Wiring Around Your Home

4-H Electric Division V
Welcome to Division V of the 4-H Electric Project

Congratulations! You've successfully completed the first four units of the 4-H electric program and are now ready to learn about even more complex aspects of the world of electricity. In the Division V manual you will build upon those things you learned in the first four manuals and learn some very useful new skills.

Each category listed below contains background information and activities that will help you learn a major project skill associated with electricity. The project skills learned in this manual include:

- Understanding the need for and purpose of Electrical Codes.
- Being able to use the correct technical terms associated with residential electrical wiring.
- Understanding how electricity is distributed and controlled throughout your home.
- Recognizing the different kinds of circuits that may be found in your home.
- Reading and creating wiring diagrams and understanding the associated symbols.
- Determining the size of a circuit (ampacity) needed for the appliance(s) you wish to use.
- Determining if a circuit is energized by using testing equipment.
- Understanding grounding and the reason it is important.
- Understanding why/when/where circuits should be GFCI protected.
- Knowing about arc-fault interrupters and when they should be used.
- Recognizing the different types of wires (conductors) and cables and how they are coded.
- Understanding the process of mechanically/electrically connecting two or more wires together.
- Understanding how to determine the different sizes and types of receptacles and switches (including three-way).
- Being able to safely replace a receptacle and/or switch.

In Wiring around Your Home you need to:
1. Attend your county’s 4-H electric meeting(s).
2. Read this manual.
3. Complete the activities presented in this manual.
4. Complete the record sheet in the back of this booklet and submit it as instructed by county 4-H youth educator or 4-H electric leader.

Upon completion of Wiring Around Your Home you will exhibit one of the following at your local or county fair:

Display board, poster, equipment wiring board, or written report in one of the following areas:
- electrical work that you did around your home or other location and how you accomplished it (preferably with models, pictures or a small part of your total installation). Be sure to include a wiring diagram of your project with your exhibit.
- analyze the current wiring situation in your home or out buildings and develop a new system that you feel would be better. Be sure to show diagrams of the old and new systems. Also, explain why the new proposed system is better.
- any topic covered in this manual.

Note: Poster and display boards should be 22” tall by 28” wide. Equipment wiring boards differ from display boards in that they show hands-on wiring techniques (i.e., complete wiring of a light controlled by a three-way switch system). Equipment wiring boards should be no larger than 3’ by 3’. The boards should be designed so that they can be displayed horizontally.

ACKNOWLEDGEMENTS

Wiring Around Your Home was written by Karen Tormoehlen, Roger Tormoehlen, Bill Vollmer, Purdue University Cooperative Extension Specialist, 4-H and the Indiana State 4-H Joint Electric Committee composed of Fred Bauman, Rex Prinell, Wayne Newhart, Roy Mohr, Dave Millis, Betty Baute, Valerie Sharp, Brad Henderson, Dan Endris, Jim Rupp, Brandon Stevens, Rob Wilson, Rachel Cruz, Darby O’Conner, Fred Jakubowicz.
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Introduction
What’s the first thing you do when you walk into a darkened room? Reach for the light switch? You probably do this without giving it a second thought unless a bulb has burned out, a fuse is blown or a circuit breaker has tripped and you are left in the dark.

Have you ever given thought to what makes it possible to microwave popcorn, listen to your stereo or have light to read with? Permanent indoor wiring is responsible for bringing electricity throughout your home. This manual will explore types of permanent indoor wiring that make our lives comfortable through the ability to use lights and appliances in our homes. You will also be given instructions on how to make safe and simple repairs to your existing electrical system.

The National Electric Code

The National Electrical Code® (NEC) was developed by the National Fire Prevention Association (NFPA) as a set of rules to encourage safe practices while working with electricity. It states “The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity.” The NEC is updated every few years. In addition to the NEC, cities, counties, and states may adopt regulations that need to be followed by consumers, electricians and builders. A permit may be required to be obtained from a local inspector whenever you make major changes to, or install something new in, your home-wiring system.

Before attempting any electrical work, contact a local inspector to learn more about the electrical code(s) in your area and the rules that you need to follow when making changes to your electrical system. Your local electrical utility may also have certain wiring and inspection requirements. Remember to always turn off the power to any circuit that you may be working on.
This manual does not attempt cover each and every aspect of the residential wiring rules as set forth in the National Electric Code (NEC). The NEC is, if fact, a very detailed and complete set of rules governing the safety and use of electricity in business, industry and the home. This manual serves as more of overview of how to make some basic repairs or improvements to an existing home electrical system which would be consistent with the rules set forth in the NEC. The language of the NEC specifies what the MINIMUM safety standards to be used are.

How Electricity Travels Throughout the Home

Electricity is supplied to your home through your electric utility’s overhead or buried power lines.* Before entering your home, electricity passes through a watt-hour meter which measures the amount of electricity used. It then continues into your house through the Service Entrance Panel (also called a “load center”), where circuit protection devices such as circuit-breakers or fuses are located (Figure 1). Electricity is then distributed throughout your home using branch circuits to provide power to appliances and lights through receptacles, switches, and fixtures.

Electricity arrives at your home on two energized (“hot”) conductors and one non-energized (“neutral”) conductor. Between the two “hot” conductors a typical voltage of 240 Volts AC will be present and between either of the “hot” conductors and the “neutral” or “grounded” conductor approximately 120 Volts will be present (Figure 1). Under the right circumstances, 120 volts can injure or kill you; 240 volts could present an even greater risk for injury or electrocution. Therefore, it is very important that power be removed from a circuit before any repairs or changes are made to it. There are a number of testing devices that can check for the presence of voltage in the circuit and one of these should be used to make sure that the power is off. These testing devices will be discussed later in this manual.

Electrical Symbols and Building Plans

Electrical symbols are used on home building plans in order to show the location, control point(s), and type of electrical device(s) required at those locations. These symbols, which are drawn on top of the floor plan, show lighting outlets, receptacle outlets, special purpose outlets, fan outlets and switches. Dashed lines are drawn between the symbols to denote which switch(es) control specific light(s) or receptacle(s). There are quite a few symbols used to represent the devices used in home wiring but some of them are very similar, so care should be used when working with them.

An “outlet” is any point in an electrical system where current is taken out of the system in order to supply power to the attached electrical equipment. An outlet can be one of two basic types: A “Receptacle” outlet or a “Lighting” outlet. A receptacle outlet is one in which one or more receptacles are installed for the purpose of attaching “plug and cord-connected” type devices, and a lighting outlet is one intended for a direct-wired connection to a lamp holder, luminaire (lighting fixture) or ceiling fan. Special-purpose outlets also exist. These may be dedicated to a specific type of equipment such as a furnace, wall oven, garbage disposal or another similar piece of equipment.

ACTIVITY #1
Identify Electrical Plan Symbols
1. Things needed
   • pencil
   • this manual
2. What you will do:
   a. Study the symbols in the table named “Electrical Symbols and Outlets.” (Figure 2)
   b. Examine the “Sample Home Electrical Plan” and notice how the symbols are used (Figure 3).
   c. Answer the questions that are found below the electrical plan (Figure 3).
   d. Check your answers on the last page of the Glossary (Appendix 3) in this manual.

