DOES MASS MATTER?

Student Design Portfolio

Student Name:	Project Start Date:
Final Project Grade:	Project Due Date:

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I Can Statements

After this activity, you should be able to say I CAN…

- Articulate Newton's Second Law of Motion and provide examples.
- Conduct an experiment and display collected data to show the relationship between mass and speed.
- Define the criteria and constraints of a design problem with enough precision to ensure a successful solution.
- Evaluate competing design solutions to determine how well they meet the criteria and constraints of the problem.
- Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- Develop a model to generate data for repeated testing and modification of a proposed object, tool, or process to achieve an optimal design

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Essential Question

Does the mass of a model rocket affect the altitude, velocity, and duration of the rocket's flight?

Criteria

The Green Egg Rocket must

- Reach a minimum altitude of 200 feet
- The payload must include between 1 and 10 pennies.

Constraints

- The Green Egg Rocket may not be altered in any way other than the addition to the payload.
  - The Pocket Lab must be included in the payload
  - No more than 10 pennies may be added to the payload
- Students will be limited in the amount of time to build the Green Egg Rocket up to teacher discretion but no more than 2 45 minute class periods.
- Students must follow the Safety Guidelines as set out by the NAR during the launch.

Client

International Space Station

End User

Astronauts on the International Space Station

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Engineering Design Process

The Engineering Design Process is at the core of this lesson. Think of the Engineering Design Process as a roadmap that guides not only engineers and inventors but also students and teachers to solve problems with available resources. All engineers ask questions, imagine solutions, plan designs, create and test models, and then make improvements. These steps are outlined below.

1 ASK
Identify and Define the Problem

2 IMAGINE
Brainstorm Solutions & Research Ideas

3 PLAN
Select & Sketch Ideas

4 CREATE
Build a Model or Prototype

5 TEST
Collect Data & Evaluate Solution

6 EVALUATE
Optimize & Redesign the Solution

7 COMMUNICATE
Share the Results

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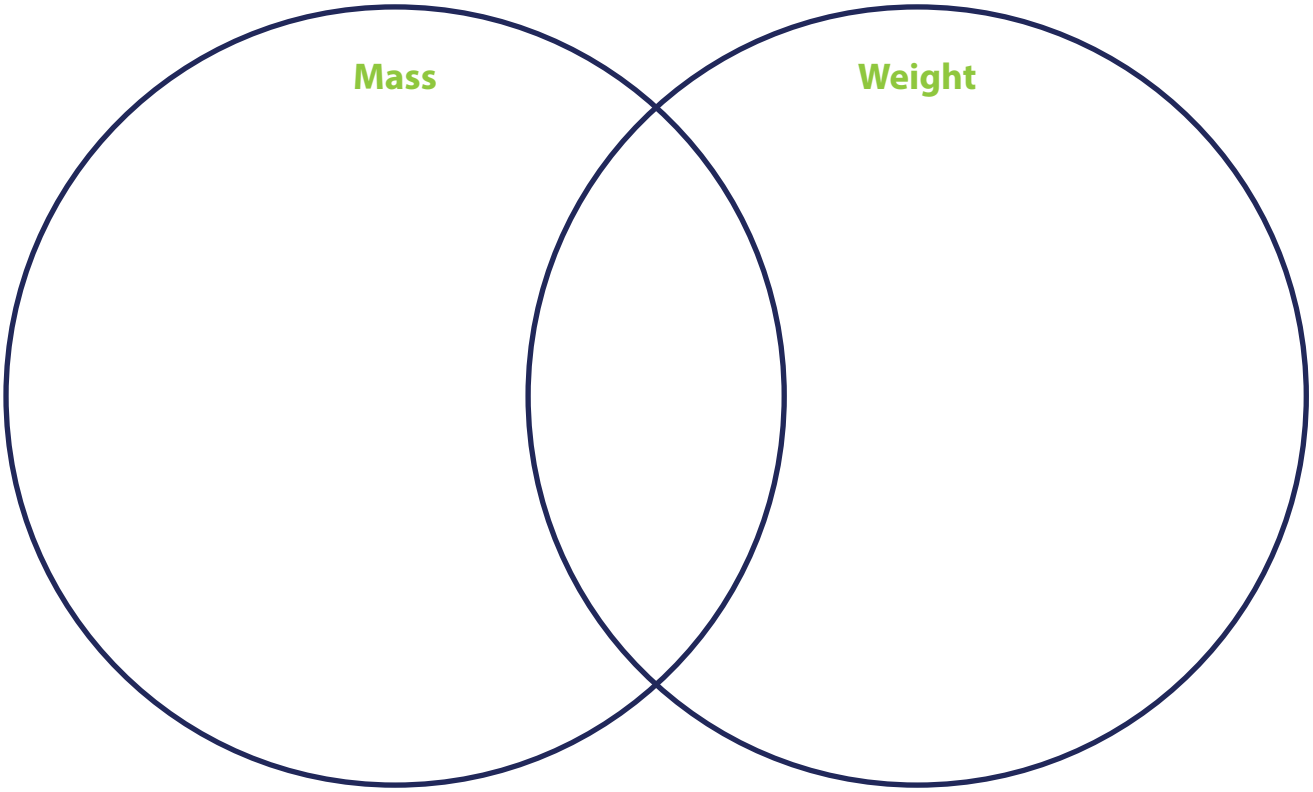
Ask | Activity 1: Pre-Assessment

