NCA &TSU Doctor of Philosophy in Mechanical Engineering Degree Requirements

Mechanical Engineering

OBJECTIVE

The objective of graduate study in Mechanical Engineering is to provide advanced level study in mechanical engineering in four distinct areas of specialization. The Master of Science in Mechanical Engineering is designed to prepare the graduate for Ph.D. level studies or for advanced mechanical engineering practice in industrial consulting or government service. The Ph.D. degree in Mechanical Engineering provides both advanced instruction and independent research opportunities to students. The Ph.D. degree is the highest academic degree offered, and graduates typically are employed in research environments in government laboratories and industries, and as university faculty.

DEGREES OFFERED

Master of Science in Mechanical Engineering (MSME)
Doctor of Philosophy (Ph.D.) in Mechanical Engineering

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

Program Description

The Master of Science in Mechanical Engineering is a graduate-level program comprising advanced studies in mechanics and materials, energy and thermal/fluid systems, design and manufacturing, and aerospace.

Admission to the MSME Program

The Master of Science in Mechanical Engineering Program is open to students with a Bachelor's Degree in Mechanical Engineering or a closely related field from an institution of recognized standing. Application packages may be obtained from the School of Graduate Studies Office, Room 120, Gibbs Hall, North Carolina A&T State University, Greensboro, NC 27411. Applicants may be admitted to the MSME Program under two categories:

Unconditional Admission or Conditional Admission. Details follow:

1. *Unconditional Admission:* An applicant may be given unconditional admission to the MSME Program if he/she possesses a MSME bachelor's degree from an ABET (Accreditation Board for Engineering and Technology) accredited institution, with an overall GPA of 3.0 or better on a 4.0 scale.
   Students admitted on an unconditional basis are also expected to have completed "key courses" below as part of their prior undergraduate program.
   Undergraduate Courses Required:
   Calculus (minimum of 8 semester hours) Statics
   Differential Equations Dynamics
   Applied Engineering Mathematics Strength of Materials
   Physics (minimum of 6 semester hours) Materials Science

   Chemistry Thermodynamics
   Fortran Programming Fluid Mechanics
   Introductory Numerical Methods Mechanical Engineering Design
   Additional undergraduate course requirements for Specialization in Mechanics and Materials: three (3) credits of Advanced Materials
   Additional undergraduate course required for Specialization in Energy and Thermal/ Sciences: three (3) credits of Heat Transfer
   Additional undergraduate courses required for Specialization in Design and Manufacturing: three (3) credits of System Dynamics and three (3) credits of

Manufacturing Processes

2. *Provisional Admission:* Applicants may be granted conditional admission if they do not qualify for unconditional admission due to one or more of the following reasons:
   a. Applicant has a baccalaureate mechanical engineering degree from a non-ABET accredited program. Undergraduate engineering degrees from foreign universities fall into this category.
   b. Applicant has a baccalaureate degree in engineering but is deficient in key background courses listed in the previous section. These deficiencies must not exceed 12 credit hours.
   c. Applicant has an undergraduate degree which is not in engineering but is in a closely related curriculum with a substantial engineering science content. Background deficiencies should not exceed 12 credit hours.
   d. Applicant's undergraduate grade point average is below that required for unconditional admission but there is also academic evidence that the student will successfully complete the degree.

   Provisional admission status will be changed to unconditional when the student has satisfied the two conditions below:

   a.. All required course deficiencies have been completed with a 3.0 GPA or above and
   b. A minimum of 3.0 GPA is attained on A&T courses taken for graduate credit at the end of the semester in which the 9th semester credit is completed.

   Failure to move to unconditional admission when first eligible will result in the student being subject to probation policies. Other admission conditions and program requirements may be imposed on a case-by-case basis as approved by the Dean of the School of Graduate Studies. Provisional admission status is the minimum level of graduate admission classification.

   In this classification, students are eligible to register for 700-level courses, provided such courses are approved by the academic advisor.

Change of Admission Status

It is the student's responsibility to apply to the department for a change in admission status. Students who fail to have their status upgraded run the risk of not receiving graduate credit for any completed graduate courses. Such students also run the risk of academic probation and dismissal.

Program Options

1. Course Work Option

This option consists of thirty-three (33) semester hours of course work. Successful completion of the comprehensive examination is a degree requirement. Approval must be obtained from the Graduate Program Coordinator to elect the course work option. A course work Option student must also take at least five courses from her/his specialization area or in a related area as specified by the academic advisor. A candidate who chooses the course work option must select a permanent advisor who will direct the course of study and who will plan the Final Comprehensive Examination. The advisor may also be part of the group of examiners who conduct the Final Comprehensive Examination. A candidate who selects this option does not have a formal advising committee.

Comprehensive Examination (Course work Option)

Candidates who elect the course work option must sit for a written comprehensive examination of six (6) hours duration, prepared as three independent two-hour examinations. A student must have completed at least twenty-one (21) hours of course work to be eligible to take the comprehensive examination.

One week each semester, at least forty-five (45) days prior to the end of the semester, will be designated as Comprehensive Examination Week. All students wishing to take the examination must do so during this period.

