Bottle Rocket

Grade Level: 8

Time Required: two weeks

Countdown:
The following supplies should be available for each group of 3 students:
2 liter soda bottles
1 liter soda bottles
Film Canisters
Aluminum Cans
Scrap cardboard and poster board
Large cardboard panels
Duct tape
Electrical tape
Glue sticks
Low-temperature glue gun
Water
Clay
Plastic garbage bags
Crepe paper
String
Paint
Safety glasses
Bottle rocket launcher
Altitude Calculator
Copies of budget/order forms
Copies of check forms

This lesson adapted from NASA Project X-35 Teachers Guide.

Ignition:
A rocket that flies straight through the air is said to be a stable rocket. A rocket that veers off course or tumbles wildly is said to be an unstable rocket. The difference between the flights of these two rockets is in the design. All rockets have two "centers." The first is the center of mass. This is where the rocket balances. If you placed a ruler under the rocket, it would balance horizontally like a seesaw. What this means is that half of the mass of the rocket is on one side of the ruler and half is on the other side.

The other center in a rocket is the center of pressure. This is a point where half of the surface area of a rocket is on one side and half is on the other. This is just a point based on the
surface of the rocket, not on what is inside. During flight, the pressure of air rushing past the rocket will balance half on one side of this point and half on the other. You can determine the center of pressure by cutting out the silhouette of the rocket from cardboard and balancing it on ruler.

The positioning of the center of mass and center of pressure is critical to the rocket stability. The center of mass should be towards the rocket's nose and the center of pressure should be towards the rocket's tail for the rocket to fly straight. This is because the lower end of the rocket has more surface area than the upper end. When the rocket flies, more air pressure exists on the lower end of the rocket than the upper end. Air pressure will keep the lower end down and the upper end up. If the center of mass and the center of pressure are in the same place, neither end of the rocket will point upward. The rocket will be unstable and tumble.

This project provides students with the opportunity to discover practical demonstrations of force and motion in actual experiments while dealing with budgetary restraints and deadlines in real life situations. Students should review Newton's Laws of Motion before beginning this project. All building materials and handouts should be reproduced before beginning this activity. Make several copies of the budget forms and checks for each group. The first day should be spent reviewing all materials, assignments and development of a project plan. Describe the student score sheet to insure the student has a clear understanding of expectations of this project.

**Students will:**

a. Design and draw a bottle rocket plan to scale (1 square = 2 cm).
b. Develop a budget for the project and stay within the budget allowed.
c. Build a test rocket on the budget and plans developed by the team.
d. Identify rocket specifications and evaluate the rocket stability by determining center of mass and center of pressure and conducting a swing test.
e. Display fully illustrated rocket design in class. Include: dimensions, center of mass, center of pressure, and flight information.
f. Successfully test the launch rocket.
g. Complete the rocket journal.
h. Develop a cost analysis and demonstrate the most economically efficient launch.

**Liftoff:**

1. Design a project plan for the two week assignment. (show sample attached)
2. Review Project Checklist
3. Assign job responsibilities.
4. Review business information and portfolio requirements.
5. Review Budget Preparation and Order forms.
6. Design and build rocket.
7. Complete the rocket journal/portfolio.

More Ideas …
➢ Research the reasons why so many different rockets have been used in space exploration.
➢ Construct models of rockets from the past.
➢ Compare rockets from science fiction movies with actual rockets.
## Bottle Rocket Project Plan

### Sample

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
</table>
| • Form rocket companies  
• Brainstorm ideas for rocket and budget  
• Sketch preliminary design for rocket | • Develop materials list  
• Prepare budget list  
• Develop scale drawing | • Demonstrate nose cone  
• Gather materials | • Construct rocket | • Construct rocket |

<table>
<thead>
<tr>
<th>Day 6</th>
<th>Day 7</th>
<th>Day 8</th>
<th>Day 9</th>
<th>Day 10</th>
</tr>
</thead>
</table>
| | • Demonstrate finding mass and center of pressure  
• Prepare rocket silhouette and analysis | • Complete silhouette and hang  
• Perform swing test | • Launch! | • Complete launch results  
• Silhouette demonstration  
• Complete journal and documentation |
Bottle Rocket Check List

Tasks of group members:

**Budget Director**
- Keeps accurate accounting of money and expenses and pays the bills. Must sign all checks.
- Arranges all canceled checks in order and staple four to a sheet of paper.
- Checks over budget projection sheet. Be sure to show total project cost estimates.
- Checks over the balance sheet. Be sure the columns are complete and show if you have a positive or negative balance.
- Complete part 3 of the score sheet.
- Assist other team members as needed.

