Hot Air Balloon Intro, Design, and Build

Prepared By: Lauren Levites

Overview & Purpose: This lesson follows a unit where Earth's layers, convection, conduction, and radiation, and density has been covered. This design allows students to explore their knowledge of convection and apply it in a direct context.

This incorporates the performance expectation that has students design, build and refine a device. In this lesson students are designing and building a device that illustrates convection, specifically a hot air balloon that operates on convection. To scale down the model they will be using birthday candles as their heat source and thin plastic as their balloon. There are many resources out there with various ideas as to how to build these balloons, so students are encouraged to explore designs and read about different rationales in order to create their own models.

After completing background research, they will outline their own design and build it using available materials.

Objectives: *Students will...*

- Formulate questions on hot air balloons
- Research background information for hot air balloon design
- Create a design
- Explain where convection fits into their design
- Design procedures for their group design
- Build group design using student created procedures

Background Information: Density, Convection Currents, Convection. Background information is covered in previous lessons

NEXT GENERATION SCIENCE STANDARDS

Performance Expectations *Students who demonstrate understanding can:*

MS-PS3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]

Classroom Activities/Procedures & Timeline
(1 block/2 traditional)

1. Introduce lab and have students read design rationale and begin design brief
2. After they discuss problem and goal, have them come up with possible questions on hot air balloon design and function
3. Have students perform background research (can also happen at home as homework assignment) and come up with possible solutions
4. In class, have students design and sketch their hot air balloons
5. Have them outline procedures for building and testing
6. Have students check in with their sketch before they begin building
7. Have students build hot air balloons with available materials
8. During building, question student rationale and knowledge about convection and density

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)

Student Hot Air Balloon Design

- Background Research
- Initial sketch and procedures
- Built model

Extensions/Homework:

Background research, design possible solutions

Equipment/Materials/Technology Needed:

- Plastic bags
- Painter's plastic
- Popsicle sticks
- Pipe cleaners
- Straws
- Birthday candles
- Lighter
- Foil/cardboard
- Hot glue
- Other building materials *(can ask for students to bring in materials as well.)*
- Place to launch balloons *(field, outside, gym)*
- Computers – for student research

Teacher Resources:

(e.g., readings, set-up instructions, lecture files, data files, etc.):

- http://www.nextgenscience.org/next-generation-science-standards
- http://www.sciencetoymaker.org/HotAirBalloon/index.html
- http://serc.carleton.edu/sp/mnstep/activities/27149.html
- http://www.cmu.edu/gipse/materials/pdf-2003/6-7/balloon-J_Delaney.pdf
- http://cases.soe.umich.edu/plans.php?nav=showplan&dqid=100&lpid=51

Student Resources:

(e.g., handouts, worksheets, data, etc.):

- Design rationale – intro project
- Design Portfolio – what they record information in as they go

Accommodations & Safety Concerns:

Students will utilize hot glue guns and lighters to light candles during the testing. If there are students who are not responsible enough to handle this, they should not be allowed to. A station with an adult or specific student could be set up for hot gluing or lighting candles.

Design Brief

Group Members: (groups of 3, preferred)

The Context:

In 1783 the Montgolfier brothers observed a shirt hanging out to dry over a fire. It billowed upward and looked to be inflated. With many questions in mind, they began experimenting with materials building larger and larger balloons. In no time, a sheep, duck, and rooster went on an eight minute tethered balloon flight. Oct. 15, 1783, Francois Pilatre de Rozier flew in the tethered Montgolfier balloon. This event was identified as the first manned lighter-than-air flight.

The Situation:

You are employed by Gore Industries, the leading manufacturer of ballooning supplies. You are a member of a materials engineering team. The company wants a new design to offer customers. This design must be durable yet offer high-flying capabilities.

The Challenge:

You must design, construct, and test a hot air balloon design. It must be durable and stay in the air for at least 10 seconds. You will compete to see whose can stay in the air the longest.

