Commonwealth Graduate Engineering Program (CGEP)

The University of Virginia (UVa), Virginia Polytechnic Institute and State University (VaTech), and Old Dominion University (ODU), Virginia Commonwealth University (VCU), and George Mason University (GMU), deliver graduate engineering distance learning courses to areas in the Commonwealth of Virginia, as well as some out-of-state sites. The primary intent of the program is to provide engineers and other qualified individuals with strong backgrounds in the sciences an opportunity to pursue a program in graduate studies leading to a master's degree in engineering. This effort is in response to one of the State Council of Higher Education's objectives to expand technical education opportunities for Virginians.

UVa courses are taught live in Charlottesville in the late afternoon or early evening and broadcast simultaneously via ATM or ISDN lines to special sites. Two-way video and audio communication is maintained during the lectures so that the remote students have direct interaction with the classroom. It should be noted that on-grounds students at the University of Virginia also take these courses in the studio classroom as they are delivered to the off-site campuses. The Master of Engineering degree requires 30 credit hours (10 courses). All required courses are available by videoconferencing or other distance learning methods. Courses may also be taken on a non-degree, continuing education basis.

DEGREE PROGRAMS AND COURSES OFFERED

Chemical

This graduate program in chemical engineering will prepare individuals for advanced work in the chemical, plastics, petroleum and pharmaceutical industries, as well as for many other industrial and government positions. A program of studies leading to the Master of Engineering (M.E.) degree usually consists of five "core" courses; i.e., ChE 625, 665, 630, 618, and 615. Elective courses offered include applied surface chemistry, polymer engineering, and biochemical engineering. Courses in related areas may be transferred from other universities. Such courses could be in the areas of mathematics, chemistry, materials science, mechanical engineering, nuclear engineering and systems engineering.

ChE 615 - ADVANCED THERMODYNAMICS
Development of the thermodynamic laws and derived relations. The application of the relations to the properties of single and multi-component systems at equilibrium in the gaseous, liquid, and solid states. Emphasis is placed on the prediction and calculation of phase and reaction equilibrium conditions in practical systems.

ChE 618 - CHEMICAL REACTION ENGINEERING
Fundamentals of chemical reaction kinetics and mechanisms, with particular emphasis on heterogeneous catalysis. Application of chemical kinetics, along with mass-transfer and heat-transfer theory, fluid mechanics, and thermodynamics, to the design and operation of chemical reactors.

ChE 625 - TRANSPORT PROCESSES
Integrated introduction to fluid mechanics, heat transfer, and mass transfer. Development of the basic equations of change for transport of momentum, energy, and mass in continuous media. Applications with exact solutions, consistent approaches to limiting cases and approximate solutions to formulate the relations to be solved in the more complicated problems.

ChE 630 - MASS TRANSFER
Fundamental principles common to mass transfer phenomena, with emphasis on treating the influence of mass transfer in a wide variety of situations arising in chemical engineering. Detailed consideration of fluxes, diffusion with and without convection, interphase mass transfer with chemical reaction, and applications.

ChE 642 - APPLIED SURFACE CHEMISTRY
Factors underlying interfacial phenomena, with emphasis on applications to areas such as emulsification, foaming, detergency, nucleation, wetting, adhesion, flotation, adsorption, heterogeneous catalysis, and electrical effects.

ChE 647 - BIOCHEMICAL ENGINEERING
Introduction to properties, production, and use of biological molecules of importance to medicine and industry, such as proteins, enzymes, and antibiotics. Topics may include fermentation and cell culture processes, biological mass transfer, enzyme engineering, purification techniques, and implications of recent advances in molecular biology, genomics, and proteomics.

ChE 649 - POLYMER CHEMISTRY AND ENGINEERING
Analyzes the mechanisms and kinetics of various polymerization reactions; relations between the molecular structure and polymer properties, and the influence of polymerization processing; fundamental concepts of polymer solution and melt rheology; and application of these principles and heat and mass transfer to polymer processing operations such as extrusion, molding and fiber spinning.

ChE 665 - TECHNIQUES FOR CHEMICAL ENGINEERING ANALYSIS AND DESIGN
Methods for analysis of steady state and transient chemical engineering problems arising in fluid mechanics, heat transfer, mass transfer, kinetics, and reactor design.

ChE 881/BIOM 695 – BIOMEDICAL NANOTECHNOLOGY
This course has been designed to meet the needs of engineering or science graduate level students who are currently working or want to work in the area of applications of nanostructures for Medicine. This course will provide the students with an introduction to the major areas in the bio-medical sectors significantly influenced by the developments in nanotechnology giving emphasis to drug delivery and prosthesis & implant areas. This online course will engage the students in a collaborative process to explore and understand latest avenues in biomedical nanotechnology. The knowledge will facilitate their ability to engage in research and study the technical literature in those fields. Pre: The proposed advanced multidisciplinary graduate level course is designed for graduate standing students in the school of engineering or school of sciences with advanced materials, engineering and biology knowledge. Students who do not satisfy the above requirements need to consult the instructor directly.

Civil

The extended graduate education program of the Civil Engineering & Applied Mechanics Department at the University of Virginia leads toward the Master of Engineering (ME) degree with an emphasis in structural mechanics and/or structural design. Typically, the University of Virginia requires that certain courses be included in programs for students pursuing Master's degrees, including differential equations, advanced mechanics of materials, finite element analysis, structural design, and structural mechanics. Students in the degree program will work with an advisor to develop a mutually agreeable plan of study.

CE 601 - ADVANCED MECHANICS OF MATERIALS
Reviews basic stress-strain concepts; constitutive relations. Studies unsymmetrical bending, shear center, and shear flow. Analyzes curved flexural members, beams on elastic foundation, torsion, bending, and twisting of thin walled sections.

CE 602 - CONTINUUM MECHANICS WITH APPLICATIONS
Introduces continuum mechanics and mechanics of deformable solids. Vectors and cartesian tensors, stress, strain, deformation, equations of motion, constitutive laws, introduction to elasticity, thermal elasticity, viscoelasticity, plasticity, and fluids. (Prerequisite: Instructor permission)

CE 604 - PLATES AND SHELLS
Includes the classical analysis of plates and shells of various shapes; closed-form numerical and approximate methods of solution of governing partial differential equations; and advanced topics (large deflection theory, thermal stresses, orthotropic plates).

