Engineering

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Calvin College offers a Bachelor of Science in Engineering degree (B.S.E.) with concentrations in Chemical, Civil and Environmental, Electrical and Computer, and Mechanical Engineering. The Engineering Program is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012 - telephone: (410) 347-7700.

Engineering (B.S.E.)

Engineering is a design-oriented profession applying the principles of mathematics, science, economics, ethics, social sciences, and humanities with judgment to the utilization of energy and materials for the benefit of humanity. The recommended first semester curriculum is Chemistry 103, Mathematics 161, Engineering 101, Engineering 181 and English 101. Students interested in engineering should consult with the department chair, R. Brouwer.

MISSION OF THE CALVIN COLLEGE ENGINEERING DEPARTMENT

Within the mission of Calvin College, the Engineering Department responds to the Creator's call to be agents of renewal by learning to design responsible technologies that serve the needs of the world. The mission of this department covers the faculty, staff, and students who together seek to build God's kingdom in the areas of engineering and technology.

Teaching

The primary mission is for students and faculty to explore not only the fundamental technical concepts of engineering (such as design principles and problem-solving), but also to place that learning in a broader interdisciplinary and liberal arts context. All teaching is marked by a strong emphasis on responsible design that builds upon a foundation of faith in Jesus Christ. Students graduating with a BSE degree from Calvin College will be…

…kingdom servants whose Christian faith leads them to engineering careers of action and involvement, to personal piety, integrity, and social responsibility, and to leadership with a prophetic voice advocating appropriate technologies;

…firmly grounded in the basic principles and skills of engineering, mathematics, science, and the humanities, for correct, perceptive, and sensitive problem assessment at a level appropriate for entry level professional work and graduate studies;

…equipped to creatively move a project from problem statement to final design utilizing the interdisciplinary and interdependent character of the engineering profession.

Research & Scholarship

The Engineering Department serves God by engaging both the profession and the general public through research and consulting that enhances the primary mission of teaching. Scholarship includes research in the engineering sciences; the design process; project management; engineering education; engineering ethics; and the relationships among engineering, technology, and the broader society.

Community Service

Individuals in this department use technological gifts and skills to care for and serve neighbors locally and globally. Community service enhances the primary mission of teaching and includes service-learning, involvement in mission projects, and consultation with groups needing engineering expertise.

The engineering program has a strong emphasis on design. Here the student meets the challenging value and technical issues that arise when societal problems are dealt with through technology. The design experience starts with several projects in the first two years, which focus on societal problems and issues, and which emphasize conceptual design, creativity, and teamwork. Design experiences are then integrated into each concentration by way of specific courses or projects. Finally, the design experience is completed by means of a capstone design project course sequence during the senior year. Within this design perspective, students are aided in the development of a thorough Christian understanding of technology and its applications.

Each of the four concentrations in the engineering program has two or three major themes or emphases. The Chemical Engineering concentration has emphases of chemistry and chemical processing. The Civil and Environmental Engineering concentration has emphases of hydraulics, structures, and environmental. The Electrical and Computer Engineering concentration has emphases of digital systems and analog circuits. Finally, the Mechanical Engineering concentration has emphases of thermal systems and machine design.

The curriculum described above is designed so that students will achieve the following outcomes. Calvin's engineering program will demonstrate that its graduates have…

(a) …an ability to apply knowledge of mathematics, science, and the engineering sciences as appropriate guidelines for design decision making,
(b) …an ability to design and conduct experiments, as well as analyze and interpret data to extract meaning,
(c) …an ability to design a system, component, or process to meet desired needs and to produce a prototype or model which can effectively test the basic principles of the design,
(d) …an ability to function on multi-disciplinary teams,
(e) …an ability to identify, formulate, and solve engineering problems using fundamental principles,
(f) …an understanding of professional and ethical responsibility from a Christian, holistic perspective,
(g) …an ability to communicate truthfully and effectively,
(h) …the broad education necessary to understand the impact of engineering solutions in a global and societal context including an understanding of Christian steward ship of resources,
(i) …a recognition of the need for, and an ability to engage in life-long learning, to aid in the fulfillment of their calling,
(j) …engaged contemporary issues demonstrating how their Christian faith relates to their profession,
(k) …an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice to develop responsible technologies, and
(l) …significant exposure to the engineering profession.

Admission. Students follow a common program for the first two years. Late in the second year, they apply for admission to a concentration in the engineering program.

The minimum requirements for admission to the program are:

- Completion of Chemistry 103, Computer Science 104, Mathematics 161, 162, 231, 232, Physics 133 and 235 with a minimum grade of "C–";
- Completion of Engineering 101, 106, 181, 202, 204, and 209 with a minimum grade of "C–";
- Completion of 16 hours of the required humanities courses
- Submission of résumé with application for admission to concentration
- Attendance at an Engineering Internship Workshop
- Have a minimum cumulative grade point average of 2.30

Students must apply for admission to a concentration in the engineering program during the semester in which they are completing the required courses listed above. Admission to a B.S.E. concentration is required for a student to enter 300-level engineering courses.

