 # 456/457 CPO PHYSICAL SCIENCE

GRADE: 10

LEVEL: 1/2

CREDITS: 5

RECOMMENDATION: MATH 300 or MATH 301

BASIC TEXT: Foundations of Physical Science, 2nd Ed., by Tom Hsu, Ph.D., 2005

SUPPLEMENTAL READINGS:

REQUIRED MATERIALS:
Pen/Pencil
Notebook
Calculator

COURSE DESCRIPTION: This is an introductory course that deals with the laws describing the behavior of matter and energy. Topics include: measurement, graphing, kinematics (a description of motion), force, the laws of motion, conservation of momentum and energy, work, power, thermodynamics (heat), waves, basic electricity and magnetism and light. A working knowledge of Algebra is required.

MISSION RELATED GOALS:
Foster problem solving
Foster communication
Academic excellence
Intellectual curiosity
Respect rights of others
Students will communicate effectively, solve complex problems and work with others towards a common goal while developing appropriate problem solving skills. The students will respect the rights of others while promoting personal growth in accepting responsibility and working individually within a group setting.

STUDENT EXPECTATIONS FOR LEARNING ADDRESSED: (How this course ties in with the Expectations for Student Learning).

• **Communicate effectively** – In their classroom discussions and other oral and written presentations, students will obtain information and present ideas in a clear, articulate manner.
• **Solve complex problems** – In their labs and projects, students will use higher order thinking skills to assess and solve multi-step problems.
• **Work with others towards a common goal** – Again, in their labs and projects, students will accept personal responsibility and work interdependently in a group setting.

• **Contribute to the community and the global society** – Students will understand that scientific knowledge will enable them as citizens to better promote the welfare of the local and global society.
• **Respect the rights of others** – In the classroom setting students will be led to establish appropriate rules and then to follow those rules for the benefit of all the members of the class.
• **Exercise life skills that promote personal growth** – Students will recognize the role that science education may play in achieving their future goals. Students will communicate effectively and work towards a common goal while developing appropriate problem solving skills. The students will respect the rights of others while promoting personal growth in accepting responsibility and working individually within a group setting.

GENERAL PERFORMANCE OBJECTIVES: The students will be able to:
• Express all units in the SI system of measurement.
• Represent types of motion by means of graphical, mathematical and conceptual models.
• Identify and apply the laws of motion to real-life situations.
• Apply Newton's Laws of Motion appropriately to various physical situations.
• Apply the law of Conservation of Momentum to colliding objects.
• Apply the law of Conservation of Mechanical Energy to various situations.
• Analyze the concepts of work and power and their relationship to Energy.
• Interpret aspects of waves by using sound and light as applications of wave motion.
• Apply basic electrical principles by designing and constructing simple electric circuits.
• Discover the relationship between heat and work.
• Demonstrate how thermal energy is applied to practical devices.
• Apply electromagnetic principles by problem solving.
• Investigate the basic properties and principles of optics.

MASSACHUSETTS CURRICULUM FRAMEWORKS STANDARDS (# and description):
From the Massachusetts Science and Technology/Engineering Curriculum Framework, October, 2006, Introductory Physics, High School.

I. CONTENT STANDARDS

1. Motion and Forces
Central Concept: Newton's laws of motion and gravitation describe and predict the motion of most objects.

1.1 Compare and contrast vector quantities (e.g., displacement, velocity, acceleration force, linear momentum) and scalar quantities (e.g., distance, speed, energy, mass, work).
1.2 Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.

1.3 Create and interpret graphs of 1-dimensional motion, such as position vs. time, distance vs. time, speed vs. time, velocity vs. time, and acceleration vs. time where acceleration is constant.
1.4 Interpret and apply Newton's three laws of motion.
1.5 Use a free-body force diagram to show forces acting on a system consisting of a pair of interacting objects. For a diagram with only co-linear forces, determine the net force acting on a system and between the objects.
1.6 Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.
1.7 Describe Newton's law of universal gravitation in terms of the attraction between two objects, their masses, and the distance between them.
1.8 Describe conceptually the forces involved in circular motion (if time allows).

2. Conservation of Energy and Momentum
Central Concept: The laws of conservation of energy and momentum provide alternate approaches to predict and describe the movement of objects.

