Name ______________________ Date __________ Class __________

Enrich

The Nature of Force

Read the passage, look at the diagrams to its right, and study the table below it. Then use a separate sheet of paper to answer the questions that follow the table.

Net Force, Mass, and Change in Motion

Unbalanced forces cause a change in an object's motion. The net force acting on the object causes it to speed up, slow down, or change direction. Changes in motion, that is, speeding up, slowing down, or changing direction, are called acceleration. When an object of a certain mass is acted upon by a net force, the amount of change in the object's motion (its acceleration) is proportional to the size of the net force.

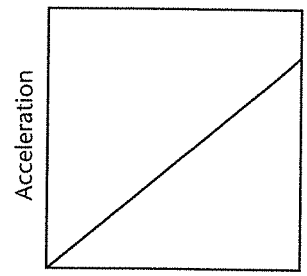
When two values are proportional, an increase in one causes the other value to increase or decrease. These relationships between proportional values are often in the natural world. For this reason, they have specific names.

Directly proportional: When the net force increases, the change in motion for an object of certain mass increases. Any two values that increase or decrease in the same way are directly proportional. Figure 1 shows a graph of this relationship.

Inversely proportional: Whenever an increase in one value results in a decrease in another value (and vice versa), the two values are inversely proportional. Figure 2 shows an inverse relationship for the amount of change in motion and mass.

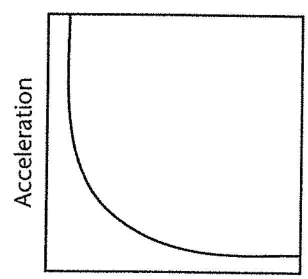
Look at the table below that shows how net force, mass, and the change in motion are related.

Figure 1



Force
(Constant Mass)

Figure 2



Mass
(Constant Force)

If acceleration is:	and mass is:	force must be:
1 m/s^2	0.1kg	0.1N
1 m/s^2	0.2kg	0.2N
1 m/s^2	0.5kg	0.5N
1 m/s^2	0.7kg	0.7N
1 m/s^2	1.0kg	1.0N

1. On graph paper, plot each pair of values for mass and force from the table. Let the horizontal axis represent mass, and the vertical axis represent force. Connect the points with lines.
2. When acceleration is held constant and objects of different mass are observed, are mass and force directly proportional or inversely proportional? Explain.

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Enrich

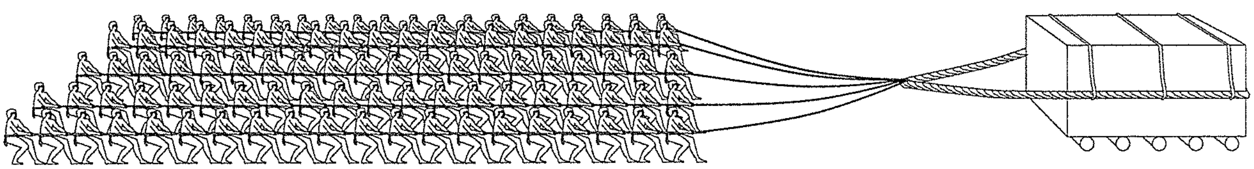
Friction and Gravity

Read the passage and look at the diagram below it. Then use a separate sheet of paper to answer the questions that follow the diagram.

The Great Pyramids

The ancient Egyptians built pyramids out of large blocks of limestone. No one knows for sure how they managed to move the blocks across land.

One idea about how the Egyptians moved the stone blocks without modern machines is a simple one. Set a heavy book on a table. If you try pushing it with your little finger, it will be hard to do. Next, place five round pencils, parallel to each other, under the book and try again. This time you can move the book easily. You have replaced sliding friction with rolling friction. The force needed to overcome rolling friction is much less than the force needed to overcome sliding friction. Some people believe that the ancient Egyptians used this understanding of friction and moved the heavy stone blocks by placing a layer of wooden logs under the blocks. As the stone was pulled forward, the logs in back were picked up and placed in front of the block again, to provide a kind of friction-reducing track along which to roll the blocks of stone.



1. List two reasons why the limestone blocks of the pyramids were so difficult to push across land.
2. How might the Egyptians have been able to move the heavy stone blocks?
3. Can you think of another way the Egyptians might have tried to reduce friction to move the heavy blocks?
4. Historians know that large stone blocks can be dragged if logs are placed under them. Is the idea that the Egyptians built the pyramids by rolling stone blocks on logs a fact or a hypothesis?

Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

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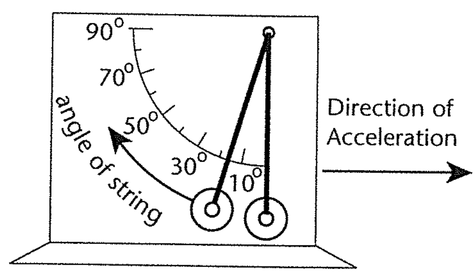
Newton's Laws of Motion

Read the passage, follow the directions for constructing an accelerometer, and use the accelerometer in the activity described. Then use a separate sheet of paper to answer the questions that follow activity description.

Measuring Acceleration

When you ride in a car that is accelerating, you can feel the acceleration, even if your eyes are closed. Sometimes however, you want to measure acceleration. Acceleration can be measured with an accelerometer.

In this exercise, you will construct and experiment with the simple accelerometer pictured below. Just draw a protractor on a large card, showing angles measured from a vertical line. Attach one end of a string to the apex of these angles, and tie four or five large washers to its end. Mount the card and string vertically on a small stand.



