

PHYSICS AND ENGINEERING

| Chair | Secretary | Location | Department Phone |
|------------------|-------------|----------------------------|------------------|
| Dr. Athula Herat | Mary Caylor | 208 Vincent Science Center | 724-738-2074 |

Department Web Site URL (<https://www.sru.edu/academics/colleges-and-departments/ches/departments/physics-and-engineering/>)

Civil Engineering Fact Sheet URL (<https://www.sru.edu/documents/programs/factsheets/undergraduate/CivilEngineering-fs.pdf>)

Industrial and Systems Engineering Fact Sheet URL (<https://www.sru.edu/documents/programs/factsheets/undergraduate/industeng-fs.pdf>)

Mechanical Engineering Fact Sheet URL (<https://www.sru.edu/documents/programs/factsheets/undergraduate/MechanicalEngineering-fs.pdf>)

Petroleum and Natural Gas Engineering Fact Sheet URL (<https://www.sru.edu/documents/programs/factsheets/undergraduate/PNGE-fs.pdf>)

Physics Fact Sheet URL (<https://www.sru.edu/documents/programs/factsheets/undergraduate/physics-fs.pdf>)

Faculty

Sagar Bhandari

Assistant Professor
Physics and Engineering
Ph.D., Harvard University
M.S., Harvard University
B.S., Trinity College

Louis Christensen

Assistant Professor
Physics and Engineering

Christopher Gioia

Assistant Professor
Physics and Engineering
Ph.D., West Virginia University
M.S., West Virginia University
B.S., Penn State University

Sajad Hamidi

Associate Professor
Physics and Engineering
Ph.D., Tarbiat Modares University
M.S.E., Sharif University of Technology
B.S.E., Sharif University of Technology

Athula Herat

Associate Professor
Physics and Engineering
Ph.D., University of Cincinnati
M.S., University of Cincinnati
B.S., University of Colombo (Sri Lanka)

Robabeh Jazaei

Assistant Professor
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Ph.D., University of Nevada
M.S., Azad University

B.S., Shahrood University of Technology

Mohammad Kazemi

Assistant Professor
Physics and Engineering
Ph.D., West Virginia University
M.S., University of Louisiana
B.S., Petroleum University of Technology

Viacheslau Kudrashou

Assistant Professor
Physics and Engineering
Ph.D., Texas A&M University
M.S., Texas A&M University
B.S., Gubkin Russian State University of Oil and Gas

Shah Limon

Assistant Professor
Physics and Engineering
Ph.D., North Dakota State University
M.S., North Dakota State University
B.S., Bangladesh University of Engineering & Technology

Krishna Mukherjee

Assistant Professor
Physics and Engineering
Ph.D., University of Pittsburgh
M.S., University of Kansas
M.Sc., University of Calcutta (India)
B.Sc., University of Calcutta (India)

Ben Shaevitz

Professor
Physics and Engineering
Ph.D., Pennsylvania State University
B.S., Purdue University

Jheng-Wun Su

Assistant Professor
Physics and Engineering
Ph.D., University of Missouri-Columbia
M.S., National Taipei University of Technology
B.S., Ching Yun University

Xindi Sun

Assistant Professor
Physics and Engineering
Ph.D., Missouri University
B.S., Missouri University

Manuel Valera

Associate Professor
Physics and Engineering
Ph.D., University of Cincinnati
M.S., University of Cincinnati
B.S., Universidad Simon Boliver (Venezuela)

Xinchao Wei

Professor
Physics and Engineering
Ph.D., West Virginia University
M.S., West Virginia University
M.S., Northeastern University

B.S., Northeastern University

Jun Zhang

Associate Professor
Physics and Engineering
Ph.D., Old Dominion University
M.S., Nanchang University
B.S., Nanchang University

Programs

All first-year students who enter SRU in the Summer and Fall terms of 2019 and after will follow Rock Studies. Students who entered SRU before Spring 2019 will follow Liberal Studies. All new transfer students beginning Summer 2019 and after will follow Liberal Studies. We anticipate that transfer students will begin to enter under Rock Studies during the Summer/Fall term of 2021.

Majors

- Civil Engineering, Bachelor of Science (BS) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/civil-engineering-bs/>)
- Industrial and Systems Engineering, Bachelor of Science (BS) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/industrial-systems-engineering-bs/>)
- Mechanical Engineering, Bachelor of Science (BS) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/mechanical-engineering-bs/>)
- Petroleum and Natural Gas Engineering, Bachelor of Science (BS) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/petroleum-natural-gas-engineering-bs/>)
- Physics, Bachelor of Arts (BA) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-ba/>)
- Physics, Bachelor of Arts (BA) - Pre Master of Education (7-12) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-ba-pre-master-education/>)
- Physics, Bachelor of Arts (BA) / Dual Degree Pre-Engineering (PSU) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-ba-dual-degree-pre-engineering/>)
- Physics, Bachelor of Arts (BA) / Pre-Engineering (Pitt) (3+2) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-ba-pre-engineering-pitt/>)
- Physics, Bachelor of Arts (BA) / Pre-Engineering (WVU) (3+2) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-ba-pre-engineering-wvu/>)
- Physics, Bachelor of Arts (BA) / Pre-Engineering (YSU) (3+2) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-ba-pre-engineering-ysu/>)
- Physics, Bachelor of Arts (BA) / Pre-Engineering Technology (YSU) (3+2) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-ba-pre-engineering-technology-ysu/>)
- Physics, Bachelor of Science (BS) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-bs/>)
- Physics, Bachelor of Science (BS) - Concentration in Computational Biophysics (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-bs-concentration-computational-biophysics/>)

- Physics, Bachelor of Science (BS) - Concentration in Computational Physics (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-bs-concentration-computational-physics/>)
- Physics, Bachelor of Science (BS) - Pre Master of Education (7-12) (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-bs-pre-master-education-7-12/>)

Minors

- Physics, Minor (<https://catalog.sru.edu/undergraduate/health-engineering-sciences/physics-engineering/physics-minor/>)

Courses

CIVL Courses

CIVL 139 - University Seminar

University Seminar serves as the entry point to the Slippery Rock University general education program. With its strong faculty-student interaction, the course promotes intellectual inquiry, critical and creative thinking, and academic excellence. Through varied content, the course introduces students to academic discourse and information literacy while exploring topics such as diversity and inclusion and global awareness. This course will set students along the path to becoming engaged with issues and scholarship important to a 21st century education while they learn about themselves and their place in the world.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with a semester level of Freshman 1 or Freshman 2.

Enrollment limited to students with the ROCK STUDIES STUDENT attribute.

CIVL 190 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

CIVL 195 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

CIVL 198 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

CIVL 210 - Elementary Survey

Introductory course in surveying methods and theory. Topics will include surveying, and route surveying.