Limitations:

- Materials are supplied by teacher
- Balloon must lift on its own power
- Revision must use original materials
- Lift must meet specified duration
- You have limited time to plan, build and revise

Materials:

- String
- Cardboard
- Plastic sheets
- Plastic grocery bags
- Birthday candles
- Pipe cleaners
- Straws
- Foil
- Any other materials you choose to bring from home (must bring on build day)

The Rules:

- Your team will have 1 day to construct your design and 1 day to test , modify the design, and test again
- Each team member must record entries in their notebook. All design modifications, the test results of these changes, conclusions, and ideas should be included. (This info will end up in your lab report!)
- You may use any materials supplied by teacher to construct the balloon
- All balloons will be launched at the same spot
- Each member of the group must take part in the construction of the hot air balloon
- You must be able to explain the science behind your design – why it lifts

Calendar:

Nov 25/26 – Design and Build	Off
Dec 2/3 – Test Balloons and Refine Design	Dec 5/6 – Test Balloons (if necessary), Discuss lab report

Design Portfolio

1 State the problem

2 What is your Goal?

3 Develop Questions *(come up with 3-5 questions about hot air balloons that you hope to answer from your research)*

4 **Background Research** (At least 3 sources): (homework) – there are LOTS of ways people have built these in the past. Write or Type this on a separate sheet of paper and staple to your packet.

Possible solutions: (Homework - at least 2)

(If there are any materials here that you would like to use that I'm not providing, please bring them M/Tu)

5 Sketch a picture of proposed design: *(after discussing with your group)*

6 List and describe the resources you will use:

7 Briefly explain your procedure:

8 List and describe all procedures (include measurements or calculations)

9 Final Sketch (after it's built)

Testing the Balloon - Data Recording:

The Effect of Balloon Type on Flight Time

Balloon Type	Trial 1	Trial 2 (s)	Trial 3 (s)	Average of Trials (s)
Original				
Revised				
Class Average (original)				
Class Average (revised)				

10 Discuss pros and cons of your design:

11 Changes or modifications you would make:

12 Sketch of Revised Balloon:

Hot Air Balloon Test, Reflection, and Refine

Prepared By: Lauren Levites

Overview & Purpose: This lesson follows a unit where Earth's layers, convection, conduction, and radiation, and density has been covered. This design allows students to explore their knowledge of convection and apply it in a direct context.

This incorporates the performance expectation that has students design, build and refine a device. In this lesson students are designing and building a device that illustrates convection, specifically a hot air balloon that operates on convection. To scale down the model they will be using birthday candles as their heat source and thin plastic as their balloon. There are many resources out there with various ideas as to how to build these balloons, so students are encouraged to explore designs and read about different rationales in order to create their own models.

After completing their initial designs, students will test them using birthday candles and determine ways to redesign.

Objectives: *Students will...*

- Determine successful design components
- Determine detrimental design components
- Engage in research
- Use evidence to redesign hot air balloon

Background Information: Density, Convection Currents, Convection. Background information is covered in previous lessons

NEXT GENERATION SCIENCE STANDARDS

Performance Expectations *Students who demonstrate understanding can:*

MS-PS3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]

Classroom Activities/Procedures & Timeline
(1 block or 2 class periods.)

1. Students will test their hot air balloons outside or in a large ventilated area.
2. Students will write observations or collect data based on their balloon trial
3. Class discussion surrounding successful balloon characteristics and unsuccessful characteristics
4. Re-design balloon based on the characteristics that were mentioned during class discussion
5. Research re-design possibilities, have students incorporate research into re-design rationale (paper, presentation, etc)
6. Students should re-submit a detailed sketch, with rationale for changing certain aspects
7. Have students peer-review re-design sketches
8. Allow students to build re-designed balloons
9. Test redesigned balloons
10. Have students write design report on the process of creating, testing and redesigning hot air balloon.

