**Intro to Forces Inquiry**

**Name:**

**Purpose:** you have all experienced forces acting on you, but have you thought about the effect the forces have on your motion? This inquiry is intended to introduce four types of forces, what the forces depend on, and the direction the forces act in.

**Applied forces:**

**Purpose:** to determine the directional relationship between an applied force and the acceleration of an object.

**Materials:** cart, string

Experiment:

1. Push on the back of a stationary cart until it begins to move. Record your observations in the appropriate row in Table 1 below and the direction you were pushing in.
2. Get the cart moving and push on the front of the cart until it stops. (As you push on the cart, move your hand with the cart) Record the results in Table 1 below.
3. Get the cart moving and push on the side of the cart until you see a noticeable change in the cart’s motion. (You will need to move your hand at the same speed as the cart) Record your results in Table 1 below.
4. Tie a string to the cart and pull on the cart to speed the cart up. Record your results in Table 1 below.
5. With the cart moving, pull on the cart to get the cart to stop the cart. Record your results in Table 1 below.
6. With the cart moving pull on the side of the cart until you see a noticeable change in the cart’s motion. Record your results in Table 1 below.

**Table 1:** In each cell, record the direction of each vector quantity with an arrow. If the quantity has no magnitude, write a 0 in the cell.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Initial Velocity** | **Final Velocity** | **Acceleration****(ΔV)** | **Direction You push/pull** | **Force and acceleration in same direction (Y/N)** |
| Pushing | Speeding up |  |  |  |  |  |
| Slowing down |  |  |  |  |  |
| Changing direction |  |  |  |  |  |
| Pulling | Speeding up |  |  |  |  |  |
| Slowing down |  |  |  |  |  |
| Changing direction |  |  |  |  |  |

1. What do you notice about the directions of force and acceleration?
2. Does the directional relationship between forces and acceleration change if you are pulling rather than pushing?

**Gravitational forces:**

**Materials:** ball, incline, soft foam, 500 g mass with a string

Experiment:

1. Hold a ball stationary over the floor. Record the direction you feel the gravitational force is directed in.
2. Drop the ball and record your findings in Table 2 below.

**Table 2:** In each cell, record the direction of each vector quantity with an arrow. If the quantity has no magnitude, write a 0 in the cell.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Initial Velocity** | **Final Velocity** | **Acceleration** | **Force** | **Force and acceleration in same direction (Y/N)** |
|  |  |  |  |  |

Direction of Gravity:

**Purpose:** To test whether gravity acts downwards when on a slope.

**Prediction:** What direction do you feel gravitational forces when standing on an incline or slope? (Draw an arrow to indicate the direction on the diagram)

Experiment:

1. Use the foam-lined incline to answer these two questions before proceeding.
* Try to push parallel to the foam’s surface. Can you create a significant depression in the foam? \_\_\_\_\_\_
* Try pushing on the foam at different angles. Can you create a significant depression in the foam? \_\_\_\_\_\_\_
1. Place a 500 g mass, with a string attached to the mass, on the incline.
2. Pull on the string in different directions to see what direction is the most effective to remove the depression from the incline **but** keep the mass hovering over the location that you set the mass. (The opposite direction that you are pulling in is the direction of gravity)
3. In what direction does the object, sitting on the incline, experience the gravitational force?
4. Do gravitational forces push or pull on objects?
5. Do inclined surfaces change the direction gravitational forces are directed on an object?

**Friction**

**Materials:** puck, paper

Experiment:

1. Slide a puck across the table and wait for it to stop.
2. Record the results in Table 3 below.
3. Based on the patterns you have seen in previous experiments, predict the direction of the frictional force.

**Table 3:** In each cell, record the direction of each vector quantity with an arrow. If the quantity has no magnitude, write a 0 in the cell.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Initial Velocity** |  | **Final Velocity** | **Acceleration** | **Predicted Direction of Force** |
|  |  |  |  |  |

Draw a vector representing the velocity of the puck in the diagram below. This is the puck’s velocity relative to the table’s surface. Draw in the predicted force vector.

Puck

Table

1. What do you notice about the direction of the frictional force vector compared to the velocity of the object relative to the surface?

Experiment:

1. Place the object on a sheet of paper and pull the paper gently so the puck does not slide on the paper.
2. Record your observations for the motion of the puck in Table 4 below.

**Table 4:** In each cell, record the direction of each vector quantity with an arrow. If the quantity has no magnitude, write a 0 in the cell.

|  |  |  |  |
| --- | --- | --- | --- |
| **Initial Velocity** | **Final Velocity** | **Acceleration** | **Predicted Direction of Force** |
|  |  |  |  |

1. Place an object on a piece of paper and pull the paper out from under the puck.
2. Did the puck move with respect to the table? \_\_\_\_\_\_\_\_\_
3. Indicate the velocity of the paper with respect to the puck with an arrow in the space provided: \_\_\_\_\_\_\_\_\_
4. Indicate the velocity of the puck with respect to the paper with an arrow in the diagram: (This is in the opposite direction that the paper was travelling in!)

Puck

Table

1. What occurred in step 3 was an extreme situation compared to step 1. Step 3 demonstrated the direction the puck attempts to move in in Step 1. In Question iv, you identified the direction the puck attempts to move in, and when the paper is pulled hard enough the puck moves in this direction. Draw the predicted force vector from Table 4 in the diagram in Question iv.
2. What is the relationship between the direction of the frictional force and direction of the attempted velocity of the object?
3. What type of force caused the object to accelerate?
4. Is the directional relationship here the same as you found in Question i?

Experiment:

1. Place a stack of books on the table and push horizontally on the books with almost no force at first. Gradually increase the force you apply on the books.
2. When the books are moving, push the books at constant speed.
3. When you are pushing lightly, do the books move?
4. Compare the force you need to apply to keep the books moving to the force you need to get the books moving.

**Normal forces**

**Materials:** ball, narrow stick, paper, pencil

Experiment:

1. Place a ruler at one end of on a piece of paper, making sure the ruler is perpendicular to the length of the paper.
2. Scribe a line along the edge of the ruler on the paper, and place a ball along the face of the board
3. Place a ball in the middle of the ruler.
4. Move the ruler along the length of the paper slowly so the ball stays with the ruler, stopping routinely to mark the position of the ball on the paper.
5. Draw a line between the positions marked for the ball to establish the path of the ball. (connect the dots)
6. Repeat these steps by varying the angle between the ruler and the direction the ruler is moved.
7. After you have done this three times, take the ball and place the ball on one of the paths. Push the ball along the path using the end of the ruler.
8. What do you notice about how you held the ruler and the path of the ball?
9. What do you notice about angle between the path and alignment of the ruler when you created the paths?
10. Normal forces are forces applied by large surfaces on objects and are always ­­applied \_\_\_\_\_\_\_\_\_\_\_\_\_\_ to the surface of the object.