VIRGINIA TECH

2023-2024

ISE GRADUATE MANUAL

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THE ISE GRADUATE PROGRAM

Introduction

The Grado Department of Industrial and Systems Engineering (ISE) offers a broad-based program allowing students to pursue graduate study commensurate with their career goals. Specific strengths of the program are in the areas of human factors engineering and ergonomics, general industrial engineering, management systems engineering, manufacturing systems engineering, operations research, engineering administration, and systems engineering. The Doctor of Philosophy (Ph.D.) degree is offered in Industrial and Systems Engineering, as is the Master of Science (M.S.) and Master of Engineering (M.Eng.), and Master of Engineering Administration (M.E.A.). The department also offers a Master of Science (M.S.) in Systems Engineering (M.S.)

The administrative staff of the academic programs. of the ISE Department includes:

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GRADUATE PROGRAM POLICIES & PROCEEDURES

1. Purpose of the Graduate Manual

This graduate manual provides requirements, policies, and procedures adopted by the faculty for current graduate students in industrial and systems engineering (ISE) for successful completion of graduate degrees. Students should be aware that the requirements provided here represent **minimum** requirements for ISE. It is imperative that you consult your advisor before taking classes since the ultimate approval for your course selection rests with the faculty. Additional information concerning graduate school requirements may be found in the Graduate Policies and Procedures and Course Catalog from Virginia Tech.

http://graduateschool.vt.edu/graduate_catalog/

If there is any doubt regarding the interpretation of any regulation or requirement in this manual, or if there are questions about the graduate program involving matters not covered in this manual, please consult the ISE Graduate Program Director, Dr. Maury A. Nussbaum, or the ISE Graduate Program Advisor, Hannah Parks. **It is each individual student's responsibility to be familiar with all university policies, procedures, and requirements**.

The provisions of this manual do not constitute a contract, expressed or implied, between any applicant or student and the ISE Department or Virginia Polytechnic Institute and State University. The university and the ISE Department reserve the right to change any of the provisions, schedules, programs., courses, rules, regulations, or fees whenever university or departmental authorities deem it expedient to do so.

2. Administration of ISE Graduate Program

The graduate program is administered by the Graduate Policy Committee (GPC), which is also charged with the responsibility for resolving conflicts that may arise regarding policy or procedural issues. The director of the ISE graduate program chairs the GPC. In addition to chairing the GPC, the director of the graduate program is responsible for implementation of requirements, policies, and procedures adopted by the ISE faculty. The director of the graduate program and members of the GPC are appointed by the ISE department head. The ISE Graduate Admissions Committee (GAC) makes all admission decisions. The GAC also assigns incoming graduate students to a temporary advisor in their primary interest area.

3. Financial Assistance

The ISE Department has limited financial assistance available for qualified graduate students in the form of graduate teaching assistantships (GTA) and graduate research assistantships (GRA). Grado, Pratt, NIOSH, Davenport, and Cunningham Fellowships are also available through the ISE department, college of engineering and the Graduate School. The monthly stipend for GTAs and GRAs varies depending on the nature of the assistantship and the graduate level of the student. All assistantships carry a waiver of tuition, except those awarded during summer terms. The student is responsible for comprehensive and other fees (visit http://www.bursar.vt.edu for current fees).

All financial assistance is awarded on a competitive basis, with awards being made to the most qualified students based on merit. GTAs are awarded by the GPC and specific course assignments are made by departmental administration based on teaching needs. A student who is awarded a

full-time GTA is obligated for 20 hours of work per week throughout the semester for which the award applies. Typically, a GTA is assigned to a member of the ISE faculty to assist in teaching a course. GRA awards are made to support research projects that are supervised by ISE faculty. Hence, the principal investigator for the research project from which the funding comes awards the GRA. A student receiving a GRA is expected to work 20 hours per week during the semester for which the award applies, the duties being assigned by the principal investigator. In a similar manner, the duties of a student on a fellowship depend on the particular fellowship and are not covered in this manual.

Students holding a full GTA or GRA must carry a course load of at least 12 credit hours per semester, and not more than 18 hours. Students holding less than full GTAs or GRAs receive a proportionally smaller stipend and reduced tuition waiver and carry a proportionally lower workload. However, all students on assistantship must be registered for a minimum of 12 hours per semester.

Graduate Research Assistant (GRA). Graduate research assistants are graduate students conducting academically significant research under the direction of a regular faculty member, who is generally a principal investigator on an external grant or contract.

Graduate Teaching Assistant (GTA). Graduate teaching assistants may assist faculty in teaching lower division courses, including laboratory teaching assignments, or in providing other appropriate professional assistance. First year GTAs with no prior teaching experience will not be assigned full responsibility for lecture courses. In ISE, it is unusual for a GTA to be assigned full course responsibility.

4. Awarding of Graduate Teaching Assistantships

GTA support depends on the number of positions available and the number of applications for these positions. Graduate student applications for GTA support are invited from continuing Ph.D. students when they submit their annual Student Activity Reports (in January or February). The ISE Graduate Policy Committee reviews these applications and awards GTAs based on the following criteria: a) degree program (Ph.D. students have higher priority than M.S. students); b) academic performance (e.g., GPA), progress (completing program milestones), and productivity (e.g., journal and conference papers); and c) performance of prior GTA duties (if applicable). Ph.D. students who have had GTA support for eight or more academic-year semesters, or have been in the doctoral program for five or more years, will have a reduced priority for support.

5. Changing from GTA to GRA

A student may give up a GTA in favor of a GRA up to two weeks (14 days) before the start of semester classes. Beyond that point in time a GTA may be vacated in favor of a GRA only with the consent of the instructor of the course to which the GTA is assigned and the department head. In the event of a GTA to GRA change, the instructor of the course will work with the GPC to determine the replacement.

6. Academic Eligibility

A student must maintain a cumulative grade point average of 3.0 or better for all courses taken while in graduate school at Virginia Tech and for all courses transferred for graduate credit at

Virginia Tech. At the end of each semester the GPC reviews the progress of each ISE graduate student. Any student with a cumulative grade point average below 3.0 for their last semester of graduate work will be placed on academic probation and may be required to appear before this committee. The purpose of this appearance is to discover the source of the difficulties evidenced by unsatisfactory progress and to outline avenues that the student should pursue to improve their performance. In accordance with Graduate School and ISE departmental policy, any student who fails to meet these requirements in two successive semesters will typically be dismissed from the ISE graduate program.

7. Graduate Honor System

Academic integrity is essential for maintaining the quality of scholarship in the department and for protecting those who depend on the results of research work performed by faculty and students in the department. The faculty of the Grado Department of Industrial and Systems Engineering expects all students to maintain academic integrity at all times in the classroom and the research laboratory and to conduct their academic work in accordance with the high ethical standards of the engineering profession. Students are expected to maintain academic integrity by refraining from academic dishonesty, and conduct that aids others in academic dishonesty or that leads to suspicion of academic dishonesty. Violations of academic integrity will result in disciplinary actions ranging from failing grades on assignments and courses to probation, suspension, or dismissal from the university.

The Graduate Honor Code establishes a standard of academic integrity. As such, this code demands a firm adherence to a set of values. In particular, the code is founded on the concept of honesty with respect to the intellectual efforts of oneself and others. Compliance with the Graduate Honor Code requires that all graduate students exercise honesty and ethical behavior in all their academic pursuits at Virginia Tech, whether these undertakings pertain to study, course work, research, extension, or teaching. Details on the Graduate Honor Code can be found at the following Virginia Tech website:

http://ghs.graduateschool.vt.edu/

It is recognized that graduate student population is very culturally diverse. In light of this, the term ethical behavior is defined as conforming to accepted professional standards of conduct, such as codes of ethics used by professional societies in the United States to regulate the manner in which their professions are practiced. The knowledge and practice of ethical behavior shall be the full responsibility of the student. Graduate students may, however, consult with their advisors, department heads, the Cranwell International Center, or the Graduate School for further information on what is expected of them.

More specifically, all graduate students, while being affiliated with Virginia Tech, shall abide by the standards established by Virginia Tech, as these are described in the Graduate Honor System Constitution. Graduate students, in accepting admission, indicate their willingness to subscribe to and be governed by the Graduate Honor Code and acknowledge the right of the university to establish policies and procedures and to take disciplinary action (including suspension or expulsion) when such action is warranted. Ignorance shall be no excuse for actions that violate the integrity of the academic community.

GRADUATE DEGREE REQUIREMENTS

Students pursuing a graduate degree in the ISE Department must satisfy the requirements of the Graduate School, the ISE Department, and those specific to the student's degree program. For a discussion of general Graduate School requirements, the student should consult the Graduate Catalog (https://secure.graduateschool.vt.edu/graduate_catalog). Listed here are the requirements within ISE and those for each of the different degree programs. It is the responsibility of each student to know these requirements; students should consult with their faculty advisor, the ISE Graduate Advisor, or the ISE Graduate Program Director (GPD) to address any questions or concerns.

1. Plan of Study (all degree programs)

After identifying a graduate advisor (and graduate committee, if required), students need to prepare their plan of study in consultation with their advisor. The plan of study summarizes completed and planned coursework and the student's advisors. Courses listed on the plan of study must include, but are not limited to, all courses required for the degree being pursued. A plan of study is required of all students pursuing graduate degrees at Virginia Tech and contains the elements below:

A. List of courses to be completed for degree completion, including the semester and year in which each course has or will be taken.
B. The names and signatures of each member of the student's graduate advisory committee.

Graduate school policies indicate the following:

- For students pursuing the Master of Engineering (M.Eng.), Master of Science (M.S.), Master of Engineering Administration (M.E.A.), or Master of Systems Engineering (M.S.), degrees, the plan of study must be completed and submitted prior to the completion of 24 credit hours or by the end of their second semester of full-time enrollment in their graduate program.
- For students pursuing a Ph.D., the plan of study must be submitted prior to the completion of 36 credit hours or by the end of their third semester of full-time enrollment in their graduate program.

However, the ISE Department expects all graduate students to **submit their plan of study prior to completing their second semester in the program**. The department expects this early submission, so that students ensure they are taking relevant foundational coursework and do not miss courses that are not offered yearly (i.e., only every two or three years). Early completion of the plan of study is particularly important for M.S. and Ph.D. students, since doing so will allow them to start their research soon and ensure that the remaining program milestones are completed in a timely fashion.

All ISE graduate students must also take ISE 5024: ISE Seminar. This seminar must be taken during the first Fall semester of enrollment in the graduate program (it is offered only in the Fall

term) and it focuses on the ISE graduate program, ethics and integrity, faculty, and faculty research areas.

All new engineering graduate students at Virginia Tech, who started Fall 2021 or later, are also required to enroll in ENGE 5304: Graduate Student Success in Multicultural Environments. This course satisfies the Graduate School's diversity education requirement, and it should be taken in a students' first year. This course is offered every Fall and Spring semester.

The Graduate School has rules on transfer credit. Students should consult the Graduate Catalog for these rules (https://secure.graduateschool.vt.edu/graduate_catalog/policies.htm). The ISE Department also has rules on transfer credit (beyond the Graduate School rules): transfer courses may not exceed one-half of graded course credit hours on a plan of study and must be graduate course hours earned at an accredited institution. All transfer courses must have a grade of B or better to be considered for transfer credit. When appropriate, these transfer credits can be used to substitute for required courses if approved by the appropriate course instructor, graduate advisor, and the ISE GPD. In all cases, transfer credits on the plan of study must be approved by the student's advisory committee.

Students who have completed a Master's degree at another university may be required to take Master's level courses in those areas where deficiencies are identified. Where such deficiencies are identified, the student's advisory committee will recommend appropriate courses to be included in the plan of study and taken by the student prior to degree completion. Normally, but not in all cases, such courses will carry graduate credit.

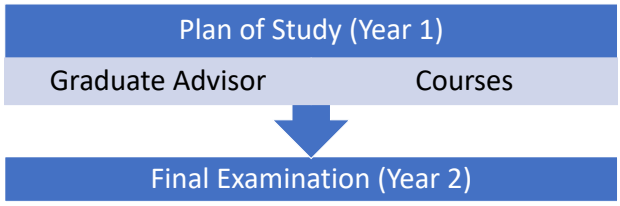
The plan of study approval process includes review and signed approval by the student's advisor, graduate committee members, and GPD. The plan of study is submitted to the ISE Graduate Program Advisor for electronic entry and approval by the Graduate School.

2. Requirements for Specific Degree Programs

Additional details on the requirements for each of the five different ISE degree programs. are given in separate sections below. Students should ensure that they follow the requirements that are appropriate for their specific degree program. Note that the expected timelines provided are for full-time students, and it is recognized that others will required addition time (e.g., part-time students or those who have taken leaves-of-absence).

2.1 Master of Engineering in ISE (M.Eng.)

An overview of the requirements and the expected timeline is given in the figure below.



