ILLINOIS VALLEY COMMUNITY COLLEGE

COURSE OUTLINE

DIVISION: Natural Sciences and Business

COURSE: PHY 2012 Engineering Physics II (Electricity, Magnetism, Waves, and Optics)

Date: Spring 2023

Credit Hours: 5

Complete all that apply or mark "None" where appropriate:

Prerequisite(s): MTH 2001 with a C or better *and* PHY 2011 with a C or better

Enrollment by assessment or other measure? ☐ Yes ☒ No
If yes, please describe:

Corequisite(s): None

Pre- or Corequisite(s): None

Consent of Instructor: ☐ Yes ☒ No

Delivery Method:

☒ **Lecture**	**3**	**Contact Hours (1 contact = 1 credit hour)**
☒ **Seminar**	**1**	**Contact Hours (1 contact = 1 credit hour)**
☒ **Lab**	**3**	**Contact Hours (2-3 contact = 1 credit hour)**
☐ **Clinical**	**0**	**Contact Hours (3 contact = 1 credit hour)**

Offered: ☒ **Fall** ☐ **Spring** ☐ **Summer**

CATALOG DESCRIPTION and IAI NUMBER (if applicable):
This is the second in sequence of engineering physics course using a calculus-based approach for students majoring in physics, chemistry, engineering, mathematics and related fields of study. The course provides a clear and precise introduction to the theory, experiment, and applications of electricity, magnetism and optics. Topics includes electric force and fields, Gauss' law; electric potential and potential energy; capacitance and dielectrics; direct current circuits and instruments; magnetic force and fields; electromagnetism, alternating current, Ampere's law, induction, electromagnetic waves, polarization, interference, diffraction and geometrical optics. **IAI Equivalent: PHY912**

ACCREDITATION STATEMENTS AND COURSE NOTES:
None

COURSE TOPICS AND CONTENT REQUIREMENTS:
1. Electric Charge and Electric Field
2. Gauss' Law
3. Electric Potential and Potential Energy
4. Capacitance and Dielectrics
5. Current, Resistance, and Electromotive Force
6. Direct Current Circuits and Instruments
7. Magnetic fields and forces
8. Sources magnetic fields and effects
9. Electromagnetic induction
10. Inductance
11. A.C. Circuits
12. Electromagnetic waves
13. Nature and propagation of light
14. Geometric Optics -- Reflection and Refraction of Light; Image Formation by Lenses and Mirrors, Optical Instruments
15. Physical Optics -- Diffraction and Interference; Polarization

1. Electric Charges and Forces
1.1 The Charge Model
1.2 Charge
1.3 Insulators and Conductors
1.4 Coulomb's Law
1.5 The Electric Field

2. The Electric Field
2.1 Electric Field Models
2.2 The Electric Field of Point Charges
2.3 The Electric Field of a Continuous Charge Distribution
2.4 The Electric Fields of Rings, Disks, Planes, and Spheres
2.5 The Parallel-Plate Capacitor
2.6 Motion of a Charged Particle in an Electric Field
2.7 Motion of a Dipole in an Electric Field

3. Gauss's Law
3.1 Symmetry
3.2 The Concept of Flux
3.3 Calculating Electric Flux
3.4 Gauss's Law
3.5 Using Gauss's Law
3.6 Conductors in Electrostatic Equilibrium

4 The Electric Potential
4..1 Electric Potential Energy
4.2 The Potential Energy of Point Charges

4.3 The Potential Energy of a Dipole
4.4 The Electric Potential
4.5 The Electric Potential Inside a Parallel-Plate Capacitor
4.6 The Electric Potential of a Point Charge
4.7 The Electric Potential of Many Charges

5 Potential and Field
5.1 Connecting Potential and Field
5.2 Finding the Electric Field from the Potential
5.3 A Conductor in Electrostatic Equilibrium
5.4 Sources of Electric Potential
5.5 Capacitance and Capacitors
5.6 The Energy Stored in a Capacitor
5.7 Dielectrics

6 Current and Resistance
6.1 The Electron Current
6.2 Creating a Current
6.3 Current and Current Density
27.4 Conductivity and Resistivity
27.5 Resistance and Ohm's Law

7 Fundamentals of Circuits
7.1 Circuit Elements and Diagrams
7.2 Kirchhoff's Laws and the Basic Circuit
7.3 Energy and Power
7.4 Series Resistors
7.5 Real Batteries
7.6 Parallel Resistors
7.7 Resistor Circuits
7.8 Getting Grounded
7.9 RC Circuits