*To refresh yourself on how electricity gets from the power generating facility to your home refer to the Division III Electric manual.
FIGURE 2 – Symbols and Outlets
1. Why do two switches connect to the paddle fan?
   Slow/Fast Speeds     One for Light/One for Fan

2. How many lights are connected to 3-way switches?
   1  4  5

3. Where are multiple lights controlled by one switch?
   Garage Exterior     Bath     Bedroom 2

4. What two appliances are shown using 240 Volts?

5. Which five areas use GFCI-protected receptacles?

6. Which room makes use of Split-Circuit receptacles?

7. Where is the Service Entrance Panel located?

8. What does WP stand for on an outdoor receptacle?
Service Entrance Panel (S.E.P.)

The electrical panel, breaker box, fuse box, load center, or service entrance panel (it is known by many names) (Figure 4) has the job of distributing power throughout your home. It provides the primary means for a homeowner to disconnect the power that comes from the feed provided by your electric utility company. It also provides circuit protection for the various branch circuits that make up a residential electrical wiring system.

Power comes from the feeder lines into the “Main Breaker” (usually the topmost breaker in the panel) which is usually rated at 100 or 200 amps. From there, individual breakers then distribute power and provide overload protection for each of the individual circuits (branch circuits) that run throughout your home.

Circuit Breakers and Fuses

Circuit breakers and fuses are designed to stop the flow of current in a circuit if it becomes overloaded. The amount of time required for a breaker to “trip” (open the circuit) or fuse to blow depends on the amount of overload current. A circuit breaker trips immediately when a short circuit occurs, but delays an appropriate amount of time before tripping in the event of an overload.

When choosing circuit protection devices for a service entrance panel, it is important to match the rating of the circuit breaker or fuse to the circuit that it will be protecting. In other words, you would want to use a 15-amp rated breaker on a 15-amp lighting branch circuit; you would not want to use a 20-amp rated breaker. Neither would you want to use a 15-amp rated circuit breaker on a 20-amp small-appliance branch circuit. The same principle would apply if fuses were being used for circuit overload protection. Also, when selecting breakers, it is important to match the service entrance panel you have with compatible-style breakers.

To be able to properly diagnose an inoperative branch circuit, it is important that you learn how to recognize when a circuit breaker has tripped or when a fuse has blown. The first clue that this has happened would be that none of the lights or devices plugged into receptacles that are a part of the circuit would be functioning.

When a fuse has “blown”, it is usually quite apparent by viewing the “fusible” metal link inside the fuse housing through the transparent window in the front. If the metal link has a gap in it, the fuse has blown (Figure 5 - the link has melted due to the excessive current flow). Another possible indicator is blackening of the transparent window as a result of the melting and vaporizing of the metal link. In this case, it could be difficult to actually inspect the metal link. If it is not visually possible to tell if a fuse is blown, you can always remove it from the panel and test it using a testing device such as an Ohm-meter or continuity tester.

Older homes, whose electrical wiring has not been upgraded, may still be using fuses for circuit protection, however, these are becoming less common. It is still useful to know about fuses because even items like your automobile make use of them to protect its electrical system.

When a “toggle-type” breaker has tripped, the “ON/OFF” toggle lever either reverts back to its “OFF” position or it sits somewhere (floats) between the “ON” and “OFF” positions. To reset the breaker, move it fully to the OFF position and then back to the ON position.

Older “Push Button” type circuit breakers usually have a small window on the front with the words “ON” and “OFF.” For a normally-functioning circuit, the breaker will display “ON” in the window.
If an overload occurs and the breaker is tripped, it will display “OFF.” Pushing the button will reset the breaker and, if the electrical fault that caused it to trip is no longer present, “ON” should then appear in the window.

Blown fuses will need to be replaced and tripped circuit breakers reset, but don’t do this before investigating the possible causes for the overload or short-circuit. There simply may have been too many items plugged into the branch-circuit receptacles and turned on at the same time, causing an overload or, there may be a short in the plug or cord of a cord-connected device.

Your service entrance panel may also be equipped with one or more Ground-Fault Circuit Interrupters (GFCIs). GFCIs function as a normal breaker but have the added capability of opening the circuit if even a small amount of current leaves the circuit and begins to flow on another path, such as through your body. This helps to protect you from injury or electrocution due to electrical shock.

You can recognize a GFCI by the “test” button on the front which, when pressed, “trips” the breaker and causes the circuit to open. When the breaker is tripped, either by using the test button or due to an actual ground fault, a colored “flag” appears behind a clear window letting you know the breaker has tripped.* Retrapping the breaker is done by switching the toggle handle to the “off” position and then back to the “on” position. GFCI receptacles and their use will be discussed later in this manual.

*Note: Not all GFCIs have visual “tripped” indicator windows.

**ACTIVITY #2**

Draw Your Home’s Electrical Plan

1. Things needed:
   - Pencil, ruler, paper, this manual
2. What you will do:
   a. Diagram the floor plan for the main floor of your home. (Refer to Activity 1.)
   b. With the help of an adult, locate the service entrance panel (Figure 4). If it is located on the main floor, draw its location on your floor plan and label it “S.E.P.” If it is not on the main floor, add some text on your floor plan that informs the reader of its location.
   c. Next, locate every switch, receptacle (accessible ones only), lighting fixture, and fan fixture on the main floor of your home.
   d. Refer to the Table of “Electrical Symbols and Outlets” (Figure 3) and place those symbols that correspond to the items mentioned in step c. on your floor plan in the approximate location they are found in the rooms. Draw dashed lines from switches to the lighting fixtures, split-circuit receptacles (those controlled by a switch) or the fans they control.

3. Check
   a. Ask your mom, dad, or 4-H electric leader to review your wiring diagram with you. Did they suggest any corrections or additions? If yes, what were the suggested changes?

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

**ACTIVITY #3**

Diagram Your Service Entrance Panel

This activity will help you become better acquainted with your Service Entrance Panel.

1. Things needed:
   - Pencil, ruler, paper, this manual
2. What you will do:
   a. Create a diagram of your service entrance panel by making a pictorial drawing of the panel that shows the location and ratings (amperes) of the installed circuit breakers and/or fuses.
   b. If there is a number embossed on the panel next to the breaker or any existing labeling that tells which branch circuit it controls, record this information on your diagram as well.
   c. Record the unused spaces that can be used for future system expansion. Unused spaces will either be stamped rectangles still attached to the panel, or there will be filler plugs that have been inserted into the panel where a breaker would normally reside.
   d. If your S.E.P. uses breakers, note your drawing how many breakers are used on 120-Volt circuits and how many are on 240-Volt circuits? (F.Y.I. 240-Volt breakers are usually thicker than 120-Volt ones.) Did you find any GFCI breakers? Note this information on your pictorial drawing as well.

What Are Branch Circuits?

Branch circuits are made up of the wires that deliver electricity throughout your home. The NEC defines a branch circuit as: the circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

A branch circuit enables appliances and lights to be operated as needed. A branch circuit should be able to handle the combined power demand for all of the attached devices without overloading the wires. Therefore, the size of the wires used as well as the location and the number of receptacles and switches is crucial for safety as well as convenience.
Types of Branch Circuits

The kind of circuit installed will depend on how it will be used by the consumer and the amount of electricity that will be required to be provided by the circuit. In general, there are three types of branch circuits:

1. **General purpose branch circuit.** Circuits that provide electricity to the lighting and receptacle outlets throughout your home. In general, these circuits are 20 amp, 120 volts and use 12 AWG* size wires or they are 15 amp, 120 volts and use 12-14 AWG wires.

2. **Small appliance branch circuit.** Circuits that provide electricity to receptacles in the kitchen, dining, and laundry or similar areas where portable appliances are often used. In general, these circuits are 20 amps, 120 volts, and use 12 AWG or larger wire. (The NEC requires that a minimum of two small-appliance branch circuits be provided for the receptacle outlets that serve countertop areas in kitchens.)