Plan of Study

The first step in defining the plan of study is the selection of a graduate advisor. M.Eng. students are advised by the ISE GPD (with additional assistance from the ISE Graduate Program Advisor). M.Eng. students do not need a formal advisory committee, other than the ISE GPD.

Final Examination

All graduate students pursuing a M.Eng. degree are required to schedule a final examination. The examination is also a requirement of the Graduate School and must be administered during a semester in which the student is registered. There is no formal deliverable or activity for the M.Eng. final examination. Note that the ISE Department expects M.Eng. students to complete the program **within two years after enrolling in the M.Eng. program**.

Graduate School policy states: "Requests to schedule final examinations must include the time, date, building and room number, title of dissertation or thesis, and the names and email addresses of the Examining Committee. These requests are due in the Graduate School at least two weeks before the examination date requested."

Students should contact the Graduate School at least two days prior to a requested examination/evaluation date if they have not received the official notification of scheduling.

Graduate School policies on scheduling examinations/evaluations can be found in the Virginia Tech Graduate Catalog.

The exam is scheduled online using the Graduate School's electronic scheduling and signature system (ESS). M.Eng. students will use the first business day following the deadline for final grade entry in the semester they are completing their degree.

2.2 Master of Science in ISE (M.S.)

An overview of the requirements and the expected timeline is given in the figure below.

Plan of Study

Graduate Advisor: The first step in defining the plan of study is the selection of a graduate advisor. New M.S. students are assigned a temporary faculty advisor in their general area of interest. The student, however, should begin working early to determine an appropriate research advisor (or co-advisors). A student's advisor or co-advisor must be a member of the ISE tenured/tenure track faculty, or an ISE Affiliate Faculty, and should have expertise in the research area(s) the student intends to pursue. In all cases, the faculty member must give their written consent to serve in the capacity of graduate advisor.

Advisory Committee: A graduate advisory committee is required for all M.S. students. The graduate advisor serves as the chair of the graduate advisory committee and the student should seek the assistance of their advisor in identifying faculty who might serve on the committee. The committee should be composed of faculty members who can assist the student in completing their graduate degree. To facilitate such assistance, the student is encouraged to send a brief summary of their future research interest(s) to potential committee members for their review. Each member is added to the student's committee after consenting to serve.

Committee Requirements: M.S. advisory committees must include a minimum of three members, at least two of which must be *Virginia Tech tenured/tenure-track faculty* (per Graduate School requirements, or at least 2/3 if there are more than four members). An additional departmental-level requirement is that at least two of the members must be *ISE tenured/tenure-track faculty* (this counts as part of the 2/3 Graduate School requirement). Having a member outside of the ISE Department or even outside of Virginia Tech is encouraged, but not required.

Committee Meetings: Committee members are expected to attend meetings as a collective body, and the student's advisor(s) must be present at all such meetings. Faculty participation on graduate student committees is an important part of ISE faculty responsibilities. To this end, ISE faculty are expected to attend all committee meetings for graduate students they advise or on whose committees they serve. In addition, university policies require that all committee members attend a student's final thesis defense.

ISE M.S. students are required to sequentially complete several milestones and to meet periodically with their graduate advisory committee. These milestones and associated committee meetings are listed below, though additional meetings can be held as needed. As noted earlier (see "Advisory Committee"), committee members are expected to attend all required meetings except in unusual circumstances.

1. Research Proposal
2. Progress Report
3. Final Defense

A note regarding ISE Policy: Students, or anyone on their behalf, are strictly forbidden from bringing food or drink to student evaluation meetings (e.g., graduate student progress meetings, proposal defenses, final defenses).

Research Proposal

Students pursuing an M.S. degree are required to complete research during their graduate study. The ISE Department expects the M.S. proposal to be defended successfully **before the end of the student's first summer in the graduate program**. Further, it is expected that the M.S. research will be proposed to the committee **before substantial aspects of the research are completed**. The student is required to prepare a written research proposal that describes the background and motivation for the research, the specific content of the research, the outcomes anticipated, the contributions to the field of endeavor, and the creative content of the effort. The written proposal does not have any required format, though many students model it on what is required by major funding agencies (e.g., NIH or NSF). The written proposal must be submitted to the committee at least two weeks prior to a meeting with the advisory committee. At this meeting, the proposal will be presented by the student and evaluated by the committee, which will provide constructive feedback. Signatures of each committee member on the proposal approval form signify approval of the proposed research effort. This form must be submitted to the ISE Graduate Program Advisor upon completion. The nature and extent of the proposed research effort depend on the degree sought. The results of M.S. research are typically equivalent to one or two journal publications.

Progress Meeting

Between the research proposal and the final examination, each student is required to provide a summary of progress to their advisory committee at a progress meeting. This meeting is expected to be held before the M.S. research is completed, typically at the **start of the second year** of the student's graduate program. A major purpose of the progress meeting is for the student to update the advisory committee on any achievements or problems. that have arisen during their research. If non-trivial changes are needed from what was presented in the proposal, these changes should be explained in detail and approved by the advisory committee. Students often give a brief presentation at this meeting. The advisory committee must sign the progress report form, and this form is submitted to the ISE Graduate Program Advisor upon completion.

Final Defense

All graduate students pursuing an M.S. degree are required to pass a final examination or defense. This is an oral examination, administered by the advisory committee. The examination is also a requirement of the Graduate School and must be administered during a semester in which the student is registered. Note that the ISE Department expects M.S.

students to defend their dissertation successfully **within two years after enrolling in the M.S. program**. The department requires that the written thesis be submitted to the committee at least two weeks prior to the oral examination.

The ISE Department requires all M.S. final defenses to be open, including the Question & Answer portion of the exam. Final defenses must be advertised in advance to ISE faculty and graduate students. Once the exam date, time, and location are scheduled, students should send the information to the ISE Graduate Program Advisor, along with an abstract of their thesis or dissertation. Exceptions to open defenses will be made for relevant situations and should be submitted to the ISE GPD at least two weeks prior to the scheduled defense. Exceptions can be full (no portion open) or partial. Some examples for exceptions are proprietary, confidential, or export control materials.

Graduate School policy states: "Requests to schedule final examinations must include the time, date, building and room number, title of dissertation or thesis, and the names and email addresses of the Examining Committee. These requests are due in the Graduate School at least two weeks before the examination date requested." As a reminder, the thesis document must be submitted to the committee at least two weeks prior to the oral defense.

Approval of a final examination request indicates that the committee member has received and read the thesis or dissertation document and agrees that the document is ready for defense. This means that no substantial additional work or changes are needed, and that only minor edits to the document will be necessary after the defense.

As a reminder, no examination or evaluation should be conducted if the committee has not received electronic notification from the Graduate School that the examination/evaluation has been officially scheduled. Students should contact the Graduate School at least two days prior to a requested examination/evaluation date if they have not received the official notification of scheduling.

Graduate School policies on scheduling examinations/evaluations can be found in the Virginia Tech Graduate Catalog.

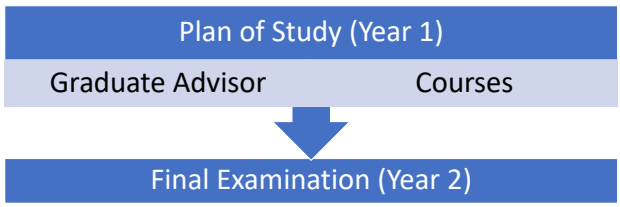
The exam is scheduled online using the Graduate School's electronic scheduling and signature system (ESS).

To pass the final examination, a degree candidate must have a favorable vote from a majority of the examining committee, with a maximum of one negative vote. If a student fails the final examination, there must be a lapse of one full semester (15 weeks) before rescheduling the examination. A student is allowed no more than two opportunities to pass the final examination.

The result of the examination is recorded in the ESS system. Each member of the student's advisory committee must approve the exam result in the ESS system. After a successful oral defense, the student has two weeks to revise the thesis to address any suggestions or concerns expressed by the committee.

2.3 Master of Engineering Administration (M.E.A.)

An overview of the requirements and the expected timeline is given in the figure below.



Plan of Study

The first step in defining the plan of study is the selection of a graduate advisor. M.E.A. students are advised by the Director of the M.E.A. program, and two additional members are appointed by the ISE Department Head as the M.E.A. Advisory Committee

Final Examination

All graduate students pursuing an M.E.A. degree are required to schedule a final examination. The examination is also a requirement of the Graduate School and must be administered during a semester in which the student is registered. The M.E.A. final exam is the M.E.A. comprehensive exam, which students complete in their final semester in the program. The advisory committee role is to verify that the student has completed their course requirements and the comprehensive exam.

Graduate School policy states: "Requests to schedule final examinations must include the time, date, building and room number, title of dissertation or thesis, and the names and email addresses of the Examining Committee. These requests are due in the Graduate School at least two weeks before the examination date requested."

The Director of the M.E.A. program will notify students who are in their final semester of the date, time, and location of the M.E.A. comprehensive exam.

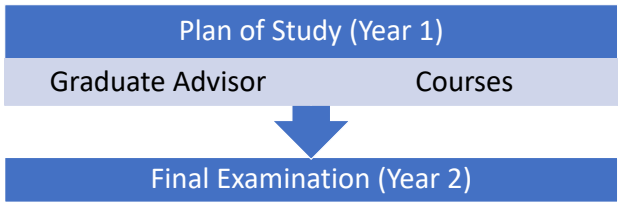
No examination or evaluation should be conducted if the committee has not received electronic notification from the Graduate School that the examination/evaluation has been officially scheduled. Students should contact the Graduate School at least two days prior to a requested examination/evaluation date if they have not received the official notification of scheduling.

Graduate School policies on scheduling examinations/evaluations can be found in the Virginia Tech Graduate Catalog.

The exam is scheduled online using the Graduate School's electronic scheduling and signature system (ESS). M.E.A. students will use the date that they take the M.E.A. comprehensive exam.

2.4 Master of Science in System Engineering (M.S.)

An overview of the requirements and the expected timeline is given in the figure below.



Plan of Study

The first step in defining the plan of study is the selection of a graduate advisor. SYSE students are advised by the Director of the SYSE program, and two additional members are appointed by the ISE Department Head as the SYSE Advisory Committee

Final Examination

All graduate students pursuing a SYSE degree are required to schedule a final examination. The examination is also a requirement of the Graduate School and must be administered during a semester in which the student is registered. The final exam for the M.S. in SYSE is conducted in ENGR 5204 (Systems Engineering Projects), in which students present their final project of the semester. The advisory committee role is to verify that the student has completed their course requirements and the final project.

Graduate School policy states: "Requests to schedule final examinations must include the time, date, building and room number, title of dissertation or thesis, and the names and email addresses of the Examining Committee. These requests are due in the Graduate School at least two weeks before the examination date requested."

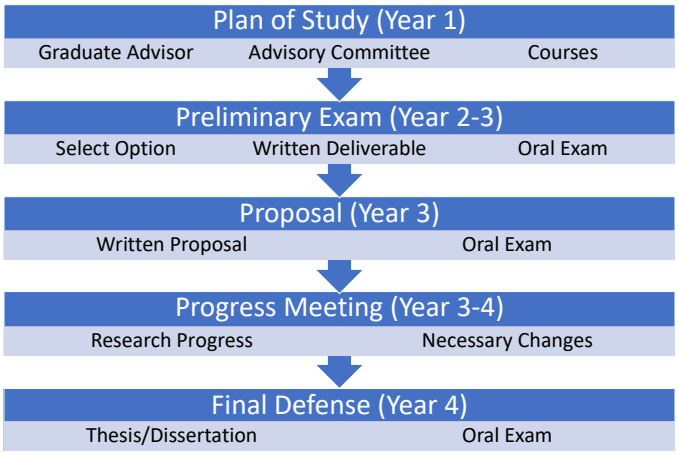
No examination or evaluation should be conducted if the committee has not received electronic notification from the Graduate School that the examination/evaluation has been officially scheduled. Students should contact the Graduate School at least two days prior to a requested examination/evaluation date if they have not received the official notification of scheduling.

Graduate School policies on scheduling examinations/evaluations can be found in the Virginia Tech Graduate Catalog.

The exam is scheduled online using the Graduate School's electronic scheduling and signature system (ESS). SYSE students will use the date of the final project presentation sin ENGR 5204.

2.5 Doctor of Philosophy (**Ph.D.**)

An overview of the requirements and the expected timeline is given in the figure below.



Plan of Study

Graduate Advisor: The first step in defining the plan of study is the selection of a graduate advisor. New Ph.D. students are assigned a temporary faculty advisor in their general area of interest. The student, however, should begin working early to determine an appropriate research advisor. A student's advisor or co-advisor must be a member of the ISE tenure/tenure track faculty, or an ISE Affiliate Faculty, and should have expertise in the research area(s) the student intends to pursue. In all cases, the faculty member must give their written consent to serve in the capacity of graduate advisor.