Conditional Admission. Conditional admission is available to assist certain students. Students who wish to take 300-level courses, but who have not completed the required courses with the stipulated minimum grade and/or who have not achieved the minimum required cumulative grade point average may be given conditional admission to the program. Conditional admission is granted at the discretion of the department chair. Conditional admission is normally granted as long as students do not have more than 8 semester hours of course deficiencies and only if their cumulative grade point average is no less than 2.20. Furthermore, the student's GPA must be raised to no less than 2.30 and all course deficiencies must be removed within the period designated by the chair (normally not exceeding one year). Students who receive conditional admission and then fail to meet these conditions within the designated time period are not eligible to reapply for admission to the program at a later date. As an alternative to conditional admission, students may delay taking 300-level courses until they have met all requirements for regular admission to the program.

Graduating with Honors. Those wishing to graduate with honors in Engineering must meet the following requirements:

1. have a minimum cumulative GPA of 3.5 and a total of six honors courses (18 hours minimum) overall, including at least two honors courses outside the major; at least two honors courses in Engineering (except Engineering 101, 181, 185, 285, 294, 337, 339, 340, 382, 385, 387, 390, and 394) with a minimum grade of A– (at least one of the Engineering courses must be a 300-level course), and
2. receive credit for Engineering 385, Engineering Internship, or Engineering 387, International Engineering Internship; and
3. receive credit for either Engineering 294 or 394, Engineering Seminar

Since the Engineering Department does not regularly offer honors sections, the honors courses in engineering are taken by special arrangement with the course instructor.

International Concentration Designation. Students may receive an international designation to their concentration (e.g., "BSE International Mechanical Concentration") by completing two of the following three items:

1. Complete an international engineering interim course.
2. Receive credit for an international internship and demonstrate some ability to speak the language of their internship country.
3. Receive credit for an international engineering summer or semester program.

Other procedures and activities may qualify for the international designation. For additional details, please contact the department chair or the department internship coordinator.

Transfer Student Admission. Students wishing to transfer from another school should apply to the Office of Admissions. In general, transfer students must meet the same course requirements as students who begin their programs at Calvin. No course completed with a grade below "C" (2.0) will receive transfer credit.

Transfer students must arrange for an analysis of transcripts by the department chair well in advance of course advising. In addition, those who wish to take 300-level courses in their first semester at Calvin must:

1. Have a 2.5 grade point average at their previous school;
2. If requested, provide a letter from that school indicating that the student was in good academic and personal standing; and
3. Receive either conditional admission or regular admission or possibly special permission from the chair.

Calvin's engineering program emphasizes the integration of Christian faith and a professional engineering education. This integration takes place in many ways. For this reason, a student seeking a B.S.E. degree from Calvin should be part of the program for the equivalent of no less than four semesters as a full-time student at Calvin. It is also stipulated that at least one non-technical course be taken for each semester at Calvin.

Notes Regarding Admission and Graduation. All students must display a high degree of personal integrity to be recommended for admission. This is demanded by the nature of Engineering as a profession. After admission to the Engineering program the student must continue to make adequate progress toward fulfilling graduation requirements. A grade below C- in a 300-level course is an example of inadequate progress, and will require repeating the course. Courses may be repeated only once. A student's admission to the program will be revoked if the student fails to show adequate progress. In addition to an overall, college-wide grade point average of 2.0, the student must obtain a grade point average of 2.0 in all engineering courses completed at Calvin to be eligible to graduate.

Advisory Council and Professional Societies. The Engineering Department is served by an advisory board, the Calvin Engineering Advisory Council (CEAC), consisting of engineers from local industries, which meet semi-annually to review the program and give advice from an industrial perspective. The council is currently co-chaired by Mr. Ron Plaisier of Pfizer Corporation and Mr. Mark Michmerhuizen of JCI Corporation. Calvin Engineering Faculty are members of a wide range of professional societies. Calvin College has student chapters of ASCE, ASME, and IEEE.

BACHELOR OF SCIENCE IN ENGINEERING

Common engineering courses (26 hours)

Common engineering courses (26 hours)
Engineering 101
Engineering 106
Engineering 181
Engineering 202
Engineering 204
Engineering 209
Engineering 339
Engineering 340

Technical Cognates (32 hours)

Business 357
Chemistry 103
Computer Science 104
Mathematics 161
Mathematics 162
Mathematics 231
Mathematics 232
Physics 133
Physics 235

Humanities Courses (31 hours)

Interdisciplinary 149 Prelude
Interdisciplinary W50 DCM
English 101
Health and Fitness
History 151 or 152
Philosophy 153
Religion 121 or 131
Economics 151
Literature
The Arts
IDIS 102 or CAS 101
Cross-Cultural Engagement
One Year of a Foreign Language (Exemption for students with at least 2 years of high school foreign language with a C or better each term)

Students must meet the requirements of at least one of the four concentrations listed below:

Chemical Engineering Concentration-Chemistry and Chemistry Processing Emphasis (44 hours)
Engineering 303
Engineering 312
Engineering 330
Engineering 331
Engineering 335
Engineering 337
Engineering Senior Special Topics Interim
Engineering 342
Chemistry 261
Chemistry 262
Chemistry 317
Chemistry elective