3. **Individual (Dedicated) branch circuit.** Circuits that provide electricity to a single receptacle or are hard-wired directly to a heavy duty appliance such as a stove, dryer, water heater, central air conditioner, heat pump or motor above 1/3 horsepower. In general, these circuits are 15 to 100 amps depending on the electrical load of the equipment. The voltage used for most dedicated heavy-duty appliance circuits is typically 240 volts.

It is critical that the electrical demand placed on a branch circuit not be in excess of what that circuit has been designed to handle. Not only can repeatedly drawing excess current damage the wiring and the circuit devices through overheating, it can also damage appliances if the supplied voltage becomes lower due to the higher current draw.

*See page 15 for an explanation of conductor sizes: "AWG" stands for American Wire Gage. The lower the number, the greater the current the wire can handle.

**ACTIVITY #4**

Is Your Permanent Wiring Adequate for Your Needs?

1. **Things needed**
   - pencil
   - this manual

2. **What you will do:**
   a. With the help of an adult, use the following checklist to identify symptoms of wiring problems in your home. Check all that apply.

   **NOTE:** Any of the following is a potentially dangerous situation and should be corrected by a qualified professional as soon as possible.

   ___ burning odors
   ___ flickering lights, dimming lights, or lights getting brighter when appliances are turned on
   ___ appliances operating slowly or not as well as they should
   ___ fuses blowing or circuit breakers tripping frequently
   ___ too few outlets and switches installed where you need them (i.e., multiple outlet strips in use)
   ___ multiple octopus connections used for several appliances at once
   ___ extension cords strung around room in order to connect lamps or appliances
   ___ overheating of motors
   ___ getting shocked

   b. If you have checked any of the symptoms of wiring problems above, identify possible solutions to this situation in your home (i.e., don’t use microwave and toaster at same time).

3. **Check**
   a. Ask your mom, dad or 4-H electric leader to review your checklist and adaptations with you. Did they suggest any changes?

   If yes, what were the suggested changes?

   ____________________________________________
   ____________________________________________
   ____________________________________________

   FIGURE 7 – Inadequate Wiring
**ACTIVITY #5**

**Typical Branch Circuits and Their Loads**

This activity will help you become better acquainted with the branch circuits that serve your home and the types of appliances that might get connected to those branch circuits.

1. **Things needed:**
   - Pencil
   - This manual

2. **What you will do:**
   a. Complete the Example Residential Branch Circuits and Loads diagram by choosing the proper item from the list of items that appear in the brown curve-shaped area below.
   b. Write the item you chose in the correct yellow box.
   c. You can check six of the seven items (those that have their wattages listed) for correct placement by making sure the total of wattage for the three items on a given circuit is equal to the total wattage shown in the rightmost column.
   d. Write the three remaining items in the last three yellow boxes.

![ACTIVITY #5 - EXAMPLE RESIDENTIAL BRANCH CIRCUITS AND LOADS](image)

**FIGURE 8 – Example Branch Circuits and Loads**
ACTIVITY#6
Is the Circuit Overloaded?

1. Things needed
   • pencil
   • paper
   • diagrams from activities #1 and #3 in this manual

2. What you will do:
   a. Choose a circuit in your home (preferably one that would be contained within the electrical plan you drew earlier in Activity #1). Ask a parent to help you determine which receptacles and lights are a part of that circuit. In the space provided below, prepare a chart of the electrical loads that are typically placed on that particular circuit. See the “Example Electrical Loads” chart (Figure 9) for assistance in preparing your chart.

   Breaker/Fuse Size (Amps) | Area Served | Voltage | Items Used | Watts
--- | --- | --- | --- | ---
20A | Living Room | 120 | Television | 350
   |  |  | 3 Lamps | 260
   |  |  | Space Heater | 1400
   |  |  | Boom Box | 10
   |  |  | Computer & Monitor | 350

Total | 2370

Maximum Load (80%) = 1920 Watts

b. List the appliances and lights generally used on the circuit. Locate the number of watts used by each lighting device or appliance.

c. Add up the total number of watts for the circuit.

d. Use the following Maximum Load formula to determine the maximum “Continuous” load that the circuit can handle:

\[
\text{Maximum Continuous Duty Load Formula}
\]

(This formula does not apply to motor circuits)

\[
\text{Amps} \times \text{Volts} = \text{Watts}
\]

\[
\text{Watts} \times 0.8 = \text{Maximum continuous duty load capacity of the circuit.}
\]

The NEC defines “Continuous Load” as “a load where the maximum current is expected to continue for 3 hours or more.”

Example: 20 amp (circuit rating) x 120 volts = 2400 watts

2400 watts x 0.8 = 1920 watts

Maximum continuous duty load = 1920 Watts

NOTE: If a circuit is subject to exceeding the Maximum Continuous Duty Load, consider shifting one or two of the receptacles on that circuit to another nearby circuit that has additional load carrying capacity available. This will serve to redistribute the load.

3. Check
   a. Did the load used on the circuit exceed the maximum load capacity for the circuit? If yes, how might you redistribute the load to other circuits?

   ____________________________

   ____________________________

   ____________________________

   ____________________________

   ____________________________

   ____________________________

b. Ask your mom, dad or 4-H leader to review your chart with you. Did they suggest any changes? If yes, what were the suggested changes?

   ____________________________

   ____________________________

   ____________________________

   ____________________________

   ____________________________

   ____________________________

   ____________________________

   ____________________________
Is the Circuit Live?

One of the best devices you can use to determine if a circuit is energized (also called "hot" or "live") is what is known as an "outlet tester" or "circuit-polarity checker."

By inserting an outlet tester into a 120V receptacle, not only can you determine if power is available at the receptacle, but you can also determine if the wiring which runs between the receptacle and the Service Entrance Panel is connected correctly. Any incorrectly wired receptacles can cause injury from electrical shock and, under the right circumstances, could cause an electrical fire.

As you may recall from the Division III electric project, power is delivered to receptacles on the "Hot" and "Neutral" conductors. A third conductor, the “Equipment Grounding Conductor” or "Safety Ground", is also included as a part of the circuit but does not carry any current unless there is an electrical fault of some kind.

When the circuit conductors are properly connected to a receptacle, the hot wire will be connected to the electrical contact behind the shorter rectangular slot in the receptacle body. The neutral wire will be connected to the electrical contact behind the longer rectangular slot, and the grounding wire to the electrical contact behind the half-round opening.

**MEMORY AID:** "Hot" is the shorter word, hence goes to the shorter slot. "Neutral" is the longer word, hence goes to the longer slot. "Ground" sounds like "round", and hence, goes to the half-round opening.

Figure 9 shows a typical outlet tester. Every tester of this style will have a series of lights that illuminate in a specific pattern based how the hot, neutral, and ground conductors are connected to the terminals of the receptacle. On the unit depicted here, the lights are on the end while the top and bottom are marked with a legend indicating the meaning of the light combinations.

![Outlet Tester](image)

There is only one correct combination of lights for a correctly wired receptacle. Figure 10 shows the legend that appears on the top of the tester. Be aware that there are two ways receptacles may have been installed into your walls... with the grounding connector facing up or with it facing down. The legends printed on the top and bottom of the device will be different, but when plugged in and viewed from above the receptacle being tested, it will read correctly.

![Example Legend for Outlet Tester](image)

**ACTIVITY#7**
Is the Circuit Live (and wired properly)?

1. Things needed
   - pencil
   - paper
   - polarity checker/outlet tester

2. What you will do:
   a. Using a polarity checker, check all of the 120-volt receptacles (easily accessible ones only!) in your home for power and proper wiring. Make sure to use the legend specific to your checker. Do not use the one shown in the figure above!

   b. In the table that follows, record any receptacles that are not working or are wired incorrectly. Note the room's name, the location of the receptacle within the room and what was indicated by the polarity checker. The first row of the table gives an example of what to do. If you find more than five problem receptacles, you can continue the table on a separate piece of paper.

   c. You may have a few receptacles in your home controlled by switches (split-circuit receptacles). These are mostly likely to be found in bedrooms or living rooms but could be in any room. These will test as "not working" if the switch that controls them is turned off.