Ready to Launch? After watching the video shared in class, answer the questions below.

1. Take a minute to brainstorm all the things the engineers who design rockets might have to take into consideration. Write down 3-5 examples.

2. What kinds of things do rockets carry to space?

3. **Find a Partner!** Those things add a lot of mass to the rocket! Do you know the difference between mass and weight? Complete a Venn Diagram with a partner to demonstrate the differences and similarities of between mass and weight.



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Ask | Activity 2: Read the Problem

Read through the following scenario and then answer the question at the end.

You are part of a group of engineers working for Rockets R US which has been contracted to build rockets that will carry the PocketLab Data Analyzer to astronauts on the International Space Station (ISS). You must be sure that your rocket reaches 200ft and can carry up to 10 pennies as a payload to the ISS.

1. Martin Moneysaver wants the rocket to carry only the data payload (PocketLab) to the ISS because he feels that would save money for fuel.
2. Sha'Niece Supersupplier says needs the rocket to be packed with as many things as possible (pennies) so that the astronauts on the ISS have fresh food, games, clothing, and comfort items from home. She doesn't think the amount of mass in the rocket really makes much of a difference.
3. Wes Wishywashy is afraid that if they don't send any supplies for the astronauts the rocket will be too light to fly.

Think, Pair Share

Think
Which one of your teammates do you think has the right idea and why? Keep in mind what you know about Newton's Second Law.

Pair
Find a partner and share your thoughts with them. Would you like to revise or add to your answer?

Share
Participate in a class discussion and share your hypothesis

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Ask | Activity 3: Vocabulary Presentation (Optional)

FLIGHTPATH B | If your teacher asks you to also take flightpath B, then complete the following sections.

Directions

1. You will create a new presentation. Discuss Google Slides, Microsoft PowerPoint, or Prezi presentation options with your teacher.
2. Title your slideshow. Include your first and last name.
3. Make a separate slide for each of the vocabulary words.
4. Research each vocabulary word.
5. Define each of the vocabulary words into a complete sentence.
6. Please use your own words.
7. Do not copy and paste from the web.
8. Insert one or more pictures for each vocabulary word.
9. Your teacher will provide details on how to turn in the presentation.