8 The Magnetic Field
8.1 Magnetism
8.2 The Discovery of the Magnetic Field
8.3 The Source of the Magnetic Field: Moving Charges
8.4 The Magnetic Field of a Current
8.5 Magnetic Dipoles
8.6 Ampère's Law and Solenoids
8.7 The Magnetic Force on a Moving Charge
8.8 Magnetic Forces on Current-Carrying Wires
8.9 Forces and Torques on Current Loops
8.10 Magnetic Properties of Matter

9 Electromagnetic Induction
9.1 Induced Currents
9.2 Motional emf
9.3 Magnetic Flux

9.4 Lenz's Law
9.5 Faraday's Law
9.6 Induced Fields
9.7 Induced Currents: Three Applications
9.8 Inductors
9.9 LC Circuits
9.10 LR Circuits

10. Electromagnetic Fields and Waves
10.1 E or B? It Depends on Your Perspective
10.2 The Field Laws Thus Far
10.3 The Displacement Current
10.4 Maxwell's Equations
10.5 ADVANCED TOPIC Electromagnetic Waves
10.6 Properties of Electromagnetic Waves
10.7 Polarization

11 AC Circuits
11.1 AC Sources and Phasors
11.2 Capacitor Circuits
11.3 RC Filter Circuits
11.4 Inductor Circuits
11.5 The Series RLC Circuit
11.6 Power in AC Circuits

12 Wave Optics
12.1 Models of Light
12.2 The Interference of Light
12.3 The Diffraction Grating
12.4 Single-Slit Diffraction
12.5 ADVANCED TOPIC A Closer Look at Diffraction
12.6 Circular-Aperture Diffraction
12.7 The Wave Model of Light
12.8 Interferometers

13 Ray Optics
13.1 The Ray Model of Light
13.2 Reflection
13.3 Refraction
13.4 Image Formation by Refraction at a Plane Surface
13.5 Thin Lenses: Ray Tracing
13.6 Thin Lenses: Refraction Theory
13.7 Image Formation with Spherical Mirrors

14 Optical Instruments
14.1 Lenses in Combination
14.2 The Camera
14.3 Vision
14.4 Optical Systems That Magnify

14.5 Color and Dispersion
14.6 The Resolution of Optical Instruments

INSTRUCTIONAL METHODS:

1. Lectures and interactive lecture demonstration (ILDs), Activity-based physics and other audio-visual aids and technologies.
2. Homework assignments and related class discussion sessions.
3. Traditional Laboratory exercises.
4. Micro – computer-based laboratory exercises.
5. Modeling and guided practice of a variety of physics problems.
6. Conceptual and ranking task exercises.

EVALUATION OF STUDENT ACHIEVEMENT:

Students are assigned approximately fifteen (15) homework problems, five ranking task exercises, and five conceptual exercises per Chapter. Solutions of graded problems are discussed after grading.

Evaluation of the students will include five (5) written class tests and one problem-orientated comprehensive final exam, written reports of twelve laboratory experiments, quizzes and homework assignments

A = 90 -100
B = 80 – 89
C = 70 – 79
D = 60 – 69
F = 59 and below

INSTRUCTIONAL MATERIALS:

Textbooks

1. Physics for Scientist and Engineers, a strategic approach, with modern physics (including student work book, with mastering physics), 4th edition. Randall D. Knight
2. Modern Physics, 3rd ed, Raymond A. Serway; Clement J. Moses; Curt A. Moyer
3. Physics Laboratory Experiments, 6thedition, Jerry D Wilson and Cecilia A. Hernandez
4. Real Time Physics (Active Learning Laboratories), 3rd ed, David R. Sokoloff, Ronald K. Thornton, Priscilla W. Laws
5. Advance physics laboratory exercises and physics with video analysis by Vernier Science Education

Resources

University Physics with Modern Physics with Mastering Physics, Hugh D. Young, Roger A. Freedman, Classical Dynamics of particles and systems, Thornton and Marion, Brooks/Cole

The Mechanical Universe and Beyond the Mechanical Universe Physics Demonstration series, by Physics Curriculum and Instruction

LEARNING OUTCOMES AND GOALS:
Institutional Learning Outcomes

- ☐ 1) Communication – to communicate effectively;
- ☒ 2) Inquiry – to apply critical, logical, creative, aesthetic, or quantitative analytical reasoning to formulate a judgement or conclusion;
- ☐ 3) Social Consciousness – to understand what it means to be a socially conscious person, locally and globally;
- ☐ 4) Responsibility – to recognize how personal choices affect self and society.

Course Outcomes and Competencies
Outcome 1 – Students will be able to demonstrate an understanding of electric charge, fields and forces including the sources of the fields.