Applications to take the examination must be submitted by the academic advisor to the Graduate Program Coordinator at least thirty (30) days prior to the scheduled beginning date of the examination. The student must initiate this process by contacting his/her advisor with an examination request.

The application should contain a description of the subject areas to be covered by the exam. In consultation with the academic advisor, the Graduate Coordinator assigns an

appropriate group of examiners as well as a test time and date. The Graduate Program Coordinator will organize the examination to arrange for as much "common" testing as possible based on material relating to the student's course work.

The candidate must achieve a satisfactory score in at least two (2) sessions of the examination. A candidate who fails to achieve a satisfactory score at the first attempt may sit again in the next regularly scheduled Comprehensive Examination Week, generally in the following semester. A candidate who fails a second time must petition the Dean of the School of Graduate Studies for permission to sit again. An unfavorable decision will result in dismissal from the program. A third failure will always result in dismissal from the program.

2. Project and Thesis Options

The Project Option consists of thirty (30) semester hours of course work and three (3) hours of special project. It is intended for students with an interest in research or independent study but who do not wish to do a full Master's thesis. Project Option students must take three hours of MEEN-796 Master's Project. An oral examination project defense/examination is required.

The Thesis Option consists of twenty-four (24) semester hours of course work and six (6) hours of thesis. Thesis Option students must take six hours of MEEN-797 Mater's Thesis. An original research topic must be chosen in conjunction with the student's advisor culminating in the preparation of a scholarly thesis. An oral thesis defense/examination is required. This option is intended for students with strong research interests who may desire to pursue further graduate studies towards a Ph.D. degree.

THE DOCTOR OF PHILOSOPHY IN MECHANICAL ENGINEERING

Program Description

The Ph.D. degree program in Mechanical Engineering provides both doctoral-level instruction and independent research opportunities for students. The Ph.D. degree is the highest academic degree offered, and graduates typically are employed in research environments in government laboratories and industries, and as University faculty.

The Ph.D. degree program is highly individualistic in nature, and the student is expected to make a significant contribution to the reservoir of human knowledge by investigating a significant topic within the domain of mechanical engineering. The Ph.D. student must rely heavily on the guidance of the academic advisor and on the academic committee in formulating a plan of work, in setting and meeting the degree goals, and in selecting a dissertation problem. The academic advisor serves to guide the student during the dissertation study phase of the program.

For details concerning admission requirements, see Admission and Other Information elsewhere in this catalog.

Ph.D. Program Policies and Requirements

The doctorate symbolizes the ability of the recipient to undertake original research and scholarly work of the highest levels without supervision. The degree is therefore not granted simply upon completion of a stated amount of course work but rather upon demonstration by the student of a comprehensive knowledge and high attainment in scholarship in a specialized field of study. As a guide however, the student is expected generally to have completed at least twenty-four (24) course credits beyond the master's degree and a minimum of twelve (12) dissertation credits. The student must demonstrate both the attainment of scholarship and independent study in a specialized field of study by writing a dissertation reporting the results of an original investigation. The student must pass a series of comprehensive examinations in the field of specialization and related areas of knowledge and defend successfully the quality, methodology, findings, and significance of the dissertation.

Advisory Committee and Plan of Graduate Work

An advisory committee of at least four graduate faculty members, one of whom will be designated as chair, will be appointed by the Dean of the School of Graduate Studies upon the recommendation of the Chairperson of the department. The committee, which must include at least one representative of the minor field, will, with the student, prepare a Plan of Graduate

Study which must be approved by the department and the School of Graduate Studies. In addition to the course work to be undertaken, the subject of the student's dissertation must appear on the plan; any subsequent changes in committee or subject or in the overall plan must be submitted for approval as with the original plan.

The program of study must be unified, and all constituent parts must contribute to an organized program of study and research. Courses must be selected from groups embracing one principal subject of concentration, the major, and from a cognate field, the minor. Normally, a student will select the minor work from a single discipline or field. If the advisory committee finds that the needs of the student will be best served by work in an interdisciplinary minor, it has the alternative of developing a special program in lieu of the usual minor.

Other Information

See "Requirements for the Doctor of Philosophy Degree" elsewhere in this catalog for information related to residence requirements, qualifying examination, preliminary examination, comprehensive examination, final oral examination, admission to candidacy, and time limit. Students should also consult the department handbook for more details.

The Dissertation

The doctoral dissertation presents the results of the student's original investigation in the field of major interest. It must be a contribution to knowledge, be adequately supported by data and be written in a manner consistent with the highest standards of scholarship. Publication is expected.

The dissertation will be reviewed by all members of the advisory committee and must receive their approval prior to submission to the School of Graduate Studies. Three copies of the document signed by all members of the student's advisory committee must be submitted to the School of Graduate Studies by a specified deadline in the semester or summer session in which the degree is to be conferred. Prior to final approval, the dissertation will be reviewed by the School of Graduate Studies to ensure that the format conforms to its specifications.

The University has a requirement that all doctoral dissertations be microfilmed by University Microfilms International of Ann Arbor, Michigan, which includes publication of the abstract in Dissertation Abstracts International. The student is required to pay for the microfilming service.