Prerequisite: MATH 225^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

CIVL 290 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

CIVL 295 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

CIVL 298 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

CIVL 310 - Structural Engineering

Introduction to the elastic behavior of structural components. Analysis of statically determinate systems. Deflection calculations by virtual work and elastic load methods. Analysis of simple statically indeterminate structures. Influence lines. Interaction of structural components. Typical structural engineering loads.

Prerequisite: ENGR 230^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 320 - Transportation Engineering

Introduction to basic concepts in transportation engineering including: planning, design, and operations. Introduces the challenges and issues in modeling transportation problems. Studies of various concepts related to the design of highway facilities, level of service, and demand for transportation services. Concepts related to signal optimization, policy implications and the basics of transportation planning.

Prerequisite: MATH 230^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 330 - Environmental Engineering

A course in environmental engineering fundamentals that applies biological, chemical, and mathematical principles to solve environmental engineering problems using the mass balance approach.

Prerequisites: MATH 230^D and BIOL 101^D and CHEM 107^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 340 - Geotechnical Engineering

Soil properties, identification and classification of earth material; subsurface exploration; soil strength, stresses, settlement, substructure design; computer applications.

Prerequisite: ENGR 230^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 350 - Water Resources Engineering

This course is designed to review the fundamentals and practices of water resources engineering with a focus on engineering applications of hydraulics and hydrology. The concepts of fluid mechanics (hydrostatics, conservation laws) will be applied to analyze flow phenomena in demonstrations and field trips.

Prerequisite: ENGR 301^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 390 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 395 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 398 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 410 - Structural Steel Design

This course covers the analysis and design of structural steel members for tensile, compressive, flexural and combined loading.

Prerequisite: CIVL 310^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 411 - Reinforced Concrete Design

This course covers strength design concepts, beams, columns, slabs, retaining walls, single and combined footings with computer applications.

Prerequisite: CIVL 310^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 412 - Finite Element Analysis

Modern analysis techniques used to investigate a variety of systems in engineering and science. Computational models of problems are developed using energy concepts, structural mechanics, and matrix operations. The methods used are implemented using a general finite element program and the accuracy of the results is evaluated. The learned theoretical approach is applied to common structural elements such as trusses, beams, frames, and plates.

Prerequisite: CIVL 310^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 420 - Traffic Engineering

This course covers the fundamentals of traffic engineering and traffic flow theory: traffic signal design, intersection design, and traffic impact studies. Students will be taught using Highway Capacity Software, SYNCHRO, and other traffic software packages.

Prerequisite: CIVL 320^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 421 - Highway Engineering

Principles of geometric design of highways, intersections, interchanges, and terminals. Practical issues of vertical and horizontal curvature, highway evaluation, driver and vehicle dynamics, and traffic safety are also addressed. Computer-aided design and modeling.

Prerequisite: CIVL 320^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 422 - Transportation Terminal Design

The course covers the transportation design of airports, rail stations and truck terminals to facilitate the transport of passengers and freight in the transportation systems. Terminals are designed to provide security, storage, and access to different modes of transportation.

Prerequisite: CIVL 320^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 430 - Storm Water Management

Quality and quantity of urban storm water. Receiving water problems and sources of pollutants. Runoff quality and quantity characteristics. Selection and design of controls; regulations.

Prerequisite: CIVL 350^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 431 - Environmental Engineering Design

Process design of treatment/remediation systems to solve specific environmental problems, including evaluation alternatives and computer simulation.

Prerequisite: CIVL 330^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 432 - Groundwater Hydrology

The course covers the fundamental science and engineering behind groundwater systems, including but not limited to: the hydrologic cycle, groundwater flow, and wellhead protection and management.

Prerequisite: CIVL 350^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 440 - Construction Management

Provides students with an overview of the responsibilities and risk associated with management within the construction industry. Emphasis is given to responsibilities and relationships between owners, contractors, labor and suppliers, construction estimates and schedules, construction contracts and safety.

Prerequisite: CIVL 340^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 441 - Sustainable Development

Provides an overview of sustainable development with emphasis on the role of the engineer. Study the role of LEED and other sustainable development programs in changing development design.

Prerequisite: CIVL 330^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 460 - Capstone Design I

This course will provide students with the opportunity to work as part of a multi-disciplinary Civil Engineering design team. The course will consist of developing the preliminary design plans with presentations and reports. Students will learn about the regulatory process, LEED design, and site planning. Lectures in professional practice and teaming will augment the design project.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Enrollment limited to students with a semester level of Senior 1 or Senior 2.

Enrollment is limited to students with a program in Civil Engineering.

CIVL 461 - Capstone Design II

This course will provide students with the opportunity to work as part of a multi-disciplinary Civil Engineering design team. The course will consist of a design project with presentations and reports. Lectures in professional practice and teaming will augment the design project.

Prerequisite: CIVL 460^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Enrollment limited to students with a semester level of Senior 1 or Senior 2.

Enrollment is limited to students with a program in Civil Engineering.

CIVL 490 - Independent Study

Independent Study courses give students the opportunity to pursue research and/or studies that are not part of the university's traditional course offerings. Students work one on one or in small groups with faculty guidance and are typically required to submit a final paper or project as determined by the supervising professor.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 495 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

CIVL 498 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ENGR Courses

ENGR 110 - Introduction to Engineering

The first in a two-semester course sequence aiming to provide students with an introduction to engineering, design process, and tools needed in the engineering professions. This course introduces students to the different disciplines of engineering, professional and ethical aspects of engineering, teamwork, engineering design process and problem solving, and various computer applications.

Credits: 2

Term(s) Typically Offered: Offered Fall Terms

ENGR 120 - Engineering Design Tools

This is the second in a two-semester course sequence aiming to provide students with an introduction to engineering, design process, and tools needed in the engineering professions. This course focuses on the design process, introduction to engineering computing tools, engineering graphics using a Computer Aided Design (CAD) software platform, and 3D printing. Students will learn the basic tools and techniques used in engineering design and problem solving.

Credits: 2

Term(s) Typically Offered: Offered Spring Terms

ENGR 130 - Engineering Computing Tools

This course provides students with computing skills required in engineering. Course content includes structured programming, engineering problems and open-ended design projects, which are solved in teams with results professionally presented.

Credits: 2

Term(s) Typically Offered: Offered Fall & Spring Terms

ENGR 139 - University Seminar

University Seminar serves as the entry point to the Slippery Rock University general education program. With its strong faculty-student interaction, the course promotes intellectual inquiry, critical and creative thinking, and academic excellence. Through varied content, the course introduces students to academic discourse and information literacy while exploring topics such as diversity and inclusion and global awareness. This course will set students along the path to becoming engaged with issues and scholarship important to a 21st century education while they learn about themselves and their place in the world.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with a semester level of Freshman 1 or Freshman 2.

Enrollment limited to students with the ROCK STUDIES STUDENT attribute.

ENGR 190 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

ENGR 195 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

ENGR 198 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

ENGR 210 - Statics

Includes the application of equilibrium conditions to structures, trusses, frames and machines, and beams with concentrated and distributed loads.

