School (Thesis/Dissertation), bound copy (1) of the dissertation, thesis (to the department)—plus bound copies to the committee members if required, or project report (not bound), microfilm form (if needed), survey and student accounts form, and letter from an outside reader (if required).

The above dates are subject to change. Students should check with the departmental office one semester prior to the deadline for up-to-date information. It is the responsibility of the student to check with the department, the Graduate School and the Office of Admissions and Records prior to the deadline dates to be sure that all of the requirements and paperwork for the degree have been completed.

Also note that full-time students registering for less than nine credit hours need to complete a *Certification of Full-Time Status* form by September 1 for June 1 graduation. This form is available online at [www.grad.buffalo.edu](http://www.grad.buffalo.edu).
PROGRESSING TOWARD THE DEGREE

The minimum acceptable grade point average (GPA) for graduate students is 3.00, which corresponds to B-level performance. Accordingly, the student is placed on academic probation if the cumulative GPA in all courses that could be applied toward the degree falls below 3.00. Failure to remove probationary status within one semester may be grounds for dismissal from the program; a cumulative GPA below 2.50 is grounds for immediate dismissal. In no case will a student with a GPA below 3.00 be allowed to graduate.

A graduate student must earn an average of at least 3.00 for all courses taken for graduate credit which could be applied toward the degree. Accordingly, graduate course work in excess of that applied toward the credit requirement for the degree will be included in the computation of the student’s grade point average.

7.1 ACADEMIC PROBATION

Probation is automatic and requires no notification or action on the part of the department; nonetheless, the student may expect a letter from the Director of Graduate Studies or the Department Chair informing her/him that the department is aware of the probationary status. The letter may also specify what the student must do in the coming semester in order to demonstrate satisfactory progress and avoid dismissal.

Probation is a clear signal that something is wrong. If this student is on probation, s/he should talk with the advisor. The student must ascertain whether continuing in the program at the requisite level of performance is feasible, what personal adjustments will be necessary, and decide whether or not these can be made. In order for the student to be allowed to continue, the student must demonstrate in the coming semester that s/he can succeed in the program.

7.2 PROVISIONAL ADMISSION

A Master's student admitted on a provisional basis must demonstrate her/his ability to perform satisfactorily at the graduate level before being admitted to degree candidacy. The department will specify the conditions of the provisional admission in a letter sent to the student.

7.3 OTHER GROUNDS FOR DISMISSAL

A student will be considered for dismissal if:

- a grade of F is earned in any course which could be applied to the degree,
- more than two grades are obtained from among C, D and U in courses which could be applied to the degree,
- the conditions of provisional admission have not been satisfied within one semester after admission,
- probationary status has not been removed after one semester,
- the conditions of admission have not been met,
- the student has had more than one failure on a Departmental examination (Comprehensive Exam, Breadth Exam, Ph.D. Advanced Exam, or Defense of Thesis, Project or Dissertation).
- the cumulative grade point average for courses which could be applied to the degree falls below 2.5 at the end of any grading period, or
- the student is found guilty of academic dishonesty according to the existing regulations.
7.4 SATISFACTORY/UNSATISFACTORY S/U GRADES

The university provides for the use of Satisfactory/Unsatisfactory (S/U) grades rather than the customary letter grades A through F under certain circumstances. A grade of “Satisfactory” corresponds to “C or better.”

S/U or L grades can be received for theses, dissertations, projects, and Departmental Seminars. No other course offered by the Department, and no required course, may be taken by IE graduate students on an S/U or L basis.

With the consent of the advisor, the student may take elective courses outside the Department on an S/U basis. If the courses are intended only to indulge the student’s outside interests and will not be applied to the program of study, advisor’s consent is unnecessary; the student need only to make arrangements with the instructor.

7.5 GRADES: IU’s AND L’s

In almost all cases, failure to complete course requirements within the allotted time results in a commensurately low grade being given. Only in cases of severe illness or similarly mitigating, unforeseeable circumstances may an instructor assign a grade of “Incomplete,” which is designated by an IU. Even in such extreme situations, the student will not qualify for an Incomplete unless the previous work in the course has been satisfactory.

Theses, projects, and dissertations are different. Such work may span more than one semester. In these cases, an L grade may be assigned to indicate ongoing effort when the instructor feels that it is impossible to decide yet whether the work is satisfactory or not. Instructors may convert an L grade to an S/U or a letter grade at a later date; otherwise, any L grade will automatically be changed to an S when the department certifies to the Office of the Graduate School, via the M-Form, that all degree requirements have been met.

If the student believes that the circumstances warrant conferral of an IU grade, the student should meet with the instructor to discuss the matter, and bring evidence (such as a note from a doctor) to document the situation. If the instructor agrees, he or she will decide what conditions that must be met in order to remove the Incomplete, and the time frame within which the work must be completed. It is the student’s responsibility to provide this information immediately in writing. The student should not simply wait until s/he feels like working on removing the Incomplete to meet with the instructor and determine what is expected—the time frame for completing the work is at the instructor’s discretion, not the student’s.