2.1 Interpret and provide examples that illustrate the law of conservation of energy.
2.2 Interpret and provide examples of how energy can be converted from gravitational potential energy to kinetic energy and vice versa.
2.3 Describe both qualitatively and quantitatively how work can be expressed as a change in mechanical energy.
2.4 Describe both qualitatively and quantitatively the concept of power as work done per unit time.
2.5 Provide and interpret examples showing that linear momentum is the product of mass and velocity, and is always conserved (law of conservation of momentum). Calculate the momentum of an object.

3. Heat and Heat Transfer
Central Concept: Heat is energy that is transferred by the processes of convection, conduction, and radiation between objects or regions that are at different temperatures.

3.1 Explain how heat energy is transferred by convection, conduction, and radiation.
3.2 Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached.
3.3 Describe the relationship between average molecular kinetic energy and temperature. Recognize that energy is absorbed when a substance changes from a solid to a liquid to a gas, and that energy is released when a substance changes from a gas to a liquid to a solid. Explain the relationships among evaporation, condensation, cooling, and warming.
3.4 Explain the relationships among temperature changes in a substance, the amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.

4. Waves
Central Concept: Waves carry energy from place to place without the transfer of matter.

4.1 Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonic motion.
4.2 Distinguish between mechanical and electromagnetic waves.

4.3 Distinguish between the two types of mechanical waves, transverse and longitudinal.
4.4 Describe qualitatively the basic principles of reflection and refraction of waves.
4.5 Recognize that mechanical waves generally move faster through a solid than through a liquid and faster through a liquid than through a gas.
4.6 Describe the apparent change in frequency of waves due to the motion of a source or a receiver (the Doppler effect).

5. Electromagnetism
Central Concept: Stationary and moving charged particles result in the phenomena known as electricity and magnetism.

5.1 Recognize that an electric charge tends to be static on insulators and can move on and in conductors. Explain that energy can produce a separation of charges.
5.2 Develop qualitative and quantitative understandings of current, voltage, resistance, and the connections among them (Ohm's law).
5.3 Analyze simple arrangements of electrical components in both series and parallel circuits. Recognize symbols and understand the functions of common circuit elements (battery, connecting wire, switch, fuse, resistance) in a schematic diagram.
5.4 Describe conceptually the attractive or repulsive forces between objects relative to their charges and the distance between them (Coulomb's law).
5.5 Explain how electric current is a flow of charge caused by a potential difference (voltage), and how power is equal to current multiplied by voltage.
5.6 Recognize that moving electric charges produce magnetic forces and moving magnets produce electric forces. Recognize that the interplay of electric and magnetic forces is the basis for electric motors, generators, and other technologies.

6. Electromagnetic Radiation
Central Concept: Oscillating electric or magnetic fields can generate electromagnetic waves over a wide spectrum.

6.1 Recognize that electromagnetic waves are transverse waves and travel at the speed of light through a vacuum.
6.2 Describe the electromagnetic spectrum in terms of frequency and wavelength, and identify the locations of radio waves, microwaves, infrared radiation, visible light (red, orange, yellow, green, blue, indigo, and violet), ultraviolet rays, x-rays, and gamma rays on the spectrum.

II. SCIENTIFIC INQUIRY SKILLS STANDARDS

Scientific literacy can be achieved as students inquire about the physical world. This curriculum does include a substantial amount of "hands-on" laboratory experiences, so that students can develop and use scientific skills in introductory physics, along with the inquiry skills listed below.

SIS1. Make observations, raise questions, and formulate hypotheses.

- Observe the world from a scientific perspective.
- Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.
- Read, interpret, and examine the credibility and validity of scientific claims in different sources of information, such as scientific articles, advertisements, or media stories.

SIS2. Design and conduct scientific investigations.

- Articulate and explain the major concepts being investigated and the purpose of an investigation.
- Identify independent and dependent variables.
- Write concise procedures that are clear and replicable.
- Employ appropriate methods for accurately and consistently
    - making observations
    - making and recording measurements at appropriate levels of precision
    - collecting data or evidence in an organized way
- Properly use instruments, equipment, and materials (e.g., scales, probe ware, meter sticks, computers) including set-up, calibration (if required), technique, maintenance, and storage.
- Follow safety guidelines.