Prerequisites: PHYS 216^D and MATH 230 (may be taken concurrently)^D
^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

ENGR 220 - Engineering Materials

This course covers the properties and uses of typical materials used in various engineering professions, their manufacturing processes, and an introduction to mechanical testing methods.

Prerequisite: CHEM 107^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

ENGR 230 - Mechanics of Materials

This course provides a review of the basic mechanical properties of the solids with lab. Topics covered will include deformation and failure of solid bodies under the action of forces, stress-strain, Mohr's circle, generalized Hooke's Law, axial bending and buckling.

Prerequisites: ENGR 210^D or PHYS 314^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

ENGR 231 - Mechanics of Materials Lab

A laboratory course to accompany ENGR 230 Mechanics of Materials. Laboratory experiments are designed to introduce experimental techniques common to structural engineering, interpretation of experimental data, comparison of measurements to numerical/analytical predictions, and formal, engineering report writing.

Prerequisite: ENGR 230 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 1

Term(s) Typically Offered: Offered Spring Terms

ENGR 240 - Dynamics

Integrates the subject content of kinematics and kinetics that deal respectively with the description of motion of bodies and the causes for their motion.

Prerequisites: PHYS 314^D or ENGR 210^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

ENGR 290 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

ENGR 295 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

ENGR 298 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

ENGR 301 - Fluid Mechanics

This course provides an overview of fluid statics and dynamics concepts. Topics covered will include fluid statics, laminar and turbulent flow of compressible and incompressible fluids, flow measurements, open channel flow and kinetics of fluids.

Prerequisites: ENGR 210^D and MATH 230^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ENGR 310 - Introduction to Electrical Engineering

This course provides a review of the basic concepts in electrical engineering. Topics covered will include electrical engineering units, circuit elements, circuit laws, measurement principles, mesh and node equations, network theorems, operational amplifier circuits, energy storage elements, sinusoids and phasors, sinusoidal steady state analysis, average and RMS values, complex power.

Prerequisites: PHYS 212^D or PHYS 217^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Enrollment limited to students with a semester level of Freshman 1, Freshman 2 or Sophomore 1.

ENGR 320 - Thermodynamics

This course provides a detailed review of the basic thermodynamic principles. Topics covered will include properties of ideal gases and vapors; first and second laws of thermodynamics; basic gas and vapor cycles; basic refrigeration.

Prerequisite: PHYS 217^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ENGR 340 - Engineering Economics

This course covers the concepts of cash flow, cash flow equivalence, cash flow before taxes, depreciation and depletion, cash flows after taxes, profits, evaluation of alternatives, financial statements and multidisciplinary team project.

Prerequisite: MATH 225^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ENGR 390 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with a semester level of Graduate.

ENGR 395 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ENGR 398 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ENGR 490 - Independent Study

Independent Study courses give students the opportunity to pursue research and/or studies that are not part of the university's traditional course offerings. Students work one on one or in small groups with faculty guidance and are typically required to submit a final paper or project as determined by the supervising professor.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ENGR 495 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ENGR 498 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE Courses**ISE 139 - University Seminar**

University Seminar serves as the entry point to the Slippery Rock University general education program. With its strong faculty-student interaction, the course promotes intellectual inquiry, critical and creative thinking, and academic excellence. Through varied content, the course introduces students to academic discourse and information literacy while exploring topics such as diversity and inclusion and global awareness. This course will set students along the path to becoming engaged with issues and scholarship important to a 21st century education while they learn about themselves and their place in the world.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with the ROCK STUDIES STUDENT attribute.

ISE 190 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

ISE 198 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

ISE 290 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

ISE 298 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

ISE 311 - Introduction to Operations Research

Topics include deterministic methods in operations research. Linear programming, duality, integer programming, dynamic programming, nonlinear programming, inventory theory, transportation and assignment and network theory.

Prerequisites: MATH 231^C or MATH 240^C or (MATH 122^C and MATH 230^C)

^C Requires minimum grade of C.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 330 - Six Sigma Methodology

Statistical methods of Six Sigma used for efficient new product development as well as methods for process improvement. The math and methodology of six Sigma including DMAIC and DMADV processes. Topics will include measurement and analysis mathematical techniques. Design of experiment will be introduced. Case studies will be used to illustrate advanced concepts of Six Sigma.

Prerequisite: STAT 350^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 362 - Lean Systems

The design and delivery of services. Topics include how to design and improve service offerings for sustained excellence, how to identify and overcome challenges in service delivery. Both traditional services as well as e-commerce service will be studied for both the private and public sector.

Prerequisite: ISE 330 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 370 - Design of Industrial Systems and Processes

This course covers advanced topics in Applied Engineering Statistics. It includes the introduction to linear regression analysis, simple linear models, multiple linear models, residual analysis, indicator variables, variable selection process, ANOVA, introduction to design of Industrial systems and processes, basic designs, factorial designs, fractional factorial designs, blocking, Taguchi designs, and response surface methodology. Extensive use of statistical software will be introduced throughout the course.

Prerequisite: STAT 350^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 372 - Manufacturing Systems Design and Analysis

Contemporary techniques used to design and analyze manufacturing systems for economic manufacture of products. Design of manufacturing systems (human and automated) to satisfy differing types of product demand will be explored.

Prerequisite: ENGR 340^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 373 - Quality Engineering

A comprehensive coverage of modern quality control techniques including the design of statistical process control systems, acceptance sampling and process improvement.

Prerequisites: MATH 230^D and (STAT 252^D or STAT 350^D)

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 382 - Sustainable Processes

Exploration of the scientific and legal progress in sustainability. Students will learn both the theory of sustainability as well as how sustainable processes can be implemented throughout an organization.

Prerequisites: PHYS 217^D and MATH 230^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 390 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 398 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 402 - Work Design

Introductory tools required for analyzing and designing both the job and the worksite in a cost-effective manner, as well as measuring the resulting output. These tools include human information processing, basic auditory and visual displays, anthropometry and musculoskeletal principles, cumulative trauma disorders, work measurement and stopwatch time study. Students taking this course should be familiar with the basic concepts of cost.

Prerequisite: ISE 372 (may be taken concurrently)^C

^C Requires minimum grade of C.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 410 - Engineering Project Management

This course is an introduction to the concepts and practices of project management. It provides students with a basic exposure to the tasks and challenges facing today's engineering projects and in particular, those of the project manager. This course also provides students with the quantitative tools for the successful management of engineering projects. The problems of selecting projects, initiating projects, and operating and controlling projects will be discussed in this course.

Prerequisite: ENGR 340^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 420 - Simulation of Industrial Systems

In this course, the student will develop an understanding and need for discrete event simulation in practice. The course will focus on basic and advanced concepts in simulation modeling including analyzing simulation results, and successfully developing simulation models useful in production/manufacturing, supply chains, transportation, and other areas related to industrial and Manufacturing Engineering. Simulation package such as ARENA will be integrated and used throughout.