Any IU grade that is not removed within two semesters plus the intervening summer will automatically become an Unsatisfactory (U) grade. Consult the academic calendar for exact dates. L grades (invalid grade) must be changed to letter grades within one semester or they will revert to F. The student is responsible for the removal of temporary grades such as IU, within the allotted time period. The default Unsatisfactory (U) grade shall become the permanent course grade of record if the ‘IU’ is not changed through formal notice by the instructor upon the student’s completion of the course. Refer to UB Graduate School policy on Incomplete Grade (IU) for details.

7.6 REQUIRED GRADE POINT AVERAGE

A graduate student must earn an average of at least 3.00 for all courses taken for graduate credit which could be applied toward the degree. Accordingly, graduate course work in excess of that applied toward the credit requirement for the degree will be included in the computation of the student’s G.P.A.

7.7 LEAVE OF ABSENCE

If the student’s personal situation requires her/him to discontinue studies for one or two semesters, the student may wish to request a Leave of Absence. If granted, the student will be able to return to the University and continue studies with minimal interruption and inconvenience.

Several regulations regarding Leaves of Absence should be noted:

- A petition of leave of absence should be filed prior to the start of the semester.
- Leaves of absence will normally be granted for only one semester at a time.
- Leaves of more than one semester require valid justification and documentation from the student and the student’s advisor. Documented cases of financial hardship, illness or compulsory military service constitute valid justification.
- A student who leaves the program after completion of some graduate work, but has not been given an approved leave of absence, must reapply and be readmitted as a new student. Continued leaves of absence beyond two years will not be granted.
FINANCIAL ASSISTANCE

A number of financial aid opportunities are available. These include:

- Fellowships awarded in university-wide competition and for specialized programs;
- Research Assistantships (RA’s);
- Teaching Assistantships (TA’s).

Assistantships usually require 15 to 20 hours per week in a teaching or research role. Summer opportunities are also available, providing valuable experience as well as additional financial support.

Continuing students who wish to be considered for financial aid for the Fall semester should make their requests known before March 1 of the same year. Continuing students who wish to be considered for financial aid for the Spring semester should make their requests known before October 1 of the preceding year. Late requests for assistance may be considered if funds are available. Requests should be in the form of a letter addressed to either the Director of Graduate Studies or the Department Chair, and should be submitted to the Departmental Graduate Secretary.

There are some limitations of the total amount of financial assistance that a student can receive from the university:

8.1 LIMITS FOR TUITION SCHOLARSHIPS

- The maximum limit for a tuition scholarship for students in the Master’s program is 30 credit hours (minus transfer credits) or two years, whichever comes first.
- The maximum limit for tuition scholarship for students in the Ph.D. program is 72 credit hours (minus transfer credits) or four years, whichever comes first.
- Lecturers are employees of the University and are not eligible for SEAS tuition scholarships.
- Ph.D. students entering with a Master’s degree from another university must attach a copy of their signed evaluation of transfer credit form to any tuition scholarship request.
- Up to three (3) credit hours of required remedial language may be excluded from the above maximums.
- Up to six (6) credit hours for undergraduate courses taken while in a graduate program of study may be excluded from the above maximums even though they do not count as degree requirements as long as they are recommended in writing by a graduate advisor.
- The above maximums for Master’s and Ph.D. programs include all credit hours of a student’s graduate program regardless of the payment source for the tuition. Essentially, the first 30 hours taken toward a Master’s degree and the first 72 hours taken toward a Ph.D. degree are eligible for a tuition scholarship. Credit hours paid for by another division (other than the School of Engineering and Applied Sciences) of the university or by the student are explicitly counted in the maximums.

8.2 LIMITS FOR STATE SUPPORT

- The maximum time limit for State support for students in the Master’s program is one and one-half years, with extension considered for another one-half year in exceptional circumstances.
- The maximum limit for State support for students in the Ph.D. program is two years beyond the Master’s degree or four years beyond the Bachelor’s degree.
- A petition for extension of the limit for State supported positions should be filed prior to the start of the semester for which the waiver is sought. Such petitions will only be approved in exceptional circumstances.
- SEAS tuition scholarship policies are established by the Associate Dean of Graduate Studies in consultation with the Academic Program Committee (Graduate).
8.3 REGISTRATION IMPLICATIONS

A student should register only for the credit hours necessary to meet degree requirements. Tuition waiver (tuition scholarships) for credit hours in excess of the degree requirements may not be granted.

Note that students who register for less than nine credit hours must file a petition for full-time status. These petitions are considered by the Graduate School only if the student has submitted an Application to Candidacy with the Graduate School.

8.4 STUDENTS RECEIVING FINANCIAL SUPPORT

Financial support is usually granted for an entire academic year. However, on occasion it is granted on a semester-by-semester basis.