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)

Balloon Design Report

Extensions/Homework:

Design Report

Personal Comments/Notes:

The peer review of redesigned sketches needs to be built out and created, this is not something I used in my original lesson, but definitely something that could benefit the process.

Equipment/Materials/Technology Needed:

- Plastic bags
- Painter's plastic
- Popsicle sticks
- Pipe cleaners
- Straws
- Birthday candles
- Lighter
- Foil/cardboard
- Hot glue
- Other building materials (can ask for students to bring in materials as well.)
- Place to launch balloons (field, outside, gym)
- Computers – for student research

Teacher Resources:

(e.g., readings, set-up instructions, lecture files, data files, etc.):

- http://http://www.nextgenscience.org/next-generation-science-standards

Student Resources:

(e.g., handouts, worksheets, data, etc.):

Report guidelines

NAME: _____ DATE: _____

Lab Report Guidelines for Hot Air Balloon Project

Follow these guidelines to create a lab report for your science investigation. Your report should thoroughly describe and/or answer each criteria. A lab report is written in COMPLETE SENTENCES with the exception of the 'MATERIALS' section, which is a short, bulleted list.

Before you get started remember these basics:

- Report should be typed in Times New Roman, 12 point font.
- When writing the lab report, use 3rd person. Do not use "I." If you must, you can say "the experimenter."
- **Boldface** each new heading. (you do not need to include the heading, "TITLE.")
- Your name should be in the top right corner of the page
- Report should be single-spaced (This is not an English Paper!).

Heading	Criteria
TITLE	Title must describe investigation and be capitalized. Example: *Hot Air Balloon Design Investigation*
PURPOSE	Answer: **a** Provide background information on Hot Air Balloons (see packet) and summarize the background research you did. **b** What do you plan to accomplish by doing this investigation? What is your goal(s)? **c** Identify the independent and dependent variable in the experiment.
PROCEDURE	**a** Describe the procedure you used to build your balloon using a numbered list. **b** List the steps you used to revise your balloon
MATERIALS	**a** Using bullet points, list the materials that were used.
DATA AND OBSERVATIONS	**a** Include your final sketch in this section and all calculations: • mass of balloon(g), surface area of balloon opening(cm^2), • volume of balloon(cm^3), height of balloon (cm) **b** Write a summary of what you observed in complete sentences. **c** Recreate your data table electronically. Include proper title and row and column headings.
CLAIMS AND EVIDENCE	*You may use I or speak in first person when writing your Claims and Evidence Section.* **a** What inferences can you make based on your results? **b** How did you adjust your design after the first trial? Why did you adjust your design the way you did? **c** Now, explain using data as evidence, which design worked better? **d** How do hot air balloons work? Use the vocabulary words density and convection in your answer.
REFLECTION	*For this section, answer the following questions. You may use I or speak in first person when writing your Reflection section.* **a** Why did you choose to design your original hot air balloon the way you did? **b** After performing this experiment, what new questions do you have? **c** What have you learned? **d** Why do you think a hot air balloon lifts off in the early morning or right before sunset? Give two reasons.

Thermal Transfer Stations

Prepared By: Lauren Levites

Overview & Purpose: This lesson comes after a brief introduction to their Earth's layers, and allows for students to understand the process of convection before studying plate tectonics. This will allow them to observe the process and ask questions that naturally lead into the theory of continental drift and plate tectonics.

Note: This is the first lesson in a sequence that builds up to the performance expectation listed below. This will give students knowledge and practice with the scientific principles, and in accompanying lessons 2-4 design, construct and test devices that maximize thermal transfer due to convection.

Objectives: *Students will...*

- Construct models of convection cells
- Compare and contrast models of convection

Background Information: Students in this course are advanced 7th graders, this lesson is written for middle school, but could easily be used in a high school earth science classroom.