Civil and Environmental Engineering Concentration-Hydraulics, Structures and Environmental Emphasis (42 hours)
Engineering 305
Engineering 306
Engineering 319
Engineering 320
Engineering 326
Engineering Senior Special Topics Interim
Engineering Elective
At least two of the following: Engineering 308, 321 or 327
Advanced Mathematics/Basic Science Elective
Advanced Mathematics/Basic Science/Engineering Elective

Electrical and Computer Engineering Concentration-Digital Systems and Analog Circuits Emphasis (42 hours)
Engineering 302
Engineering 304
Engineering 307
Engineering 311
Engineering 325
Engineering 332
Engineering Senior Special Topics Interim
Engineering Elective
Advanced Mathematics/Basic Science Elective
Advanced Mathematics/Basic Science/Engineering Elective
Computer Science 112

Mechanical Engineering-Thermal Systems and Machine Design Emphasis (42 hours)
Engineering 305
Engineering 319
Engineering 322
Engineering 324
Engineering 328
Engineering 333
Engineering 334
Engineering 382
Engineering Senior Special Topics Interim
Engineering Elective
Advanced Mathematics/Basic Science Elective
Advanced Mathematics/Basic Science/Engineering Elective

Group majors combining Engineering and another discipline (but not accredited by ABET) may be appropriate for some students (see the chair for more information).

ENGINEERING MINOR

The Engineering Minor consists of six approved engineering courses, including:
Engineering 106 or Chemistry 104
At least two of the following: Engineering 202, 204 or 209
At least two 300-level courses including one of the following design courses:
- Chemical: Engineering 331 (Reactors) or Engineering 335 (Separations)
- Civil & Environmental: Engineering 308 (Environmental), Engineering 321 (Hydraulics) or Engineering 327 (Structures)
- Electrical & Computer: Engineering 325 (Digital) or Engineering 332 (Analog)
- Mechanical: Engineering 333 (Thermal/Fluids) or Engineering 322 (Machines)

The minor is not accredited by ABET.

COURSES

101 **Introduction to Engineering Design** (2). F. An introduction to the engineering design process and resource design tools by means of projects, lectures, homework, mentor visits, and team meetings. Team projects, including service learning, require applica-

tion of creativity, engineering analysis, and computational tools. Readings, lectures, and discussions also examine the areas of technology in society, engineering ethics, and library research methods. Various computer software tools are introduced and used. This course fulfills the Foundations of Information Technology core category.

106 **Engineering Chemistry and Materials Science** (4). S. An introduction to the science of engineering materials. Engineering properties of materials - mechanical, electrical, and chemical - are closely linked to the underlying solid state and molecular structure. Chemistry relating to various aspects of design including phase change, solution theory, acid-base solutions, and chemical equilibrium is presented. This course is team-taught by chemists and engineers to facilitate the integration of basic chemical principles and engineering design. Issues of stewardship of resources are addressed. Laboratory. Prerequisites: Chemistry 103, Engineering 101, and Mathematics 160 or 161.

181 **Engineering Graphical Communication Lab** (2). F. This laboratory course focuses on techniques and computer software tools used for visualization and engineering communication. The course introduces graphical techniques for spatial analysis, including orthographic projection, free-hand sketching, pictorial representation, descriptive geometry, sections, basic dimensioning, and tolerancing.

202 **Statics and Dynamics** (4). F and S. A study of fundamental principles of mechanics and their application to the problems of engineering. Vector algebra, forces, moments, couples, friction, virtual work, kinematics of a particle, kinematics of a rigid body, dynamics of particles and rigid bodies, impulse, momentum, work, and energy are presented in two and three dimensions. Prerequisites: Physics 133, Mathematics 162.

204 **Circuits Analysis and Electronics** (4). S. An introduction to the theory and application of electronic circuits and devices. The following topics are covered: basic linear circuits (including frequency and transient response), semiconductor devices (diodes, op-amps, comparators, etc.), electric power, electric safety, and DC machines. Laboratory exercises are used to illustrate the material covered in the lecture portion of the course. Students will measure voltage, current, resistance, power, transient response, resonant circuits, voltage regulators, operational amplifiers. Students will investigate digital logic circuits. Co-requisite: Mathematics 231 Prerequisite: Physics 235.

209 **Introduction to Conservation Laws and Thermodynamics** (4). F and S. This course introduces several foundational engineering topics. Included are single and multi-component process material and energy balances (conservation laws), the first and second laws of thermodynamics and heat transfer. Study of chemical kinetics and equilibrium demonstrates the link between science and design begun in Engineering 106 and also broadens the student's knowledge of chemistry. Issues of stewardship of materials and resources are addressed. Laboratory. Prerequisites: Engineering 106 and Mathematics 162 or permission of the instructor.