Advisory Committee: A graduate advisory committee is required for all Ph.D. students. The graduate advisor serves as the chair of the graduate advisory committee and the student should seek the assistance of their advisor in identifying faculty who might serve on the committee. The committee should be composed of faculty members who can assist the student in completing their graduate degree. To facilitate such assistance, the student is encouraged to send a brief summary of their future research interest(s) to potential committee members for their review. Each member is added to the student's committee after consenting to serve.

Committee Requirements: Ph.D. advisory committees must include a minimum of four members, at least three of which must be *Virginia Tech tenured/tenure-track faculty* (per Graduate School requirements, or at least 2/3 if there are more than four members). An additional departmental-level requirement is that at least two of the members must be *ISE*

tenured/tenure-track faculty (this counts as part of the Graduate School requirement). Having a member outside of the ISE Department or even outside of Virginia Tech is encouraged, but not required.

Committee Meetings: Committee members are expected to attend meetings as a collective body, and the student's advisor(s) must be present at all such meetings. Faculty participation on graduate student committees is an important part of ISE faculty responsibilities. To this end, ISE faculty are expected to attend all committee meetings for graduate students they advise or on whose committees they serve. In addition, university policies require that all committee members attend a student's final dissertation defense.

ISE Ph.D. students are required to sequentially complete several milestones and to meet periodically with their graduate advisory committee. These milestones and associated committee meetings are listed below, though additional meetings can be held as needed. As noted earlier (see "Advisory Committee"), committee members are expected to attend all required meetings except in unusual circumstances.

1. Preliminary examination
2. Research Proposal
3. Progress Report
4. Final Defense

A note regarding ISE Policy: Students, or anyone on their behalf, are strictly forbidden from bringing food or drink to student evaluation meetings (e.g., graduate student progress meetings, proposal defenses, prelim defenses, final defenses).

Preliminary Examination

The oral portion of the preliminary examination is a requirement of the Graduate School and must be successfully completed by all Ph.D. students. The Graduate School requires this to be completed at least six months prior to completing the Ph.D. degree (final defense of the dissertation). The ISE Department expects the Preliminary Examination to be **completed before the end of a student's fourth or at the start of their fifth semester in the** Ph.D. **program**. Prior to starting the Preliminary Exam, it is expected that the student will complete all (or the vast majority) of their coursework and have identified fairly specific areas of research interest for their Dissertation.

The ISE Preliminary Exam has the primary purpose of evaluating the extent to which Ph.D. students are prepared to pursue independent research at a level expected in the department. This examination includes both written and oral parts; it is used to identify any weaknesses or gaps in the student's abilities, skills, and knowledge; and the primary outcome of this exam is an appropriate plan to address any identified weaknesses or gaps. This examination is an essential demonstration of the likelihood that a student will complete their Ph.D.

successfully. Thus, the ISE faculty consider this examination to be a major milestone and decision point for both students and faculty regarding the appropriateness of a student continuing in the program.

Since Ph.D. students come from diverse academic backgrounds and progress through the program differently, several options are available to complete this examination as described below. For each option, a *deliverable must be submitted at least two weeks prior to a pre-scheduled, two-hour oral examination* with the committee, in which the discussion will focus on the student's deliverable and any other topics determined to be of relevance by the committee.

Students must confer with committee members **prior to** selecting one of the specific options described below, and the student must have approval from all committee members regarding the option selected. Regardless of the option used to complete the exam, the deliverable to the committee **must represent substantially independent work completed by the student**. Ideally, the preliminary examination is to be solely the work of the student, although input from the advisor or committee in the form of general mentoring or guidance is fully acceptable. Use of proofreaders or writing assistance is not acceptable, and to do otherwise is considered a violation of the honor code.

When submitting the required deliverable for any of the four options, the student **must indicate what, if any, assistance was received** in creating the deliverable.

For options 2, 3, and 4, the topic may be determined by the student; in these cases, the topic needs to be approved in advance by the committee. Such approval can be obtained in a meeting or via individual discussions. Alternatively, the topic can be suggested by the committee. Deliverables for these same options must represent work done since starting the Ph.D. program at VT. Any material provided in these deliverables may be used by the student in subsequent program milestones without limitation.

1. Written Examination:
   The student will respond to written questions posed by the advisory committee. Questions can cover any aspect of ISE study desired by the advisory committee, though these are often focused on the student's area(s) of research interest. Students are therefore strongly encouraged to submit the brief description of their research interests, noted above, to the advisory committee, and to do so well before the examination. Students will have two weeks after receiving questions to provide written responses to the advisory committee questions and may not receive any assistance with their written responses.

2. Research Paper:
   The student will submit to the committee a paper that represents a completed research effort. This effort should represent original work led by the student and should be

prepared in a format and with a writing style appropriate for a leading peer-reviewed journal in their research area.

3. Review Paper:
   The student will submit to the committee a critical review of the literature in a research area, which summarizes the current state of knowledge and associated limitations or future needs. This effort should represent original work led by the student and should be prepared in a format and with a writing style appropriate for a leading peer-reviewed journal in their research area.

4. Proposal for a Research Effort:
   The student will submit to the committee a written proposal for a research effort, the scope of which should be roughly equivalent to one publication in a peer-reviewed journal in their research area. It will be acceptable for the student to include this material as a portion of their subsequent dissertation proposal. The proposal should include clear motivation for the proposed work, a critical review of relevant literature, and a detailed research plan.

The oral portion of the examination is administered at least two weeks after completion of the written portion and must be scheduled through the Graduate School. Students must be enrolled during the semester the oral portion of the examination is taken and may not schedule the preliminary examination until they have a plan of study that has received final approval from the Graduate School. The oral preliminary examination must be scheduled through the Graduate School at least two weeks prior to the date the exam will be held. The exam is scheduled online using the Graduate School's electronic scheduling and signature system (ESS).

Graduate School policy states: "Requests to schedule examinations must include the time, date, building and room number, title of dissertation or thesis, and the names and email addresses of the Examining Committee. These requests are due in the Graduate School at least two weeks before the examination date requested."

As a reminder, no examination or evaluation should be conducted if the committee has not received electronic notification from the Graduate School that the examination/evaluation has been officially scheduled. Students should contact the Graduate School at least two days prior to a requested examination/evaluation date if they have not received the official notification of scheduling.

Graduate School policies on scheduling examinations/evaluations can be found in the Virginia Tech Graduate Catalog.

The student's advisor administers the oral portion of the preliminary examination. This **examination should be closed to outside members**. One negative vote by a committee

member is permitted for successful completion of the examination. If performance on the preliminary examination is unsatisfactory, one full semester must lapse (15 weeks) before the examination is administered a second time. Students failing the preliminary examination twice will be dismissed from the program. The result of the examination is recorded in the ESS system. Each member of the student's advisory committee must approve the exam result in the ESS system. Advisory committees reserve the right to alter a plan of study based on performance on the preliminary exam.

Research Proposal

Students pursuing a Ph.D. degree are required to complete research during their graduate studies. The ISE Department expects the Ph.D. proposal to be defended successfully **before the end of the student's third year in the graduate program**. Further, it is expected that the Ph.D. research will be proposed to the committee **before substantial aspects of the research are completed**. The student is required to prepare a written research proposal that describes the background and motivation for the research, the specific content of the research, the outcomes anticipated, the contributions to the field of endeavor, and the creative content of the effort. The written proposal does not have any required format, though many students model it on what is required by major funding agencies (e.g., NIH or NSF). The written proposal must be submitted to the committee at least two weeks prior to a meeting with the advisory committee. At this meeting, the proposal will be presented by the student and evaluated by the committee, which will provide constructive feedback. Signatures of each committee member on the proposal approval form signify approval of the proposed research effort. This form must be submitted to the ISE Graduate Program Advisor upon completion.

The nature and extent of the proposed research effort depend on the degree sought. A student pursuing a Ph.D. degree should demonstrate, through the dissertation, the ability to carry out original and creative research. The results of Ph.D. research are typically equivalent to three or more journal publications.

Progress Meeting

Between the research proposal and the final examination, each student is required to provide a summary of progress to their advisory committee at a progress meeting. This meeting is expected to be held before the Ph.D. research is completed, typically at the **end of the third year or the start of the fourth year** of the student's graduate program. A major purpose of the progress meeting is for the student to update the advisory committee on any achievements or problems. that have arisen during their research. If non-trivial changes are needed, from what was presented in the proposal, these changes should be explained in detail and approved by the advisory committee. Students often give a brief presentation at this meeting. The advisory committee must sign the progress report form, and this form is submitted to the ISE Graduate Program Advisor upon completion.

Final Defense

All graduate students pursuing a Ph.D. degree are required to pass a final examination or defense. This is an oral examination, administered by the advisory committee. The examination is also a requirement of the Graduate School and must be administered during a semester in which the student is registered. Note that the ISE Department expects Ph.D. students to defend their dissertation successfully **within four years after enrolling in the** Ph.D. **program**. The department requires that *the written dissertation be submitted to the committee at least two weeks prior to the oral examination*. There is no requirement for the student to have an accepted or submitted journal paper from their dissertation work, prior to the final defense. Submitting and publishing papers from the research is, however, strongly encouraged at any time during the program.

The ISE Department requires all Ph.D. final defenses to be open, including the Question & Answer portion of the exam. Final defenses must be advertised in advance to ISE faculty and graduate students. Once the exam date, time, and location are scheduled, students should send the information to the ISE Graduate Program Advisor, along with an abstract of their thesis or dissertation. Exceptions to open defenses will be made for relevant situations and should be submitted to the ISE GPD at least two weeks prior to the scheduled defense. Exceptions can be full (no portion open) or partial. Some examples for exceptions are proprietary, confidential, or export control materials.

Graduate School policy states: “Requests to schedule final examinations must include the time, date, building and room number, title of dissertation or thesis, and the names and email addresses of the Examining Committee. These requests are due in the Graduate School at least two weeks before the examination date requested.” As a reminder, the dissertation document must be submitted to the committee at least two weeks prior to the oral defense.

Approval of a final examination request indicates that the committee member has received and read the thesis or dissertation document and agrees that the document is ready for defense. This means that no substantial additional work or changes are likely needed, and that only minor edits to the document will be necessary after the defense.

As a reminder, no examination or evaluation should be conducted if the committee has not received electronic notification from the Graduate School that the examination/evaluation has been officially scheduled. Students should contact the Graduate School at least two days prior to a requested examination/evaluation date if they have not received the official notification of scheduling.

Graduate School policies on scheduling examinations/evaluations can be found in the Virginia Tech Graduate Catalog.

The exam is scheduled online using the Graduate School’s electronic scheduling and signature system (ESS).

To pass the final examination, a degree candidate must have a favorable vote from a majority of the examining committee, with a maximum of one negative vote. If a student fails the final examination, there must be a lapse of one full semester (15 weeks) before rescheduling the examination. A student is allowed no more than two opportunities to pass the final examination.

The result of the examination is recorded in the ESS system. Each member of the student's advisory committee must approve the exam result in the ESS system. After a successful oral defense, the student has two weeks to revise the dissertation to address any suggestions or concerns expressed by the committee.

3. Frequently Asked Questions (and answers)

3.1 *Should I pursue the ISE thesis (M.S.) or non-thesis (M.Eng.) Master's?*

This is a common question among Master's students. Each area of study may have a different focus in this regard; however, there are some general issues students should consider.

Thesis Advantages: A thesis provides a formal experience with research and good preparation for pursuit of a Ph.D. (application reviewers may see this experience as a positive if a student applies for a Ph.D. program). A thesis may also be valued by future employers, depending on the field of study. Note that students who pursue an M.S. degree are required to take three fewer courses than those pursuing a M.Eng.

Thesis Disadvantages: Students will generally invest at least one summer working on their research, as well as substantial time during the academic year.

3.2 *What are the faculty expectations for the Preliminary Exam, Proposal Defense, and Final Defense?*

Students working on the M.S. or Ph.D. are evaluated at these major program milestones using a shared rubric. A copy of this rubric is available to students on a Canvas site for ISE graduate students. Major areas of evaluation include the following (not all areas will be relevant for all students at all milestones):

- Knowledge of and ability to critique the body of knowledge related to the area(s) of research.
- Ability to properly use methods, or develop new methods, as relevant to the area(s) of research and proposed research topic(s).
- Creativity and originality in formulating a research plan.
- Ability to articulate the significance of the research (plan).
- Ability to present the technical and broader societal impacts and implications of the research (plan).
- Written communication skills (including organization, flow, writing quality, level of detail and completeness, and data presentation).
- Oral communication skills (including organization, flow, speaking quality, use of media, and responses to questions).
- Ability to perform future independent research.

4. Continuing from the M.S. to the Ph.D.

Students in the Master's program who wish to continue in the ISE department to pursue a Ph.D. degree need to formally apply to the Ph.D. program (i.e., by submitting an application to the Graduate School). The ISE Graduate Admissions Committee will review the student's academic performance, and a decision on admission to the Ph.D. program will be made upon completion of the review. If accepted, the student will be officially notified by the Graduate School.

