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Vision

We, the Elmer W. Engstrom Department of Engineering, seek to honor the Lord Jesus Christ in every endeavor and earnestly desire to cultivate engineers who are committed to moral excellence and who are exemplary in character, conduct, and skill. Therefore, we strive to provide an excellent educational environment that will nurture our students to honor the Lord in all things and help them to grow in spiritual maturity, wisdom, knowledge, and expertise for purposeful lives of service.

Program Distinctives

The Cedarville University engineering program blends the academic subjects required of all accredited engineering programs with "hands-on" experience through extensive laboratory work and design project opportunities. Our curriculum introduces freshmen to 3-D Solid Modeling in the Computer Aided Engineering Graphics course and digital electronics in the Digital Logic Design course. This provides students with practical experience and early insight into subsequent theory.

Our program enjoys the rich technical environment in the surrounding community by providing frequent opportunities for interaction with engineers working on the latest aerospace, automotive, and electronics technology. Many companies are recognizing the excellent performance of our students in the workplace and provide summer internships and employment after graduation. Engineering students are encouraged to join professional societies and participate in one of the many extracurricular national and international design competition projects sponsored by the department.

Career Opportunities

Engineers are in leadership positions in a variety of settings. They work at all stages of developing ideas into products: research, development, design, construction, production, operations, marketing, sales, and management. In this era of rapid technological change, an engineering education serves our society well. In the decades ahead, society's needs and problems—such as communications, computers, energy sources, transportation, manufacturing, research, and preservation of the environment—will call for engineering contributions on a scale not previously experienced.

Programs of Study

The Department of Engineering offers two programs of study which lead to the Bachelor of Science in Electrical Engineering (B.S.E.E.) degree and the Bachelor of Science in Mechanical Engineering (B.S.M.E.) degree.

Students interested in studying engineering but uncertain of the specific engineering major have until the fall quarter of the sophomore year to choose electrical or mechanical engineering as a major. The curriculum of each program is designed so that all engineering students take the same courses during the first three quarters. Faculty advisors, the Career Services Office, and engineering field trips represent some of the resources available to students contemplating which engineering major to choose.

First year engineering students develop and apply their design skills making cardboard canoes and racing them across Cedar Lake during Homecoming Weekend.

Accreditation and Licensure

National

The B.S.E.E. and B.S.M.E. programs are accredited by the Engineering Accreditation Commission (EAC) of the Accreditation Board for Engineering and Technology (ABET).

State

The B.S.E.E. and B.S.M.E. programs have full approval by the Ohio Board of Regents.

Registration

Seniors and graduates are eligible to take the NCEES Fundamentals of Engineering (FE) Examination offered by the Ohio Society of Professional Engineers. This exam is the first of two required to become a registered professional engineer and is offered each spring at Cedarville University. Cedarville students have a passing rate that exceeds 90%, which is higher than the state and national averages. In the Spring of 1998, Cedarville was the only engineering school in Ohio to have a 100% passing rate.

Engineering Advisory Board

The Engineering Advisory Board consists of professional engineers, researchers, and business leaders representing a variety of engineering related businesses. Through annual meetings, these experts advise the University and evaluate its plans for building upon Cedarville's reputation for excellence in undergraduate engineering education. Board members include:

Eugene Apple, General Electric Corporation, retired
Ronald Baker, GE Aircraft Engines
Carl Bertsche, Jr., Production Engineering Company
James Brandeberry, Wright State University
Robert Bremer, Jr., Cedar Ridge Community Church
Gary Clasby, Duriron Company, Incorporated
Donald Copland, Procter and Gamble Company, retired, ANOVA Limited
Harry Couch, Delco Products Division GMC
Kevin Crawford, Dayton Power and Light
Tom Curran, WPAFB, Aero Propulsion and Power, retired
Jerry Drobinski, Global Development
James Engelman, Delphi Energy and Engine Management, retired
William Engstrom, Engstrom Foundation
Dennis Ferrigno, Bateman Engineering, Incorporated
Stephen Harris, Rixan Associates
Dennis Hess, Ameritech
Carole Holmes, Holmes and Mays
Richard Holmes, Holmes and Mays
Phillip Houston, Greene County Department of Development
Dan Kerr, GM Specialty Cars Division
Frank Klatt, Rockwell International, retired
Tim Lawrence, Ball Aerospace
Joe Mays, Holmes and Mays
Walker Mitchell, Mitchell Consulting
Rolan Polsdorfer, Cedarville University
Fritz Russ, Russ Venture Group, Incorporated
Brian Schlake, Prince Corporation
Terry Smith, Rittal Corporation
Ted Tate, Tate Model and Engineering, Incorporated
Jay Tieber, Ohio Department of Development
Ron Weber, Lowrance Electronics, Incorporated
Walt Weisel, Robotic Workspace Technologies
Bryan Williams, Procter and Gamble
Riad Yammine, Speedway/Super America, retired
Edwin Young, University of Michigan

Department Academic Requirements

New students

Students who enjoy and excel in science and mathematics have the highest potential for careers as engineers. Entering students are required to have an ACT composite score of at least 22 (or an SAT of at least 1010) in order to declare an engineering major. Students who do not meet this standard or do not demonstrate equivalent competency may request admission to the department on a provisional status.

To prepare for engineering, high school students should take a college preparatory curriculum that includes:

4 units of English
4 units of mathematics (algebra, geometry, trigonometry, and advanced mathematics or precalculus)
4 units of science (physical science, biology, chemistry, and physics)
3 units of social science
2 units of a single foreign language

Students should take electives in computers and learn a programming language such as BASIC, VisualBasic, PASCAL, C, C++, or FORTRAN. Experience with spreadsheets and word processors is also helpful.

Retention Requirement

Engineering majors must earn a cumulative grade point average of 2.0 and a grade point average of 2.0 in their engineering and cognate courses by the end of their sophomore year (prior to completing 109 quarter hours specified in the engineering curriculum) in order to advance into the junior year.

Graduation Requirements

1. Earn a cumulative grade point average of 2.0 or above in all engineering and cognate courses.
2. Take an assessment exam similar to the Fundamentals of Engineering Examination.
3. Meet specific University graduation requirements.

