STEM on Site Summer Program

Passive Energy Housing Design

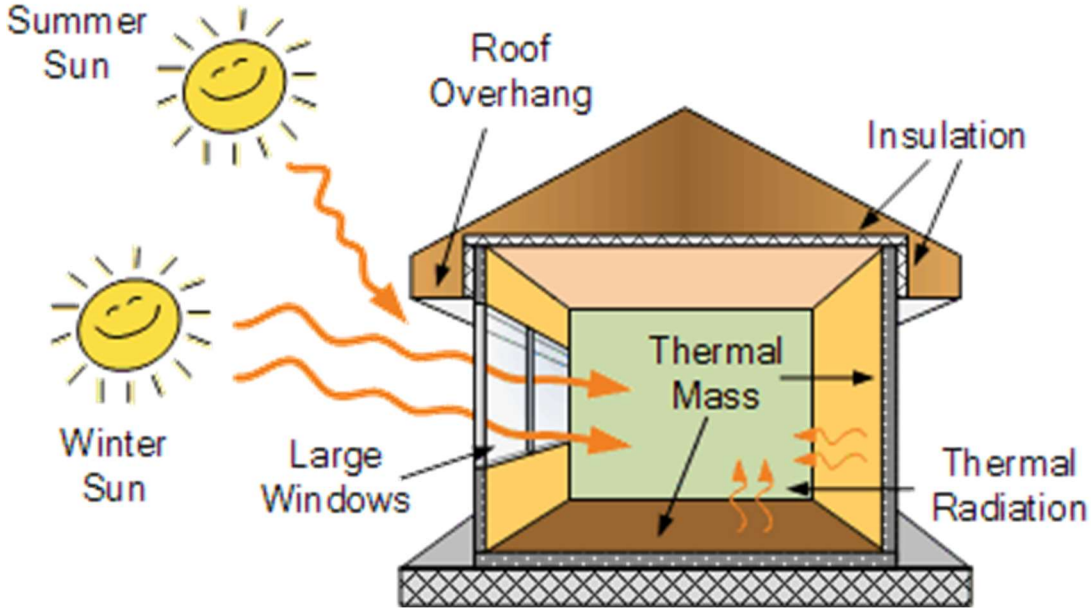

Image Source: Alternative Energy Tutorials

Recommended for Grade Levels: 9 - 12

Content Notice

This activity has been put together as a free, open source resource from the Milwaukee School of Engineering STEM team for self-guided, at home learning. Unless otherwise noted, in person or live instruction is not provided and questions should be directed to stem@msoe.edu.

Curriculum has been adapted from Teach Engineering's Zero Energy Housing curriculum.

Safety Notice

Parents or guardians should review activity materials before students begin the activity. Some activities from MSOE may require cutting, hot gluing, electricity, manipulating sharp objects, and other tasks that may warrant adult supervision. MSOE is not liable or responsible for any injury, property damage, or other incidents that arise from completing these activities at home. If you have questions or concerns about any activities, please contact stem@msoe.edu

Note about this Activity

This activity has been adapted from Teach Engineering's zero-energy housing curriculum. MSOE has added videos and questions to consider along with post activities to adapt this activity to fit the at-home learning models currently being used during the pandemic.

If you enjoy this activity and would like to try other activities in the Teach Engineering's energy-efficient housing unit, you can learn more here.

You can also visit this site to see examples of what other students have done for this project with the University of Colorado Boulder team.

Goals

- Learn what passive solar heating is and how architects and engineers use it in building design
- Learn how different materials and designs influence a building's passive solar heating ability
- Explain why passive solar heating is important
- Create a studio-style home that uses passive solar heating to warm up a house and keep it at that temperature as long as possible

Learning at Home

While we've tried to select activities that utilize materials you might have around your home or able to procure without too much difficulty, we know that may not be the case for everyone.

One of our favorite parts of engineering is the problem solving and critical thinking skills required, and we encourage you to consider the following question when looking at the materials list for this activity:

If I don't have a certain material, what is the material being used for in this activity? Is there something else I could substitute that serves the same or a similar purpose? How can I modify this activity with what I have at home?

Materials List

Note that the goal for this activity to see how different insulating materials impact your house design. If you're gathering materials at home, feel free to try other materials if you don't have something below. Think of the purpose a material might serve and what items you have on hand that may do the same.

If you ordered a kit from MSOE, all materials except those marked with an asterisk (*) are included in your kit.