DOCTOR OF PHILOSOPHY (PH.D.) PROGRAM

The Grado Department of Industrial and Systems Engineering has a reputation as one of the top ISE Ph.D. programs. in the world. This reputation stems. from the cutting-edge research conducted here by the collaboration of a strong and experienced faculty with the top graduate students in the field. Doctoral students in ISE experience rigorous academic study requiring independent investigation that results in original scholarly work of the highest quality. Graduates are well prepared for positions in both academia and the private or public sector.

Prospective Ph.D. students should have a strong academic background that is commensurate with their desired field of study within the department. Students will need to select one of the Ph.D. Concentrations that are listed below with information on the respective domains and curriculum requirements. Please go to the department website (http://www.ise.vt.edu/academics/graduate/Ph.D./index.html) to obtain more details about the specific faculty supporting each concentration.

1. Common Requirements for Concentrations

The following applies to all concentrations. Please note, however, that several of these are minimum requirements that may be exceeded by the requirements of a given concentration, and that additional requirements may exist in some concentrations.

- The Graduate School requires a total of 90 credits for a Ph.D.
- All Ph.D. student must complete a minimum of 36 graded credit hours, including 24 graded ISE course hours (post BS.) Note that ISE 5804 and ISE 5814 can be counted toward the ISE course-hour requirement, unless otherwise indicated for a given concentration
- All students must take ISE 5024 – ISE Graduate Seminar in their first fall semester of enrollment and ENGE 5034 – Graduate Student Success in Multicultural Environments within their first year of enrollment. *Please note that these courses do not count towards the minimum 36 graded credits.*
- P/F and other non-graded courses cannot be counted toward minimum credit-hour requirements, unless there is no other grade option for the course.
- All required courses in a concentration must be taken for a grade (i.e., A-F)
- Courses not listed as pre-approved electives in a concentration may be taken, or substitutions for required concentration courses made, pending approval of the student's Ph.D. advisory committee

2. Ph.D. Program Concentrations

1. Cognitive Engineering
2. Human Factors of Systems & Product Design
3. Management Systems Engineering
4. Manufacturing Systems Engineering
5. Occupational Ergonomics and Safety
6. Operations Research

2.1 Cognitive Engineering - Cognitive engineering is a multidisciplinary endeavor concerned with the analysis, design, and evaluation of complex systems of people and technology. This field of study embraces knowledge from human factors, psychology/cognitive science, human-computer interaction, and systems engineering. This concentration provides interdisciplinary training and exposure to the major approaches, methods, and tools to understand the capabilities and limitations of human cognition and their impact on interactive systems design. The concentration also covers design techniques for

developing technology in sociotechnical systems. The course work builds the foundation for impactful dissertation research in the areas of cognitive engineering analysis, human performance and measurement, human-computer systems and human-systems integration.

This concentration is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Cognitive Engineering Ph.D. students are required to complete: 1) **two** required core courses; 2) **four** additional concentration courses; and 3) a minimum of **six** additional preapproved elective courses, which can be selected from the list of Preapproved Electives below, one of which should be outside of the ISE department. Ph.D. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. Ph.D. students must also complete a minimum of 30 credit hours of ISE 7994 – Research and Dissertation.

Core Courses

Course	Course Title	Credits
ISE 5104 or ISE 5814	Operations Research or System Dynamics Modeling of Socio-Technical Systems	3
ISE 5624	Human Factors Research Design	4

Concentration Courses

Course	Course Title	Credits
ISE 5604	Human Information Processing	3
ISE 5654	Human Factors System Design	3
ISE 5714	Usability Engineering	3
ISE 6984	Cognitive Task and Work Analysis	3

Preapproved Electives

Course	Course Title	Credits
ISE 5034	Mathematical Probability and Statistics	3
ISE 5154	Applied Human Factors Engineering	3
ISE 5424	Simulation I	3
ISE 5474	Statistical Theory of Quality Control	3
ISE 5614	Human Physical Capabilities	3
ISE 5644	Human Audition and Auditory Display Design	3
ISE 5674	System Safety Analysis	3
ISE 5694	Macroergonomics	3
ISE 6604	Human Factors in Visual Display Systems	3
ISE 6624	Advanced Topics in Human Factors	3
ART 5524	Topics in Human Centered Design	3
CS 4624	Multimedia, Hypertext, and Information Access	3
CS 5724	Models and Theories of Human-computer Interaction	3
CS 5734	Social Computing and Computer-Supported Cooperative Work	3
CS 5754	Virtual Environments	3

CS 5764	Information Visualization	3
CS 5774	User Interface Software	3
CS 6724	Advanced Topics in Human-computer Interaction	3
ECE 5564	Wearable and Ubiquitous Computing	3
GRAD 5134	Topics in Interdisciplinary Research (when topic is HCD)	3
PSYC 5344	Cognitive Psychology	3
STAT 4504	Applied Multivariate Analysis	3
STAT 5015G	Advanced Theoretical Statistics	3
STAT 5204	Experimental Design and Analysis I	3
STAT 5504	Multivariate Statistical Methods	3

ART = Art & Art History; **CS** = Computer Science & Applications; **ECE** = Electrical & Computer Engineering; **GRAD** = Graduate Studies; **PSYC** = Psychology; **STAT** = Statistics

2.2 Human Factors of Systems & Product Design - Human factors engineering plays a central role in the design and operation of many systems which involve humans as consumers, operators, controllers, passengers, and/or monitors. Inadequate or even suboptimal design can lead to market failure, product recall, system ineffectiveness and errors, rapid obsolescence, safety issues and hazards, and lack of viability as a consumer product or other human interface. To perform design, development, and evaluation of these systems, the ergonomist must gain proficiency in human visual and auditory processing and display design, cognitive ergonomics, usability testing, empirical methods, ethics and legal issues, and intellectual property development and protection. In this concentration, a two-pronged coursework path is designed to instill skill and knowledge in both: a) empirical research supported by human subject experimentation, and b) analytical, modeling, and physical measurement methodologies.

This concentration is available only at the Blacksburg campus.

Required Courses

Course	**Course Title**	**Credits**
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Human Factors of Systems & Product Design Ph.D. students are required to complete: 1) **two** required core courses; 2) **six** additional concentration courses; and 3) a minimum of **four** additional preapproved elective courses, which can be selected from the list of Preapproved Electives below. Ph.D. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. Ph.D. students must also complete a minimum of 30 credit hours of ISE 7994 – Research and Dissertation.

Core Courses

Course	**Course Title**	**Credits**
ISE 5104 or ISE 5814	Operations Research or System Dynamics Modeling of Socio-Technical Systems	3
ISE 5624	Human Factors Research Design	4

Concentration Courses

Course	**Course Title**	**Credits**
ISE 5604	Human Information Processing	3
ISE 5654	Human Factors System Design	3
ISE 5644	Human Audition and Auditory Display Design	3

ISE 5714	Usability Engineering	3
ISE 6604	Human factors in Visual Display Design	3
ISE 6624	Special topics: Forensics, Litigation, and Intellectual Property for HFE	3

Preapproved Electives

Course	Course Title	Credits
ISE 4624	Work Physiology	3
ISE 5614	Human Physical Capabilities	3
ISE 5674 or ISE 4644	System Safety Analysis or Occupational Safety and Hazard Control	3
ISE 5694	Macroergonomics	3
ISE 6614	Human Computer Systems	3
ISE 6624	Advanced Topics in Human Factors	3
ISE 6644	Cognitive Work and Task Analysis	3
CS 5754	Virtual Environments	3
STAT 4504	Applied Multivariate Analysis	3
PSYC 5134	Advanced Psychometric Theory	3
PSYC 4074	Sensation and Perception	3

CS = Computer Science & Applications; **PSYC** = Psychology; **STAT** = Statistics

2.3 Management Systems Engineering - Management Systems Engineering is focused on the theory, research, design, implementation, evaluation, and improvement of systems comprised of decision makers, information, organizational structures, technology, decision tools, work processes, and people, with an emphasis on the interactions among these components. Management Systems Engineering involves the application of engineering design and analysis methodologies and tools to these management systems. One of the primary objectives of this area is to advance the theory and science of designing and understanding of complex management and engineered systems. The Management Systems Engineering Ph.D. concentration is designed to provide students with the knowledge and skills to meet the challenges posed by increasingly complex organizational systems within dynamic, global environments.

The Management Systems Engineering concentration is designed to expose students to a breadth of industrial engineering topics at the graduate level, depth in management systems engineering topics, and the opportunity to take technical electives in specialized areas within industrial engineering and other areas.

This concentration is available at the Blacksburg and National Capital Region campuses.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Management Systems Engineering Ph.D. students are required to complete: 1) **five** required core courses; and 2) a minimum of **seven** additional preapproved elective courses, which can be selected from the list of Preapproved Electives below. Ph.D. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. Ph.D. students must also complete a minimum of 30 credit hours of ISE 7994 – Research and Dissertation.

Core Courses

Course	Course Title	Credits
ISE 5015 or ISE 5124	Management of Change, Innovation & Performance in Organizational Systems I or Quality Management	3
ISE 5016 or ISE 5144	Management of Change, Innovation & Performance in Organizational Systems II or Management and Measurement of Efficiency & Productivity	3
ISE 5804	Fundamentals of Systems Engineering	3

Ph.D. Level Course in Management Systems

ISE 6024 or	Advanced Topics in Management Systems Engineering or any ISE 6000 level course developed for Management Systems Engineering	3

Modeling and Analysis Course

ISE 5104 or	Operations Research or a graduate course in Statistics (STAT) or any 54xx or 64xx ISE course	3

Preapproved Electives

Course	Course Title	Credits
ISE 5044	Production Systems Analysis	3
ISE 5134	Enterprise Information Systems	3
ISE 5154	Applied Human Factors	3
ISE 5174	Engineering Program and Project Management	3
ISE 5434	Economic Project Evaluation	3
ISE 5694	Macroergonomics	3
ISE 5714	Usability Engineering	3
ISE 6014	Proposing Industrial Engineering Research	3
PAPA 5014	Concepts and Approaches to Public Administration	3
PAPA 6214	Public Policy Processes and Analytical Approaches	3
PAPA 6224	Design, Implementation, and Evaluation of Public Policy Programs.	3
STS 5105	Contemporary Issues in Science and Technology Studies	3
STS 5444	Issues in Bioethics	3
STS/PAPA 5614	Introduction to Science and Technology Policy	3
STS 6614	Advanced Topics in Technology Studies	3
CEE 5600	Civil Infrastructure Systems Analysis	3
CEE 5624	Transportation and Land Use	3
STAT 5214G	Advanced Methods of Regression Analysis	3
STAT 5364	Hierarchical Modeling	3
STAT 5504	Multivariate Statistical Methods	3
STAT 5514	Regression Analysis	3

CEE = Civil and Environmental Engineering; **PAPA** = Public administration; **STAT** = Statistics; **STS** = Science & Technology in Society

2.4 Manufacturing Systems Engineering - Manufacturing Systems Engineering aims. to provide students with both a fundamental and advanced understanding of industrial manufacturing processes. To this end, the MFG curriculum at Virginia Tech exposes students to state-of-the-art methods, research, and results in additive manufacturing, metallurgy, electronic components manufacturing, biomanufacturing, robotics, dynamics, and control theory, data sciences and analytics, machine learning, and artificial intelligence. To capture both the breadth and the depth of manufacturing in Industry 4.0 and beyond, this curriculum has been structured to include a set of core courses, which capture the minimal requirements for any manufacturing systems expert, and three emphasis areas, namely "Production Planning and Logistics Systems", "Advanced Manufacturing Processes and Automation", and "Cybermanufacturing, Data Science, and Artificial Intelligence".

This concentration is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Manufacturing Systems Engineering Ph.D. students are required to complete: 1) **two** required core courses; 2) at least **33** additional credit hours of graded coursework (post-BS) from the predefined emphasis areas listed in the in the concentration courses below. Coursework must include at least **24** credit hours of ISE courses. The only 4000-level ISE courses allowed are those listed below. Ph.D. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. Ph.D. students must also complete a minimum of 30 credit hours of ISE 7994 – Research and Dissertation.