   To identify if a receptacle is connected to a split circuit, test both halves of the receptacle with all the wall switches in the room turned off. One-half of the receptacle should have power while the other half should not. If turning the wall switch(es) back on provides power to the unpowered half, it is on a split-circuit. Remember, more than one receptacle on a split-circuit may be controlled by the same switch.
d. Re-examine your main-floor electrical plan that you created in activity #2. If you were not able to determine earlier which receptacles, if any, were wired into split-circuits, go ahead and mark them as such on your diagram now. If you need an example, look at Bedroom 1 on the electrical plan used in Activity #1. Notice, it shows five split-circuit receptacles controlled by one switch.

4. Check
a. Ask your mom, dad or 4-H electric leader to review your findings with you. Discuss with them the possible process you would use to troubleshoot why the receptacles are not working as they should be. Will you, or someone in your family be able to make repairs, or will an electrician be needed?

Other devices that could be used to test to determine if power is being supplied to a receptacle would be: 1) A Digital Multimeter that measures and displays the actual AC voltage present at the receptacle; 2) a Non-Contact Voltage Tester, or 3) a Neon Light Type Voltage Tester. These will not be discussed any further in this manual but you may wish to investigate these devices on your own to learn about their capabilities. For your reference, examples of these items are shown in Figure 11.

Grounding

"Grounding" (verb) refers to connecting, to the earth, the metal parts of the electrical equipment and devices (distribution panel, electric box, receptacle, switch, etc.) that make up the electrical system. The bare copper or green-insulated wires that connect the electrical system to the earth are called grounding (adj.) wires. These wires do not normally carry circuit current. However, they do carry current when they are directing abnormal electrical flow, such as that caused by a short circuit or lightning strike, into the earth to help prevent personal injury or property damage.

The "grounding wire" (sometimes called bonding wire) should be connected to all metallic boxes of receptacles and light switches as well as to the green screw of receptacles. Grounding wires must connect to metallic boxes by using a bonding clip or green-colored machine screw.

The white-insulated electric wires that carry normal circuit current are called "grounded wires" (also known as the neutral wires). Grounded wires are connected to the earth by the grounding wires. This normally occurs at only one point in a residential electrical system - inside the service entrance panel.

For any electrical system to function safely and properly, a high-quality earth ground is needed (Figure 12). Metal rods embedded in a building’s concrete foundation would be the first choice for an effective electrical ground. This would be followed by well casings or buried metallic water pipes. If such items are not available, a ground rod needs to be used. Often, a ground rod is used to supplement other methods of grounding. A typical ground rod is a copper-plated steel rod about 5/8” in diameter and 8-10 feet in length. It is driven almost fully into the ground near the service entrance panel. A grounding wire is run from the S.E.P. ground terminal and connected securely to the ground rod.
NOTE: An improperly grounded receptacle may present a safety issue to you and your family members. If any of the receptacles you tested in the last activity indicated any type of fault (including “open ground” or “hot/ground reversed”), let your parents know as this may present a safety issue to you and your family members.

TIP: A good safety practice when doing electrical wiring is to connect the grounded (neutral) and grounding wires first when assembling the wiring and to disconnect these wires last when disassembling the wiring.

Ground Fault Circuit Interrupters (GFCI)

A Ground Fault Circuit Interrupter (GFCI) (Figure 13) is an electronic device used to protect persons against faulty appliances. GFCI circuitry detects the abnormal flow of electricity (current leaving the circuit and flowing on an unintended path). It opens the circuit to prevent electricity from reaching the user where it could cause serious injury or death. GFCIs are designed to trip within 15-30 milliseconds (0.015 - 0.030 second), whenever a 4-6 milliamp difference in current flow exists between the hot and neutral wires.

These devices are available as portable units and also are built into receptacles and circuit breakers. GFCI breakers were discussed briefly earlier in this manual. GFCIs are required by Code in certain locations in a home (usually wet/damp spaces) such as bathrooms, garages, kitchens, basements, around swimming pools and for all outdoor receptacles. In addition, some hand-held appliances, especially hair dryers, are being equipped with GFCI protection built right into the plug.

GFCI circuit breakers have the advantage of providing protection for every receptacle on that circuit, but keep in mind that when a GFCI breaker trips, power is removed from every receptacle and lighting fixture on that circuit.

GFCI-protected wall receptacles can function in one of two ways: 1) They can offer protection for just the one receptacle into which the GFCI is built, or 2) Other receptacles can be supplied with power through the protected one and these receptacles would then offer GFCI protection as well.

ACTIVITY#8

Identifying GFCIs in Your Home

1. Things needed
   - pencil
   - this manual
   - outlet tester

2. What you will do
   a. Locate and identify* the GFCIs in your home and record their location in the space provided below. (HINT: Pay particular attention to the receptacles in your bathroom, kitchen, garage, receptacles on the outside of your home, and the plugs of hand held electrical devices such as hair dryers.)

   b. *Use the "TEST" button on any GFCIs receptacles you find to see if they are working correctly and help determine if they are protecting any other receptacles on the circuit. After pressing the test button, take the outlet tester and check the GFCI receptacle for power. If the power is off, plug the tester into other nearby wall receptacles to see if they are being protected by this GFCI. If you find others off, "RESET" the GFCI receptacle and check those other receptacles again. If power was restored, congratulations... you have found those other receptacles that also offer you GFCI protection.
Wiring System Components

3. Check
   a. Ask your mom, dad, or another adult to verify your results with you. Did they know of any GFCIs that you didn’t find? If yes, where were they located?

   b. Were there any locations in your home that you didn’t find a GFCI protected receptacle where there should have been one?

Arc Fault Circuit Interrupters (AFCI)

An Arc Fault Circuit Interrupter serves a much different purpose than that of a GFCI. It is designed to sense and respond to an electrical arcing fault within a wiring system. Arcing can cause intense heat of up to 10,000°F and the molten metal coming from the arc can ignite surrounding flammable materials. A major cause of house fires is from arcing caused by wires with loose connections.

Unless your home was built fairly recently, it may not make use of AFCI’s. Some Electrical Codes may now require them for new construction. Just like GFCIs, AFCIs are available for use in breaker panels, come built into wall receptacles, and are available as a portable device that can be plugged into by a cord and plug-connected appliance or power tool.

Types of Wire Insulation

There are four basic types of wire covering (insulation):
1. **Type T** - Thermoplastic coated wire. Most commonly used in homes in dry locations.
2. **Type TW** - Thermoplastic coated, moisture resistant wire. Used in basements and for outdoor wiring.
3. **Type THW** - Thermoplastic coated, heat resistant, and moisture resistant wire. May be used in both wet and dry locations.
4. **Type THHN** - Thermoplastic coated, heat resistant. Used in dry locations.

Wire Covering Color Codes

Wires are covered with plastic insulation to provide both protection and a method of identification. The insulation color normally used for hot wires is either black, red, or blue. Grounded wire insulation is white or natural gray. Grounding wire insulation is green, green/yellow, or bare copper (not insulated). These colors help to prevent errors when doing electrical installations or making repairs.

