ENERGY: FORCE AND MOTION

OVERVIEW:

The activities provide an opportunity for students to learn about force and motion by doing. A force is a push or pull on an object. A force has strength and direction. Forces can set objects in motion or it can change the speed and/or direction the object is moving in.

CONCEPTS:

National Science Foundation Standards:

Standard B: Physical Science

(Motions and Forces):

Describe the position, direction of motion, and speed of an object. Graphing motion and inertia.

Effect of multiple forces on the movement, speed, and direction of an object.

Benchmark 4: The Physical Setting

G: Forces of Nature

Every object exerts gravitational force on every other object. The force depends on how much mass the objects have and on how far apart they are. The force is hard to detect unless at one of the objects has a lot of mass.

OBJECTIVES:

Student will identify the basic principles of force, weight, time, velocity, and acceleration.

BACKGROUND:

Inquiry based approach to science focuses on student constructed learning as opposed to teacher-transmitted information. This process aims to enhance learning based on increased student involvement, multiple ways of knowing and sequential phases of cognition. By using student derived investigations knowledge is more relevant and meaningful. This investment in the curriculum and learning process leads to active construction of meaningful knowledge.

MATERIALS:

Ball
Ramp
Track
Spring scale
Rolling cart
Level

PROCEDURES:

Allow 3 hours to present the background information and to complete the activity.
Complete the activities -10- (Part A.)
Questions follow each activity. These questions may be used for assessment purposes.

ACTIVITY:

Part A:

Activity 1. Measuring Time: How long does it take for something to fall from eyelevel to the floor?

1. When you measure how long it takes for something to fall – from eye level to the floor – you should consider these things: Do you get the same number every time for the same object? If not, how do you come up with the "best" number?
(There are some papers with blank tables on them if you want to use one.)
1A. *Explain your method.*

1B. *What are your conclusions?*

2. Does the mass of an object affect how long it takes to fall?
2A. *Design an experiment to answer this, and explain your method..*

2B: *What did you find out?*

3. *What other variable besides mass could you test to see if it affects fall time?*

Activity 2. Position, time, and velocity
What does a graph of position vs. time for a rolling ball tell you?

Getting started
This rolling ball system consists of a ball, a ramp (to start the ball rolling), and a track.

1. *How long does it take for the ball to get to the end of the track?*
Start timing the ball at the place where the ramp ends and the level track starts.
Use repeated trials, always starting from the same place on the ramp.
How do you determine the "best" number for the time it takes the ball to cover a certain distance?

distance ball travels on level track:	
trial number	time (seconds)
best number for the time it takes:	

2. How long does it take for the ball to get to other places along the track, instead of to the end?
Repeat step 1 for three different places along the track. Always start the ball from the same height on the ramp. Start timing at the place where the ramp ends and the level track starts.
Figure out how long it takes for the ball to get to 4 different places along the track.
Explain your method too.

distance ball travels on level track:	
trial number	time (seconds)
best number for the time it takes:	

(more tables on next page)

distance ball travels on level track:	
trial number	time (seconds)
best number for the time it takes:	

distance ball travels on level track:	
trial number	time (seconds)
best number for the time it takes:	

3. *Make a graph (using of your "best numbers") of distance on the vertical axis and time on the horizontal axis.*

Distance vs. time for a rolling ball on a level track.

4. What does your graph tell you?

Velocity is calculated as how far something goes in one direction divided by / how long it takes to get there.

Velocity = distance / time

5. Calculate the velocity of the ball for each of the track positions that you used to make the graph.

distance ( )	time (seconds)	velocity ( )

6. Make a graph of velocity vs. time.

7. What does this graph tell you about the ball's motion?

Activity 3. What's a Newton?
Measuring force and weight

This device is called a spring scale. When you pull on the two ends of the scale, the spring stretches. It stretches more when you pull harder. The scale tells you the size of forces, in Newtons.

When you hang an object from the scale, you measure the gravitational force on the object (also called "the weight of the object").

* Does the scale read zero when there is nothing hanging on it? If not, find out how to adjust it so it does read zero.

1. *What is the largest weight the scale can measure?*

Give an example of an object that is nearly this weight.

2. If an object is too light for the scale to sense it, how can you use the scale to determine its weight? For example: *Determine the weight of one paper clip*

3. *What's a Newton?*

Activity 4

4. If a tow truck is pulling a car up a hill, how hard does the car pull on the truck? Does the steepness of the incline affect how hard it pulls?
(This question could also be worded as "if a tow truck is pulling a car up a hill, how hard does the truck pull on the car?)

