Proposal for a Graduate Certificate in Computer-Aided Mechanical Engineering

Submitted

by the

Department of Mechanical Engineering
School of Engineering and Technology

IUPUI
Computer-Aided Mechanical Engineering Certificate

To be offered as a Purdue Certificate at IUPUI

Revised: March 28, 2002

Purpose of the program

Computer tools have become an essential part of modeling, analysis, and design in engineering practice. With the advent of fast and powerful computers, it is expected that decisions in engineering and sciences will be based upon computational simulations that will be of unprecedented magnitudes, size, scope, and complexity. With the advances in computers there have been a great deal of advances in the field of computer-aided engineering where engineers are required to routinely solve complex problems in fluid mechanics, heat and mass transfer, structural mechanics, vibrations, and acoustics. Most of these problems require the use of computational tools such as solid modelers, computer-aided design and computer-aided manufacturing (CAD/CAM) systems, system simulators, and finite element simulation codes. Engineers who use commercial codes for design and analysis must be highly proficient with mathematical and computational aspects of the methods involved as well as the physical principles associated with these phenomena.

This certificate program is designed to address industry's increased needs for engineers in these areas who can model complex engineering design and analysis problems competently using computers. It will prepare today's engineers to be experts in various aspects of computer-aided engineering. The emphasis will be on fundamentals of analysis and design and the use of commercially available computer codes such as ProEngineer, Ansys, StarCD, Patran, and Abaqus.

The purpose of this new graduate-certificate program in mechanical engineering is to enable engineers to become certified in a computer-aided mechanical engineering field without formally pursuing a graduate degree. The certificate in computer-aided mechanical engineering will provide a core set of integrated courses on fundamentals of the finite element analysis and CAD/CAM. Also, the students are allowed to select two related courses either in mechanical systems or thermal/fluid systems. Students completing this certificate will be able to understand the theoretical foundations of the modeling and analysis of various mechanical components and their performance analysis.

The certificate is being proposed as a Purdue University certificate that would appear on a student's transcript upon completion.

Relation to existing certificate programs

Currently, there is no certificate program in "Computer-Aided Engineering" available on the IUPUI campus. It is anticipated that other certificate programs focusing on the computational simulations may be developed by other disciplines in engineering and sciences. The core courses of the proposed program on computational methods include the finite element method and computational fluid dynamics courses which may serve as a foundation to computer simulations in other multidisciplinary fields such as biomechanics, mechatronics, nanotechnology, and computational physics.
The target audience

Indianapolis is a major town for many engineering and manufacturing companies such as Allison Transmission, Carrier Corporation, Cummins Engine Company, DaimlerChrysler, Delphi Delco Electronics, Diversified Systems, Eli Lilly and Company, Ford Motor Company, Motorola, Raytheon Systems Company, Roche Diagnostics, Rolls-Royce Corporation, Texas Instruments, Delta Faucet, and Thomson Consumer Electronics. In all the above companies, engineers utilize computational tools to design and analyze various mechanical and electronic components. It is anticipated that practicing engineers who joined the workforce after the bachelor's degree should be interested in obtaining some proficiency in computational skills in order for them to be current in solving complex engineering problems. The proposed certificate program in "Computer-Aided Mechanical Engineering" will provide them with the required skills.

Students after receiving the certificate may choose the option of applying to the graduate program in Master of Science in Mechanical Engineering (MSME) in the department with the courses taken during the certificate program transferred.

Plan for sustaining steady-state enrollment

In the first year (Fall 2002), five students will likely participate in the program. It is anticipated that this number will rise rapidly to ten per year in the next two to three years, as the awareness of the program increases. The potential exists for much greater growth beyond this subsequently.

New resources

The required infrastructure (computers and software) needed to support the certificate program is already in place in the Department of Mechanical Engineering and the School of Engineering and Technology. The graduate-level courses will continue to be taught by the faculty in the department. Therefore, the certificate program can be offered with no additional demands for faculty or facilities.

Proposed date of the initiation of the certificate program

Proposed date of implementation is Fall 2002, assuming all necessary approvals have been met.

Persons designated as the certificate program head

Dr. Nasser Paydar, Associate Dean of Academic Programs, Purdue School of Engineering and Technology, will provide the school administrative oversight.

Dr. Hasan U. Akay, Professor and Chair, Department of Mechanical Engineering will provide the department administrative oversight.

Dr. Ramana M. Pidaparti, Professor, Department of Mechanical Engineering will advise students.

Faculty initially involved in the program and their credentials

Dr. Hasan U. Akay
Professor and Chair
Department of Mechanical Engineering

Research and Teaching Interests: Computational fluid mechanics, computational mechanics, parallel computing, fatigue and creep modeling, electronic packaging reliability, finite element method.
Faculty initially involved in the program and their credentials (condt.)

Dr. Ramana M. Pidaparti  
Professor of Mechanical Engineering  
*Research and Teaching Interests:* Composites, computational intelligence applications, biomechanics and biomaterials, biomedical engineering device design, neural networks, smart materials and structures, fracture mechanics, finite element method.

