# ENGINEERING PRACTICES IN ACTION



## HEAVY LIFT ROCKET ACTIVITY

### MISSION

Heavy lift rockets will help the space program progress by lowering the cost of sending cargo and supplies into space.

Working as an engineer, you will use engineering practices to design and develop heavy lift rockets.

### DIRECTIONS

- Use the materials provided to lift as much cargo (paper clips) into space as possible on a given launch.
- You can use any or all of the materials provided to develop your rocket.
- How to launch:
  - Use the fishing line or smooth string that is attached to the ceiling as a guide for the rocket's path.
  - Thread the string/line through the straw(s) so that the straw(s) can slide straight up toward the ceiling as propelled by your rocket.
- The rest of the design is up to your team. Your goal is to get as many paper clips (cargo) as possible to reach the ceiling (space) using your launch system.

### MATERIALS (PER TEAM)

- Large binder clip
- Fishing line/smooth string
- 4 long balloons per team - 5" x 24" or 3" x 60"
- Bathroom size (3 oz) paper cup
- 2 straight drinking straws
- 50 small paper clips
- Sandwich-size plastic bag
- Masking tape
- Wooden spring-type clothespins (optional)
- Scissors

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## INVESTIGATE

1. What are the problems you are working to solve?

   *We need to build a rocket that can carry a payload of paperclips to the ceiling.*

2. What criteria and constraints have you been provided within which to work? What are you allowed to use to solve the problem? What are the limits to your solution? As you are building your heavy lift rockets, what materials can you use? Is there anything you're not allowed to use? How long do you have to complete the task?

   *We have materials that we have been provided and can use any or all of them. We must use the fishing line or string to guide the rocket's path. We cannot use other materials not provided to us. We have two sessions to complete this task.*

3. What else do you need to know to fully understand the problem?

   *We need to know which of the materials will be helpful to use and which will not be.*

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## DEVELOP SOLUTIONS

4. What questions or ideas do you have for achieving this challenge? Brainstorm some ideas, designs, materials, and anything else that can assist the performance of your heavy lift rocket. Create one or more diagrams that explain the problem and solution ideas. If needed, use additional paper to draw your design.

   *What will be the challenge for getting the rocket to the ceiling? What will be the challenge for getting the rocket to the ceiling with paperclips? Will one balloon serving as a rocket be enough to get paperclips to the ceiling? How can I modify the balloon to make it go higher? How much will the weight of the paperclips impact the launch?*

   *Student diagrams will vary. Some students may include cups, clips, plastic bags, or clothespins. Other students may consider how to include more than one balloon or a "multi-stage" approach where multiple balloons are used but deflate one at a time.*

5. What is your plan for collecting and measuring the data from each trial? Consistency in testing and collecting data is important. Describe exactly how you will measure the weight that your rocket lifts.

   *Student answers will vary. Students should describe a consistent methodology for collecting and measuring data. They may want to measure the weight of the balloon with all parts included (paperclips, tape, straw piece, any additional items) so as they make modifications, changes in weight will be noted. They should use the same approach when conducting each test.*

6. Predict how much mass your rocket lift system will lift. (1 paper clip = 2 grams)

   *Student answers will vary.*

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## BUILD YOUR ROCKET

7. Use the materials to build your model rocket, per your design.

## EVALUATE

8. Launch your model rocket and record data.

*Student answers will vary. In the Observations section, they should be very specific about what occurred. Sample answers may include: the balloon did not lift off the ground, the balloon launched up two feet before falling back to the ground, or the balloon lost all air without leaving the ground. Students can use slow motion video on their phones to make observations.*

| FLIGHT TEST | ACTUAL MASS LIFTED | OBSERVATIONS |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

9. What needs to be improved? What needs to be changed?

*Student answers will vary. They may note that they need to find a faster way for air to escape their balloon or that they need to reduce weight. They may provide suggestions for ways to alter the balloon to make it work better, such as cutting the end of the balloon to allow air to launch the "rocket" up.*

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## DEVELOP SOLUTIONS

10. As you learned, some engineering practices need to be repeated in order to solve for a problem.

    In this space, re-design and draw modifications for your heavy lift system. Include details about the changes you've made to the shape, materials, and other factors.

    *Student answers will vary. Students may draw a shorter end, aka "nozzle", or, they may reduce the length of the straw they used in order to reduce weight.*

11. Once again, predict how much mass your rocket lift system will lift. (1 paper clip = 2 grams)

    *Student answers will vary. Preferably, students will estimate a higher mass, given they have developed a solution that will work.*

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## EVALUATE

12. Launch your modified rocket and record data.

*Student answers will again vary. In the Observations section, they should be very specific about what occurred, especially if different than the previous test. Sample answers may include: the balloon did not lift off the ground, the balloon launched up two feet before falling back to the ground, or the balloon lost all air without leaving the ground. Students can use slow motion video on their phones to make observations.*

| FLIGHT TEST | ACTUAL MASS LIFTED | OBSERVATIONS |
|---|---|---|
| 4 | | |
| 5 | | |
| 6 | | |

13. Were the modifications to your heavy lift system an improvement from your original design? Why or why not? Describe what happened and if there were any differences in performance between your first and second rocket launches.

*Student answers will vary. Adding more thrust—meaning more balloons—may or may not be helpful in solving the problem. More likely, cutting the end of the balloon to create a shorter nozzle will help the balloon carry a heavier payload.*

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## SHARE YOUR FINDINGS

14. Provide a 1- to 2-minute explanation of how your design functions, what you learned through your testing, what modifications you made as a result, and how your rocket performed with particular reference to the engineering practices you used.

    Be prepared to defend the design choices you made, and also be ready to describe what limitations, errors, and ideas you have for moving forward with the design, as well as what you learned.

    *Presentations will vary. Students should clearly describe their thinking in their original design and address each material they included and why. They should share observations they made in their first test, what challenges it presented if it did not carry a payload to the ceiling, and how they used engineering practices to make modifications to their rocket to address its shortcoming. They should share how each modification they made improved their rocket's performance.*

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