**Details-Design Process**

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| **Duration** | 45 minutes |
| **Group Size** | 1 |
| **Primary Concepts or Objectives** | * Discuss what affects the weight of a rocket.
* Explain why the weight distribution of a rocket is important.
* Identify some factors that engineers must consider when designing rockets.
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**Materials List**

Each student needs:

* 1 facial tissue
* 1 cup; narrow cups work better but are not required
* 4-inch length of cotton string
* 1 half-sized piece of letter-sized paper, measuring 8.5 × 5.5 inches
* 1 quarter-sized piece of letter-sized paper, measuring 4.25 × 5.5 inches
* 1 pencil
* 1 drinking straw
* 2 cotton balls
* 1 pair of scissors
* [Weight Analysis Worksheet 1](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_weight_worksheet1.pdf)
* [Weight Analysis Worksheet 2](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_weight_worksheet2.pdf)
* [Weight Quiz](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_weight_quiz.pdf)

For the entire class to share:

* target pictures of each of the nine planets: [Inner Planets Target](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_targetinner.pdf) and [Outer Planets Target](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_targetouter.pdf)
* cellophane tape provided in several dispensers
* 1 box of paperclips

**Introduction:**

The weight of a rocket is incredibly important to engineers who design them, and especially to you as Tess' engineering team. More weight means more energy is required to get the rocket off the ground. Engineers strive to make rockets as light as possible while still making them strong, and all as inexpensively as possible. Engineers cannot simply just remove all the weight from a rocket because it needs to be able to carry fuel, electronics, cargo and a structure to hold it all together. And, in Tess' case, she needs to transport satellites up to space to communicate with Maya. If the rocket structure is too light, it will not be strong enough to withstand the stresses of the launch. Engineers could use super strong and light materials, such as titanium, but titanium is very expensive. This means engineers must consider the tradeoffs between weight and cost and come to some affordable yet safe compromise between the weight of the rocket and the cost of the rocket.

Engineers also must be careful about which part of the rocket is heavier. They consider the weight distribution. Should they make the rocket heavier in the front, the back or equally heavy all around? Where does the cargo go? What might happen if the front of the rocket is much heavier than the back? Well, we will find out. Today we will attempt to answer these questions by making small paper rockets, called strawkets, and experimenting to see how weight affects their flight.

**Vocabulary/Definitions**
[center of gravity:](https://en.wikipedia.org/wiki/Special%3ASearch?search=center+of+gravity) The point at which the entire weight of a body may be thought of as centered so that if supported at this point, the body would balance perfectly.

**Procedure**

Before the Activity

1. Gather materials and make copies of the [Weight Analysis Worksheet 1](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_weight_worksheet1.pdf), [Weight Analysis Worksheet 2](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_weight_worksheet2.pdf) and [Weight Quiz](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_weight_quiz.pdf).
2. Print out the planet targets, [Inner](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_targetinner.pdf) and [Outer](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_targetouter.pdf). If possible, do so in color and laminate for reuse.
3. Cut enough pieces of letter-sized paper into halves so that each student receives one half, measuring 8.5 × 5.5 inches.
4. Remove the straws from their paper packaging, if necessary.
5. Use tape or string to mark a starting line on the floor.
6. Lay out the planet targets on the floor beyond the starting line. For a somewhat realistic layout, use one of the attached patterns: [Launch from the Earth](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_launchearth_handout.pdf) or [Launch from the Sun](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_launchsun_handout.pdf). Note: Refer to the [Planet Comparison Datasheet](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_datasheet.xls) for actual planet diameters and distances.

With the Students

1. Have students make predictions, as described in the Assessment section.
2. Present to the class the Introduction/Motivation content.
3. Hand out materials.
4. Have students wrap one half-sheet of paper around a pencil, starting from the eraser end and working up to the graphite tip. When wrapping, spiral the paper to make a cone shape (see Figure 2); it helps to hold it tighter at the eraser end and wrap upward.



 Figure 2. A cone-shaped paper tube.

1. Have students tape the paper tube near each end so it keeps its shape. Then remove the pencil. Check the final length of paper tubing to make sure it is at least a few centimeters shorter than the straws; otherwise, students will have nothing to hold onto for the launch. If necessary, use scissors to cut the paper tube shorter.
2. Have students pinch and fold the smaller end of the tube over and tape it so it is airtight. This end is the "nose" of the strawket. See Figure 1.
3. Because engineers always consider safety measures in their designs, direct students to tape a cotton ball to the nose of each strawket. To prevent the cotton from falling off the strawket, place the tape over the top of the cotton ball (that is, not wrapped inside/out and placed underneath the cotton ball as it sits on the nose of the paper tubing). Note: Some cotton balls are big enough to pull apart; only use as much cotton as necessary to provide some protective padding.
4. Have students personalize their strawkets. Suggest they write their names or draw designs on them so they know which one is theirs.
5. Have students find the center of gravity (CG) of their strawkets by balancing them on the side of a finger. While they may not be able to balance it perfectly, they will be able to get an idea of where it is close to balancing. The spot touching the finger is the CG. Alternatively, students can fold a piece of paper in half to make a fulcrum on which to balance their strawkets. For strawkets with no fins or paper clips, expect the CG to be near the middle of the strawket (depending on how much cotton is used).
6. Have students sketch their strawkets on the worksheet 1, noting the location of the center of gravity on their sketches.
7. Have students measure the lengths of their strawkets and mark the exact middle.
8. Give each student a cup and a 4-inch piece of string.
9. Have students tie the piece of string onto the strawket at the middle mark.