Vocabulary Words:

- Weight
- Mass
- Velocity
- Force
- Acceleration
- Velocity
- Payload
- Apogee
- Prototype

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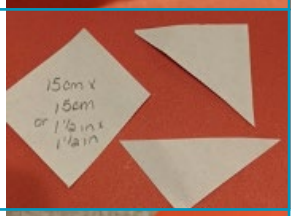
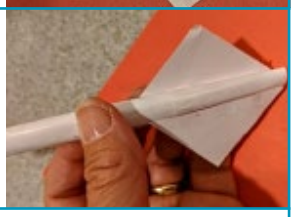
Imagine | Activity 1: Build a Straw Rocket

Building Directions

Gather materials: Paper, straw, scissors, clear tape, ruler, paper clips	
Cut a strip of printer paper: 2 inches (6 cm) wide and 8 ½ inches (21.5 cm) long.	
Place your straw on the paper and wrap the paper tightly around it. Tape it in place.	
Fold down one end of the tube and tape it securely so that air will not be able to get through it.	
Next you will add fins to the other end of the tube - be careful not to block the open end of the tube as this is where you will be adding the "fuel" (your breath). Your fins should be triangles. Cut a square that is 15 cm x 15cm (or 1.5 in x 1.5 in) size(this is a control) and then cut the square diagonally.	
Tape one triangle to the side of the rocket close to the bottom of the tube. Repeat with the other fin - aim to have the fins evenly spaced.	
If time permits, decorate your rocket!	
Let your teacher know you are ready to test!	

Do not blow into the rocket until instructed to do so by your teacher!

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Imagine | Activity 2: Make a Prediction

You will use your straw rocket to see the effect of mass on the rocket's duration and distance flown. You will create your own rocket; however, you will need a partner to help with testing. This straw rocket will serve as a prototype (a first model from which other models are developed) for the model rockets you will be building in the next class to help you learn more about mass and weight.

Choose a Hypothesis

Hypothesis: You will be writing a hypothesis about what you think will happen during this experiment. Remember that a hypothesis is a prediction or an educated guess. It always begins with IF and a little later in the sentence has a THEN...

What do you think will happen to your straw rocket when you add weight to it? Circle or highlight which of the hypotheses you think is correct. You may only choose ONE!

- If I add more weight to the straw rocket, then the rocket will travel ***farther*** and will fly for a ***shorter*** period of time.
- If I add more weight to the straw rocket, then the rocket will travel ***farther*** and will fly for a ***longer*** period of time.
- If I add more weight to the straw rocket, then the rocket will travel a ***shorter distance*** and will fly for a ***shorter*** period of time.
- If I add more weight to the straw rocket, then the rocket will travel a ***shorter distance*** and will fly for a ***longer*** period of time.

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Variables

Variables are anything that is change in a scientific experiment. It is what is manipulated, controlled or measured. There are independent variables, dependent variables and controls.

Independent Variable

The **INDEPENDENT VARIABLE** is what you as the scientist manipulates or changes. HOW are you changing in the straw rocket? (HINT: This is what follows "IF" in your hypothesis)

Circle or highlight the correct response:

Making it longer | Making it shorter | Making it heavier | Making it lighter

Dependent Variable

The **DEPENDENT VARIABLE**, is what you as the scientist is measuring. WHAT are you measuring in the straw rocket experiment? (Hint: This is the THEN part of the hypothesis)

Circle or highlight ALL the correct response:

How long it flies | How far it flies | How high it flies | How big a breath you take

Controls

The **CONTROLS** are the things that stay the same – what will stay the same in your straw rocket experiment?

Circle or highlight ALL the correct response:

The length of the rocket | The weight of the rocket | How far it flies

How big a breath you take | The size of the fins | The same classroom

The size of the nose cone | The number of paper clips | The size of the straw

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Imagine | Activity 3: Collect Data

Review Safety Guidelines

- Students will wear goggles when testing.
- Students will stand behind the line established by the teacher. Rockets are ONLY launched in one direction and only after the teacher gives instructions.
- While a student is blowing into the rocket, his/her partner is responsible for timing the duration of the flight and marking where the rocket lands.
- All rockets will be launched at 180° - straight.
- Students will not share rockets!