220 **Introduction to Computer Architecture** (4). F. A study of computer organization (including memory hierarchy, I/O, bus-based systems, distributed systems, and parallel systems), and computer architecture (including CPU control, pipelining, and instruction set architecture). Laboratory exercises emphasize principles. Prerequisites: A programming language course, normally Computer Science 104 or 108 or permission of the instructor.

Prerequisite to all courses numbered 300 or higher is formal admission to a B.S.E. concentration.

302 **Engineering Electromagnetics** (4). S. A study of the laws and engineering applications of electric and magnetic fields in various conductive, dielectric, and magnetic materials and under various boundary conditions. Emphasis is on the analysis and design aspects of transmission line circuits. Prerequisites: Mathematics 231, Mathematics 232, and Physics 235.

303 **Chemical Engineering Principles and Thermodynamics** (3). F. This course continues the study of chemical engineering principles begun in Engineering 209. Included are material and energy balances with reaction

and introduction to vapor-liquid and liquid-liquid equilibrium including the concepts of dew and bubble points and the flash process. Process simulators (HYSYS) are introduced. Principles are reinforced with an in-depth team design project of a commercial process. Basic concepts of thermodynamics, i.e., equilibrium, reversibility, system are presented. The first and second laws are studied including the Carnot cycle and reversible process equipment as models of best performance. This material provides the foundation for the in-depth study of thermodynamics in Engineering 312. Prerequisites: Engineering 209, Mathematics 231, and concurrent registration in Chemistry 317.

304 **Fundamentals of Digital Systems** (4). S. An introduction to the fundamental principles of logic design in digital systems. Topics include: Boolean algebra, analysis and synthesis of combinational and sequential networks, register transfer language, micro-operational description and applications to computer design, computer organization and assembly language programming, and asynchronous logic. The student is introduced to digital logic families and programmable logic devices, digital logic CAD tools, logic synthesis and hardware description languages (VHDL). Laboratory work will include logic design and assembly language programming. Prerequisites: Engineering 204 and a programming language course (normally Computer Science 104).

305 **Mechanics of Materials** (4). F. Application of principles of mechanics to the solution of problems in stress and strain of engineering materials, including resistance to force, bending, torque, shear, eccentric load, deflection of beams, buckling of columns, compounding of simple stresses, introduction to theory of failure, and energy methods. Prerequisites: Engineering 106 and 202.

306 **Principles of Environmental Engineering** (4). F. A study of environmental engineering and science principles relevant to engineered and natural systems. Topics considered in this course include an overview of the domains of environmental engineering; relevant units of measurement; population dynamics; contaminant types, sources and presence; chemical stoichiometry, equilibria, and kinetics; mass and energy balances; mass/particle transport processes; microbial ecosystem structure and function; biogeochemical cycling; and oxygen demand. Prerequisites: Engineering 209, or permission of the instructor.

307 **Electrical Signals and Systems** (4). F. Advanced techniques for the analysis of analog electrical systems. Topics include: frequency domain analysis, Laplace transforms, Fourier series, Fourier transforms, and continuous versus discrete signal analysis. Frequency response is analyzed using transfer functions, Bode plots, and spectral plots. Digital Signal Processing (DSP) is introduced. Prerequisites: Engineering 204, Mathematics 231. Co-requisite: Mathematics 232.

308 **Environmental Engineering Design** (4). S. Application of environmental engineering and science principles to the design of environmental control measures and engineered systems. Problems considered in this course will include design of water supply and treatment processes; wastewater treatment processes; processes for air pollution control, groundwater remediation; and solid and hazardous waste management. Prerequisites: Engineering 306, or permission of the instructor.

311 **Electronic Devices and Circuits** (4). F. A study of the characteristics and qualitative internal action of commonly used microelectronic devices for discrete and integrated circuits, such as diodes, junction field-effect transistors (JFETs), metal-oxide semi-conductors FETs (MOSFETS), and bipolar junction transistors (BJTs). Application of these devices in basic amplifier circuits is explored. Laboratory exercises are used to illustrate concepts. Prerequisite: Engineering 204 and Mathematics 231.

312 **Chemical Engineering Thermodynamics** (4). S. Thermodynamic topics important in Chemical Engineering are addressed. The properties of real fluids and equations of state, properties of mixtures, phase equilibrium, and chemical equilibrium. Prerequisites: Engineering 303, and Chemistry 317.

314 **Vibration Analysis** (4). S. Analysis of mechanical vibration in both transient and steady state regimes, employing analytical and computer techniques for solution. Linear and nonlinear problems are investigated with original inquiry suggested and encouraged. Prerequisites: Engineering 202 and Mathematics 232.

315 **Control Systems** (4). F. An introduction to linear feedback control theory, including transient and frequency response, stability, systems performance, control modes, and compensation methods. Hydraulic, electrical, pneumatic, and inertial components and systems are investigated and employed. Prerequisites: Engineering 204 and Mathematics 232.

318 **Soil Mechanics and Foundation Design** (4). S, alternate years. Soils studied as engineering materials whose behavior is dependent upon soil types, index properties, and soil moisture conditions. The scope of the course includes soil structures, index properties, soil classification, permeability, compressibility and consolidation, soil testing, soil stresses, and foundation design. Laboratory experiments are used to emphasize principles. Prerequisite: Engineering 305.