As chairman of the Department of Engineering, Dr. Larry Zavodney provides capable leadership and direction to the program.

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Engineering Honors Program

The **engineering honors program** is designed to challenge exceptional students and encourage them to reach their highest possible potential. Because the program is integrated with the university's honors program, students who wish to participate must first be admitted into the university honors program; the details are listed in the Interdisciplinary Studies section of the catalog. Admission can occur in either the freshman or sophomore year. Admission to the engineering honors program occurs after the student completes the sophomore year. A cumulative GPA of 3.5 or above is required for participation. Once admitted, failure to enroll in an engineering honors course will terminate the program.

Engineering coursework involves taking the honors version of four courses and one additional engineering elective course. Though scheduled and taken with other students, these engineering honors courses involve enrichment opportunities and exposure to advanced topics through special assignments and sessions.

Course requirements for the **engineering honors program** include:

HON-101,102, and 103 (substitutes for HUM-140, and one HIST elective) 15
ENGR-480* Professional Ethics 4
One additional 400-level engineering elective 3
Requirements for electrical engineering majors include:
ENGR-312* Electronics II 5
ENGR-316* Microprocessors 4
ENGR-432* Communications Theory 5
Requirements for mechanical engineering majors include:
ENGR-341* Properties of Material 4
ENGR-360* Fluid Mechanics 5
ENGR-374* Kinematics 4
*Engineering honors students register for section H

Students who earn a "B" or above in HON-101, 102, and 103, earn a "B" or above in all engineering honors courses, and graduate with a cumulative GPA of 3.5 or higher will earn the "engineering honors graduate" designation.

Engineering laboratories are equipped with advanced technical equipment, enabling students to practice and demonstrate their skills.

Faculty

Lawrence Zavodney, *Chairman:* Professor of Mechanical Engineering. *Education:* B.S.M.E., The University of Akron, 1974; M.S.M.E., The University of Akron, 1977; Ph.D., Virginia Polytechnic Institute and State University, 1987; registered professional engineer. At Cedarville since 1992.

Tom Wailes, Associate Professor of Electrical Engineering and Assistant to the Chair. *Education:* B.S., United States Air Force Academy, 1977; M.S., Air Force Institute of Technology, 1983; Ph.D., Purdue University, 1992. At Cedarville since 1997.

Charles Allport, Assistant to the Academic Vice President; Associate Professor of Mechanical Engineering. *Education:* B.S., United States Air Force Academy, 1962; M.A., George Washington University, 1963; M.S.E., Arizona State University, 1965; registered professional engineer. At Cedarville since 1990.

Robert Chasnov, Associate Professor of Mechanical Engineering. *Education:* B.S., Rensselaer Polytechnic Institute, 1978; M.S., University of Illinois, 1980; Ph.D., University of Illinois, 1983. At Cedarville since 1991.

Timothy Dewhurst, Associate Professor of Mechanical Engineering. *Education:* B.S.M.E., Cornell University, 1980; M.Eng.M., Cornell University, 1981; Ph.D., Cornell University, 1985. At Cedarville since 1996.

Keith Francis, Associate Professor of Electrical Engineering. *Education:* B.S.E.E., United States Air Force Academy, 1976; M.Eng.E., Cornell University, 1984; Ph.D. Electrical Engineering, University of Dayton, 1997. At Cedarville since 1991.

Harwood Hegna, Associate Professor of Mechanical Engineering. *Education:* B.S.A.E., University of Minnesota, 1969; M.S.A.E., University of Minnesota, 1971; M.S.M.E., University of Minnesota, 1973; Ph.D., Air Force Institute of Technology, 1981; registered professional engineer. At Cedarville since 1992.

Jay H. Kinsinger, Adjunct Instructor of Mechanical Engineering and Mechanical Engineering Technician. *Education:* B.S., Mechanical Engineering and Manufacturing Engineering Technologies, University of Dayton, 1993; M.S., Rehabilitation Engineering, Wright State University, 2000. At Cedarville since 1999.

Clint Kohl, Assistant Professor of Electrical Engineering. *Education:* B.S.E.E., South Dakota State University, 1988; M.S.E.E., University of North Dakota, 1990; Ph.D., Iowa State University, 1992. At Cedarville since 1994.

Robert Laramore, Associate Professor of Electrical Engineering. *Education:* B.S.E.E., University of Missouri at Rolla, 1973; M.S.E.E., University of Missouri at Rolla, 1975; registered professional engineer. At Cedarville since 1992.

Thomas Thompson, Assistant Professor of Mechanical Engineering. *Education:* B.S.M.E., University of Nebraska-Lincoln, 1984; M.S.M.E., University of Nebraska-Lincoln, 1986; Ph.D., Iowa State University, 1995; registered professional engineer. At Cedarville since 1995.

Sam SanGregory, Assistant Professor of Electrical Engineering. *Education:* B.S.E. Wright State University, 1988; M.S.C.E. Air Force Institute of Technology, 1992; Ph.D., Air Force Institute of Technology, 1999. At Cedarville since 1993.

D. Jeff Shortt, Associate Professor of Electrical Engineering. *Education:* B.S.E.E., Virginia Polytechnic Institute and State University, 1974; M.S.E.E., Virginia Polytechnic Institute and State University, 1979; Ph.D., Virginia Polytechnic Institute and State University, 1982. At Cedarville since 1996.

Technical Support Staff

David Denlinger, Mechanical Engineering Technician. At Cedarville since 1993.

Jonathan Gain, Electrical Engineering Technician. *Education:* B.S.E.T., LeTourneau University, 1968. At Cedarville since 1992.

Electrical Engineering

Course requirements for the B.S.E.E. degree are comprised of the following and may be modified by the department chairman.