Remember

Velocity: is the rate of motion or speed in a given direction. Measured in terms of distance moved per unit time,in a specific direction

Time: is how long the rocket was in the air

Acceleration: is the $\frac{\text{change in velocity (final velocity - initial velocity)}}{\text{Time}}$

And the initial velocity is 0.

Force: is Mass x Acceleration

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Launch 1

1. Gently remove your straw and weigh your rocket. Record below and be sure to include the unit!

My rocket weighs _____

2. When your teacher instructs you to do so, put on your goggles and advance to the firing line. Make sure your partner is ready to time your flight. You must BOTH be behind the firing line.
3. Put your rocket on to the straw. At your partner's countdown, blow into your rocket.
4. Record the duration of the flight and the distance traveled.
5. Repeat for at least 3 trials. Try to keep the amount of breath you use consistent.
6. Return the favor for your partner! Calculate the velocity of the rocket for each trial and average it. Use the average velocity to calculate the acceleration and the force.

Trial	Qualitative data (what did you see, hear, etc.	Duration (seconds)	Distance (cm)	Velocity (Distance/time)
1.				
2.				
3.				
Average (add each of the trials and then divide by 3)				

Using the average velocity, calculate the acceleration of the rocket.

The acceleration is: _____ *(don't forget your units)*

Using the acceleration you just calculated, determine the force of the rocket.

The force is: _____ *(don't forget your units)*

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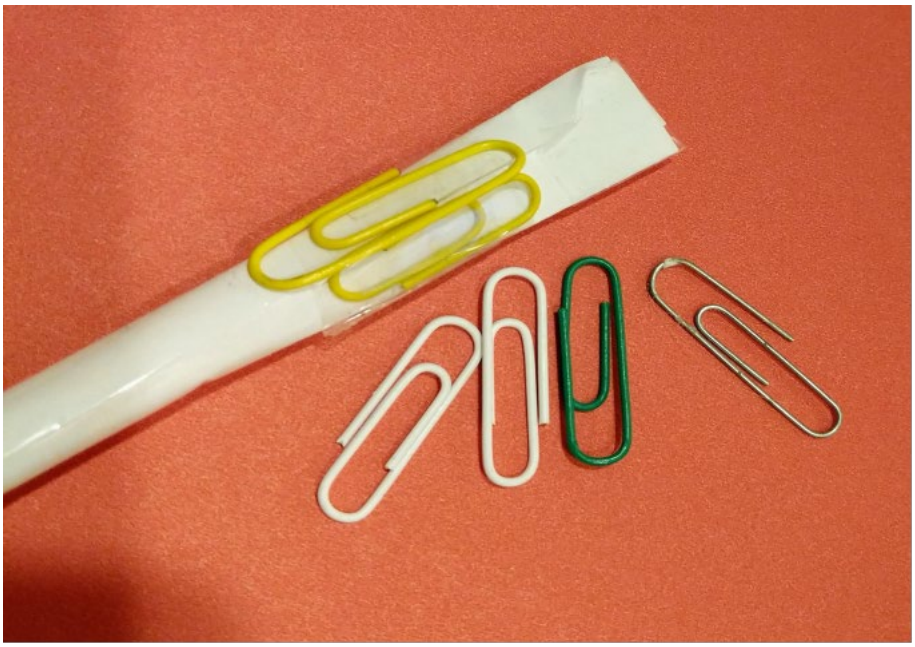
Add Mass



Now that you have had a successful straw rocket flight, you need to add some mass to the rocket. After all, the astronauts need supplies. Sending them an empty rocket is not very useful. In this section, you will alter your straw rocket by adding mass to it.

7. Add the mass of your rocket by taping paper clips securely to the folded end of the rocket. The location is a control. Re-insert the straw when securing the paper clips. It will be up to you to decide how many paper clips to add, but remember, you should not be altering the amount of breath you are blowing into the rocket.