319 **Introduction to the Thermal/Fluid Sciences** (4). F. An introduction to the engineering thermal and fluid sciences including elements of thermodynamics, fluid mechanics, and heat transfer. Concepts include the properties of fluids, first and second laws of thermodynamics, external and internal viscous and ideal flows, and conduction, convection, and radiation heat transfer. Laboratory and project exercises are used to illustrate concepts. Prerequisites: Engineering 202 and 209, Mathematics 231.

320 **Hydraulic Engineering** (4). S. Application of the basic principles of fluid mechanics to practical problems in hydraulic and hydrologic analysis. Topics include fluid statics, hydrology, open channel flow, closed conduit flow, and centrifugal pumps. Computer techniques and laboratory exercises are used to emphasize principles. Prerequisite: Engineering 319.

321 **Hydraulic Engineering Design** (4). F. Application of principles of hydraulics and hydrology to the design of hydraulic systems. Problems considered in this course will include design of pipe networks for water distribution, design of sewage collection systems, design of pumping facilities, design of groundwater remediation systems, and design of flood control structures. Computer techniques will be frequently employed. Prerequisite: Engineering 320.

322 **Machine Design** (4). S. Application of engineering mechanics, materials, and failure theories to the analysis and design of mechanical elements and systems. Computer techniques are used as aids to analysis and design. Prerequisite: Engineering 305.

324 **Materials and Processes in Manufacturing** (4). S. This course introduces students to the various mechanical and management issues involved in the fabrication of manufactured goods. Scientific and engineering principles are applied to fabricating processes such as casting, forming, and machining so as to determine the relation of process to material properties, economics, dimensional accuracy, and energy requirements. Topics such as computer-aided manufacturing (CAM), numerical control (NC), statistical quality control (SQC), and quality management are also explored. Field trips and laboratories are used to support the lecture material. Prerequisites: Engineering 106 and 305.

325 **Computer Architecture and Digital Systems Design** (4). F. Design of advanced digital systems using programmable logic, Application-Specific Integrated Circuits (ASICs), and microprocessors. Microprocessor architecture including pipelining, memory hierarchy, cache, instruction set architecture, CPU control, bus standards, I/O, superscalar, and Very Long Instructive Word (VLIW) approaches. Interfacing and communication techniques, including data error detection and correction codes. Introduction to parallel processing. Laboratory exercises emphasize the design of microprocessor-based digital systems. Prerequisite: Engineering 304.

326 **Structural Analysis** (4). S. A study of beams, two-dimensional trusses, and rigid frames. Course work includes calculation of shear forces and bending moments due to fixed and moving loads, calculation of deflection, analysis of moving loads using influence lines, and the analysis of statically indeterminate structures. The course also includes an introduction to matrix methods in structural analysis. Prerequisite: Engineering 305.

327 **Structural Design** (4). F. Application of principles of mechanics of solids and structural analysis to the design of structural members made of steel or reinforced concrete. Load and factored resistance design

procedures are studied along with the current steel specification for the design, fabrication, and erection of structural steel for buildings and the building code requirements for reinforced concrete. Computer techniques are used as aids to analysis and design. Prerequisite: Engineering 181, Engineering 326.

328 **Intermediate Thermal/Fluid Sciences and Design** (4). S. An intermediate treatment of heat transfer and thermodynamics including analysis and design related to steady and unsteady conduction with an emphasis on two and three dimensions, free and forced convection, radiation modes of heat transfer, power and refrigeration cycles, air conditioning processes, chemical equilibrium, and combustion. Laboratory, design, and computer exercises are utilized to emphasize principles. Prerequisite: Engineering 319.

330 **Fluid Flow and Heat Transfer** (4). S. Applications of fluid flow and heat transfer fundamentals to Chemical Engineering problems including heat exchanger design and designs for the transportation and metering of fluids. Unit operations of filtration and evaporation are covered. Prerequisites: Engineering 209 and 303.

331 **Kinetics/Reactor Design** (4). F. An introduction to chemical kinetics and reactor design. Principles of kinetics of homogeneous and heterogeneous reactions with differential and integral analysis of kinetic data are included. Ideal reactor design concepts, nonisothermal reactor design, and design of catalyzed fluid-solid reactors are presented. Mass transfer, as it impacts multiphase reactor design, is introduced. One open-ended team design project and one kinetics lab project will be done to reinforce concepts presented in class. Prerequisites: Engineering 312, 330, and Chemistry 317.

332 **Analog Circuits and Systems Design** (4). S. Feedback principles and electronic circuit theory and device theory applied to multistage transistor amplifiers. Detailed study of operational amplifier specs, nonidealities, and compensation. Introduction to filter theory and practical realizations. Power supply design: Rectifier circuits, linear, and switching regulators. Nonlinear circuits: Comparators, multipliers, Schmitt trigger, S/H circuits, multivibrators, and oscillators. Introduction to noise analysis and low noise design. Emphasis on realization of designs using commercially available IC's. Design experience emphasized in projects and the laboratory. Prerequisites: Engineering 307 and 311.