Core Courses

Course	Course Title	Credits
ISE 5034	Mathematical Probability and Statistics	3
ISE 5405	Optimization: Linear and Nonlinear Programming I	3

Concentration Courses

Production Planning and Logistics Systems

Course	Course Title	Credits
ISE 4214	Lean Manufacturing	3
ISE 5044	Production Systems Analysis	3
ISE 5144	Performance and Productivity Measurement and Evaluation	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5414	Random Processes	3
ISE 5424	Simulation I	3
ISE 5454	Production Planning and Control	3
ISE 6404	Graph Theory & Network Flows	3
ISE 6424	Dynamic Programming	3
ISE 6434	Scheduling and Sequence Theory	3

Advanced Manufacturing Processes & Automation

Course	Course Title	Credits
ISE 5204	Manufacturing Systems Engineering	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5314	Industrial Robotics	4
ISE 5414	Random Processes	3
ISE 5454	Production Planning and Control	3
ISE 6424	Dynamic Programming	3
ISE 6574	Adaptive Control	3
AOE/ECE 5744 or ME 5544	Linear Systems Theory	3
AOE/ECE/ME 5754	Applied Linear Systems	3
AOE/ECE 5764 or ME 5564	Applied Linear Control	3
AOE/ME 5774	Nonlinear Systems	3

AOE = Aerospace and Ocean Engineering; **ECE** = Electrical & Computer Engineering; **ME** = Mechanical Engineering

Cybermanufacturing, Data Science & Artificial Intelligence

Course	Course Title	Credits
ISE 5204	Manufacturing Systems Engineering	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5414	Random Process	3
ISE/STAT 5474	Statistical Theory of Quality Control	3
ISE 6424	Dynamic Programming	3
STAT 5105G	Theoretical Statistics	3
STAT 5114	Statistical Inference	3
ECE 5424	Advanced Machine Learning	3
ECE 5434	Cyber-Physical Systems	3
CS/ECE 6524	Deep Learning	3

STAT = Statistics; **ECE** = Electrical & Computer Engineering; **CS** = Computer Science & Applications

Rules for taking Courses Prior to Having a Formal Advisor

Ph.D. students who have not yet chosen a research advisor should consider the core Manufacturing Systems Engineering courses as being pre-approved. That is, these core courses can be taken without consultation with a faculty advisor. Once ISE 5034 and ISE 5405 and have been passed, or concurrently with these two courses, the following courses can also be considered as pre-approved:

Production Planning and Logistics Systems

Course	Course Title	Credits
ISE 4214	Lean Manufacturing	3
ISE 5044	Production Systems Analysis	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5454	Production Planning and Control	3

Advanced Manufacturing Processes & Automation

Course	Course Title	Credits
ISE 5204	Manufacturing Systems Engineering	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5314	Industrial Robotics	4
ISE 5414	Random Processes	3
ISE 5454	Production Planning and Control	3

Cybermanufacturing, Data Science & Artificial Intelligence

Course	Course Title	Credits
ISE 5204	Manufacturing Systems Engineering	3
ISE 5414	Random Process	3
STAT 5105G	Theoretical Statistics	3
ECE 5424	Advanced Machine Learning	3

STAT = Statistics; **ECE** = Electrical & Computer Engineering

2.5 Occupational Ergonomics and Safety - Work-related injuries, illnesses, and fatalities remain a substantial concern in the U.S. and globally. These adverse events and outcomes involve major human suffering and impose a significant economic burden to individuals, businesses, and nations. This concentration is designed to provide interdisciplinary training and exposure to the major methods, tools, and approaches needed to improve occupational safety and health in the U.S. and beyond.
The concentration is also intended to provide the foundation for impactful dissertation research in the areas of occupational ergonomics and safety.

Note: this concentration is required of all students funded through the department's NIOSH Training Grant and is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Occupational Ergonomics and Safety Ph.D. students are required to complete: 1) **two** required core courses; 2) **five** additional concentration courses; and 3) a minimum of **five** additional preapproved elective courses, which can be selected from the list of Preapproved Electives below. Ph.D. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. Ph.D. students must also complete a minimum of 30 credit hours of ISE 7994 – Research and Dissertation.

Core Courses

Course	Course Title	Credits
ISE 5104	Operations Research	3
ISE 5624	Human Factors Research Design	4

Concentration Courses

Course	Course Title	Credits
ISE 5604	Human Information Processing	3
ISE 5614	Human Physical Capabilities	3
ISE 5654	Human Factors System Design	3
ISE 5674	System Safety Analysis	3
ISE 5734	Occupational Health and Safety Practicum	3

Preapproved Electives

Course	Course Title	Credits
ISE 4624	Work Physiology	3
ISE 4654	Principles of Industrial Hygiene	3
ISE 5644	Human Audition and Auditory Display Design	3
ISE 5694	Macroergonomics	3
ISE 6014	Proposing Industrial Engineering Research	3
ISE 6624	Advanced Topics in Human Factors	3
BMES 5024	Biomedical Engineering & Human Disease	3
BMES 5184	Injury Physiology	3
BMVS 6554	Advanced Epidemiology	3
CEE 4114	Fundamentals of Public Health Engineering	3
CEE 4684	Transportation Safety	3
STAT 5504	Multivariate Statistical Methods	3
STS 5444	Issues in Bioethics	3

BMES = Biomedical Engineering & Sciences; **BMVS** = Biomedical & Veterinary Sciences; **CEE** = Civil & Environmental Engineering; **STAT** = Statistics; **STS** = Science & Technology in Society

2.6 Operations Research - Operations Research is a scientific, mathematical modeling-based approach to problem solving and management. Operations Research is used for the efficient design and management of systems, usually seeking to determine an optimal or effective utilization and allocation of scarce resources. Operations Research is widely used in many diverse application areas, e.g., the design and management of service and manufacturing systems, supply chain management, humanitarian logistics, healthcare and public policy. The curriculum provides a methodological foundation, and is flexible, allowing students to focus on methodological research or applications.

This concentration is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Operations Research Ph.D. students are required to complete: 1) **seven** required core courses and 2) **six** additional concentration courses. Ph.D. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. Ph.D. students must also complete a minimum of 30 credit hours of ISE 7994 – Research and Dissertation.

Core Courses

Course	Course Title	Credits
ISE 5405	Optimization: Linear and Nonlinear Programming I	3

ISE 5406	Optimization: Linear and Nonlinear Programming II	3
ISE 5414	Random Processes	3
ISE 5424	Simulation I	3
MATH 4225	Elementary Real Analysis I	3
ISE 5034 or STAT 5105G	Mathematical Probability & Statistics for Industrial Engineers or Advanced Theoretical Statistics	3
STAT 5114	Statistical Inference	3

MATH = Mathematics; **STAT** = Statistics

Concentration Courses

Below are some pre-defined emphasis areas. At least **4 courses are required for a primary emphasis area**, and at least **2 courses for a secondary emphasis**. Some emphasis areas have required classes. Because Operations Research works well with methodologies traditionally from other disciplines (e.g., computer science, statistics, mathematics), and can be applied to application areas beyond those represented in the following emphasis areas, students can develop customized emphasis areas, subject to the approval of their Ph.D. advisory committee.

Optimization

Course	Course Title	Credits
ISE 6404	Graph Theory and Network Flows	3
ISE 6414	Integer Programming, **Required**	3
ISE 6424	Dynamic Programming	3
ISE 6454	Stochastic & Robust Optimization	3
ISE 6514	Advanced Topics in Math Programming	3
CS 5114	Theory of Algorithms.	3
MATH 4226 or MATH 5226	Elementary Real Analysis II or Real Analysis II	3
MATH 5454	Graph Theory	3
MATH 5464	Combinatorics	3

CS = Computer Science & Applications; **MATH** = Mathematics

Simulation, Stochastic Processes, and Applied Probability

Course	Course Title	Credits
ISE 5464	Queueing Theory	3
ISE 6444	Inventory and Operations Management	3
ISE 6474	Reliability Theory	3
ISE 6494	Advanced Simulation	3
STAT 5204	Experimental Design & Analysis I	3
STAT 5434	Applied Stochastic Processes	3
STAT 5444	Bayesian Statistics	3
STAT 5504	Multivariate Statistical Methods	3
STAT 5544	Spatial Statistics	3
STAT 5574	Response Surface Design and Analysis I	3
STAT 6424	Multivariate Statistical Analysis	3
STAT 6504	Experimental Design and Analysis II	3
STAT 6574	Response Surface Design and Analysis II	3

STAT = Statistics

Healthcare and Public Policy

Course	Course Title	Credits
BMVS 6554	Advanced Epidemiology	3
PAPA 5014	Concepts and Approaches in Public Administration	3
PAPA 6214	Public Policy Processes and Analytical Approaches	3
PAPA 6224	Design, Implementation, and Evaluation of Public Policy Programs.	3
STS 5444	Issues in Bioethics	3

BMVS = Biomedical and Veterinary Sciences; **PAPA** = Public Administration/Public Affairs; **STS** = Science and Technology Studies

Production Supply Chain and Logistics

Course	Course Title	Credits
ISE 4424	Logistics Engineering	3
ISE 4434	Supply Chain and Operations Engineering	3
ISE 5044	Production Systems Analysis	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5454	Production Planning and Control	3
ISE 6434	Scheduling and Sequencing Theory	3
ISE 6444	Inventory and Operations Management	3
ISE 6474	Reliability Theory	3

MASTER'S DEGREE PROGRAMS

The Grado Department of Industrial and Systems Engineering has a strong and diverse master's program that provides opportunities for study in specific areas in industrial and systems engineering, as well as general master's study. Both thesis (M.S.) and non-thesis (M.Eng.) degrees are available for all students. Master's graduates can select a plan that leads to advanced study at the Ph.D. level, or one that prepares them for challenging positions in the public or private sectors.

Students must select one of the following focus areas for their graduate study – General Industrial Engineering, Human Factors Engineering and Ergonomics, Management Systems Engineering, Manufacturing Systems Engineering, and Operations Research.

1. Master of Science (M.S.)

1.1 General Industrial Engineering - The General Industrial Engineering focus area is designed to provide flexibility for students in order to tailor their graduate program to fit their individual educational objectives. A short list of required courses is supplemented by wide latitude in the selection of elective courses to complete the General Industrial Engineering degree requirements. This allows the student to pursue a broad path, or to pursue a very narrow path in a particular area of study or with a particular faculty member. Students will also gain experience in performing independent research in a chosen area of interest approved by the student's advisory committee. The culmination of this research is the M.S. thesis.

This focus area is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, General Industrial Engineering M.S. students are required to complete: 1) **one** required core course; 2) a minimum of **four** additional concentration courses; and 3) a minimum of **two** preapproved elective courses. M.S. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. M.S. students must also complete a minimum of 6 credit hours of ISE 5994 – Research and Thesis.

Core Courses

Course	Course Title	Credits
ISE 5104 or ISE 5405	Operations Research or Optimization: Linear and Nonlinear Programming I	3

Note: ISE 5405 is a pre-requisite for several more advanced courses; students interested in such courses should thus not take ISE 5104.

Concentration Courses (Select at least 4 courses from the following list)

Course	Course Title	Credits
ISE 4214	Lean Manufacturing	3
ISE 5015	Management of Change, Innovation & Performance in Organizational Systems I	3

ISE 5034	Mathematical Probability and Statistics for Industrial Engineers	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5424	Simulation I	3
ISE 5474	Statistical Theory of Quality Control	3
ISE 5654	Human Factors System Design	3
ISE 5814	System Dynamics Modeling of Socio-Technical Systems	3

Preapproved Electives
Complete additional three courses, which can be any combination of additional courses from the list above and/or from pre-approved electives. Pre-approved electives are listed in the Ph.D. concentrations. Any of these pre-approved electives can count towards the General Industrial Engineering M.S. degree.

Research Credit Requirement

Course	**Course Title**	**Credits**
ISE 5994	Research and Thesis	6 - 9

1.2 Human Factors Engineering and Ergonomics – The Human Factors Engineering and Ergonomics focus area is concerned with designing and evaluating products, processes, tasks, and systems so that they benefit from human capabilities and avoid their limitations. Human Factors Engineering and Ergonomics experts make critical contributions to improving safety and health, product usability, and the interactions of humans with other humans and diverse technology.

This focus area is available only at the Blacksburg campus.

Required Courses

Course	**Course Title**	**Credits**
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Human Factors Engineering and Ergonomics M.S. students are required to complete: 1) **three** required core courses; 2) a minimum of **three** additional concentration courses; and 3) a minimum of **one** additional elective course, which can be selected from among the list of Concentration Courses or Preapproved Electives below. M.S. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. M.S. students must also complete a minimum of 6 credit hours of ISE 5994 – Research and Thesis.