NEXT GENERATION SCIENCE STANDARDS

Performance Expectations *Students who demonstrate understanding can:*

MS-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]

Classroom Activities/Procedures & Timeline

50 minutes

- Bell Ringer – Earth's Layers Review (10 min)
- Model Earth's Layers – "Egg in a basket" (5 min)
- Discuss/Reflect similarities and differences of model (5 min)
- What allows Earth's crust to move? Introduce convection
- Stations of examples of convection (20-25 min)
- Water boiling
- Pie pan convection
- Earth's atmospheric convection (http://www.ucar.edu/learn/images/solcirc.gif)
- Sun diagram (http://spot.pcc.edu/~aodman/GS%20107%20web/sunlecture/suns%20release%20of%20heat.jpg)
- Body of water convection example (http://cleanet.org/images/clean/community/climateworkshop/workspace/thermohaline_circulation.gif)
- http://www.hole-in-the-wall.com/ABeL/ABeL.aspx
  CLICK ON "SWIRL TWIRL" – Simulation for convection
- Wrap Up/Discuss stations – have different groups share their compare/contrast between the model and Earth's layers for each station
- Exit ticket – summary of convection

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)

- Compare/Contrast
- Oral presentation of inferences/conclusions based on models
- Exit ticket – explain convection

Extensions/Homework:

Students will read about radiation and conduction and compare and contrast both to convection. They will use a simulation online - http://www.wisc-online.com/Objects/ViewObject.aspx?ID=SCE304

Equipment/Materials/Technology Needed:

- Hot plate
- Beaker
- Food coloring
- Pie pan
- Candle
- Diagrams

Teacher Resources:

(e.g., readings, set-up instructions, lecture files, data files, etc.):

- http://www.nextgenscience.org/next-generation-science-standards
- http://mail.colonial.net/~hkaiter/Layers_of_the_Earth.html
- http://cleanet.org/images/clean/community/climateworkshop/workspace/thermohaline_circulation.gif
- http://spot.pcc.edu/~aodman/GS%20107%20web/sunlecture/suns%20release%20of%20heat.jpg
- http://www.ucar.edu/learn/images/solcirc.gif
- http://www.exploratorium.edu/snacks/pie_pan_convection/
- http://www.ucar.edu/learn/1_1_2_7t.htm (pie pan convection, a little different)
- http://www.ucmp.berkeley.edu/education/dynamic/session1/sess1_earthcurrents.html

Student Resources:

(e.g., handouts, worksheets, data, etc.):

- Stations worksheet
- Stations info sheets and analyusis questions

Accommodations & Safety Concerns:

Hot plate, lighter, candle – discuss safety with fire, don't allow students to use lighters or leave it laying around.
Remind students not to touch hot glass or hot plates.

STATION 1
Water Boiling

Observe:

Carefully watch as the water boils in the beaker.

Analysis Questions:

1. Where is the heat source?
2. Is the water only hot at the source of heat?
3. How do you think the water is heated?

STATION 2
Pie Pan Convection

Procedure:

Light the candle under the pie pan in front of you, wait 1 minute and carefully observe the surface of the soapy water. With your group, try these things to help you figure out what is happening:

1. Add one drop of food coloring to the center of the liquid, directly above the candle flame.
2. Add one drop of food coloring of a different color to the liquid between the center and the rim of the pan.
3. Add one drop of food coloring of a different color to the edge of the liquid, near the rim of the pan.

Time how long it takes the color to spread through the pan.