CE 610 – CONCRETE MATERIALS
This course covers basic properties of hydraulic cements and mineral aggregates and their interactions in concrete as well as properties of plastic and hardened concrete. Modifications through admixtures; concrete test methods and behavior under various loads and durability of concrete as well as performance of concrete are also covered. Production, handling, and placement problems; lightweight, heavyweight, and other special concretes topics are discussed.

CE 612 - ELASTICITY
Review of the concepts of stress, strain, equilibrium, compatibility; Hooke's law (isotropic materials); displacement and stress formulations of elasticity problems; plane stress and strain problems in rectangular coordinates (Airy's stress function approach); plane stress and strain problems in polar coordinates, axisymmetric problems; torsion of prismatic bars (semi-inverse method using real function approach); thermal stress; and energy methods.

CE 620 - ENERGY PRINCIPLES IN MECHANICS
Derivation, interpretation, and application to engineering problems of the principles of virtual work and complementary virtual work. Related theorems such as the principles of the stationary total potential complementary energy, Castigliano's theorems, theorem of least work, and unit force and displacement theorems. Introduction to generalized, extended, mixed, and hybrid principles. Variational methods of approximation, Hamilton's principle, and Lagrange's equations of motion. Approximate solutions to problems in structural mechanics by use of variational theorems.

CE 623 - VIBRATIONS
Topics include free and forced vibration of undamped and damped single-degree-of-freedom systems and undamped multi-degree-of-freedom systems; use of Lagrange's equations, Laplace transform, matrix formulation, and other solution methods; normal mode theory, introduction to vibration of continuous systems.

CE 665 - MECHANICS OF COMPOSITE MATERIALS
Analyzes the properties and mechanics of fibrous, laminated composites; stress, strain, equilibrium, and tensor notation; micromechnics, lamina, laminates, anisotropic materials, classical lamination theory, stiffness and strength, interlaminar stresses, fabrication, and test methods; thermal stresses, analysis, design and computerized implementation.

CE 671 - INTRODUCTION TO FINITE ELEMENT METHODS
Focuses on the fundamentals and basic concepts of the finite element method; modeling and discretization; application to one-dimensional problems; direct stiffness method; element characteristics; interpolation functions; extension to plane stress problems.

CE 672 - NUMERICAL METHODS IN STRUCTURAL MECHANCS
Focuses on solutions to the static, dynamic, and buckling behavior of determinate and indeterminate structures by numerical procedures, including finite difference and numerical integration techniques.

CE 675 - THEORY OF STRUCTURAL STABILITY
Introduces the elastic stability of structural and mechanical systems. Studies classical stability theory and buckling of beams, trusses, frames, arches, rings, and thin plates and shells are studied. Also covers the derivation of design formulas, computational formulation and implementation.

CE 677 - RISK AND RELIABILITY IN STRUCTURAL ENGINEERING
Studies the fundamental concepts of structural reliability; definitions of performance and safety, uncertainty in loadings, materials and modeling. Analysis of loadings and resistance. Evaluation of existing design codes. Development of member design criteria, including stability, fatigue and fracture criteria; and the reliability of structural systems.

CE 681 - ADVANCED DESIGN OF METAL STRUCTURES
Analysis of the behavior and design of structural elements and systems, including continuous beams, plate girders, composite steel-concrete members, members in combined bending and compression. Structural frames, framing systems, eccentric connections, and torsion and torsional stability are also studied.

CE 683 - PRESTRESSED CONCRETE DESIGN
Analyzes prestressing materials and concepts, working stress analysis and design for flexure, strength analysis and design for flexure, prestress losses, design for shear, composite prestressed beams, continuous prestressed beams, prestressed concrete systems concepts, load balancing, slab design.

CE 684 - ADVANCED REINFORCED CONCRETE DESIGN
Study of advanced topics in reinforced concrete design, including design of slender columns, deflections, torsion in reinforced concrete, design of continuous frames and two-way floor systems. Introduction to design of tall structures in reinforced concrete, and design of shear walls.

CE 691 - SPECIAL TOPICS: BEHAVIOR AND LRFD OF STEEL STRUCTURES
Concepts and probabilistic background of LRFD. Elastic and inelastic buckling of columns, residual stresses, beam column theory; LRFD provisions for column buckling. Critical analysis of effective length provisions. Elastic and inelastic buckling of plates, and evaluation of limiting b/t ratios. Postbuckling stiffness and effective width of stiffened plate elements. Unrestrained and warping torsion of thin walled beams. Torsional buckling of columns. Limit states for beam failure: plastic, elastic, and inelastic lateral torsional buckling provisions. LRFD provisions for torsional and lateral torsional instabilities.

CE 691 - SPECIAL TOPICS: COMPUTATIONAL PROCEDURES IN STRUCTURAL MECHANICS
Brief review of governing equations in structural mechanics and the associated computational problems. Overview of available commercial finite element software tools and their capabilities. Discuss basic numerical methods including numerical integration, numerical differentiation, solving systems of linear and nonlinear algebraic equations, and eigensolvers. Develop computational procedures using these methods to solve linear and nonlinear quasi-static problems, linear eigenvalue problems (buckling and vibration), and linear and nonlinear transient dynamics problems. Prerequisites: Numerical methods, finite element basics, energy methods.

CE 773 - ADVANCED FINITE ELEMENT APPLICATIONS IN STRUCTURAL ENGINEERING
Development and application of two- and three-dimensional finite elements; plate bending; isoparametric formulation; solid elements; nonlinear element formulation with application to material and geometric non-linearities; stability problems; formulation and solution of problems in structural dynamics; use of commercial computer codes.

CE 780 - OPTIMUM STRUCTURAL DESIGN
Introduces basic concepts, numerical methods and applications of optimum design to civil engineering structures; formulation of the optimum design problems; development of analysis techniques including linear and nonlinear programming and optimality criteria; examples illustrating application to steel and concrete structures.