**Design and Launch Director**
- Supervises the design and construction of the rocket.
- Directs others during launch.
- Arranges to have a creative cover made for the portfolio/journal.
- Assist other team members as needed.

**Project Manager**
- Oversees the project.
- Keeps others on task.
- Communicates with the teacher.
- Makes a neat copy of the team's journal/portfolio. Uses labels when necessary.
- Checks over the balance sheet. List all materials used in rocket construction.
- Completes silhouette information and display properly in room.
- Assist other team members when needed.

**Suggested Project Grade:**
- 50% Documentation. Should be complete, neat, accurate and on time.
- 25% Proper display and documentation of rocket silhouette.
- 25% Launch data: Measurements, accuracy, and completeness
Project Journal/Portfolio: Check off as you complete each item.

- Creative cover with names of the members of your team, date, project number and company name

- Certificate of Assumed Name (Name of your business)

- Scale drawing of rocket plans. Indicate scale size. Label: Top, Side, and End View

- Budget

- Balance Sheet

- Canceled Checks. Staple or tape checks in ascending numerical order, four to a sheet of paper

- Pre-Launch Analysis

- Rocket Launch Day Log

- Score Sheet
State of ________
Certificate of Assumed Name

All information on this form is public information. Please type or print legibly in black ink.

Project Number

1. State the exact assumed name under which the business is or will be conducted:
   __________________________________________________________________

2. List the name and title of all persons conducting business under the above assumed name:
   ______________________________________________________________________
   ______________________________________________________________________
   ______________________________________________________________________
   ______________________________________________________________________
   ____________________________

Today's Date _____________________, 19_______ Class Hour ____________________

Filing Fee:  A $25 fee must accompany this form.

___________________________________
Signature/title

___________________________________
Signature/title

___________________________________
Signature/title
Bottle Rocket Budget

Each team has a budget of $1,000,000. Use money wisely and keep accurate records of all expenditures. Once your money runs out, you will operate in the "red" and this will count against your team score. If you are broke at the time of launch, you will be unable to purchase rocket fuel. You will then be forced to launch only with compressed air. You may purchase as much rocket fuel as you can afford at the time of launch.

All materials not purchased from the list of subcontractors will be assessed an import duty tax of 20% of the market value. Materials not from the subcontractors list will be assessed an Originality Tax of $5,000 per item.

A project delay penalty fee will be assessed for not working, lacking materials, etc. This penalty fee could be assessed as high as $300,000 per day.

Approved Subcontractor List

<table>
<thead>
<tr>
<th>Subcontractor</th>
<th>Market Price</th>
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<tbody>
<tr>
<td><strong>Bottle Engine Corporation</strong></td>
<td></td>
</tr>
<tr>
<td>2 L bottle</td>
<td>$200,000</td>
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<tr>
<td>1 L bottle</td>
<td>$150,000</td>
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<tr>
<td><strong>Aluminum Cans Unlimited</strong></td>
<td></td>
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<tr>
<td>Can</td>
<td>$ 50,000</td>
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<tr>
<td><strong>International Paper Corporation</strong></td>
<td></td>
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<tr>
<td>Cardboard - 1 sheet</td>
<td>$ 25,000</td>
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<tr>
<td>Tagboard - 1 sheet</td>
<td>$ 30,000</td>
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<tr>
<td>Manila Paper - 1 sheet</td>
<td>$ 40,000</td>
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<tr>
<td>Silhouette Panel - 1 sheet</td>
<td>$100,000</td>
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<tr>
<td><strong>International Tape and Glue Company</strong></td>
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<tr>
<td>Duct Tape - 50 cm segments</td>
<td>$ 50,000</td>
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<tr>
<td>Electrical Tape - 100 cm segments</td>
<td>$ 50,000</td>
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<tr>
<td>Glue Stick</td>
<td>$ 20,000</td>
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<tr>
<td><strong>Blast Off Rocket Fuel Service</strong></td>
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<td>1 ml</td>
<td>$ 300</td>
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<td><strong>String, Inc.</strong></td>
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<td>1 m</td>
<td>$ 5,000</td>
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<tr>
<td><strong>Plastic Sheet Goods</strong></td>
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<tr>
<td>1 bag</td>
<td>$ 5,000</td>
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<td><strong>Earth Works</strong></td>
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<tr>
<td>Modeling Clay - 100 g</td>
<td>$ 5,000</td>
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<tr>
<td><strong>NASA Launch Port</strong></td>
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<tr>
<td>Launch Rental</td>
<td>$100,000</td>
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<tr>
<td><strong>NASA Consultation</strong></td>
<td></td>
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<tr>
<td>Question</td>
<td>$ 1,000</td>
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</tbody>
</table>

SpaceExplorers http://www.tsgc.utexas.edu/spaceexplorers/
Orbital Mechanics: Bottle Rocket
Texas Space Grant Consortium http://www.tsgc.utexas.edu/
Bottle Rocket Budget Proposal

Company Name________________

Record below all expenses your company expects to incur in the design, construction, and launch of your rocket.