Competency 1.1 Students will be able to explain the difference between a conductor and an insulator, and various ways how an object can receive a net charge.
Competency 1.2 Students will be able to explain and use Coulomb's Law to determine both the magnitude and direction of electric force, including using calculus.
Competency 1.3 Students will be able to explain what is meant by an electric field and determine magnitude and direction for electric fields mathematically, including using calculus.

Outcome 2 – Students will be able to demonstrate an understanding of electric flux, Gauss's law, electric potential and capacitance and dielectrics.

Competency 2.1 Students will be able to define electric flux and Gauss's law and use gauss's law to solve electric field problems.
Competency 2.2 Students will be able to define electric potential and electric potential energy and solve problems involving these concepts.
Competency 2.3 Students will be able to explain what is meant by a capacitor and the term capacitance; determine the capacitance of a capacitor; combine capacitors which are in series or in parallel; and determine the energy stored in a charged capacitor.
Competency 2.4 Students will be able to explain what is meant by a dielectric and how a dielectric affects the capacitance of a capacitor and the energy stored in a capacitor.

Outcome 3 – Students will be able to demonstrate understanding of current, resistance, electromotive force and direct-current circuits design.

Competency 3.1 Students will be able to define the terms: current, electrical resistance, electromotive force, electric work and power, and solve problems involving these concepts, especially problems involving Ohm's Law.
Competency 3.2 Students will be able to combine resistors in series and in parallel and solve problems involving D.C. circuits by applying Kirchoff's Laws.
Competency 3.3 Students will be able to explain the principles of operation and uses of ammeters, voltmeters, ohmmeters, potentiometers, and solve problems involving these instruments.
Competency 3.4 Students will be able to solve problems involving R-C series circuits and power distribution systems.

Outcome 4 – Students will be able to demonstrate a basic understanding of magnetic fields including the sources of the fields and the effects they have on moving particles.

Competency 4.1 Students will be able to compute the force on a charged particle due to a magnetic field and determine the motion of a charged particle in a magnetic field.

Competency 4.2 Students will be able to compute the magnetic force on a current-carrying wire or coil and the magnetic torque on a current-carrying coil.

Competency 4.3 Students will be able to compute the magnetic field produced by a moving charged particle, by a current element, and by a current-carrying conductor.

Competency 4.4 Students will be able to know and apply Ampere's Law to determine a magnetic field.

Outcome 5 – Students will be able to demonstrate a basic understanding of dynamic electromagnetic fields and their applications to simple electronics.

Competency 5.1 Students will be able to describe what is meant by, and compute, a nonelectrostatic field and an induced electric field.

Competency 5.2 Students will be able to know and apply Faraday's Law and Lenz's Law to the solution of problems involving induced electric fields, including motional emfs.

Competency 5.3 Students will be able to solve simple problems involving electric motors.

Competency 5.4 Students will be able to define and compute mutual and self-inductance and the energy associated with an inductor.

Competency 5.5 Students will be able to solve problems involving R-L and L-C circuits.

Competency 5.6 Students will be able to solve simple A.C. circuit problems involving resistors, capacitors, and inductors. This includes computing capacitive and inductive reactance, impedance, and electric power.

Competency 5.7 Students will be able to solve simple transformer problems.

Outcome 6 – Students will be able to demonstrate a basic understanding of geometrical optics including refraction, reflection, lenses, mirrors, and various optical devices.

Competency 6.1 Students will be able to know and apply the laws of reflection and refraction of light to the solution of problems.

Competency 6.2 Students will be able to describe the dispersion of light by a prism and by lenses.

Competency 6.3 Students will be able to describe total internal reflection of light and solve problems involving total internal reflection.

Competency 6.4 Students will be able to describe, in words and determine graphically and mathematically, the formation of images by a single reflection or refraction at a plane or spherical surfaces. This includes determining the position and size of any image formed.

Competency 6.5 Students will be able to describe in words and compute mathematically and graphically the position and size of images formed by lenses and various optical instruments, including the eye, the magnifier, the camera, the compound microscope, and the telescope.

Outcome 7 – Students will be able to demonstrate a basic understanding of the wave nature of light.

- Competency 7.1 Students will be able to be able to describe in words and mathematically the diffraction and interference of light by a single slit, a double slit, and a diffraction grating.
- Competency 7.2 Students will be able to describe in words and mathematically the interference of light from coherent sources, by thin films, by the Michelsen interferometer, by a crystal.
- Competency 7.3 Students will be able to describe in words what is meant by a polarized light and four ways (reflection, double refraction, absorption, and scattering) in which light may be polarized; solve simple problems involving polarized light. Describe, in words, optical stress analysis and optical activity, as these terms relate to polarized light.