Electrical

This Master of Engineering degree program allows the student to attain additional knowledge in advanced areas of Electrical Engineering. Students may develop their M.E. program with courses selected from the fields of automatic control, digital systems, pattern recognition and image processing, computer aided design, semiconductor devices, networks, microwave systems, communications and information theory, optics and optoelectronics, and signal processing, as well as from mathematics and other related disciplines. The M.E. program is designed for engineers currently in practice who feel the need to become knowledgeable in the latest areas of Electrical Engineering. Applicants for the Masters degree program must have a baccalaureate degree from a recognized college or university. While this degree is normally in Electrical Engineering, persons with degrees in other fields of engineering, applied science, and physics are encouraged to apply.

ECE 556 - MICROWAVE ENGINEERING I

Design and analysis of passive microwave circuits. Topics to be covered will include transmission lines, electromagnetic field theory, waveguides, microwave network analysis and signal flow graphs, impedance matching and tuning, resonators, power dividers and directional couplers, and microwave filters.

ECE 563 – VLSI DESIGN, A TOP-DOWN PERSPECTIVE

Digital CMOS circuit design and analysis: combinational and sequential circuits. Computer microarchitecture: datapath, control, memory, I/O. Global design issues: clocking and interconnect. Design methodologies: custom, semicustom, automatic. Faults: testing and verification. VLSI circuit design, layout and implementation using the MOSIS service. (Prerequisite: introductory Digital Logic Design)

ECE 564 - INTEGRATED CIRCUIT FABRICATION PROCESSES

Explores fabrication technologies for the manufacture of integrated circuits and microsystems. Emphasizes processes used for monolithic silicon-based systems and basic technologies for compound material devices. Topics include crystal properties and growth, Miller indices, Czochralski growth, impurity diffusion, concentration profiles, silicon oxidation, oxide growth kinetics, local oxidation, ion implantation, crystal annealing, photolithography and pattern transfer, wet and dry etching processes, anisotropic etches, plasma etching, reactive ion etching, plasma ashing, chemical vapor deposition and epitaxy; evaporation, sputtering, thin film evaluation, chemical-mechanical polishing, multilevel metal, device contacts, rapid thermal annealing, trench isolation, process integration, and wafer yield.

ECE 576 - DIGITAL SIGNAL PROCESSING

The fundamentals of discrete-time signal processing are presented. Topics include discrete-time linear systems, z-transforms, the DFT and FFT algorithms, and digital filter design. Problem-solving using the computer will be stressed.

ECE 613 - COMMUNICATION SYSTEMS ENGINEERING

A first graduate course in principles of communications engineering. Topics include a brief review of random process theory, principles of optimum receiver design for discrete and continuous messages, matched filters and correlation receivers, signal design, error performance for various signal geometries, Mary signaling, linear and nonlinear analog modulation, and quantization. The course also treats aspects of system design such as propagation, link power calculations, noise models, RF components, and antennas.

ECE 621 - LINEAR AUTOMATIC CONTROL SYSTEMS

Provides a working knowledge of the analysis and design of linear automatic control systems using classical methods. Introduces state space techniques; dynamic models of mechanical, electrical, hydraulic and other systems; transfer functions; block diagrams; stability of linear systems, and Nyquist criterion; frequency response methods of feedback systems design and Bode diagram; root locus method; System design to satisfy specifications; PID controllers; compensation using Bode plots and the root locus. Powerful software is used for system design.

ECE 622 – LINEAR STATE SPACE CONTROL SYSTEMS

Studies linear dynamical systems emphasizing canonical representation and decomposition, state representation, controllability, observability, normal systems, state feedback and the decoupling problem. Representative physical examples. Cross-listed as MAE 652. (Prerequisite: Linear Algebra, Linear Automatic Control Systems, or instructor permission)

ECE 631 - ADVANCED SWITCHING THEORY

Review of Boolean Algebra; synchronous and asynchronous machine synthesis; functional decomposition; fault location and detection; design for testability techniques.

ECE 642 - OPTICS FOR OPTOELECTRONICS

Covers the electromagnetic applications of Maxwell's equations in photonic devices such as the dielectric waveguide, fiber optic waveguide, and Bragg optical scattering devices. Includes the discussion of the exchange of electromagnetic energy between adjacent guides; i.e., mode coupling. Ends with an introduction to nonlinear optics. Examples of optical nonlinearity include second harmonic generation and soliton waves.

ECE 663 - SOLID STATE DEVICES

Introduces semiconductor device operation based on energy bands and carrier statistics. Describes operation of p-n junctions and metal semi-conductor junctions. Extends this knowledge to descriptions of bipolar and field effect transistors, and other microelectronic devices.

ECE 673 - ANALOG INTEGRATED CIRCUITS

Design and analysis of analog integrated circuits. Topics include feedback amplifier analysis and design including stability, compensation, and offset-correction; layout and floor-planning issues associated with mixed-signal IC design; selected applications of analog circuits such as A/D and D/A converters, references, and comparators; and extensive use of CAD tools for design entry, simulation, and layout. Includes an analog integrated circuit design project.

ECE 686 – PHOTONICS

The photonics course is a one-semester course designed to provide a fundamental understanding of the subject of photonics. Topics that will be covered include optics, optical thin films (high reflection and anti reflection coating design and fabrication), guided wave optics, fiber optics, lasers, detectors, optical modulators, optical information communication, optical data storage, displays, photovoltaic devices and fiber optic sensors.

ECE 686 – NANOPHOTONICS
Course is designed to learn light matter interactions at nanoscale as well as applications of Photonics for nanotechnology and nanobiotechnology. Nanophotonics, the development of new ways to generate and manipulate light using ultra small, engineered structures is one of the fastest growing fields in nanotechnology. Nanophotonics spans the disciplines of physics, chemistry, electrical engineering and bioengineering, and it holds promise for important technological advances in industries as diverse as microelectronics, optoelectronics, magnetic recording, biomedicine, environmental remediation and homeland security. Nanophotonics is of considerable technological significance.