Prerequisites: (MATH 311^D or ISE 311^D) and STAT 350^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 421 - Supply Chain & Logistics Engineering

Overview of key logistics and supply chain management processes, concepts and methodologies. Emphasis is given to the Lean development of supply chain management, the analysis of logistics cost and service trade-offs among inventory transportation and warehousing activities, the strategic role of information technology in supply chains, the use of third-party logistics providers, and the methods of measuring the value of logistics performance. Instruction may include problem-based learning pedagogy.

Prerequisites: ISE 311 (may be taken concurrently)^D and ISE 373^{*D} (may be taken concurrently).

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 430 - Production Planning & Control

This course equips students with knowledge of fundamental issues in production and inventory planning and control while developing the students' modeling and analytical skills. This course emphasizes the application of industrial engineering theory and practice to the area of operations management and production planning/control. This course will cover analysis and understanding of forecasting, aggregate planning, operations strategy, capacity planning, supply-chain management, just-in-time systems, lean manufacturing, agile manufacturing, materials replacement planning, inventory management, and scheduling and sequencing.

Prerequisites: ENGR 340^D and ISE 372^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 432 - Productivity Analysis

Techniques for measuring and assessing productivity for output, labor, capital and input. Aggregation of productivity growth will also be discussed.

Prerequisite: MATH 231^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 440 - Health Care Systems Engineering

The course examines the technical structure of the healthcare delivery system and the role that industrial engineering (IE) plays in its design and improvement. Included will be how healthcare systems work in hospitals, medical offices, clinics and other healthcare organizations. Traditional IE methods for improving quality, patient safety, and employee productivity and satisfaction will be present within a systematic application of value chain engineering designed to produce lean processes.

Prerequisites: ISE 311^D and ISE 373^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 442 - Human Factors Engineering

An analytic study of human factors that need to be taken into account in the design and engineering of complex workplace systems.

Body mechanics will be used to understand the needs of humans in the workplace under a variety of different constraints: physical demands, environmental conditions, human capability. system design considerations aimed at reducing safety hazards will be studied.

Prerequisite: ISE 402^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 460 - Engineering Risk Analysis

This course is an introduction to risk, risk assessment, and risk management in engineering systems. It focuses on building mathematical models to assess and quantify risk principally by following the methodologies of probabilistic risk analysis. In particular, the course covers concepts of risk analysis, risks in engineered systems; methods of risk analysis, fault trees and event trees; quantification of probabilities, use of data, models, and expert judgments; risks and decisions, interlinking risk analysis with risk management; applications to cybersecurity.

Prerequisite: STAT 350^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 480 - Industrial and Systems Engineering Undergraduate Research

Research and design problems of limited scope approved on an individual basis intended to promote independent study; results of study presented in writing.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with a semester level of Junior 1, Junior 2, Senior 1 or Senior 2.

ISE 487 - Industrial and Systems Engineering Senior Project I

This course provides a proposal preparation for ISE 488 which includes defining a comprehensive problem in design involving systems in manufacturing, service, and other systems to improve efficiency and quality, and optimize the resources utilization.

Prerequisites: ISE 370^D and ISE 420^D and ISE 421^D

^D Requires minimum grade of D.

Credits: 1

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 488 - Senior Project II

Senior project in industrial and systems engineering. Requires students to complete a multi-dimensional project in their area of interest: industry, health-care, etc. The project must be approved by ISE faculty no later than the end of the fourth week of the start of the course. Students will be invited to propose their own projects or create one in collaboration with ISE faculty.

Prerequisite: ISE 487^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Enrollment limited to students with a semester level of Senior 1 or Senior 2.

ISE 490 - Independent Study

Independent Study courses give students the opportunity to pursue research and/or studies that are not part of the university's traditional course offerings. Students work one on one or in small groups with faculty guidance and are typically required to submit a final paper or project as determined by the supervising professor.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

ISE 498 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH Courses

MECH 139 - University Seminar

University Seminar serves as the entry point to the Slippery Rock University general education program. With its strong faculty-student interaction, the course promotes intellectual inquiry, critical and creative thinking, and academic excellence. Through varied content, the course introduces students to academic discourse and information literacy while exploring topics such as diversity and inclusion and global awareness. This course will set students along the path to becoming engaged with issues and scholarship important to a 21st century education while they learn about themselves and their place in the world.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with a semester level of Freshman 1 or Freshman 2.

Enrollment limited to students with the ROCK STUDIES STUDENT attribute.

MECH 190 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

MECH 195 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

MECH 198 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

MECH 290 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

MECH 295 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

MECH 298 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

MECH 310 - Machines and Mechanisms

Analysis of motion and forces in linkages and mechanisms. Synthesis of plane mechanisms, analysis of cams, gears and gear trains. Fundamentals of vibrations in machines. Analysis techniques include graphical, analytical and computational methods.

Prerequisite: ENGR 240^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 320 - Manufacturing Processes

Introduction to properties and uses of engineering materials. Introduction to mechanical testing methods, metrology, tolerances, testing and inspection; semi-finished product manufacturing; macro-processing (forming, casting, powder metallurgy, metal working, composite fabrication); joining; nontraditional manufacturing processes; and surface processing.

Prerequisites: ENGR 220^D and ENGR 230^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 330 - Introduction to Mechatronics

Selection of mechanical and electronic components and integration of these components into complex systems. Hands-on laboratory and design experiments with components and measurement equipment used in the design of mechatronic products.

Prerequisite: ENGR 310^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 340 - Heat Transfer

One-, two-, three-dimensional steady state conduction; transient conduction; free and forced convection; radiation; heat exchangers; heat and mass transfer by analytical, numerical analogical and experimental methods; design of thermal systems.

Prerequisites: ENGR 320^D and MATH 301^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 390 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 395 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 398 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 410 - Machine Design

Application of fundamental engineering principles to the design of various elements found in machines. Elements include connections, shafts, keys, couplings, springs, gears, belts, chains, bearings, clutches, brakes, screws, etc.

Prerequisite: MECH 310^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 411 - Mechanical Control Systems

Introduction to theory of feedback and control. Performance and stability of linear systems. Design of feedback control systems. Practical application and introduction to state-space methods.

Prerequisites: ENGR 310^D and MECH 410^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 412 - Finite Element Analysis

Modern analysis techniques used to investigate a variety of systems in engineering and science. Computational models of problems are developed using energy concepts, structural mechanics, and matrix operations. The methods used are implemented using a general finite element program and the accuracy of the results is evaluated. The learned theoretical approach is applied to common structural elements such as trusses, beams, frames, and plates.

Prerequisite: ENGR 230^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 420 - Design and Manufacturing

Manufacturing methods and operations. The interaction between design and manufacturing stressed in terms of drawing specifications versus process capability and tolerances, including standards applications and 1redesign for producibility.

Prerequisite: MECH 320^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 421 - Mechanical Vibrations

Introduction to mechanical vibrations: single and multi-degree of freedom systems, free and forced vibrations, impedance and modal analysis including applications.