Course requirements involve 100 quarter hours including:

ENGR-101 Introduction to Engineering Design 3
ENGR-102 Introduction to Engineering Design Lab 0
ENGR-171 Introduction to Engineering Graphics 3
ENGR-191 Digital Logic Design 4
ENGR-274 Mechanics I-Statics 4
ENGR-275 Mechanics II-Dynamics 5
ENGR-280 "C" Programming 3
ENGR-302 Circuits I 4
ENGR-303 Circuits II 4
ENGR-311 Electronics I 5
ENGR-312 Electronics II 5
ENGR-316 Microprocessors 4
ENGR-318 Linear Systems 5
ENGR-321 Electronics Laboratory I 1
ENGR-322 Electronics Laboratory II 1
ENGR-333 Electromagnetics 5
ENGR-347 Feedback Control Systems 5
ENGR-351 Thermodynamics I 4
ENGR-421 Electrical Design 4
ENGR-422 Electrical Design Laboratory 3
ENGR-432 Communications Theory 5
ENGR-461 Senior Design I 5
ENGR-462 Senior Design II 5
[1]ENGR-480 Professional Ethics 4
ENGR-495 Senior Seminar 0
Electrical engineering electives, two 300- or 400-level courses 6
One 400-level elective course 3

Additional required cognates:

CHEM-158 Chemistry for Engineers 5
[2]MATH-281,282,283 Analytic Geometry/Calculus I, II, III 15
MATH-387 Differential Equations 5
MATH-388 Advanced Calculus I 5
[3]PHYS-271,272,273 General Physics I, II, III 15
Mathematics elective 5

Chosen from ENGR-320 Probability and Random Process for Engineers, MATH-374 Complex Variables, or MATH-394 Linear Algebra.

[1]satisfies humanities General Education Requirement
[2]satisfies mathematics General Education Requirement
[3]satisfies physical science General Education Requirement

Electrical Engineering Major Curriculum Summary

Proficiency requirements 0-13
Other General Education Requirements 66-71
Electrical Engineering requirements 100
Additional required cognates 50
Total (minimum, not including proficiency) 216

A complete description of the General Education Requirements is found on page 30.

Suggested Four-Year Curriculum for a Major in Electrical Engineering

First year:

BEGE-171 The Christian Life 4
BEGE-172 Introduction to Bible Study 4
CHEM-158 Chemistry for Engineers 5
COM-110 Fundamentals of Speech 5
ENG-110 Composition I 5
ENG-140 Composition II 5
ENGR-101 Introduction to Engineering Design 3
ENGR-102 Introduction to Engineering Design Lab 0
ENGR-171 Introduction to Engineering Graphics 3
ENGR-191 Digital Logic Design 4
MATH-281,282,283 Calculus I, II, III 15
PEF-199 P.A.C.L. 2
PHYS-271 General Physics I 5
Total 60

Second year:

BEGE-273 Old Testament Survey 4
BEGE-274 New Testament Survey 4
ENGR-274 Mechanics I-Statics 4
ENGR-275 Mechanics II-Dynamics 5
ENGR-280 "C" Programming 3
ENGR-302 Circuits I 4
ENGR-303 Circuits II 4
HUM-140 Introduction to the Humanities 5
MATH-388 Advanced Calculus I 5
MATH-387 Differential Equations 5
PHYS-272,273 General Physics II, III 10
Total 53

Third year:

BEGE-375 God and History 4
BEGE-376 God and the Church 4
ENGR-311,312 Electronics I, II 10
ENGR-316 Microprocessors 4
ENGR-318 Linear Systems 5
ENGR-321,322 Electronics Laboratory I, II 2
ENGR-333 Electromagnetics 5
ENGR-432 Communications Theory 5
GSS-100 Foundations of Social Science 5
Engineering elective 3
History elective 4
Mathematics elective 5
Total 56

Fourth year:

ENGR-347 Feedback Control Systems 5
ENGR-351 Thermodynamics I 4
ENGR-421 Electrical Design 4
ENGR-422 Electrical Design Laboratory 3
ENGR-461,462 Senior Design I, II 10
ENGR-480 Professional Ethics 4
ENGR-495 Senior Seminar 0
Biology elective 5
Engineering electives 6
Literature elective 5
Physical Education elective 1
Social Science/Global Awareness elective 5
Total 52

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Mechanical Engineering

Course requirements for the B.S.M.E. degree are comprised of the following and may be modified by the department chairman.

Course requirements involve 105 quarter hours including:

ENGR-101 Introduction to Engineering Design 3
ENGR-102 Introduction to Engineering Design Lab 0
ENGR-171 Introduction to Engineering Graphics 3
ENGR-191 Digital Logic Design 4
ENGR-221 FORTRAN Programming 2
ENGR-250 Numerical Methods in Engineering 4
ENGR-274 Mechanics I-Statics 4
ENGR-275 Mechanics II-Dynamics 5
ENGR-276 Mechanics III-Strength of Materials 4
ENGR-290 Engineering Economy 2
ENGR-302 Circuits I 4
ENGR-310 Electronics and Instrumentation 4
ENGR-337 Principles of Automatic Control 4
ENGR-341 Properties of Engineering Materials 4
ENGR-351 Thermodynamics I 4
ENGR-352 Thermodynamics II 4
ENGR-360 Fluid Mechanics 5
ENGR-365 Heat Transfer 4
ENGR-374 Kinematics and Design of Machines 4
ENGR-381 Mechanical Engineering Laboratory I 3
ENGR-382 Mechanical Engineering Laboratory II 3
ENGR-425 Mechanical Design 4
ENGR-461 Senior Design I 5
ENGR-462 Senior Design II 5
ENGR-471 Electrical Machines 4
[1]ENGR-480 Professional Ethics 4
ENGR-495 Senior Seminar 0
Mechanical engineering electives, two 300- or 400-level courses 6
One 400-level elective course 3

Additional required cognates:

CHEM-158 Chemistry for Engineers 5
[2]MATH-281,282,283 Analytic Geometry/Calculus I,II,III 15
MATH-387 Differential Equations 5
MATH-388 Advanced Calculus I 5
[3]PHYS-271,272,273 General Physics I,II,III 15

[1]satisfies humanities General Education Requirement
[2]satisfies mathematics General Education Requirement
[3]satisfies physical science General Education Requirement

Mechanical Engineering Major Curriculum Summary

Proficiency requirements 0-13
Other General Education Requirements 66-71
Mechanical Engineering requirements 105
Additional required cognates 45
Total (minimum, not including proficiency) 216

A complete description of the General Education Requirements is found on page 30.