Core Courses

Course	**Course Title**	**Credits**
ISE 5604 or ISE 5614	Human Information Processing or Human Physical Capabilities	3
ISE 5624	Human Factors Research Design	4
ISE 5654	Human Factors System Design	3

Concentration Courses

Course	**Course Title**	**Credits**

ISE 4624	Work Physiology	3
ISE 4644	Risk and Hazard Control	3
ISE 4654	Principles of Industrial Hygiene	3
ISE 5604	Human Information Processing *(if not taken as a Core Course)*	3
ISE 5614	Human Physical Capabilities *(if not taken as a Core Course)*	3
ISE 5644	Human Audition & Auditory Display Design	3
ISE 5674	System Safely Analysis	3
ISE 5714	Usability Engineering	3
ISE 5734	Occupational Health and Safety Practicum	3
ISE 6604	Human Factors in Visual Display Systems	3
ISE 6614	Human Computer Systems	3
ISE 6624	Advanced Topics in Human Factors & Ergonomics	3
ISE 6644	Cognitive Work and Task Analysis	3

Preapproved Electives

Course	Course Title	Credits
BMES 5124	Advanced Musculoskeletal Biomechanics	3
CS 5724	Models and Theories of Human-computer Interaction	3
CS 5734	Social Computing and Computer-supported Cooperative Work	3
CS 5754	Virtual Environments	3
CS 5764	Information Visualization	3
CS 5844/ME 5824	Human-Robot Interaction	3
ESM 4424	Biodynamics	3

BMES = Biomedical Engineering & Sciences; **CS** = Computer Science & Applications; **ME** = Mechanical Engineering

Research Credit Requirement

Course	Course Title	Credits
ISE 5994	Research and Thesis	6 - 9

Other Requirements & Additional Information

- ISE 5154 – Applied Human Factors Engineering, cannot be counted toward the requirements listed above.
- Graduate students supported under the department's NIOSH Training Grant must complete all of the following courses: ISE 5604, ISE 5614, ISE 5615, ISE 5654, ISE 5674, and ISE 5734.
- ISE 6624 can be completed more than once, as long as distinct topics are presented.
- P/F and other non-graded course do not count toward the above credit-hour totals.
- Per Graduate School policy, a maximum of six credits of 4000-level courses can be included in the plan of study.
- Courses not listed above may be taken, or substitutions made, pending approval of the student's Advisory Committee and the ISE Graduate Program Director.

1.3 Management Systems Engineering - The Management Systems Engineering focus area is designed to provide in-depth coverage of Management Systems Engineering topics and experience in performing independent research in a chosen area of interest approved by the graduate advisory committee. All students pursuing a M.S. must a research advisor in the Management Systems Engineering domain.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Management Systems Engineering M.S. students are required to complete: 1) **four** required core courses; 2) a minimum of **two** additional concentration courses; and 3) a minimum of **one** free elective course, which can be selected from among the list of Concentration Courses or any graduate level course in a related field. M.S. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. M.S. students must also complete a minimum of 6 credit hours of ISE 5994 – Research and Thesis.

Core Courses

Course	Course Title	Credits
ISE 5015 or ISE 5124	Management of Change, Innovation & Performance in Organizational Systems I or Quality Management	3
ISE 5016 or ISE 5144	Management of Change, Innovation & Performance in Organizational Systems II or Management and Measurement of Efficiency & Productivity	3
ISE 5804	Fundamentals of Systems Engineering	3
ISE 5814	System Dynamics Modeling of Socio-Technical Systems	3

Concentration Courses (Select two courses from any of the three tracks below)

Operations Research

Course	Course Title	Credits
ISE 5405	Optimization: Linear and Nonlinear Programming I	3
ISE 5406	Optimization: Linear and Nonlinear Programming II	3
ISE 5414	Random Process	3
ISE 5424	Simulation I	3
ISE 5464	Queueing Theory	3
ISE 5474	Statistical Theory of Quality Control	3

Manufacturing Systems Engineering

Course	Course Title	Credits
ISE 5204	Manufacturing Systems Engineering	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5314	Industrial Robotics	3

Human Factors Engineering and Ergonomics

Course	Course Title	Credits
ISE 5154	Applied Human Factors Engineering	3
ISE 5604	Human Information Processing	3
ISE 5614	Human Physical Capabilities	3
ISE 5624	Human Factors Research Design	3
ISE 5644	Human Audition and Auditory Display Design	3
ISE 5654	Human Factors System Design	3

ISE 5674	System Safety Analysis	3
ISE 5694	Macroergonomics	3
ISE 5714	Usability Engineering	3

Free Electives
One additional graduate level course in either ISE or a related field.

Research Credit Requirement

Course	Course Title	Credits
ISE 5994	Research and Thesis	6 - 9

1.4 Manufacturing Systems Engineering – The Manufacturing Systems Engineering focus area aims. to provide students with both a fundamental and advanced understanding of industrial manufacturing processes. To this end, the Manufacturing Systems Engineering curriculum at Virginia Tech exposes students to state-of-the-art methods, research, and results in additive manufacturing, metallurgy, electronic components manufacturing, biomanufacturing, robotics, dynamics, and control theory, data sciences and analytics, machine learning, and artificial intelligence. To capture both the breadth and the depth of manufacturing in Industry 4.0 and beyond, this curriculum has been structured to include a set of core classes, which capture the minimal requirements for any manufacturing systems expert, and three emphasis areas, namely "Production Planning and Logistics Systems", "Advanced Manufacturing Processes and Automation", and "Cybermanufacturing, Data Science, and Artificial Intelligence". Students are recommended to choose classes from only one of the emphasis areas. However, in agreement with their advisers and Ph.D. committees, students can customize their plans of study to their research needs by selecting classes from multiple categories within the MFG concentration; from other concentrations, such as Operations Research or Management Systems Engineering; and from other departments in agreement with the guidelines provided in the following.

This focus area is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Manufacturing Systems Engineering M.S. students are required to complete: 1) **three** required core course and 2) at least **four** concentration courses, for a minimum of 21 course credits. For every two ISE classes, one non-ISE class not listed below can be included in a student's plan of study. The only 4000-level ISE classes allowed are those listed below. M.S. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. M.S. students must also complete a minimum of 6 credit hours of ISE 5994 – Research and Thesis.

Core Courses

Course	Course Title	Credits
ISE 5034	Mathematical Probability and Statistics	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5405	Optimization: Linear and Nonlinear Programming I	3

Concentration Courses

Production Planning and Logistics Systems

Course	Course Title	Credits
ISE 4214	Lean Manufacturing	3
ISE 5044	Production Systems Analysis	3
ISE 5144	Performance and Productivity Measurement and Evaluation	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5414	Random Processes	3
ISE 5424	Simulation I	3
ISE 5454	Production Planning and Control	3
ISE 6404	Graph Theory & Network Flows	3
ISE 6424	Dynamic Programming	3
ISE 6434	Scheduling and Sequence Theory	3

Advanced Manufacturing Processes & Automation

Course	Course Title	Credits
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5314	Industrial Robotics	4
ISE 5414	Random Processes	3
ISE 5454	Production Planning and Control	3
ISE 6424	Dynamic Programming	3
ISE 6574	Adaptive Control	3
AOE/ECE 5744 or ME 5544	Linear Systems Theory	3
AOE/ECE/ME 5754	Applied Linear Systems	3
AOE/ECE 5764 or ME 5564	Applied Linear Control	3
AOE/ME 5774	Nonlinear Systems	

AOE = Aerospace and Ocean Engineering; **ECE** = Electrical & Computer Engineering; **ME** = Mechanical Engineering

Cybermanufacturing, Data Science & Artificial Intelligence

Course	Course Title	Credits
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5414	Random Process	3
ISE/STAT 5474	Statistical Theory of Quality Control	3
ISE 6424	Dynamic Programming	3
STAT 5105G	Theoretical Statistics	3
STAT 5114	Statistical Inference	3
ECE 5424	Advanced Machine Learning	3
ECE 5434	Cyber-Physical Systems	3
CS/ECE 6524	Deep Learning	3

STAT = Statistics; **ECE** = Electrical & Computer Engineering; **CS** = Computer Science & Applications

Research Credit Requirement

Course	Course Title	Credits
ISE 5994	Research and Thesis	6-9

Rules for taking Courses Prior to Having a Formal Advisor

M.S. students who have not yet chosen a research advisor should consider the core Manufacturing Systems Engineering courses as being pre-approved. That is, these core courses can be taken without consultation with a faculty member. Once ISE 5034 and ISE 5405 and have been passed, or concurrently with these two courses, the following courses can also be considered as pre-approved:

Production Planning and Logistics Systems

Course	Course Title	Credits
ISE 4214	Lean Manufacturing	3
ISE 5044	Production Systems Analysis	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5454	Production Planning and Control	3

Advanced Manufacturing Processes & Automation

Course	Course Title	Credits
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5314	Industrial Robotics	4
ISE 5414	Random Processes	3
ISE 5454	Production Planning and Control	3

Cybermanufacturing, Data Science & Artificial Intelligence

Course	Course Title	Credits
ISE 5414	Random Process	3
STAT 5105G	Theoretical Statistics	3
ECE 5424	Advanced Machine Learning	3

STAT = Statistics; **ECE** = Electrical & Computer Engineering

1.5 Operations Research – The Operations Research focus area is a scientific, mathematical modeling-based approach to problem solving and management. Operations Research is used for the efficient design and management of systems, usually seeking to determine an optimal or effective utilization and allocation of scarce resources. Operations Research is widely used in many diverse application areas, e.g., the design and management of service and manufacturing systems, supply chain management, humanitarian logistics, healthcare and public policy.

This focus area is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Operations Research M.S. students are required to complete: 1) **five** required core courses and 2) a minimum of **two** additional concentration courses from the list below or any relevant graduate courses offered by the university subject to the approval of the student's advisory committee. M.S. students should also work closely with their advisor and advisory committee, so that sufficient coursework is completed relevant to their area of research. M.S. students must also complete a minimum of 6 credit hours of ISE 5994 – Research and Thesis.

Core Courses

Course	Course Title	Credits
ISE 5034	Mathematical Probability and Statistics for Industrial Engineers	3
ISE 5405	Optimization: Linear and Nonlinear Programming I	3
ISE 5406	Optimization: Linear and Nonlinear Programming II	3
ISE 5414	Random Process	3
ISE 5424	Simulation I	3

Concentration Courses

Course	Course Title	Credits
ISE 4424	Logistics Engineering	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5434	Economic Project Evaluation	3
ISE 5454	Production Planning and Control	3
ISE 5464	Queueing Theory	3
ISE 5474	Statistical Theory of Quality Control	3
ISE 6404	Graph Theory and Network Flows	3
ISE 6414	Integer Programming	3
ISE 6424	Dynamic Programming	3
ISE 6434	Scheduling and Sequence Theory	3
ISE 6444	Inventory and Operations Management	3
ISE 6454	Stochastic & Robust Optimization	3
ISE 6464	Queueing Networks	3
ISE 6474	Reliability Theory	3
ISE 6494	Advanced Simulation	3
ISE 6514	Advanced Mathematical Programming	3

Research Credit Requirements

Course	Course Title	Credits
ISE 5994	Research and Thesis	6 - 9

2. Master of Engineering (M.Eng.)

2.1 General Industrial Engineering - General Industrial Engineering is designed to provide flexibility for students in order to tailor their graduate program to fit their individual educational objectives. A short list of required courses is supplemented by wide latitude in the selection of elective courses to complete the General Industrial Engineering degree requirements.

This focus area is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, General Industrial Engineering M.Eng. students are required to complete: 1) **one** required core course; 2) a minimum of **four** additional concentration courses; and 3) a minimum of **five** preapproved elective courses.

Core Courses

Course	Course Title	Credits
ISE 5104 or ISE 5405	Operations Research or Optimization: Linear and Nonlinear Programming I	3

Note: ISE 5405 is a pre-requisite for several more advanced courses; students interested in such courses should thus not take ISE 5104.

Concentration Courses

Course	Course Title	Credits
ISE 4214	Lean Manufacturing	3
ISE 5015	Management of Change, Innovation & Performance in Organizational Systems I	3
ISE 5034	Mathematical Probability and Statistics for Industrial Engineers	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5424	Simulation I	3
ISE 5474	Statistical Theory of Quality Control	3
ISE 5654	Human Factors System Design	3
ISE 5814	System Dynamics Modeling of Socio-Technical Systems	3

Preapproved Electives

Complete additional five courses, which can be any combination of additional courses from the list above and/or from pre-approved electives. Pre-approved electives are listed in the Ph.D. concentrations. Any of these pre-approved electives can count towards the General Industrial Engineering M.Eng. degree.

2.2 Human Factors Engineering and Ergonomics - Human Factors Engineering and Ergonomics is concerned with designing and evaluating products, processes, tasks, and systems so that they benefit from human capabilities and avoid their limitations. Human Factors Engineering and Ergonomics experts make critical contributions to improving safety and health, product usability, and the interactions of humans with other humans and diverse technology.

This focus area is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Human Factors Engineering and Ergonomics M.Eng. students are required to complete: 1) **three** required core courses; 2) a minimum of **four** additional concentration courses; and 3) a minimum of **three** additional elective courses, which can be selected from among the list of Concentration Courses or Preapproved Electives below.