Prerequisites: MECH 410^D and ENGR 240^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 422 - Thermal System Design

Device design and system design of compressors, turbines, heat exchangers, piping systems, internal combustion engines, and other component equipment. Optimization including thermo-economic evaluation and energy analysis.

Prerequisite: MECH 340^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 423 - Additive Manufacturing

Introduction to technologies and processes used to translate virtual solid model data into physical models for prototyping and end-use manufacturing applications. Discussion of design tools and design considerations for additively manufactured components.

Prerequisite: MECH 320^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 430 - Mechatronics

Instrumentation and measurements emphasizing systems that combine electronics and mechanical components with modern controls and microprocessors. First and second order behavior, transducers and intermediate devices, measurement of rapidly changing engineering parameters, microcontrollers and actuators.

Prerequisite: MECH 330^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 431 - Introduction to Robotics

Introduction to robots and their types. Homogeneous transformations. Kinematic equations and their solutions. Motion trajectories, statics, dynamics, and control of robots. Robot programming. Actuators, sensors and vision systems.

Prerequisites: ENGR 310^D and MECH 330^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 440 - HVAC Systems

The analysis and design of heating air conditioning systems. Topics include: psychometrics, comfort & health, heating and cooling loads, solar radiation, air distribution systems and refrigeration.

Prerequisites: MECH 340^D and ENGR 301^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 441 - Sustainable Energy

The technical, economic, environmental and physical resources constraints of energy sources are discussed in terms of both national and global development needs. The current states of both non-renewable and renewable technologies are presented in terms of their potential contribution to sustainable energy resources required for continued viable economic development.

Prerequisite: ENGR 320^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 460 - Capstone Design I

Capstone Design course is the culmination of the educational experience in Mechanical Engineering. The courses require students to draw upon all previous coursework and cultivate new skills in order to solve complex design problems associated with an assigned group project. This is the first course of a year-long design experience.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Enrollment limited to students with a semester level of Senior 1 or Senior 2.

Enrollment limited to students with department of Physics and Engineering.

MECH 461 - Capstone Design II Capstone Design II

Capstone Design course is the culmination of the educational experience in Mechanical Engineering. The courses require students to draw upon all previous coursework and cultivate new skills in order to solve complex design problems associated with an assigned group project. This is the second course of a year-long design experience.

Prerequisite: MECH 460^D

^D Requires minimum grade of D.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

Enrollment is limited to students with a program in Mechanical Engineering.

Enrollment limited to students in the Coll of Health, Engineer & Sci college.

MECH 490 - Independent Study

Independent Study courses give students the opportunity to pursue research and/or studies that are not part of the university's traditional course offerings. Students work one on one or in small groups with faculty guidance and are typically required to submit a final paper or project as determined by the supervising professor.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 495 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

MECH 498 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS Courses

PHYS 101 - Concepts of Science I with Lab

A descriptive and conceptual course in physics designed for the non-science major. Topics are selected from light, sound, motion, and astronomy to develop a necessary scientific attitude and background for today's society. There are two lectures and one-two hour laboratory per week.

Credits: 3

Term(s) Typically Offered: Offered Every Term

PHYS 102 - Concepts of Science II

A descriptive and conceptual course in physics designed for the non-science major to study energy systems. Topics are selected from heat, electricity, magnetism, and the structure of matter and modern areas of physics, such as lasers, X-rays, and nuclear energy. The purpose of the course is to develop a positive scientific attitude and background for today's society. No laboratory.

Credits: 3

PHYS 103 - Investigating Matter and Energy/ Lab

This is an activity-based and discussion-oriented course designed for the non-science major. The topics of light, matter, heat, and electricity have been selected to help students develop meaningful understanding of some powerful ideas that they can apply to a wide variety of interesting phenomena. Laboratory credit is given for taking this liberal studies enrichment course.

Credits: 3

PHYS 139 - University Seminar

University Seminar serves as the entry point to the Slippery Rock University general education program. With its strong faculty-student interaction, the course promotes intellectual inquiry, critical and creative thinking, and academic excellence. Through varied content, the course introduces students to academic discourse and information literacy while exploring topics such as diversity and inclusion and global awareness. This course will set students along the path to becoming engaged with issues and scholarship important to a 21st century education while they learn about themselves and their place in the world.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with a semester level of Freshman 1 or Freshman 2.

Enrollment limited to students with the ROCK STUDIES STUDENT attribute.

PHYS 140 - Engineering Graphics I

A beginning laboratory course in technological design and drawing.

Topics: lettering, scales, geometric construction, orthographic sketching, and auxiliary views.

Credits: 2

Term(s) Typically Offered: Offered Fall Terms Odd

PHYS 141 - Engineering Graphics II

An advanced laboratory course in technological drawing and implementation. Topics: Vectors, graphing, nomography, isometric pictorials, technical illustration, computer graphics, and working drawings.

Prerequisite: PHYS 140^D

^D Requires minimum grade of D.

Credits: 1

Term(s) Typically Offered: Offered Spring Terms

PHYS 190 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

PHYS 195 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

PHYS 198 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

PHYS 201 - Elements of Physics I with Lab

Introduction to physics at the algebra/trigonometry mathematical level. Topics include: mechanics, fluids, oscillations, waves, and sound. Course is especially designed for students enrolled in health science majors. This course must be taken with Elements of Physics Lab PHYS021.

Credits: 4

Term(s) Typically Offered: Offered Fall, Spring, & Summer

Enrollment limited to students with department of Exercise & Rehabilitative Sci.

PHYS 202 - Elements of Physics II/ Lab

Introduction to physics at the algebra/trigonometry mathematical level. Topics include: thermal physics, optics, electricity and magnetism, and nuclear physics. Course is especially designed for health science majors. This course must be taken with Elements of Physics II Lab PHYS022.

Prerequisite: PHYS 201^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Spring & Summer Terms

Enrollment limited to students with department of Exercise & Rehabilitative Sci.

PHYS 204 - Environmental Biophysics

An introductory course covering the energy problem and alternative solutions; radiation and its effects on man; the eye and vision; the ear, hearing and noise pollution; electrical power production alternatives and the environmental costs; some instruments used in biophysics and medicine.

Credits: 3

PHYS 211 - General Physics I with Lab

Introduction to physics using calculus and including extensive problem solving. Topics include mechanics statics, kinematics, kinetics, work-energy, rotational motion, and impulse-momentum. This course must be taken with General Physics Lab PHYS011.

Prerequisite: MATH 225 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Fall & Spring Terms

PHYS 212 - General Physics II with Lab

This is a calculus based course, which follows PHYS 211. It develops the concepts of electric and magnetic fields. Topics covered are Gauss' Law, Ampere's Law, Biot's Law, Faraday's Law, electric charges and their dynamics, capacitance, resistance inductance, etc. Offered fall semester only. Includes a lab.