All foreign students receiving financial support must pass the English Speak Test within their first year. Failure to do so can result in the termination of financial support.
THE DEPARTMENT

9.1 RESEARCH FACILITIES

The Department of Industrial and Systems Engineering occupies facilities in Lawrence D. Bell Hall on the University's North Campus. Research centers affiliated with the Department include the Research Institute for Safety and Security in Transportation (RISST), Center for Excellence in Global Enterprise Management, Center for Multisource Information Fusion, and several other research facilities.

Research Institute for Safety and Security in Transportation (RISST)

Co-Directors: Professor Rajan Batta and Assistant Professor Jun Zhuang

Location: 433 Bell Hall
Website: http://www.eng.buffalo.edu/Research/RISST/

RISST, established jointly by the University at Buffalo and the Transportation Security Administration (TSA), is a resource to the aviation community for improving human factors aspects of security and maintenance system performance. Rajan Batta, director of RISST, has over 20 years of experience in research and development leadership in aviation inspection and maintenance human factors, plus human aspects of security systems performance. Successful innovation in cooperation with major airline research partners has assisted the Federal Aviation Administration (FAA), in cooperation with Sandia National Laboratories. RISST’s mission is to apply valid knowledge and models of human performance to improve system performance in maintenance and inspection, and to enhance of safety and security of transportation systems.

Center for Excellence in Global Enterprise Management

Director: Professor Li Lin
Location: 438 Bell Hall
Website: http://wings.buffalo.edu/gemc/

The Center for Global Enterprise Management (GEM) was established in 1998 to deliver leading-edge research, driven by industrial need, with results that have immediate practical impact. During the process, GEM also delivers technology know-how that enables enterprises to not only benefit from the improvement of their operations, but also manage the improvements with the necessary knowledge and skills. The combination of the core competencies leveraged in such academic disciplines as engineering, management, computer science, etc., through the GEM center and the functional competencies of its enterprise partners form win-win strategic relationships.

GEM provides an arena for collaborative efforts leading to frontier academic research and high-impact industrial developments in both fundamental research with a long-term impact and applied work with significant near-term impact. Joint industrial and academic ventures include e-business, supply chain management, and traditional manufacturing system design that will forge the charter for this new millennium’s approach to synergistic Big-M Manufacturing, covering all aspects of enterprise management.

Past projects have included assistance in the design of manufacturing facilities at American Axle and Delphi Harrison automotive facilities, activities to identify appropriate e-business approaches in automobile manufacturing, as well as supply-chain management projects at Lockheed Martin and General Motors. To date, approximately ten IE graduate students and five IE faculty have participated in projects through this center. The center has an established research laboratory in 438 Bell Hall.
The Center for Multisource Information Fusion (CMIF) is a joint government-industry-university initiative originally created through an Air Force-sponsored contract to the Calspan-University at Buffalo Research Center (CUBRC) in October of 1996. The specific original USAF sponsors were Rome Laboratory (Rome, NY) and Wright Laboratory (Dayton, OH), who shared equally in the center's support. While the contract was purposefully implemented through CUBRC (in part to allow for occasional research opportunities involving classified information), the bulk of the (unclassified) work at present is occurring at the University at Buffalo (UB). The center's research focus is on basic and applied research in multiple-source information processing environments, such as in multiple-sensor or multiply-instrumented systems. Such environments occur frequently in defense applications for advanced surveillance and reconnaissance systems but also in robotics, civil infrastructure systems, medical monitoring systems, intrusion detection systems, intelligent transportation systems, and in environmental monitoring applications, among others.

While the initial focus has necessarily been on Air Force and defense-type problems, this highly multidisciplinary technology is broadly applicable to many problems as mentioned above, and the center is now conducting research in “Condition-Based Maintenance” with Penn State, and in “Multi-Spectral Mammography” for the National Institutes of Health. In addition to the baseline tasks started under the initial CUBRC grant, CMIF has received numerous additional grants since its inception, sponsored by the Air Force Office of Scientific Research, the Office of Naval Research, the Army, and the National Security Agency, among others. Industrial partners are also being cultivated, and the center has just signed a nondisclosure agreement with Lockheed-Martin Corporation, is exploring possibilities with Sterling Software, and has already received funding from Boeing. The center’s activities of course fluctuate over time, and student support has ranged from about four to thirteen students and faculty support from three to seven faculty members. The center has an established research laboratory in 421 Bell Hall.

Cognitive Engineering Laboratory

This research facility supports investigation in the areas of human computer interaction, information displays, and human decision making. The facilities have supported the work of more than a dozen graduate students completing their M.S. or Ph.D. research, as well as several undergraduate students who have been paid research assistants on these projects. Projects conducted in the laboratories have been funded by the National Science Foundation, the U.S. Air Force, and several defense-related companies. The laboratory is equipped with five personal computers (Pentium II or newer), and software available for research purposes includes SPSS, Visual Studio, and Noldus Observer (an analysis package for coding continuous audio, video, and screen capture data).

