MESABI RANGE COMMUNITY & TECHNICAL COLLEGE – VIRGINIA/EVELETH

Course Outline

Course Title: Modern Physics I
Semester Course Prefix and Number: PHYS 2430
Old Quarter Course Prefix and Number:

Submitted By: M. Threapleton
Approval Date: April 2002
Revision Date:

Number of Credits: 3
Semester(s) Offered: SP
Negotiated Class Size: 30

Number of Lecture Credits: 3
Number of Lab Credits: 0 **Number of Lab Hours:** 0
Number of Studio/Demonstration/Internship Credits: 0

Course Purpose Code:

______ **0 –** Developmental Courses
______ **1 –** Non-transferable, General Education
______ **2 –** Technical course related to career programs
______ **3 –** College course which has the primary goal of applying certain concepts (e.g. vocal ensemble)
______ **4 –** Other college course not considered a part of general education (MNTC) e.g. computer science, health, physical education
__X__ **5 –** Course which is intended to fulfill the Minnesota Transfer Curriculum (MNTC) requirements.
______ **9 –** Continuing Education/Customized Training specialized credit course (not occurring in 0-5)

Catalog Description:
Modern Physics is the third course in the physics sequence for students majoring in physics or engineering. This course focuses on physical discoveries made during the 20th century, including relativity, particle physics, quantum mechanics, and nuclear physics.

Prerequisites and/or recommended entry skills/knowledge:
Course Prerequisite(s): Phys 1572 Engineering Physics II
Reading Prerequisite: None
Composition Prerequisite: None
Mathematics Prerequisite: Higher School Higher Algebra

Career Programs and Transfer Majors Accessing this Course:
Engineering transfer students in most engineering majors and physics.

Minnesota Transfer Curriculum Goal(s) partially met by this course if applicable: Notes: No more than two goals may be met by any one course. (Curriculum Committee review and the Chief Academic Officer's approval are required).

0. __X__ None
1. _____ Communications
2. _____ Critical Thinking
3. _____ Natural Sciences
4. _____ Mathematical/Logical Reasoning
5. _____ History and the Social and Behavioral Sciences
6. _____ The Humanities and Fine Arts
7. _____ Human Diversity
8. _____ Global Perspectives
9. _____ Ethical and Civic Responsibility
10. _____ People and the Environment

Learning outcomes, including any relevant competencies listed in the Minnesota Transfer Curriculum:
The student will:

1. Define the significance of Maxwell's Equations and demonstrate how they imply the existence of electromagnetic waves.
2. Use Maxwell's Equations to derive the speed of light.
3. Calculate the energy, momentum, and radiation pressure of plane EM waves.
4. Learn the postulates of special relativity and their implications.
5. Calculate time dilation and length contraction for objects moving at speeds close to the speed of Light.
6. Use the Lorentz Transformation to add relativistic velocities correctly.
7. Determine the mass and energy of objects at relativistic speeds.
8. Cite the evidence for particle-like properties of waves and point out the failing of classical physics to explain observations.
9. Distinguish between the photoelectric effect, the Compton effect, and pair production and properly assess mass and energy in each case.
10. Cite the evidence for wave-like properties of particles and point out the failing of classical physics to explain observations.
11. Properly use De Broglie's wavelength to analyze particles.
12. Use probability theory to calculate position, momentum, and energy.
13. Apply the uncertainty principle to particles and waves.
14. Describe the early modes for atoms and recognize their failings.
15. Utilize the Bohr model to calculate energy levels and spectra.
16. Apply atomic excitation theory to the operation of lasers.
17. Use quantum mechanics to explain the observed electron probability densities of atoms and molecules, the tunnel effect, radiative transitions, atomic structure, the periodic table of elements, molecular bonding, specific heats of solids and ideal gases, rotational and vibrational energy levels, and the conductivity of metals.
18. Apply the exclusion principle appropriately.
19. Identify the early models of the nucleus.
20. Describe the composition and properties of the nucleus.
21. Assess the stability of nuclei.
22. Identify the source of radioactivity.
23. Distinguish between nuclear fission and fusion, and be able to calculate the energy liberated in various nuclear reactions.
24. Write a comprehensive research paper and give an oral presentation.
25. Complete assign homework on time.
26. Work in a cooperative team environment that is conducive to learning.
27. Communicate all written work in a clear professional manner.

