THE GOVERNOR'S SCHOOL for SCIENCE AND TECHNOLOGY

Modern Physics PHY-243
2022-2023

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Class Fees: none

Course Title: Modern Physics

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1. **Course Description:** Learning fundamental knowledge of physics and engineering disciplines and the requisite skills to problem-solve, be innovative, and create opportunities in the real world are the overarching goals of this course. Extending the first year physics material, the course includes also investigations in calculus-based modern physics topics such as relativity, quantum mechanics, and nuclear physics, including, for example, conceptual understanding and practical applications of relativity of time and space, the wave function, Schrödinger's Equation, and radiation and radioactivity. This course includes also various physical and virtual laboratory activities with which students will be able to enhance and apply their comprehension of the course material.

2. **Course Texts:** Physics for Scientists and Engineers (2nd edition) by Randall D. Knight. Modern Physics For Scientists and Engineers (4th edition) Stephen T. Thornton.

3. **Prerequisites/Co-requisites**
   - Engineering Physics I, II

4. **Required Materials**
   - Notebook (3-ring binder preferred)
   - Pencil(s), erasers, graduated straight edge
   - Scientific Calculator (e.g. TI-30, Casio fx-300, or better)

5. **Academic Integrity:** Any cheating on any exams or quizzes will result in a grade of "0" for that test. Cheating is defined as either the giving or the receiving of unauthorized help. Any indication of cheating will result in a grade of zero for the exam; **a second violation and there will be conferencing with the director**.

6. **Grading:** Each course consists of classwork, homework, exams and quizzes, and projects. Student work will be evaluated using the following weighted components and grade scale. All assessments will be timed to correspond to nationally normed standardized testing.

7. **Evaluation**

Weighted Components

a. 15% Homework, Attendance, Research reports and presentations
b. 20% Quizzes, Problem sessions and
c. 25% Exams, projects

Course Grade Scale

Final course grades will be assigned using the following scale as a guide:

90-100 A
80-89 B
70-79 C
60-69 D
0-59 F

8. **Course Outline**

I. **Modern Physics** - Survey of contemporary physics including special theory of relativity, an introduction to general theory of relativity, quantum mechanics, atomic, nuclear and particle physics, and topics of recent and future of physics research.

a. Special Theory of Relativity
    i. Einstein's Theories
    ii. Simultaneity
    iii. Time Dilation
    iv. Length Contraction
    v. Lorentz Transformations
    vi. Relativistic Momentum
    vii. Relativistic Energy
b. General Theory of Relativity
    i. Invariance Principle
    ii. Accelerated Reference Frames
    iii. Gravitation and Curvature of Space-Time
    iv. Expansion of the universe, black holes and neutron stars
c. Limits of Classical Physics
    i. Thomson and the electron
    ii. Rutherford and the Nuclear Atom
    iii. Absorption and Emission of Light – Wien's Law and Balmer's formula
d. Quantization
    i. Photoelectric Effect
    ii. Einstein's postulates and quantized energy
    iii. DeBroglies' postulate and matter waves
    iv. Bohr's hydrogen atom

v. The hydrogen spectrum

e. Wave Functions and Uncertainty
   i. Wave properties of matter
   ii. Normalization
   iii. Wave Packets
   iv. Heisenberg Uncertainty Principle

f. Quantum Mechanics
   i. Schrödinger's Equation
   ii. Correspondence Principle
   iii. Potential Wells
      1. Infinite wall
      2. Finite wall
      3. Forbidden regions
   iv. Sample Quantum Mechanical models
      1. Quantum well oscillator
      2. Molecular vibrations
      3. Quantum capacitor
      4. Covalent bonds
      5. Quantum mechanical tunneling

g. Atomic Physics
   i. The hydrogen atom
   ii. Electron spin
   iii. Multi-electron atoms
   iv. Excited states of the atom

h. Nuclear & Particle Physics
   i. Nuclear structure
   ii. Nuclear stability
   iii. Shell model
   iv. Radiation and Radioactivity
   v. Nuclear Decay

9. Laboratory activities include:
   a. Michelson-Morley Experiment
   b. Cosmic muon lifetime experiment
   c. Atomic Spectrum/Hydrogen Spectrum
   d. Photoelectric effect
   e. Plancks constant
   f. Heisenberg experiment
   g. Cloud chamber particle detector
   h. Milikan oil drop experiment

10. Times and topics are subject to change. Updated schedules will be announced.