Human Factors Data Collection Laboratories

This is a two-room research facility devoted to studying how people interact when working remotely on computerized tasks together. Projects performed in this laboratory have been funded by the National Science Foundation, the U.S. Air Force, and defense-related companies. This experimental space contains three networked computers (Pentium III); software available for research purposes includes SPSS, Visual Studio, Noldus Observer, and Contasia Screen Capture software.

Work Analysis and Design Laboratory

This laboratory has been used for research projects that involve evaluating how the physical requirements of work impact human performance, including the effects of work on physiological, psychophysical, and biomechanical outcomes, such as heart rate, perceived exertion, and low back and upper extremity motion. This laboratory contains both general and special-purpose facilities for the simulation of a variety of manufacturing tasks and conditions, coupled with the ability to record and analyze the complex human reactions (physiological and behavioral) to these inputs. Laboratory equipment includes a Lumbar Motion Monitor System, three Biometrics Electrogoniometers and Data Acquisition Systems, an MVTA Multimedia Video Analysis System, a Personal Heat Stress Monitor, EMG Measurement Equipment (Mytrac II), a Digital Dynamometer, an electromagnetic motion analysis system and electromechanical three-dimensional point data acquisition system.

Occupational Biomechanics Laboratory

Location: 433 Bell Hall
This facility is used to conduct research in the areas of physical ergonomics and occupational biomechanics. The laboratory is equipped with a HUMAC NORM dynamometer system with a trunk flexion/extension module, an Xsens motion capture system with 5 inertial trackers, a 10-channel surface EMG system, a Bertec forceplate, an OptiTrack full body motion capture system with 8 high-speed cameras, a ProForm treadmill, and data analysis computers and software.

Applied Operations Research Laboratory
This lab supports the application of operations research tools to real-world problems. Its primary objective is to provide infrastructure support for sponsored program activity in this area. Research sponsors have included the National Science Foundation, the National Institute of Justice, Boeing, Lockheed Martin Systems Integration, United Airlines, and the Center for Transportation Injury Research. Several graduate students use this facility. There are also some undergraduate students affiliated with this lab, and over the past two summers a high school senior has completed a summer internship in the lab. The lab has four computers, a printer, and high-tech OR software (CPLEX, AMPL, ARENA). Key journals in the OR area are also housed in this lab.

**Manufacturing Design and Engineering Laboratory**

This laboratory has been used for research activities in production and manufacturing systems. The research projects in manufacturing systems are in the areas of computational geometry in computer-aided design and manufacturing (CAD/CAM), CAD/CAM/CAE (computer aided engineering) integration, rapid prototyping and product realization. The facilities are used to develop advanced software tools and methods in design and manufacturing. The facility houses four IBM personal computers (Pentium III or newer), IBM industrial computers, and the supporting interface for digital/analog control. Three Silicon Graphics workstations are available for research use.

### 9.2 THE FACULTY

All information on faculty is listed on the department webpage.
10

THE COURSES

This section provides brief descriptions of many of the graduate courses recently offered by the Department of Industrial and Systems Engineering. Students are also strongly encouraged to take advantage of the broad range of courses offered by other engineering departments and departments such as Economics, Geography, Mathematics, Management Science & Systems, Psychology, and Physiology.

The following table lists the official course numbers and names associated with various common registration needs. Notice that the numbers sometimes change from fall to spring.

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<th>Common Name</th>
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<td>IE 691</td>
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10.1 COURSE DESCRIPTIONS

Core courses for each of the programs are offered annually. Other courses may or may not be offered on an annual basis. The courses are described below.

**EAS 521 Principles of Engineering Management I**

This course covers the basic service management functions of planning, organizing, leading, and controlling, as applied to project, team, knowledge, group/department and global settings. Discussion of the strengths and weaknesses of engineers as managers, and the engineering management challenges in the global economy will also be featured. Emphasis is placed on the integration of engineering technologies and management. Students will master the basic functions in engineering management, the roles and perspectives of engineering managers, and selected skills required to become effective engineering managers in the new millennium. 

[http://www.eng.buffalo.edu/Courses/eas521].

Because of its perceived importance, this course is offered by the UB’s School of Engineering and Applied Sciences. It may be taken by students as an acceptable elective toward their master’s degrees in any engineering disciplines. For students pursuing the "Master Degree of Engineering in Engineering Management" with the UB’s Industrial Engineering department, this is a required core course.

**EAS 522 Principles of Engineering Management II**

This course covers the fundamentals of cost accounting, financial accounting, financial management, and marketing management in order to prepare service managers to meet future challenges in the marketplace. Business cases are used to discuss technologies for promoting service innovations, globalization of both service industries and labor markets, and the impact of these emerging market forces on service enterprises and managerial functions in the new millennium.