ECE 687 – FUNDAMENTALS OF NANOELECTRONICS
The aim of this course is to provide a theoretical introduction to electronic conduction in nanosystems at their fundamental atomic limits, suitable for beginning graduate and advanced undergraduate students in engineering, physics, chemistry and materials science. Starting with the simplest system (a hydrogen atom with just one level), I will proceed to discuss electronic properties and current flow through a molecule, a solid, artificial hetero-structures (such as quantum dots and carbon nanotubes), and finally a present-day transistor. The course is primarily aimed at students with no background in quantum mechanics or solid state physics -- these topics will be covered in the course itself. At the same time, it offers plenty of new material for the initiated, such as 'hands-on' experience with solving quantum chemical problems, calculating band structures, solving transport problems and modeling device properties.

ECE 712 - DIGITAL COMMUNICATIONS
An in-depth treatment of digital communications techniques and performance. Topics include performance of uncoded systems such as Mary, PSK, FSK, and multi-level signaling; orthogonal and Bi-orthogonal codes; block and convolutional coding with algebraic and maximum likelihood decoding; burst correcting codes; efficiency and bandwidth; synchronization for carrier reference and bit timing; baseband signaling techniques; intersymbol interference; and equalization.

ECE 728 - DIGITAL CONTROL SYSTEMS
Includes sampling processes and theorems, z-transforms, modified transforms, transfer functions, and stability criteria; analysis in frequency and time domains; discrete state models of systems containing digital computers. Some in-class experiments using small computers to control dynamic processes.

ECE 757 - COMPUTER NETWORKS
Analyzes network topologies; backbone design; performance and queuing theory; data-grams and virtual circuits; technology issues; layered architectures; standards; survey of commercial networks, local area networks, and contention-based communication protocols; encryption; and security.

Engineering Physics

The Engineering Physics distance learning program is primarily targeted at students interested in earning a Masters of Engineering degree in Engineering Physics. However, the University of Virginia's Engineering Physics program is very research oriented, and students interested in considering a research-based Masters of Science or Ph.D. degree should inquire with the program's director, Dr. Robert E. Johnson (rej@virginia.edu), about the feasibility of pursuing such degrees in conjunction with coursework through the distance learning program. The Masters of Engineering in Engineering Physics program requires a minimum of 2 courses in graduate physics, 2 courses in graduate engineering, and 1 course in mathematics. Beyond those distributional requirements, students have the opportunity to formulate a Plan of Study that most closely corresponds to their technical area of interest. For more information, see the program web site.

APMA 641 - ENGINEERING MATHEMATICS I
See MAE 641 (under Mechanical & Aerospace)

APMA 642 - ENGINEERING MATHEMATICS II
See MAE 642 (under Mechanical & Aerospace)

EP 734 - SPECIAL TOPICS: SPACE PHYSICS/RADIATION EFFECTS
Description not yet available for this Special Topics course.

PHYS 521 - THEORETICAL MECHANICS I
Studies the statics and dynamics of particles and rigid bodies. Discusses methods of generalized coordinates, the Lagrangian, Hamilton- Jacobi equations, and action-angle variables. Relation to the quantum theory is explained.

PHYS 531 - OPTICS
Includes reflection and refraction at interfaces, geometrical optics, interference phenomena, diffraction, Gaussian optics, and polarization.

PHYS 562 – INTRODUCTION TO SOLID STATE PHYSICS
Includes crystal structures, lattice vibrations, and electronic properties of insulators, metals, and semiconductors; super-conductivity.

PHYS 725 - MATHEMATICAL METHODS OF PHYSICS I
Discusses matrices, complex analysis, Fourier series and transforms, ordinary differential equations, special functions of mathematical physics, partial differential equations, general vector spaces, integral equations and operator techniques, and Green's functions.

PHYS 742 - ELECTRICITY AND MAGNETISM I
A consistent mathematical account of the phenomena of electricity and magnetism; electrostatics and magnetostatics; macroscopic media; Maxwell theory; and wave propagation.

PHYS 751 - QUANTUM THEORY I
Introduces the physical basis of quantum mechanics, the Schroedinger equation and the quantum mechanics of one-particle systems, and stationary state problem.

Materials Science & Engineering

The purpose of this distance learning program is to provide graduate level instruction in Materials Science and Engineering to industrial personnel throughout the State of Virginia and to selected sites outside Virginia. Distance learning courses may be taken either for credit leading to a Master of Materials Science and Engineering (MMSE) degree or for general information. The courses are taught live in Charlottesville in the late afternoon or early evening to graduate students at UVA and broadcast simultaneously via video conferencing to special sites in Virginia as well as out of state. Two-way video and audio communication is maintained during the lectures so that the students have direct interaction with the classroom. The lectures are video recorded and each site is provided with equipment so that any student who must miss a regularly scheduled class due to job commitments can view the lecture later. Applicants for the MMSE Degree program must have a Bachelor's Degree in engineering or related fields from a recognized college or university. Each applicant is required to submit a copy of GRE test scores, official transcripts and three references. The application process is on going, but applications must be completed by the end of the first semester of study.

MSE 524 – MODELING IN MATERIALS SCIENCE
Introduces computer modeling in several primary areas of Materials Science and Engineering; atomistics, kinetics and diffusion, elasticity, and processing. Applications are made to the energy and configuration of defects in materials, solute segregation, phase transformations, stresses in multicomponent systems, and microstructural development during processing, for example.

MSE 532 - DEFORMATION AND FRACTURE OF MATERIALS DURING PROCESSING AND SERVICE
Deformation and fracture are considered through integration of materials science microstructure and solid mechanics principles, emphasizing the mechanical behavior of metallic alloys and engineering polymers. Metal deformation is understood based on elasticity theory and dislocation concepts. Fracture is understood based on continuum fracture mechanics and microstructural damage mechanisms. Additional topics include fatigue loading, elevated temperature behavior, material embrittlement, time-dependency, experimental design, and damage-tolerant life prediction.

