MECHANICAL ENGINEERING (MECH)

Faculty

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Associate Professors: Craig E. Beal, M. Laura Beninati, Indranil Brahma, Christine M. Buffinton (Associate Co-chair)

Assistant Professors: James Arthur, José Madero Muñoz, William Scott, Andrew R. Sloboda, Jonathan Torres, Benjamin Wheatley

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The discipline of mechanical engineering is the branch of engineering that deals predominantly with the conversion, transmission and storage of mechanical and thermal energy; the generation, transmission and control of forces; the production and regulation of mechanical motion; and the optimal use of materials in the design and fabrication of the requisite machines and mechanisms.

Mission Statement

The Department of Mechanical Engineering is committed to providing the best undergraduate mechanical engineering education possible within the constraints of a four-year curriculum. In accord with the College of Engineering Mission Statement, the mechanical engineering department strives to nurture the intellectual, professional and personal development of its students. The mechanism for achieving the department's educational mission is the curriculum in mechanical engineering designed to satisfy its Program Educational Objectives. The department strives to achieve a process of continuous improvement of the curricula, to provide a faculty who are professionally current in their field and to maintain state-of-the-art facilities.

Program Educational Objectives

The Department of Mechanical Engineering seeks to prepare students to be successful in engineering or other careers, and to be recognized for qualities associated with their Bucknell educational experiences. Graduates of our program will:

- Develop innovative solutions to challenging problems consistent with professional expectations.
- Pursue advanced studies that supplement their Bucknell education and further their career.
- Demonstrate effective communication and an ability to contribute successfully in a multidisciplinary team.
- Make decisions by considering multiple factors including ethics, sustainability and societal impact.
- Advance professionally by accepting new responsibilities and demonstrating leadership potential.

It is our expectation that our graduates will have demonstrated significant progress toward a subset of these objectives within five years of graduation from Bucknell.

Student Outcomes

Graduates of the program shall demonstrate the following at the time of graduation:

1. An ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed using appropriate learning strategies.

The mechanical engineering program at Bucknell University is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (https://www.abet.org/).

Bachelor of Science in Mechanical Engineering

The **Bachelor of Science** in Mechanical Engineering requirements are:

First Year

First Semester	Credits	Second Semester	Credits
ENGR 099	0	MATH 202	1
ENGR 100	1	MECH 220	1
MATH 201	1	ENGR 214	1
PHYS 211	1	MECH 202	.5
W-1 course	1	Elective	1
	4		**4.5**

Sophomore

First Semester	Credits	Second Semester	Credits
CHEM 203[1]	1	MATH 212	1
MATH 211	1	MATH 227	1
MECH 213	1	MECH 353	1
ENGR 240	1	Elective	1
	4		**4**

Junior

First Semester	Credits	Second Semester	Credits
MECH 252	1	MECH 312	1
MECH 313	1	MECH 392	1
MECH 355	1	MECH 222	.5
ECEG 205	1	Two electives	2
	4		**4.5**

Senior

First Semester	Credits	Second Semester	Credits
MECH 401	.5	MECH 402	.5
MECH 403	1	Four electives	4
MECH 405	1		
Two electives	2		
	4.5		**4.5**

Total Credits: 34

[1] CHEM 203 General Chemistry for Engineers must be taken within the first two years.

The 11 elective courses shown above are distributed as follows:

- One full-credit science or math elective selected from any of the following:
    1. any full-credit, 200-level or 300-level courses in physics, astronomy, biology, chemistry or geology for which prerequisites have been satisfied;
    2. any of the following 100-level geology courses (must be taken within the first three years):
       GEOL 107 Global Change - Past and Present, GEOL 108 When Rocks Attack, GEOL 109 Energy and Natural Resources, GEOL 117 Environmental Geohazards
    3. MATH 245 Linear Algebra, MATH 280 Logic, Sets, and Proofs or any 300-level MATH course for which prerequisites have been met;
- Five elective courses selected from any of the following: social science courses, arts & humanities courses, university courses, residential college courses, or foundation seminars. These courses must include one course in arts & humanities and one course in social sciences. At a minimum, one course must also fulfill the college's global perspectives requirement.
- Three full-credit, 400-level MECH elective courses. One of these courses may be replaced with a) a course needed to fulfill a minor if the minor is otherwise not possible without an overload in the senior year, or b) an approved 400-level course in any department within the College of Engineering, for which the prerequisites have been met.
- Two courses in any department or program of the University.

MATH 212 Differential Equations and its prerequisite courses must be completed prior to the start of the junior year.

Three courses in each student's program must fulfill the University's writing requirement, which includes a W1 course taken in the first semester and two subsequent W2 courses.

