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Home Builders Association of Central Arizona



## Educator Guide

Come explore the science and technology involved in home construction. This guide will help you to ask questions, participate in activities, and make connections to practical applications. Activities in this guide are excellent for educators (or parents) and children ages 8 and up.

Inside you will find directions to the exhibits included in the trail (Where To Go), questions and activities designed to engage students (What to Do), and interesting and practical additional information (Did You Know?).

For further exploration of this topic, try some of the activities we have suggested for "Continuing the Trail" at home.





## Construction Crossword Clues

### ACROSS

- 1 Ground Fault Circuit Interrupter (abbreviation)
- 5 Material used to slow heat transfer through walls
- 7 Pipe that carries wastewater away from a house
- 8 A hammer is an example of this simple tool
- 9 Heating, ventilation, and air conditioning (abbreviation)

### DOWN

- 2 Material used for slab foundation
- 3 “--- cooler” or evaporative cooler (Arizona term)
- 4 Kind of diagram used by plumbers
- 6 Seasonal Energy Efficiency Ratio (abbreviation)

## Making a House a Home

A home of your own... It's what many people dream of. Whether it's a cozy cottage, a sprawling family homestead, an efficiency apartment or a tidy trailer, everyone needs a place to live. People need different things in a home, and our needs change as our families change and as we grow older. The home building industry, and all of the trades and workers it includes, has played an important part in the growth and development of communities in the Valley of the Sun. Take a minute to look at the long list of careers involved in the construction industry (on the column beside the aerial photo). People in many of these jobs have played a role in building **your** house!

Now follow the directions to these activities, and learn some of the science involved in designing and constructing a house. Do you know how your foundation supports your floors, walls, and roof? Do you know how your house is cooled, or how electricity gets to your light switch? Come on, let's find out!

## Tools

Tools can be thought of as machines that make work easier. Simple machines have few or no moving parts, and do work with one movement. You provide the energy to make them work. There are six simple machines: the inclined plane, the wedge, the screw, the lever, the pulley, and the wheel and axle. Complex machines are two or more simple machines working together. A wheelbarrow is an example of a complex machine that uses a lever and a wheel and axle

**Where to Go:** The tool wall and plumber's, electrician's, and carpenter's toolboxes.

**What to Do:** Look through the tool sets for examples of simple machines. Look at the shape of the working edge, and imagine how it is used to get a job done.

Find the claw hammer and the pry bar. These are both good examples of the same simple machine. Can you figure out which one?

Today, there are many power tools for large jobs that repeat the same motion. These include tools like strip nailers, power saws and hammer drills. Most of these are examples of complex machines. They combine gears, pulleys and levers inside a case, and are powered by a motor.

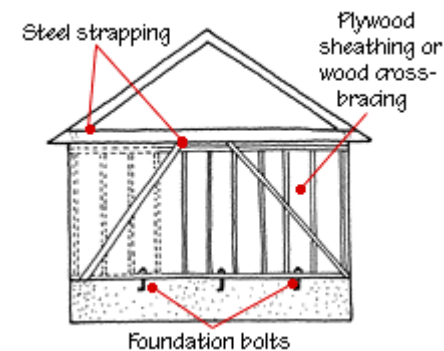
Now look carefully as you explore the rest of the Science Center. There are lots of examples of simple machines in other galleries!



### Did You Know?

All of the materials used in the construction of your home absorb and transfer heat. " R values " measure a material's ability to resist the conduction of heat through a solid. The higher the R-value, the greater the resistance to heat flow: it's more difficult for heat to pass through R-19 insulation than it is to pass through R-11. Heat always moves from the warmer side to the cooler side of a wall. This is why summer heat increases interior temperatures in your home and winter heat loss results in higher heating bills.

Many insulation products work by trapping the heat in air pockets contained between the fibers in the product. Air is a good insulator against conduction, but once the insulation becomes saturated with all the heat it can absorb, remaining heat is readily transferred through the wall.