Suggested Four-Year Curriculum for a Major in Mechanical Engineering

First year:

BEGE-171 The Christian Life 4
BEGE-172 Introduction to Bible Study 4
CHEM-158 Chemistry for Engineers 5
COM-110 Fundamentals of Speech 5
ENG-110 Composition I 5
ENG-140 Composition II 5
ENGR-101 Introduction to Engineering Design 3
ENGR-102 Introduction to Engineering Design Lab 0
ENGR-171 Introduction to Engineering Graphics 3
ENGR-191 Digital Logic Design 4
MATH-281,282,283 Calculus I, II, III 15
PEF-199 P.A.C.L. 2
PHYS-271 General Physics I 5
Total 60

Second year:

BEGE-273 Old Testament Survey 4
BEGE-274 New Testament Survey 4
ENGR-221 FORTRAN Programming 2
ENGR-250 Numerical Methods in Engineering 4
ENGR-274 Mechanics I-Statics 4
ENGR-275 Mechanics II-Dynamics 5
ENGR-276 Mechanics III-Strength of Materials 4
ENGR-290 Engineering Economy 2
ENGR-302 Circuits I 4
MATH-387 Differential Equations 5
MATH-388 Advanced Calculus I 5
PHYS-272,273 General Physics II, III 10
Physical Education elective 1
Total 54

Third year:

BEGE-376 God and the Church 4
ENGR-310 Electronics and Instrumentation 4
ENGR-341 Properties of Engineering Materials 4
ENGR-351,352 Thermodynamics I, II 8
ENGR-360 Fluid Mechanics 5
ENGR-365 Heat Transfer 4
ENGR-374 Kinematics and Design of Machines 4
ENGR-381,382 Mechanical Engineering Laboratory I, II 6
GSS-100 Foundations of Social Science 5
HUM-140 Introduction to the Humanities 5
Engineering elective 3
Total 52

Fourth year:

BEGE-375 God and History 4
ENGR-337 Principles of Automatic Control 4
ENGR-425 Mechanical Design 4
ENGR-461,462 Senior Design I, II 10
ENGR-471 Electrical Machines 4
ENGR-480 Professional Ethics 4
ENGR-495 Senior Seminar 0
Biology elective 5
Engineering electives 6
History elective 5
Literature elective 5
Social Science/Global Awareness elective 5
Total 56

Course Descriptions

ENGR-101 Introduction to Engineering Design—A **3 hours**
Introduction to the basic concepts and skills necessary for effective functioning as a Christian engineer; participation in group activities; design problems introducing the profession and history of engineering; introduction to ethical and moral issues in the application of engineering principles. Introduction to computer applications. Term project introduces Christian heritage in science and engineering. Two lectures per week. *Corequisite: ENGR-102 Introduction to Engineering Design Lab.* (Fee: $25)

ENGR-102 Introduction to Engineering Design Lab—A **0 hours**
Introduction to electrical and mechanical engineering laboratory for students enrolled in ENGR-101 Introduction to Engineering Design. Students conduct experiments in probability, commercial computational software packages, strength of materials and instrumentation, soldering, VLSI design, product disassembly, and other related areas. Team design project required. Weekly 90-minute lab. *Corequisite: ENGR-101 Introduction to Engineering Design.*

ENGR-171 Introduction to Engineering Graphics—A,W,Sp **3 hours**
Introduction to using a microcomputer system and commercial software to create engineering drawings; basic techniques of drawing, editing, dimensioning, multiple views, sectioning, multiview projections, pictorial views, two- and three-dimensional modeling. Introduction to solid modeling. (Fee: $20)

ENGR-191 Digital Logic Design—W,Sp **4 hours**
Introduction to the fundamentals of digital logic design, number systems, Boolean Algebra, Karnaugh maps, computer simulation tools, combinational network design, flip flops, counters, state machines, sequential networks; circuits are designed in class and are built and evaluated in the laboratory. Three lectures and one two-hour laboratory per week. (Fee: $20)

ENGR-196 Competition Project—Sp **0 hours**
Engineering Freshmen on an Engineering Department Intercollegiate Design Competition may use this course to provide on their transcript a record of their participation throughout the year. The name of the competition will be designated.

ENGR-221 FORTRAN Programming—Sp **2 hours**
Introduction to computer programming techniques using FORTRAN 77, application to science and engineering problems. *Prerequisite: familiarity with algebraic expressions.*

ENGR-250 Numerical Methods in Engineering—Sp **4 hours**
Introduction to the computational methods for solving transcendental equations, ordinary differential equations, integration, and linear algebra; introduction to finite-difference, approximations, and least-squares curve fits. *Prerequisite: MATH-388 Advanced Calculus I; MATH-387 Differential Equations. Corequisite: ENGR-221 FORTRAN Programming or instructor's permission.*

Sophomore Dynamics students compete for the prize by building the lightest-weight structure to catch a baseball dropped from the second floor while a packed crowd watches intently.

ENGR-274 Mechanics I-Statics—A,W **4 hours**
Introduction to the analysis of forces in isolated and connected rigid-body systems; vector analysis, forces, moments, resultants, two- and three-dimensional equilibrium, centroids, moment of inertia, friction, trusses, frames, and machines. Design project required. *Prerequisite: ENGR-171 Introduction to Engineering Graphics; PHYS-271 General Physics I; MATH-282 Analytical Geometry and Calculus II.* (Fee: $10)

ENGR-275 Mechanics II-Dynamics—W **5 hours**
Introduction to the kinematic and kinetic analysis of particles, systems of particles, and rigid bodies; position, velocity, acceleration, frames of reference; Newton's laws, work, energy, impulse, momentum; conservative and non-conservative systems; vibration of single-degree-of-freedom systems. Design project required. *Prerequisite: ENGR-274 Mechanics I.* (Fee: $10)

ENGR-276 Mechanics III-Strength of Materials—Sp **4 hours**
Introduction to the theoretical and experimental analysis of deformable bodies to applied loads; normal and shearing stress and strain, energy, torsion, flexure, deflection, combined stress, failure theories, and columns. Three lectures and one two-hour laboratory per week. Design project required. *Prerequisite: ENGR-274 Mechanics I.* (Fee: $5)

ENGR-280 "C" Programming—Sp **3 hours**
Introduction to the "C" programming language; algorithms, data structures, unique capabilities, application to science and engineering problems.

