ILLINOIS VALLEY COMMUNITY COLLEGE

COURSE OUTLINE

DIVISION: Natural Sciences and Business

COURSE: PHY 2013 Engineering Physics III: Thermal & Quantum Physics

Date: Spring 2023

Credit Hours: 5

Complete all that apply or mark "None" where appropriate:
Prerequisite(s): PHY 2012 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
This is the third in sequence of engineering physics course using a calculus-based approach for students intending to major 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 thermal and quantum physics. Topics include macroscopic description of matter, work, heat, heat engines, ideal gas laws, first and second law of thermodynamics, kinetic theory of gasses, entropy and statistical mechanics, introduction to application of free energy and Boltzmann factor, relativity, the foundations of modern physics quantization, wave functions and uncertainty, quantum mechanics, solid state physics and conduction, nuclear physics, elementary particle physics and interaction. **IAI equivalent: PHY915A**

ACCREDITATION STATEMENTS AND COURSE NOTES:
None

COURSE TOPICS AND CONTENT REQUIREMENTS:

1. A Macroscopic Description of Matter
2. Work, Heat, and the First Law of Thermodynamics
3. The Micro/Macro Connection
4. Heat Engines and Refrigerators
5. Entropy and statistical mechanics (Advanced topic)
6. Introduction to application of free energy and Boltzmann factor (Advanced topic)
7. Relativity
8. The Foundations of Modern Physics
9. Quantization
10. Wave Functions and Uncertainty
11. One-Dimensional Quantum Mechanics
12. Solid state physics
13. Atomic Physics
14. Nuclear Physics and its applications
15. Fundamental Particles and Interactions

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, 6th edition, 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, 14/E, Hugh D. Young, Roger A. Freedman,

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 macroscopic description of matter

Competency 1.1 Students will be able to explain the difference between solids, liquids and gases using the microscopic motions of atoms and molecules.

Competency 1.2 Students will be able to demonstrate an understanding of thermal expansion.

Competency 1.3 Students will be able to state, explain and use the ideal gas laws (model) to solve problems involving the change in state of a gas.

Outcome 2– Students will be able to demonstrate an understanding of thermodynamics

Competency 2.1 Students will be able to explain the meaning of the term temperature, and distinguish between temperature and heat, and convert between the Celsius, kelvin, and Fahrenheit temperature scales.

Competency 2.2 Students will be able to define, explain and solve problems involving thermal expansion, thermal stress, heat capacity and changes of phase. They will also be able explain/describe the three methods by which heat is transferred and solve problems involving these methods of heat transfer.

Competency 2.3 Students will be able to describe/explain the molecular properties of matter, the kinetic theory of gases, apply the ideal gas law to solve problems involving gases.

Competency 2.4 Students will be able to explain a thermodynamic system and know the first law of thermodynamics, as well as explain and solve problems involving thermodynamic processes using the first law.

Competency 2.5 Students will be able to know and explain the heat engines and second law of thermodynamics and solve problems involving heat engines and the second law

Outcome 3 Students will be able to demonstrate an understanding of the application of the law of thermodynamics to chemical reactions and other transformations of matter.

Competency 3.1 Students will be able to explain free energy as available work and apply the concepts in solving related problems.

Competency 3.2 Students will be able to explain free energy as a force towards equilibrium and apply the concepts in solving related problems.

Competency 3.3 Students will be able to explain and apply phase transformation of pure substance and mixtures

Outcome 4 Students will be able to demonstrate an understanding of Boltzmann statistics

Competency 4.1 Students will be able to explain and apply the Boltzmann factor in solving problems.

Competency 4.2 Students will be able to explain, in words and mathematically, equipartition theorem, use it to solve related problems.

Outcome 5 Students will be able to demonstrate an understanding of the structure and properties of atoms.

Competency 5.1 Students will be able to describe and explain the new theories of matter and light that arouse in the 20th century

Competency 5.2 Students will be able to describe and explain the experimental evidence for how we know about atoms and their structure.

Outcome 6– Students will be able to demonstrate a basic understanding modern physics including, quantum mechanics, and wave/particle duality.

Competency 6.1 Students will be able to describe, in words, the photoelectric effect, the Compton effect, and pair production; solve problems based on the photoelectric effect and the Compton effect.

Competency 6.2 Students will be able to describe, in words and mathematically, the structure of the atom, including the Rutherford atom, the Bohr models of the atom, and the Quantum Mechanical model of the atom.

Competency 6.3 Students will be able to describe and mathematically use the concepts of special relativity for discussions and problem solving.

Outcome 7– Students will be able to demonstrate an understanding of nucleus and explain and describe some applications of nuclear physics. Students will also understand the most fundamental constituents of our universe and the forces acting between them.

Competency 7.1 Students will be able to describe and explain how the nucleus is constructed and what holds it together.

Competency 7.2 Students will be able to explain isotopes and their stability.

Competency 7.3 Students will be able to mathematically determine the energy of decaying particles and mass defect

Competency 7.4 Students will be able to describe the process of nuclear decay, its causes and resulting particles.

Competency 7.5 Students will be able to describe and explain the physics of neutrinos, the dark universe and some fundamental physics and quantum technologies.