Wire Sizes and Use

Wires come in a variety of sizes designed for specific jobs and amp loads (Figure 14). It is available in either solid or stranded (for increased flexibility) conductor types. Conductor sizes are numbered using the American Wire Gauge (AWG) rating system. Smaller numbered wires are larger in size and are more capable of carrying larger loads of electricity (amps). 14 AWG wire is used for general purpose/lighting branch circuits. 12 AWG wire is used for small-appliance branch circuits. 6-10 AWG wire is used for higher power appliances such as clothes dryers, ranges, furnaces and central air-conditioners. Conductors 2 AWG and larger are normally reserved for use by the main service entrance conductors or to feed a sub-panel.

Copper wire is most often used to wire homes since it is a good conductor of electricity. Some older homes have been wired with aluminum wire. (Note: Aluminum wire is no longer approved for general purpose circuits. Aluminum tends to oxidize over time and can create poor electrical connections with those items to which it connects. Also, Aluminum connections tend to become loose over time which can cause the possibility of arcing to occur.) Service Entrance Conductors, however, are usually Aluminum because Copper conductors that size are very expensive.

When choosing devices, receptacles, switches, or wire connectors, make sure you choose ones that are made to be used with the type of wire you are working with.

- **Copper wire** should be used for devices with no markings or those marked CU-AL or CO-ALR.
- **Copper-clad aluminum wire** (CO-ALR) can be used with devices marked CO-ALR.
- **Aluminum wire** can only be used with devices marked CO-ALR.

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Solder should not be used to make home wiring connections! When you need to connect two or more wires together, a "solderless" connector should be used. In most lighting and general-purpose circuits, U.L. (Underwriter’s Laboratory) approved twist-on "wire-nut"* connectors are used. This plastic insulator contains a tapered threaded metallic interior that simply screws tightly over the bare ends of the wires, connecting them safely and securely (Figure 15).

*"Wire-Nut" is actually a registered trademark for this type of twist-on connector made by Ideal Industries.

To connect the wires together, a short length of insulation must be removed from the end of each of the wires to be connected. Remove just enough insulation so that no bare wire is exposed when the nut is screwed on all the way. Begin by twisting the wires together, slide the nut over them, and then screw it on tightly (Figure 15). This makes a solid connection and prevents any voltage drop from occurring or a potential fire being caused due to a loose connection. When the nut is properly installed, no bare wire should be visible. If there is bare wire showing, remove the nut, and clip off the ends of the wire to shorten them and then replace the nut as before.

ACTIVITY#9
Using Wire Nuts/Making Good Connections

1. Things needed
   - pencil
   - this manual
   - several pieces of 14 AWG Solid Insulated Wire
   - several pieces of 10 AWG Solid Insulated Wire
   - red, yellow and orange wire nuts
   - linesman pliers

2. What you will do
   a. Connect different combinations of wires together (both sizes and quantities) using the different sized wire nuts. Try connecting both same size wires and different size wires. Try connecting both two conductors and three conductors together.
   b. In the table below, record the wiring configuration you used (see example in first row) and list your observations (i.e., loose connection, wires too big, bare wire showing, nut pulls off of wires easily, etc.) for each of the combinations you try:

<table>
<thead>
<tr>
<th>Wiring Configuration</th>
<th>Your Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Yellow Nut 1-10AWG + 2-14AWG</td>
<td>Fits OK/wires are secure</td>
</tr>
<tr>
<td>a.</td>
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<td>e.</td>
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</table>
3. Check
   a. Based on your observations, what size wire nut should be used when connecting two 14 AWG conductors? (If not in your table, try it now.)

   Does your observation agree with the wire-capacity chart on the back of the package of wire nuts?

   If no, what size wire nut does the chart suggested for use with two 14 AWG sized conductors?

   b. Based on your observations, what size wire nut should be used when connecting two 10 AWG conductors? (If not in your table, try it now.)

   Does your observation agree with the wire-capacity chart on the back of the package of wire nuts?

   If no, what size nut is suggested for use with two 10 AWG sized conductors?

   NOTE: If you do not have the package the wires nuts came in, visit the manufacturer’s website to try to locate the information needed to answer the above questions.

Types of Electrical Cable

For most home wiring systems, a cable consisting of two or more insulated conductors, surrounded by an outer moisture-resistant, flame-retardant, nonmetallic insulating jacket, are used to supply electricity to the various branch circuits. Cable comes in a variety of standard sizes designed for specific uses. The conductor size, outer covering, and the type and number of wires determine how and where a cable can be used.

This type of cable is referred to as Nonmetallic-Sheathed Cable (NM). A term still commonly used to refer to this type of cable is “Romex.” This name served as the trademark for this type of cable originally manufactured by the Rome Wire and Cable Company. This name is still commonly used today to refer to NM-type cable.

There are three basic types of cable for residential use:

1) Nonmetallic Sheathed Cable. (NM, NM-B, NMC-B)
2) Underground (Feeder) Cable (UF-B) - specifically designed for direct burial in the ground without any additional protection required.
3) Service Entrance Cable (SE, USE) - generally used as a service entrance conductor.

Cable is available with either two or three current-carrying conductors. Figures 17 and 18 show two and three-wire cable. In cables, conductors range in size from 14 AWG through 2 AWG for copper conductors. Two-wire cable contains one conductor with black insulation, another with white insulation, and a bare equipment grounding conductor (also called the “ground wire”). Three-wire cable contains one conductor with black insulation, one with white insulation, a third with red insulation, and also a bare equipment grounding conductor. Equipment grounding conductors are permitted to have green insulation, but bare is the most common.

All cable must be marked with the following information:

- Manufacturer
- Type of wire
- Wire size
- Maximum Working Voltage
- Number of Current Carrying Conductors

To make installations easier and to help inspectors make sure that your wiring installation meets code requirements, the outer sheath of nonmetallic-sheathed cables are color-coded in order to indicate the wire size (AWG) being used. One part of the next activity will help you learn which color sheathing is associated with a specific wire size.
Cables that have two current-carrying conductors (hot and neutral) plus equipment grounding conductor are used for 120-volt branch circuits while cables having three current-carrying conductors (two hot and neutral) plus grounding conductor are used for 240-volt branch circuits. Three-wire cable is not only used for 240-volt-branch circuits, it is often used in the wiring of 120-volt lighting circuits where three-way switches are being used to control lights from two locations. Three-way switches will be discussed a little later in this manual.

The markings on some NM cables are embossed in the jacket (not printed) and are a bit difficult to read. This one reads: AWG 12 CU 2 CDR WITH AWG 12 GROUND TYPE NM-B 600 VOLTS

**Figure 17** – NM-B Cable – Two-wire plus ground

Note the markings on the outer insulating jacket. These indicate the type of wire, the number of current carrying conductors, the AWG, the maximum working voltage, and a few other items.

**ACTIVITY #10**

Symbols and Markings on Wires and Cables

1. Things needed
   - pencil
   - this manual

2. What you will do
   a. With a parent or 4-H electric leader, visit a local electrical supply or hardware store to see what types of wires and cables are available to the consumer.
   b. Choose several different cables and/or wires and list them in the following table.
   c. For each cable and/or wire you listed, identify in the space provided, what the symbols (coding) mean for each cable or wire. If necessary, ask for assistance from store personnel or research the answers in the library or on the internet.

3. Check
   a. Ask your parents or 4-H leader to review your work. Did the leader suggest any changes? If yes, what were the suggested changes?