MSE 567 – ELECTRONIC, OPTICAL AND MAGNETIC PROPERTIES OF MATERIALS
Explore the fundamental physical laws governing electrons in solids, and show how that knowledge can be applied to understanding electronic, optical and magnetic properties. Students will gain an understanding of how these properties vary between different types of materials, and thus why specific materials are optimal for important technological applications. It will also be shown how processing issues further define materials choices for specific applications.

MSE 601 - MATERIALS STRUCTURE AND DEFECTS
Provides a fundamental understanding of the structure and properties of perfect and defective materials. Topics include: crystallography and crystal structures, point defects in materials, properties of dislocations in f.c.c. metals and other materials, surface structure and energy, structure and properties of interphase boundaries.

MSE 602 – MATERIALS CHARACTERIZATION
Develops a broad understanding of the means used to characterize the properties of solids coupled with a fundamental understanding of the underlying mechanisms in the context of materials science and engineering. The course is organized according to the type of physical property of interest. The methods used to assess properties are described through integration of the principles of materials science and physics. Methods more amenable to analysis of bulk properties are differentiated from those aimed at measurements of local/surface properties. Breadth is achieved at the expense of depth to provide a foundation for advanced courses.

MSE 605 - STRUCTURE AND PROPERTIES OF MATERIALS I
This is the first of a sequence of two basic courses for first-year graduate students or qualified undergraduate students. Topics include atomic bonding, crystal structure, and crystal defects in their relationship to properties and behavior of materials (polymers, metals, and ceramics); phase equilibria and non-equilibrium phase transformations; metastable structures; solidification; and recrystallization.

MSE 606 - STRUCTURE AND PROPERTIES OF MATERIALS II
This is the second of a two-course sequence for the first- year graduate and qualified undergraduate students. Topics include diffusion in solids; elastic, anelastic, and plastic deformation; and electronic and magnetic properties of materials. Emphasizes the relationships between microscopic mechanisms and macroscopic behavior of materials.

MSE 608 – CHEMICAL AND ELECTROCHEMICAL PROPERTIES OF SOLID MATERIALS
Introduces the concepts of electrode potential, double layer theory, surface charge, and electrode kinetics. These concepts are applied to subjects that include corrosion and embrittlement, energy conversion, batteries and fuel cells, electro-catalysis, electroanalysis, electrochemical industrial processes, bioelectrochemistry, and water treatment.

MSE 610 – INTRODUCTION TO NANOMATERIALS

This course will introduce students to the relevant concepts governing the synthesis, science, and engineering of nanomaterials. Course modules will cover the fundamental scientific principles controlling assembly of nanostructured materials; the types of nanomaterials that are extent; synthesis, measurement and computational tools; new properties at the nanoscale, and existing and emerging applications of nanomaterials. Synthesizing this information, students should be equipped with understanding of the fundamental principles and tools that will prepare them for subsequent more specific advanced study and/or research into virtually any class of nanomaterials.

MSE 623 - THERMODYNAMICS OF MATERIALS

Emphasizes the understanding of thermal properties such as heat capacity, thermal expansion, and transitions in terms of the entropy and the other thermodynamic functions. Develops the relationships of the Gibbs and Helmholtz functions to equilibrium systems, reactions, and phase diagrams. Open systems, chemical reactions, capillarity effects and external fields are also discussed.

MSE 624 – KINETICS OF SOLID-STATE REACTIONS

Serves as an introduction to basic kinetic processes in materials, develops basic numerical and computer programming skills. Students will learn to formulate the partial differential equations and boundary conditions used to describe basic materials phenomena in the solid state including mass and heat diffusion in single- and two-phase systems, the motion of planar phase boundaries, and interfacial reactions. Students will develop analytical and numerical techniques for solving these equations and will apply them to understanding microstructural evolution during growth and coarsening in one, two, and three dimensions.

MSE 635 - PHYSICAL METALLURGY OF LIGHT ALLOYS

Develops the student's literacy in aluminum and titanium alloys used in the aerospace and automotive industries. Considers performance criteria and property requirements from design perspectives. Emphasizes processing microstructure development, and structure-property relationships.

MSE 647 - PHYSICAL METALLURGY OF TRANSITION-ELEMENT ALLOYS

Reinforces fundamental concepts, introduces advance topics, and develops literacy in the major alloys of transition elements. Emphasizes microstructural evolution by composition and thermomechanical process control. Topics include phase diagrams, transformation kinetics, martensitic transformation, precipitation, diffusion, recrystallization, and solidification. Considers both experimental and model-simulation approaches.

MSE 662 - MATHEMATICS OF MATERIALS SCIENCE

Representative problems in materials science are studied in depth with the emphasis on understanding the relationship between physical phenomena and their mathematical description. Topics include rate processes, anelasticity, tensor calculus, and elasticity theory.

MSE 722 - SURFACE SCIENCE

Analyzes the structure and thermodynamics of surfaces, with particular emphasis on the factors controlling chemical reactivity of surfaces; adsorption, catalysis, oxidation, and corrosion are considered from both theoretical and experimental viewpoints. Modern surface analytical techniques, such as Auger, ESCA, and SIMS are considered.

MSE 731 - MECHANICAL BEHAVIOR OF MATERIALS

Studies the deformation of solids under stress, emphasizing the role of imperfections, state of stress, temperature and strain-rate; description of stress, strain, strain rate and elastic properties of materials comprise the opening topic. Then considers the fundamental aspects of crystal plasticity, along with the methods for strengthening crystals at low temperatures. Covers deformation at elevated temperatures and deformation maps. Emphasizes the relationships between microscopic mechanisms and macroscopic behavior of materials.

MSE 732 – FATIGUE AND FRACTURE OF ENGINEERING MATERIALS

Develops the tools necessary for fatigue and fracture control in structural materials. Presents continuum fracture mechanics principles and discusses fracture modes from the interdisciplinary perspectives of continuum mechanics and microscopic plastic deformation/fracture mechanisms. Includes cleavage, ductile fracture, fatigue, and environmental cracking, emphasizing micromechanical modeling.