INTEGRATED MS/PH.D. PROGRAM

The Integrated MS/Ph.D. program is to attract outstanding and motivated students into the Ph.D. program. A student with a BSME degree from an ABET accredited program with superior credentials (high GPA, high GRE scores, and strong reference letters) may be admitted to this program. Students in this program are admitted to the Ph.D. program on a provisional basis, but will not be formally admitted to the Ph.D. program until completion of the requirements for a master's degree. The admission is therefore a dual admission such that students are accepted into master's program unconditionally to pursue a MS degree and accepted into Ph.D. program provisionally at the same time.

A student in this program must complete his/her MSME degree (thesis option) within 24 months with a minimum GPA of 3.5 and must pass the Ph.D. qualifier exam within this time frame to qualify for the unconditional admission to the Ph.D. program. Students who fail the qualifier exam will be dismissed from the Ph.D. program.

Up to two (2) Ph.D. level courses in the MEEN curriculum may be "double counted" to satisfy both requirements of the MS degree and the Ph.D. degree for students in this program. These courses should be at MEEN 800 level and a grade of "B" or better is required for the course to be counted toward both degrees.

MECHANICAL ENGINEERING COURSE SUMMARY

Course	Title
MEEN 602	Advanced Strength of Materials
MEEN 604	Intermediate Dynamics
MEEN 606	Mechanical Vibrations

MEEN 608	Experimental Stress Analysis
MEEN 610	Theory of Elasticity
MEEN 613	Composite Materials
MEEN 614	Mechanics of Engineering Modeling
MEEN 618	Numerical Analysis for Engineers
MEEN 626	Advanced Fluid Dynamics
MEEN 642	Materials Joining
MEEN 645	Aluminum Product Design and Manufacturing
MEEN 646	Advanced Manufacturing Processes
MEEN 647	Computer Integrated Mechanism Design
MEEN 649	Design of Robot Manipulators
MEEN 650	Mechanical Properties and Structure of Solids
MEEN 651	Aero Vehicle Structures II
MEEN 652	Aero Vehicle Stability and Control
MEEN 653	Aero Vehicle Flight Dynamics
MEEN 654	Advanced Propulsion
MEEN 655	Computational Fluid Dynamics
MEEN 656	Boundary Layer Theory
MEEN 657	Design of Thermal Systems
MEEN 660	Selected Topics in Engineering
MEEN 663	Energy Conversion Systems Design
MEEN 667	Environmental Control
MEEN 668	Gas Dynamics
MEEN 670	Internal Combustion Engines
MEEN 671	Turbo machinery
MEEN 675	Solar Energy Fundamentals and Design
MEEN 702	Continuum Mechanics
MEEN 706	Theory of Vibrations
MEEN 707	Real Time Analysis of Dynamic Systems
MEEN 716	Finite Element Methods
MEEN 719	Advanced ComputerAided Design
MEEN 731	Conduction Heat Transfer
MEEN 732	Convection Heat Transfer
MEEN 733	Radiation Heat Transfer
MEEN 742	Tools, Jigs, and Fixtures
MEEN 743	Instrumentation
MEEN 785	Special Topics
MEEN 792	Master’s Seminar
MEEN 796	Master’s Project
MEEN 793	Master’s Supervised Teaching
MEEN 794	Master’s Supervised Research
MEEN 797	Master’s Thesis
MEEN 804	Advanced Dynamics
MEEN 808	Energy Methods in Applied Mechanics
MEEN 810	Advanced Theory of Elasticity
MEEN 813	Composite Structures
MEEN 814	Mathematical Theory of Plasticity
MEEN 820	Advanced Classical Thermodynamics
MEEN 822	Statistical Thermodynamics
MEEN 824	Irreversible Thermodynamics
MEEN 834	Special Topics in Applied Heat Transfer
MEEN 838	Solar Thermal Energy Systems
MEEN 840	Machine Tool Design
MEEN 846	Stochastic Modeling of Mechanical Systems
MEEN 847	Computational Engineering Dynamics
MEEN 848	Digital Control of Machines and Processes
MEEN 849	Computer Control of Robot Manipulators
MEEN 850	Phase Equilibria
MEEN 858	Mechanical Metallurgy

MEEN 860	Fracture Mechanics
MEEN 885	Special Topics
MEEN 992	Doctoral Seminar
MEEN 993	Doctoral Supervised Teaching
MEEN 994	Doctoral Supervised Research
MEEN 995	Doctoral Preliminary Examination
MEEN 997	Doctoral Dissertation
MEEN 999	Continuation of Thesis/Dissertation for Mechanical Engineering

MECHANICAL ENGINEERING COURSE DESCRIPTIONS

MEEN-602. Advanced Strength of Materials **Credit 3 (3-0)**
This course covers stress-strain relations as applied to statically indeterminate structures, bending in curved bars, plates, shells, and beams on elastic foundations. Topics include: strain energy concepts for formulation of flexibility matrix on finite elements, bending in beams and plates, Cartesian tensor notation, and matrix structural analysis. Prerequisites: MEEN 336, MATH 432 or equivalent.

