COURSE SYLLABUS

Course Title: Physics
Department: Science, Technology and Engineering
Primary Course Materials: Conceptual Physics, 2006

Course Description:
Essential Questions: How can core physics concepts and equations be utilized in the analysis of electrical systems, home plumbing and heating, automotive design and function, and athletic performance, with a focus on the:
1. Planning, purchasing, and integration of electronic systems in a dormitory design project.
2. Design and small-scale rough-in of a complete plumbing, waste, heating and cooling system, while maintaining thermal regulations.
3. Construction of a vehicle with propulsion, braking and electrical systems, based on collaborative engineering, and
4. Video analysis of the kinematics involved in athletic performance and achievement.

Course Objectives: To answer each unit's essential questions through inquiry based lab experiments, interactive class discussions, elaborate use of technology, and utilize common forms of summative and formative assessment to measure expected outcomes.

Common Goals:
Thinking and Communicating
1) Read information critically to develop understanding of concepts, topics and issues.
2) Write clearly, factually, persuasively and creatively in Standard English.
3) Speak clearly, factually, persuasively and creatively in Standard English.
4) Use computers and other technologies to obtain, organize and communicate information and to solve problems.
5) Conduct research to interpret issues or solve complex problems using a variety of data and information sources.

Gain and Apply Knowledge in and across the Disciplines
6) Gain and Apply Knowledge in:
a) Literature and Language
b) Mathematics
c) Science and Technology
d) Social Studies, History and Geography
e) Visual and Performing Arts
f) Health and Physical Education

Work and Contribute
7) Demonstrate personal responsibility for planning one's future academic and career options.
8) Participate in a school or community service activity.
9) Develop informed opinions about current economic, environmental, political and social issues affecting Massachusetts, the United States and the world and understand how citizens can participate in the political and legal system to affect improvements in these areas.

Content and Learning Standards from the Massachusetts Curriculum Framework:

<table>
<thead>
<tr>
<th>I. Content Standards</th>
<th>1. Motion and Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>☑ 1.1</td>
<td>Compare and contrast vector quantities (e.g., displacement, velocity, acceleration force, linear momentum) and scalar quantities (e.g., distance, speed, energy, mass, work).</td>
</tr>
<tr>
<td>☑ 1.2</td>
<td>Distinguish between displacement, distance, velocity, speed, and acceleration. Solve problems involving displacement, distance, velocity, speed, and constant acceleration.</td>
</tr>
<tr>
<td>☑ 1.3</td>
<td>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.</td>
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<tr>
<td>☑ 1.4</td>
<td>Interpret and apply Newton's three laws of motion.</td>
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<tr>
<td>☑ 1.5</td>
<td>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.</td>
</tr>
<tr>
<td>☑ 1.6</td>
<td>Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.</td>
</tr>
</tbody>
</table>
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.**

### 2. Conservation of Energy and Momentum

- 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

- 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

- 4.1 Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, and 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

- 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

- 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

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

- 1 Observe the world from a scientific perspective.
- 2 Pose questions and form hypotheses based on personal observations, scientific articles, experiments, and knowledge.
- 3 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.

- 1 Articulate and explain the major concepts being investigated and the purpose of an investigation
- 2 Select required materials, equipment, and conditions for conducting an experiment
- 3 Identify independent and dependent variables
- 4 Write procedures that are clear and replicable
- 5 Employ appropriate methods for accuracy and consistency
- 6 Properly use instruments, equipment, and materials (e.g., scales, probeware, meter sticks, microscopes, computers) including set-up, calibration (if required), technique, maintenance, and storage
- 7 Follow safety guidelines

SIS3. Analyze and interpret results of scientific investigations.

- 1 Present relationships between and among variables in appropriate forms
- 2 Use mathematical operations to analyze and interpret data results
- 3 Assess the reliability of data and identify reasons for inconsistent results, such as sources of error or uncontrolled conditions
- 4 Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis
- 5 State questions raised by an experiment that may require further investigation

SIS4. Communicate and apply the results of scientific investigations.