MSE 734 - PHASE TRANSFORMATIONS

Includes the fundamental theory of diffusional phase transformations in solid metals and alloys; applications of thermodynamics to calculation of phase boundaries and driving forces for transformations; theory of solid-solid nucleation, theory of diffusional growth, comparison of both theories with experiment; applications of thermodynamics and of nucleation and growth theory to the principal experimental systematics of precipitation from solid solution, the massive transformations, the cellular and the pearlite reactions, martensitic transformations, and the questions of the role of shear in diffusional phase transformations.

MSE 741 - CRYSTAL DEFECT THEORY

Studies the nature and major effects of crystal defects on the properties of materials, emphasizing metals. The elasticity theory of dislocations is treated in depth.

MSE 751 - POLYMER SCIENCE
Emphasizes the nature and types of polymers and methods for studying them. Surveys chemical structures and methods of synthesis, and develops the physics of the special properties of polymers (e.g., rubber elasticity, tacticity, glass transitions, crystallization, dielectric and mechanical relaxation, and permselectivity). Discusses morphology of polymer systems and its influence on properties.

Mechanical and Aerospace

The graduate degree offered off campus by the Department of Mechanical and Aerospace Engineering is a Master of Engineering (ME) in Mechanical and Aerospace Engineering. The purpose of the masters degree program is to strengthen and extend undergraduate training and competence. This extension is achieved through coursework for the Master of Engineering degree. Each Master of Engineering student's Program of Study must include at least 18 semester hours of approved UVa courses out of the 30 semester hours required for this degree. Each Master's student must also include in his or her program of study at least one analytical mathematics course and at least one primarily computationally oriented course. No other specific course requirements are imposed except that each masters program must form some reasonable whole and be submitted and approved by both the student's MAE academic advisor and the Graduate Studies Office. The Program of Study should be submitted no later than the second semester of study.

MAE 610 **-** THERMOMECHANICS
Review of classical thermodynamics; introduction to kinetic theory; quantum mechanical analysis of atomic and molecular structure; statistical mechanical evaluation of thermodynamic properties; chemical thermodynamics and equilibria.

MAE 611 – CONDUCTION AND CONVECTION HEAT TRANSFER
Fundamentals of conduction and convection heat transfer. Steady, unsteady and multidimensional heat conduction. Phase change problems with moving boundaries. Derivation and application of conservation equations for heat convection in laminar and turbulent flows. Applications to free and confined flows. Heat convection at high speeds. Natural convection, condensation and evaporation.

MAE 621 - ANALYTICAL DYNAMICS
The topics covered are: Newtonian mechanics: Newton's laws, energy, work, conservation principles; Reference frames: transformations, Euler angles, kinematics; Rotational motion: rigid bodies, inertia tensors; constraints and generalized coordinates; other equations of motion: Kane's equations, Lagrange's equations, Gibbs-Appell equations; Variational principles.

MAE 623 – VIBRATIONS
Topics include free and forced vibrations of undamped and damped single- and multi-degree-of-freedom systems; modal analyses; continuous systems; matrix formulations; finite element equations; direct integration methods; and eigenvalue solution methods.

MAE 625 - MULTI-BODY MECHANICAL SYSTEMS
Analytical and computational treatment for modeling and simulation of three-dimensional multibody mechanical systems. Provide a systematic and consistent basis for analyzing the interactions between motion constraints, kinematics, static, dynamic, and control behavior of multibody mechanical systems. Applications to machinery, robotic devices and mobile robots, biomechanical models for gait analysis and human motions, and motion control. Matrix modeling procedures with symbolic and numerical computational tools will be utilized for demonstrating the methods developed in this course. Focus on the current research and computational tools and examine a broad spectrum of physical systems where multibody behavior is fundamental to their design and control.

MAE 631 - FLUID MECHANICS I
Hydrostatics, including surface tension. Kinematics; non-inertial reference frames; rigorous formulation of conservation equations for mass, momentum, and energy dimensional analysis. Euler and Bernoulli equations; vorticity dynamics; two-dimensional potential flow theory; complex potentials; applications to airfoils; the Navier-Stokes equations; selected exact and approximate solutions; the laminar boundary layer equations; differential and integral; elementary similar and integral solutions; and introduction to and modeling of turbulent flows.

MAE 641 - ENGINEERING MATHEMATICS I
Review of ordinary differential equations. Initial value problems, boundary value problems, and various physical applications. Linear algebra, including systems of linear equations, matrices, eigenvalues, eigenvectors, diagonalization, and various applications. Scalar and vector field theory, including the divergence theorem, Green's theorem, and Stokes theorem, and various applications. Partial differential equations that govern physical phenomena in science and engineering. Solution of partial differential equations by separation by variables, superposition, Fourier series, variation of parameter, d'Alembert's solution. Eigenfunction expansion techniques for non-homogeneous initial-value, boundary-value problems. Particular focus on various physical applications of the heat equation, the potential (Laplace) equation, and the wave equations in rectangular, cylindrical, and spherical coordinates.

MAE 642 - ENGINEERING MATHEMATICS II
Further and deeper understanding of partial differential equations that govern physical phenomena in science and engineering. Solution of linear partial differential equations by eigenfunction expansion techniques. Green's functions for time-independent and time-dependent boundary value problems. Fourier transform methods, and Laplace transform methods. Solution of a variety of initial-value, boundary-value problems. Various physical applications. Study of complex variable theory. Functions of a complex variable, and complex integral calculus, Taylor series, Laurent series, and the residue theorem, and various applications. Serious work and efforts in the further development of analytical skills and expertise.

MAE 643 - STATISTICS FOR ENGINEERS AND SCIENTISTS
Role of statistics in science, hypothesis tests of significance, confidence intervals, design of experiments, regression, correlation analysis, analysis of variance, and introduction to statistical computing with statistical software libraries.

MAE 651 - LINEAR AUTOMATIC CONTROL SYSTEMS
Studies the dynamics of linear, closed-loop systems; mechanical, electrical, hydraulic, and other servo systems. Analysis of transfer functions; stability theory. Considers compensation methods.