## Where Do You Live?

Lots of people work together to decide where houses can be built. Geologists and hydrologists decide what soils can support houses, and how water from rivers and rain will affect them. Environmental scientists and archaeologists map the natural and cultural resources at a building site to be sure that rare plants and animals and traces of our past are preserved. Surveyors and planners lay out streets and neighborhoods so that they are easy to get around and have access to community centers and businesses.

**Where to Go:** The aerial photo and Keyhole terminal in the center of the Many Hands Make a Home (MHMH) Gallery.

**What to Do:** Find your home from the sky, on the aerial photo or using the Keyhole viewer.

Does it look different than you thought?  
Are houses in your neighborhood close together or far apart?

Now take a step back and look at the whole aerial photo. Look at the green squares and rectangles on the east (right) and west (left) sides of the map.

Do you think these crop fields might one day hold houses? Can you find areas of new house construction?

## My Bedroom (plan view)

## Plumbing

Most urban and suburban houses are connected to the city water main (supply) by a single water pipe. All appliances or fixtures draw water from this single water source. A water heater diverts some of the incoming water, which is heated and piped through the house. All drains return waste or gray water to a single sewer pipe that leads to a city water treatment center.

**Where to Go:** Foundation wall, then **Water in the House**

**What to Do:** Find where water enters the house from the street connection. Can you also locate the sewer pipe that removes wastewater? Where is there a meter for this system?

**Water in the House:** Push the red button that shows the hot water system. Can you follow the flashing lights to the hot water heater?

Now press the blue, cold-water button. How many fixtures or appliances use *only* cold water?

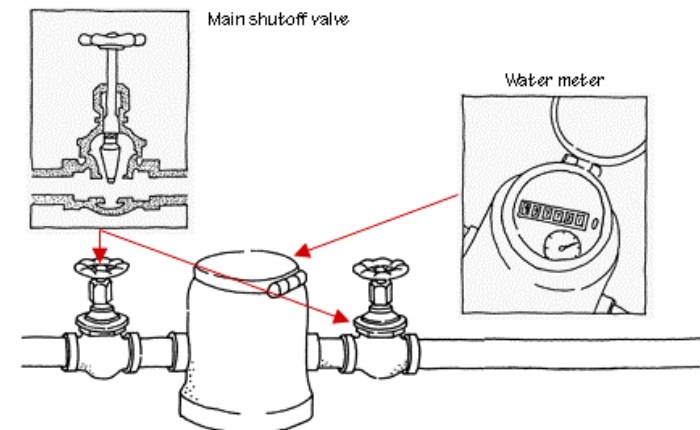
The green button shows the flow of waste or *gray* water from the house. Where are all of the drains and waste water pipes located in the house?



### Did You Know?

About 95 percent of the water used by Phoenix comes from surface sources, including the Salt, Verde, and Colorado rivers; the remaining 5 percent comes from wells. The Central Arizona Project (CAP) and Salt River Project (SRP) deliver surface water to the city. City reservoirs have a combined storage capacity of nearly 350 million gallons.

The total service area for Phoenix is about 530 square miles. Water is delivered to customers through more than 6,011 miles of water mains. *In Phoenix, each person uses about 170 gallons each day at home.* The city operates about 4,363 miles of sewer lines, the largest pipe being 90 inches in diameter. Pipes connecting homes to the sewer system are four inches in diameter.





## Electricity

Electricity is generated at power plants. Transformers increase the voltage to push the power over long distances. The electrical charge travels through high-voltage transmission lines. When it reaches a substation, the voltage is lowered so it can be sent on smaller power lines. It travels through these distribution lines to your neighborhood, where smaller pole-top or curbside transformers reduce the voltage again to take the power safely to our homes.