ENGR-290 Engineering Economy—Sp **2 hours**
Introduction to the time value of money and equivalence, discounted cash flow analysis, break-even and payback analysis, economic analysis of engineering alternatives for justification of mechanical designs, machine procurement and assembly processes; issues in corporate accounting practices; depreciation and inflation accounting, cost control and budgeting; overhead cost and their application; cost estimation; sources and use of funds; make or buy decisions.

ENGR-296 Competition Project—Sp **0 hours**
Engineering Sophomores on an Engineering Department Intercollegiate Design Competition may use this course to provide on their transcript a record of their participation throughout the year. The name of the competition will be designated.

Electrical and mechanical engineering students in the vibrations course conduct an experiment on a model of a multistory building. Dr. Larry Zavodney, chairman of the Department of Engineering, observes the demonstration.

ENGR-302 Circuits I—W, Sp **4 hours**
Introduction to basic circuit analysis using Ohm's law, Kirchoff's laws, independent and dependent sources, Thévenin and Norton equivalency and source transformations, transient responses in RC and RL circuits; phasor analysis of RLC circuits, power in AC circuits, introduction to 3-phase; computer simulations and bread-board circuits are designed and tested. Three lectures and one two-hour laboratory per week. Design project required. *Prerequisite: PHYS-272 General Physics II; MATH-387 Differential Equations.* (Fee: $20)

ENGR-303 Circuits II—Sp **4 hours**
Introduction to the phasor analysis of RLC circuits, mutual inductance, frequency response of operational amplifier circuits, Fourier and Laplace Transforms, Laplace Circuits, and introduction to transfer functions. Computer simulations and bread-board circuits are constructed and evaluated in the laboratory. Design project required. Three lectures and one two-hour laboratory per week. *Prerequisite: ENGR-302 Circuits I.* (Fee: $30)

ENGR-310 Electronics and Instrumentation—A **4 hours**
Introduction to voltmeters, analog and digital oscilloscopes, characteristics of amplifiers, operational amplifiers, characteristics of active and passive filters, Fourier Analysis of signals, PC-based data acquisition, and transducers and conditioning circuits to measure force, acceleration, velocity, displacement, temperature, and strain. Three lectures and one three-hour laboratory per week. *Prerequisite: ENGR275 Mechanics II-Dynamics; ENGR-276 Mechanics III-Strength of Materials; ENGR-302 Circuits I.* (Fee: $20)

ENGR-311 Electronics I—W **5 hours**
Introduction to the analysis of semiconductor electronic devices and their applications; operational amplifiers, diodes, bipolar-junction and field-effect transistors. *Corequisite:* ENGR-321 Electronics Laboratory I. *Prerequisite: ENGR-303 Circuits II.*

ENGR-312 Electronics II—Sp **5 hours**
Continuation of ENGR-311 Electronics I to include frequency response of amplifier circuits, multi-stage and power transistor amplifiers, feedback, power supplies, filters, and oscillators. *Prerequisite: ENGR-311 Electronics I. Corequisite: ENGR-322 Electronics Laboratory II.*

ENGR-315 Power Electronics—Sp **3 hours**
Introduction to the fundamentals of power electronics, characteristics and application of semiconductor switches, and device applications. Design project required. *Prerequisite: ENGR-311 Electronics I; ENGR-321 Electronics Laboratory I.* (Fee: $15) (odd years)

ENGR-316 Microprocessors—A **4 hours**
Introduction to microprocessor characteristics, assembly language, memory layouts, peripheral devices, microcomputer structures, interface design, control and data communications. Three lectures and one two-hour laboratory per week. Design project required. *Prerequisite: ENGR-191 Digital Logic Design.* (Fee: $30)

ENGR-318 Linear Systems—A **5 hours**
Introduction to linear time-invariant analysis of continuous and discrete-time systems using both time and frequency domain methods that includes Fourier, Laplace, and Z transforms. *Prerequisite: ENGR-303 Circuits II.*

ENGR-319 Analog Filters—W **3 hours**
Introduction to theory, design, and how to implement passive and active analog filters; basic filter structures, passive network synthesis, operational amplifier limitations, multiple-amplifier filters, and filter realization methods. *Prerequisite*: *ENGR-318 Linear Systems.* (odd years)

ENGR-320 Probability and Random Processes for Engineers—Sp **5 hours**
Introduction to sample points, sample spaces, probability, random variables, random vectors, statistical averages, linear transformations, spectral analysis and random processes. May be used to satisfy the mathematics elective requirement for electrical engineers. *Prerequisite*: *ENGR-318 Linear Systems.*

ENGR-321 Electronics Laboratory I—W **1 hour**
Laboratory applications of the Electronics I course; solid-state electronic devices, emphasis on bread-boarding, testing, analysis, synthesis, and reporting. One two-hour laboratory per week. *Prerequisite*: *ENGR-303 Circuits II. Corequisite: ENGR-311 Electronics I.* (Fee: $30)

The SAE Mini Baja Competition attracts over 100 teams from the Midwest every year. Cedarville students design and build a one-person all-terrain dune buggy-type car to compete in a variety of events.

ENGR-322 Electronics Laboratory II—Sp **1 hour**
Laboratory applications of the Electronics II course; design, analysis, bread-boarding, and testing of circuits discussed in lecture using bipolar junction and field-effect transistors. Design project required. One two-hour laboratory per week. *Prerequisite*: *ENGR-321 Electronics I Lab. Corequisite: ENGR-312 Electronics II.* (Fee: $30)

ENGR-333 Electromagnetics—A **5 hours**
Review of vector calculus; Maxwell's equations, propagation of uniform plane waves, transmission lines, Smith Chart, wave guides, Laplace's and Poisson's equations. Four lectures and one two-hour laboratory or recitation period per week. *Prerequisite*: *MATH-387 Differential Equations; MATH-388 Advanced Calculus I.* (Fee: $15)

ENGR-337 Principles of Automatic Control—A **4 hours**
Introduction to theoretical and experimental analysis of classical analog feedback control systems for mechanical engineers; modeling, transfer function formulation; frequency response, root locus, Bodé plots, stability and compensation design. Three lectures and one two-hour laboratory per week. Design project required. *Prerequisite*: *ENGR-302 Circuits I.*(Fee: $20)

