



Math and Science with a Model Hot Air Balloon II

Students will practice math and physical science skills while building and launching a model hot air balloon.

LESSON PLAN

Learning Objectives

The students will:

- Build and launch a hot air balloon
- Identify the physical science principles involved
- Identify the math principles involved
- Apply knowledge to formulate and test a hypothesis
- Time the rate of balloon ascent, calculate volume, and determine the relationship of volume to ascent/altitude

Purpose

Students will practice math and physical science skills while building, launching and analyzing a model hot air balloon. Students will hypothesize on the rate of ascent and then proceed to launch the balloon. During this lesson they may learn the history of balloons, properties of gases used to launch the balloons, and the relationship between air temperature, air pressure, and volume.

Background

The teacher may choose to cover the history of balloons to show the evolution and uses of balloons from past to present, based on the grade level of students. Suggested readings are included in the resources section below.

Grade Levels: 6 – 8

[Ohio Learning Standards/Science \(2018\)](#)

Ohio's Cognitive Demand for Science

[Demonstration Science Knowledge](#)

Nature of Science

[Scientific Inquiry, Practice and Applications](#)

[Science is a Way of Knowing](#)

Physical Science

[6.PS.3](#): Kinetic and potential energy

[6.PS.4](#): Object's motion described by speed and direction

[8.PS.1](#): Objects experience a force due to outside field

[8.PS.2](#): Forces can act to change the motion of objects

[Ohio Learning Standards/Math \(2017\)](#)

Ratios and Proportional Relationships

[6.RP.3](#): Ratio language to describe relationship between two quantities.

Statistics and Probability

[7.SP.2](#): Summarize and describe distributions

Geometry

[7.G.4](#): Know and use formulas for the area of a circle

[8.G.9](#): Solve problems involving cylinders and spheres

Materials Required:

- Heavy paper or cardboard, scissors, sharp utility knife, pencil, ruler or yard stick, glue sticks, string, aluminum wire and sheets of paper, spring scale, stop watch and fire extinguisher
- Fishing Rod and reel (optional for outdoor launch)
- Tissue paper-10 panels (each panel is 20" x 108") for each balloon
- Fan or heavy duty hand-held hair dryer to inflate balloon
- A camp stove with a section of duct pipe as the heat source

Procedure

A. Warm-up

- Review concepts of volume.
- Review with students how to use a stopwatch.
- Have students write a hypothesis on the balloon's rate of ascent relative to its size/volume.

B. Activity

- Before construction of the balloon, explain that the tissue paper is very delicate and can be easily punctured or torn. The glue must be applied heavily but carefully. It should be applied in the same direction along the edges of the paper.
- Students will work in teams of four to six to construct each balloon. Each group will build a slightly different sized balloon. Kits are available on line or students may choose to build their own. Model hot air balloon launch equipment is also available online.
- Build a hot air balloon.
(Instructions are at the end of the lesson plan)
- Give each group of students a ruler, yard stick, ball of string, pencil and worksheet. Students can determine the radius, diameter and circumference of the opening at its widest point. Students will also determine the radius, diameter and circumference of the widest part of the balloon. Record the data and share with the class.
- Instruct students to estimate the volume of each balloon using the volume of a sphere ($V = \frac{4}{3}\pi r^3$) or volume of a cylinder ($V = \pi r^2 h$). Have students round their answer to the nearest hundredth. Record the data.
- Before the launch, students will compare the balloons and make inferences as to which balloon might perform better by going higher and/or faster. *(For an inside launch, average speed can be calculated by knowing the height of the ceiling. For an outside launch, average speed can be calculated knowing the length of the fishing line.)*
- Launching instructions: A launch in a gymnasium or auditorium is preferred. Also, you are urged to use a fishing rod and reel and attach the line to the metal ring, so the balloon may be retrieved.



- Have a fire extinguisher available. Use a heavy-duty hair dryer as the heat source to inflate the balloon and check the balloon for any tears or gaps in the seams before launching. Use caution not to ignite the balloon or to overload the electrical circuits. Light a camp stove and allow it to burn a few minutes. Place a piece of duct pipe over the heat source. Have an adult hold the top of the balloon, while the instructor holds the bottom of the balloon about 6 to 8 inches over the stovepipe (see diagram to the right). After the air is sufficiently heated, the balloon will stand on its own, and you will feel the lifting ability.
- Timekeepers should check to make sure watches are clear and ready.
- Using a spring scale, have students measure the pull just before the lunch and record their data.
- Each group's balloon should be inflated and released in the same manner. Countdown and release inflated balloons. At the moment of release, the timekeeper should start his/her stopwatch. They should stop their stopwatch when the balloon touches the ceiling or fishing line is fully extended. Record the time of ascent and calculate the rate of speed.
- Compare the actual time of ascent to the hypothesis. A discussion should be held to determine which balloon performed the best. Determine the reasons behind its success (maybe its size or maybe it was built with no leaks, etc.)



Safety

Use caution when operating the hair dryer; it can get very HOT and may ignite the paper balloon. Have a fire extinguisher available. Use caution when operating the camp stove. Make sure students stand away from the stove when the teacher is heating the balloon. When launching the balloon outdoors, use a fishing rod and reel and attach the line to the balloon's metal ring, so the balloon can be easily retrieved. Free flights can carry the balloons for miles and result in safety hazards. You can also tether the balloon by attaching a roll of fishing line to the balloon and allowing it to unroll as the balloon rises (with a pencil through the center of the roll).

C. Wrap-up

Have students take time to compare their results to that of the other groups. Special attention should be given to the results based on the size of the balloons. As a class discuss the results, making sure to relate it to the properties of air including pressure, temperature, and volume

Assessment/Evaluation

Students should be evaluated on their ability to follow directions and work cooperatively with other students. Accuracy of recorded data and ability to formulate and evaluate a hypothesis should be checked.

