tion as related to the context of education, curriculum theory, instructional theory, and disciplinary concentration are reviewed. By means of broad unifying themes, students will be expected to integrate into a coherent unity what they have learned in the program. The broad range of knowledge in the field of Curriculum and Instruction will be integrated with an authentic Christian perspective. In the process, students will reflect on how their education and professional experiences can be used for personal growth and to influence society. The seminar will include a final integrative master's thesis. Prerequisites: All other courses in the M.Ed. Program. *J. Gormas.*

598 Graduate Seminar: Learning Disabilities (3). S. This seminar is designed to integrate program components in the M.Ed. Program in Learning Disabilities. Developments in theory, research, and practice in learning disabilities as related to psychology, education, language, and social practice are reviewed. Students submit integrative papers to demonstrate an understanding of principles and current issues in the field of learning disabilities. Emphasis is placed on developing leadership roles in the field of learning disabilities. Guided supervision of individual assessment and educational programming is required. The seminar will include a final integrative master's thesis. Prerequisites: All other courses in the M.Ed. Program. *D. Buursma.*

Engineering

Professors R. Brouwer (chair), R. DeJong, †R. Hoeksema, E. Nielsen, P. Ribeiro, A. Sykes, S. Vander Leest, W. Wentzheimer
Associate Professors G. Ermer, L. De Rooy, M. Heun, S. Yost
Assistant Professors J. Jewett Van Antwerp, J. Van Antwerp, D. Wunder

Calvin College offers a Bachelor of Science in Engineering degree (B.S.E.) with concentrations in Chemical, Civil, Electrical and Computer, and Mechanical Engineering. The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (A.B.E.T.) accredits the B.S.E. program. The recommended first semester curriculum is Chemistry 103, Mathematics 161, Engineering 101, and English 101.

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.

Students at Calvin College prepare to be engineers by following a program leading to a Bachelor of Science in Engineering (B.S.E.) degree. This degree is attained by completing courses in one of four concentrations—chemical engineering, civil engineering, electrical and computer engineering, or mechanical engineering. The Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (A.B.E.T.) accredits this curriculum. Students interested in engineering should consult with the department chair, R. Brouwer.

The core mission of the Calvin College Engineering Program is to train engineers as designers, to solve problems in society through the responsible use of technology for the glory of God. The educational objectives of the engineering program are that its graduates will be:

- *Individuals* who are firmly grounded in the basic principles and skills in engineering, mathematics, science, and the humanities, for correct, perceptive, and sensitive problem assessment at a level appropriate for entry level work both in industry and graduate school;
- *Designers* who are able to creatively bring a project from problem statement to final design and prototype while realizing the interdisciplinary and interdependent character of the engineering profession; and
- *Servants* whose Christian faith leads them to an engineering career of action and involvement, to personal piety, integrity, and social responsibility.

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 year, 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 major themes or emphases. The Chemical Engineering concentration has emphases of chemistry and chemical processing. The Civil Engineering concentration has emphases of hydraulics and structures. 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.

Admission. Students follow a common program for the first two years, at the end of which they apply for admission to a concentration in the Department of Engineering. The minimum requirements for admission to the program are:

- Completion of Chemistry 103, 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; and
- Have a minimum cumulative grade point average of 2.30.

Students must apply for admission to a concentration in the Department of Engineering during the semester in which they are completing the required courses listed above. After a student is accepted, the chair completes a major counseling form for the student, indicating the remaining requirements. Admission to a B.S.E. concentration allows the student entry into 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 or who have not achieved the minimum required cumulative grade point average may be given conditional admission to the program. Such students may not have more than two course deficiencies nor may their cumulative grade point average be lower than 2.2 and, furthermore, all deficiencies must be removed within a designated period of time, not to exceed one year. Students who fail to meet these conditions are not eligible to reapply for admission to the program at a later date. Students should request conditional admission when applying for admission to the Engineering program. (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 take at least two honors courses in engineering and must receive credit for either Engineering 294 or 394 (Engineering Seminar) and Engineering 385 (Engineering Internship). Since the Engineering Department does not regularly offer honors sections,

the two honors courses are taken by special arrangement with the course instructor. The minimum grade to receive honors credit in engineering courses is an "A–".