Lay the spring scale on the inclined ramp, and attach it to the ramp by its top clip, Attach the rolling cart to the bottom of the spring scale, so that you can measure the force that the cart exerts on the scale. Put the 200 g weight in the cart.

- *Measure the height of the top end of the ramp*, as a way of determining how steep is the incline.
- Then *measure the force on the scale.*

Repeat these measurements for various positions of the ramp, ranging from nearly horizontal to nearly vertical. *Enter the results in the table.*

Force on scale vs. how steep the incline is

height of top of ramp above table (meters)	force the cart exerts on the scale (Newtons)

Make a graph that shows how the force exerted by the rolling cart depends on the height of the top end of the ramp.

If you wanted to put the actual weight of the cart on this graph, *where should you put it?*

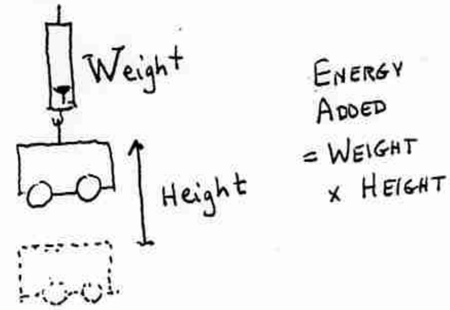
(Key question) *Explain how you could use an inclined plane to weigh another object that is too heavy for the spring scale.*

Activity 5. Force and energy; compare the energy required to lift an object in different ways.

Getting ready

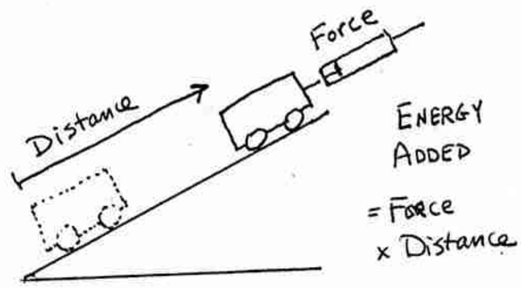
The amount of energy needed to lift an object depends on the weight of the object and how far you lift it.

Energy exerted = height x weight



The amount of energy needed to pull a rolling cart up a ramp depends on the force you exert to pull it, and the distance that it moves.

Energy exerted = distance (length of ramp) x force



In each case the amount of energy is the force exerted on the object times the distance the object moves. Energy = Newtons x meters.

The energy calculated this way is sometimes called "work."

The unit of energy calculated this way is called a "Joule." 1 Joule = 1 Newton x 1 meter.
(If you use centimeters instead of meters, the result will be in centiJoules).

1. How does the energy exerted to lift an object straight up to a certain height compare with the energy needed to take it to the same height by rolling it up an inclined plane?
Set up the equipment as shown above and make the measurements of height, weight, distance and force. Then calculate the energy exerted in each case.

2. What conclusions can you draw about the amount of energy needed to lift the object in the two different ways?

Activity 6. Force, motion.

When we release a ball on an inclined ramp, its velocity changes as it rolls down. When velocity changes, we say the ball is accelerating. Let's measure the acceleration of the rolling ball.

(Short form)

- Set up the inclined ramp and determine how long it takes the ball to roll down it.
- Then determine the velocity of the ball on the runway after it leaves the inclined ramp. This is also the velocity of the ball when it reaches the end of the inclined ramp.
- Calculate the acceleration by dividing the velocity of the ball by the time it takes to roll down the ramp.

Questions to explore:
If we start the ball at different places on the inclined ramp, does this change the acceleration?

If we use a different ball, does this change the acceleration?

If we change the steepness of the incline, does this change the acceleration?

Activity 10. Force and motion. What can a bubble level tell you about motion?

1. Place the level on a smooth surface, and verify that the surface is level. *What does it mean if the bubble is not at the center?*

2. Practice sliding the level in a straight line at constant velocity. *Where is the bubble when the level is moving at constant velocity?*

3. *Which way does the bubble go when you push on the level to get it moving?*

4. *Which way does the bubble go when you stop the level?*

Interpret your observations in questions 2, 3 and 4. What is the bubble in the level telling you?

5. Suppose you wanted to move the level from one place to another, as fast as possible but without getting the bubble very far off center. *How can you do this?*

6. Move the level in a circle, trying to keep the speed constant. *What does the bubble in the leve do?*

7. *Which way are you pushing on the level, to make it move in a circle?*

8. (Key question) *What does the bubble tell you about the motion of the level? How is this related to how you are pushing on it?*