Master of Science in Mechanical Engineering
Program code: 063010

INTRODUCTION

The Department of Mechanical Engineering offers a Master of Science Program in **Mechanical Engineering**. Research requirements include either thesis or non-thesis options. The program is a balanced combination of the theoretical and practical aspects of mechanical engineering with enough flexibility to allow for interaction with the ever developing sciences and technologies and with the changing needs of the region.

The program is designed to deepen and broaden the scientific and engineering skills in one of the following two lines:

- Mechanical Design and Manufacturing
- Thermo-Fluid Engineering

The general research interests in the department are focused in these two lines. They include works in mechanical vibration, dynamics and control, stress analysis, tribology, computer-aided design, robotics, computer-aided manufacturing, mechanical behavior of materials, composite materials, corrosion, thermodynamics, heat transfer, experimental and computational fluid mechanics, energy management, combustion and combustion engines, solar energy, heating and air-conditioning systems, desalination, aerodynamics, turbulence, and dual-purpose power plants.

According to the University Council decision dated 4/2/2007, Thesis students admitted with effect from September 2007 are exempted from the comprehensive examination.

PROGRAM REQUIREMENTS

33 (33) TOTAL COURSE CREDITS (non-thesis option in parenthesis)

3 (3) CORE COURSES (3 credits each)

0600-505 Finite Element Methods
0600-506 Continuum Mechanics
0600-507 Mathematical Optimization
0600-508 Random Variables and Stochastic Processes
0600-513 Advanced Engineering Mathematics II

9 (9) SUBDISCIPLINE COURSES(3 credits each)

Student can select 9 credits from any of the following two sub-disciplines.

I. MECHANICAL DESIGN AND MANUFACTURING

0630-509 Analytical Mechanics
0630-511 Stress Analysis in Mechanical Design
0630-512 Mechanical Vibrations
0630-513 Dynamic Analysis and Design of Machines

0630-514 Computer-Aided Design
0630-515 Engineering Materials: Selection and Applications
0630-516 Reliability and Maintainability
0630-517 Optimal Design
0630-519 Stability of Structures and Systems
0630-534 Modeling Dynamic Systems **Equivalent to 0670-515**
0630-542 Computer Integrated Manufacturing
0630-543 Fracture Mechanics
0630-554 Special Topics in Mechanical Design

II. THERMO-FLUID ENGINEERING

0630-520 Advanced Conduction Heat Transfer
0630-522 Radiation Heat Transfer
0630-523 Advanced Convection Heat Transfer
0630-524 Air-Conditioning
0630-525 Non-Conventional Energy Conversion Systems
0630-527 Power Plants
0630-528 Heat Exchangers Design
0630-529 Refrigeration Engineering
0630-531 Fluid Mechanics **OR** 0600-510 Advanced Fluid Mechanics
0630-532 Gas Dynamics
0630-533 Computational Fluid Mechanics
OR 0600-511 Computational Fluid Dynamics
0630-535 Mechanical Aspects of Desalting Systems
0630-538 Special Topics in Thermo-Fluid Engineering
0630-539 Advanced Thermodynamics

9 (15) FREE ELECTIVE COURSES

A maximum of 3 credits hours (thesis students) and 6 credits hours (project students) of graduate courses can be taken from:
· Area of Engineering (Core and elective)
· Area of Science
· Area of Joint Graduate Programs (Engineering/Science Specialization)
with the approval of the graduate program director before registering for the course.

12 (6) COMPULSORY COURSES

0600-512 Advanced Engineering Mathematics I
0630-592 Seminar (0)
0630-593 Project (3) (non-thesis option only)
0630-597 Thesis (0)
0630-598 Thesis (0)
2000-599 Thesis (9)

COURSE DESCRIPTION

0630-509: ANALYTICAL MECHANICS
CR: 3

Review of Newtonian mechanics. The principle of virtual work. D'Alemberts principle. Hamilton's principle. Lagrange's equations of motion. Case of impulsive forces. Conservation laws. Ralyleigh's dissipation function. Hamilton's equations. Motion relative to rotating frames. Rigid body dynamics. Gyroscopic effects. Canonical transformations. The Hamilton-Jacobi equation.

0630-511: STRESS ANALYSIS IN MECHANICAL DESIGN
CR: 3

Stress and strain in two and three dimensions. Plane theory of elasticity. Failure theories. Stress concentration. Residual Stresses. Thermal stresses. Contact stresses. Impact loading. Fracture mechanics and design. Fatigue and cumulative damage. Structural instability. Experimental stress analysis. Energy approach and numerical methods. Case Studies.

0630-512: MECHANICAL VIBRATIONS
CR: 3

Lagrange's equations. Response of multi-degree-of-freedom systems. Vibration of continuous systems. Approximate solutions. Introduction to nonlinear vibrations. Introduction to random vibrations. Spectral analysis.