- 1 Develop descriptions of and explanations for scientific concepts that were a focus of one or more investigations
- 2 Review information, explain statistical analysis, and summarize data collected and analyzed as the result of an investigation
- 3 Explain diagrams and charts that represent relationships of variables
- 4 Construct a reasoned argument and respond appropriately to critical comments and questions
- 5 Use language and vocabulary appropriately, speak clearly and logically, and use appropriate technology (e.g., presentation software) and other tools to present findings
- 6 Use and refine scientific models that simulate physical processes or phenomena

III. Mathematical Skills

- 1 Construct and use tables and graphs to interpret data sets
- 2 Solve simple algebraic expressions
- 3 Perform basic statistical procedures to analyze the center and spread of data
- 4 Measure with accuracy and precision (e.g., length, volume, mass, temperature, time)
- 5 Convert within a unit (e.g., centimeters to meters)
- 6 Use common prefixes such as milli-, centi-, and kilo-
- 7 Use scientific notation, where appropriate
- 8 Use ratio and proportion to solve problems
- 9 Determine the correct number of significant figures
- 10 Determine percent error from experimental and accepted values
- 11 Use appropriate metric/standard international (SI) units of measurement for mass (kg); length (m); time (s); force (N); speed (m/s); acceleration (m/s²); frequency (Hz); work and energy (J); power (W); momentum (kg•m/s); electric current (A); electric potential difference/voltage (V); and electric resistance (Ω)
- 12 Use the Celsius and Kelvin scales
### Major Evaluation Strategies:

<table>
<thead>
<tr>
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<th>Type of Assessment</th>
<th>Common Goals Assessed</th>
<th>Standards Assessed</th>
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<td>Resistance Activity 1</td>
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<td>Series Circuit Activity</td>
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<td>Density Activity</td>
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<td>Sink or Swim Activity</td>
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<td>Inflation Activity</td>
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<td>Solar Energy Activity</td>
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<td>Insulating Pipes Activity</td>
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<td>Water Flow Activity</td>
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<td>Fluids Unit Project</td>
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<td>Engine Research Activity</td>
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<td>Forces Activity</td>
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<td>Conservation of Energy Activity</td>
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<tr>
<td>Balanced Torque Activity 1</td>
<td>Formative Summative</td>
<td>1, 2, 3, 4, 5, 6b, 6c</td>
<td>1, SIS1, SIS2, SIS3, SIS4, III</td>
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<tr>
<td>Balanced Torque Activity 2</td>
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<td>Vehicular Schematic Quiz</td>
<td>Formative Summative</td>
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<td>1, SIS1, SIS2, SIS3, SIS4, III</td>
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<td>Automotive Unit Project</td>
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<td>Distance vs. Displacement Activity</td>
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<td>Speed Activity</td>
<td>Formative Summative</td>
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<tr>
<td>Projectile Motion Activity Set</td>
<td>Formative Summative</td>
<td>1, 2, 3, 4, 5, 6b, 6c, 7</td>
<td>1, SIS1, SIS2, SIS3, SIS4, III</td>
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<td>Video Analysis Activity</td>
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<td>Sports Science Unit Project</td>
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<td>1, SIS1, SIS2, SIS3, SIS4, III</td>
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<tr>
<td>Vocabulary and Conceptual Quizzes</td>
<td>Formative Summative</td>
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<td>Unit Tests</td>
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<td>Mid Year Practicum/Exam</td>
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<td>Final Practicum/Exam</td>
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<td>SIS1, SIS2, SIS3, SIS4, III</td>
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**CONTENT OUTLINE**