[http://www.eng.buffalo.edu/Courses/eas521],

Because of its perceived importance, this course is offered by the UB’s School of Engineering and Applied Sciences. It may be taken by students as an acceptable elective toward their master’s degrees in any engineering disciplines. For students pursuing the "Master Degree of Engineering in Engineering Management" with the UB’s Industrial Engineering department, this is a required core course.

**EAS 523 Capstone Project in Service Systems Engineering**

Students will be involved with the planning, benchmarking and implementation of engineering strategies central to the application of specific engineering principles and methodologies in real-world service settings. The focus of a capstone SSE project is on the innovative application of engineering knowledge of diversified sources to add value. Students will prepare a written report and present results in an open seminar.

**EAS 580 Technical Communications for Engineers**

This course introduces students to the knowledge, skills, and attitudes essential for professional engineers to effectively communicate. The course focuses on three goals: 1) to acquaint students with the standards, conventions, and techniques used to manage technical information within a collaborative workplace; 2) to offer opportunities to apply, proact, and refine communication skills; and 3) to
inculcate a process of iterative review, evaluation, and revision in oral, written, and graphical communication that will demonstrate how to meet professional standards. Projects and assignments are constructed to ensure that students learn the craft of technical communication through concentrating on the steps of the writing/project development process, with an emphasis on the importance of constant revision.

**EAS 590 Case Studies in Engineering Management**
This capstone course should be taken in the last year of the student's program. A case-oriented course which examines in detail the role of the engineering manager as strategic planner and policymaker. Five or six case studies will be presented for discussion, analysis and report. The use and efficacy of engineering management methods will be evaluated for each case.

**IE 500 Topics in Human-Machine Systems**
The emphasis in this course is on issues concerning modeling and aiding human decision-making and control in human-computer interactive environments. Various topics are covered that directly or indirectly address the objective of designing an effective joint human-computer decision and control system. Examples of topics include allocation of functions between human and computer, computer aiding, and applications of fuzzy sets and knowledge-based systems.

**IE 501/502 Individual Problems (for M.S./M.Eng. students)**

**IE 504 Facilities Design**
Facilities Design teaches the analytical tools necessary to effectively tackle the problem of designing the layout of a productive facility. Both non-quantitative and quantitative, computer-based approaches are detailed. The course also discusses location problems, i.e., analytical methods to determine optimal locations of machines/workcenters in a manufacturing facility. Also, the course discusses warehouse storage policies, i.e., analytical methods for effective management of warehouse storage space. Finally, there is discussion of automated guided vehicles and their utility in a modern flexible manufacturing system.

**IE 505 Production Planning and Control**
This course covers the production management related problems in manufacturing systems. It blends quantitative and qualitative material, theoretical and practical perspectives, and thus, bears relevance for academic as well as industrial pursuits. The introduction consists of the production and operations management strategy. The topics covered include simple forecasting methods, workforce planning, inventory control, production planning, materials requirements planning, operations scheduling, and project management. Recent developments in production management such as just-in-time (JIT) inventory systems, and flexible manufacturing systems (FMS) are also discussed.

**IE 506 Computer Integrated Manufacturing**
Design and analysis of computer integrated manufacturing systems of discrete part production. Focus on advanced topics in computer-based manufacturing systems, automation and emerging trends. Laboratory assignments included.

**IE 507 Design and Analysis of Experiments**
This course introduces the student to the fundamental principles of planning, designing, and analyzing statistical experiments. (This course is, at times, replaced by Statistics 526.)

**IE 508 Quality Assurance**
Familiarizes students with the application of statistical quality problem-solving methodologies used to characterize, leverage, and reduce process variability. This course emphasizes the application of sampling methodologies, sample size determination, hypothesis testing, analysis of variance, correlation, regression, measurement systems analysis, design and analysis of saturated experimental designs, design and analysis response surface experimental designs, and statistical process control.

**IE 509 Six Sigma Quality**
This course describes a set of management principles and methods for dramatically improving product/services quality and, ultimately, the productivity of the organization. The course is based on four principles: (1) business organizations should satisfy the requirements of internal and external customers; (2) employees must be empowered to solve problems; (3) continuous process improvement is essential to improving quality and productivity of the organization; and (4) management excellence is achieved by creating a vision of the corporate future and implementing this vision through departmental and employee involvement at all levels. Learning in the course is founded on team participation.

**IE511 Network Behavior Analysis**
A review and discussion of concepts, models, tools and applications pertaining to social network formation and behavior. Social network analysis is an emerging field in modern science. En route to accumulate knowledge and gain understanding about social network structure and behavior, researchers across multiple domains engage in theoretical and applied investigations. This course is intended to review key concepts and findings with network perspectives on communicating and organizing. It will rely on scholarship on the science of networks in
communication, computer science, economics, engineering, organizational science, life sciences, physical sciences, political science, psychology, and sociology, with the purpose of taking an in-depth look at theories, methods, and tools to examine the structure and dynamics of networks.