Start Landing Sequence!

1. Have students place the cup on the floor, open side up. Then, stand above the cup and hold the string attached to the strawket, centering their hand above the cup. Wait until the strawket stops swinging. Then drop the strawket toward the cup.
2. If the strawket did not land in the cup, have them add a paperclip to the tail end and try again. Once a paperclip end landing is achieved, have the students write on the worksheet the number of paperclips they used.
3. Have students mark the new center of gravity on the sketch and label it (using the method described earlier).
4. **Blast Off:** Have students launch their strawkets with the paperclips attached. Have each student launch from the Earth or Sun (depending on the pattern you selected before the activity). Direct students to insert their straws into their strawkets—holding onto the straw, not the paper part of their strawket—aim at a planet, and blow. Expect the straket to flip and land tail first.
5. Repeat steps 9-17, but place the paperclips on the nose this time, instead of the tail. Then, have them answer the worksheet questions.
6. On worksheet 2, have students write down whether they think a strawket made out of a tissue will work. (In general, tissue strawkets are too light! Not only does air resistance slow them down quickly, often after one or two launches, the tissue bunches up inside and the straw cannot be reinserted.)
7. Have students repeat steps 4-7 with a tissue this time.
8. Have students find the center of gravity of their strawkets, as before in step 9.
9. Have students sketch their strawkets on worksheet 2, and mark the center of gravity on their sketches.
10. **Blast Off:** Have each student launch from the Earth or Sun (depending on the pattern you selected before the activity). To do this, students insert their straws into their strawkets—holding onto the straw, not the tissue part of the strawket—aim at a planet, and blow.
11. After retrieving their strawkets, direct students to complete the worksheet 2 questions before launching a second time. Have them write down the factors that they think helped or hurt them.
12. Now, have students make mini-strawkets . Using a quarter-sized piece of paper that is 4.25 × 5.5 inches in sizse, have them cut it as small as they like while warning them that making it too small will prevent them from being able to spiral it into a cone.
13. Have students repeat steps 1-9 with the mini piece of paper this time.
14. Have students sketch their rockets on worksheet 2 and mark the center of gravity on their sketches.
15. **Blast Off:** Have each student launch from the Earth or Sun (depending on the pattern you selected before the activity). To do this, students insert their straws into their strawkets—*holding onto the straw, not the paper part of their strawket*—aim at a planet, and blow.
16. Direct students to complete the worksheet 2 questions before launching a second time. Have them write down the factors they think helped or hurt them.
17. Conclude by administering a post-activity quiz, leading a class discussion and assigning some graphing practice using class data, as described in the Assessment section.

**Assessment or Summation**

*Quiz:* Administer the [Weight Quiz](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_weight_quiz.pdf), which covers simple division as well as how thrust is affected by weight. Review the answers as a class.

*Discussion Questions:* Solicit, integrate and summarize student responses. Ask the students the following questions:

* With no paperclips on it, why is the center of gravity slightly toward the nose of a strawket? (Answer: Because the nose is made by folding the paper over and adding tape and a cotton ball, which adds weight to the nose.)
* Is tissue a good material to use to build strawkets? (Answer: No, it is too light; it does not hold the cone shape and becomes unusable after several launches.)
* Would a strawket made of lead would work very well? Could you blow hard enough to launch a lead strawket? (Answer: No and no.)

*Graphing Practice:* Have students create bar graphs of the class results using the [Results from Earth Math Sheet](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_resultsearth.pdf) or the [Results from Sun Math Sheet](https://www.teachengineering.org/content/cub_/activities/cub_rockets/cub_rockets_lesson03_activity2_resultssun.pdf) (depending on where the students started their rocket from in step 17). You can also have students make comparison bar graphs of the distances achieved for tissue strawkets and mini-strawkets using the same results sheets.

**Troubleshooting Tips**

* Make a strawket or two in advance to confirm that your materials are suitable.
* Also, it is a good idea to have some extra strawkets in case someone's gets lost or crushed during the activity.
* If you do not have access to enough pencils, use extra drinking straws instead to help wrap the paper cone.
* Distributing tape to each student can be difficult while demonstrating how to build. If possible, have have several helpers pass out the tape or have pieces stuck on the table edges in advance.
* The tape used to secure the cotton balls should be fairly long so they are adhered properly.
* Make sure kids are not holding onto the bottom of the rocket when they blow through the straw!