Period 4 Activity Sheet: Forces and Newton's Laws

4.1 What Are the Four Fundamental Forces?
Give examples of each force based on your class activities and your instructor’s explanation.

a) Gravitational Force
An attractive force between all objects. The gravitational force causes objects to roll downhill, causes dropped objects to fall toward the Earth, and holds the Earth in an orbit around the Sun.

b) Electromagnetic Force
An attractive force between particles of opposite charge, and a repulsive force between particles with like charge (both positive or both negative). The electromagnetic force holds atoms together and causes charged objects to attract or repel one another.

c) Weak Nuclear Force
The force responsible for radioactive decay of atomic nuclei, such as the decay that produces radon gas.

d) Strong Nuclear Force
An attractive force that holds protons and neutrons together in the nuclei of atoms. The strong force acts only when particles are close together.

e) 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.

4.2 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? __Static friction__
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 drag the cart upside down at a constant velocity across the smooth board. How much force is required to move the cart and 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.

   **The greater the mass of the cart, the more force it exerts on the board. The greater the force between the cart and the board, the more friction between their surfaces.**

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) 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. (Or use your measurement from part 4.2.b.1) How much force is required to move the cart at a constant velocity? ______________

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.

   **Coefficient of friction** = \( \frac{\text{force to pull cart across smooth board}}{\text{weight of cart}} \)

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.

   **Coefficient of friction** = \( \frac{\text{force to pull cart across rough board}}{\text{weight of cart}} \)

6) In which case is the coefficient of friction greater? Explain how the amount of friction is related to surface smoothness.

   Dragging the cart across the rough surface results in a larger coefficient of friction than dragging it across the smooth surface. A rough surface produces more friction than a smooth surface.
<table>
<thead>
<tr>
<th>Name ______________________________</th>
<th>Section ___________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>d) <strong>Is friction always undesirable?</strong> 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.</td>
<td></td>
</tr>
<tr>
<td><strong>As the cars go up the incline, the car with metal wheels slips sooner than the car with rubber band wheels because there is more friction between the rubber bands and the surface of the incline.</strong></td>
<td></td>
</tr>
<tr>
<td>e) <strong>Group Discussion Question:</strong> Why was the invention of wheels such an important event in human history? Hint: turn the cart over (wheels down) and pull it by the scale over the smooth and rough boards. Why is reducing friction so important in energy use and conservation?</td>
<td></td>
</tr>
</tbody>
</table>

### 4.3 How Do Newton’s Laws of Motion Describe Forces?

Your instructor will introduce Newton’s Laws of motion.

<table>
<thead>
<tr>
<th>a) <strong>Newton’s First Law:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) 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? __________</td>
</tr>
<tr>
<td>2) 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.</td>
</tr>
<tr>
<td><strong>As Newton’s first law states, stationary objects remain at rest unless a force acts on them. If you pull the paper out from under a small stack of pennies, the force of friction between the bottom penny and the paper is small enough that the pennies remain at rest.</strong></td>
</tr>
<tr>
<td>3) Which of the following makes it possible to pull the paper from under more pennies in a stack? More or less friction between the bottom penny and the paper? More or less friction between each penny in the stack?</td>
</tr>
<tr>
<td><strong>More friction between the bottom penny and the paper makes it more difficult to pull out the paper. More friction between each penny in the stack makes it easier to pull out the paper because the pennies would be less likely to slip off one another.</strong></td>
</tr>
<tr>
<td>b) <strong>Newton’s Second Law:</strong></td>
</tr>
<tr>
<td>1) 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.</td>
</tr>
<tr>
<td><strong>Convert 60 MPH to m/s:</strong> ( \frac{60 \text{ mi}}{\text{hr}} \times \frac{1,609 \text{ m}}{\text{mi}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} = 26.8 \text{ m/s} )</td>
</tr>
<tr>
<td>[ a = \frac{v_f - v_i}{t} = \frac{26.8 \text{ m/s}}{4.3 \text{ s}} = 6.24 \text{ m/s}^2 ]</td>
</tr>
<tr>
<td>[ F = Ma = 1,580 \text{ kg} \times 6.24 \text{ m/s}^2 = 9,854 \text{ N} = 9.9 \times 10^3 \text{ N} ]</td>
</tr>
</tbody>
</table>
c) **Newton’s Third Law:** 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 the fan blows, or not move?

   **The cart moves in the opposite direction that the fan blows.** The fan exerts a force on nearby air molecules, which exert a force back on the fan and cart, giving it a push.

2) Your instructor will add 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 of the carts move when the fan is turned on?

   **The carts move apart.** The cart with the fan pushes air molecules against the sail, accelerating the sail cart. The sail pushes back against the air molecules that strike it. The air molecules exert a force on the fan cart, accelerating it. The forces are equal and opposite.

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

   **The carts do not move.** The forces that pushed the carts apart cancel each other.

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?

   **If the fan blades push the air to the left, then the air pushes the fan blades back to the right with an equal and opposite force.** If the air is also pushing the metal sail to the left, then the force of the air pushing the sail to the left is equal and opposite to the force of the air pushing the fan to the right. Since both the sail and the fan are attached to the same cart, the cart does not move.

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 pointing a powerful fan at the sail?