Core Courses

Course	Course Title	Credits
ISE 5604 or ISE 5614	Human Information Processing or Human Physical Capabilities	3
ISE 5624	Human Factors Research Design	4
ISE 5654	Human Factors System Design	3

Concentration Courses

Course	Course Title	Credits
ISE 4624	Work Physiology	3
ISE 4644	Risk and Hazard Control	3
ISE 4654	Principles of Industrial Hygiene	3
ISE 5604	Human Information Processing *(if not taken as a Core Course)*	3
ISE 5614	Human Physical Capabilities *(if not taken as a Core Course)*	3
ISE 5644	Human Audition & Auditory Display Design	3
ISE 5674	System Safely Analysis	3
ISE 5714	Usability Engineering	3
ISE 5734	Occupational Health and Safety Practicum	3
ISE 6604	Human Factors in Visual Display Systems	3
ISE 6614	Human Computer Systems	3
ISE 6624	Advanced Topics in Human Factors & Ergonomics	3
ISE 6644	Cognitive Work and Task Analysis	3

Preapproved Electives

Course	Course Title	Credits
BMES 5124	Advanced Musculoskeletal Biomechanics	3
CS 5724	Models and Theories of Human-computer Interaction	3
CS 5734	Social Computing and Computer-supported Cooperative Work	3
CS 5754	Virtual Environments	3
CS 5764	Information Visualization	3
CS 5844/ME 5824	Human-Robot Interaction	3
ESM 4424	Biodynamics	3

BMES = Biomedical Engineering & Sciences; **CS** = Computer Science & Applications; **ME** = Mechanical Engineering

Other Requirements & Additional Information

- ISE 5154 – Applied Human Factors Engineering, cannot be counted toward the requirements listed above.
- Graduate students supported under the department's NIOSH Training Grant must complete all of the following courses: ISE 5604, ISE 5614, ISE 5615, ISE 5654, ISE 5674, and ISE 5734.
- ISE 6624 can be completed more than once, as long as distinct topics are presented.
- P/F and other non-graded course do not count toward the above credit-hour totals.

- Per Graduate School policy, a maximum of six credits of 4000-level courses can be included in the plan of study.
- Courses not listed above may be taken, or substitutions made, pending approval of the ISE Graduate Program Director.

2.3 Management Systems Engineering - Management Systems Engineering is designed to provide coverage of a wide range of Management Systems Engineering topics, and an exposure to a range of industrial engineering topics, through core and concentration courses.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Management Systems Engineering M.Eng. students are required to complete: 1) **four** required core courses; 2) a minimum of **three** additional concentration courses; and 3) a minimum of **three** additional elective courses, which can be selected from among the list of Concentration Courses or any graduate course in a related field.

Core Courses

Course	Course Title	Credits
ISE 5015 or ISE 5124	Management of Change, Innovation & Performance in Organizational Systems I or Quality Management	3
ISE 5016 or ISE 5144	Management of Change, Innovation & Performance in Organizational Systems II or Management and Measurement of Efficiency & Productivity	3
ISE 5804	Fundamentals of Systems Engineering	3
ISE 5814	System Dynamics Modeling of Socio-Technical Systems	3

Concentration Courses (*Select one course from each of the three tracks below)*

Operations Research

Course	Course Title	Credits
ISE 5405	Optimization: Linear and Nonlinear Programming I	3
ISE 5406	Optimization: Linear and Nonlinear Programming II	3
ISE 5414	Random Process	3
ISE 5424	Simulation I	3
ISE 5464	Queueing Theory	3
ISE 5474	Statistical Theory of Quality Control	3

Manufacturing Systems Engineering

Course	Course Title	Credits
ISE 5204	Manufacturing Systems Engineering	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5314	Industrial Robotics	3

Human Factors Engineering and Ergonomics

Course	Course Title	Credits

ISE 5154	Applied Human Factors Engineering	3
ISE 5604	Human Information Processing	3
ISE 5614	Human Physical Capabilities	3
ISE 5624	Human Factors Research Design	3
ISE 5644	Human Audition and Auditory Display Design	3
ISE 5654	Human Factors System Design	3
ISE 5674	System Safety Analysis	3
ISE 5694	Macroergonomics	3
ISE 5714	Usability Engineering	3

Free Electives
Three additional graduate level courses either in ISE or a related field.

2.4 Manufacturing Systems Engineering - Manufacturing Systems Engineering aims. to provide students with both fundamental and advanced notions of industrial manufacturing processes. To this goal, the MFG curriculum at Virginia Tech exposes students to classical and state-of-the-art results in additive manufacturing, metallurgy, electronic components manufacturing, biomanufacturing, robotics, dynamics, and control theory, data sciences and analytics, machine learning, and artificial intelligence. To capture both the breadth and the depth of manufacturing in Industry 4.0 and beyond, this curriculum has been structured to include a set of core classes, which capture the minimal requirements for any manufacturing systems expert, and three emphasis areas, namely "Production Planning and Logistics Systems", "Advanced Manufacturing Processes and Automation", and "Cybermanufacturing, Data Science, and Artificial Intelligence". Students are required to choose classes from only one of the emphasis areas. Students seeking to take classes outside their emphasis areas will need to request written consent from the Manufacturing Systems Engineering group representative; this request will need to be motivated by explaining their professional needs and how the requested classes relate to their plan of study.

This focus area is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Manufacturing Systems Engineering M.Eng. students are required to complete: 1) **three** required core course and 2) **seven** concentration courses, for a minimum of 30 course credits. For every two ISE classes, one non-ISE class not listed below can be included in a student's plan of study. The only 4000-level ISE classes allowed are those listed below.

Core Courses

Course	Course Title	Credits
ISE 5034	Mathematical Probability and Statistics	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5405	Optimization: Linear and Nonlinear Programming I	3

Concentration Courses
Production Planning and Logistics Systems

Course	Course Title	Credits
ISE 4214	Lean Manufacturing	3

ISE 5044	Industrial Automation	3
ISE 5144	Performance and Productivity Measurement and Evaluation	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5414	Random Processes	3
ISE 5424	Simulation I	3
ISE 5454	Production Planning and Control	3
ISE 6404	Graph Theory and Network Flows	3
ISE 6424	Dynamic Programming	3
ISE 6434	Scheduling and Sequence Theory	3

Advanced Manufacturing Processes & Automation

Course	Course Title	Credits
ISE 4264	Industrial Automation	3
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5414	Random Processes	3
ISE 5454	Production Planning and Control	3
ISE 6424	Dynamic Programming	3
ISE 6574	Adaptive Control	3
AOE/ECE 5744 or ME 5544	Linear Systems Theory	3
AOE/ECE 5754 or ME 5554	Applied Linear Systems	3
AOE/ECE 5764 or ME 5564	Applied Linear Control	3
AOE/ECE 5774 ME 5574	Nonlinear Systems	3

AOE = Aerospace and Ocean Engineering; **ECE** = Electrical Engineering; **ME** = Mechanical Engineering

Cybermanufacturing, Data Science & Artificial Intelligence

Course	Course Title	Credits
ISE 5264	Modeling and Analysis of Semiconductor Manufacturing	3
ISE 5414	Random Process	3
ISE/STAT 5474	Statistical Theory of Quality Control	3
ISE 6424	Dynamic Programming	3
CS/ECE 6524	Deep Learning	3
ECE 5424	Advanced Machine Learning	3
ECE 5434	Cyber-Physical Systems	3
STAT 5104	Probability and Distribution Theory	3
STAT 5114	Statistical Inference	3

CS = Computer Science & Applications; **ECE** = Electrical Engineering; **STAT** = Statistics

2.5 Operations Research - Operations Research is a scientific, mathematical modeling-based approach to problem solving and management. Operations Research is used for the efficient design and management of systems, usually seeking to determine an optimal or effective utilization and allocation of scarce resources. OR is widely used in many diverse application areas, e.g., the design and management of

service and manufacturing systems, supply chain management, humanitarian logistics, healthcare and public policy.

This focus area is available only at the Blacksburg campus.

Required Courses

Course	Course Title	Credits
ISE 5024	ISE Seminar	1
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the two courses listed above, Operations Research M.Eng. students are required to complete: 1) **five** required core courses and 2) a minimum of **five** additional concentration courses from the list below or any relevant graduate courses offered by the university subject to the approval of the student's advisor.

Core Courses

Course	Course Title	Credits
ISE 5034	Mathematical Probability and Statistics for Industrial Engineers	3
ISE 5405	Optimization: Linear and Nonlinear Programming I	3
ISE 5406	Optimization: Linear and Nonlinear Programming II	3
ISE 5414	Random Process	3
ISE 5424	Simulation I	3

Concentration Courses

Course	Course Title	Credits
ISE 4424	Logistics Engineering	3
ISE 5204	Manufacturing Systems Engineering	3
ISE 5244	Facilities Planning and Material Handling	3
ISE 5434	Economic Project Evaluation	3
ISE 5454	Production Planning and Control	3
ISE 5464	Queueing Theory	3
ISE 5474	Statistical Theory of Quality Control	3
ISE 6404	Graph Theory and Network Flows	3
ISE 6414	Integer Programming	3
ISE 6424	Dynamic Programming	3
ISE 6434	Scheduling and Sequence Theory	3
ISE 6444	Inventory and Operations Management	3
ISE 6454	Stochastic & Robust Optimization	3
ISE 6464	Queueing Networks	3
ISE 6474	Reliability Theory	3
ISE 6494	Advanced Simulation	3
ISE 6514	Advanced Mathematical Programming	3

3. Master of Engineering Administration (M.E.A.)

The Master of Engineering Administration degree is designed for engineering professionals seeking to advance to leadership positions within an engineering enterprise. Graduates learn how to apply engineering expertise in a business context to manage and lead an engineering enterprise toward innovative opportunities. Courses are offered in the late afternoon or evening to accommodate those working full-time. This program is a non-thesis, coursework-only degree, focused on applying management and executive expertise within an engineering enterprise.

This degree is available on all Virginia Tech campuses.

Required Courses

Course	Course Title	Credits
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the course listed above, M.E.A. students are required to complete: 1) **five** required core courses and 2) **five** elective courses, for a minimum of 30 course credits.

Core Courses

Course	Course Title	Credits
ISE 5104	Operations Research	3
ISE 5124	Quality Management	3
ISE 5164	Transfer and Application of Emerging Technology	3
ISE 5174	Engineering Program and Project Management	3
ISE 5434	Economic Project Evaluation	3

Preapproved Electives

Course	Course Title	Credits
ISE 5015	Management of Change, Innovation & Performance in Organizational Systems I	3
ISE 5016	Management of Change, Innovation & Performance in Organizational Systems II	3
ISE 5134	Enterprise Information Systems	3
ISE 5144	Management and Measurement of Efficiency & Productivity	3
ISE 5154	Applied Human Factors Engineering	3
*ISE 5204	Manufacturing Systems Engineering	3
ISE 5804	Fundamentals of Systems Engineering	3
ISE 5814	System Dynamics of Socio-Technical Systems	3
ISE 5834	Decision Analysis for Engineers	3
ISE 5844	Health Systems Engineering & Modeling	3
ISE 5874	Digital Engineering	3
MGT 5314	Dynamics of Organization Behavior	3
MGT 5804	Strategic Leadership in Technology-based Organizations	3
PAPA 5315	Government Administration	3
PAPA/STS 5614	Introduction to Science and Technology Policy	3

MGT = Management; **PAPA** = Public Administration and Public Affairs; **STS** = Science, Technology, and Society (**Courses are typically only offered on the Blacksburg campus)*

Selected Topic Elective
Select one course from this list:

Course	Course Title	Credits
ISE 5804	Fundamentals of Systems Engineering	3
ISE 5814	System Dynamics Modeling of Socio-Technical Systems	3
ISE 5984	SS: Engineering Management and Administration: Capstone	3
PAPA 5315	Government Administration	3
PAPA 5614	Introduction to Science and Technology Policy	3
MGT 5314	Dynamics of Organization Behavior	3
MGT 5804	Strategic Leadership in Technology-based Organizations	3

PAPA = Public Administration and Public Affairs; **MGT** = Business, Management

Master of Engineering Administration Comprehensive Examination
Presently, the program requires a comprehensive exam, the M.E.A. Exam, to earn the degree. This requirement is being phased out, to be replaced by the *Engineering Management and Administration: Capstone* course. This Capstone course is currently offered as a 5984: Special Study course, and so cannot be classified as a core, required course. Students may, however, elect to take the Capstone course in lieu of the comprehensive exam.

4. Master of Science (M.S.) in Systems Engineering

The Systems Engineering graduate program leads to a Master of Science degree. It is designed to enable engineers specialized in disciplinary fields (e.g., aerospace, ocean, civil, electrical, mechanical, nuclear, computer science, and/or industrial engineering) to develop an understanding of systems engineering as an interdisciplinary strategic discipline that focuses on analysis and successful realization of complex engineered systems. It is presumed that a student entering the program already has a solid foundation in some specialized field of engineering (or the equivalent) and wishes to broaden their technical knowledge base. The Systems Engineering program has a flexible structure that allows for customization of coursework based on the students' needs and career interests and is ideal for individuals who are employed full-time and wish to pursue an advanced degree on a part-time basis; however, full-time employment is not obligatory for admission to the program. Classes are offered in hybrid format (both in person and streamed synchronously online), typically during the late afternoon and evening hours.

The Systems Engineering program objective is to present an opportunity to master systems engineering as a strategic discipline, along with a broad interdisciplinary perspective of complex systems and management of the engineering activities required for successful development of systems.