**IE 512 Decision Analysis**
This is a first course in decision analysis that extends the domain of decision making problems from those considered in traditional statistical hypothesis testing scenarios. The course consists of three major sections: 1. Modeling decisions, where the emphasis is on structuring decision problems using techniques such as influence diagrams and decision trees; 2. Modeling uncertainty, which covers subjective probability assessment, the use of classical probability models, Bayesian analysis, and value of information; and 3. Modeling preferences, which introduces the concepts of risk preference, expected utility, and multi-attribute value and utility models.

**CIE 573/IE 515 Transportation Analytics**
This course aims to provide students with a general background of various statistical analysis techniques and data mining methods that are used in transportation systems. It covers various practical analytical topics in transportation and logistics, including model estimation, data analysis, traffic forecasting, and incident prediction. A broad range of transportation related techniques are covered in statistics and data analysis skills, such as Logistic Regression, and Time Series Modeling. Popular statistical modeling software will be used to solve various practical problems.

**IE 530 Human Factors Fundamentals**
Human Factors is presented from an engineering viewpoint as a discipline for analysis and design of the interactions between people and systems. The nature of the interaction varies from biomechanics and physiology of physical tasks, through cognitive encounters with equipment interfaces to socio-technical interactions of multi-person teams. Two complementary design techniques are used: top-down systems design and bottom-up participative design. Models of the human operator of complex systems are used throughout to provide a consistent viewpoint of the use of human factors data in the design process. This course has been designed as a first course in the Human Factors graduate program to enable students from widely varying backgrounds to understand a common set of principles as they proceed to more specialized courses. The course is also valuable to those from other disciplines who need to utilize Human Factors concepts and data in their own work.

**IE 531 Human Factors Research Methodology**
The purpose of this course is to allow students to gain familiarity with a broad range of methods appropriate for studying humans, tasks, environments, and their interaction; to be able to formulate research hypotheses, and to understand the relationship between research hypotheses and appropriate methods for testing the hypotheses. Student will read journal papers demonstrating a variety of research methods as well as learn to prepare a research proposal.

**IE 532 Human Information Processing**
Introduction to basic behavioral and psychological factors, such as sensory, perceptual, learning, and cognitive processes. Emphasis is placed upon the application of knowledge about these factors to the design and development of human-machine systems.

**IE 533 Socio-Technical Systems**
This course examines the impact of automation and computer technologies on organizational and job design. The intent is to demonstrate how automation changes processes and work within organizations, and the implications for organizational efficiency and quality of working life. Topics include: communication processes, decision-making, job design, job satisfaction, motivation and acceptance of innovation.

**IE 535 Human-Computer Interaction**
The primary objective of the course is to introduce graduate and senior-level undergraduate students to the principles and methods underlying human-computer interaction and the design of effective computer interfaces. In contrast to the design of computer systems based primarily on technological constraints and capabilities, theories and methods in human-computer interaction emphasize the design of computer systems which are designed to support user capabilities and task requirements. This course will provide students the opportunity to gain in-depth knowledge in the area of human factors, as well as the opportunity to apply principles of user- and use-centered design to a real world design problem.

**IE 536 Physiological Foundations of Human Factors**
Introduction to the structure and functioning of the human body, including anthropometry, biomechanics, and physiology. Predictive models of human interaction with task factors such as posture and workload, and environmental factors such as temperature and humidity. Emphasis is on the applications and implications of physiological measures such as energy expenditures, heart rate, and E.M.G.

**IE 538 Human Factors Laboratory**
This course provides techniques for testing hypotheses and making numerical estimates based on data collected on human subjects. The lecturer content covers measurement strategies, issues of simulation fidelity, and laboratory vs. field experimentation. The laboratory and field content provides a series of tests of current issues in human factors practice from manufacturing, transportation, and office systems.
This course provides techniques for testing hypotheses and making numerical estimates based on data collected on human subjects. The lecturer content covers measurement strategies, issues of simulation fidelity, and laboratory vs. field experimentation. The laboratory and field content provides a series of tests of current issues in human factors practice from manufacturing, transportation, and office systems. C-requisites: IE 531, STA 526

**IE 541 Human Factors in Safety**

**IE 551 Simulation and Stochastic Models**
Introduction to computer simulation. Topics include Monte Carlo simulation, event-oriented simulation, process-oriented simulation, continuous simulation, generating random numbers and random variates, selecting input probability distributions, statistical analysis of simulation results, variance reduction techniques, design of simulation experiments, and some advanced topics in simulation modeling such as simulation metamodels, object-oriented simulation, and parallel discrete-event simulation. Prerequisites: basic statistics, some computer programming experience.