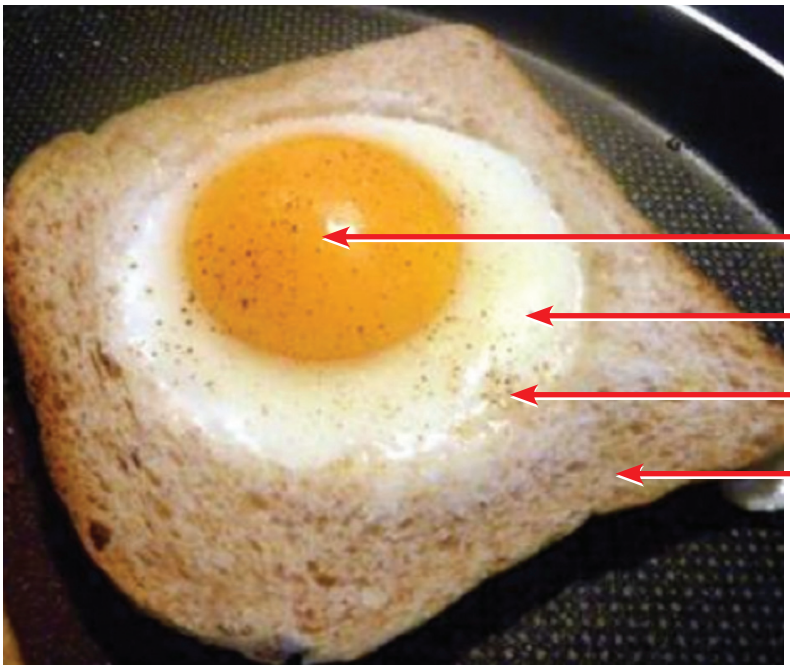
Record your observations for each of the three trials.

Analysis Questions:

1. Compare and contrast what happens during the three trials.
2. Which one spread through the water the quickest? Give evidence.
3. Which one spread through the water the slowest? Give evidence.

NAME: _____ DATE: _____

Model of Earth's Layers



_____

_____

_____

_____

We know Earth's crust moves over time, will this egg make the bread crust move?

Something makes the crust move in the Earth's layers, that "something" is called CONVECTION. Use the following stations to investigate convection and determine **WHAT IS CONVECTION**.

Station Observations	Analysis Questions	Compare to Earth's layers	Contrast with Earth's layers

Energy Transfer

Name: _____

Go to http://www.wisc-online.com/Objects/ViewObject.aspx?ID=SCE304

1 Use the simulation to discover conduction, convection and radiation.

Conduction:

2 Click on "conduction"

3 In your own words what is a conductor?

4 Click "light burner" explain, using the word conductor or conduction, why you need an oven mitt to pick up the pan.

5 Give examples of good conductors and poor conductors.

Convection:

6 Click on "convection"

7 In your own words, what is convection?

8 Explain how a convection current moves in a fireplace. (use the description and the picture to answer this)

9 What are some other examples of convection?

Radiation:

10 Click on "radiation."

11 In your own words, what is radiation?

12 Explain how the sun heats a house using the term radiation.

13 What are other examples of radiation heat transfer?

Lava Lamps

Prepared By: Lauren Levites

Overview & Purpose: This lesson builds on students previous experience with Earth's layers and convection. Here they will use principles of convection and engineering to analyze how common items utilize convection.

Objectives: *Students will...*

- Use models to explain convection
- Create an explanation as to how lava lamps use convection

Background Information:

This lesson requires a short review of density.

NEXT GENERATION SCIENCE STANDARDS

Performance Expectations *Students who demonstrate understanding can:*

MS-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

[Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]

Classroom Activities/Procedures & Timeline

Do Now: Intro to density - review basic density concepts – have students calculate density http://science.howstuffworks.com/framed.htm?parent=question36.htm&url=http://www.nyu.edu/pages/mathmol/textbook/density.html

Activity 1: Demo – density and review of convection – Steve Spangler *Science Tea Bag Rockets* http://www.stevespanglerscience.com/lab/experiments/tea-bag-rocket

Students discuss in small groups what happen with the "tea bag rockets" and share out with the class

Activity 2: *How does a lava lamp work?*

- Put a lava lamp out for students to examine and observe
- Have students work in small groups to create diagrams and explanations for how lava lamps work using the terms "density" and "convection"
- Have students share ideas with the class as to how the lava lamp work

Activity 3: Have students compare and contrast their model to the model of a typical lava lamp
http://betterlesson.com/document/156228/lava-lamp-picture-worksheet-doc

Activity 4: Have students come up with other devices that utilize convection *(radiators, refrigerators, laptops/computers (forced convection))*

Wrap up/Discussion

Exit Ticket

Assessments: (e.g., lab, quiz, test, oral presentation, survey, rubric, etc.)