Prerequisites: MATH 225^D and PHYS 211^D and MATH 230 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

PHYS 213 - General Physics III/ Lab

Covers fluids, hydrostatics and hydro-dynamics, heat transfer and measurements, laws of thermodynamics, vibrating bodies, wave motion, light lenses and optical instruments, interference and diffraction, polarization. This course must be taken with General Physics III Lab PHYS023. Offered spring term only.

Prerequisite: PHYS 211^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Spring Terms

PHYS 216 - University Physics 1 with Lab

First of a two semester calculus based introduction to physics sequence for science, engineering, and mathematics students. Students will acquire knowledge of fundamental physics principles and their applications as well as problem solving skills and laboratory and data acquisition experience. Topics covered: kinematics, dynamics, momentum of particles and rigid bodies, work and energy, gravitation, simple harmonic motion, and waves. This course must be taken with University Physics 1 Lab.

Prerequisite: MATH 225 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 4

PHYS 217 - University Physics 2 with Lab

Second of a two semester calculus based introduction to physics sequence for science, engineering, and mathematics students. Students will acquire knowledge of fundamental physics principles and their applications as well as problem solving skills and laboratory and data acquisition experience. Topics Covered: Fluids, Thermodynamics, Electricity and Magnetism, Circuits, and Optics. This course must be taken with University Physics 2 Lab.

Prerequisites: PHYS 216^D and MATH 230 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 4

PHYS 271 - Astronomy

This course is designed for the general student. Recent findings in astronomy are discussed, i.e., black holes, quasars, etc. Other topics of interest are the evolution of stars, galaxies, and the universe since the big bang. No math required.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Thematic Thread(s): The Future, Revolutions, Transfer Thread Completion Course

PHYS 290 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

PHYS 295 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

PHYS 298 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

PHYS 301 - Physical Chemistry I

Thermodynamics and chemical kinetics. Cross listed as CHEM301.

Prerequisites: CHEM 108^D and CHEM 112^D and (PHYS 212^D or PHYS 213^D) and MATH 230^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 312 - Modern Physics 1

An introductory course that focuses on the transition from classical physics covered in the calculus based introductory physics sequence to contemporary physics. Topics include: Brief overview of special relativity, experimental and theoretical developments that led to the discovery of the atomic structure, early quantum mechanics, Schrodinger's equation and its application and a brief introduction to solid state physics.

Prerequisites: PHYS 212^D and PHYS 213^D and MATH 230^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 314 - Statics

Includes the application of equilibrium conditions to structures, trusses, frames and machines, and beams with concentrated and distributed loads.

Prerequisites: PHYS 211^D and MATH 230 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 315 - Dynamics

Integrates the subject content of kinematics and kinetics that deal respectively with the description of motion of bodies and the causes for their motion.

Prerequisites: PHYS 314^D and ENGR 210^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 317 - Space Science

Introductory course in space exploration. It emphasizes the evolution of the earth with respect to its neighbors in the solar system. Other topics covered are the earth's ionosphere, magnetosphere, hazards of satellite communication, and orbital dynamics.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Thematic Thread(s): The Future, Transfer Thread Completion Course

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 325 - Analog & Digital Electronics

An introductory analog and digital electronics course designed primarily for science students. The course will start with an analysis of AC and DC circuits using Kirchhoff's laws and complex numbers. The analog part will include a study of discrete components including diodes, transistors, and SCRs as well as linear integrated circuits. The digital part will include basic gates as well as MSI and LSI circuits and will be center around interfacing computers to experiments.

Prerequisite: PHYS 212^D

^D Requires minimum grade of D.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 331 - Mathematical Methods of Physics

Applications in physical science and engineering of the following: vector analysis, complex variables, Fourier and Laplace transforms, linear algebra, and some boundary value problems. Cross-linked as MATH 331. This course may be counted as a physics course or as a mathematics course, but not both.

Prerequisites: MATH 240^D and PHYS 211^D and MATH 231 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 371 - Physical Optics

This is a physical optics course dealing with the nature and transmission of light. Topics covered will include the propagation of light, coherence, interference, diffraction, Maxwell's Equations, optics of solids, thermal radiation, optical spectra and lasers.

Prerequisites: PHYS 212^D and PHYS 213^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms Odd

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 375 - Thermal Physics

This is an introductory course in thermodynamics and statistical mechanics, with application to both physics and engineering.

Prerequisites: PHYS 213^D and MATH 231^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 381 - Advanced Physics Laboratory

Selected experiments in all branches of physics that are of a more advanced grade than those given at the general or intermediate level. Each experiment will be an extended piece of careful, thorough work, culminating in a detailed report.

Prerequisites: PHYS 211^D and PHYS 212^D and PHYS 213^D

^D Requires minimum grade of D.

Credits: 2

Term(s) Typically Offered: Offered Spring Terms Even

Students with a semester level of Freshman 1, Freshman 2, Sophomore 1 or Sophomore 2 may **not** enroll.

PHYS 382 - Optics Laboratory

This course will provide in depth experience in laboratory techniques, data acquisition and analysis in the field of Optical Physics. Experiments are of a more advanced grade than those given at the general or intermediate level. Each experiment will be an extended piece of careful, thorough work, culminating in a detailed report. Appropriate for students majoring in the Biological, Earth, Environmental, Health, Mathematics and Physical sciences.

Prerequisites: PHYS 211^D and PHYS 212^D and (PHYS 213^D or PHYS 201^D) and PHYS 202^D and (MATH 225^D or MATH 230^D or MATH 231^D)

^D Requires minimum grade of D.

Credits: 2

Term(s) Typically Offered: Offered Spring Terms Odd

Students with a semester level of Freshman 1, Freshman 2, Sophomore 1 or Sophomore 2 may **not** enroll.

PHYS 385 - Computational Physics

An introduction to scientific computational methods and their application in physics. A range of numerical and symbolic computing techniques will be explored, including numerical integration, matrix methods, differential equations, random walks, and Monte Carlo simulations. These techniques together with visualization methods will be used to solve problems taken from different physics topics, such as classical mechanics, electricity and magnetism, thermodynamics, quantum mechanics, and biophysics.

Prerequisites: PHYS 213^D and MATH 240^D and CPSC 140^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 390 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 395 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 398 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 410 - Electricity and Magnetism

Electric fields and potentials of charge distributions and polarized materials, magnetic fields and vector potentials of current distributions and magnetized materials; electric and magnetic energies and application of Maxwell's equations.

Prerequisites: PHYS 212^D and PHYS 331^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms Even

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 412 - Modern Physics 2

This course explores the applications of Quantum mechanics and relativity. Topics covered will include atomic physics, quantum statistics, solid state physics, nuclear physics, astrophysics and cosmology.

Prerequisites: PHYS 312^D and MATH 231^D and PHYS 331 (may be taken concurrently)^D

^D Requires minimum grade of D.