MEEN-604. Intermediate Dynamics **Credit 3 (3-0)**
This course reviews particle and system dynamics, and introduces rigid body dynamics with solution techniques for the non-linear systems of ordinary differential equations as initial value problems. Other topics covered include: angular and linear momentum, energy and Langrangian methods of body problems, generalized variables, small vibrations, and gyroscopic effects and stability. Prerequisites: MEEN 337, MATH 432 or equivalent.

MEEN 606. Mechanical Vibrations **Credit 3(3-0)**
This is a course in modeling, analysis and simulation of free and forced vibrations of damped and undamped, single and multi-degree of freedom systems. Prerequisites: MEEN 440 and MATH 431.

MEEN-608. Experimental Stress Analysis **Credit 3 (3-0)**
Principles and methods of experimental stress analysis are covered in this course. Photo-elastic and micromeasurement techniques applied to structural models are also addressed. Prerequisites: AREN 457 or MEEN 602 or equivalent.

MEEN-610. Theory of Elasticity **Credit 3 (3-0)**
This course introduces stress, strain-strain relations, energy principles, and other related topics. Prerequisites: MATH 432, MEEN 336 or equivalent.

MEEN-613. Composite Materials **Credit 3 (2-2)**
This course introduces the processing of fiber-reinforced composite materials, anisotropic theory, and test methods for composites. Topics include different methods of processing polymeric composites, process control parameters, anisotropic constitutive equations, classes of anisotropy and associated elastic constants, micromechanics models, theories of failure, test methods, classical laminate theory, and special types of laminates. The concepts are applied to the design of simple composite structural components. This course includes a laboratory component for students to learn processing and testing of composite materials. Prerequisites: MEEN 260 and MEEN 336 or their equivalents.

MEEN-614. Mechanics of Engineering Modeling **Credit 3 (3-0)**
This is a course in engineering modeling techniques including time dependent integration simulation models of systems, and finite difference and finite element methods in mechanics. Prerequisites: MEEN 210, MEEN 336, MATH 432 or equivalent.

MEEN-618. Numerical Analysis for Engineers **Credit 3 (3-0)**
This course is a study of scientific programming, error analysis, matrix algebra, eigenvalue problems, curve-fitting approximations, interpolation, numerical differentiation and integration, solutions to simultaneous equations, and numerical solutions of differential equations. Prerequisite: MEEN 210 or equivalent.

MEEN-626. Advanced Fluid Dynamics **Credit 3 (3-0)**
This course presents an overview of Navier-Stokes Equations, continuity equation, energy equation, inviscid flow, potential theory, complex potentials, and conformal mapping. Prerequisite: MEEN 416 or equivalent.

MEEN-642. Materials Joining **Credit 3 (3-0)**
This course covers theories and applications of joining of metals, ceramics, and plastics by the standard industrial techniques: arc, gas, electron beam, laser, ultrasonic, and diffusion bonding. Additional topics covered include: phase diagrams, diffusion equations, and physical/chemical properties in joining considerations. Prerequisites: MEEN 446 and MATH 432 or equivalent.

MEEN-645. Aluminum Product Design and Manufacturing **Credit 3 (3-0)**
This course introduces students to the principles of product and manufacturing process design specifically applicable to aluminum-based materials. Material properties of aluminum are compared with those of other commercial materials. Raw material fabrication and product manufacturing processes are presented. The interactions between processes and material properties are described. Case studies are presented to guide the student in successful completion of design projects. Prerequisites: MEEN 260 and MEEN 474.

MEEN-646. Advanced Manufacturing Processes **Credit 3 (3-0)**
Theory, application, and design considerations for forming and machining are covered in this course. Additional topics covered include: machines and tooling in modern manufacturing processes, dimensional and tolerance analysis, and control of work piece and tool. Design projects of molds, dies, presses, jigs and fixtures or automated machinery are required. Prerequisites: MEEN 446, MEEN 474, MATH 231, or equivalent.

MEEN-647. Computer Integrated Mechanism Design **Credit 3 (3-0)**
This is a course in modern computer simulation tools and the underlying theories for synthesis and analysis of mechanical systems consisting of linkages, cams, and gears. Prerequisite: MEEN 440.

MEEN-648. Computer Controlled Manufacturing **Credit 3 (3-0)**
This course introduces students to computer integrated manufacturing, numerical control and group technology. Topics include: manufacturing process interfacing, discrete process modeling, analysis and control techniques and algorithms, characteristics and software of control computers, sensors for computer control, programmable controllers, and sequential control. Prerequisites: MEEN 446, MATH 331, or consent of the instructor.

MEEN-649. Design of Robot Manipulators **Credit 3 (3-0)**
This course covers fundamentals of kinematics, dynamics, computer graphics, sensing devices, measurements and control in robot manipulators. Prerequisites: MEEN 440 or equivalent.

MEEN-650. Mechanical Properties and Structure of Solids **Credit 3 (3-0)**
This course examines the elastic and plastic behavior of matter in relation to its structure, both macroscopic and microscopic. Major representative classes of materials to be examined are thermoplastic materials, elastomers, glasses, ceramics, metals, and composites. Prerequisite: MEEN 460 or equivalent.