**Unit 1: Electricity**

*Chapter 32 Electrostatics*

1. Describe electrical forces between objects
2. Explain how an object becomes (a) positively charged and (b) negatively charged
3. Describe Coulomb's Law
4. Distinguish between a conductor and an insulator
5. Describe how an insulator can be charged by friction and by contact
6. Describe how a conductor and be charged without contact
7. Describe how an insulator can be charged by charge polarization
Chapter 33 Electric Fields and Potential
1. Describe how to measure the strength of an electric field at different points.
2. Describe how electric fields are represented by vectors and by electric field lines
3. Describe how objects can be completely shielded from electric fields
4. Explain why a charged object in an electric field is considered to have electrical potential energy
5. Distinguish between electrical potential energy and electric potential
6. Describe how electrical energy can be stored
7. Describe the operation of a Van de Graff generator

Chapter 34 Electric Current
1. Describe the flow of electric charge
2. Describe what is happening inside a current-carrying wire
3. Give examples of voltage sources that can maintain a potential difference in a circuit
4. Describe the factors that affect the resistance of a wire
5. Describe Ohm’s Law
6. Explain the causes of electric shock
7. Distinguish between DC and AC and describe how AC is converted to DC
8. Compare the drift speed of conduction electrons in a current carrying wire to the signal speed of changes in current
9. Compare the motion of electrons in a wire carrying AC to the flow of energy through the wire
10. Relate the electric power used by a device to current and voltage

Chapter 35 Electric Circuits
1. Describe the configuration of a working circuit
2. Distinguish between series and parallel circuits
3. Describe the characteristics of series connections and of parallel connections
4. Interpret circuit diagrams
5. Determine the equivalent resistance of circuits having two or more resistors
6. Explain the cause and prevention of overloading house circuits

Unit 2: Fluid Applications
Chapter 19 Liquids
1. Describe what determines the pressure of a liquid at any point.
2. Explain what causes a buoyant force on an immersed or submerged object.
3. Relate the buoyant force on an immersed or submerged object to the weight of the fluid it displaces.
4. Describe what determines whether an object will sink or float in a fluid.
5. Given the weight of a floating object, determine the weight of fluid it displaces.
6. Describe how Pascal’s Principle can be applied to increase the force of a fluid on a surface.

Chapter 20 Gases
1. Explain why the molecules in Earth’s atmosphere neither escape nor settle to the ground.
2. Describe the source of atmospheric pressure.
3. Explain why water cannot be raised higher than 10.3 m.
4. Describe the aneroid thermometer.
5. Describe the relationship between pressure and density for a given amount of gas at a constant temperature.
6. Explain what determines whether an object will sink or float.
7. Describe the relationship between the speed of a fluid at any point and the pressure at that point, for steady flow.
8. Describe some applications of Bernoulli’s Principle.

Chapter 21 Temperature, Heat and Expansion
1. Define temperature in terms of KE and describe the common temperature scales
2. Define heat.
3. Define thermal equilibrium
4. Distinguish between internal energy and heat
5. Describe how the quantity of heat that enters or leaves a substance is measured
6. Compare the specific heat capacities of different substances
7. Describe how water’s high specific heat capacity affects climate
8. Give examples and applications of thermal expansion of solids
9. Describe the behavior of water as it is heated from 0°C to 15°C.

Chapter 22 Heat Transfer
1. Explain conduction and the effects.
2. Distinguish between conduction and convection.
3. Explain how heat can be transmitted through an empty space.
4. Given the color and shininess of two objects, predict which is likely to absorb radiant energy more easily.
5. Compare the ability of an object to emit radiant energy with its ability to absorb radiant energy.
6. Relate the temperature difference between an object and its surroundings to the rate at which it cools.
7. Describe global warming and Earth's greenhouse effect.

Chapter 24 Thermodynamics
1. Describe the concept of absolute zero.
2. State the first law of thermodynamics and relate it to energy conservation.
3. Describe adiabatic processes and cite examples.
4. State the second law of thermodynamics.
5. Define the ideal efficiency of a heat engine in terms of input and output temperatures.
6. Explain how order tends to disorder.
7. Define entropy and give examples.

