ENGINEERING PHYSICS (E P)

E P 271 – ENGINEERING PROBLEM SOLVING I
3 credits.

Solution of engineering problems using commercially-available software tools (spreadsheets, symbolic manipulators, and equation solvers). The emphasis will be on nuclear engineering problems, including radioactive decay, nuclear cross sections, scattering, and criticality.
Requisites: MATH 222 and (E M A 201, PHYSICS 201, 207, 247, or concurrent enrollment) or member of Engineering Guest Students
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Apply mathematical models to describe engineering problems across an array of disciplines
Audience: Undergraduate

2. Implement computational solutions of mathematical models that represent engineering problems
Audience: Undergraduate

3. Combine multiple computational problem solving steps for complex problems
Audience: Undergraduate

4. Demonstrate a fundamental understanding of data, conditional execution, and loops for basic programming
Audience: Undergraduate

E P 418 – SUSTAINABLE ENERGY CHALLENGES AND SOLUTIONS
1 credit.

Interdisciplinary survey of energy research topics. Understand how sustainable energy challenges are being studied and solved by different disciplines, from science and engineering to social sciences and humanities. Analyze energy sustainability using a multi-disciplinary, systems-based approach.
Requisites: Declared in the Certificate in Engineering for Energy Sustainability or Engineering: Sustainable Systems Engineering, MEng
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Analyze the causes of and solutions for the sustainability challenge of affordable and clean energy
Audience: Undergraduate

2. Analyze sustainability issues and/or practices using a systems-based approach
Audience: Undergraduate

3. Describe the technical, social, economic, and environmental dimensions of affordable and clean energy and identify potential trade-offs and interrelationships among these dimensions at a level appropriate to the course
Audience: Undergraduate

E P 468 – INTRODUCTION TO ENGINEERING RESEARCH
1 credit.

An introduction to the conduct of engineering research: the scientific method, ethics in research, documentation and treatment of research data, publication practices, and the structure of the broader research community are covered.
Requisites: Declared in Engineering Physics
Course Designation: Honors - Accelerated Honors (!)
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Develop an introductory understanding of research practices involving documentation and treatment of research data and publication practices in research
Audience: Undergraduate

2. Demonstrate knowledge of professional and ethical standards and a basic understanding of research safety
Audience: Undergraduate

3. Demonstrate skills associated with finding and citing relevant technical literature
Audience: Undergraduate

4. Identify a campus research project and research mentor for further engagement during the remainder of the research sequence courses
Audience: Undergraduate

E P 469 – RESEARCH PROPOSAL IN ENGINEERING PHYSICS
1 credit.

An introduction to current research topics in engineering physics. Development of an undergraduate research proposal supervised by faculty members.
Requisites: E P 468 and declared in Engineering Physics
Course Designation: Honors - Accelerated Honors (!)
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Design a research project with clear milestones and a detailed timeline in collaboration with a research mentor
Audience: Undergraduate

2. Establish deeper understanding of the literature in the research project area, including the ability to analyze and interpret relevant techniques and data
Audience: Undergraduate

3. Demonstrate technical writing skills
Audience: Undergraduate

4. Demonstrate technical presentation skills
Audience: Undergraduate

5. Demonstrate the ability to critique the research and technical writing of others
Audience: Undergraduate

6. Develop and present a research proposal in both written and oral form
Audience: Undergraduate

E P/E M A 471 – INTERMEDIATE PROBLEM SOLVING FOR ENGINEERS
3 credits.

Use of computational tools for the solution of problems encountered in engineering physics applications. Topics covered include orbital mechanics, structural vibrations, beam and plate deformations, heat transfer, neutron diffusion, and criticality. Emphasis will be on modeling, choice of appropriate algorithms, and model validation.
Requisites: (E P 271 or COMP SCI 220) and (MATH 319, 320, 376 or concurrent enrollment), graduate/professional standing, or member of Engineering Guest Students
Course Designation: Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Numerically solve systems of ordinary differential equations (ODEs)
Audience: Undergraduate

2. Numerically solve 1-D boundary value problems
Audience: Undergraduate

3. Numerically solve eigenvalue problems
Audience: Undergraduate

4. Apply the basic techniques of Monte Carlo methods
Audience: Undergraduate

5. Apply the basic techniques of numerically solving partial differential equations (PDEs)
Audience: Undergraduate

6. Apply techniques from outcomes 1-5 to multi-step engineering problems
Audience: Undergraduate

E P/E M A 476 – INTRODUCTION TO SCIENTIFIC COMPUTING FOR ENGINEERING PHYSICS
3 credits.