MEEN-651. Aero Vehicle Structures II **Credit 3 (3-0)**
This course covers deflection of structures, indeterminate structures, fatigue analysis, and minimum weight design. Finite element methods and software are utilized. Prerequisite: MEEN 336 and MEEN 474..

MEEN-652. Aero Vehicle Stability and Control **Credit 3 (3-0)**
This course covers longitudinal, directional, and lateral static stability and control of aerospace vehicles. It also covers linearized dynamics analysis of the motion of a six degree-of-freedom flight vehicle in response to control inputs and disturbance through the use of the transfer function concept, plus control of static and dynamics behavior by vehicle design (stability derivatives)

and/or flight control systems. Prerequisites: MEEN 415, MEEN 422, and ELEN 410.

MEEN-653. Aero Vehicle Flight Dynamics **Credit 3 (3-0)**
This course covers the basic dynamics of aerospace flight vehicles including orbital mechanics, interplanetary and ballistic trajectories, powered flight maneuvers and spacecraft stabilization. Prerequisites: MATH 432, MEEN 337, and MEEN 422.

MEEN-654. Advanced Propulsion **Credit 3 (3-0)**
This course is a second course in propulsion. It covers the analysis and design of individual components and complete air-breathing propulsion systems including turbo fans, turbo jets, ram jets, and chemical rockets. Prerequisite: MEEN 576.

MEEN-655. Computational Fluid Dynamics **Credit 3 (3-0)**
This course provides an introduction to numerical methods for solving the exact equations of fluid dynamics. Finite difference methods are emphasized as applied to viscous and inviscid flows over bodies. Students are introduced to a modern computational fluid dynamics computer code. Prerequisites: MATH 432 and MEEN 415 or MEEN 416.

MEEN-656. Boundary Layer Theory **Credit 3 (3-0)**
This course covers the fundamental laws governing flow of viscous fluids over solid boundaries. Exact and approximate solutions are studied for various cases of boundary layer flow including laminar, transitional and turbulent flow. Prerequisite: MEEN 415 or 416.

MEEN-657. Design of Thermal Systems **Credit 3 (3-0)**
This is a course in the selection of components for fluid and energy processing systems to meet system performance requirements. Computer-aided thermal design, simulation and optimization techniques, and investment economics are discussed. Design projects are assigned to demonstrate application of these topics. Prerequisites: MEEN 562 and INEN 260.

MEEN-660. Selected Topics in Engineering **Credit 3 (3-0)**
This course consists of selected mechanical engineering topics of interest to students and faculty. The topics will be selected before the beginning of the course and will be pertinent to the programs of the students enrolled. Prerequisite: Consent of instructor.

MEEN 663. Energy Conversion Systems Design **Credit 3 (3-0)**
This course covers the design of steam power systems, internal combustion power systems, refrigeration and heat pump systems, and an overview of direct energy conversion devices. Power system design projects are assigned. Prerequisites: MEEN 416 and MEEN 442.

MEEN 667. Environmental Control **Credit 3 (3-0)**
This course deals with the principles of heating and air conditioning and their applications to design of environmental control systems and determination of building heating and cooling loads. Principal equipment, layout and control are discussed for various types of systems. Prerequisites: MEEN 442 and MEEN 562.

MEEN 668. Gas Dynamics **Credit 3 (3-0)**
The course covers the principles of one-dimensional compressible fluid flow, normal shocks, and flow with friction, heating, and cooling. Two-dimensional flows are also introduced. Prerequisites: MEEN 415 or MEEN 416 and MEEN 441.

MEEN 670. Internal Combustion Engines **Credit 3 (3-0)**
This course deals with the fundamental principles of spark-ignition and compression ignition engines, combustion phenomena, the effect of fuel-air mixture, design of components of an internal combustion engine, and testing and performance curves. Design projects are assigned. Prerequisite: MEEN 442.

MEEN 671. Turbomachinery **Credit 3 (3-0)**
This course covers the application of the cascade method to turbomachines, impulse and reaction turbines, compressible fluid dynamics, gas turbine principles, pumps, compressors and blowers, and the design of turbine elements. Project work is assigned. Prerequisites: MEEN 415 or MEEN 416 and MEEN 442.

MEEN 675. Solar Energy Fundamentals and Design **Credit 3 (3-0)**
This course deals with the characterization of solar radiation at the earth's surface. Solar collectors of both flat and concentrating types, and storage and distribution systems are discussed and analyzed. System sizing, design and economic analysis for space heating, water heating and industrial process are covered. Prerequisite: MEEN 562.

MEEN-702. Continuum Mechanics **Credit 3 (3-0)**
This course covers the applications of the laws of mechanics and thermodynamics to the continuum. Topics include a rigorous development of the general equations applied to a continuum and the application and reduction of the general equations for specific cases of both solids and fluids. Prerequisite: MEEN 336 or equivalent.