Dr. Andrew Hsu  
Associate Professor of Mechanical Engineering  
*Research and Teaching Interests:* Computational fluid mechanics, combustion, turbulence modeling, cardiovascular hemodynamics.

Dr. Jie Chen  
Professor of Mechanical Engineering  
*Research and Teaching Interests:* System design and simulation, hybrid electrical vehicle simulation, engineering design, kinematics, biomechanics, implantology, joint mechanics, mechanics of orthodontics, dental restorations.

Dr. Akin Ecer  
Professor of Mechanical Engineering  
*Research and Teaching Interests:* Computational fluid dynamics, parallel computing, dynamic load balancing, finite element method.

Dr. Hazim El-Mounayri  
Assistant Professor of Mechanical Engineering  
*Research and Teaching Interests:* Advanced manufacturing, intelligent machining, CAD/CAM, solid modeling, machining process control, simulation and optimization, automation.

Dr. Razi Nalim  
Assistant Professor of Mechanical Engineering  
*Research and Teaching Interests:* Unsteady fluid mechanics, combustion, wave rotors, pollution control in combustion engines, propulsion.

Admissions requirements and procedures

In order to be eligible to this certificate program, the students must have a bachelor's degree in an area which provides the necessary mathematical preparation for an engineering degree with a recommended minimum GPA of 3.0 out of 4.0. 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.

Students admitted directly to the Purdue University graduate program will not be considered for this certificate program, unless the student decides to leave the graduate program before completion. In that case, a petition must be submitted to the graduate committee to receive approval provided that all the requirements of the certificate program are satisfied.
Completion requirements and audit and certification procedures

a. Requirements for the certificate program

Total requirement: 12 credit hours.

It is not necessary to be admitted to the Graduate School to earn the certificate. However, at most, twelve hours of coursework taken prior to admission to Graduate School can be counted towards a graduate degree provided that the admission requirements are met. Thus, a decision to apply to Graduate School by qualified students should be made at an earlier time in order not to lose credits. Credit may be counted both for the certificate and master's degree, subject to approval by the Graduate Committee.

To earn a certificate, the students admitted to this certificate program are required to complete twelve credit hours of graduate courses. There are two specialty areas for this certificate in the mechanical engineering program, which are:

• Computations of Mechanical Systems
• Computations of Fluid and Thermal Systems

There are two required and two elective courses for each specialty area. The required courses for both specialties are:

1. ME 551 Finite Element Analysis
2. ME 597 CAD/CAM: Theory and Applications

Electives for Mechanical Systems specialty area include:

- ME 552 Advanced Applications of the Finite Element Method
- ME 561 Optimum Design: Theory and Practice
- ME 563 Mechanical Vibrations
- ME 569 Mechanical Behavior of Materials
- ME 597 Composite Materials
- ME 597 Advanced Mechanical Engineering Projects I

Electives for Fluid and Thermal Systems specialty area include:

- ME 505 Intermediate Heat Transfer
- ME 509 Intermediate Fluid Mechanics
- ME 525 Combustion
- ME 552 Advanced Applications of the Finite Element Method
- ME 581 Numerical Heat Transfer and Fluid Flow
- ME 597 Advanced Mechanical Engineering Projects I
- ME 614 Computational Fluid Dynamics

Substitutions to the above courses are possible with approval of the Graduate Committee of the department.
Minimum overall GPA

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

Maximum number of credits that can be transferred from another institution

Applicants who have already earned credit for one or more of the equivalent courses from other institutions and other certificate programs may request to apply up to a maximum of three credits of these courses toward this certificate. Any waivers or substitutions have to be approved by the committee that oversees the program.

Maximum number of undergraduate courses that can be applied

No undergraduate courses can be applied to this certificate program.

Maximum time for completion

All requirements for the certificate must be completed within three years. Most students enrolled in this program will be part-time students, employed full time. Thus two years may be needed for the completion of all courses if students take one course per semester.

Number of credit hours taken prior to admission to the certificate program that may be counted to completion of the degree

Up to 6 equivalent credit hours taken prior to admission to the certificate program, including 3 hours taken from another institution, will 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.

Course lists for the program including course descriptions

The majority of the graduate courses in the department are offered in late afternoon hours to accommodate the needs of part-time students. The following list contains the catalog description of the courses.


ME 509 Intermediate Fluid Mechanics (3) Class: 3 Lab: 0 Rec: 0 P: ME 310 or equivalent; C: None. Fluid properties, basic laws for a control volume, kinematics of fluid flow, dynamics of frictionless incompressible flow, basic hydrodynamics, equations of motion of viscous flow, viscous flow applications, boundary layer theory, wall turbulence, and lift and drag of immersed bodies.

ME 551 Finite Element Analysis (3) Class: 3 Lab: 0 Rec: 0 P: Graduate standing or consent of instructor; C: None. Concepts of finite elements methods; formulations for different engineering problems and their applications. Variational methods, the finite element concept, and applications in stress analysis, dynamics, fluid mechanics, and heat transfer.