HOME CONSTRUCTION MATERIALS

	QTY	NAME
	1	32 x 20 inch sheet of 1/8" foam core board (sometimes sold in smaller or larger sheets - that's ok)
	1	sq ft. of clear plastic (Saran Wrap or kitchen plastic wrap works great) (*)
	1	sq ft. of aluminum foil
	2	sq ft. thin rubber sheet
	2	sq ft. black fabric (any kind)

REQUIRED TOOLS (*)

	Writing tool for designing and graphing
	Hot glue guns or tacky glue
	Scissors
	Utility knife - not required, but helpful
	Thumbtacks
	Scotch tape
	Masking tape
	Protractor
	Ruler

TESTING STATION (*)

See notes in the testing instructions for possible modifications if you cannot access these materials

	QTY	NAME
	1	300-watt light bulb
	1	Desk or clamp lamp that can safely accommodate a 300 watt light bulb
	1	Floor or box fan
	1	Ice
	1	Bucket or plastic container for the ice
	1	Thermometer
	1	Timer or watch to determine 30 second intervals

Background Knowledge

Recommended Resources

Before starting the activity, we recommend checking out some of the following videos to provide useful background knowledge.

- How does heat transfer work?
- Passive solar home design overview
- Which materials make good insulators? – this video provides ideas for what insulation materials you may want to consider outside of those we listed along with an optional testing activity.
- Design guide from the US Department of Energy – this guide gives a lot of extra detail if you want to explore beyond the guidance given for this activity

Knowing how to graph data and find the slope of a line from a graph is helpful for this activity.

Key Points

Check out the following guide from the U.S. Department of Energy, to help you as you think about designing your home in this activity.

Questions to Consider

After watching the videos, take a moment to reflect on the following questions.

1. Would your home be a good candidate for passive solar heating? Why or why not?

2. What benefits would there be to using passive heating – either completely or combined with an existing HVAC system – in a home?

3. How big do you want your model home to be – will it be easier or more difficult to achieve the goal of this activity with a larger home?

4. Would your design work in both winter and summer? What did the videos discuss about keeping homes cooler in the summer and warmer in the winter?

Designing & Building Your Home

Before building your home, use the graph paper in this packet to sketch out your design. Use the following design constraints to guide your design:

- Your home is a studio style home – one bathroom with an open layout for remaining spaces. You can make your home more complex if you'd like.
- Your floor size should be at least 70 square inches
- Your roof height (as measured from the top of your wall) should be at least 4 inches
- Your door should be able to accommodate a thermometer of your choosing. Ideal testing conditions are having the thermometer sit in the middle of your house with the door closed and the ability to read the thermometer through a window
- 4 walls is not a requirement, but your structure should be enclosed with no open sides

Review the materials sheet included in this packet to see what materials we recommend using while thinking about your design. TeachEngineering has the following guidelines for how materials might be used:

- Foam core board: for walls and roofing, to mimic insulation and thermal mass
- Thin clear plastic: to let light in as windows, to heat up the homes
- Aluminum foil: to imitate metal surfaces; while not a thermal mass, it does reflect heat and light
- Thin rubber: to imitate a thermal mass
- Black fabric: while not a thermal mass, it absorbs a lot of heat from light
- Glue: besides holding the house together, it serves as a final insulator to seal up any cracks and small air leaks in the model homes

Testing Your Design

In the materials sheet, you're provided an ideal materials lists for a testing set-up to mimic day time conditions and night time conditions. If you don't have all of the materials recommended, think about what the materials purpose is in the testing and how you might be able to use what you have access to at home as a substitute.

Teach Engineering has a full testing instructions here.

Daytime Conditions Note

If you don't have access to a high wattage bulb, see if there is an especially hot and sunny day coming up. You can try setting your house outside in a sunny, hot location. It may take longer to heat up than a testing set-up with a lightbulb directly on top of your unit, so we recommend taking temperature measurements in longer increments like 5-10 minutes instead of 30 seconds.

Data Collection Table

If you want to take more data points, feel free! You can also use a computer program like Google Sheets or Excel to track your data instead of on paper.

Daytime Conditions	
Time (Minutes)	Temperature (Degrees)
Night-time Conditions	
Time (Minutes)	Temperature (Degrees)

After you've collected your data, graph it on the included graph paper on using data entry software like Excel or Google Sheets. After graphing, consider the following:

1. What was your slope during the day? How about during the evening?

2. Did your slope during the day indicate that your house captured a lot of heat quickly, or was it a slow process? Do you think your house did a good job collecting passive solar energy during the day?

3. What was your slope during the evening? Did your home do a good job retaining heat?

4. Is there anything you would change in your design based on the data you received?

If you have the ability to, we recommend using your data to inform changes to your design and trying them out! How did the changes you made impact your home's performance?

Optional Post-activity

Do a Home Energy Audit

Use the U.S Department of Energy's DIY Home Energy Audit guide to see how energy efficient your home is. Be sure to check in with the owner of the home before exploring the attic, roof, and any other difficult to access or potentially dangerous locations. Do not tamper, adjust, or play with electrical outlets, panels or equipment (including HVAC equipment) without professional guidance.