MEEN-706. Theory of Vibrations **Credit 3 (3-0)**
Vibration analysis of systems with one-, two- or multi-degrees of freedom are introduced in this course. Topics include instrumentation, continuous systems, and computer techniques. Prerequisites: MEEN 440, MATH 432, and MEEN 606.

MEEN-707. Real Time Analysis of Dynamic Systems **Credit 3 (3-0)**
This course covers the theory and application of real time analysis (RTA) used in system identification and machinery fault detection. RTAapplications in production engineering and product development are addressed to study short-lived events or to analyze system operation in time domain or frequency domain to identify system characteristics or possible problems. Prerequisite: Consent of instructor.

MEEN-716. Finite Element Methods **Credit 3 (3-0)**
This course covers fundamental concepts of the finite element method for linear stress and deformation analysis of mechanical components. Topics include the development of truss, beam, frame, plane stress, plane strain, axisymmetric isoparametric, solid, thermal, and fluid elements. ANSYS and NASTRAN software will be used for solving practical stress analysis problems. Prerequisite: Consent of instructor.

MEEN-719. Advanced Computer-Aided Design **Credit 3 (3-0)**
This course covers important methods and techniques for using the computer to aid the design process. Simulation and optimization methods are applied to the design of mechanical systems. Prerequisite: Consent of instructor.

MEEN-731. Conduction Heat Transfer **Credit 3 (3-0)**
This course presents the development of the general heat conduction equation and its applications to one-, two-, and three-dimensional steady and unsteady boundary value problems. Closed form and numerical solution techniques are addressed. Prerequisite: MEEN 562 or equivalent.

MEEN-732. Convection Heat Transfer **Credit 3 (3-0)**
This course presents the analysis of heat convection in laminar and turbulent boundary layer and pipe flow. Topics include: dimensional analysis, free convection, condensation, and boiling. Prerequisite: MEEN 562 or equivalent.

MEEN-733. Radiation Heat Transfer **Credit 3 (3-0)**
A comprehensive treatment of basic theories is reviewed in this course. Topics include: radiation characteristics of surfaces, radiation properties taking account of wave length and direction, and analysis of radiation exchange between idealized and real surfaces. The course also addresses fundamentals of radiation transfer in absorbing, emitting, and scattering media. The interaction of radiation with conduction and convection is discussed. Prerequisite: MEEN 562

or equivalent.

MEEN-742. Tools, Jigs, and Fixtures **Credit 3 (3-0)**
This course covers tool design methods, tool-making practices, tool materials and heat treatments, and plastics for tool materials. Additional topics include: design of cutting tools for N/C machine tools, design of size and fixture, basics of clamping, and chucking and indexing for various machining processes. Prerequisites: MEEN 460, MATH 432 or equivalent.

MEEN-743. Instrumentation **Credit 3 (3-0)**
Principles and practices of industrial measurement are presented in this course. Topics include: instrument dynamics and response characteristics; theory of transducers for temperature, pressure, flow, motion, force; and other physical phenomena. Special topics in instrumentation, data acquisition and data reduction are covered. A project is assigned in an instrumentation application. Prerequisites: Consent of instructor.

MEEN-785. Special Topics **Credit 3 (3-0)**
This course is designed to allow the introduction of potential new courses on a trial basis or special content courses on a once only basis at the Master's level. The topic of the course and title are determined prior to registration. Prerequisite: Consent of instructor.

MEEN-792. Master's Seminar **Credit 1 (1-0)**
This course provides a forum for discussions and reports of subjects in mechanical engineering and allied fields. Prerequisite: Master's level standing.

MEEN-793. Master's Supervised Teaching **Credit 3 (3-0)**
Students will gain teaching experience under the mentorship of faculty who assist the student in planning for the teaching assignment, observe and provide feedback to the student during the teaching assignment, and evaluate the student upon completion of the assignment. Prerequisite: Master's level standing.

MEEN-794. Master's Supervised Research **Credit 3 (3-0)**
This course is supervised research under the mentorship of a faculty member. It is not intended to serve as the project nor thesis topic of the master's student. Prerequisite: Consent of instructor.

MEEN-796. Master's Project **Credit 3 (3-0)**
The student will conduct advanced research of interest to the student and the instructor. A written proposal, which outlines the nature of the project must be submitted for approval. This course is only available to project option students. Prerequisite: Master's level standing.

MEEN-797. Master's Thesis **Credit 3 (3-0)**
Master of Science thesis research will be conducted under the supervision of the thesis committee chairperson leading to the completion of the Master's thesis. This course is only available to thesis option students. Prerequisite: Consent of advisor.

MEEN-799 - Continuation of Master's Thesis/Project **Credit 1 (1-0)**
This course is for master's students who have completed all required credit hour requirements. Prerequisite: Completion of all course work and thesis/project Credits.

MEEN-804. Advanced Dynamics **Credit 3 (3-0)**
This course covers Lagrange's equations of motion as applied to rigid body dynamics. Topics include: generalized coordinates, generalized conservative and dissipative forces, degrees of freedom, holonomic constraints as related to rigid body motion, calculus of variations, and Hamilton's equations of motion. Prerequisite: MEEN 604 or equivalent.

