Graduate Certificate in Systems Engineering

Systems Engineering is a multi-disciplinary field that aims at integrating the engineering and management functions in the development and creation of a product, process, or service. The definition given by International Council on Systems Engineering (INCOSE) is a good description of what SE encompasses: “Systems Engineering is concerned with the overall process of defining, developing, operating, maintaining, and ultimately replacing quality systems. While other engineering disciplines concentrate on the details of individual aspects of a system (electronics, mechanics, ergonometrics, aerodynamics, software, etc.), systems engineering is concerned with the integration of all of these aspects into a coherent and effective system. Systems engineers concentrate their efforts on the aspects of the engineering process (requirements definition, top-level functional designs, project management, life cycle cost analysis, etc.) that serve to organize and coordinate other engineering activities. The systems engineer is the primary interface between management, customers, suppliers, and specialty engineers in the systems development process.” Based on this description, all engineering and manufacturing firms, and many other complex institutions, need Systems Engineering to improve productivity and quality as well as reduction in overall cost.

This certificate program is designed to address industry's increased needs for engineers who have expertise in Systems Engineering. It will prepare today's engineers to be competitive in taking on the new challenges facing the industry so that our companies can compete globally.

The certificate is a Purdue University certificate that would appear on a student’s transcript upon completion.

Who should join the program?

Practicing engineers who joined the workforce after bachelor’s degree and graduate students would be interested in obtaining training on this area in order for them to be current in solving demanding systems engineering problems. The proposed certificate program will provide them with the required technical skills.

What are the requirements to complete the graduate certificate program?

1. Total requirement: 12 credit hours

2. GPA requirements

   - Minimum overall GPA

   Successful completion of the certificate requires at least a B average over all courses counting toward the certificate.

   - Minimum grade:

   Courses with a grade of C- or less must be taken again to count towards the certificate. The minimum grade that will be accepted in any single course is C. For transfer credits, only the courses taken that result in a grade of B or better may be transferred for this certificate program.

3. Curriculum

There are two courses in the primary area and a number of courses in the related area. The certificate requires completion of both courses in the primary area and the remaining two courses in the related area.

The primary area courses consist of:

- ME 59700 Introduction to Systems Engineering Principles
- ME 59700 Systems and Specialty Engineering

The related courses include:

- ME 57500 Theory and Design of Control Systems
- ME 58100 Numerical Methods in Mechanical Engineering
- ME 59700 Advanced Mechanical Engineering Projects I
- ME59700 Design Optimization Methods
- ECE 53600 Introduction to Computational Intelligence
- ECE 56500 Computer Architecture
- ECE 51500 Software Engineering Methodology
- ECE 58000 Optimization Methods for Systems and Control
- ECE 60200 Lumped System Theory
- ECE 68000 Modern Automatic Control
- STAT 51100 Statistical Methods I
- STAT 51200 Applied Regression Analysis
- STAT 51400 Designs of Experiments

Are there on-line options for these courses?
Yes. The majority of the graduate courses are offered in late afternoon hours to accommodate the needs of part-time students. In addition, the two required courses may be available in both live lecture and online via video streaming modes.

Will any of these four courses count toward a graduate degree?
Yes! All four courses may be used toward the requirements for a Master of Science in Engineering Degree, if one wishes to pursue a formal degree program.

What are the requirements for admission to the certificate program?
In order to be eligible for this certificate program, the students must have a bachelor's degree from an accredited institution in an area which provides the necessary mathematical preparation for an engineering degree with a minimum undergraduate GPA of 3.0 out of 4.0. A conditional admission may be offered for applicants not meeting this criterion who have superior overall credentials. Applicants with non-engineering degrees, including mathematics, physical sciences, and engineering technology, may be required to take undergraduate mechanical engineering courses before admission to the program. Appropriate work experience also will be taken into account in making decisions about admission. Students will be required to submit a statement of interest and three letters of recommendation. A minimum TOEFL score of 550 (paper based) / 77 (internet based) or higher is required for international applicants whose native language is not English. Applicants taking IELTS must score at least 6.5 on the academic module.

Students admitted directly to the Purdue University graduate program can be considered for this certificate program, provided the student formally applies for the certificate program and receives admission. Courses completed under certificate program are not automatically

transferred to a graduate degree program, unless the student makes a petition to the graduate committee in respective departments. A student already enrolled in a graduate degree program may complete the certificate irrespective of his / her major so long as the requirements of the certificate are fulfilled.

I have completed a few graduate courses in the past. Can I use the credits toward the certificate program?
If you have already earned credits for one or more of the equivalent courses from another institution or another certificate program, you may request to transfer up to a maximum of three credits of these courses toward this certificate. A maximum of 6 equivalent credit hours taken prior to admission to the certificate program, including 3 credit hours taken from another institution, may be counted towards the certificate. The rest of the courses must be completed at IUPUI within a three-year period from the time of admission. Any waivers or substitutions require approval. No undergraduate courses can be applied to this certificate program.

How do I apply for admission to the certificate program?
To apply for admission, contact Valerie Lim Diemer, Coordinator for Graduate Engineering Programs by telephone at (317) 278-4961 or by email: wvlim@iupui.edu .