Resources:

<https://www.space.com/16595-montgolfiers-first-balloon-flight.html>

https://www.nasa.gov/pdf/544372main_PS1_Bag%20Balloon_C1_Final.pdf

<https://www.britannica.com/video/164692/ballooning-brothers-Montgolfier>

https://www.nasa.gov/pdf/205702main_Bag_Ballons.pdf

<https://www.youtube.com/watch?v=ABsVP41-EeY>

<https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196758/lighter-than-air-flight/>

<https://www.nationalballoonmuseum.com/about/history-of-ballooning/>

<https://www.explainthatstuff.com/how-hot-air-balloons-work.html>

<https://www.real-world-physics-problems.com/hot-air-balloon-physics.html>

<https://www.youtube.com/watch?v=cFrm4Fgdxlk>

Buoyancy:

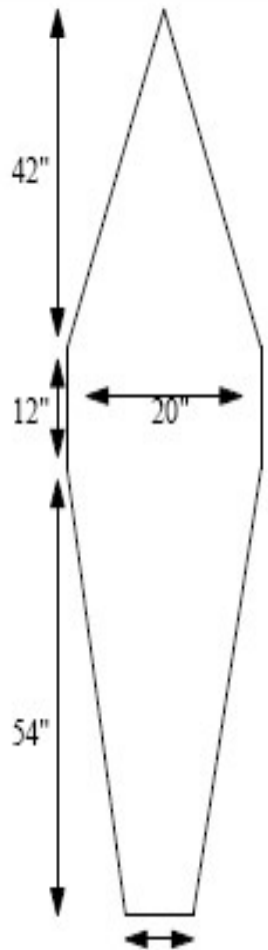
<https://www.real-world-physics-problems.com/hot-air-balloon-physics.html>

<https://www.ck12.org/physics/buoyancy/lesson/Buoyancy-MS-PS>

Instructions to Build a Hot Air Balloon

(Hot air balloon kits made from tissue paper are available at several different vendors searchable on the Internet)

1. Using heavy paper or cardboard, draw and cut a template. (Figure 1)
2. Assemble tissue paper into 9 foot lengths or use a 9 foot length from a roll. (Each balloon requires 10 sheets of tissue paper, each 9 feet in length). This is the most time consuming portion of the activity.
3. Lay out 10 sheets of the 9 foot long tissue paper, placing each sheet exactly on top of the other. These sheets will become the panels of the balloon. Using the template and a sharp utility knife, cut all the panels at once. (A sharp knife is critical as the tissue paper will tear easily.) If possible, pre-cut the balloons for the students.
4. To begin construction, take two of the panels. Lay one panel on top of the other so that the bottom panel has $\frac{1}{2}$ " or $\frac{3}{4}$ " margin sticking out along the farther side of the top panel. (Figure 2)
5. Spread a small amount of glue (glue sticks work the best) on the margin of the bottom panel, folding the margin over the top panel as you go along.
6. Place panel 3 on panel 2, letting the nearer margin of panel 2 stick out about $\frac{1}{2}$ " to $\frac{3}{4}$ " from beneath panel 3. Glue and fold the margin of panel 2 over panel 3. (Figure 3)
7. Using this method, alternate gluing the farther and nearer margins together. (Make a giant accordion)
8. When all 10 panels are glued together, join the unglued edge of panel 1 with panel 10 and glue together in the same manner. (Be careful, as it is easy to glue all the edges together) You now have a tissue-paper balloon with 10 panels.
9. Tie off the tissue paper balloon with a string about 5" from the top to hold the panels together. Tie securely, but avoid "snapping" it tight as it is possible to cut through the paper.
10. Gently open the balloon and make a ring out of lightweight aluminum wire to fit inside the bottom of the balloon. Hold it in place by folding the bottom of the balloon over the ring and gluing the paper in place.
11. Hold the balloon by the top and inflate it with a fan or a hand-held hair dryer so you can check it for any tears or loose seams. Make any necessary repairs with glue and left-over tissue paper. (Hint: Tear a piece of paper for a patch, put glue on the patch, and then attach the patch to the balloon surface). Let the repair dry thoroughly. Now you are ready to launch.



Montgolfier Hot Air Balloon

Figure 1

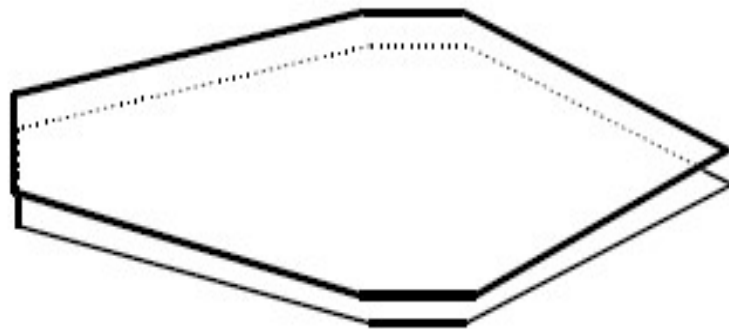


Figure 2

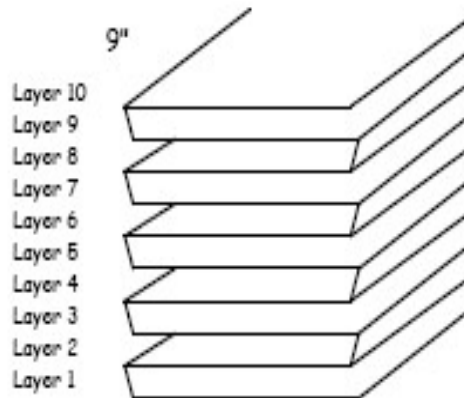


Figure 3