333 **Thermal Systems Design** (4). F. Advanced heat transfer, thermodynamic, and fluid flow topics important for the design of thermal systems are presented. Availability (exergy) analysis and methods for the optimization of system components are given. Selection and design of fluid flow and heat transfer equipment used in energy conversion systems are emphasized. Economic evaluation is studied. A co-generation system is studied throughout the semester to emphasize basic principles of analysis and design. A project is required. Prerequisite: Engineering 328.

334 **Dynamics of Machinery** (3). S. This course investigates various dynamic aspects of machinery. An in-depth study is made of mechanisms such as the four-bar linkage. Cams and gears are studied in the context of their use in machines. Vibration concerns are addressed including methods of balancing rotating machinery. Kinematics and kinetics are studied in a three-dimensional space with an emphasis on application in the area of robotics. Computer simulation of mechanisms is used to reinforce basic concepts. Prerequisite: Engineering 202.

335 **Mass Transfer and Staging Operations** (4). F. Mass transport fundamentals are applied to Chemical Engineering design problems. Principles of equilibrium mass transport operations are applied to distillation, gas absorption, extraction, and humidification design. Prerequisite: Engineering 312 and 330.

337 **Chemical Engineering Laboratory** (2). S. Principles of fluid flow, heat transfer, mass transfer, stage-operations, and chemical kinetics are studied using small-scale equipment. Evaluation and analysis of experimental observations, project proposals, and report writing is emphasized. Prerequisites: Engineering 331, 335, and Chemistry 317.

338 **Introduction to Traffic Engineering and Highway Design** (4). S, alternate years.

Introduction to the basic concepts of traffic engineering and highway design. The traffic-engineering portion introduces basic concepts including how the motorist, vehicle, road, and pedestrian interact, roadway capacity and Level-of-Service, traffic flow and queue theory, and traffic signal timing. Software applications are introduced regarding traffic simulation and capacity analysis. The highway design portion of the course focuses on the basics of horizontal and vertical alignment of roadways, design vehicle, design speed, superelevation, sight distance, and other design considerations. Prerequisite: Admission to engineering program or permission of the instructor.

339 **Senior Design Project** (2). F. This is the first course in the senior design project sequence. Emphasis is placed on design team formation, project identification, and production of a feasibility study. Students focus on the development of task specifications in light of the norms for design and preliminary validation of the design by means of basic analysis and appropriate prototyping. Lectures focus on integration of the design process with a reformed Christian worldview, team building, and state-of-the-art technical aspects of design. Interdisciplinary projects are encouraged. Prerequisites: Concurrent registration in the seventh semester of the model program for a particular concentration or permission of the instructors; Biblical Foundations I or Theological Foundation I, Developing a Christian Mind, and Philosophical Foundations.

340 **Senior Design Project** (4). S. This is the second course in the senior design project sequence. Emphasis is placed on the completion of a major design project initiated in Engineering 339. This project should entail task specifications in light of the norms for design by means of engineering analysis and an appropriate prototype focused on primary functionality. A final presentation is given at the May senior design project program. Lectures continue to focus on integration of the design process with a reformed Christian worldview, team activity, and state-of-the-art technical aspects of design. Prerequisites: Engineering 339 (taken the semester immediately prior). This course fulfills the Integrative Studies core category.

342 **Process Dynamics, Modeling, and Control** (4). S. Introduction to the analysis of process dynamics, and to the design and analysis of process control systems. Covers transient and frequency response, transfer functions, stability, performance, linearization, decoupling, and multivariable control. Prerequisites: Engineering 209 and Mathematics 232.

382 **Engineering Instrumentation Laboratory** (1). S. Laboratory course, which serves as an introduction to the characteristics and uses of transducers to measure displacement, strain, pressure, temperature, velocity, acceleration, and other physical quantities. Emphasis is on the usefulness, accuracy, and reliability of measurement systems in actual applications. Electronic signal conditioning techniques are covered. A design project using LabVIEW software and FilePoint data acquisition hardware is required. Written reports required. Prerequisites: Engineering 204.

390 **Independent Study**. F, I, and S. Independent readings and research. Prerequisite: Permission of the chair.

Architecture

W81 Advanced Computer Architecture with VHDL. This course explores advanced computer architecture techniques including superscalar machines, Very Long Instruction Word (VLIW) scheduling, Explicitly Parallel Instruction Computing (EPIC) architectures, predicated execution, interrupts in a pipelined machine, and compiler optimizations for specific hardware platforms. Hardware designs are examined through the use of VHDL (VHSIC [Very High Speed Integrated Circuit] Hardware Description Language). The course examines the VHDL design methodology and compares the behavioral, dataflow, and structural architecture description styles. Syntax constructs for describing sequential and concurrent modules are studied in detail. Verification techniques are also covered. Students design a variety of circuits and modules using sophisticated CAD tools, implement microprocessor subsystems and microprocessor interface circuits in the lab, and demonstrate their understanding of VHDL design principles. Prerequisite: Engineering 325 or permission of the instructor.