**IE 559/560 Thesis (for M.S. students)**

**IE 561 Information Systems**
This course affords students the background and skills needed to design information systems typically found in manufacturing and industrial organizations. The focus will be on modeling business processes using structured methodologies, deriving data models that support the functional requirements, and implementation using the relational database approach. Topics covered in this course are: Relational Databases and SQL; Functional Architecture and IDEFO Methodology; Information Architecture and Entity Relationship Modeling; Database Design and Implementation using MS Access.

**IE 562 Linear Programming**
Algebraic and geometric characterization of the linear programming problem. Adjacent extreme point methods, duality, postoptimality analysis, decomposition, and interior point methods.

**IE 563 Discrete Optimization**
Presentation of specific mathematical techniques used frequently in Operations Research. Topics include integer programming modeling, branch and bound, polyhedral description, graph theory, networks and computational complexity.

**IE 565 Stochastic Methods**
This course teaches the fundamentals of applied probability theory. Topics include algebra of events, sample space representation of the model of an experiment (any non-deterministic process), random variables, derived probability distributions, discrete and continuous transforms and random incidence. The course also introduces elementary stochastic processes including Bernoulli and Poisson processes and general discrete-state Markov Processes. This is followed by a discussion of some basic limit theorems and some common issues and techniques of both classical and Bayesian statistics.

**IE 566 Applied Stochastic Processes**
A continuation of IE 565. Topics include discrete-time and continuous-time Markov chains, Poisson processes and renewal theory, branching processes. Emphasis is placed on applications to operations research problems in areas such as queuing and inventory theory.

**IE 568 Robotic Systems**
Analysis of robots and robotic systems. Kinematics, coordinate transform, vision systems, off-line programming, and simulation of robotic systems. Laboratory assignments included.

**IE 569 Manufacturing Systems**
Study of different types of manufacturing systems, and the tools and techniques used in their analysis design and operation. Systems considered include Flow Line Systems, Assembly Systems, Cellular Manufacturing Systems, and Flexible Manufacturing Systems.

**IE 591/592 Project (for M.Eng. Students)**

**IE 603 Location Theory**
This course is concerned with analyzing the problem of optimally locating one or more facilities. The approach is a purely analytical one, and the focus is on studying the vast academic literature in this field of Operations Research. Specific topics that are covered include the p-median, p-center, and stochastic queue median problems. Both network and planar location topologies are considered. Analytical tools are developed for these various problems, and solution algorithms are detailed.
IE 620 Agile Manufacturing*
Justification of the agile manufacturing paradigm. Issues and challenges in geographically distributed partnership-based product realization. The role of Information Technology and Modeling in future integrated product and process design. This advanced course provides a core set of fundamental tools, example applications and open research topics in agile manufacturing.
Prerequisite: IE 506, Programming proficiency or consent of instructor.

IE 631 Personnel Subsystem Development*

IE 632 Advanced Topics in Human Factors*
Recent offerings of this course have focused on Cognitive Engineering, Applied Work Measurement Methods, and Musculoskeletal Epidemiology.

IE 640 Human Reliability Analysis and System Safety*
This course examines a variety of perspectives associated with assessing human error and human reliability. Some of the approaches to human reliability analysis that are covered include: THERP, SLIMMAUD, the application of classical engineering reliability methods, and simulation methods. The nuclear power industry serves as the primary application domain.

IE 659/660 Dissertation

IE 661 Scheduling Theory*
This course is concerned with analyzing the problem of optimally scheduling jobs on one or more machines in a production facility. The initial focus is on the simplistic single-machine case. These results are then extended to the multi-machine context, and later to a jobshop situation where jobs are to be routed through the production facility. The approach is an analytical one, with the focus being on the development of a precise mathematical theory for studying such problems.

IE 662 Queuing Theory*
Development and application of mathematical models for queuing systems. Topics include Poisson and Erlang systems, bulk and priority queues, queuing networks, and the optimal design and control of queuing systems. A prerequisite knowledge of stochastic processes is recommended.

IE 663 Inventory Theory*
Development and application of mathematical models for inventory and production control. Topics include deterministic and stochastic demand for both time-stationary and time-varying (dynamic) demand, and multiechelon problems. The course also covers stochastic leadtimes and the relation of these models to queuing systems.

IE 670 Topics in Operations Research*
In-depth analysis of selected topics in Operations Research. Course content will focus upon particular interests of the students and the instructor.

IE 671 Nonlinear Programming*
Single and multivariate classical optimization and Kuhn-Tucker theory. Computational methods, including penalty function, barrier function, gradient, and cutting plane approaches.

IE 674 Integer Programming*
Optimization problems in which some or all variables are restricted to be integers. Enumeration and relaxation methods, cutting planes for integer programs, polyhedra and complexity. Specific models like the traveling salesman, postman, set covering, set packing, set partitioning and Steiner tree problems are considered.