Graduates of the program shall demonstrate the following student outcomes at the time of graduation:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety and welfare, as well as global, cultural, social, environmental and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Courses

MECH 151. Machining for Manufacturing Technology. 0 Credits.
Offered Fall Semester Only; Lecture hours:1,Other:2
Develop an understanding of the processes needed to produce manufactured parts. Emphasis on hands-on machining and fabrication.

MECH 202. Graphics for Design and Manufacture. .5 Credits.
Offered Spring Semester Only; Lecture hours:1,Lab:2
Graphical representation techniques for visualization and communication of mechanical engineering designs and concepts. Creation, storage, and manipulation of production drawings and 3-D geometric representations using state-of-the-art software. Introduction to fabrication through rapid prototyping tools.

MECH 205. Engineering Professionalism. .5 Credits.
Offered Either Fall or Spring; Lecture hours:1,Other:2
Ethical and professional responsibilities in engineering decision making. Consideration of the impact of engineering solutions in environmental, economic, global, and societal contexts.

MECH 213. Thermodynamics. 1 Credit.
Offered Fall Semester Only; Lecture hours:4
Thermodynamic principles including properties of substances, the first and second laws of thermodynamics, efficiencies, power and refrigeration cycles. Prerequisites: MATH 201 and ENGR 214 or permission of the department. Not open to students who have taken ENGR 200 or CHEG 310.

MECH 220. Mechanics. 1 Credit.
Offered Spring Semester Only; Lecture hours:4
Equilibrium of two-and three-dimensional rigid bodies and systems. Trusses, frames, and machines. Friction. Distributed forces and equivalent systems. Internal loads. Prerequisite: PHYS 211 and MATH 201 or permission of the instructor. Not open to students who have taken ENGR 221 or ENGR 229.

MECH 222. Introduction to Mechanical Engineering Lab Practice. .5 Credits.
Offered Spring Semester Only; Lecture hours:1,Lab:2
Sensors, measurement techniques for static and dynamic measurements, data processing, statistical data analysis, propagation of error, actuators and motors. Corequisite: MECH 222L. Prerequisites: MATH 202, ECEG 205, and ENGR 214.

MECH 252. Dynamics. 1 Credit.
Offered Fall Semester Only; Lecture hours:4
Kinematic and kinetic analysis of rigid bodies in planar motion. Absolute and relative analysis of displacements, velocities, and accelerations; force, energy, and momentum methods; analysis of mechanical vibrations; analytical and computer-simulated solution techniques. Prerequisites: MECH 220 and MATH 212.

MECH 285. Independent Study for Sophomores. .5-1 Credits.
Offered Either Fall or Spring; Lecture hours:Varies,Other:4; Repeatable
Independent investigation under the direction of a faculty member for students who have completed their first year. Sophomore standing in mechanical engineering and permission of the instructor.

MECH 302. Finite Elements in Analysis and Design. 1 Credit.
Offered Occasionally; Lecture hours:3,Lab:2
Introduction to finite element method (FEM) and commercial FEM software for design and analysis of mechanical components and thermal problems. Applications in mechanical and thermal component/system design. Co-Requisites: MECH 302L. Prerequisites: MECH 202 and MECH 353.

MECH 312. Heat Transfer. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Lab:2
Principles and engineering applications of heat transfer by conduction, convection, and radiation. Co-Requisites: MECH 312L. Prerequisite: MECH 313 or permission of the instructor.

MECH 313. Fluid Dynamics. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:2
Fundamentals of fluid dynamics including integral and differential control volume analysis, conservation equations, dimensional analysis, incompressible inviscid flows, internal and external viscous flows. Prerequisites: MATH 212, MECH 213, or permission of the department. Not open to students who have taken ENGR 222 or ENGR 233.

MECH 353. Solid Mechanics. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Lab:2
Analysis of stress, strain, and failure of engineering components under axial, torsional, flexural, and combined loading conditions. Introduction to stability of compression members, energy methods, and failure theory. Bridge to computational methods in solid mechanics.

MECH 355. Manufacturing Processes. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:2
Analytical and technological study of materials processing including deformation, solidification, material removal, plastics forming, and additive manufacturing methods. Laboratory fabrication projects and introduction to numerical control and CAD/CAM. Co-Requisite: MECH 355L. Prerequisites: ENGR 240 and MECH 202, or permission of instructor.

MECH 385. Independent Study for Juniors. .5-1 Credits.
Offered Either Fall or Spring; Lecture hours:Varies,Other:4; Repeatable
Independent investigation under the direction of a faculty member for students who have completed two years of study. Junior standing in mechanical engineering and permission of the instructor.

MECH 392. Mechanical Design. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Lab:2
Principles and techniques for creative design of machines in relation to specifications and user requirements. Design using a solid modeling CAD package. Co-Requisites: MECH 392L. Prerequisites: MECH 252 and MECH 353, or permission of the instructor.