<table>
<thead>
<tr>
<th>Type of Wire (Copper, Aluminum)</th>
<th>Wire - AWG or Cable - AWG/#Conductors</th>
<th>Wire Insulation Color or Sheathing Color</th>
<th>Wire or Sheathing Coding</th>
<th>Meaning of the Code</th>
<th>Purpose for which the wire/cable might be used</th>
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</table>

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**Figure 18** – NM-B Cable – Three-wire plus ground
Electrical Boxes

Electrical boxes are recessed into walls to hold switches, receptacles, or fixtures (Figure 19). Boxes serve to protect the connections made to these devices and to isolate them from any flammable material in case arcing would ever occur due to a connection becoming loose. Electrical boxes (made of plastic, metal, or fiberglass) must be covered yet remain accessible. A cover plate (or the baseplate – for a lighting fixture) is placed over the front of the box to keep the current-carrying parts out of contact with any individuals.

Wires should never be crowded into an electrical box. In fact, the Electrical Code specifically limits the number of wires that a box can contain in order to prevent them from becoming damaged. Every electrical box has a parameter associated with it called “box fill.” Box fill is the maximum number of conductors of a given wire size that is permitted to be contained in a specific-sized box.

Boxes come in various device capacities. Where more than one wiring device is to be installed at a single location, “multiple-gang” boxes are used. A box chosen to contain a single device such as a duplex receptacle would be called a “single-gang” box. A box selected to hold two wall switches, for example, a “two-gang” box. Nonmetallic boxes are available in one-gang through four-gang.

Metal boxes come only as one-gang or two-gang (called a “square box”) but they do have the ability to be ganged together to form larger boxes by removing the sides of adjacent boxes. Although metal boxes are readily available, today, most residential wiring is done using nonmetallic boxes.

Metal and Plastic Electrical Boxes

Electrical boxes must have a clamping device to secure the cable to the box. For plastic boxes, the clamp is typically molded into the back corners of the box. Metal boxes use a “Romex Connector” which is placed into a hole (called a “knock-out”) in one of the sides or in the top or bottom of the box and is secured to the box with a nut. A clamp, tightened down onto the cable with screws, holds the cable securely to the box. Metal boxes require that the grounding conductors to be tied to the box with either a “Grounding Clip” or a “Grounding Screw.” Code requires that individual wires to extend into the box past the clamping device by at least six inches and the sheath to extend at least ½ inch past the clamping device.

Receptacles

Receptacles or “plug-in” outlets supply electricity to lamps, radios or other small appliances through the cord and plug to which they are connected. General purpose and small-appliance receptacles come in both two-slot (non-grounding) and three-slot (grounding) varieties. Receptacles are rated for specific amperage, voltage, and type of wire to be used. They should be marked with the U.L. marking to show they have passed the requirements of the Underwriters Laboratory’s safety standards.

The most common receptacle is the standard grounding duplex receptacle. “Duplex” means that there are two sets of connections available from which power can be taken. Figure 20 shows a pair of polarized grounding-type duplex receptacles on the left along with a pair of polarized non-grounding type receptacles on the right. Note that the rectangular slots on polarized-type receptacles are of different sizes. The longer slot is for the neutral connection; the shorter slot is for the hot (energized) connection; and where there is a partially-round hole, it is for the grounding connection. The receptacles with the “T-shaped” neutral slot are used with 120-volt, 20-amp branch circuits. This allows for 20-amp plug and cord-connected devices to be used. The neutral prong (of the plug) of a 20-amp device would be turned 90 degrees, not allowing it to be accidentally plugged in to a 15 amp circuit.

Figure 19 – Metal and Plastic Electrical Boxes

Figure 20 – Duplex Receptacles

Some 120-volt appliances and devices (a toaster or table lamp, for example) use a two-pronged plug to connect to the receptacle. A two-pronged polarized plug when connected to a polarized receptacle will not allow it to be inserted into the receptacle backwards. If it were possible to insert the plug of a table lamp backwards, then the screw shell that holds the bulb would end up being connected to the energized conductor and would create potential safety issues when replacing a bulb. Remember, not all two-pronged plugs are polarized, especially on older appliances and devices.
Most often, duplex receptacles are side-wired (Figure 21). They are equipped with several terminal screws that are used to attach the wires. Hot wires are attached to the brass (gold-colored) screws, neutral wires to the silver screws and the grounding wire is attached to a separate green screw.

A “Connecting tab” causes the two brass screws to be tied together electrically. The same is true for the two silver screws. This means you can place your wires under either of the silver screws and under either of the brass screw to make your connections.

![Figure 21 – Anatomy of a Duplex Receptacle](image)

For split-circuit receptacle installations (one-half controlled by a switch), the tab connecting the brass screws is removed. Using long-nose pliers, as shown in Figure 22, the tab can be bent back and forth several times until it has broken off. The hot wire connects to one of the brass screws The other brass screw receives power from the switch using what is called a “switch loop.”

![Figure 22 – Making a “Split-Circuit” Receptacle](image)

<table>
<thead>
<tr>
<th>2 Pole (Non-grounding)</th>
<th>2 Pole (with ground)</th>
<th>3 Pole (with ground)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 Volts</td>
<td>120 Volts</td>
<td>240 Volts</td>
</tr>
<tr>
<td>15 ampere</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 ampere</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 ampere</td>
<td></td>
<td></td>
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</tbody>
</table>

The National Equipment Manufacturers Association (NEMA) has produced a set of standards to which today’s receptacles and matching plugs mechanically and electrically conform. You can do an internet search for “NEMA Connector Identification” to learn more about the various receptacles and plugs available and their ratings.

**ACTIVITY#11**

Identifying Different Receptacles Available

1. Things needed
   - pencil
   - this manual
   - reference materials or a visit to your local hardware or electrical supply store

2. What you will do
   a. For each of the receptacle configurations (the combination of amps/volts/wires) listed below, draw the receptacle’s slot configuration.

3. Check
   a. What was your source of information (i.e., electrical supply store, library book)?
b. Did you have any difficulty locating information on any of the receptacles? If yes, which ones?

Switches

Switches are used to control the flow of electricity in many of the circuits in your home. They can be basic switches that simply turn lights or receptacles on and off, or they can be more complex and perform additional functions. Some switches have additional circuitry built in to them that allows the lights in a room to be dimmed in order to set the room’s “mood” or to save energy. Others contain a timer that allows power to be supplied to a light or another device for a certain amount of time. Some switches can even be operated by touch and there is no button to push or handle (“toggle”) to flip. Switches come rated for specific amperages, voltages, and types of wires that can be used.

In general, there are four basic types of switches available for use with home wiring: Single Pole, Two Pole, Three-Way, and Four-Way. Let’s take a look at these now.

1. The Single Pole Switch: (Figure 23) This type of switch controls a light or receptacle from a single location. Its toggle is marked with the labels “ON” and “OFF” and it has two brass-colored screw terminals used to attach the wires. The energized supply (hot) wire connects to either one of the brass screw terminals and the other wire (the switched wire) connects to the other terminal and goes from there to the light or receptacle. The grounding wire connects to the metal part of the switch body using a green screw.

Sometimes it can be confusing when working with switches. Often the wires used to connect to the switch are those contained in a single NM-type cable (Figure 25). This means that one of the wires connected to the switch would have white insulation. While the white wire is normally reserved for the non-energized neutral conductor, a white wire is also allowed to be used as an energized conductor as long as it is marked with a black band to indicate that it is an energized conductor.

Figure 24 shows a wiring schematic plus an illustration showing two sections of NM cable running into the switch’s electrical box. One comes from the power source and the other comes from the lighting fixture. The black wire from each cable is connected to a brass screw on the switch. The two white neutral conductors are connected together using a wire nut inside the switch’s electrical box.