The program requires a capstone course that involves completion of an approved systems engineering project. The objectives of the required capstone experience are to apply and demonstrate the practice of systems engineering for design or improvement of any complex system. The capstone experience is structured to illustrate the student's expertise of life-cycle design, technology integration, and management of the collaborative engineering effort

This degree is available on all Virginia Tech campuses.

Required Courses

Course	Course Title	Credits
ENGE 5304	Graduate Student Success in Multicultural Environments	1

In addition to the course listed above, Systems Engineering M.S. students are required to complete: 1) **four** required core courses; 2) **five** electives courses, for a minimum of 30 course credits; 3) **one** capstone course.

Core Courses

Course	Course Title	Credits
ISE 5434	Economic Project Evaluation	3
ISE 5804	Fundamentals of Systems Engineering	3
ISE 5814	System Dynamics Modeling of Socio-Technical Systems	3
ISE 5834	Decision Analysis for Engineers	3

Electives

Select any five courses from other disciplinary areas, with four that must be from engineering departments (e.g., ISE 5XXX, AOE 5XXX, CEE 5XXX, CS 5XXX, ECE 5XXX, and ME 5XXX). The electives should be approved by the Systems Engineering program director. Below is a list of pre-approved ISE courses, as an example of electives that may be taken for those interested in specializing further in ISE for their electives.

ISE electives

Course	Course Title	Credits
ISE 5015	Management of Change, Innovation & Performance in Organizational Systems I	3
ISE 5016	Management of Change, Innovation & Performance in Organizational Systems II	3
ISE 5144	Management and Measurement of Efficiency & Productivity	3
ISE 5854	Mission Engineering I	3
ISE 5874	Digital Engineering	3
ISE 5884	Systems Architecture	3
ISE 5984	Socio Technical Systems: Principles, Conceptualization, & Design	3

Capstone Course

Course	Course Title	Credits
ENGR 5024	Systems Engineering Projects	3

(The capstone course can only be taken in the final Spring semester of the program.)

GRADUATE CERTIFICATES

5. Graduate Certificate Programs

A graduate certificate is a non-degree program that requires the student to complete specific higher-level courses. It tends to be focused on one particular aspect or area of the field. This is often used when a student needs to add an additional skill, upgrade technology knowledge, gain continuing education points, or hold a professional certificate for a particular position. Sometimes, graduate certificates can act as steppingstones toward the completion of a master's degree. Often, they can be built right into a master's degree program.

Below is a list of ISE graduate certificate offerings. There are other graduate certificates available to ISE graduate students, and several include ISE graduate courses. A complete list of available graduate certificates can be found in the Virginia Tech Graduate Catalog. Both certificates are available to students at the Blacksburg campus, and students at the extended campuses as well.

Students who wish to pursue a graduate certificate must complete a graduate certificate application, which can be found on the Graduate School's website.

All certificate courses must have a grade of B or better and transfer courses are not permitted.

5.1 Human-System Integration - The Graduate Certificate in Human-System Integration (HSI) is a research-based academic program that serves to expand and improve systems management and engineering practice, with emphasis on "human-technology interface" at various levels in the hierarchy and throughout the life cycle of complex systems.

Coursework Requirements

Course	Course Title	Credits
ISE 5144	Management and Measurement of Efficiency & Productivity	3
ISE 5154	Applied Human Factors Engineering	3
ISE 5434	Economic Project Evaluation	3
ISE 5804	Fundamentals of Systems Engineering	3

5.2 Mission Engineering - The Graduate Certificate in Mission Engineering is designed to teach students engineering methods to design, develop, and assess complex system-of-systems using mission engineering tools and practices in combination with the tactical insights of operational planning. Students will learn how to identify mission-level operational needs to develop clear problem statements and apply mission engineering techniques to translate these needs into specific programmatic guidance for critical programs.

Core Courses

Course	Course Title	Credits
ISE 5854	Mission Engineering I	3

Electives

Select three courses from the following list:

Course	Course Title	Credits
ISE 5434	Economic Project Evaluation	3
ISE 5804	Fundamentals of Systems Engineering	3
ISE 5814	System Dynamics Modeling of Socio-Technical Systems	3

ISE 5834	Decision Analysis for Engineers	3
ISE 5874	Digital Engineering	3
ISE 5884	Systems Architecture	3

5.3 Technology Management - The Graduate Certificate in Technology Management serves to expand and improve enterprise capabilities for the management of technological innovation – addressing the full spectrum of basic science (research), technology development, intellectual property, product/service development, deployment, maintenance, modernization, and retirement of complex technologies and systems of integrated technology.

Coursework Requirements

Course	**Course Title**	**Credits**
ISE 5134	Enterprise Information Systems	3
ISE 5154	Applied Human Factors Engineering	3
ISE 5164	Transfer and Application of Emerging Technology	3
ISE 5174	Engineering Program and Project Management	3

ISE GRADUATE PROGRAM FACULTY

Dr. Manish Bansal, *Associate Professor* - Operations Research, Data-Driven Optimization, Decision Making under Uncertainty

Dr. Peter Beling, *Professor* - Management Systems Engineering, Artificial Intelligence and Machine Learning, Systems Theory and Modeling, Cyber Resilience, Autonomy and Controls/Control Systems, Digital and Mission Engineering

Dr. Esra Buyuktahtakin Toy, *Associate Professor* - Operations Research, Integrated Optimization and Machine Learning, Decision Making under Uncertainty

Dr. John G. Casali, CPE, *John Grado Endowed Professor* - Human Factors Engineering, Ergonomics, Acoustics, Human Hearing

Dr. Xi Chen, *Associate Professor* - Operations Research, Stochastic Modeling and Simulation, Applied Probability and Statistics, Computer Experiment Design and Analysis, Simulation Optimization

Dr. Deborah E. Dickerson, CIH, CSP, *Associate Professor* - Human Factors Engineering and Ergonomics, Worker Safety, Process Safety, Healthy Work Design, Health Behaviors, Innovation Acceptance, Training System Design, Work Organization, Prevention through Design, User Experience and User-centered Design

Dr. Kimberly P. Ellis, *Associate Professor* - Manufacturing Systems Engineering, Logistics Systems Analysis and Design, Production Planning and Process Planning, Manufacturing Systems Analysis and Design, Applied Operations Research

Dr. Joseph L. Gabbard, *Professor* - Human Factors Engineering and Ergonomics, Augmented Reality, Virtual Reality, Usability Engineering, Human-Computer Interaction

Dr. Navid Ghaffarzadegan, *Associate Professor* - Management Systems Engineering, System Dynamics, Socio-technical Systems, Policy Analysis, Policy Informatics

Dr. Robert Hildebrand, *Assistant Professor* - Operations Research, Mixed-Integer Nonlinear Optimization, Cutting Plane Theory and Practice, Redistricting, Stochastic Scheduling and Machine Learning

Dr. Niyousha Hosseinichimeh, *Assistant Professor* - Management Systems Engineering, Health and Healthcare Systems

Dr. Myounghoon "Philart" Jeon, *Associate Professor* – Human Factors Engineering and Ergonomics, Human-Computer Interaction/ Human-Robot Interaction, Sound and Music Computing, Affective Computing, Assistive Technologies, Automotive User Interfaces, Aesthetic Computing

Dr. Ran Jin, *Associate Professor* - Manufacturing Systems Engineering, System Informatics and Control in Industrial Engineering, Quality Engineering in Manufacturing Scale-up, Sensing, Modeling and Process Optimization based on High Definition Profile Data

Dr. Blake N. Johnson, *Associate Professor* - Manufacturing Systems Engineering, Biomanufacturing and Biosensing, Autonomous Chemistry and Materials Science, Biosensors and Bioelectronics, Bioprocess Design, Monitoring, and Control

Dr. Rohit Kannan, *Assistant Professor* – Operations Research, Optimization

Dr. Sajad Khodadadian, *Assistant Professor* – Operations Research, Stochastic Operations Research

Dr. Charlie Klauer, *Associate Professor* - Human Factors Engineering and Ergonomics, Driver Distraction, Novice Teen Drivers, Driver Fatigue

Dr. Brian M. Kleiner, *Ralph H. Bogle Professor and Director, Myers-Lawson School of Construction* - Human Factors Engineering and Ergonomics, Macroergonomics, Computer Augmented Work Systems, Computer Supported Collaborative Work, Function Allocation in Automation and Job Design, Human Reliability and Decision Making in Quality Control

Dr. Zhenyu "James" Kong, *Professor* - Manufacturing Systems Engineering, Real-time Sensing, Advanced Analytics, and Process Monitoring/Control for Smart Manufacturing, Modeling, Synthesis, and Diagnosis for Large and Complex Manufacturing Systems, Applications of Machine Learning for Manufacturing and Service Systems

Dr. Andrea L'Afflitto, *Associate Professor* - Manufacturing Systems Engineering, Autonomous Robots and Unmanned Systems, Control Theory, Lightweight Robotics

Dr. Nathan Lau, *Associate Professor* - Human Factors Engineering and Ergonomics, Cognitive Engineering, Human Performance, Interface Design, Situation Awareness, Ecological Interface Design, Cognitive Work Analysis

Dr. Sol Lim, *Assistant Professor* - Human Factors Engineering and Ergonomics, Ergonomics & Human Factors, Wearable Technology, Predictive Modeling, Occupational Health & Safety, Healthcare Ergonomics, Biomechanics in Disability and Inclusive Design

Dr. Michael Madigan, *Professor* - Human Factors Engineering and Ergonomics, Occupational Biomechanics and Ergonomics, Slips, Trips, and Falls, Work-related Musculoskeletal Disorders, Work Physiology and Fatigue, Aging, Obesity, Expert Witness Consulting

Dr. Maury Nussbaum, CPE, *H.G. Prillaman Professor, Assistant Department Head, and Graduate Program Director* - Human Factors Engineering and Ergonomics, Occupational Ergonomics & Injury Prevention, Basic & Applied Biomechanics, Measuring and Modeling Balance & Postural Control, Work Physiology & Muscle Fatigue, Ambulatory Ergonomics Exposure Assessment, Consumer Product Design & Evaluation, Individual Differences in Work Capacity & Injury Risks, Slip, Trip & Fall Prevention, Ergonomic Design & Evaluation Guidelines

Dr. Rafael Patrick, *Assistant Professor* - Human Factors Engineering and Ergonomics, Human Factors Psychology and Systems Engineering, Applied Psychophysics, Auditory Situation Awareness, Human-Machine Systems, Human Information Processing, Sensation & Perception, Usability Interaction & Experience, User-Centered Design, Product Design & Evaluation

Dr. Prahalada Rao, A*ssociate Professor* - Manufacturing Systems Engineering, Sensing, Robotics, Additive Manufacturing

Dr. Subhash Sarin, *Paul Y. Norton Endowed Professor* - Operations Research, Production Scheduling, Planning, and Control, Applied Mathematical Programming, Design and Mathematical Analysis of Manufacturing Systems

Dr. John Shewchuk, P. Eng., *Associate Professor and Associate Department Head, and Undergraduate Program Director* - Manufacturing System Engineering, Green Production Systems, Lean Green Manufacturing, Hybrid Manufacturing/Remanufacturing Systems, Circular Manufacturing Systems, Reverse Manufacturing Supply Chains

Dr. Binyang Song, *Assistant Professor* – Management Systems Engineering, Systems Engineering

Dr. G. Don Taylor, *Executive Vice Provost, and Charles O. Gordon Professor* - Management Systems Engineering, Operations Research, Logistics, Production Systems, Simulation and Optimization

Dr. Taylan G. Topcu, *Assistant Professor* - Management Systems Engineering, Systems Engineering, Data Science, Microeconomics

Dr. Konstantinos P. Triantis, *John Lawrence Professor* - Management Systems Engineering, Data Envelopment Analysis, Critical Infrastructure Systems, Productivity Measurement and Analysis, Engineering Economics, Operations Research, Dynamic Performance Measurement and Evaluation, Complex Adaptive Systems Analysis of Productive Efficiency, Complex Adaptive Performance Evaluation for Collaborative Design, Evacuation Planning, Health System Engineering

Dr. Kwok-Leung Tsui, *Professor* – Operations Research, Quality Engineering, Process Control and Surveillance, System Informatics, Data Mining, Health Informatics, Bioinformatics, Infectious Disease Modeling, Logistics and Supply Chain Management

Dr. Sait Tunc, *Assistant Professor* – Operations Research, Queuing Theory, Markov Decision Processes, Stochastic Modeling and Simulation, Game Theory, Information Theory

Dr. Eileen Van Aken, *Professor and Department Head* - Management Systems Engineering, Performance Measurement and Management Systems, Improvement System Design and Implementation, Organizational Assessment, Lean Work Systems, Collaborative Work Systems

Dr. Huaiyang Zong, *Assistant Professor* – Operations Research, Stochastic Operations Research, Health Systems