MECH 401. Senior Design I. .5 Credits.
Offered Fall Semester Only; Lecture hours:2,Common Hour:2
Student teams design systems to solve open-ended problems with consideration of broad perspectives through the use of the design process, modeling and analysis, resource management, and documentation. Co-Requisite: MECH 401C. Prerequisites: MECH 312 and MECH 392, or permission of the instructor.

MECH 402. Senior Design II. .5 Credits.
Offered Spring Semester Only; Lecture hours:2,Common Hour:2
Student teams validate systems designed in MECH 401 with consideration of broad perspectives through modeling and analysis, fabrication, instrumentation, and testing. Professional practice in engineering and ethics. Design of experiments for design validation. Co-requisite: MECH 402C. Prerequisite: MECH 401.

MECH 403. Thermal Design. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:2
Design of thermal-fluid energy conversion systems; equipment selection; codes and standards; and economic analysis. Mini-design laboratories and design projects. Co-Requisites: MECH 403L. Prerequisites: MECH 312.

MECH 405. System Dynamics. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:2
Modeling and analysis of dynamic systems consisting of mechanical, electrical, and fluid elements. Frequency response methods. Sampled data systems. Experimental system identification. Co-Requisites: MECH 405L. Prerequisites: MATH 212, MECH 222, MECH 252, and ECEG 205.

MECH 420. Solar Energy Conversion. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Fundamental aspects of the design and operation of solar energy conversion systems including photovoltaics, solar thermal power, solar heating and chemical fuel production. Prerequisite: MECH 312 or permission of the instructor. Crosslisted as MECH 620.

MECH 422. Renewable Energy Conversion. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:4
Current energy demands, environmental effects, renewable energy resources, includes solar, wind, tidal, ocean thermal, wave energies; clean coal, nuclear energy, smart grid technology. Prerequisites: CHEG 200 or ENGR 200 or MECH 213 or permission of instructor. Crosslisted as MECH 622.

MECH 424. Internal Combustion Engines. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Description of internal combustion engines, methods of evaluating performance, the thermodynamics of combustion, engine testing, and design. Prerequisite: MECH 312 or permission of instructor. Crosslisted as MECH 624.

MECH 433. Advanced Fluid Mechanics. 1 Credit.
Offered Occasionally; Lecture hours:4
Kinematics of fluid flow. Conservation equations. Viscous flow. Turbulent flow (description, statistics, equations, physics, modeling, boundary layers, analyses). Selected applied topic(s) e.g. design applications of computational fluid dynamics, reservoir flow. Selected laboratory projects. Prerequisite: MECH 313 or equivalent, or permission of the instructor. Crosslisted as MECH 633.

MECH 435. Aerodynamics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Two-dimensional flow theory; vortex and momentum theories of finite wings; viscous flows, boundary layers and drag; high lift devices. Prerequisites: MECH 313 or equivalent and permission of the instructor. Crosslisted as MECH 635.

MECH 451. Vibration Analysis. 1 Credit.
Offered Occasionally; Lecture hours:4
Damped and undamped vibrations in free and forced systems. Resonance conditions. Vibration measuring equipment. Multi-degree of freedom discrete systems. Continuous systems. Prerequisites: MECH 252 or MATH 212 or permission of the instructor. Crosslisted as MECH 651.

MECH 452. Advanced Dynamics. 1 Credit.
Offered Occasionally; Lecture hours:4
Kinematics and dynamics of particles and rigid bodies. Degrees of freedom. Partial velocities. Generalized active and inertia forces. Kane's equation. Lagrange's equation. Numerical simulation of motion. Prerequisites: MECH 252 and permission of the instructor. Crosslisted as MECH 652.

MECH 453. Robotics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
History, evolution, capabilities, and applications of robotic devices. Introduction to robot kinematics, dynamics, and control via mathematical and computational modeling approaches. Research into current topics in robotics. Prerequisites: MECH 252 or permission of the instructor. Crosslisted as MECH 653.

MECH 454. Vehicle Dynamics and Control. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Introduction to modeling of vehicles for analysis and control. Topics include tire models, handling response, stability control, suspension design, race tuning. Prerequisites: MECH 252 and MECH 353 and MECH 405 or permission of the instructor. Crosslisted as MECH 654.

MECH 460. Engineering Optimization. 1 Credit.
Offered Occasionally; Lecture hours:4
Mathematical representation and modeling of engineering decision-making problems. Applied methods of linear, nonlinear, discrete and global optimization. Numerical techniques for solving constrained and unconstrained problems. Prerequisites: ENGR 214, MATH 212, and MATH 245 or permission of the instructor. Crosslisted as MECH 660.