Credits: 1

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 421 - Materials Safety and Equipment Overview for Nanofabrication - NMT 311

This course provides an overview of basic nanofabrication processing equipment and materials handling procedures with a focus on safety, environment, and health issues. Topics covered include: cleanroom operation, environmental, safety, and health issues, vacuum pump systems operation, environmental safety and health issues (covering direct drive mechanical, roots blowers, turbomolecular, and dry mechanical systems); thermal- processing equipment operation, safety, environmental, and health issues (covering horizontal, vertical, rapid thermal annealing tools); chemical vapor deposition system operation, safety, environmental, and health issues (covering gas delivery, corrosive and flammable gas storage and plumbing, regulators, and mass flow controllers); and vacuum deposition/etching system operation, safety, environment, and health issues (covering microwave and RF power supplies and tuners, heating and cooling units, vacuum gauges, valves, and process controllers). Specific materials handling issues include those arising from using deionization water, solvents, cleansers, organic materials, ion implementation sources, diffusion sources, photoresists, developers, metal dielectrics and toxic, flammable, corrosive and high purity gases as well as packaging materials.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 422 - Basic Nanofabrication Processes - NMT 312

The course provides an overview of basic processing steps used in all applications of nanofabrication. Both top-down and bottom-up nanofabrication are included. The majority of the course details a step-by-step description of the equipment and processes needed to fabricate devices and structures such as bio- chips, CMOS transistors, power devices, microelectromechanical (MEM) devices, and opto-electronic structures. Students learn the similarities and differences in both the equipment and process flows needed in fabricating all of these various structures.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 423 - Thin Films in Nanofabrication - NMT 313

This course covers thin film deposition and etching practices in nanofabrication. The deposition techniques addressed in the first part of the course include atmospheric, low pressure, and plasma enhanced chemical vapor deposition and sputtering, thermal evaporation, and beam evaporation physical vapor deposition. Also included are self-assembling molecule based techniques. Materials considered include organics, dielectrics (e.g., nitrides, oxides), polysilicon (doped and undoped), metals (e.g., aluminum, tungsten, copper), adhesion promoters and diffusion barriers. The second part of the course focuses on etching processes and emphasizes reactive ion etching (single wafer, batch), high-ion-density reactors, ion beam etching and wet chemical etching. Students receive hands-on experience in depositing and etching dielectric, semiconductor, and metal materials using state-of-the-art tools and experience practicing the steps critical to micro- and nanofabrication of structures used in a variety of fields from biotechnology and the biomedical fields to microelectronics.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 424 - Advanced Lithography and Dielectrics Nanofabrication - NMT 314

This course covers all aspects of lithography from design and mask fabrication to pattern transfer and inspection. The course is divided into three major sections. The first section describes the lithographic process from substrate preparation to exposure. The second section examines the processes from development through inspection (both before and after pattern transfer). This section introduces optical masks, aligners, steppers and scanners. In addition, critical dimension (CD) and profile control of photoresists are investigated. The last section discusses advances in optical lithographic techniques such as phase shifting masks and illumination schemes as well as molecular ruler, e-beam, x-ray, EUV, and ion beam lithography.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 425 - Materials Modification in Nanofabrication - NMT 315

This course covers in detail the processing steps used in modifying material properties in nanofabrication. Included are chemical reaction, growth and annealing processes. The impact of thermal processing and thermal processing on defects, gettering, and impurities and overall electrical, mechanical, optical, and chemical properties are studied. The student grows and measures gate and field oxides, implants and activates source and drain regions, and evaluates thermal budget requirements using state-of-the-art tools. Included also are other modification technologies such as ion implantation, diffusion and chemical surface preparation and treatment. Substrate preparation processing such as slicing, etching, polishing and epitaxial growth are also covered.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 426 - Characterization, Packaging and Testing of Nanofabrication Structures - NMT 316

This course examines a variety of measurements and techniques essential for controlling micro- and nanofabrication processes. Monitoring techniques such as residual gas analysis (RGA), optical emission spectroscopy (OES) and end point detection are discussed. Characterization techniques such as scanning electron microscopy x-ray photoelectron spectroscopy, atomic probe methods advanced optical microscopy, optical thin film measurements, ellipsometry, and resistivity/conductivity measurements are introduced and tied to process control. Basic measurements for yield analysis and process control are also stressed. These include breakdown measurements, junction testing, and capacitance-voltage and current voltage characterization. In addition, the characteristics of some simple bio-chip structures and MEMs devices are obtained and discussed. The student learns about the manufacturing issues involved in interconnects, materials compatibility and final device assembly. Aluminum, refractory metals and plastic fabrication techniques and characterization are discussed in detail along with topics such as diffusion barriers, contact resistance, electro migration, corrosion, and adhesion. The importance of planarization techniques such as deposition/etchback and chemical/mechanical polishing are emphasized. Lastly, procedures such as die separation, bonding, and sealing and final test for both conventional Cs and MEMs and biomedical devices are examined.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 450 - Internship

Supervised placement and research in selected public and private agencies.

Credits: 1-12

Term(s) Typically Offered: Offered as Needed

PHYS 480 - Quantum

In this introductory course in quantum mechanics, the foundations and origins will be covered. Other topics will include wave packets, the uncertainty principle, the Schroedinger equation, operator formalism, eigen functions, spherically symmetric systems, angular momentum, spin and scattering theory.

Prerequisites: PHYS 331^D and PHYS 411^D and MATH 240^D and MATH 301^{*D} (may be taken concurrently).

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 490 - Independent Study

Investigation of the theoretical or experimental area following a plan or proposal initiated by the student and approved by the major advisor. Independent Study courses give students the opportunity to pursue research and/or studies that are not part of the university's traditional course offerings. Students work one on one or in small groups with faculty guidance and are typically required to submit a final paper or project as determined by the supervising professor.

Credits: 1-3

Term(s) Typically Offered: Offerings Vary

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 495 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PHYS 498 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE Courses

PNGE 139 - University Seminar

University Seminar serves as the entry point to the Slippery Rock University general education program. With its strong faculty-student interaction, the course promotes intellectual inquiry, critical and creative thinking, and academic excellence. Through varied content, the course introduces students to academic discourse and information literacy while exploring topics such as diversity and inclusion and global awareness. This course will set students along the path to becoming engaged with issues and scholarship important to a 21st century education while they learn about themselves and their place in the world.

Credits: 3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with a semester level of Freshman 1 or Freshman 2.

Enrollment limited to students with the ROCK STUDIES STUDENT attribute.

PNGE 190 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

PNGE 195 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

PNGE 198 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

PNGE 201 - Introduction to Petroleum and Natural Gas Engineering

This course provides an overview of different aspects of petroleum and natural gas engineering from generation to exploration of petroleum reservoirs to drilling and production from these resources.

Credits: 1

Term(s) Typically Offered: Offered Fall Terms

PNGE 290 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

PNGE 295 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

PNGE 298 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

PNGE 312 - Petrophysics

This course provides an in depth review of the properties of the reservoir rock and fluids. Topics covered will include theoretical and applied phase behavior of hydrocarbon systems and hydrocarbon fluid properties, basic properties of petroleum reservoir rocks and laboratory evaluation of basic and special petroleum reservoir rock and fluid properties.