0630-513: DYNAMIC ANALYSIS AND DESIGN OF MACHINES
CR: 3

General concepts in the dynamic analysis and design of machines, with reference to machine tools. Structure compliance, integrity, static and thermal deformations, structure design concepts. Drive systems, slides and bearings. Feed drives. Types of control systems; numerical, adaptive and computer control. Steady and dynamic cutting forces. Dynamics of machine tools. Receptance concept. Interaction between cutting and structural response. Machine tool stability. Vibration reduction of machine tools in the design stage and in the field. Design for fabrication by bonding.

0630-514: COMPUTER-AIDED DESIGN
CR: 3

Computer Graphics including solid modeling and image synthesis, curve and surface description, 3-D transformations. Use of prepackaged software. Review of optimization techniques: linear, non-linear and dynamic programming. Design applications in mechanical engineering systems.

0630-515: ENGINEERING MATERIALS: SELECTION AND APPLICATIONS
CR: 3

Mechanical behavior of materials: elastic and plastic behavior, yielding fracture, crack propagation, fatigue, creep. Behavior at low and high temperatures. Engineering properties of metallic and non-metallic materials. Functional requirements of engineering materials. Material selection process, criteria and techniques. Aspects of design for selection. Applications: material selection for springs, fasteners, gears, bearings etc. Material selection for abrasive-wear and corrosion-resistance applications. Case studies.

0630-516: RELIABILITY AND MAINTAINABILITY
CR: 3

Component factors in durability and reliability. Reliability concepts and assessments. The performance requirements. Static and dynamic reliability models. Random variables in design. Sampling estimation and confidence.

Maintainability down-time and repair-time. Design factors determining down-time. Maintainability prediction. Maintainability and reliability in contracts. Maintenance handbook.

0630-517: OPTIMAL DESIGN
CR: 3

Survey of single-variable unconstrained optimization methods. Multi-variable unconstrained optimization. Single and multi-variable constrained optimization techniques. Applications from mechanical design, vibrations, solid mechanics, and thermal fluid systems.

0630-519: STABILITY OF STRUCTURES AND SYSTEMS
CR: 3

Concept of stability. Lejeune-Dirichlet criterion. Nyquist criterion. Routh and Hurwitz criterion. Liapunov second method. Examples from rigid body dynamics. Effects of damping. Gyroscopic effects. Elastic stability under static load: Beam-columns, bars and frames, torsional buckling, buckling of rings, curved bars and arches. Dynamic instability: Divergence and flutter. Instability under nonconservative forces. Examples.

0630-520: ADVANCED CONDUCTION HEAT TRANSFER
CR: 3

A generalized treatment of the solution of steady and transient heat conduction in finite and infinite regions. Approximate and exact methods of solution of problems involving phase change, variable thermal properties, heat generation, and non-linear boundary conditions. Heat conduction in composite media and in anisotropic solids.

0630-522: RADIATION HEAT TRANSFER
CR: 3

Exact and approximate methods of solution of radiative heat transfer. Heat radiation of black bodies and non black bodies. Radiation between surfaces and through participating and non-participating media. Experimental methods. Radiation heat processes. Radiative properties of surfaces and gases. Multimode heat transfer in thermal systems. Numerical modeling.

0630-523: ADVANCED CONVECTION HEAT TRANSFER
CR: 3

Differential forms of the balance laws of mass, linear momentum, and energy, Boundary layer theory, Scale Analysis, Similarity solutions, Forced and free convention in laminar and turbulent, internal and external flows. Analogy between momentum and heat transfer. Heat and mass transfer in compressible flow.

0630-524: AIR-CONDITIONING
CR: 3

Air-Conditioning systems and their physchrometric process, analysis and performance of direct contact heat and mass transfer exchanges: cooling towers, analysis of extended surface heat exchangers, analysis of cooling coils, air conditioning control.

0630-525: NON-CONVENTIONAL ENERGY CONVERSION SYSTEMS
CR: 3

Analysis and performance characteristics based on thermodynamics and fluid flow of non-conventional energy conversion systems.

0630-527: POWER PLANTS
CR: 3

Thermodynamics review, Availability, Irreversibility, Entropy creation efficiency and effectiveness. Rankine cycle: Ideal and real cycle, effects of superheating, reheating, feed water heat regeneration, condenser. Fossil-fuel steam generations: water tube boilers, design of natural and forced flow, furnace design with tube walls, evaporators, superheaters, economizers, fans, stacks. Rating of steam generators. Fuels and combustion. Steam turbines: Impulse and reaction turbines, analysis and sizing. Turbine rating methods, turbine losses, gas turbines cycles (simple open, regenerative and cooled), Combined cycle, rating of gas and gas/steam cycles. Condensate-feed water system: Condensers types and designs, feed water heaters types and designs, dearators, make up water. Circulating water systems.