**Where to Go:** *Circuit Challenge* and *Build a Circuit*

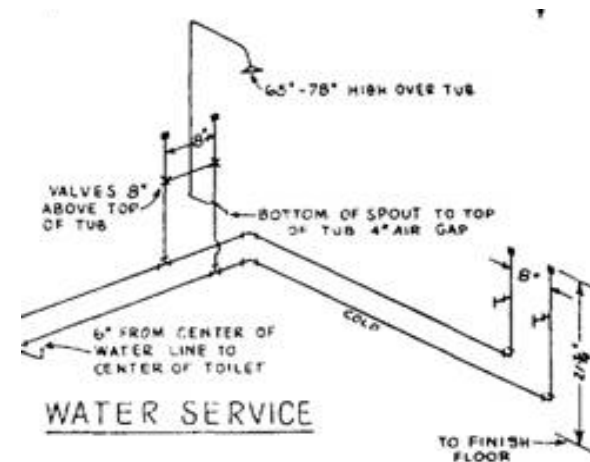
**What to Do:** At the *Circuit Challenge*, see how many appliances you can turn on in before the circuit must be reset. Can you tell what the maximum load is (in amps) for this circuit?

Now try *Build a Circuit*. Can you arrange the blocks to power both the fan and the light at the same time? Which one of these draws more electricity from the power supply? (Hint: use the current meter to test the fan and light separately!)



## Did You Know?

Plumbers and HVAC (heating, ventilation and air-conditioning) contractors sometimes use an *isometric riser diagram*. Find the isometric in the MNMH gallery. This diagram gives a three-dimensional representation of a plumbing system. A riser diagram is usually not drawn to scale, but it should be correctly proportioned. In other words, a long run of piping in the plumbing plan should be shown as a long line of piping in the diagram; short runs should be shown as short lines. There is also a specialized set of symbols that show how pipe fittings connect (in Y, T or + connections, for example).



## Maps, Plans, and Diagrams

Lots of different kinds of maps and plans are used in building a home. A *plan view* map shows a “bird’s eye” view of a house or room from above. A *section* shows a slice through a foundation or structure. Electricians, plumbers, and heating and cooling specialists use their own kinds of diagrams. See how many of these you can locate and understand!

**Where to Go:** Blue entry way to the MHMH Gallery, inside the walk-behind wall

**What to Do:** Look at the neighborhood map on the left side of the blue entry door.

Which lot would you pick for your house? Think of how you want your house to face. Remember – the directions that your windows face affect how hard it is to keep you home cool in summer and warm in winter!

Now look at the house plan on the opposite wall, showing room layout. Can you find the symbol that shows where the doors are in this house?

Go to the walk-behind wall and find the electrician’s map of a two-story house. How many symbols for phone outlets can you see in this house (see legend for symbol list)?



### Did You Know?

Fuses and circuit breakers protect equipment and wiring from overloads and faults. Ground Fault Circuit Interrupters (GFCI) protect PEOPLE.

GFCIs are installed where electrical circuits in appliances may come into contact with water. They are most often found in kitchens, bath and laundry rooms. If there is an imbalance in the current - either through faulty wiring, damaged cords, faulty or mishandled appliances or poorly insulated wires - the GFCI monitoring the current will detect the mismatch. The GFCI will “sense” the difference in the amount of electricity flowing into the circuit to that flowing out and, if working properly, will quickly trip or break off the circuit or flow of electricity.



GFCI

## Walls

A wall is much more than a flat place to hang a picture! Walls hold up an upper floor and a roof, insulate the indoors from the outdoors, hide wires, pipes, and ducts, and divide living spaces. Let's look closer at what's in a wall.

**Where to Go:** Walk-behind wall, at the rear of the gallery

**What to Do:** Walk behind the finished wall and look at all of the utility connections hidden there. How many are there?

Now go to the finished side of the wall and use the stud finder. Can you find any more studs by tapping your knuckles on the wall as you walk along it? Listen carefully and check by looking up at the crosspieces at the top of the wall.

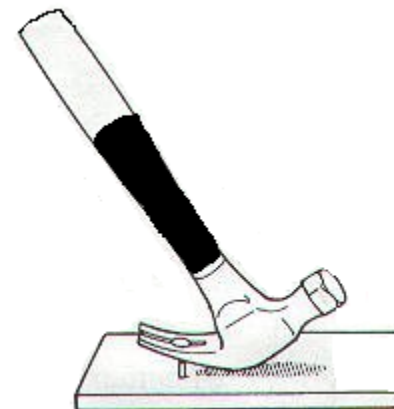
Walls are finished with layers of different materials to give insulation and protect from water.