Program Course Listing and Descriptions

ME 57500 Theory and Design of Control Systems (3 cr.) Class 3. P: consent of instructor. Modern control techniques, state space representations, performance evaluation, controllability, observability, and observer design are introduced. The Bond graph is developed as a versatile computer-aided method of modeling coupled systems.

ME 58100 Numerical Methods in Mechanical Engineering (3 cr.) Class 3. P: 31400, 37200, and ENGR 19700 or graduate standing. The solution to problems arising in mechanical engineering using numerical methods. Topics include nonlinear algebraic equations, sets of linear algebraic equations, eigenvalue problems, interpolation, curve fitting, ordinary differential equations, and partial differential equations. Applications include fluid mechanics, gas dynamics, heat and mass transfer, thermodynamics, vibrations, automatic control systems, kinematics, and design.

ME 59700 Design Optimization Methods (3 cr.) Class 3. P: Math17100 and 26200, or graduate standing. General theory of optimization, concepts and problem statement are presented. Methods for minimization of a function of one and multiple variables with and without constraints are covered along with response surface methods and design of experiments. A class project uses a commercial software package to solve typical engineering design optimization problems. In addition to various engineering disciplines, the methods studied can be applied to a variety of diverse disciplines including finance, life sciences and physics.

ME 59700 Advanced Mechanical Engineering Projects I (1-6 cr.) Sem. 1 and 2. Summer Session. P: Graduate standing. Projects or special topics of contemporary importance or of special interest that are outside the scope of the standard graduate curriculum can be studied under the Mechanical Engineering Projects courses. Interested students should seek a faculty advisor by meeting with individual faculty members who work in their area of special interest and then prepare a brief description of the work to be undertaken in cooperation with the advisor.

ECE 53600 Introduction to Computational Intelligence (3 cr.) Class 3. P: C programming skills; graduate standing or permission of instructor. Basic concepts in theory and paradigms for

neural networks, evolutionary computation, and fuzzy logic; algorithms and applications for hybrids of these tools known as computational intelligence are explored. Topics include artificial neural networks, fuzzy systems, and evolutionary computation. Implementations of a number of paradigms are presented, including particle swarm optimization. Applications to various areas such as biomedical engineering and non-linear control are examined.

ECE 56500 Computer Architecture (3 cr.) Class 3. P: ECE36500 or graduate standing. An introduction to problems of designing and analyzing current machine architectures. Major topics include performance and cost analysis, pipeline processing, vector machines and numerical applications, hierarchical memory design, and multiprocessor architectures. A qualitative approach allowing a computer system designer to determine the extent to which a design goal is emphasized.

ECE 51500 Software Engineering Methodology (3 cr.) Class 3. P: ECE35900 or equivalent. Life-cycle models, software planning, software analysis, software design including data flow and data structure design, software testing methods, and software documentation. Software design project required.

ECE 58000 Optimization Methods for Systems and Control (3 cr.) Class 3. P: consent of instructor or graduate standing. Introduction to optimization theory and methods, with applications in systems and control. Nonlinear unconstrained optimization, linear programming, nonlinear constrained optimization, various algorithms and search methods for optimizations, and their analysis. Examples from various engineering applications are given.

ECE 60200 Lumped System Theory (3 cr.) Class 3. P: ECE30100. P or C: MATH 51100 or consent of instructor. An investigation of basic theory and techniques of modern system theory, emphasizing linear state model formulations of continuous- and discrete-time systems in the time and frequency domains. Coverage includes notion of linearity, time invariance, discrete- and continuous-times state models, canonical forms, associated transfer functions and impulse response models, the state transition matrix, the Jordan form, controllability, observability, and stability.

ECE 680 Modern Automatic Control (3 cr.) Class 3. P: 60200 or consent of instructor. Theoretical methods in optimal control theory. Topics include the calculus of variations and the Pontryagin minimum principle with applications to minimum energy problems. Geometric methods will be applied to the solution of minimum time problems. Computational methods, singular problems, observer theory, and sufficient conditions for existence of solutions are also discussed.

STAT 51100 Statistical Methods I (3 cr.) P: MATH 16600. Descriptive statistics; elementary probability; random variables and their distributions; expectation; normal, binomial, Poisson, and hypergeometric distributions; sampling distributions; estimation and testing of hypotheses; neway analysis of variance; correlation and regression.

STAT 51200 Applied Regression Analysis (3 cr.) P: 51100. Inference in simple and multiple linear regression, estimation of model parameters, testing and prediction. Residual analysis, diagnostics and remedial measures. Multicollinearity. Model building, stepwise and other model selection methods. Weighted least squares. Nonlinear regression. Models with qualitative independent variables. One-way analysis of variance. Orthogonal contrasts and multiple comparison tests. Use of existing statistical computing package.

STAT 51400 Designs of Experiments (3 cr.) P: 512. Fundamentals, completely randomized design, randomized complete blocks. Latin squares, multiclassification, factorial, nested factorial, incomplete blocks, fractional replications, confounding, general mixed factorial, split-plot and optimum design. Use of existing statistical computing packages.