MAE 662 - MECHANICAL DESIGN ANALYSIS
Topics include the design analysis of machine elements subject to complex loads and environments; emphasis on modern materials and computer analysis; theory of elasticity, energy methods; failure theories, fracture, fatigue, creep; contact, residual, and thermal stresses; experimental stress analysis; and corrosion.

MAE 671 - APPLIED FINITE ELEMENT ANALYSIS
The topics covered are: review of vectors, matrices, and numerical solution techniques; discrete systems; variational formulation and approximation for continuous systems; linear finite element method in solid mechanics; formulation of isoparametric finite elements; finite element method for field problems, heat transfer, and fluid dynamics.

MAE 672 - COMPUTATIONAL FLUID DYNAMICS
Includes the solution of flow and heat transfer problems involving steady and transient convective and diffusive transport; superposition and panel methods for inviscid flow, finite-difference methods for elliptic, parabolic and hyperbolic partial differential equations, elementary grid generation for odd geometries, primitive variable and vorticity-steam function algorithms for incompressible, multidimensional flows. Extensive use of personal computers/workstations including interactive graphics.

MAE 692 - SPECIAL TOPICS: CREATIVITY AND NEW PRODUCT DEVELOPMENT
Course objectives: To develop the skills for successfully creating and developing a new product through a hands-on approach to creativity and the development process. To provide an overview of the basic process for new product development in a competitive marketplace by simulating the process in class. Expected result: Filing of Disclosure Document or Provisional Patent with the U.S. Patent and Trademark Office on an idea developed in the class. Format: Students will work in teams to design a new product, assess its feasibility and market potential, build a prototype, develop a business plan and submit a provisional patent application.

Systems

Systems Engineering is concerned primarily with improving the processes of problem-solving and decision-making within the functions of forecasting, planning, design, development, testing, evaluation, control, operation, and management. Emphasis in the curriculum is placed on preparing individuals for careers concerned with the solution of significant large-scale interdisciplinary problems. The student is expected to gain an understanding of the theoretical and methodological foundations for problem-solving and decision-making systems. This is accomplished through a judicious selection of coursework that draws from disciplines such as mathematical systems theory, decision theory, control theory, economics, operations research, management science, computer science, artificial intelligence, cognitive science and human factors. In addition, each student's program is tailored to the particular needs and interests of the student through the selection of elective courses and the completion of a supervised project. The Master of Engineering degree requires thirty semester-hours of course work and a two semester-hour supervised project. A minimum of fifteen semester-hours of course work must be taken in courses taught by University of Virginia faculty of the Systems Engineering Department. The remaining fifteen hours of course work can be taken in courses taught by University of Virginia faculty or may be transferred from other institutions. The two-semester-hour project research must be under the supervision of University of Virginia faculty. The University of Virginia extended classroom advisor for Systems Engineering must approve each student’s plan of study.

SYS 581 – ENGINEERING ECONOMIC SYSTEMS
An introduction to the theory of the industrial organization from a game-theoretic perspective. Particular emphasis will be made in industries with strong engineering content (electricity, telecommunications, software & hardware, etc.)

SYS 582 – HUMAN COMPUTER INTERFACES
Basic aspects of human factors in the design of information support systems. Topics covered include: 1. basic human performance issues (physiology, memory, learning, problem-solving, human error); 2. the user interface design process (task analysis, product concept, functional requirements, prototype, design, and testing). Students will gain basic skills in the analysis and design of human-machine systems through in-class exercises and a course project. The course is also designed to help the student practice different communication skills (interviewing, written analysis, and oral presentation).

SYS 601 - INTRODUCTION TO SYSTEMS ENGINEERING
An integrated introduction to systems methodology, design, and management. An overview of systems engineering as a professional and intellectual discipline, and its relation to other disciplines, such as operations research, management science, and economics. An introduction to selected techniques in systems and decision sciences, including mathematical modeling, decision analysis, risk analysis, and simulation modeling. Overview of contemporary topics relevant to systems engineering such as reengineering and total quality management. Elements of systems management, including decision styles, human information processing, organizational decision

processes, and information system design for planning and decision support. Emphasizes relating theory to practice via written analyses and oral presentations of individual and group case studies.

SYS 602 - SYSTEMS INTEGRATION

Provides an introduction to the problems encountered when integrating large systems, and also presents a selection of specific technologies and methodologies used to address these problems. Includes actual case studies to demonstrate systems integration problems and solutions. A term project is used to provide students with the opportunity to apply techniques for dealing with systems integration.

SYS 603 - MATHEMATICAL PROGRAMMING

Presents the foundations of mathematical modeling and optimization, with emphasis on problem formulation and solution techniques. Coverage includes linear programs, nonlinear programs, combinatorial models, optimality conditions, search strategies, and numerical algorithms. Topics are illustrated through classic problems such as service planning, operations management, manufacturing, transportation, and network flow.

SYS 605 - STOCHASTIC SYSTEMS

Covers basic stochastic processes with emphasis on model building and probabilistic reasoning. The approach is non-measure theoretic but otherwise rigorous. Topics include a review of elementary probability theory with particular attention to conditional expectations; Markov chains; optimal stopping; renewal theory and the Poisson process; martingales. Applications are considered in reliability theory, inventory theory, and queuing systems.

SYS 614 - DECISION ANALYSIS

Principles and procedures of decision-making under uncertainty and with multiple objectives. Topics include representation of decision situations as decision trees, influence diagrams, and stochastic dynamic programming models; Bayesian decision analysis, subjective probability, utility theory, optimal decision procedures, value of information, multi-objective decision analysis, and group decision making.

SYS 616 - KNOWLEDGE-BASED SYSTEMS

Introduces the fundamental concepts necessary for successful research in, and real-world application of, knowledge-based decision support systems. Emphasizes knowledge acquisition, system design principles, and testing systems with human subjects. Students are required to work through several design and testing exercises and develop a final project that applies principles learned in class.