International Concentration Designation. Any student who completes an international interim course, receives credit for an international internship, and demonstrates mastery of the native language of the country of their international internship may receive an international designation to their concentration. 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. 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. The Engineering Department is served by an advisory council consisting of engineers from local industries, which meet semi-annually to review the program and give advice from an industrial perspective. Calvin College is an affiliate member of the American Society for Engineering Education (ASEE) and the Junior Engineering Technical Society (JETS), and is an associate member of the Michigan Chemical Council (MCC). Calvin College has student chapters of ASCE, ASME, and IEEE.

BACHELOR OF SCIENCE IN ENGINEERING

Common engineering courses (26 hours)

Engineering 101 - core
Engineering 106
Engineering 181
Engineering 202
Engineering 204
Engineering 209
Engineering 339 - core
Engineering 340 - core

Technical Cognates (32 hours)

Business 357
Chemistry 103
Computer Science 150 or 155 or 153/154
Mathematics 161 - core
Mathematics 162
Mathematics 231
Mathematics 232
Physics 133 - core
Physics 235 - core

Humanities Courses (29 hours)

Interdisciplinary 149 Prelude - core
Interdisciplinary W50 DCM - core
English 101 - core

Health and Fitness - core
History 151 or 152 - core
Philosophy 153 - core
Religion 121 or 131 - core
Economics 151 - core
Literature - core
The Arts - core
Cross-Cultural Engagement - core

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 interim
Engineering 342
Chemistry 261
Chemistry 262
Chemistry 317
Chemistry elective

Civil Engineering Concentration-Hydraulics and Structures Emphasis (42 hours)
Engineering 305
Engineering 318
Engineering 319
Engineering 320
Engineering 321
Engineering 326
Engineering 327
Engineering Interim
Engineering Elective
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 Interim
Engineering Elective
Advanced Mathematics/Basic Science Elective
Advanced Mathematics/Basic Science/Engineering Elective
Computer Science 186

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 Interim
Engineering Elective
Basic Science Elective/Mathematics
Mathematics Elective/B.S./Engineering
Group majors not accredited by A.B.E.T. may be appropriate for some students and are described below.

ENGINEERING AND GEOLOGY GROUP MAJOR

Engineering 101
Engineering 202
Engineering 205
Engineering 305
Geology 151
Geology 152
Geology 201
Geology 212
Four approved electives (two from engineering or geology and two approved cognates from a third department within the Science Division). At least two of the geology and/or engineering courses must be at the 300-level.

ENGINEERING AND PHYSICS GROUP MAJOR

The group major in engineering and physics consists of twelve courses. Ten of these must be from the engineering and physics departments, with no fewer than four from either. The remaining two cognate courses must be chosen from a third department within the Science Division.

ENGINEERING MINOR

The Engineering Minor consists of six approved engineering courses:

Engineering 106 (unless students have credit for 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- 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)

COURSES

101 Introduction to Engineering Design (2). F. An introduction to the design process and engineering computer design tools by means of lectures, computer work, and projects. Readings are assigned in design related areas of creative thinking and modeling. Readings, lectures, and discussions also examine the areas of technology (especially the computer) in society, engineering ethics, engineering liability, and library research methods. The student is introduced to the computer and its application as a resource tool. Computer software tools for engineering design are explored, including email, the world wide web, and spreadsheet software. This course fulfills the Research and Information Technology core category. *Staff.*

103 Architectural Communication and Concept Design (4). F. Graphical techniques for spatial analysis; a study of basic topics in architectural drawing to provide facility in the transmission of ideas through accepted graphical means. Areas covered include orthographic projection, free-hand sketching, pictorial representation (including perspective), sections and conventions, basic dimensioning, shade and shadows, and computer graphics. The student is introduced to the design process by means of lectures and assigned architectural projects. Readings are also assigned in design-related areas of creative thinking, aesthetics, economics, and human satisfaction. *Staff.*

106 Engineering Chemistry and Materials Science (4). S. An introductory course in 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. *Staff.*

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. *Staff.*

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 and concurrent registration in Mathematics 231. *Staff.*

204 Circuits Analysis and Electronics (4). S. An introduction of 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, and timers), electric power, electric safety, and DC machines. Laboratory exercises are used to illustrate the material covered in the lecture portion of the course. Measurements of voltage, current, resistance, power, transient response, resonant circuits, voltage regulators, operational amplifiers, and timer circuits will be made and digital logic circuits will be examined. Prerequisites: Mathematics 231 and Physics 235. *Staff.*

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. *Staff.*

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. *Staff.*

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, dialectric, 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. *Staff.*