Student assessment methods:
The final grade is determined by grades earned on homework problems, a research paper, periodic examinations, and a comprehensive final examination.

Use of instructional technology (includes software, interactive video and other instructional technologies):
The students will use Microsoft Office computer software, and computer projection equipment.

Outline of the major course content:
Electromagnetic waves

- A. Maxwell's Equations
  1. Unification of electromagnetism
  2. Hertz's discovery
  3. Plane electromagnetic waves
  4. Derivation of the speed of light
- B. Properties of electromagnetic waves

1. Poynting vector
2. Momentum
3. Radiation pressure
4. Production of EM waves by an antenna
5. Spectrum of EM waves

II. Special relativity
   A. Einstein's postulates
      1. Time dilation
      2. Length contraction
      3. Twin paradox
      4. Simultaneity and the order of events
   B. Lorentz Transformation
      1. Velocity addition
      2. Mass and energy
      3. Electricity and magnetism
      4. Massless particles

III. Particle physics
   A. Particle properties of waves
      1. Blackbody radiation
      2. Photoelectric effect
      3. Compton effect
      4. Pair production
      5. Photons and gravity
   B. Wave properties of particles
      1. De Broglie waves
      2. Probability waves
      3. Phase and group velocities
      4. Particle diffraction
      5. Particle in a box
      6. Uncertainty principle
   C. Atomic structure
      1. Early atomic models
      2. Atomic spectra
      3. Bohr atom
      4. Energy level and spectra
      5. Correspondence principle
      6. Atomic excitation
      7. Lasers

IV. Quantum Mechanics
   A. Schrodinger's equation
      1. Expectation values
      2. Particle in a box
      3. Finite potential well
      4. Tunnel effect
      5. Harmonic oscillator
   B. Quantum theory of the hydrogen atom
      1. Quantum numbers
      2. Electron probability density
      3. Radiative transitions
      4. Selection rules
      5. Zeeman effect
   C. Many-electron atoms
      1. Electron spin
      2. Exclusion principle
      3. Symmetric and anti-symmetric wave functions
      4. Periodic table

        5. Atomic structures
        6. Spin-orbit coupling
        7. X-ray spectra
    D. Molecules
        1. Molecular bonds
        2. Rotational energy levels
        3. Vibrational energy levels
        4. Electronic spectra of molecules
    E. Statistical mechanics
        1. Statistical distributions
        2. Maxwell-Boltzmann statistics
        3. Ideal gas
        4. Rayleigh-Jeans formula
        5. Planck radiation law
        6. Specific heats of solids
        7. Free electrons in metals
        8. Dying stars

V. Nuclear physics
    A. Nuclear structure
        1. Nuclear composition
        2. Nuclear properties
        3. Stable nuclei
        4. Binding energy
        5. Liquid-drop model
        6. Shell model
        7. Meson theory of nuclear forces
    B. Nuclear transformations
        1. Radioactive decay
        2. Half-life
        3. Decay processes: alpha, beta, gamma
        4. Nuclear fission
        5. Nuclear fusion

VI. Cosmology
    A. Elementary particles
    B. History of the universe

Additional special information (special fees, directives on hazardous materials, etc.)
A scientific calculator capable of numeric integration is required for this course. Engineer's paper will be required for all homework assignments.

Transfer Information: (Please list colleges/majors that accept this course in transfer.)
University of Minnesota; University of Minnesota-Duluth; Minnesota State University, Mankato; St. Cloud State University; Michigan Technological University; North Dakota State University; University of North Dakota all accept for engineering majors.

Approvals:

Body	Representative Signatures	Date
Curriculum Committee	Kim Giermann	April 2, 2002
Faculty Association	Georgia Suoja	April 8, 2002
Meet and Confer	Dr. Jill Peterson	April 17, 2002
Chief Academic Officer	Dr. Jill Peterson	April 17, 2002

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