

How to Balance Anything

Thank you for downloading the science and mathematics activity packet! Below you will find a list of contents with a brief description of each of the items. This activity packet contains all the information (including any handouts) you will need to run this activity in your own classroom or at a science festival.

Please note: some activities might require the need for a facilitator to be present to oversee the activity. Activities that require a facilitator will be clearly noted.

-Community Resources for Science



How to Balance Anything

ACTIVITY PACKET CONTENTS

1. Organizer instructions
 - Print suggestion: 1 for the facilitator
 - Includes information for setup prior to the event (e.g., materials prep)
 - Estimated cost for one set of supplies, excluding common household items
 - Estimated number of participants per one set of supplies
2. Background information
 - Extra information for the organizer/facilitator to better understand and explain the science behind the activity
3. What's Going On? (tabletop sign/printout)
 - Print suggestion: 1 to put in a plastic sign holder
 - Explains the science and background information behind the activity
4. Participant instructions (tabletop)
 - Print suggestion: 1 to put in a plastic sign holder (will need 3 sign holders, if using); plus any extras for the table (recommended for this activity)



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ORGANIZER INSTRUCTIONS

Grade(s): 3-6

Next Generation Science Standards: Science and Engineering Practices

- **Developing and Using Models:** Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system
- **Planning and Carrying Out Investigations:** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered

Objective: Determine the balance point of an object and how it changes when you change the structure of the object

Activity overview and background: Students will build structures using marshmallows, skewers, and toothpicks and find the center of mass of the structure. As students add to the structure, they will determine the new center of mass.

A facilitator is recommended to explain and demonstrate activity step-by-step

Estimated cost for activity supplies: \$6

Estimated number of participants per set of supplies: 12

Materials:

- Toothpicks (2/participant); \$2 for 500 ct box
- Large marshmallows (5/participant); \$2.50/16 oz bag (approx. 64 pieces/bag)
- Wood or bamboo skewers (use caution with sharp skewer ends; 2/participant); \$1.50/approx. 100 skewers
- Paper
- Pens or pencils

Set Up:

- Set out all materials on a table, including What's Going On sign and Instructions
- If you have time, go through the activity and keep it out as an example

Note: participants can re-use others' marshmallows to reduce cost of activity, but it's more fun to eat the marshmallows at the end of the activity!

<http://www.scientificamerican.com/article/bring-science-home-circus-balance/>



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BACKGROUND INFORMATION

Observations and Results

Did you find that the center of mass of the original rectangular structure was just below the middle marshmallow? When you added two more marshmallows to the middle one, did you find that the center of mass shifted up?

An object will more stably balance if a vertical line from its center of mass passes through the balance point. In this activity, the balance point was the spot you marked with an X, where your finger was, and the vertical line is the same as the one you drew. (This vertical line is also known as the plumb line.)

By finding where the vertical lines intersected, you could figure out where the structure's center of mass was. You should have found that the first rectangular structure had a center of mass below the middle marshmallow, whereas the second rectangular structure's center of mass was higher up, within the middle marshmallow. Adding two more marshmallows on top of the middle marshmallow should have shifted the center of mass even higher up.

Additionally, an object should be more stably balanced if its center of mass is under the balance point, but unstable if the center of mass is above the balance point.

Consequently, the first structure you made (with just three marshmallows) should have been less stable than the rectangular structures and, likewise, the original rectangular structure should have been more stable than the one with two marshmallows added.



What's Going On?

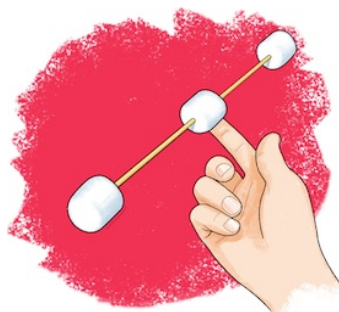
Have you ever wondered why it is harder to keep your balance with a heavy backpack on? Or how tightrope walkers manage their impressive circus acts? Or perhaps you want to know how to make your toy car less prone to toppling over when racing through a sharp curve. The balance of an object has everything to do with the distribution of its mass.