ME 552 Advanced Applications of Finite Element Methods (3) Class: 3 Lab: 0 Rec: 0 P: ME 551 or equivalent; C: None. Various algorithms for nonlinear and time-dependent problems in two-and three-dimensions. Emphasis on advanced applications with problems chosen from fluid dynamics, heat transfer, and solid mechanics areas. Independent project required.

ME 561 Optimum Design: Theory with Practice (3) Class: 3 Lab: 0 Rec: 0 P: None; C: None. Optimization as an element of the engineering design process. Case studies that demonstrate the theory and application of nonlinear programming as a design tool. Comparative examination of unconstrained algorithms. Development and application of methods for the constrained case. Selected contemporary topics.


ME 569 Mechanical Behavior of Materials (3) Class: 3 Lab: 0 Rec: 0 P: MSE 345 or equivalent; C: None. How loading and environmental conditions can influence the behavior of materials in service. Elastic and plastic behavior, fracture, fatigue, low- and high-temperature behavior. Fracture mechanics. Failure analysis case studies emphasis on design.

ME 581 Numerical Methods in Mechanical Engineering (3) Class: 3 Lab: 0 Rec: 0 P: ME 314, ME 197 or equivalent, and ME 372; C: None. 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 597 Advanced Mechanical Engineering Projects I (3) Class: 1-6 Lab: 0 Rec: 0 P: Master’s standing; C: None. 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 course. Interested students should seek a faculty advisor by meeting with individual faculty members who work in their area of special interest and prepare a brief description of the work to be undertaken in cooperation with their advisor.

ME 597 CAD/CAM - Theory and Applications (3) Class: 3 Lab: 0 Rec: 0 P: ME 197 & ME 262; C: None. Introduction to computer-aided design (CAD) and computer-aided manufacturing (CAM) theory and applications. Topics include CAD/CAM systems (Hardware and Software), geometric modeling using curves, surfaces, and solids, CAD/CAM data exchange, CAD and CAM integration, mechanical assembly, mechanical tolerancing, mass property calculations, process planning and tool path generation, integration of CAD/CAM with the production machine, and computer control of machines and processes in manufacturing systems. Projects will focus on development of geometric procedures for design and manufacturing applications and the use of commercial CAD/CAM software for automating the production cycle. Applications will include NC machining, design of (optimum) cutting tools, and modeling and design of fixtures for dies and molds. Hands-on experience is attained through laboratory experiment.
ME 614 Computational Fluid Dynamics (3) Class: 3 Lab: 0 Rec: 0 P: ME 581 or AAE 516 or equivalent or ME 509 or ME 510 or equivalent; or consent of instructor; C: None. Application of finite difference methods, finite element methods, and the method of characteristics for the numerical solution of fluid dynamics problems. Incompressible viscous flows: vorticity transport equation, stream function equation, and boundary conditions. Compressible flows: treatment of shocks, implicit and explicit artificial viscosity techniques, and boundary conditions. Computational grids.

Procedures for governing the program including construction of committees that will provide oversight

A committee comprised of Dr. Hasan Akay, Dr. Ramana Pidaparti and Dr. Andrew Hsu will jointly oversee the program. All advising will be done by these faculty members. The Department of Mechanical Engineering and Ms. V. Lim, the graduate coordinator, will take responsibility for all record keeping and tracking of students.

Procedures for program evaluation including the criteria for success

Upon completion of the program, exit interviews will be conducted for all students to determine the effectiveness of the program in meeting their needs and to identify how they are using the skills and tools learned in the program in their professions. Follow-up interviews will be conducted after three and five years. Given the projected enrollment of this program, and the fact many of the graduates will remain employed locally, it is anticipated that most students will be tracked this way.

Success of the program will be defined in terms of demand (enrollment) and the responses of the students surveyed upon completion of their degree and in the follow-up interviews.
October 24, 2001

Professor Phil Pope
Purdue University
Grad School - YONG
West Lafayette, IN 47907

RE: IUPUI Certificate in "Computer Aided Mechanical Engineering"

Dear Professor Pope:

I reviewed the proposal with Prof Anil Bajaj, Associate Head for Research and Graduate Programs in the School, and on that basis submit the following comments.

The program should have no negative impact on the WL campus ME degree offerings. I cannot comment in detail on the potential demand for the proposed certificate program, but certainly wish the IUPUI faculty well and am interested in seeing the results.

- The proposed graduate certificate in "Computer Aided Mechanical Engineering" seems relevant to the needs of the industry, as substantial design and development work is now being carried out using advanced computational tools. While we do not believe the proposed set of courses would be of interest to WL distance students, the program could fill a need in the Indianapolis area. Very few of the engineers and designers with Bachelor's degree have much experience with advanced computational simulation before they join industry. Thus, the engineers need to develop these skills after graduating, and the certificate can serve as a good and convenient vehicle for that purpose. It will also be able to serve the needs of the employers/industries in the vicinity of Indianapolis.

Finally, I would request that in all advertising for the course, the fact that it is not affiliated in any way with the West Lafayette campus or WL degree programs should be made explicit.

Please let me know if you need further information.

Sincerely,

E. Dan Hirleman
William E. and Florence E. Perry Head
School of Mechanical Engineering