Once the accelerometer is assembled, practice using it. The instrument measures the acceleration when it is moved horizontally in a direction parallel to the card. The greater the acceleration, the greater the angle formed by the accelerometer's string and vertical line. The point of greatest acceleration is represented by the largest angle. On a separate sheet of paper, make a data table with three columns. Label them: Activity, Greatest Acceleration Angle, and Observations. Next, perform the activities listed below and complete your table. For best results, have one person move the accelerometer while another watches and records the results.

- Begin to push the accelerometer across the table.
- From a standing start, begin walking.
- Observe the accelerometer while riding inside a car or bus. Watch the accelerometer as the vehicle begins to move from a complete stop.
- Observe the accelerometer while riding inside a moving car or bus. Watch the accelerometer as the vehicle slows to a complete stop.

1. Why didn't the accelerometer maintain a constant angle during most of these activities?
2. What is the greatest acceleration angle you observed? Do you think you would ever obtain a 90° angle?

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Momentum

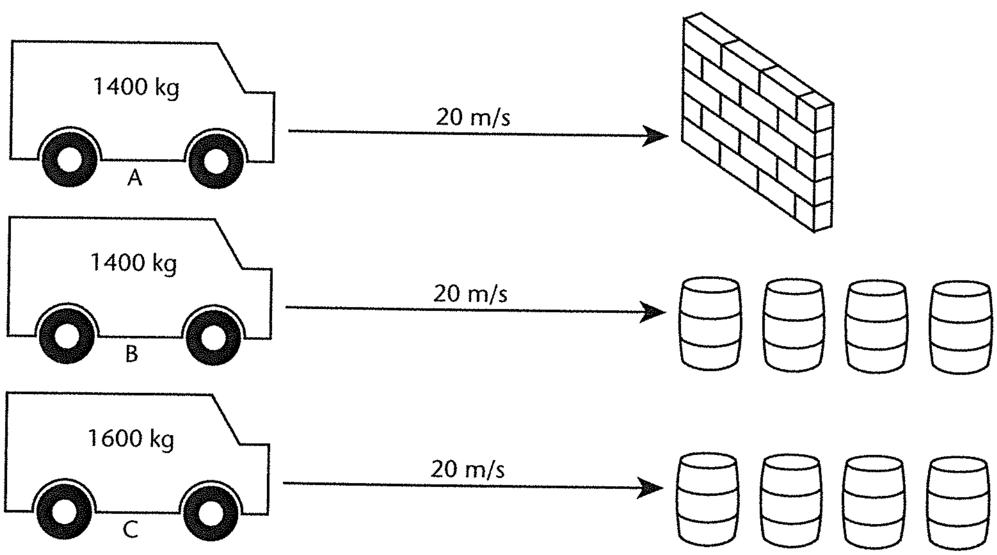
Read the passage and study the diagrams below it. Then use a separate sheet of paper to answer the questions that follow the diagrams.

Life-Saving Barrier

On January 14, 1998, a former racing car driver by the name of John Fitch received an award for "his life-long contributions in the field of roadside safety." Back in the late 1960s, Fitch had invented a device that is now used in all 50 states of the United States. The device is believed to have saved thousands of lives.

You've probably seen it—or, really, them—near the exit ramps of bridges and highways or other places where roadways divide. They are plastic, sand-filled barrels called Fitch Barriers. And their purpose is to slowly absorb the momentum of a vehicle that might otherwise be stopped dead by a solid wall or highway divider.

Study the drawings below. They show the mass and velocity of four different cars on a collision course with a concrete wall or Fitch Barriers.



1. Which car has the greatest momentum? What is its momentum?
2. Of the cars that strike the Fitch Barriers, which will penetrate the least distance? Explain your answer.
3. Compare the forces exerted by the wall and the Fitch Barriers on Cars A and B and describe differences, if any, about how those forces are applied.

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Free Fall and Circular Motion

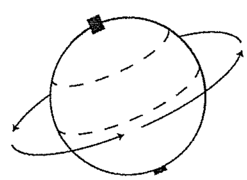
Read the passage and study the diagram below it. Then use a separate sheet of paper to answer the questions that follow the diagram.

The Easy Way to Launch a Satellite

Imagine that a professional baseball player can pitch a fastball at 90 mi/h. If he were on a train moving at 50 mi/h, and he threw his fastball in the same direction that the train was moving, the ball would travel at 140 mi/h. The pitch gets a "boost" from the train's movement. In a similar way, rocket scientists get a boost in launching satellites by "throwing" them from a moving platform—Earth.

If you could look down on Earth from a point in space that is stationary relative to Earth's rotation, you would see Earth rotating beneath you, from west to east. Every 24 hours, the same point on the surface would pass underneath you. The speed at which a point on Earth moves because of Earth's rotation depends on how far that point is from the equator. A point on the equator rotates at a speed of a little less than 1,700 km/h. A point near the North Pole hardly moves at all in 24 hours, it just turns in a circle, like the center point of a fan.

In a way similar to the pitcher throwing his fastball, a rocket scientist can "throw" the rocket carrying the satellite toward the east, in order to take advantage of the rotation of the Earth. Cape Canaveral in Florida, where many satellites are launched, is traveling about 1,500 km/h. So instead of accelerating from zero, the satellite must be accelerated from 1,500 km/h to an orbital velocity of 19,200 km/h. That is still a lot of acceleration needed, but it is less than going from zero to 19,200 km/h.



1. Why can't you feel Earth moving?
2. Some satellites move around Earth in polar orbits, that is, in a north to south direction, rather than west to east. Can scientists who want to put a satellite into a polar orbit take advantage of Earth's rotation to give the rocket a "boost"? Explain.
3. Imagine you wanted to launch a satellite so that it traveled in the opposite direction from usual, that is east to west, rather than west to east. How fast would the rocket launching that satellite have to travel, relative to the launch site, if you launched it from a point on the equator? Explain.
4. What would be the effect on satellites now in orbit if Earth were to stop rotating?