Look at the layers of the wall near the shower stall. How many layers can you count? Compare the exterior wall above the foundation and the bathroom wall. Which has more layers? Can you tell what they are for?



### Did You Know?

The word “work” means different things to different people. Adults go to work each day; children are often expected to help with work around the house. Homework is something that a teacher assigns you to do at home on your own time. In science, work has a different meaning. Work is the result of a force applied to an object and the measure of the distance that object has moved. In mathematical terms,  $Work = Force \times Distance$ . Machines of all types make work easier by changing the size or direction of the force you need to apply.



## Cooling Your Home

People in Phoenix have cooled their homes in different ways in different times. Early residents slept outside in summer, often wrapped in wet sheets. Or they hung wet sheets in windows. As the breeze blew through these wet sheets, moisture evaporated and cooled the air. Evaporative coolers (“swamp coolers”) were installed in businesses and in some homes starting in the late teens and early '20s. With the introduction of air conditioners (“refrigeration”) Phoenix’s population exploded, more than quadrupling between 1950 and 1960. Most standard homes today contain a heat pump, which functions to cool in the summer **and** heat in the winter.

### Where to Go: Act Like a Heat Pump

**What to Do:** Crank the handle and watch the two dials that measure the pressure along the coil. Which dial shows higher pressure?

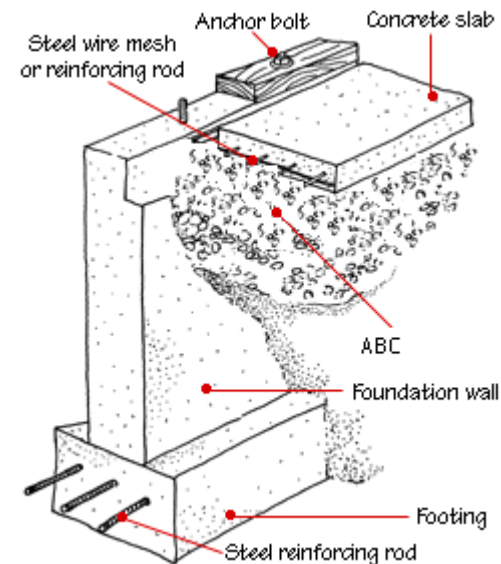
Look in the two sight glasses. Can you tell when the refrigerant is in a liquid state and when it passes through the sight glass as a gas?

Compare the evaporator in the exhibit with the one in the real heat pump. How are they alike?