Unit 3: Mechanical Automation

Chapter 4 Newton's First Law of Motion – Inertia
1. Describe Aristotle's concepts of natural and violent motion.
2. Describe Copernicus' idea about Earth's motion.
3. Describe Galileo's contribution to the science of motion.
4. State Newton's First Law of Motion.
5. Distinguish among mass, volume, and weight, and their units of measurement.
6. Explain how something that is not connected to the ground is able to keep up with the moving Earth.
7. Explain why a clothesline or wire that can easily support an object when strung vertically may break when strung horizontally and supporting the same object.
8. Describe how the angle between vectors affects their resultant vector.

Chapter 5 Newton's Second Law of Motion – Force and Acceleration
1. State the relationship between acceleration and net force.
2. State the relationship between acceleration and mass.
4. Describe the effect of friction on stationary and on moving objects.
5. Distinguish between force and pressure.
6. Explain why the acceleration of an object in free fall does not depend upon the mass of the object.
7. Describe the effect of air resistance on a falling object.

Chapter 6 Newton's Third Law of Motion – Action and Reaction
1. Define force as part of an interaction.
2. State Newton's 3rd Law of Motion.
3. Given an action force, identify the reaction force.
4. Explain why the accelerations caused by an action force and by a reaction force do not have to be equal.
5. Explain why an action force is not cancelled by the reaction force.
6. Describe the horse-cart problem.
7. Explain why you cannot touch something without being touched.

Chapter 7 Momentum and Energy
1. Define momentum.
2. Define impulse and describe how it affects changes in momentum.
3. Explain why an impulse is greater when an object bounces than when the same object comes to a stop.
4. State the law of conservation of momentum.
5. Distinguish between an elastic collision and an inelastic collision.
6. Give an example of how the vector nature of momentum affects the law of conservation of momentum.

Chapter 8 Work and Energy
1. Define and describe work.
2. Define and describe power.
3. Define mechanical energy
4. Define potential energy
5. Define kinetic energy and describe the work-energy theorem
6. State the law of conservation of energy
7. Describe simple machines and mechanical advantage
8. Explain why no machine can have an efficiency of 100%
9. Describe the role of energy in living organisms

Chapter 9 Circular Motion
1. Distinguish between rotate and revolve
2. Describe rotational speed
3. Give examples of centripetal force
4. Describe the motion of an object if the centripetal force acting on it ceases
5. Explain why centrifugal force is “fictitious”
6. Describe how a simulated gravitational acceleration can be produced

Chapter 11 Rotational Mechanics
1. Define and describe torque
2. Describe the condition required for one torque to balance another
3. Given the location of the center of gravity of an object and the position and direction of the forces on it, tell whether the forces will produce rotation
4. Describe on what the rotational inertia of an object depends
5. Give examples of how a gymnast changes the rotational inertia of the body in order to change the spin rate
6. Define angular momentum and describe conditions under which it (a) remains the same and (b) changes

Unit 4: Sports Science

Chapter 2 Linear Motion
1. Explain the idea that motion is relative
2. Define speed and distinguish between instantaneous speed and average speed
3. Distinguish between speed and velocity, and describe how to tell whether a velocity is changing
4. Define acceleration and give examples of units
5. Describe the motion of free fall
6. Describe the motion of an object thrown straight up and allowed to fall until it hits the ground
7. Determine the speed and the distance fallen at any time after an object is dropped from rest, when air resistance is negligible
8. Explain how graphs can be used to describe relationships among distance, time and speed
9. Describe how air resistance affects the motion of falling objects
10. Explain why acceleration is a rate of a rate

Chapter 3 Projectile Motion
1. Distinguish between a vector quantity and a scalar quantity, and give examples of each
2. Draw vector diagrams for velocities and use the parallelogram method to find the resultant of two vectors that have different directions
3. Given a vector, resolve it into horizontal and vertical components
4. For a projectile, describe the changes in the horizontal and vertical components of its velocity, when air resistance is negligible
5. Explain why a projectile moves equal distances horizontally in equal time intervals, when air resistance is negligible
6. Describe satellites as fast moving projectiles