W82 Finite-Element Analysis. The finite-element method is a design and analysis tool widely used in many areas of engineering. In this course students consider the historical development, the fundamental principles, and the various applications of this method in the areas of structural mechanics and heat transfer. Exercises are assigned to orient the student to available general-purpose software. There is an in-depth focus on several design projects. Prerequisite: Engineering 305 or permission of the instructor.

W83 Water and Wastewater Treatment Design. This course addresses the application and theory of chemical, physical, and biological processes related to potable water treatment and wastewater treatment systems. Problems considered include unit process design for the following potable water treatment plant components: screening, coagulation, mixing, flocculation, chemical softening, filtration, disinfection, ion exchange, adsorption, membrane filtration, and residuals handling. Additional coverage includes unit process design for wastewater treatment components including: activated sludge, trickling filters, membrane bioreactors, aeration, clarification, and solids handling and stabilization. Prerequisites: Engineering 209 and senior standing or permission of the instructor.

W84 Advanced Topics in Chemical Engineering Design. This course addresses essential advanced topics that build on the foundational concepts from several earlier chemical engineering courses. Design topics covered include: mass transfer and staging operations, radiation heat transfer, nonelementary kinetics, corrosion, and materials of construction. In addition, fundamental concepts of environmental, health, and safety issues for design are presented. Prerequisites: Engineering 330, 331, 335, and senior standing.

W85 Stormwater Management. Civil engineers today are frequently faced with the problem of managing the impact of stormwater within the urban environment. Management involves addressing issues of both stormwater quantity as well as quality. There are three specific goals for this course. The first goal is to introduce the basic principles and computational methods associated with stormwater flows, collection, storage, and treatment. The second goal is to understand basic stormwater management approaches used in practice today. The third goal is to learn how to use numerical modeling software to solve stormwater management design problems. Guest speakers, field trips, and case study reviews are also used to emphasize basic principles and management techniques. Prerequisite: Engineering 320 or permission of instructor.

W86 Introduction to Power Systems. This course is intended to serve as an introduction to electric energy systems and its basic operation principles. Students will be learn about the theory and methods related to AC power system analysis and design. Major components are to develop familiarity with power system engineering components, equipment and analytical tools; to understand and study of the largest machine ever built-the integrated power grid; to understand the use of transmission grids as a means of transport/delivery of energy; to use tools for the analysis of power systems (MATLAB/Simulink, PowerWorld, EasyPower, PSCAD/EMTP); to investigate flow of power on a power grid; to understand voltage regulation, real and reactive power, three phase power, power quality, efficiency, practical stability limits, etc.; and finally to become familiar with management and environmental issues associated with transmission grids / power systems. Prerequisite: ENGR 204 and senior standing or permission of the instructor.

W88 Masonry Design. In this course the student will become familiar with basic masonry materials, including clay brick, concrete block, mortar, grout and reinforcing accessories. The student will be able to analyze and design unreinforced masonry structures using engineering methods. The student will understand the behavior of reinforced masonry structures and be able to design for flexure, shear, axial forces, combined flexure and axial forces, and in-plane shear forces. Problem sets and a final design-project report are required. Prerequisite: Engr326 or permission from instructor. Mr. L. De Rooy

Off Campus Interims

Business and Engineering for the International Market. This course introduces the student to the nuances of business practices and product development in the international

market, focusing on business, research, and development in Europe. Students learn how the languages, history, culture, economics, regulations, and politics of Europe shape the business and design process through tours of businesses, engineering-research facilities (industrial and academic), and manufacturing facilities as well as discussion sessions with leading business executives and research engineers in Europe. Locales include Amsterdam, Rotterdam, Delft, Brugge, Brussels, Paris, Koblenz, Offenbach, Zurich, Munich, Nürnberg, Leipzig, Berlin, Bremen, and Koln. Additional religious and cultural locales include The Begijnhof, The Hague, Louvain, Versailles, Notre Dame Cathedral, Reims, Heidelberg, Dachau, Neuschwanstein, Prague, St. Vitus Cathedral, Wittenberg, Magdeberg, and Koln Cathedral. Students keep a daily journal and complete study assignments that focus attention on key issues related to the day's tour. Prerequisite: Business 160 or Engineering 101 or permission of the instructor. E. Nielsen.

Dutch Landscapes: Society, Technology, and Environment. Few countries exist where human activities have exerted a greater influence in the shaping of the land than the Netherlands. With daily field excursions and detailed topographic maps, students study this country's richly varied and historically layered cultural landscapes. Land reclamation, water management, and environmental preservation technologies used over many centuries are an important part of understanding the complex interrelationships between society, technology, and land. Additionally, students have opportunities for direct engagement with people from this country. Briefings, interpretation en route, topographic maps, and study-sheet assignments guide each field trip. Students spend one Sunday with a Dutch family. Open days are integrated to provide opportunities for personal travel. R. Hoeksema. Not offered Interim 2008.