Center of mass of an object: a point where the entire mass of the object may be represented as being concentrated—it's the weighted average of the mass particles of the object

- For example, it is easier to stand upright on the edge of a curb when you're holding a heavy backpack lower down in front of you, but it gets quite a bit more challenging when that backpack is higher up on you
- This has to do with how your combined center of mass with the backpack changes in these scenarios

If the mass is uniformly distributed, the center of mass will be in the center of the object (such as with a hula hoop)

- If the mass is not uniformly distributed (such as with a car), the center of mass is shifted to the heavier side of the object
- In some cases the center of mass is a point in space outside the actual object (e.g., the center of mass for a hula hoop is in its empty middle)



Instructions

1. On a **skewer**, place one marshmallow in the middle and one on each end. Place the tip of your finger under the middle marshmallow and try to balance the structure on your finger
 - *Can you balance it?* Move the middle marshmallow a bit to one side or the other until you find just the right spot that enables you to balance the structure with your finger
 - We will call this spot the original balance point
2. Poke a **toothpick** into each end marshmallow. Add one marshmallow to the end of each toothpick and connect the two new marshmallows with **another skewer** so you get a rectangular shape (with a marshmallow on each corner and one marshmallow at the center of one skewer)
 - Place your finger under the original balance point on your new rectangular structure (with most of the structure hanging below this point) and try to balance it on your finger. *Is it easier or more difficult than balancing the simpler structure?* Move the middle marshmallow a bit to one side or the other until you can.
3. Draw the structure on a piece of paper and then try to balance the structure by putting your finger under the original balance point again
 - *Is the structure completely horizontal, or is it tilted to one side?*
 - Rotate the paper your drawing is on so that it has the same angle as your actual structure. On your drawing, mark where your finger is with an "X" and draw a vertical line down from the X
4. Now balance the structure by putting your finger under one of the toothpicks
 - *Is the structure hanging down completely vertically or is it tilted?*

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- Rotate the paper your drawing is on so that it has the same angle as your actual structure. Make an X where your finger is and draw a vertical line down from the X
5. Now balance the structure by putting your finger under one of the two corner marshmallows that are farthest away from the middle marshmallow
- *Is the structure hanging down completely vertically, or is it tilted?*
 - Rotate the paper your drawing is on so that it has the same angle as your actual structure. Make an X where your finger is and draw a vertical line down from the X.
6. On your drawing, the area where the three lines intersect is the center of mass of your structure
- *Where is the center of mass of your structure? Where is it in relationship to the middle marshmallow?*
7. Reorient your structure so that the middle marshmallow is on top. On the middle marshmallow, use toothpicks to attach two more marshmallows, clustered near the middle one. Place your finger under the original balance point and try to balance it
- *Can you balance it? Is it easier or more difficult than balancing the previous structure?*
8. Repeat the drawing steps you did before to determine where the three lines intersect and figure out where the center of the mass is now
- *Based on your new drawing, where is the center of mass of your new structure? Where is it in relationship to the middle marshmallow? If it has changed, how has it changed? Why do you think this is?*

Extra Structures to Balance

Extra 1: Try building some other structures using marshmallows, toothpicks and skewers

- *Where is the center of mass for your other structures?*
- *Can you alter it by adding marshmallows to specific places?*

Extra 2: Find some non-symmetrical objects, such as a toy truck, and see how their distribution of mass affects how stable they are

- *If you park the toy truck on a hill, how will its distribution of mass influence its balance?*

Extra 3: As you did at the beginning of this activity, take a skewer and place one marshmallow in the middle and one on each end. Use toothpicks to stack marshmallows on top of the middle marshmallow and try to balance the structure on your finger each time you add another marshmallow.

- *How many marshmallows can you add until you can no longer balance the structure?*

Extra 4: Make other structures and similarly try stacking marshmallows until they are no longer stable

- *Can the other structures hold more stacked marshmallows, indicating that their basic structures may be more stable?*