SIS3. Analyze and interpret results of scientific investigations.

- Present relationships between and among variables in appropriate forms.
    - Represent data and relationships between and among variables in charts and graphs.
    - Use appropriate technology (e.g., graphing software, if available) and other tools.
- Use mathematical operations to analyze and interpret data results.
- Assess the reliability of data and identify reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis.

SIS4. Communicate and apply the results of scientific investigations.

- Review information and summarize data collected and analyzed as the result of an investigation.
- Explain diagrams and charts that represent relationships of variables..
- Use and refine scientific models that simulate physical processes or phenomena.

III. MATHEMATICAL SKILLS

Students are expected to know the content described in the *Massachusetts Mathematics Curriculum Framework,* through grade 8. Below are some specific skills from the *Mathematics Framework* that students in this course should have the opportunity to apply:

- ✓ Construct and use tables and graphs to interpret data sets.
- ✓ Solve simple algebraic expressions.
- ✓ Measure with accuracy and precision (e.g., length, volume, mass, temperature, time)
- ✓ Convert within a unit (e.g., centimeters to meters).
- ✓ Use common prefixes such as *milli-, centi-,* and *kilo-*.
- ✓ Use scientific notation, where appropriate.
- ✓ Use ratio and proportion to solve problems.

The following skills are **not** detailed in the *Mathematics Framework*, but are necessary for a solid understanding in this course:

- ✓ Determine the correct number of significant figures.
- ✓ Determine percent error from experimental and accepted values.
- ✓ Use appropriate metric/standard international (SI) units of measurement for mass (kg); length (m); time (s); force (N); speed (m/s); acceleration (m/s^2); frequency (Hz); work and energy (J); power (W); momentum (kg•m/s); electric current (A); electric potential difference/voltage (V); and electric resistance (Ω).
- ✓ Use the Celsius and Kelvin scales.

UNITS AND THEMES (Topical Outline including duration of unit) STANDARD # COVERED:

I. Mathematical Relationships 1 Week 1.12
II. Kinematics 2 Weeks 1.1 – 1.4
III. Forces 3 Weeks 1.5 – 1.10
IV. Momentum 2 Weeks 2.1 – 2.6
V. Energy 2 Weeks 2.1 – 2.6
VI. Circular Motion; Gravitation 2 Weeks 1.11
VII. Thermodynamics 1 Week 3.1 – 3.4
VIII. Waves 1 Week 4.1 – 4.9
IX. Light 1 Week 4.5 – 4.6
X. Basic Electricity 2 Weeks 5.1 – 5.6
XI. Electromagnetism 1 Week 6.1 – 6.4

UNITS AND THEMES COVERED: STANDARD #

(Topical Outline including duration of unit)

Each chapter contains 2 – 4 Lab exercises.

I. Forces and Motion

Chapter 1: Science and Measurement 2 Weeks

1.1 Time and Distance
- SI Units
- Scientific notation/significant digits

1.2 Investigations and Experiments
- Measurement
- Scientific Method

1.3 Speed
- Calculating speed
- How to solve science problems

Chapter 2: Mathematical Models 2 Weeks

2.1 Use Scientific Model to Predict Speed
- Scientific Models
- Graphical Models

- Cause & Effect Relationships

2.2 Position & Time
- Position vs. Time graph
- Determine speed from slope of graph

2.3 Acceleration
- Units of Measurement
- Acceleration & v vs. t graph

Chapter 3: Forces & Motion **2 Weeks**

3.1 Force, Mass & Acceleration
- Measure Force & Mass
- Graph Force, Mass & Acceleration
- Newton's 2nd Law of Motion
- Balanced & Unbalanced Forces