The South African Miracle: Challenges and Accomplishments in Politics and Industry. This course introduces students to a country with a tragic past but also a promising future. The primary academic objective is to gain firsthand knowledge and understanding of how racial injustice has been encountered in political and industrial contexts. Participants read and study South African history, culture, and industrial change as well as experience South African townships, meet with political leaders from a variety of political parties, and visit gold mines. Students explore South Africa's apartheid past, the struggles for and painful miracle of its democratic transition and the political-economy of the mining industry where interaction of politics, business, and race are poignant. Specific on-site visits include Robben Island, Soweto mining hostels, the University of Cape Town, the Apartheid Museum, and much more. M. Heun. Not offered Interim 2008.

Transforming Cambodia. The goal of this class is to identify and experience the root causes of abject poverty in Cambodia. Issues to be engaged include food production capacity, land use trends, availability of adequate water or reasonable quality, availability of education and human health. This course plans to engage a variety of non-governmental organizations involved in supporting the holistic transformation of communities; CRWRC village projects enabling people to produce greater quantities of healthier food, water filtration and pumping methods, orphanages, Kindergarten classes, a hospital, and several evangelical churches, and the launch of a new Christian university (AIU). Students will contribute service-learning hours in these venues. Additionally, students will engage the cultural underpinnings of the current situation in Cambodia. A visit of the Angkor Wat temples will lay a ancient historical foundation of Cambodian culture, followed by the Killing Fields and Tuol Sleng prison to assess the recent impact of the Khmer Rouge. Students will gain a clear understanding of what current living conditions are in Cambodia, how they have come to be as they are, what the impediments to change are, what can and is being done to make a positive and sustainable change to the average Cambodian citizen, or in other words, how to be agents of redemption in a deeply troubled society. This class is a cooperative learning adventure with Calvin College and Handong Global University (South Korea). Student evaluation will be based on participation with local culture, group discussion, individual journaling, and in a final report describing key features of their learning experience. D. Dornbos Jr., L. De Rooy, and A. Kim (Handong Global University).

Seminars/Internships

185/285/385 **Engineering Internship** (0). Students who complete an Engineering Internship during the summer as part of the department's internship program, may receive transcript recognition for their effort. Freshmen, sophomores, and juniors will receive credit for Engineering 185, 285, and 385 respectively. These internships, consisting of engineering work at an appropriate level, should be for a minimum of nine (9), full-time, consecutive weeks. Students must provide a brief written report of their activities under the signature of their supervisor. The students must also make a presentation of their internship work during the following semester. The report and copies of the presentation material should be submitted to the department's internship coordinator for approval. Other procedures and activities may be given internship credit. Application for exceptional cases must be made to the internship coordinator.

294/394 **Engineering Seminar** (0). F and S. A seminar devoted to an exploration of topics in engineering. Seminars will cover areas such as the practice of engineering design, non-technical issues in engineering practice, engineering graduate studies, and aspects of engineering analysis. Students will receive transcript recognition for Engineering 294 if they attend eight (8) seminars before being admitted to a B.S.E. concentration and will receive transcript recognition for Engineering 394 if they attend eight (8) seminars after being admitted to a BSE concentration. Plant tours and technical society meetings may be substituted for seminars upon approval. Engineering 294 is not a prerequisite for Engineering 394.

387 **International Engineering Internship** (0). Students, who complete an International Engineering Internship during the summer as part of the department's internship program, may receive transcript recognition for their effort. These internships, consisting of engineering work at an appropriate level, should be for a minimum of nine (9), full-time, consecutive weeks and shall take place in a country other than the United States and Canada. Students must provide a brief written report of their activities under the signature of their supervisor. The students must also make some type of presentation of their internship work during the following semester. The report and copies of the presentation material should be submitted to the internship coordinator for approval. Other procedures and activities may be given international internship credit. Application for exceptional cases must be made to the internship coordinator.

English

*Professors R. Anker, S. Felch, **D. Hettinga, K. Saupe, G. Schmidt, J.H. Timmerman, W. Vande Kopple (co-chair), D. Ward*
*Associate Professors J. Holberg, B. Ingraffia, D. Rienstra, *J. Vanden Bosch, E. Vander Lei (co-chair)*
Assistant Professors C. Engbers, G. Fondse, N. Hull, L. Klatt, L. Naranjo-Huebl, D. Urban, J. Williams, J. Zwart
Adjunct M. Admiraal

The department offers a major and minor in English, majors and minors in secondary and elementary English education, a minor in writing, and interdisciplinary minors in ESL, in linguistics, and in journalism. A student may alter any of the recommended programs with the permission of an academic advisor. All professors in the department advise for the general major and minor. The advisors for the secondary-education programs are K. Saupe, W. Vande Kopple, and J. Vanden Bosch. The advisors for the elementary-education programs are D. Hettinga, N. Hull, and G. Schmidt. The advisor for the linguistics minor is W. Vande Kopple. The advisor for the journalism minor is D. Hettinga. The advisor for the ESL minor is E. Vander Lei. The advisors for the writing minor are C. Engbers, D. Hettinga, J. Netland, G. Schmidt, and E. Vander Lei.