Newton's Laws of Motion with PocketLab and Estes Air Rocket

Lab 1: Newton's First Law - Unbalanced forces of launching rocket

Exploration

Previously you learned that the net force acting on an object is related to the object's motion. The net force determines whether the velocity of an object will change. This is described in Newton's First Law of Motion:

"An object at rest will remain at rest or an object in motion will remain in uniform motion unless acted upon by an outside force".

In this experiment you will investigate Newton's First Law. You will observe and measure the acceleration of an air rocket and determine how the forces interacting with it are causing the observed acceleration.

Objective

In this exploration, you will:

1. Observe and measure the acceleration of an air rocket.
2. Use qualitative and quantitative observation to determine and diagram the balance of forces acting on the rocket at different points in flight.
3. Use the observed data and the created force diagrams to explain and provide evidence for Newton's First Law.

Materials

- Estes T-Bolt Air Rocket
- Duct Tape
- Foam padding or bubble wrap
- PocketLab

Discussion

Using your understanding of Newton's First Law of Motion, describe the motion of an object in the following scenarios by completing the sentences.

1. When the sum of net forces on an object is zero (balanced), the object will….
2. When the sum of net forces on an object is not zero (unbalanced), the object will…

Define the following key terms:

Velocity

Acceleration

Force

Balanced and unbalances forces

Air Rocket Launch

1. Using duct tape attach the PocketLab to the nosecone of the air rocket and sync the PocketLab to the PocketLab app on the device.
2. With the PocketLab app the Acceleration Scalar and Altitude graphs will record the rocket's flight. Use 10 air pumps for this launch.
3. While the rocket is in the air, make qualitative observations about the rockets flight and write them down. After the rocket lands, fill in the diagram below of the rocket's height and acceleration values at different points during the flight.

1. Moment of Launch

Acceleration:

Height:

2. Any Moment During Ascent

Acceleration:

Height:

3. Max Height

Acceleration:

Height:

4. Any Moment During Descent

Acceleration:

Height:

5. Moment of Landing

Acceleration:

Height:

Force Diagrams/Data Analysis

For each moment in the diagram of the air rocket label vector arrows with the type of force acting on the rocket and label whether the force is balanced $(F = 0)$ or unbalanced $(F \neq 0)$

- Describe the acceleration of the rocket from the moment of launch until it landed. How would that relate to the speed of the rocket at each moment?
- What forces do think caused the acceleration of the rocket?

Conclusion

- Describe how you knew to draw each force diagram the way you did. How did you know whether the forces were balanced and unbalanced? How did you know in which direction they were balanced or unbalanced?
- Describe how the evidence you collected and the observation you made support or refute Newton's First Law of Motion.

Lab 2: Newton's Second Law - Mass, Force, and Acceleration

Exploration

Previously you learned that an object's acceleration is related to the net force acting on the object and the object's mass. The greater the net force acting on the object, the greater the acceleration of the object. The greater the mass of the object, the lesser the acceleration of the object. This is described in Newton's Second Law of Motion:

"The acceleration of an object is directly proportional to the net force acting on the object and inversely proportional to the mass of the object."

Using an air rocket and PocketLab's accelerometer, you will create your own experiment that accurately tests Newton's Second Law of Motion. The goal of your investigation will be to collect data that either proves or refutes Newton's claim.

Objective

In this exploration, you will:

1. Design a controlled investigation that accurately tests how different independent variables affect a dependent variable. In the design, you will determine what the independent and dependent variables are, and how best to collect data on those variables.
2. Plan an accurate method to collect data and make qualitative observations in order to determine how the movement of an object is affected by the object's mass and the strength of the forces acting on the object.
3. Use collected data and qualitative observations to draw a conclusion that explains and provide evidence for the natural phenomenon described in Newton's Second Law of Motion.

Materials

- Estes T-Bolt Air Rocket
- Duct Tape
- Foam padding or bubble wrap
- Material to add mass
- PocketLab

Discussion

Using your understanding of Newton's Second Law of Motion, describe the motion of an object in the following scenarios:

- When the mass of the object increases, how does the momentum of the object change? How could this relate to the acceleration of the object if it were moving?
- When the force exerted on an object increases, what happens to the acceleration of that object?

Define the following key terms:

Velocity Acceleration Force Mass Momentum

Design your lab

You will design an investigation to test Newton's Second Law of Motion. In your you will launch the air rocket to test Newton's Second Law.

First, determine the independent and dependent variables you wish to test in your experiments. Remember, you are trying to collect evidence which supports Newton's Second Law. Write them in the chart below.

Independent Variable(s)	Dependent Variable(s)

Write out your design to test how your independent variable(s) will affect your dependent variable(s). Be sure to include the following: Control variables and how you will control them, a precise way to accurately manipulate the independent variables, a precise way to accurately collect data on your dependent variable(s) using PocketLab or any other available tool.

Data Analysis and Conclusion

Newton's Second Law states:

"The acceleration of an object is directly proportional to the net force on the object, and inversely proportional to the mass of the object"

Looking at the strength of your experimental designs and the data you collected, make a claim that either supports or refutes Newton's Second Law of Motion. Support your claim with evidence from all three experimental designs and the data you collected. Describe why your evidence supports your claim using scientific reasoning related to the motion of objects.