ENGR-341 Properties of Engineering Materials—A **4 hours**
Introduction to the properties of metallic, ceramic, polymeric, and composite materials; plastic deformation, strengthening, fracture, fatigue, corrosion, diffusion, equilibrium and nonequilibrium processes, phase diagrams, and electrical and magnetic properties; application to materials selection. Three lectures and one three-hour laboratory per week. *Prerequisite*: *ENGR-276 Mechanics III-Strength of Materials.* (Fee: $30)

ENGR-342 Principles of Physical Metallurgy **3 hours**
Introduction to physical and mechanical properties of metals and alloys; crystal structure, phase equilibria, defects, strengthening mechanisms, and kinetics of reactions. *Prerequisite*: *ENGR-341 Properties of Engineering Materials.*

ENGR-343 Manufacturing Processes—W **3 hours**
Introduction to the contemporary materials processing: molding, casting, forming, machining, and hot and cold working; fundamentals of manufacturing, inspection techniques, and quality assurance. *Prerequisite*: *ENGR-341 Properties of Engineering Materials.*

ENGR-344 Plastic and Composite Materials **3 hours**
Introduction to properties and processing of plastics, resins, and adhesives; rheology, creep-deformation history, and injection molding. Fiber-reinforced, carbon-carbon, and metal-matrix composites are analyzed for strength, anisotropy, and applicability. *Prerequisite*: *ENGR-341 Properties of Engineering Materials*.

ENGR-347 Feedback Control Systems—A **5 hours**
Introduction to the analysis and design of analog feedback control systems; modeling, transfer functions, root locus, frequency response, Bodé plots, Nyquist Criterion; stability, robustness, compensator design for performance and robustness, PID, phase-lead, phase-lag, and lead-lag. Four lectures and one two-hour lab per week. Design project required. *Prerequisite*: *ENGR-318 Linear systems.* (Fee: $20)

ENGR-351 Thermodynamics I—A **4 hours**
Introduction to engineering thermodynamics; properties of pure substances, work, heat, first and second laws of thermodynamics, energy, enthalpy, and entropy. *Prerequisite*: *CHEM-158 Chemistry for Engineers; PHYS-272 General Physics II.*

ENGR-352 Thermodynamics II—W **4 hours**
Continuation of ENGR-351 with specific application to power, refrigeration cycles, and combustion processes. *Prerequisite*: *ENGR-351 Thermodynamics I; MATH-388 Advanced Calculus I.*

ENGR-353 Internal Combustion Engines—Sp **3 hours**
Introduction to the development and design of piston engines and turbines, special design of combustion chambers, valve mechanisms, dynamic balancing, and alternative fuels. *Prerequisite*: *ENGR-275 Mechanics II-Dynamics; ENGR-352 Thermodynamics II.*

ENGR-356 VHSIC Hardware Description Language—A **3 hours**
Design, testing, and verification of combinational logic circuits and finite-state machines using the VHSIC Hardware Description Language (VHDL); top-down design methodology beginning with purely behavioral description broken down into a structural description using basic logic gates. Three lectures and one one-hour laboratory per week. *Prerequisite*: *ENGR-191 Digital Logic Design and ENGR-221 FORTRAN, ENGR-280 "C" Programming, or instructor's permission.* (Fee: $15) (odd years)

ENGR-358 Advanced Digital Logic Design—A **3 hours**
Survey of logic families, arithmetic circuits, advanced finite-state machines; introduction to computer organization, controller implementations using jump counters, branch sequencers, and microprogramming; emphasis on rapid electronic prototyping and the effective use of advanced computer aided design tools for minimizing, simulating, and implementing digital circuits. *Prerequisite*: *ENGR-191 Digital Logic Design; ENGR-302 Circuits I.*

ENGR-360 Fluid Mechanics—W **5 hours**
Basic concepts and fundamentals of subsonic fluid flows; introduction to boundary layers and transition to turbulence. *Prerequisite*: *MATH-388 Advanced Calculus I; MATH-387 Differential Equations; ENGR-221 FORTRAN.*

ENGR-365 Heat Transfer—Sp **4 hours**
Introduction to conduction, convection, and radiation heat transfer; analytical and computational techniques. Design project required. *Prerequisite*: *ENGR-351 Thermodynamics I; ENGR-360 Fluid Mechanics. Corequisite: ENGR-250 Numerical Methods.*

ENGR-373 Electrical Machines for Electrical Engineering Majors—W **3 hours**
Introduction to the principles of analysis and characteristics of AC and DC rotating machines and transformers. Three lectures per week for seven weeks and one two-hour laboratory each week for 10 weeks. Will not substitute for ENGR-471 Electrical Machines (for mechanical engineers). *Prerequisite*: *ENGR-303 Circuits II*. (Fee: $20)

ENGR-374 Kinematics and Design of Machines—Sp **4 hours**
Introduction to analysis and synthesis of motion in planar mechanisms and linkages; velocity and acceleration, cam design, gears, simple and compound gear trains; computer solution and simulation. Design project required. *Prerequisite*: *ENGR-275 Mechanics II.* (Fee: $10)

ENGR-378 Introduction to Finite Element Analysis **3 hours**
Introduction to the basic components of the finite element method including element selection, shape functions, strain-displacement and stress-strain relations, formulation of the stiffness matrix, imposition of boundary conditions, interpretation of results; experience using a commercial code. *Prerequisite*: *ENGR-221 FORTRAN or ENGR-280 "C" Programming; ENGR-276 Mechanics III-Strength of Materials; ENGR-250 Numerical Methods.* (Fee: $25)

ENGR-381 Mechanical Engineering Laboratory I—W **3 hours**
Experiments using the wind tunnel, engine test cell, mechanics laboratory, refrigeration, and heat transfer laboratory are conducted. Students will measure mechanical phenomena such as acceleration, force, pressure, temperature, strain, fluid flow, viscosity, and heat transfer using transducers, instrumentation, and PC-based data acquisition. Two three-hour laboratories per week. Students design some of the experiments. *Prerequisite*: *ENGR-250 Numerical Methods; ENGR-310 Electronics and Instrumentation. Corequisite: ENGR-352 Thermodynamics II; ENGR-360 Fluid Mechanics.* (Fee: $30)