Figure 25 shows a wiring schematic plus an illustration showing two sections of NM cable entering the lighting fixture’s electrical box, one coming from the power source and the other going to the switch. In this case, the white wire in the cable going to the switch serves to extend the energized hot conductor to the switch. Notice that the hot wire from the source is tied to the white wire in the second NM cable with a wire nut.
You will notice that white wire in the cable going to the switch has been clearly marked with a black band at each end. This indicates that it has become a part of the “always energized” part of the circuit. This marking is usually done with black electrical tape, but might be made with a black permanent marker or other approved marking method. Notice that both ends have been marked.

**NOTE:** With any type of switch, only the energized conductor(s) should be switched. Never place a switch within a neutral conductor’s path.

2. **Three-Way Switch:** (Figure 26) The next most common type of switch used in home wiring is the three-way switch. This type of switch allows you to control a light from two separate locations, usually opposite ends of the same room or at the top and bottom of a stairway. There are no “ON” or “OFF” markings on a three-way switch. Just like the single-pole switch, a three-way switch has two brass-colored screws but also has one additional screw terminal that is either black or copper in color. This additional screw is called the “Common Terminal.” The wires that get connected to the brass screws are called the “Traveler Wires.”

Three-wire (with grounding wire) NM cable is typically used when wiring three-way switches.

Figure 27 shows a three-way circuit with power being brought in at the first switch. The red and black wires in the three-wire NM cable are the “traveler” wires. The black wire from the source is connected to the “common” terminal of the first switch. The black wire coming from the light’s electrical box is connected to the “common” terminal of the second switch. The neutral wire is carried through from the source all the way to the lamp fixture.

Figure 28 shows a three-way circuit with power being brought in at the lamp. Notice how the white wire that is attached to the source’s energized wire is marked with black tape to show it is also energized. The two “traveler” wires are the red wire and the white wire in the three-wire NM cable that has been marked with red tape to identify as one of the traveler wires. The neutral wire goes from the source directly to the lamp fixture.
3. **Four-Way Switch:** (Figure 29) A four-way switch allows you to control lights or receptacles from three or more locations such as a large living room or workshop. It has four brass-colored screws for connecting the wires. Just like the three-way switch, it has no “ON” or “OFF” markings. Only one four-way switch is needed for control from three locations. The other two switches needed in the circuit are both three-way. This manual will not go into the wiring of four-way switch circuits since it is fairly complex; you can research it on your own if you are interested.

![Four-Way Switch](image)

**Figure 29 – Four-way Switch**

4. **Double-Pole Switch:** A double-pole switch is used with 240 volt appliances and motors. It looks like a four-way switch with its four brass screws, except that it has “ON” and “OFF” markings on its toggle. It switches both of the hot wires at the same time. You can think of it as two single-pole switches operated at the same time by the same toggle.

**IMPORTANT SAFETY GUIDELINES**

1. Don’t attempt any electrical project unless you fully understand how to complete it. If required by Code, have it checked by the local inspector. Complicated electrical work may require the help of a competent electrician. In some locations, only licensed electricians are allowed to perform major electrical work.

2. Don’t attempt to work on a live circuit. Before doing any electrical work or repairs, shut off the electricity to the circuit on which you will be working. This may require removing a fuse or shutting off the circuit breaker at the service entrance panel. Keep the power off until the job is completed. (It is a good practice to make a note at the breaker box indicating that work is being done on a circuit.)

3. Before touching any wires, use a voltage testing device (voltmeter, neon tester, non-contact voltage tester) to make sure the power is off to the circuit.

4. Do stand on dry boards or rubber mat before touching the service entrance panel or working with electricity if there is even a slight chance that the floor may be damp or wet.

5. Metallic plumbing pipes should be grounded to the electrical system; use caution around them.

6. When the project or repair is completed, test the circuit with an electrical tester to make sure that everything is in good working order.

7. Do install ground fault circuit interrupters (GFCI) to protect against electric shocks in bathrooms, kitchens, garages, outdoor circuits and other places as required by Code.

8. Do use only wire and electrical accessories stamped with “U.L.”, indicating that the product has been tested and approved by Underwriters Laboratory.

9. Do not attach two or more wires under the same screw; instead, use a short piece of wire (a “pigtail”) and connect it along with the other wires using a wire nut or other approved splices.

When to Replace a Switch or Receptacle

Switches and receptacles must be replaced if they are malfunctioning, cracked, or broken. Examples of problems requiring further investigation:

- hot faceplate
- loose outlet connection - appliance plug slips out of or is easily pulled from outlet
- switch that arcs or sparks or causes light controlled by it to flicker
- switches or receptacles that don’t work

In general, when replacing a switch or receptacle, replace it with the same type - check ratings. For example, if your house is fitted with two prong (ungrounded) receptacles, you cannot replace them with three prong (grounded) receptacles since there may be no grounding wire in the circuit. If updating circuits, it is necessary to follow Code. This would most likely require updating circuits to accept three prong receptacles or make use of Ground Fault Circuit Interrupters (GFCI).
**Putting it Together**

By now you should have learned about the circuits in your home, how many appliances of various wattages can be tied into a circuit, what size and kind of conductors should be used in a circuit, how receptacles and switches are wired, and how to make sure that a circuit is “dead” (not energized) before working on it. In this next activity, you will use these skills to redesign your bedroom.

**ACTIVITY#12**

**Redesigning Your Bedroom**

1. Things needed
   - pencil
   - paper
   - this manual

2. What you will do
   a. How would you change the electrical circuit(s) in your bedroom *(or another room)* if you could? Changes may include the addition, deletion or movement of switches, receptacles, lights or appliances.

3. Check
   a. Ask your mom, dad, or 4-H electric leader to review your diagrams and explanations. What comments and suggestions did they share with you?

   __________________________________________
   __________________________________________
   __________________________________________

   b. Did you find any receptacles or switches that you feel needed to be replaced? If yes, why should they be replaced?

   __________________________________________
   __________________________________________
   __________________________________________

**Things to remember**

- The National Electric Code® makes specific suggestions on the distance between receptacles, numbers allowed per circuit size, etc. For more specific information on these suggestions, refer to the NEC or your local code.
4-H CLUB RECORD

Electric Project
Division V

NAME _________________________________________________ AGE__________ YEAR _________

NAME OF CLUB ________________________________________ YEARS IN CLUB _________________

TOWNSHIP _______________________________ COUNTY ________________________________

I have reviewed the progress of this record and believe it to be correct:
Signature of Leader _________________________________________________________ Date _____________
Signature of Leader _________________________________________________________ Date _____________
Signature of Leader _________________________________________________________ Date _____________

Demonstration you gave on something you learned in the electric project this year.
Title or subject ______________________________________________________________________________
Given before: Local 4-H Club ________________________ County electric meeting ______________________
County demonstration contest ________________________ Other organization _________________________
How many times given? ____________________________

FIELD TRIPS
To where _________________________________________________________________________________

What new things did you learn about electricity on the field trip? _________________________________
_________________________________________________________________________________________
What did you learn?
1. A light fixture can be controlled from three separate locations by installing what types of switches?

2. When replacing a receptacle you encountered two brass, two silver and one green screw on the receptacle. The wires are black, white and bare copper. Which wire(s) should be connected to the brass screws?

Which wire(s) should be connected to the silver screws?

Which wire(s) should be connected to the green screw?