0630-528: HEAT EXCHANGERS DESIGN
CR: 3

Double-pipe heat exchangers. Shell and tube heat exchanger. Flow arrangements for increased heat recovery in shell and tube exchangers. Gases cooling and heating. Extended surfaces. Condensation of vapors and condensers design.

Evaporation and evaporators. Steam generator design: Furnaces, superheaters, economizers, evaporators, cooling towers.

0630-529: REFRIGERATION ENGINEERING
CR: 3

Machinery for vapor compression systems: Compressors (reciprocating, rotary positive displacement and turbo), condensing equipment, evaporators, expansion valves, cooling towers. Equipment design, characteristic and rating methods, equipment matching. Multistage vapor compression systems. Ammonia absorption refrigeration system design and characteristics. Lithium bromide-water absorption system design and characteristics. Steam jet regeneration systems design. Cold storage. Defrosting methods.

0630-531: FLUID MECHANICS
CR: 3

Conservation laws and Navier-Stokes equations closed-form solutions of standard viscous flow problems. Boundary layer theory. Ideal-fluid flow equations, potential flow. Elementary flows.

0630-532: GAS DYNAMICS
CR: 3

Basic concepts of gas dynamics and gas properties. Subsonic flow. Supersonic flow. Hypersonic flow. Shock-wave phenomena. Dimensional analysis. Experimental techniques and other selected topics.

0630-533: COMPUTATIONAL FLUID MECHANICS
CR: 3

Characteristics of different types of partial differential equations. Scalar representations of Navier-Stokes equations. Covarient and contravarient base vectors and calculus. Transformation of Navier-Stokes equations from physical space to computational space; Grid generation methods. Numerical methods for inviscid flows. Numerical methods for incompressible viscous flows.

0630-534: MODELING DYNSMIC SYSTEMS
CR: 3

Unified approach to modeling, analysis and simulation of energetic dynamic system. Introduction to multi-domain system. System dynamic response in time and frequency domains. Introduction to model reduction. Application to Various dynamic system such as mechanical, thermal, fluid, electric, chemical, electormechanical system, emphasis on modeling and simulation of hybrid system using modern computer-aided tools.

0630-535: MECHANICAL ASPECTS OF DESALTING SYSTEMS
CR: 3

Design of submerged and falling film evaporators. Single and multi-effect desalting systems and component design. Multi-stage flash (MSF) desalting system design. MSF components design (pumps, stages, brine heater, evacuating system,..). Mechanical vapor compression desalting system. Reverse osmosis desalting systems.

0630-538: SPECIAL TOPICS IN THERMO-FLUID ENGINEERING
CR: 3

An upper division of graduate technical elective treating topics in mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

0630-539: ADVANCED THERMODYNAMICS
CR: 3

Availability analysis. Irreversible Thermodynmics applied to engineering systems. Energy Analysis for power plants, refrigeration systems. Equilibrium and stability of thermodynamics system. General relations.

0630-542: COMPUTER INTEGRATED MANUFACTURING
CR: 3

Fundamentals of manufacturing and automation, production systems (types, analysis, automation, simulation), numerical control production systems (NC, DNC, CNC, ACO, ACC) - industrial robotics (technology-programming, and application in manufacturing systems). Materials handling systems - flexible classification, coding machine cells, workstations, computer control). Control systems (feedback, optimal, sequence control). Computer integrated manufacturing (fundamentals of CAD/CAM computer planning of material process, and capacity) shop floor control and automation-order release, scheduling, identification systems. Computer network.

0630-543: FRACTURE MECHANICS
CR: 3

Stationary crack under static loading. Energy balance fracture mechanisms: Crack initiation and growth. Fracture modes. Stress intensity factors. Fracture toughness. Brittle and ductile fractures. Dynamic crack growth. Fatigue. crack propagation and component's life prediction. Experimental methods. Case studies.

0630-554: SPECIAL TOPICS IN MECHANICAL DESIGN
CR: 3

An upper division of graduate technical elective treating topics in Engineering mostly not covered in other courses, chosen at the discretion of the Graduate Program Committee.

0630-592: SEMINAR
CR: 0 CO-Requisites: 0630-593 Or 0630-597

With the guidance of the graduate program committee, the seminar topics include:
- Research writing methods.
- Presentation skills
- Surveying literature.
- Bibliography style.
- New tools (LaTeX, Data analysis etc...)

0630-593: PROJECT
CR: 3 CO-Requisites: 0630-592

The student undertakes an independent project on a research topic of theoretical and/or experimental focus under the supervision of a faculty member listed in the supervisory list of the College of Graduate Studies. The objective is to provide the student with an opportunity to integrate and apply the knowledge gained throughout the course of study in a practical problem. The student must document the project in a scientific report following standard research writing guidelines and give a public presentation to the project examination committee.

0630-597: THESIS
CR: 0 CO-Requisites: 0630-592

0630-598: THESIS
CR: 0

2000-599: THESIS
CR: 9