IE 675 Game Theory*
A development of the mathematical theory of conflict, cooperation competition and coercion among economic decision-makers. Classical n-person game theory and its relationship to linear programming. Dynamic cooperative games, their applications to decentralized control systems and the analysis of the behavior of decision-makers in organizations.

IE 677 Network Optimization*
Solutions to graph theory and optimization problems on directed and undirected graphs. Shortest path, maximum flow, minimum weight flows and matching problems. Also, the traveling salesman and Chinese postman problems.
IE 678 Urban Operations Research*
This is an applied Operations Research course, where the focus is on the utilization of the analytical tools that students have learned in other Operations Research courses to study problems of urban significance. The course starts off with a review of basic probabilistic concepts. The first topic covered is that of geometrical probability, a powerful tool to approach urban problems. Then a discussion on queuing theory is presented. This is followed by a discussion of spatial queues that are used in modeling urban emergency service systems. The next topic is on network problems that are useful in an urban context. The final topic is on simulation modeling as applied to urban problems. All topics are reinforced with real-world examples and in-depth homework assignments.

IE 679 Multiple Criteria Decision Making
Both from a theoretical and practical perspective, Multiple Criteria Decision Making (MCDM) influences all aspects of engineering design, analysis and decision making. The goal of MCDM is to help a human decision maker (DM) consider several conflicting objectives simultaneously to find one or more Pareto optimal solutions that satisfy a DM's preferences. Trade-offs must be considered since no single solution individually optimizes each criterion. Theory and application will be studied. Methods can be classified as (1) No-preference methods (2) a Priori methods (DM preference information before considering alternatives (3) A posteriori methods (DM preference information after generating alternatives) and (4) Interactive methods (solution algorithms formed with DM preference information and repeated with new information at each iteration).

IE 680 Advanced Topics in Manufacturing (3D Printing)
Rapidly advancing 3D printing or additive manufacturing (AM) technologies provide us direct way of converting digital data into physical objects. Based on the AM processes, rapid prototyping (RP) and rapid tooling (RT) have been widely adopted as common practice in product development. In the past few years, advances in material, process, and machine development have enabled AM processes to evolve from the prototyping stage to direct product manufacturing. Such rapid manufacturing (RM) capabilities will revolutionize industries such as aerospace, defense, biomedical, and jewelry to name a few. Understanding the advantages and limitations of AM technologies is important for future engineers in developing new engineering systems and identifying emerging opportunities in developing products for mass customization.

IE 681 E-Business and Supply Chain Management
This course will cover the fundamentals of e-Enterprise Management including E-Business and Supply Chain and culminate with leading edge concepts and quantitative approaches. A system wide view is developed of the New Economy which integrates manufacturer, supplier, and customer networks. The role of IT, resource management, optimization and stochastic models will be discussed. Basic models for back end supply chain network design, inventory and risk management, and distributions strategies will be discussed, in the context of industrial software. Similarly, front end processes e-commerce and e-business models such as exchanges and auctions will be discussed, along with linkages to the backend. Reality is captured through cases and mini-projects with industry.
Required Courses: IE 572, IE 575 or equivalent course or remedial preparation approved by instructor.

IE 682 Advanced Engineering and Systems Design
This PhD level and research-oriented course will discuss advanced engineering and systems design theories and applications. Integrated product life cycle design, engineering and manufacturing systems design, information systems design, organization design and ergonomic design will be covered. Class format: lectures, student presentation and research projects.
Prerequisite(s): Graduate students in engineering, or instructor approval.

CSE 507 Services-Oriented Architectures and Web Services
SOA is a design model for linking computation resources, data and applications to perform services and deliver results to service consumers. Web Service standard provides a platform-independent method for messaging-based interaction of applications. This course covers the basic concepts, technologies that support SOA, and the design/implementation of a SOA using web services. Topics covered include: loose coupling of systems, enterprise service bus, composition of complex services, workflow design, policies and service-level agreements, process engineering and system design, WSDL, publication and discovery, and service encapsulation.

CSE 530 Computer Communications
An introduction to communication networks for computer and telecommunication applications. Review of stochastic processes and introductory queuing theory. Local area networks (such as Ethernet, Token Ring, and FDDI), wide area networks (such as SNA, and Internet), ISDN and SONET are considered. Focus is on the data link control, network and transport layers of the OSI protocol suite.
HOW TO REACH US

By Mail:  Office of Graduate Affairs  
Department of Industrial and Systems Engineering  
407 Lawrence D. Bell Hall  
State University of New York at Buffalo  
Buffalo, New York  14260-2050  
USA

By Telephone:  (716) 645-4709

By FAX:  (716) 645-3302. Be sure to send a cover page, addressing your document to:
Office of Graduate Affairs  
Department of Industrial and Systems Engineering  
407 Lawrence D. Bell Hall

By Electronic Mail:  iegrad@buffalo.edu

WEB SITE:  
http://www.ie.buffalo.edu/index.shtml  
http://www.ie.buffalo.edu/graduate-admission.shtml

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