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Launch 2

1. Gently remove your straw and weigh your rocket. Record below and be sure to include the unit!

My rocket with paper clips weighs _____

2. When your teacher instructs you to do so, put on your goggles and advance to the firing line. Make sure your partner is ready to time your flight. You must BOTH be behind the firing line.
3. Put your rocket on to the straw. At your partner's countdown, blow into your rocket.
4. Record the duration of the flight and the distance traveled.
5. Repeat for at least 3 trials. Try to keep the amount of breath you use consistent.

Trial	Qualitative data (what did you see, hear, etc.	Duration (seconds)	Distance (cm)	Velocity (Distance/time)
1.				
2.				
3.				
Average (add each of the trials and then divide by 3)				

Using the average **velocity**, calculate the acceleration of the rocket.

The acceleration is: _____ ***(don't forget your units)***

Using the **acceleration** you just calculated, determine the force of the rocket.

The force is: _____ ***(don't forget your units)***

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Graph

Directions

You will create two graphs. These may be created on graph paper, in a program such as Excel or Sheets, or use the grid below. You will graph only the averages.

- **Duration:** For this graph, your x axis (horizontal axis, independent variable) will be the weight of the rocket and the y axis (vertical, dependent variable) will be how long the rocket remained in the air.
- **Distance:** For this graph, your x axis (horizontal axis, independent variable) will be the weight of the rocket and the y axis (vertical, dependent variable) will be how far the rocket travelled.

Optional:

Wait for your teacher's instructions to determine if you should do the step below.

SHARE your accelerations and forces with your class through a class spreadsheet.

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Imagine | Activity 4: Reflect & Apply

Analyze Your Results:

1. Did the mass of the rocket affect the duration of your rocket's flight? Was the class data similar? Explain!

2. Did the mass of the rocket affect the distance your rocket traveled? Was the class data similar? Explain!

3. Which of the dependent variables, duration or distance, was most affected? Was the class data similar? Explain!

Reflect

4. Was your hypothesis proven or disproven? Explain!

5. What were the possible sources of error?

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6. If you could do this experiment again, what would you change and why?

Apply

7. Review your answer to the scenario that stated this lesson. Make any changes, additions or deletions, and add them here:

8. How does this experiment relate to sending a real rocket to the ISS? What considerations must the engineers con sider when they design a rocket?

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Plan | Activity 1: Learn About the PocketLab

The PocketLab is required to go into your rocket when it launches. The astronauts "need" this equipment to continue their research on the ISS.

The Pocket Lab will also help you collect data on your rocket's flight.

Watch this short video on the Pocket Lab and answer the question below.

Pocket Lab Video

After watching the video, which of these features will be the most useful for answering the question, Does Mass Matter?

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Plan | Activity 2: Write a Hypothesis

You will be using the information you learned about Newton's Laws and the effect of mass on a Green Eggs rocket to see the effect of mass on a model rocket's duration and distance flown.

Hypothesis

(HINT!!!You may want to review the hypotheses that you chose for the straw rocket experiment.)

If I add _____pennies to the model rocket, then the rocket will have a greater average velocity than a model rocket with _____pennies and smaller velocity than a rocket with _____pennies.

Variables

Write the independent, dependent and control variables in the boxes below.

Independent Variable

The **INDEPENDENT VARIABLE** is what you as the scientist manipulates or changes. HOW are you changing in the straw rocket? (HINT: This is what follows "IF" in your hypothesis)

Dependent Variable

The **DEPENDENT VARIABLE**, is what you as the scientist is measuring. WHAT are you measuring in the straw rocket experiment? (Hint: This is the THEN part of the hypothesis)

Control

The **CONTROLS** are the things that stay the same – what will stay the same in the Green Egg Rocket experiment? (HINT: There is more than one control!)

