# SOLAR HOUSE

## TEACHER LAB TEMPLATE

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## Permission to Reprint Statement

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# Objectives

- Students will research passive and active solar house designs.
- Students will design a house that may incorporate any of the following:
  - Roof overhangs that shade the house during the summer but allow light to enter during the winter
  - A solar mass that absorbs heat during the day and releases it at night
  - Fans and louvers that direct air flow
  - Insulation innovations such as double-pane windows
  - Water-heating devices that use the heated water to regulate temperature
  - Shades, shutters, and curtains to block sunlight
  - Photovoltaic cells positioned to collect sunlight at an efficient angle
  - Swamp coolers
  - Any number of other innovations, limited only by the students' creativity
- Students will build the model house from materials provided and scrounged.
- Students will test the ability of their model house to remain cool in the summer and retain heat during the winter.

# Why Use This Lab in the APES Course?

This exercise is inquiry based and encourages creativity and innovation. It is an opportunity for students to put theory into practice. Well-designed house models really do a better job of utilizing solar energy than do poorly designed and built models. Students enjoy using their hands to build something. They respond well to the challenge of building the house that produces the best temperature data. This exercise is fun and generates a lot of interest. It makes an ideal after-AP Exam project.

# Correlation to the Topic Outline in the Course Description

III. Renewable and Nonrenewable Resources: Distribution, Ownership, Use, Degradation (15 percent)

E. Energy

1. conventional sources
2. alternative sources

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# Correlation to National Standards

Content Standard A: As a result of activities in grades 9-12, all students should develop, design, and conduct scientific investigations and use technology and mathematics to improve investigations and communication.

Content Standard E: As a result of activities in grades 9-12, all students should develop:

- Abilities of technological design
- Understandings about science and technology

Identify a Problem or Design an Opportunity. Students should be able to identify new problems or needs and to change and improve current technological designs.

Propose Designs and Choose Between Alternative Solutions. Students should demonstrate thoughtful planning for a piece of technology or technique. Students should be introduced to the roles of models and simulations in these processes.

Implement a Proposed Solution. A variety of skills can be needed in proposing a solution depending on the type of technology that is involved. The construction of artifacts can require the skills of cutting, shaping, treating, and joining common materials -- such as wood, metal, plastics, and textiles. Solutions can also be implemented using computer software.

# Introduction

A solar house takes advantage of solar energy to minimize the use of traditional energy sources. This can include design elements that take advantage of the sun's rays to light and heat the house, to heat water, and to set up a favorable flow of air. Many solar houses contain a solar mass that will absorb the heat during the day and release it slowly at night. A passive solar house also takes into account the angle of the sun's rays to maximize heating during the winter and shade during the summer. Insulation is important to keep the house cool in the summer and warm in the winter. In addition to passive solar elements, solar cells (photovoltaic cells) may be used to actively absorb sunlight and transform it into electricity. The electricity can be used to run a motor, a fan, a heater, or another electrical device.

# Group Size

Four students per group

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# Lab Length

This exercise requires two weeks, depending how much of the work is done at home. Students require at least a day to research and about two days to draw up their plans. Construction can take a week. Testing may take two days or a double lab period.

# Preparation and Prep Time

Teacher prep consists mostly of obtaining materials.

# Materials/Equipment

Most of the building materials can be purchased at a building supply store, such as Home Depot. The 120-watt flood lamps are safer than the 250-watt heat lamps, since they do not become as hot.

Because 1 square foot is standard for a tile, this lab is best done using feet and inches rather than metric units. Linoleum tiles may be used and cut with a linoleum cutter, which allows students to create houses that are not square.

Acetate for the windows and oversized graph paper for the plans can be purchased at an office supply store as overhead projector overlay or at an art supply store. The graph paper should be ruled in some fraction of inches.

Either thermometers or CBL temperature probes can be used to obtain the temperature data.

Box cutters are useful for foamboard and cardboard. Linoleum cutters are needed for linoleum. Both require a discussion of safety procedures.

Solar kits containing a panel, motor, and fan can be purchased at:

http://sundancesolar.com

http://www.theenergyalternative.com/catalog/?category=80

http://www.sciencekit.com/Search/Products.cfm

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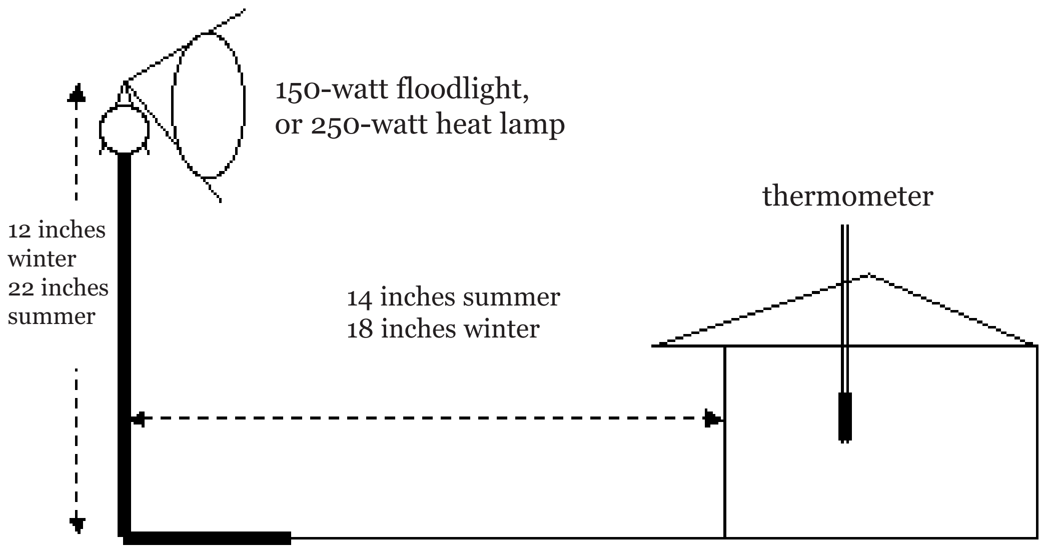
The setup was designed to take advantage of a standard IPS pegboard, with the lamp clamped to the top of the pegboard during the summer trial. A ring stand will work just as well. The pegboard can then be turned on its side, and the light can be clamped to the base for the winter trial. This simply represents a high summer sun angle and a low winter sun angle. If you want to design the equipment to use the exact angle for your area, you can obtain information about the sun's angle in your area at http://www.susdesign.com/sunangle. You might use lamps that hold the lamp at a different height than in the diagram below, so measure your setup.




# Safety and Disposal

Designate a place for cutting and discuss the safety of using box cutters and any other cutting devices.

# Teaching Tips

- Be critical of the designs. Ask students to explain their innovations and send them back to the drawing board rather than let them proceed with a poor or difficult design.
- Set the classroom up so that cleaning is easy. This is a messy lab.
- Solar panels are expensive. The exercise may be done without the solar panels, making it a passive solar house.

- If you have plenty of solar panels, students may attach them to the house with clear tape, so they can be removed and reused. Otherwise, you can set up one set of solar panels at each test area, and have the students provide leads that can be attached to the solar panels. Test the solar panel with the lights to be certain that there will be enough light to run the motor. If there is not enough light, the test area can be set up with a separate light that shines directly on the solar panel whenever the main light is on. Be careful that you don't melt the panels.
- Encourage students to measure the angles of the summer sun and winter sun to the roof of their house, since the best designs include overhangs that block summer sun and take advantage of the winter sun.
- Ask students how air will flow through the house and how the air flow affects the temperature.
- Some of the best results come from simple houses that are carefully insulated.
- Students can design swamp coolers, complicated water-heating devices, etc. There is plenty of opportunity for creativity.
- You may want to provide students with resistors to use as heaters, but check to see whether the resistors will receive enough current and voltage from the solar panels. The size of the solar panels, the wattage of the lamp, and the distance to the lamp will determine the resistance needed for a heating unit, so check your setup ahead of time.

# Assessment

*Write-up*:

Students submit their final design and a typed report explaining the following:

1. Reasons for the design and choice of building materials -- 2 points
2. A plan of the house as seen from above for a small lot (about a half acre), compass directions, and major vegetation -- 2 points
3. The approved initial design -- 1 point
4. An analysis of how well each of the innovations worked -- 1 point
5. Suggestions for improvements -- 1 point

**8 points**: summer performance -- daytime only

Increase in temperature after 15-minute exposure to light, 14 inches from model at a height of 22 inches. A solar house should have a low increase in temperature during the summer.

**8 points**: winter performance -- both day and night

Change in initial temperature after being exposed to 15 minutes of light, 18 inches from model at a height of 12 inches, and then 15 minutes without light. A solar house should have a high heat retention during winter.

**2-3 points for every energy-saving innovation**, up to a maximum of 12 points

**5 points**: aesthetic appeal (judged by suitable panel of instructors)

**7 points**: write-up

Best temperature data: change in winter temperature -- change in summer temperature

No write-up necessary: automatic 40 points.

The following is an example of an Excel chart with student data from the temperature trials. What numbers represent full credit (8 points) for each section is best determined after you obtain the data, since it varies greatly depending upon the wattage of the lamps and the availability and make of solar panels and fans.

| group | winter initial | winter final | winter $\Delta T$ | summer initial | summer final | summer $\Delta T$ | winter $\Delta T$- summer $\Delta T$ |
|---|---|---|---|---|---|---|---|
| | 23.892 | 30.112 | 6.22 | 20.471 | 21.715 | 1.244 | 4.976 |

When judging the aesthetics of the houses, get other teachers to help and score the houses from 1 to 5 points.

If time allows, have the students present their houses to the rest of the class. You may want to display the best houses with the students' descriptions of the projects.