

Name _____ Section _____

Period 5 Activity Sheet: Forces and Newton's Laws

5.1 What Are the Four Fundamental Forces?

a) Based on your class activities and your instructor's explanation, give examples of each of the fundamental forces.

1) **Gravitational Force**

2) **Electromagnetic Force**

3) **Strong Nuclear Force**

4) **Weak Nuclear Force**

b) The space between an atomic nucleus and its electron cloud is so great that the majority of the volume of an atom is empty space. Since atoms are mostly empty space, explain in terms of fundamental forces why a solid object sitting on a table does not fall through the table.

c) Group Discussion Question: Since all objects contain positive and negative electrical charges, shouldn't we feel an electromagnetic force from every object we encounter? Explain why we do not.

5.2 How Do Newton's Laws of Motion Describe Forces?

a) **Newton's First Law:**

Your instructor will demonstrate a metal cart on an air track, which minimizes the amount of friction between the cart and the metal track.

1) As the cart moves along the track, is there a net force acting on the cart?

2) Is a net force required to keep the cart moving at a constant speed? _____
Explain why or why not.

b) **Newton's Second Law: $F = M a$**

A Lamborghini Diablo sports car can accelerate from 0 MPH to 60 MPH in 4.3 seconds. The mass of the car is 1,580 kg. Calculate the force (in newtons) needed to accelerate the car. (We assume that its acceleration is constant.)

1) Convert 60 miles/hour into meters/second. Hint: 1 mile = 1,609 meters. _____

2) Find the acceleration of the car using $a = \frac{V_{final} - V_{initial}}{t}$ _____

3) Use Newton's second law to find the force on the car during its acceleration. _____

c) **Newton's Second Law applied to falling objects: $F = M g$**

In Period 4, we found that the force of gravity acting on a falling rock is given by

$$F = \frac{G M_{rock} M_{planet}}{D^2} = M_{rock} g$$

Where D = the radius of the planet and g is the acceleration of gravity on that planet.

Calculate the acceleration of gravity on the surface of Mars. The mass of Mars = 6.42×10^{23} kg and the radius of Mars = 3.4×10^6 m _____

d) Calculate the gravitational force acting on a 5 kg rock that is dropped above the surface of Mars. _____

5.3 Newton's Third Law

a) Your instructor will demonstrate a cart with a fan attached to it. Before you see each demonstration, predict the cart's motion.

1) When the fan is turned on, will the cart move in the direction the fan blows, move in the opposite direction that the fan blows, or not move?

Prediction: _____

Watch the demonstration and describe what happened. Explain the motion of the cart in terms of Newton's third law.

- 2) Your instructor will place on the track a second cart with a metal "sail" attached. When the fan on the first cart is turned on, it blows against the sail on the second cart. Will either cart move when the fan is turned on?

Prediction: _____ Describe and explain what happened.

- 3) Next, we connect the two carts together. Will the carts move when the fan is turned on?

Prediction: _____ Describe and explain what happened.

- 4) Finally we put the fan and the sail on the same cart so that the fan blows against the sail. When the fan is turned on, will the cart move? If so, in which direction?

Prediction: _____ Describe and explain what happened.

- d) Group Discussion Question: You are sitting in a sailboat that is not moving because no wind is blowing. Could you move the boat by holding a powerful fan and pointing it at the sail?

5.4 Frictional Force - What Determines the Amount and Type of Friction?

- a) **Types of Friction: Static and Sliding.** Your instructor will demonstrate a toy truck pulling a wooden block with a spring scale attached.

- 1) How much force does the scale measure just before the block starts to move?

- 2) How much force does the scale measure while the block is moving? _____
- 3) Which of the two types of friction is greater? _____

b) How Does the Amount of Force Pressing Surfaces Together Affect Friction?

- 1) Attach the spring scale to the screw eye on the front of the wooden cart. Drag the cart **upside down** at a constant velocity across the smooth board. How much force is required to move the cart at a constant velocity? _____
- 2) Place a 1 kg mass on the cart and again drag the cart upside down at a constant velocity across the smooth board. How much force is required to move the cart with the 1 kg mass at a constant velocity? _____
- 3) Explain how the amount of force pressing the cart against the board affects the amount of friction between the cart and the board.

- c) **How Does Surface Smoothness Affect Friction?** Compare the amount of friction between a wooden cart and the surfaces it slides across by calculating the coefficient of friction between the cart and the surfaces.
- 1) Find the weight in newtons of the wooden cart by suspending it from the blue spring scale. _____
 - 2) How much force is required to move the cart at a constant velocity across the **smooth** board? (Use your measurement from part 5.4.b.1) _____
 - 3) Calculate the coefficient of friction between the cart and the smooth board by forming the ratio of the force required to drag the cart divided by the weight of the cart.

 - 4) Drag the cart upside down at a constant velocity across the **rough** board. How much force is required to move the cart at a constant velocity? _____
 - 5) Calculate the coefficient of friction between the cart and the rough surface.

 - 6) In which case is the coefficient of friction greater? Explain how the amount of friction is related to surface smoothness.
 - 7) Group discussion question: Which of the fundamental force(s) is/are responsible for the force of friction?
- d) **Is friction always undesirable?**
- 1) Your instructor will demonstrate two toy cars moving up an incline. Explain the differences in the motion of the cars as they go up the incline.
 - 2) Balance a meter stick on two fingers. Start with one finger under each end of the meter stick. Slowly slide your fingers together while balancing the meter stick on them. Explain what happens to your fingers in terms of the downward force of the stick on your finger, the friction between the stick and your finger, and the center of mass of the meter stick.
 - 3) Stack several pennies on a sheet of paper. Try to pull the paper out from under the pennies without toppling them. How high a stack of pennies can you pull the paper out from under? _____

Explain why it is possible to pull the paper from under the pennies in terms of Newton's first law and the frictional forces acting between the bottom penny and the sheet of paper. Why does the height of the stack of pennies matter?