Background for professional numerical computation in Linux environments begins with shell scripting and software archiving. Programming skills in a compiled language are then developed through scientific and engineering examples. Engineering problem-solving skills are reinforced through applications that require numerical solutions to systems of differential and/or integral equations, while motivating progressively more advanced computational methods.
Requisites: (E P 271, COMP SCI 300, or 310) and (MATH 319, 320, or 375), or graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Repeatable for Credit: No
Last Taught: Spring 2022
Learning Outcomes: 1. Create UNIX or Linux shell scripts to aid workflow in scientific computing
Audience: Undergraduate

2. Formulate physical problems in mathematical and computational terms
Audience: Undergraduate

3. Identify software needs for solving numerical models of science and engineering applications
Audience: Undergraduate

4. Write and modify computer programs in a compiled programming language
Audience: Undergraduate

5. Estimate the accuracy of computed results
Audience: Undergraduate

E P/E M A 547 – ENGINEERING ANALYSIS I
3 credits.

Methods of higher mathematics; stress on problem solving rather than rigorous proofs; linear algebra, calculus of variations, Green's function.
Requisites: MATH 321, or graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2024
Learning Outcomes: 1. Solve ordinary differential equations in the form of initial-value and boundary-value problems through substitution, integrating factors, and Laplace and Fourier transforms
Audience: Both Grad & Undergrad

2. Apply methods of undetermined coefficients, variation of parameters, and Green’s functions to solve inhomogeneous ordinary differential equations
Audience: Both Grad & Undergrad

3. Identify whether linear algebraic systems have a unique solution, no solution, or an infinite number of solutions and apply methods for solving algebraic systems
Audience: Both Grad & Undergrad

4. Determine eigenvalues and eigenvectors of algebraic eigenvalue problems
Audience: Both Grad & Undergrad

5. Determine whether a function is analytic in the neighborhood of some point in the complex plane and apply contour integration to evaluate integrals
Audience: Both Grad & Undergrad

6. Identify appropriate combinations of methods for solving problems arising in engineering and scientific applications
Audience: Graduate

E P/E M A 548 – ENGINEERING ANALYSIS II
3 credits.

Function of complex variable, series solution of differential equations, partial differential equations. A year of math beyond calculus
Requisites: (MATH 322 and 320), (MATH 322 and E P/E M A 547), or (MATH 322, 319, and 340), or graduate/professional standing, or member of Engineering Guest Students
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Intermediate
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Apply local analysis and asymptotic methods to distinguish analytical and singular behavior of ordinary differential equations to approximate their solutions
Audience: Both Grad & Undergrad

2. Apply asymptotic methods to estimate the values of integrals
Audience: Both Grad & Undergrad

3. Use perturbative methods such as boundary-layer theory, WKB theory, and multi-scale analysis to analyze ordinary differential equations
Audience: Both Grad & Undergrad

4. Apply the method of characteristics and separation of variables to solve partial differential equations
Audience: Both Grad & Undergrad

5. Identify appropriate combinations of methods for solving problems arising in engineering and scientific applications
Audience: Graduate

E P/M E 566 – CRYOGENICS
3 credits.

Applications of cryogenics, material properties at low temperatures, refrigeration and liquefaction systems, measurement techniques, insulation, storage and transfer of cryogenics, safety and handling.
Requisites: (M E 361 or PHYSICS 415) and (CBE 320 or M E 364), or graduate/professional standing, or member of Engineering Guest Students
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2019
Learning Outcomes: 1. Describe the similarities and distinctions between the cryogens
Audience: Both Grad & Undergrad

2. Characterize the operation and performance of large scale cryogenic refrigerators and liquefiers
Audience: Both Grad & Undergrad

3. Characterize the operation and performance of recuperative and regenerative cryocoolers
Audience: Both Grad & Undergrad

4. Select appropriate instrumentation to measure temperature, pressure, flow, and level in cryogenic systems
Audience: Both Grad & Undergrad

5. Determine the cooldown time for a cryogenic system including temperature dependent material properties, heat transfer, and refrigeration characteristics
Audience: Both Grad & Undergrad

6. Design a cryogenic system accounting for strength, insulation, fluid flow, and electrical characteristics
Audience: Graduate

E P 568 – RESEARCH PRACTICUM IN ENGINEERING PHYSICS I
3 credits.

Undergraduate research projects supervised by faculty members.
Requisites: E P 469 and declared in Engineering Physics
Course Designation: Honors - Accelerated Honors (!)
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Acquire new and apply existing knowledge of mathematics, science and engineering to research
Audience: Undergraduate

2. Use techniques, skills and modern engineering tools for engineering research in collaboration with a research mentor
Audience: Undergraduate

3. Conduct a research project, using applicable experimental, theoretical, and computational methods
Audience: Undergraduate

4. Function effectively in a diverse research environment
Audience: Undergraduate

5. Demonstrate technical writing skills
Audience: Undergraduate

6. Demonstrate technical presentation skills
Audience: Undergraduate

7. Adjust to research obstacles by adapting technical approach, milestones, and/or timeline
Audience: Undergraduate

E P 569 – RESEARCH PRACTICUM IN ENGINEERING PHYSICS II
3 credits.