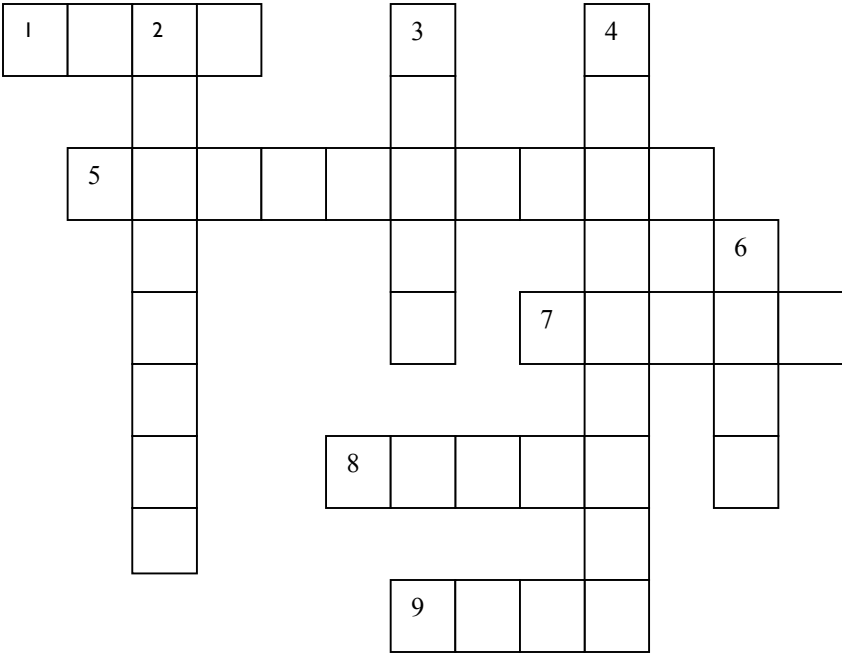


### Did You Know?

Concrete is very strong in compression but weak in tension: it can hold a great deal of weight but will crack when forces bend it or pull it apart. In areas where there are expansive clays or soils, cycles of swelling and shrinking can lead to cracks in concrete slabs poured on graded soil. Post-tension construction uses cables that tighten to strengthen the slabs.



# Construction Crossword



## A Foundation to Build On

Many houses in Arizona are built on a concrete slab without cellars or basements. The footing of a slab outlines the perimeter of a structure and supports its weight. A layer of mixed gravels and sand (ABC) often underlays the main part of the slab and absorbs stress and moisture.

**Where to Go:** The foundation wall, to the left as you enter the MHMH gallery.

**What to Do:** What is supporting this section of the slab? Can you guess why it is thicker at the bottom?

Find the ABC layer beneath the slab. Touch it with your fingertips, and compare the texture to the slab above it. Can you see and feel a difference in the texture and size of particles in these two layers?

Next, go to the small table with the round spinbrowser control and face the videoscreen. Set the dial to Day 1 on the video and watch the old house come down!

How much time does it take for the workers to clear the ground and lay the foundation for the new house? Does the new house have a basement?

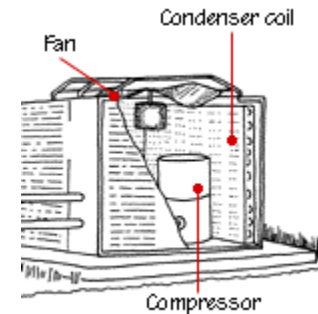
Now freeze the video at a single moment. How many workers can you count?



### Did You Know?

In the Phoenix area, cooling costs can account for as much as 45 percent of your annual electric bill. Energy use increases significantly during the summer's hottest months — June through September. After September you can look forward to a decrease in temperatures and energy use. Winter bills are typically less than half of summer bills.

The efficiency of heat pumps and air conditioners is expressed by the Seasonal Energy Efficiency Ratio (SEER). The higher the SEER number, the more cooling you will get for your dollar.



## Continuing the Trail (activities for home)

**Keep a Water Log** – Track water use in your home for a week. How can you do this? If your water meter is easy to find and read, record the number at a specific time on a specific day. Repeat this reading a week later. If you can't find or read the meter, try this: use a watch to count the number of minutes that water runs at sinks, showers or tubs in your house. Don't forget to count the number of toilet flushes and the number of times your dishwasher or clothes washer is run. Try to reduce these numbers in a second week.

**Electrical Patrol** – You can help keep down electrical costs in your home by making sure all lights are out when you leave a room. Did you ever hear that it takes more power to turn a switch on and off than to just leave it on? Help bust this myth – It is **always** cheaper to leave power off!

Look in you bathroom and kitchen to see if you can identify the Ground Fault Circuit Interrupters (GFCI) in your house.

**Never, ever play with an electrical outlet!**

**Draw a plan view map of your bedroom** -Mark where all of the electrical outlets and appliances are located. Describe where you think the electrical wires run behind your walls. Do you have any pipes behind the walls in your room? Is your bedroom next to a bathroom, kitchen or laundry room?



### Did You Know?

The original main survey line of the valley started from a point near what is now the Phoenix International Raceway. The rest of the valley was measured from a line running east and west of that point: this line was named Baseline Road.

The basic layout of Phoenix is a simple grid, still visible in many parts of the valley. The major streets running east-west were named for the U.S. Presidents, with Indian names for north-south streets. Many of these have been dropped in favor of numbers, ascending in both directions from Central Avenue: Avenues to the west, Streets to the east