MEEN-808. Energy Methods in Applied Mechanics **Credit 3 (3-0)**
The use of energy methods in solving applied mechanics problems is presented in this course. Applications in beams and frames, deformable bodies, plates and shells, and buckling are

addressed. Variational methods are also discussed. Prerequisite: MEEN 610 or equivalent.

MEEN-810. Advanced Theory of Elasticity **Credit 3 (3-0)**
This is a course in strains, stresses, and the equations of elasticity. Topics include general formulation of the 2-D boundary value problems and the formulation of certain three-dimensional problems with symmetry. Prerequisite: MEEN 610 or equivalent.

MEEN-813. Composite Structures **Credit 3 (3-0)**
This course focuses on the application of composite materials to the design and analysis of structures. The topics covered are two- and three-dimensional hydrothermal anisotropic elastic constitutive equations; classical laminate theory; static stress, vibration, and buckling analysis of laminated beams and plates; environmental effects; and fatigue and fracture of laminated composites. Prerequisite: MEEN 613 or equivalent.

MEEN-814. Mathematical Theory of Plasticity **Credit 3 (3-0)**
This course covers stress and strain tensors, transformations and equilibrium, and elastic behavior. Topics include: theories of strength, plastic stress/strain, classical problems of plasticity, including thick-walled pressure vessels and rotating cylinders in elastic-plastic conditions, and slip line theory with applications. Prerequisite: MEEN 610 or equivalent.

MEEN-820. Advanced Classical Thermodynamics **Credit 3 (3-0)**
This course covers conditions of equilibrium, processes and thermodynamic systems, first and second order phase transitions, and Nernst Postulate. Prerequisite: MEEN 442 or equivalent.

MEEN 822. Statistical Thermodynamics **Credit 3 (3-0)**
Statistical mechanics and macroscopic properties from statistical methods are presented in this course. Topics include: equilibrium information, generalized coordinates, and general variables. Prerequisite: MEEN 442 or equivalent.

MEEN-824. Irreversible Thermodynamics **Credit 3 (3-0)**
This course is a study of processes which are inherently entropy producing. Topics include: development of general equations for the theory of minimum rate of entropy production, mechanical processes, life processes, and astronomical processes. Prerequisite: MEEN 820 or equivalent.

MEEN-834. Special Topics in Applied Heat Transfer **Credit 3 (3-0)**
Selected special topics in applied heat transfer are presented in this course. Topics include: heat exchanger design and performance, cooling of electronic equipment, and advanced thermal insulation systems. Prerequisite: MEEN 562 or equivalent.

MEEN-838. Solar Thermal Energy Systems **Credit 3 (3-0)**
Characteristics of extraterrestrial and terrestrial solar radiation transfer are presented in this course. Topics include: analysis of thermal performance of concentrating and non-concentrating solar collectors, thermal energy storage systems and energy transport systems, and life cycle cost analysis of solar energy systems. Computer simulation software is introduced. Prerequisites: MEEN 731 and MEEN 732 or equivalent.

MEEN-840. Machine Tool Design **Credit 3 (3-0)**
This course presents general features and requirements of machine tools and design principles. Topics include: static and dynamic stiffness and rigidity, cutting forces, machine tool vibrations, stability against chatter, damping and dampers, transmission of motion, and standardization of speed change gears. This course will cover the design of constructional elements: bearings, electrical components, pneumatics, hydraulics, material selection, and main spindle layouts. Prerequisites: MEEN 565 and MEEN 646 or equivalent.

MEEN-846. Stochastic Modeling of Mechanical Systems **Credit 3 (3-0)**
This course introduces an engineering approach to the analysis of time series and discrete linear transfer function models. Applications include the analysis of experimental data for system modeling, identification, forecasting, and control. Prerequisite: Consent of instructor.

MEEN-847. Computational Engineering Dynamics **Credit 3 (3-0)**
This course introduces computer-oriented methods for the analysis and design of engineering dynamic systems. Topics include: analytical and experimental techniques for model development, design refinement of components in flexible dynamics systems (machine tools, robots, moving vehicles, etc), and optimization techniques for transient response analysis on both constrained and unconstrained systems. Prerequisite: Consent of instructor.

MEEN-848. Digital Control of Machines and Processes **Credit 3 (3-0)**
This course covers control algorithms and design of discrete controllers. Interfaces and command generation for machines and process control are treated. Applications in numerically controlled machines and industrial robots are covered. Prerequisite: MEEN 648.

MEEN-849. Computer Control of Robot Manipulators **Credit 3 (3-0)**
This course covers basic and adaptive robot control systems, sensory requirements and capabilities, and robotic system diagnosis and applications. Prerequisite: MEEN 649 or Consent of instructor.

MEEN-850. Phase Equilibria **Credit 3 (3-0)**
This course presents interpretation and mathematical analysis of unary, binary and ternary, inorganic, phase equilibria systems with examples for solving practical materials science problems. Topics include: isoplethal and isothermal sections, crystallization paths, and thermodynamic fundamentals. Prerequisite: Consent of instructor.