ENGR-382 Mechanical Engineering Laboratory II—Sp **3 hours**
Continuation of ENGR-381. Two three-hour laboratories per week. *Prerequisite*: *ENGR-381 Mechanical Engineering Laboratory I. Corequisite: ENGR-365 Heat Transfer.* (Fee: $30)

ENGR-391 Electrical Engineering Internship **1-3 hours**
Opportunity in which an electrical engineering student works closely with an industrial advisor. Specific attention is given to solving a particular problem(s) in that industry or firm. A faculty advisor assists in supervising and approving the internship, including assessing the number of credit hours. A final report (approximately 7 pages per credit hour) describing the experience—including the problem and solution—is required. Cannot be used to satisfy elective credit requirements. *Prerequisite*: *junior or senior engineering status and faculty advisor's permission.*

ENGR-392 Mechanical Engineering Internship **1-3 hours**
Opportunity in which a mechanical engineering student works closely with an industrial advisor. Specific attention is given to solving a particular problem(s) in that industry or firm. A faculty advisor assists in supervising and approving the internship, including assessing the number of credit hours. A final report (approximately seven pages per credit hour) describing the experience—including the problem and solution—is required. Cannot be used to satisfy elective credit requirements. *Prerequisite*: *junior or senior engineering status and faculty advisor's permission.*

ENGR-394 Topics in Electrical Engineering **3 hours**
Selected topics in electrical engineering at the 300 or 400 level; likely candidates are extensions of present courses such as electro-optics,

Engineering professors teach in classrooms and labs designed specifically for engineering and utilizing the latest technology.

solid-state devices, microprocessor applications, antenna theory, or others presented by the faculty or requested by engineering students. *Prerequisite*: *instructor's permission.*

ENGR-395 Topics in Mechanical Engineering **3 hours**
Selected topics in mechanical engineering at the 300 or 400 level; likely candidates are extensions of present courses such as advanced dynamics, non-linear vibrations, 3-D kinematics, thermodynamics III, continuum mechanics or others. *Prerequisite*: *instructor's permission.*

ENGR-396 Competition Project—Sp **0 hours**
Engineering Juniors on an Engineering Department Intercollegiate Design Competition may use this course to provide on their transcript a record of their participation throughout the year. The name of the competition will be designated.

ENGR-398 Independent Study in Engineering **1-3 hours**
Opportunity to perform independent research or study in the various branches of engineering and allied fields of application. A formal proposal for study must be approved by the faculty advisor before registering for this course. Three credit hours of engineering electives can be satisfied by three hours of independent study. *Prerequisite: a junior or senior engineering major and advisor's permission.*

ENGR-399 Project Design **1-3 hours**
An elective course for students to get academic credit for extracurricular design work related to their ministry or design competitions. Cannot be used to satisfy engineering elective requirements. *Prerequisite*: *instructor's permission.*

ENGR-411 Finite Difference Methods In Engineering **3 hours**
Finite-difference approximations for derivatives and differential equations; consistency, stability, and truncation error; introduction to grid generation; applications of finite-difference methods to engineering problems. *Prerequisite*: *ENGR-250 Numerical Methods in Engineering.*

ENGR-412 CMOS VLSI Design—Sp **3 hours**
Fundamentals of CMOS VLSI design; circuit analysis, modeling, mask layout, simulation, and design verification; theoretical concepts and CAD tools used together for circuit design and verification. Three lectures and one two-hour laboratory per week. *Corequisite*: *ENGR-312 Electronics II.* (Fee: $15) (even years)

Well-equipped laboratories facilitate professor to student interaction during experimentation.

ENGR-416 Computer Architecture and Advanced Microprocessors—Sp **3 hours**
Introduction to computer architecture and survey of advanced microprocessor architectures; architectural concepts including RISC vs. CISC, pipeline and vector processing, I/O, and memory hierarchy. Students design and implement a microprocessor using the DIGLOG Logic simulator. *Prerequisite*: *ENGR-316 Microprocessors*. (odd years)

ENGR-421 Electrical Design—A **4 hours**
Introduction to electronic instrument design to meet specific requirements. The top-down design method, cost, engineering analyses, project management, electronic design tools, prototype methods, and important electronic considerations are emphasized. Students prepare a senior design project proposal which outlines the work which will constitute their capstone project in ENGR-461 and ENGR-462. Students design prototype electronic subsystems using analog and digital integrated circuits to build a working instrument in ENGR-422. *Prerequisite*: *ENGR-312 Electronics II; ENGR-316 Microprocessors; ENGR-432 Communications Theory; ENGR-322 Electronics Laboratory II.* (Fee: $15)

ENGR-422 Electrical Design Laboratory—W **3 hours**
Design laboratory for the electrical design course; the top-down design method is used to design, build, and test a working electronic instrument to meet specific requirements within a given time frame and budget; final project and report required. *Prerequisite*: *ENGR-421 Electrical Design.* (Fee: $30)

ENGR-425 Mechanical Design—A **4 hours**
Introduction to mechanical component design to achieve a stated objective; load and deformation analysis, reliability, and static and dynamic failure theories. Students prepare a senior design project proposal which outlines their work which will constitute the capstone project in ENGR-461 and ENGR-462. *Prerequisite*: *ENGR-341 Properties of Engineering Materials; ENGR-374 Kinematics and Design of Machines; ENGR-382 Mechanical Engineering Laboratory II.* (Fee: $25)

ENGR-427 Digital Signal Processing—Sp **3 hours**
Introduction to digital signal processing, application of Z-transforms and Fourier Transforms, spectral analysis, sampling theory, sampled spectrums; theory of, realization of, and frequency response of discrete-time systems; Fast Fourier Transform, properties and design of FIR and IIR filters. Design project required. *Prerequisite*: *ENGR-318 Linear Systems; ENGR-221 FORTRAN or ENGR-280 "C" Programming.* (even years)

ENGR-432 Communications Theory—W **5 hours**
Introduction to communications theory, modulation techniques, and detection techniques. Probability and random processes are developed and used to analyze noise. Four lectures and one two-hour laboratory per week. Design project required. *Prerequisite*: *ENGR-318 Linear Systems.* (Fee: $20)