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Create | Activity 1: Build Your Rocket

Directions

1. Form a small group and wait for your teacher to had out supplies and rocket kits
2. Open your rocket kit when instructed to do so. Ensure you have all the pieces.
3. Follow the instructions to build with your group

Remember

- Be sure to work as a TEAM! Communicate your ideas and have patience when building.
- Follow the instructions closely.
- Keep track of all the pieces of your rocket. Do not lose anything.

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Create | Activity 2: Prep Your Rocket

Directions

1. Insert an engine into the bottom of your rocket.
2. Add recovery wadding into the body tube.
3. Fold your parachute and insert it into the rocket.
4. Close the nose cone.
5. Weigh your rocket and record it below.

Rocket Weight (no additional mass): _____

6. Wrap the Pocket Lab Voyager in several sheets of recovery wadding.
7. Weigh your Pocket Lab and record it below.

Pocket Lab Weight: _____

8. Insert it into the payload section of the rocket with the padding.
9. With your group/partner, decide how much mass you will add to the rocket. How did you decide on this amount?
10. Tape the pennies together in a short stack.
11. Be sure to obtain the mass of the pennies you are adding. NOTE that not all pennies have the same mass- be sure you check YOUR pennies!

Payload (Pennies) Weight: _____

12. Add your payload (pennies) to the payload section of your rocket (green capsule).
13. Tape the nose cone to the green payload section.
14. Hand your rocket to your teacher.

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Create | Activity 3: Safety First!

1. **Materials:** I will use only lightweight, non-metal parts for the nose, body, and fins of my rocket.

2. **Motors:** I will use only certified, commercially-made model rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer.

3. **Ignition System:** I will launch my rockets with an electrical launch system and electrical motor igniters. My launch system will have a safety interlock in series with the launch switch, and will use a launch switch that returns to the "off" position when released.

4. **Misfires:** If my rocket does not launch when I press the button of my electrical launch system, I will remove the launcher's safety interlock or disconnect its battery, and will wait 60 seconds after the last launch attempt before allowing anyone to approach the rocket.

5. **Launch Safety:** I will use a countdown before launch, and will ensure that everyone is paying attention and is a safe distance of at least 15 feet away when I launch rockets with D motors or smaller, and 30 feet when I launch larger rockets. If I am uncertain about the safety or stability of an untested rocket, I will check the stability before flight and will fly it only after warning spectators and clearing them away to a safe distance. When conducting a simultaneous launch of more than ten rockets I will observe a safe distance of 1.5 times the maximum expected altitude of any launched rocket.

6. **Launcher:** I will launch my rocket from a launch rod, tower, or rail that is pointed to within 30 degrees of the vertical to ensure that the rocket flies nearly straight up, and I will use a blast deflector to prevent the motor's exhaust from hitting the ground. To prevent accidental eye injury, I will place launchers so that the end of the launch rod is above eye level or will cap the end of the rod when it is not in use.

7. **Size:** My model rocket will not weigh more than 1,500 grams (53 ounces) at liftoff and will not contain more than 125 grams (4.4 ounces) of propellant or 320 N-sec (71.9 pound-seconds) of total impulse.

8. **Flight Safety**: I will not launch my rocket at targets, into clouds, or near airplanes, and will not put any flammable or explosive payload in my rocket.

9. **Launch Site:** I will launch my rocket outdoors, in an open area at least as large as shown in the **accompanying table**, and in safe weather conditions with wind speeds no greater than 20 miles per hour. I will ensure that there is no dry grass close to the launch pad, and that the launch site does not present risk of grass fires.

10. **Recovery System:** I will use a recovery system such as a streamer or parachute in my rocket so that it returns safely and undamaged and can be flown again, and I will use only flame-resistant or fireproof recovery system wadding in my rocket.

11. **Recovery Safety:** I will not attempt to recover my rocket from power lines, tall trees, or other dangerous places.

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Test | Activity 1: Launch!