Exit ticket

A pasta pot on the stove boils. Using the terms, "convection" "convection current" and "density" explain how the water heats up in the pot. Bonus, explain why a pot with a lid boils quicker than a pot without a lid.

Extensions/Homework:

Students will work to design a way to keep a pop can filled with water as warm as possible and another one as cool as possible. They must use the terms "convection" "conduction" and "radiation."

Equipment/Materials/Technology Needed:

- Tea bags
- Lighter
- Plate
- Lava lamps (2-3)

Teacher Resources:

(e.g., readings, set-up instructions, lecture files, data files, etc.):

- http://www.nextgenscience.org/next-generation-science-standards

Student Resources:

(e.g., handouts, worksheets, data, etc.):

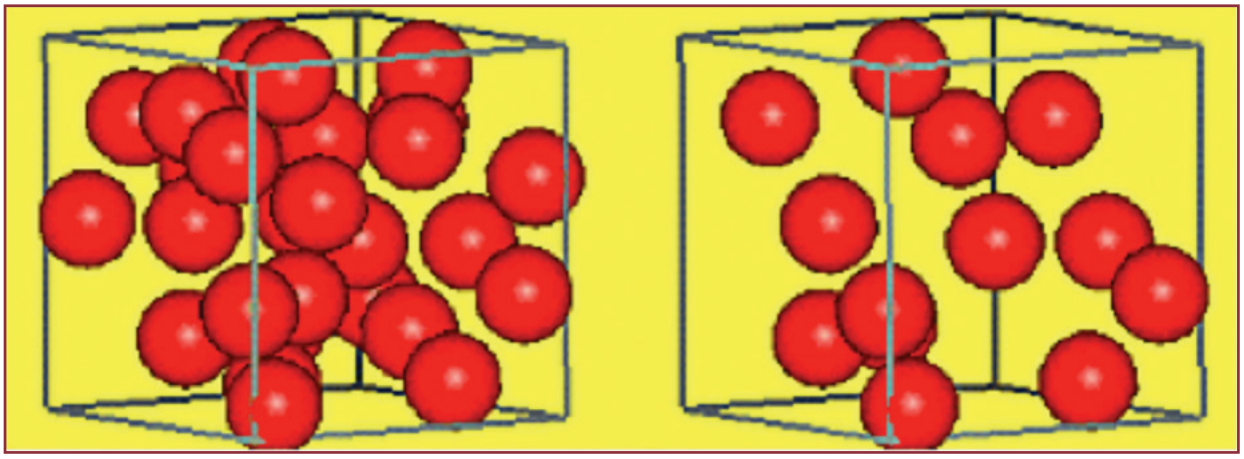
- Lava lamp picture
- Do Now worksheet

Accommodations & Safety Concerns:

Fire concerns – lighter, tea bag rocket
Students who are close to the demo should wear googles

NAME: _____ DATE: _____

Take a look at the two boxes below. Each box has the same volume.



1 If each ball has the same mass, which box would weigh more? Why?

Density is the mass of a substance per unit volume.

In other words, it is the mass of a sample (in grams) divided by its volume (in mL = cm^3).

We calculate density using the formula Density = Mass/Volume. Density is a property of matter that does not depend on the amount of matter present; it is constant under constant temperature and pressure conditions.

As temperature changes, the density of the object can change, as its molecules move closer together as it cools and move further apart as it warms.

2 The image above has layers of different substances, using what you now know about density, explain why.

3 Do you think the bottom layer is the most dense or the least dense? Why?

4 In your own words, how does temperature affect density?