ENGR-435 Power Systems—W **3 hours**
Principles of electrical power generation, transmission, and distribution, three-phase circuits, power system analysis, load flow, fault currents, system protection, and stability. *Prerequisite*: *ENGR-333 Electromagnetics.* (Fee: $30) (even years)

ENGR-437 Advanced Communications and Networks—Sp **3 hours**
Introduction to the performance of analog and digital communication systems and networks in the presence of noise; M-ary signals, signal space concepts, orthogonal signals; introduction to communication networks. *Prerequisite: ENGR-432 Communications Theory. Corequisite: ENGR-320 Probability and Random Processes for Engineers, or instructor's permission.* (odd years)

ENGR-441 Introduction to Fracture Mechanics **3 hours**
Introduction to failure modes due to both static and dynamic loading; brittle fracture criteria, elastic behavior, stress fields around cracks, fatigue failure, stress corrosion cracking, strain hardening mechanisms. *Prerequisite*: *ENGR-341 Properties of Engineering Materials.*

ENGR-447 Digital Control Systems—W **3 hours**
Analysis and design of discrete-time sampled-data control systems, signal sampling, A/D and D/A conversion, quantization, Z-domain transfer functions, transient response, frequency response, stability and performance of computer controlled systems, controller design. *Prerequisite*: *ENGR-347 Feedback Control Systems.*

ENGR-451 Propulsion **3 hours**
Introduction to the principles of thrust production and compressible flow; thermodynamics of jet propulsion systems. *Prerequisite*: *ENGR-352 Thermodynamics II; ENGR-360 Fluid Mechanics.*

ENGR-460 Compressible Fluid Flow **3 hours**
Introduction to the compressible flow of gases in engineering systems, isentropic flow in variable-area passages, shock and expansion waves, flow with wall friction and heat transfer. *Prerequisite*: *ENGR-250 Numerical Methods in Engineering; ENGR-351 Thermodynamics I; ENGR-360 Fluid Mechanics.*

ENGR-461 Senior Design I—W **5 hours**
Senior design project for engineers. Each student works on the project chosen in the previous fall quarter design class. Student teams work independently to find a solution consistent with the specifications in the design proposal and acceptable to the faculty advisor. Mid-term design review and end-of-quarter oral presentation. *Prerequisite: electrical engineering students: ENGR-421 Electrical Design; mechanical engineering students: ENGR-425 Mechanical Design; and senior status engineering.* (Fee: $45)

ENGR-462 Senior Design II—Sp **5 hours**
A continuation of ENGR-461 emphasizing prototyping, trouble-shooting, design modifications, project finalization, reporting and oral presentation. Capstone course. *Prerequisite*: *ENGR-461 Senior Design I.* (Fee: $45)

ENGR-466 Radiation and Solar Energy—A **3 hours**
Introduction to the fundamentals of radiation heat transfer including shape factors, wave length dependence, and material properties. Applications to solar energy engineering and design problems. *Prerequisite*: *ENGR-365 Heat Transfer*. (even years)

ENGR-471 Electrical Machines—W **4 hours**
Introduction to the fundamentals of power circuits and the principles of analysis and characteristics of transformers and AC and DC rotating machines. Three lectures and one two-hour laboratory per week. *Prerequisite*: *ENGR-310 Electronics and Instrumentation.* (Fee: $20)

ENGR-474 Dynamics of Machines **3 hours**
Dynamic analysis of machines and mechanisms; Newton's laws of motion, energy methods, force analysis, shaking forces, static and dynamic balancing, engine dynamics, multi-cylinder engines, and cam dynamics. *Prerequisite*: *ENGR-374 Kinematics and Design of Machines.*

ENGR-476 Advanced Strength of Materials **3 hours**
Analysis of beams with non-symmetrical sections, non-circular torsion, beams on elastic foundations, failure theories, Mohr's circle for stress and strain, load-deflection analysis by energy methods. *Prerequisite*: *ENGR-276 Mechanics III Strength of Materials.*

ENGR-480 Professional Ethics—Sp **4 hours**
Professional conduct, engineer-client relations, product liability, legal problems, theories of morality, and the ethics code established by the engineering profession studied from a biblical perspective; students explore ethical problems encountered in the application of engineering practice. *Prerequisite*: *senior engineering status*.

ENGR-486 Vibrations **3 hours**
Free and forced vibrations of mechanical systems having lumped mass and elasticity, single and multiple degree-of-freedom systems, matrix formulation, eigenvalues and eigenvectors, Laplace Transform, dissipative systems; introduction to random, continuous, and nonlinear vibrations; engineering applications. *Prerequisite*: *ENGR-275 Mechanics II-Dynamics; ENGR-310 Electronics and Instrumentation; MATH-387 Differential Equations.* (Fee: $20)

ENGR-487 Vibrations Laboratory **1 hour**
Laboratory experiments to demonstrate and support ENGR-486 Vibrations; function and calibration of motion detection transducers, measurement of the frequency response and impulse response function, electrodynamic shakers, instrumentation, Fast Fourier Transform and spectral analysis. One two-hour laboratory per week. (Fee: $30)

ENGR-488 Random Vibration and Signature Analysis **3 hours**
Introduction to vibration analysis of discrete and continuous systems to random excitation; harmonic vibration, transient response, convolution integral, Laplace and Fourier Transform, Discrete Fourier Transform and Fast Fourier Transform; random variables, coherence, correlation, auto- and cross-correlation, power spectral density, transfer function, and modal analysis; experience using a commercial FFT analyzer and Model Analysis software. *Prerequisite*: *ENGR-486 Vibrations. Project required.* (Fee: $30)

ENGR-495 Senior Seminar—A **0 hours**
Required weekly meeting of senior engineering majors to address the transition into the professional work environment. *Prerequisite*: *senior status in engineering.* (Fee: $30)

ENGR-496 Competition Project—Sp **0 hours**
Engineering Seniors on an Engineering Department Intercollegiate Design Competition may use this course to provide on their transcript a record of their participation throughout the year. The name of the competition will be designated.

The SAE Micro Baja Competition challenges students to design and build autonomous vehicles to race through an obstacle course in the shortest time.