MEEN-858. Mechanical Metallurgy **Credit 3 (3-0)**
This course covers continuum mechanics and the microscopic basis of plastic behavior. Emphasis is on the development and use of dislocation theory. Prerequisite: Consent of instructor.

MEEN-860. Fracture Mechanics **Credit 3 (3-0)**
This course introduces the student to the concept of stress and strain singularities and their effect on fracture strength and fatigue life of isotropic and anisotropic materials. Topics covered include: computation of the stress-strain field around a crack-tip, stress-intensity-factor, strain energy release rate, J-integral, fracture toughness, residual strength, and fatigue crack propagation life. The course concepts are applied to the design of damage tolerant structures. Prerequisite: MEEN-460 or equivalent.

MEEN-885. Special Topics **Credit 3 (3-0)**
This course is designed to allow the introduction of potential new courses on a trial basis or special content courses on a once only basis at the doctorate level. The topic of the course and title are determined prior to registration. Prerequisite: Consent of instructor.

MEEN-992. Doctoral Seminar **Credit 1 (1-0)**
In this course, doctoral students attend colloquia or seminars. They consist of presentations by doctoral students on dissertation topics and works-in-progress and by guests on important classical, contemporary, or research problems in mechanical engineering. Prerequisite: Doctoral level standing.

MEEN-993. Doctoral Supervised Teaching **Credit 3 (3-0)**
This course is designed to introduce the doctoral student to classroom or laboratory teaching under the supervision of a faculty mentor. Doctoral students who serve as teaching assistants or as instructors are required to take this course during the first semester they teach. Others planning to undertake a teaching career are also strongly encouraged to take it. Topics covered include: course planning, classroom teaching, lecture preparation, student evaluation, and grading. The supervisor(s) will observe and provide feedback to the student and evaluate the student's performance. Prerequisite: Doctoral level standing.

MEEN-994. Doctoral Supervised Research **Credit 3 (3-0)**
This is supervised research under the mentorship of a member of the graduate faculty. It is not intended to serve as the dissertation topic of the doctoral student. Prerequisite: Consent of

instructor.

MEEN-995. Doctoral Preliminary Examination **Credit 3 (3-0)**
This is required of students who have completed the qualifier examination and who are taking the preliminary examination during the semester. This is a supervised program to help prepare the student for the preliminary examination under the mentorship of the academic advisor. Prerequisite: Must have passed Doctoral Qualifier Exam.

MEEN-997. Doctoral Dissertation **Credit 3 (3-0)**
This supervised research serves as the dissertation of the doctoral student. Twelve credits of dissertation are required for graduation. Prerequisites: Doctoral standing and consent of advisor.

MEEN-999. Continuation of Dissertation for Mechanical Engineering **Credit 1 (1-0)**
The course is for master's and doctoral students who have completed all required credit hour requirements. Prerequisite: Completion of all Thesis/Dissertation Credits.

Directory of Faculty

Suresh Chandra, B.S., Banaras Hindu University; M.S., University of Louisville; Ph.D., Colorado State University; Research Professor

William J. Craft, P.E.; B.S., North Carolina State University; M.S. & Ph.D., Clemson University; NIA Liaison Professor and Interim Dean of Graduate School

John Kizito **……** Assistant Professor
B.S., Makerere University, Uganda, M.S, Ph.D., Case Western Reserve University

Dhananjay Kumar……Assistant Professor and ORNL Joint Faculty
B.S., Bhagalpur University; M.S., Magadh University,
Ph.D., Indian Institute of Technology

DeRome O. Dunn, B.S., M.S., North Carolina A&T State University; Ph.D., Virginia Polytechnic Institute and State University; Associate Professor

Frederick Ferguson, M.S., Kharkov State University; Ph.D., University of Maryland; Professor and Director of NASA/CAR

George J. Filatovs, B.S., Washington University; Ph.D., University of Missouri at Rolla; Professor

Samuel P. Owusu-Ofori, P.E.; B.S., University of Science and Technology - Kumasi, Ghana; M.S., Bradley University; Ph.D., University of Wisconsin at Madison; Boeing Professor of Manufacturing

Devdas M. Pai, P.E.; B.S., Indian Institute of Technology, Madras; M.S., Ph.D., Arizona State University; Professor

Messiha Saad, M.S. North Carolina A&T State University; PhD., North Carolina State University, Assistant Professor

Japannathan Sankar, B.E., University of Madras; M.E., Concordia University; Ph.D., Lehigh University; Professor and Director of CAMSS

K. N. Shivakumar; B.E., Bangalore University; M.E., Ph.D., Indian Institute of Science; Research Professor and Director for CCMR

Mannur Sundaresan, PhD., Virginia Polytechnic Institute and State University, Associate Professor and Graduate Program Coordinator

Leonard C. Uitenham, B.S., M.S., Ph.D., Case Western Reserve University; Professor and Chairperson.

Shih-Liang Wang, P.E.; B.S., National Tsing Hua University; M.S., Ph.D., Ohio State University; Professor

Cindy Waters ……Adjunct Associate Professor
B.S., M.S., Virginia Tech, Ph.D., NC A&T State University.