NAVAL HISTORY STEM-H LESSON PLAN

TEACHER HELP GUIDE

LESSON PLAN: Newton's 2nd Law Revisited: Sea vs. Air, Fast Attack Submarine vs. Airborne Laser
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INSTRUCTIONAL GOAL: Review and Practice calculations involving Kinematics, Newton's Second Law, Non-Conservative Forces, Energy and Power. This is an algebra based lesson plan, but the problems could easily be adjusted to challenge students familiar with calculus based physics. It covers material from multiple chapters, such that it could be used as an end of term review activity, or broken up and used throughout the year as the concepts were covered.

BACKGROUND: What is Better Than the Army Navy Game?!?!?!

How about Navy vs. Air Force, Sea vs. Land. Los Angeles Class Submarines were instrumental in establishing our strategic dominance during the Cold War. The Airborne Laser represents the Star Wars technology envisioned during the Reagan years.

- Which has the more powerful propulsion system?
- Does one speeds-up more quickly than the other? ...why?

RESOURCES: None

STANDARDS:

Learning Objectives for AP Physics, © 2012 The College Board
http://apcentral.collegeboard.com/apc/public/repository/ap-physics-course-description.pdf

The following objectives apply to both AP Physics B and AP Physics C Mechanics.

I. NEWTONIAN MECHANICS

A. Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration)

1. Motion in one dimension

b) Students should understand the special case of motion with constant acceleration, so they can:

(2) Use the kinematics equations to solve problems involving one-dimensional motion with constant acceleration.

B. Newton's laws of motion

1. Static equilibrium (first law) Students should be able to analyze situations in which a particle remains at rest, or moves with constant velocity, under the influence of several forces.

2. Dynamics of a single particle (second law)

a) Students should understand the relation between the force that acts on an object and the resulting change in the object's velocity, so they can:

(1) Calculate, for an object moving in one dimension, the velocity change that results when a constant force F acts over a specified time interval.

(3) Determine, for an object moving in a plane whose velocity vector undergoes a specified change over a specified time interval, the average force that acted on the object.

b) Students should understand how Newton's Second Law, $\Sigma F = F_{net} = ma$, applies to an object subject to forces such as gravity, the pull of strings, or contact forces, so they can:

(1) Draw a well-labeled, free-body diagram showing all real forces that act on the object.

(2) Write down the vector equation that results from applying Newton's Second Law to the object, and take components of this equation along appropriate axes.

c) Students should be able to analyze situations in which an object moves with specified acceleration under the influence of one or more forces so they can determine the magnitude and direction of the net force, or of one of the forces that makes up the net force, such as motion up or down with constant acceleration.

C. Work, energy, power

1. Work and the work-energy theorem

a) Students should understand the definition of work, including when it is positive, negative, or zero, so they can:

(1) Calculate the work done by a specified constant force on an object that undergoes a specified displacement.

b) Students should understand and be able to apply the work-energy theorem, so they can:

(1) Calculate the change in kinetic energy or speed that results from performing a specified amount of work on an object.

(2) Calculate the work performed by the net force, or by each of the forces that make up the net force, on an object that undergoes a specified change in speed or kinetic energy.

2. Forces and potential energy

a) Students should understand the concept of a conservative force, so they can:

(1) State alternative definitions of "conservative force" and explain why these definitions are equivalent.

(2) Describe examples of conservative forces and non-conservative forces.

3. Conservation of energy

a) Students should understand the concepts of mechanical energy and of total energy, so they can:

(1) State and apply the relation between the work performed on an object by nonconservative forces and the change in an object's mechanical energy.

(2) Describe and identify situations in which mechanical energy is converted to other forms of energy.

(3) Analyze situations in which an object's mechanical energy is changed by friction or by a specified externally applied force.

b) Students should understand conservation of energy, so they can:

(1) Identify situations in which mechanical energy is or is not conserved.

4. Power

Students should understand the definition of power, so they can:

a) Calculate the power required to maintain the motion of an object with constant acceleration (e.g., to move an object along a level surface, to raise an object at a constant rate, or to overcome friction for an object that is moving at a constant speed).

Virginia Standards of Learning

http://www.doe.virginia.gov/testing/sol/standards_docs/science/courses/stds_physics.doc

PH.4 The student will investigate and understand how applications of physics affect the world. Key concepts include

a) examples from the real world; and
b) exploration of the roles and contributions of science and technology.

PH.5 The student will investigate and understand the interrelationships among mass, distance, force, and time through mathematical and experimental processes. Key concepts include

a) linear motion;
b) uniform circular motion;
c) projectile motion;

d) Newton's laws of motion;
e) gravitation;
f) planetary motion; and
g) work, power, and energy.

PH.6 The student will investigate and understand that quantities including mass, energy, momentum, and charge are conserved. Key concepts include
a) kinetic and potential energy;
b) elastic and inelastic collisions; and
c) electric power.

INSTRUCTIONAL PROCEDURES FOR LESSON: None

INSTRUCTIONAL PROCEDURES FOR ACTIVITIES: None