<table>
<thead>
<tr>
<th>Item</th>
<th>Supplier</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Total Cost</th>
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</table>

Projected Total Cost
# Bottle Rocket Balance Sheet

## Company Name

<table>
<thead>
<tr>
<th>Check No.</th>
<th>Date</th>
<th>To</th>
<th>Amount</th>
<th>Balance</th>
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</tbody>
</table>
Rocket Measurements
For Scale Drawing

Project No. ___________
Date _______________

Company Name_______________________________________________

Use metric measurements to measure and record the data in the blanks below. Be sure to accurately measure all objects that are constant (such as the bottles) and those you will control (like the size and design of fins). If additional data lines are needed, use the back of this sheet.

<table>
<thead>
<tr>
<th>Object</th>
<th>Length</th>
<th>Width</th>
<th>Diameter</th>
<th>Circumference</th>
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<tbody>
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</table>

Use graph paper to draw a side, top, and bottom view of your rocket, to scale (1 square = 2 cm), based on the measurements recorded above. Attach your drawings to this paper.
Pre-Launch Analysis

Company Name: _____________________________ Project Number:  

Employee Name: _____________________________
    Job Title: _____________________________

Employee Name: _____________________________
    Job Title: _____________________________

Employee Name: _____________________________
    Job Title: _____________________________

Rocket Specifications

Total Mass: ____________g                                     Number of Fins: ____________

Total length: ___________cm                                  Length of Nose Cone: _________cm

Width (widest part) ____________cm                      Volume of Rocket Fuel to be used on
Circumference: _______________cm                        _____________mL, ___________ L

Launch Day:

Rocket Stability

<table>
<thead>
<tr>
<th>Center of Mass (CM)</th>
<th>Center of Pressure (CP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Nose: ___________ cm</td>
<td>Distance from Nose: _________ cm</td>
</tr>
<tr>
<td>Distance from Tail: ___________ cm</td>
<td>Distance from Tail: _________ cm</td>
</tr>
<tr>
<td>Distance of CM from CP: ___________ cm</td>
<td></td>
</tr>
</tbody>
</table>

Did your rocket pass the swing test?
☐ Yes
☐ No
Flight Day Log

Date: ____________

Time: ____________

Project No. _______________________

Company Name: _______________________________________________________

Launch Director: ______________________________________________________

Weather Conditions: _____________________________________________________

______________________________________________________________________

Wind Speed: _________________ Wind Direction: _________________

Air Temperature: _______________ C

Launch Location: _______________________________________________________

Launch Angle (degrees): _______________ Launch Direction: ____________

Fuel (water) volume: _______________ mL _______________ L

Flight Altitude: _______________ M

Evaluate your rocket's performance:

Recommendations for future flights:
Bottle Rocket Score Sheet

Total Score: ___________________  Project No. ___________________

Date: _______________________

Company Name: ___________________________________________________

Part I: Documentation: 50% of project grade

<table>
<thead>
<tr>
<th>Neatness</th>
<th>Completeness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>Order</td>
</tr>
<tr>
<td>On Time</td>
<td></td>
</tr>
</tbody>
</table>

SCORE: ___________________

Part II: Silhouette: 25% of project grade

<table>
<thead>
<tr>
<th>Neatness</th>
<th>Completeness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>Proper balance</td>
</tr>
<tr>
<td>Correct labels</td>
<td></td>
</tr>
</tbody>
</table>

SCORE: ___________________

Part III: Launch Results: 25% of project grade (teams complete this section)

a. Rocket Altitude ___________________  Rank ___________________

b. Expenditures and Penalty Fees ___________________
   (Check total from Balance Sheet)

c. Investment and Penalty Fees ___________________
   (Total check amount column on Balance Sheet)

d. Final Balance ___________________
   (New Balance on Balance Sheet)

e. Efficiency (Cost/Meter) ___________________
   (Divide Investment (b) by Rocket Altitude (a))

f. Contract Award ___________________

g. Profit ___________________
   (Contract Award (f) minus Investment (c))

SCORE: ___________________