Undergraduate research projects supervised by faculty members. Senior thesis.
Requisites: E P 568 and declared in Engineering Physics
Course Designation: Honors - Accelerated Honors (!)
Repeatable for Credit: No
Last Taught: Spring 2025
Learning Outcomes: 1. Acquire new and apply existing knowledge of mathematics, science and engineering to research
Audience: Undergraduate

2. Use techniques, skills and modern engineering tools for engineering research in collaboration with a research mentor
Audience: Undergraduate

3. Conduct a research project, including analyzing and interpreting data
Audience: Undergraduate

4. Function effectively in a diverse research environment
Audience: Undergraduate

5. Communicate technical information effectively
Audience: Undergraduate

6. Complete a research thesis project and present it in both written and oral form
Audience: Undergraduate

E P 602 – SPECIAL TOPICS IN ENGINEERING PHYSICS
1-3 credits.

Subject matter, credits and prerequisites vary.
Requisites: None
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Fall 2022

E P/E M A 615 – MICRO- AND NANOSCALE MECHANICS
3 credits.

An introduction to micro- and nanoscale science and engineering with a focus on the role of mechanics. A variety of micro- and nanoscale phenomena and applications covered, drawing connections to both established and new mechanics approaches.
Requisites: Graduate/professional standing or E M A 303 or M E 306
Course Designation: Breadth - Physical Sci. Counts toward the Natural Sci req
Level - Advanced
L&S Credit - Counts as Liberal Arts and Science credit in L&S
Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Fall 2021
Learning Outcomes: 1. Describe the current state and potential future impact of micro and nanotechnology
Audience: Both Grad & Undergrad

2. Explain how mechanics enters a new regime at the micro and nano scales where surfaces, interfaces, defects, material property variations, and quantum effects play more dominant roles
Audience: Both Grad & Undergrad

3. Use or adapt engineering mechanics concepts to describe behavior at the micro and nano scale
Audience: Both Grad & Undergrad

4. Describe cross-disciplinary intersections and how mechanics is integrated with the fields of materials science, chemistry, physics, and biology at the micro/nano scale
Audience: Graduate

E P/COMP SCI/E C E/E M A/M E 759 – HIGH PERFORMANCE COMPUTING FOR APPLICATIONS IN ENGINEERING
3 credits.

An overview of hardware and software solutions that enable the use of advanced computing in tackling computationally intensive Engineering problems. Hands-on learning promoted through programming assignments that leverage emerging hardware architectures and use parallel computing programming languages. Students are strongly encourage to have completed COMP SCI 367 or COMP SCI 400 or to have equivalent experience.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2025

E P/M E 777 – VACUUM TECHNOLOGY
3 credits.

Topics defining modern vacuum technology, including the kinetic theory of gases, conductance, pumping systems, pump technologies, pressure measurement, gas-surface interactions, sealing technologies, leak detection, and residual gas analysis will be addressed through a combination of lectures, laboratory activities, problem solving, and group discussions. Knowledge of fluid mechanics [such as M E 363 or B M E 320] strongly encouraged.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: No
Last Taught: Spring 2022
Learning Outcomes: 1. Use kinetic theory to determine key characteristics of a rarified gas such as the mean free path length, molecular flux and the average velocity
Audience: Graduate

2. Calculate the conductance of a vacuum system for molecular, viscous, and transitional flow regimes
Audience: Graduate

3. Calculate the time dependent pump down behavior of a vacuum system

Audience: Graduate

4. Repair a rotary vane vacuum pump
Audience: Graduate

5. Characterize the operation, advantages and disadvantages of low, medium, and high vacuum pumps
Audience: Graduate

6. Characterize the operation, advantages and disadvantages of low and high vacuum gauges
Audience: Graduate

7. Define and utilize appropriate leak detection methods for small, medium, and large leak rates
Audience: Graduate

E P 920 – ENGINEERING PHYSICS GRADUATE SEMINAR
0-1 credits.

Students will be able to enroll for credit more than once because the topics of the course will differ substantially from semester to semester. Our MS requirements permit up to 3 credits within the 30-credit minimum for the degree.
Requisites: Graduate/professional standing
Course Designation: Grad 50% - Counts toward 50% graduate coursework requirement
Repeatable for Credit: Yes, unlimited number of completions
Last Taught: Spring 2025
Learning Outcomes: 1. Demonstrate curiosity for topics within their broader field but outside of their specific specialty
Audience: Graduate