Prerequisites: CHEM 107^D and CHEM 111^D and PNGE 201^D

^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 315 - Reservoir Fluids

Thermodynamic behavior of naturally occurring hydrocarbon mixtures; evaluation and correlation of physical properties of petroleum reservoir fluids including laboratory and empirical methods.

Prerequisites: PNGE 312^D and CHEM 108^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 325 - Reservoir Engineering

This course provides an in depth review of reservoir characteristics and behavior. Topics covered will include fluid flow through porous materials, evaluation of oil and gas resources and the reserves under a variety of production methods, and prediction of reservoir performance to achieve maximum conservation.

Prerequisites: EGEO 327^D and PNGE 315^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 330 - Unconventional Reservoir Engineering

This course addresses topics that are specific to exploration of unconventional reservoirs - identification and characterization, economics, efficient completion technologies and development strategies. Tight gas and shale gas reservoirs and coal bed methane engineering are addressed.

Prerequisite: PNGE 325^D

^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 390 - Experimental

A unique and specifically focused course within the general purview of a department which intends to offer it on a "one time only" basis and not as a permanent part of the department's curriculum.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 395 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 398 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 410 - Drilling engineering with Lab

This course provides an in depth review of drilling engineering practices. Topics covered will include functions and design considerations for the rotating system, hoisting system and circulating system; drilling fluids calculations and selections; hydraulic programs; drilling optimization; casing string design; cementing programs; and pressure control; laboratory evaluation of mud weight control filtration, chemical contaminants and rheological models.

Prerequisites: ENGR 301 (may be taken concurrently)^D and PNGE 312^D
^D Requires minimum grade of D.

Credits: 4

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 420 - Production Engineering

This course provides an in depth review of petroleum production engineering practices. Topics covered will include well completion, performance of productive formations, drill stem tests, completion of wells, flowing wells, gas lift methods and equipment, pumping installation design, well stimulation, emulsion, treating, gathering and storage of oil and gas, field automation.

Prerequisites: PNGE 410 (may be taken concurrently)^D and PNGE 325^D
^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 430 - Reservoir Simulation

Mathematical models governing fluid flow in reservoirs; relevant numerical methods; numerical reservoir simulations; treatment of wells; history matching; simulation project performed using a commercial simulator.

Prerequisites: PNGE 325^D and ENGR 130^D
^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 432 - Formation Evaluation

This course provides an in depth review of techniques for formation evaluation. Topics covered will include various well logging methods and related calculations with exercises in interpretation of data from actual well logs.

Prerequisite: PNGE 312^D
^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 435 - Pressure Transient Analysis

This course provides an in depth review of the well test analysis methods. Topics covered will include pressure transient tests and interpretation methods, unsteady-state fluid flow through porous rock, analysis of the drawdown and buildup tests, wellbore storage, application of pressure derivative in pressure transient data analysis, testing of hydraulically fractured wells, type curve method, testing of horizontal wells, unified method of analysis, well test design.

Prerequisite: PNGE 420^D
^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 440 - Hydraulic Fracturing

This course starts with a general overview of different types of unconventional reservoirs and their geological and petrophysical properties. Second part of the course emphasizes hydraulic fracturing design and data collection for proper fracture design. Economic analysis of hydraulic fracturing will be covered as well as more advanced topics such as completion design optimization.

Prerequisite: PNGE 325^D
^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 441 - Oil and Natural Gas Resource Valuation and Economics

This course provides an in depth review of the techniques for oil and gas property evaluation. Topics covered will include reserve estimation, decline analysis, petroleum property evaluation, interest calculations, cost estimation, and tax evaluation, investment decision analysis and computer applications in property evaluation.

Prerequisites: PNGE 325^D and PNGE 432^{*D} (may be taken concurrently).
^D Requires minimum grade of D.

Credits: 3

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 443 - Enhanced Oil Recovery

This course teaches an integrated version of the basics of waterflooding and enhanced oil recovery (EOR), illustrating the connection of each process to a few fundamental principles. It reviews the specifics of thermal and solvent EOR by relating basic principles to the results of cases from the field.

Prerequisite: PNGE 325^D
^D Requires minimum grade of D.

Credits: 3

Enrollment limited to students with a semester level of Senior 1 or Senior 2.

Enrollment is limited to students with a program in Petro & Natl Gas Engineering.

Enrollment limited to students in the Coll of Health, Engineer & Sci college.

PNGE 445 - Natural Gas Engineering with Lab

This course provides an in depth review of natural gas evaluation and production engineering practices. Topics covered will include natural gas properties, compression, transmission, processing and application of reservoir engineering principles to predict the performance and design of gas, gas-condensate and storage reservoirs. Includes a laboratory devoted to gas measurements.

Prerequisite: PNGE 325^D
^D Requires minimum grade of D.

Credits: 3

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 450 - Internship

Supervised placement and research in selected public and private agencies.

Credits: 3-9

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 459 - Petroleum and Natural Gas Design/Capstone I

This course provides a proposal preparation for PNGE 460 which includes defining a comprehensive problem in design involving systems in oil and gas production, field processing, transportation, and storage.

Prerequisites: PNGE 325^D and PNGE 410^D and PNGE 420^{*D} and PNGE 432^{*D} (may be taken concurrently).

^D Requires minimum grade of D.

Credits: 1

Term(s) Typically Offered: Offered Fall Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 460 - Petroleum and Natural Gas Engineering Design/Capstone II

This course provides comprehensive problems in design involving systems in oil and gas production, field processing, transportation and storage.

Prerequisite: PNGE 459^D
^D Requires minimum grade of D.

Credits: 2

Term(s) Typically Offered: Offered Spring Terms

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 470 - Petroleum and Natural Gas Engineering Undergraduate Research

Research and design problems of limited scope approved on an individual basis intended to promote independent inquiry.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Enrollment limited to students with a semester level of Junior 1, Junior 2, Senior 1 or Senior 2.

Enrollment limited to students with the SPECIAL APPROVAL attribute.

PNGE 490 - Independent Study

Investigation of the theoretical or experimental area following a plan or proposal initiated by the student and approved by the major advisor. Independent Study courses give students the opportunity to pursue research and/or studies that are not part of the university's traditional course offerings. Students work one on one or in small groups with faculty guidance and are typically required to submit a final paper or project as determined by the supervising professor.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 495 - Workshop

A workshop is a program which is usually of short duration, narrow in scope, often non-traditional in content and format, and on a timely topic.

Credits: 1-6

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.

PNGE 498 - Selected Topics

A Selected Topics course is a normal, departmental offering which is directly related to the discipline, but because of its specialized nature, may not be able to be offered on a yearly basis by the department.

Credits: 1-3

Term(s) Typically Offered: Offered as Needed

Students with a semester level of Freshman 1, Freshman 2 or Sophomore 1 may **not** enroll.