3.2 Weight, Gravity & Friction
- Gravity
- Mass & Weight
- Newton's Law of Gravitation
- Friction & Motion

3.3 Equilibrium, Action & Reaction
- Newton's 3rd Law of Motion
- Momentum

Chapter 4: Machines & Mechanical Systems **1 Week**

4.1 Forces in Machines
- Simple machines
- Mechanical Advantage
- Block & tackle

4.2 The Lever
- Classes of levers
- Mechanical Advantage for a lever

4.3 Gears
- Engineering Cycle
- Gears

2. Work and Energy

Chapter 5: Work, Energy & Power **2 Weeks**

5.1 Work
- Work done by a machine
- Efficiency
- Power

5.2 Energy Conservation
- Potential Energy
- Kinetic Energy
- Conservation of Energy

5.3 Energy Transformations
- Work-Energy theorem
- Other forms of energy

3. Electricity & Magnetism

Chapter 6: Electricity & Electric Circuits **1 Week**

6.1 Circuits
- Electric Circuits
- Circuit Diagrams & Symbols
- Open & closed circuits

6.2 Charge
- Electric charge
- The Coulomb

Chapter 7: Measuring Electricity **1 Week**

7.1 Voltage
- Measuring Voltage
- Voltage drops

7.2 Current
- Measuring Current
- Electricity in the house

7.3 Resistance
- Conductors & Insulators
- Conductivity
- Resistance
- The Ohm

Chapter 8: Electrical Relationships **1 Week**

8.1 Ohm's Law
- Using Ohm's Law to analyze circuits
- Graphing & Ohm's Law
- Temperature & Ohm's Law
- Resistors

8.2 Work, Energy & Power
- Electrical Power
- Kilowatt-hour
- Electricity, power & heat

Chapter 9: Circuits **1 Week**

9.1 More Electric circuits
- Household wiring

9.2 Series Circuits
- Current in a series circuit
- Voltage in a series circuit

9.3 Parallel Circuits
- Current in a parallel circuit
- Voltage in a parallel circuit

4. Sounds & Waves **1 Week**

Chapter 11: Harmonic Motion

11.1 Harmonic Motion

- Cycles, Systems & Oscillators
- Harmonic Motion in nature & technology
- Investigating Harmonic Motion
- Amplitude

11.2 Graphs of Harmonic Motion

- Reading Harmonic Motion Graphs
- Determining amplitude & period from a graph
- Circles & Harmonic Motion

11.3 Simple Mechanical Oscillators

- Examples of oscillators

Chapter 12: Waves **1 Week**

12.1 Waves

- Transverse & Longitudinal waves
- Frequency, amplitude & wavelength

12.2 Waves in Motion

- Wave Shapes
- Reflection
- Refraction
- Diffraction

12.3 Natural Frequency & Resonance

- Natural Frequency
- Resonance
- Standing waves
- Interference

5. Light and Optics **1 Week**

Chapter 14: Light & Color

14.1 Introduction to Light

- What makes light?
- Energy levels & light
- Electromagnetic spectrum
- Speed of light
- Polarization

14.2 Color

- Where does color come from?
- How does the human eye see color?
- Why are plants green?

Chapter 15: Optics **1 Week**

15.1 Seeing an Image
- Light rays
- Images
- Reflection & mirrors
- Refraction & lenses
- Forming images with lenses
- Index of refraction

15.2 The Human Eye
- Nerves
- Forming an image
- Optical Illusions

15.3 Optical Technology
- Fiber optics
- Lasers

9 Heating & Cooling

Chapter 26: Measuring Heat **1 Week**

26.1 Temperature Scales
- Temperature
- Temperature Scales
- Thermometers

26.2 Measuring Changes is Heat
- Temperature, thermal energy & heat
- Measuring heat

26.3 Specific Heat
- Flow of heat & equilibrium
- Specific Heat

SUGGESTED INTEGRATED ACTIVITIES

- Bridge Design and Construction
- "Egg Drop"
- Time line of significant scientific advances and historical events from Copernicus's birth to Newton's death. Students should include scientists such as Brahe and Kepler as well as

I mportant political leaders, musicians, writers and artists.

USE OF TECHNOLOGY:

Use of Classroom computer(s) and an integrated software package

- Use of scientific calculators
- **Graphical Analysis/Logger Pro** software
  Computerized data collection/analysis hardware & software (proposed)
- Video programs
- Overhead projector and transparencies
- Smart Board technology

ASSESSMENT:

- White-Board presentations of homework problem solutions
- White-Board presentations of Laboratory data/analysis
- Laboratory Reports
- Projects
- Chapter/Unit tests
- End-of-course exam
- School-wide rubric will be utilized where appropriate