Launch Day Procedure

1. Your teacher will be launching a rocket WITHOUT any additional mass. Be sure to record the data from that launch as well in the table below.
2. When your teacher instructs you to do so, put on your goggles and advance to the launch pad. Make sure your partner is ready to time your flight and to make observations.

Data Table

Trial	Qualitative data (what did you see, hear, etc.	Duration (seconds)	Altitude	Average Velocity
Teacher's Rocket: Without Additional Mass				
Rocket with additional mass of the payload, and the Pocket Lab				

3. When you have safely recovered your rocket, remove the Pocket Lab Voyager and record the data. Make notations about the qualitative aspects of the rocket's flight as well.
4. Calculate the **Average Velocity**. Remember, velocity is the rate of motion or speed in a given direction. Measured in terms of distance moved per unit time, in a specific direction. Your time is the total amount of time the rocket was in the air. Your distance is the altitude the rocket reached times TWO (It not only went up; it also came down!)
5. When you return to the classroom, SHARE your data with your class through a class spreadsheet.

My Teacher's Rocket's Average Velocity: _____

My Rocket's Average Velocity: _____

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Remember

Velocity: is the rate of motion or speed in a given direction. Measured in terms of distance moved per unit time,in a specific direction

Time: is how long the rocket was in the air

Acceleration: is the $\frac{\text{change in velocity (final velocity - initial velocity)}}{\text{Time}}$

And the initial velocity is 0.

Force: is Mass x Acceleration

Using the average **velocity**, calculate the acceleration of the rocket.

The acceleration is: _____ ***(don't forget your units)***

Using the **acceleration** you just calculated, determine the force of the rocket.

The force is: _____ ***(don't forget your units)***

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Test | Activity 2: Review Data

Analyze Your Results

1. Did the mass of the rocket affect the duration of your rocket's flight? Was the class data similar? Explain!

2. Did the mass of the rocket affect the altitude to which your rocket traveled? Was the class data similar? Explain!

3. Which of the dependent variables, duration or altitude, was most affected? Was the class data similar? Explain!

4. Which rocket had the longest flight? Which one had the greatest velocity? Was it the same rocket? Explain!

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Improve | Activity 1: Plan an Adjustment

1. Was your hypothesis proven or disproven? Explain!

2. What were the possible sources of error?

3. Which character was right?

4. If you could do this experiment again, what would you change and why?

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Improve | Activity 2: Relaunch

FLIGHTPATH B | If your teacher asks you to also take flightpath B, then complete the following sections.

Directions

Complete steps 1-4 from the prep your rocket procedure on pg. 23. Record your new weights below.

Weight All Parts of the Rocket

Don't forget to include your units!

Rocket Weight (no additional mass): _____

Pocket Lab Weight: _____

Payload (Pennies) Weight: _____

Relaunch your rocket as instructed by your teacher and complete the table below.

Data Table

Trial	Qualitative data (what did you see, hear, etc.	Duration (seconds)	Altitude	Average Velocity
My First Rocket (copy data from test section)				
My Second Rocket launch				

Rocket Weight (no additional mass): _____

Pocket Lab Weight: _____

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Answer this question below

1. How did the adjustment to my rocket impact the flight? Explain using the data above!

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Share | Activity 1: Claims-Evidence-Reasoning

Using this Claims- Evidence-Reasoning template below, answer the question:

Does the mass of a model rocket affect the altitude, velocity and duration of the rocket's flight?

Claim A conclusion that answers the original question		• Scientifically accurate • Completely answers the question • Common inaccurate claim(s) are clearly addressed.
Evidence Scientific data that supports the claim		• The data are scientifically appropriate to support the claim. • The data are thorough and convincing – enough details and evidence provided. • Proper units are used in data • Shows with evidence why alternate claims do not work
Reasoning A justification that links the claim and evidence		• Reasoning clearly links evidence to claim • Shows why the data count as evidence by using appropriate scientific principles • There are sufficient scientific principles to make links clear between claim and evidence

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