MECH 462. Computer Integrated Manufacturing. 1 Credit.
Offered Occasionally; Lecture hours:4
Issues of integrated information and advanced machinery in modern manufacturing systems. In-depth study of solid modeling. Study of the effects of the integration of computers in manufacturing, via topics such as control of manufacturing processes, quality control, process planning, assembly, additive manufacturing, etc. Prerequisite: MECH 355 or permission of instructor. Crosslisted as MECH 662.

MECH 463. Introduction to Mechatronics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
This multidisciplinary course is the synergistic integration of mechanical engineering with electronic and computer engineering. This course will study actuators, drive systems, sensors, controllers, micro- controllers programming and interfacing, and automation systems integration. Prerequisites: ENGR 214, and ECEG 205 or PHYS 235, or permission of the instructor. Crosslisted as MECH 663 and ECEG 463 and ECEG 663.

MECH 464. Mechanism Design. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Design of traditional and compliant mechanisms. Topics include kinematics, analytical and graphical synthesis methods, and topics in research. Prerequisites: MECH 392 and permission of the instructor. Crosslisted as MECH 664.

MECH 465. Advanced Mechanics of Solids. 1 Credit.
Offered Occasionally; Lecture hours:4
Fundamentals of the theory of elasticity and plasticity. Classical methods for solution of problems, thermal stress, plate bending torsion, residual stress, plastic collapse. Numerical analysis in plasticity. Prerequisite: permission of the instructor. Crosslisted as MECH 665.

MECH 466. Applied Fracture Mechanics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Fundamentals of fracture mechanics and its applications to the design of damage tolerant structures. Case studies in the fields of aerospace, pressure, vessels, rotating machinery, railroads, etc. Illustrating fracture mechanics principles in design. Prerequisite: permission of the instructor. Crosslisted as MECH 666.

MECH 467. Finite Element Methods. 1 Credit.
Offered Occasionally; Lecture hours:3,Other:2
Fundamental theory and applications for civil and mechanical engineering. Multidimensional elements, and axisymmetric elements, and their formulations; stress recovery techniques; modeling considerations; convergence criteria and error estimates, includes use of commercial and developmental finite element analysis programs. Prerequisites: CEEG 401 or MECH 302 and permission of the instructor. Crosslisted as CEEG 408 and CEEG 608.

MECH 470. Engineering Composite Materials. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Fundamental composite mechanics, including micromechanics and laminated plate theory. Design and analysis of composite structures; composite manufacturing techniques; current research topics in composite area. Prerequisites: ENGR 240 and MECH 353 or permission of the instructor. Crosslisted as MECH 670.

MECH 471. Soft Tissue Mechanics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Introduction and application of tissue-scale biomechanics and advanced solid mechanics theories. Implementation of materials testing and computational modeling to characterize the behavior of orthopaedic soft tissues, with an emphasis on structure-function mechanisms. Specific course content includes material anisotropy, nonlinearity, viscoelasticity, biphasic behavior, damage, and microstructural imaging. Prerequisite: MECH 353. Crosslisted as MECH 671.

MECH 473. Materials Characterization. 1 Credit.
Offered Occasionally; Lecture hours:4
Theory and practice of materials characterization techniques including phase identification, mechanical testing, and various forms of microscopy. Prerequisite: ENGR 240 or permission of instructor. Crosslisted as MECH 673.

MECH 476. Biomechanics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Principles of mechanics applied to biological systems. Background in anatomy, physiology, and cell biology will be presented. Mechanical behavior of hard and soft biological materials. Topics in cellular, cardiovascular, musculoskeletal, implant, and sport/motion biomechanics. Prerequisite: MECH 353 or permission of the instructor. Crosslisted as MECH 676.

MECH 484. Machine Learning for Engineering Systems. 1 Credit.
Offered Either Fall or Spring; Lecture hours:4
Machine Learning is a branch of Artificial Intelligence (AI). This course focuses on system modeling and optimization using established machine learning tools such as neural networks and genetic algorithms. MATLAB based. Prerequisite: ENGR 214 or equivalent, or permission of the instructor. Crosslisted as MECH 684.

MECH 485. Advanced Engineering Problems. .25-1 Credits.
Offered Either Fall or Spring; Lecture hours:Varies,Other:4; Repeatable
An investigation under the direction of a faculty member. Senior-level topics not covered in other courses may be studied in this course. Prerequisites: Senior standing in mechanical engineering and permission of the instructor.

MECH 495. Advanced Topics in Engineering Mathematics. 1 Credit.
Offered Fall Semester Only; Lecture hours:4
Linear algebra and analytical/computational techniques for solving ordinary and partial differential equations relevant to engineering applications. Crosslisted as CEEG 495 and CHEG 495 and MECH 495 and ENGR 695 and ECEG 495 and ECEG 695. Prerequisite: permission of the instructor.