SYS 623 - COGNITIVE SYSTEMS ENGINEERING

Introduces the field of cognitive systems engineering, which seeks to characterize and support human-systems integration in complex systems environments. Covers key aspects of cognitive human factors in the design of human performance (memory, learning, problem-solving, expertise and human error); characterizes human performance in complex, socio-technical systems, including naturalistic decision making and team performance; reviews different types of decision support systems, with a particular focus on representation aiding systems; and covers the human-centered design process (task analysis, knowledge acquisition methods, product concept, functional requirements, prototype, design, and testing).

SYS 634 - DISCRETE-EVENT STOCHASTIC SIMULATION

A first graduate course on the theory and practice of discrete-event simulation. Coverage includes Monte Carlo methods, generating random numbers and variates, sampling distributions, and spreadsheet applications; the dynamics of discrete-event stochastic systems, simulation logic and computational issues, output analysis, experiment design, and model verification and validation. Emphasizes modern simulation programming languages.

SYS 650 - RISK ANALYSIS

A study of technological systems, where decisions are made under conditions of risk and uncertainty. Part I: Conceptualization: the nature of risk, the perception of risk, the epistemology of risk, and the process of risk assessment and management. Part II: Systems engineering tools for risk analysis basic concepts in probability and decision analysis, event trees, decision trees, and multi-objective analysis. Part III: Methodologies for risk analysis: hierarchical holographic modeling, uncertainty taxonomy, risk of rare and extreme events, statistics of extremes, portioned multi-objective risk method, multi-objective decision trees, fault trees, multi-objective impact analysis method, and uncertainty sensitivity index method.

SYS 654 - FINANCIAL ENGINEERING

Provides an introduction to basic topics in finance from an engineering and modeling perspective. Topics include the theory of interest, capital budgeting, valuation of firms, futures and forward contracts, options and other derivatives, and practical elements of investing and securities speculation. Emphasis is placed on the development and solution of mathematical models for problems in finance, such as capital budgeting, portfolio optimization, and options pricing; also predictive modeling as it is applied in credit risk management. One of the unique features of this course is a stock trading competition hosted on www.virtualstockexchange.com or a similar site.

SYS 670 - ENVIRONMENTAL SYSTEMS ANALYSIS

Examines the constitution of environmental systems and the science underlying observed perturbations to these systems. Presents the main tools used to analyze the effect of perturbations to environmental systems and to frame policy interventions for mitigating the impacts of such disturbances. Begins with a treatment of technology design and the environment with a focus on automobiles, electric power, drinking water supply, wastewater and sewage treatment, and solid waste management. Moves to a study of modeling of environmental processes, and a focus on photochemical smog, PCBs in the aquatic environment, CFCs and the ozone hole, and global warming and the greenhouse effect. Progresses to a study of the tools in environmental systems analysis: lifecycle assessment, environment economics and natural resource accounting, benefit-cost analysis, risk analysis and environmental forecasting Includes an analysis of environmental justice and the role of stakeholders in environmental systems and closes with a synthesis of the course material in he context of sustainable development.

SYS 674 - TOTAL QUALITY ENGINEERING
Comprehensive study of quality engineering techniques; characterization of Total Quality Management philosophy and continuous improvement tools; statistical monitoring of processes using control charts; and process improvement using experimental design.

SYS 727 - QUANTITATIVE MODELS OF HUMAN PERFORMANCE
This course provides an introduction to quantitative methods of measuring human performance in complex systems. The focus of the selected methodologies is based on providing insight into human performance in order to guide design and/or training. Assignments involve applying the methods to a human-machine system problem. In addition, each student will be responsible for presenting the concepts of at least one of the quantitative approaches presented in the readings.

Long-Range Plan

Fall 2007	BIOM 695/ChE 881- Biomedical Nanotechnology (on-line course) CE 610 - Concrete Materials CHE 642 - Applied Surface Chemistry ECE 576 - Digital Signal Processing ECE 622 - Linear State Space Control Systems ECE 642 – Optics for Optoelectronics MSE 532 - Deformation & Fracture Mechanics of Structural Materials MSE 605 - Structure & Properties of Materials I MAE 641 - Engineering Mathematics I MAE 692 - Creativity and New Product Development PHYS 521 - Theoretical Mechanics SYS 603 - Mathematical Programming
Spring 2008	CE 604 - Plates and Shells CHE 647 - Biochemical Engineering ECE556 – Microwave Engineering I MSE 606 - Structure & Properties of Materials II MSE 608 - Chemical & Electrochemical Properties of Solid Materials MAE 672 – Computational Fluid Dynamics MAE 625 – Multi-Body Mechanical Systems SYS 613 – Multivariate Statistics
Fall 2008	CE 683 - Prestressed Concrete CHE 665 - Techniques for Chemical Engineering Analysis & Design ECE ___ - TBA MSE 601 - Materials Structure and Defects MSE 771 - Advanced Electrochemistry MAE 602 - Continuum Mechanics MAE 641 - Engineering Mathematics I MAE 651 - Linear Automatic Control Systems SYS 605 - Stochastic Systems
Spring 2009	CE 623 - Vibrations CHE 649 - Polymer Chemistry & Engineering ECE ___ - TBA MSE 732 - Fatigue and Fracture of Engineering Materials MSE 792 - Physics of Solids MAE 611 - Heat and Mass Transport Phenomena MAE 642 - Engineering Mathematics II SYS 623 - Cognitive Systems Engineering
Fall 2009	CE 684 - Advanced Reinforced Concrete Design* CHE 625 - Transport Processes ECE ___ - TBA MSE 567 - Electrical, Optical, and Magnetic Properties of Materials MSE 623 - Thermodynamics of Materials MAE 641 - Engineering Mathematics I MAE 625 - Multibody Mechanical Systems SYS 601 - Introduction to Systems Engineering

Spring 2010 CE 671 - Intro to the Finite Element Method*
CHE 630 - Mass Transfer
ECE ___ - TBA
MSE 602 - Materials Characterization
MSE 624 - Kinetics of Solid State Reactions*
MAE 643 - Statistics for Engineers and Scientists
MAE 671 - Finite Element Analysis
SYS 581 - Engineering Economic Systems

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