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 case study 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 thermodynamic in Engineering 312. Prerequisites: Engineering 209, Mathematics 231, and concurrent registration in Chemistry 317. *Staff.*

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 (including TTL and CMOS) and programmable logic devices, digital logic CAD tools, and hardware description languages. Logic systhesis, including VHDL. Laboratory work will include logic design and assembly language programming. Prerequisites: Engineering 204 and a programming language course (normally Computer Science 104). *R. Brouwer, Staff.*

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. Laboratory experiments are used to emphasize principles. Prerequisites: Engineering 106 and 202. *R. Hoeksema, Staff.*

306 Principles of Environmental Engineering (4). S, alternate years. Decision-making in the selection of environmental control measures and equipment. The emphasis is on water supply and wastewater treatment, solid waste management, and hazardous waste disposal. Prerequisite: Junior or senior standing in the Engineering Department or approval of the instructor. *Staff.*

307 Advanced Network Analysis (4). F. Advanced techniques for the analysis of analog electrical networks. Topics include: Sinusoidal steady-state power calculations (including 3-phase), mutual inductance and transformers, s-domain analysis, Laplace trans-

forms, Fourier series, Fourier transforms, and continuous versus discrete signal analysis. Frequency response is analyzed using transfer functions, Bode plots, and spectral plots. Prerequisites: Engineering 204 and Mathematics 231 and 232. *R. Brouwer.*

311 Electronic Devices and Circuits (4). F. A study of the characteristics and qualitative internal action of commonly used micro-electronic 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. *Staff.*

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 209, Engineering 303, and Chemistry 317. *Staff.*

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 non-linear problems are investigated with original inquiry suggested and encouraged. Prerequisites: Engineering 202 and Mathematics 232. *R. De Jong.*

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. *Staff.*

318 Soil Mechanics and Foundation Design (4). S. 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 identification, permeability, compressibility and consolidation, soil testing, static and dynamic pressures, effective pressures, and foundation design. Laboratory experiments are used to emphasize principles. Prerequisite: Engineering 305. *R. Hoeksema.*

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 exercises are used to illustrate concepts. Prerequisites: Engineering 202 and 209, Mathematics 231, and permission of the instructor. *Staff.*

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, groundwater flow, open channel flow, closed conduit flow, and Centrifugal Pumps. Computer techniques and laboratory exercises are used to emphasize principles. Prerequisite: Engineering 319. *R. Hoeksema.*

321 Hydraulic Engineering Design (4). F. Application of principles of hydraulics and hydrology to the design of hydraulic systems and structures. 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, design of flood control structures, and design of dams and reservoirs. Computer techniques will be frequently employed. Prerequisite: Engineering 320. *R. Hoeksema.*

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. *L. Van Poolen.*

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 com-

puter-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. *G. Ermer.*

325 Computer Architecture and Digital Systems Design (4). F. Design of advanced digital systems using programmable logic, ASICs, and microprocessors. Microprocessor architecture including pipelining, memory hierarchy, cache, instruction set architecture, CPU control, bus standards, I/O, superscalar, and 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. *Staff.*

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. *L. De Rooy.*

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 AISC specification for the design, fabrication, and erection of structural steel for buildings and the ACI building code requirements for reinforced concrete. Computer techniques are used as aids to analysis and design. Prerequisite: Engineering 326. *L. De Rooy.*

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. *L. Van Poolen.*

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. *J. Van Antwerp.*

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. Prerequisites: Engineering 312, 330, and Chemistry 317. *W. Wentzheimer.*

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. *Staff.*

333 Thermal Systems Design (4). F. Advanced heat transfer, thermodynamic, and fluid flow topics important for the design of thermal systems are presented. Availability (energy) 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. *L. Van Poolen.*

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. *G. Ermer.*

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

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. *J. Van Antwerp.*

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 the concepts of capacity and Level-of-Service as they pertain to freeways, signalized intersections, and freeway weave sections. Software applications are used for the optimization and stimulation of traffic signal networks. 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. *Staff.*

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. *Staff.*

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 banquet. 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, Biblical Foundations I or Theological Foundations I, Developing a Christian Mind, and Philosophical Foundations. *Staff.*

342 Process Control (4). S. This course is 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 applications to process control are discussed. Prerequisites: Engineering 204 and Mathematics 231. *Staff.*

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. Written reports required. Prerequisites: Engineering 204. *Staff.*

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

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 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 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. *E. Nielsen.*

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. *E. Nielsen.*