3. Determine the number of circuits, the type of circuits, and the size of breaker (or fuse) needed for each circuit for a kitchen with the following appliances: microwave, popcorn popper, coffee maker, dishwasher, refrigerator, toaster, food processor, and electric fry pan. (Note: if the wattage is not listed on the appliance’s nameplate you will need to calculate the watts using the formula: volts x amps = watts.)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>VOLTS</th>
<th>AMPS</th>
<th>WATTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>microwave</td>
<td>120</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>popcorn popper</td>
<td>120</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>coffee maker</td>
<td>120</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>dishwasher</td>
<td>120</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>refrigerator</td>
<td>120</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td>toaster</td>
<td>120</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>food processor</td>
<td>120</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>electric fry pan</td>
<td>120</td>
<td>10.0</td>
<td></td>
</tr>
</tbody>
</table>

Draw a diagram, in the space provided, of each circuit with the breaker (or fuse) size and appliances connected to each. (NOTE: Indicate which appliances on each circuit cannot be used at the same time.)
### 4-H ELECTRIC POSTER & DISPLAY BOARD CHECK SHEET

<table>
<thead>
<tr>
<th>Item</th>
<th>Satisfactory</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Title</td>
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</tr>
<tr>
<td>Suitable Subject and Size</td>
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<td></td>
</tr>
<tr>
<td>(as outlined in 4-H Electric manuals)</td>
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<td></td>
</tr>
<tr>
<td>Attracts Interest</td>
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<td></td>
</tr>
<tr>
<td>(original, good use of color)</td>
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</tr>
<tr>
<td>Subject</td>
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<td></td>
</tr>
<tr>
<td>(encourages thought)</td>
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<td></td>
</tr>
<tr>
<td>Accomplishes Purpose</td>
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<td></td>
</tr>
<tr>
<td>Mounting on Stiff Backing</td>
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<tr>
<td>Workmanship</td>
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<tr>
<td>(neat, safe)</td>
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<td></td>
</tr>
<tr>
<td>Placing</td>
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</table>

### 4-H ELECTRIC EQUIPMENT CHECK SHEET

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<th>County</th>
<th>Per Cent</th>
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<tbody>
<tr>
<td>WORKMANSHIP</td>
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<td>30</td>
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<tr>
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<td>Purchased vs. Made</td>
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</tr>
<tr>
<td>Quality—Electrical</td>
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<tr>
<td>Quality—Mechanical</td>
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</tr>
<tr>
<td>Materials—Practical</td>
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<tr>
<td>USEFULNESS</td>
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<tr>
<td>SAFETY</td>
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</tr>
<tr>
<td>Electrical</td>
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<td></td>
</tr>
<tr>
<td>Mechanical</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>ORIGINALITY</td>
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<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Placing ..................
Appendix 1.

Replacing an Outlet/Receptacle

Materials and Tools Needed:
• screwdriver
• needle nose pliers
• outlet tester
• new receptacle
• sandpaper

Replacing an existing receptacle (outlet) is a relatively simple procedure. Always replace any receptacle with the same type (same ratings, not necessarily the same brand) as the one you are removing. Most outlets in the home will be duplex (accepts two plugs). Make sure that the new receptacle is U.L. approved.

Replacing an End of the Run Receptacle

An “end of the run” receptacle is an outlet at the end of a circuit. There may be three conductors coming into the box: one black-insulated current carrying conductor(wire), a white-insulated grounded conductor, and a bare or green-insulated grounding conductor.

Removing receptacle from the wall:

1. Turn off power to the circuit containing the receptacle which you are about to replace. This can be done by flipping the correct breaker or removing the correct fuse. If in doubt, turn off all the power in the house.
2. Using an outlet tester (or other voltage testing device), double check to make sure that the receptacle is dead.
3. Remove the screws holding the cover plate.
4. Remove the cover plate.
5. Remove the mounting screws attaching the receptacle to the box.
6. Pull the receptacle away from the box as far as the wires will easily allow.
7. Loosen the hot, neutral and grounding terminal screws and unhook the wires from the old receptacle.

   Note: The black wire should be attached to the brass terminal; the white wire should be attached to the silver terminal; the grounding wire (bare copper or green) should be connected to the grounding terminal located at one corner of the receptacle. If you are looking at the receptacle because a polarity checker test indicated a wiring problem, examine the connections to see if the wires were incorrectly attached. If they were, simply reconnect the wires to the proper terminals following the procedure outlined below.

Installing a new receptacle:

1. Scraper the bare ends of the wires to remove dirt and corrosion. Sometimes a better way is to use a fine-grit sandpaper to remove dirt and corrosion from the wires.
2. Loosen the screw terminals on the new receptacle as much as possible but do not remove them.
3. Hook the white wire around the shank of the silver-colored terminal screw. Be sure the end of the hook faces in the same direction that the terminal screw tightens (clockwise). Tighten the screw on the wire securely.
4. If the receptacle is a grounding type, connect the grounding wire (copper or green) to the green grounding terminal screw. Be sure the end of the hook faces in the same direction that the terminal screw tightens (clockwise). Tighten the screw on the wire securely.
5. Hook the black wire to the brass terminal on the opposite side of the receptacle. Be sure the end of the hook faces in the same direction that the terminal screw tightens (clockwise). Tighten the screw on the wire securely.
6. Recheck your connections. An error in connecting the wires could cause a short circuit.
7. Fold the wires as needed to get any excess length of wire back into the box, then push the receptacle into the outlet box. (NOTE: Make sure any grounding conductor(s) stay well clear of the hot terminals on the receptacle.)
8. Replace the mounting screws and secure the receptacle to the box.
9. Replace the cover plate and screws.
10. Turn on power to the receptacle.
11. Use an outlet tester (or other voltage testing device), to check for correct polarity and grounding.
Replacing a Middle of the Run Receptacle

Replacing a “middle of the run” receptacle is similar to replacing an “end of the run” receptacle except there are more wires involved. These extra wires (black and white) supply electricity to another receptacle(s) further “down-stream” in the circuit. In addition to the extra hot and neutral wires, there are incoming and outgoing grounding wires.

Removing receptacle from wall:

- Follow the same steps as with the end of the run receptacle. You will have two black and two white wires in the box (one coming from the previous receptacle and one going to the next). You may notice the two black wires are “pigtailed” together with a third short black wire (using a wire nut) which goes to one of the brass screws. If there is no pigtail, the two wires would simply be attached individually to the two brass screw terminals on the receptacle. Like the black wires, the white wires may be pigtailed together with a third wire or attached individually to silver screw terminals.

- If non-metallic (plastic, fibreglass) boxes are being used, the two grounding wires (bare or green insulated) in the NM cable must be tied together with a third short wire (bare or green insulated) in a pigtail using a wire nut. The third wire connects to the grounding screw on the receptacle.

- If metal boxes are being used, the grounding conductors in the NM cable would be pigtailed together with two short bare or green-insulated grounding conductors. One of the short wires is connected to the green-colored machine screw on the receptacle. The other is secured to the box with a grounding clip or a green machine screw using the threaded hole in the back of the box.

Installing a new receptacle:

- Follow the same steps as in the end of the run receptacle.

- Remember that the two black wires and the two white wires may be connected with a pig-tail so that only one black and one white wire will need to be connected to the proper screws on the receptacle or, all each of the four of the wires may go to individual screws. The pigtail method is the “preferred” method and is used most often today.

- Remember, for non-metallic boxes, the grounding conductor is simply attached to the grounding terminal on the receptacle. For metal boxes, a short grounding wire must be attached to the grounding terminal on the receptacle and another short grounding wire must be attached to the electrical box.

Note: When using a metal box, the grounding conductors in the NM cables must connect to the grounding screws on both the box and the receptacle. Notice how the next size larger (red) wire nut is being used to connect four wires.
Appendix 2. Replacing Switches

<table>
<thead>
<tr>
<th>Materials and Tools Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>• screwdriver</td>
</tr>
<tr>
<td>• needle nose pliers</td>
</tr>
<tr>
<td>• new switch</td>
</tr>
<tr>
<td>• sandpaper</td>
</tr>
<tr>
<td>• wire stripper</td>
</tr>
</tbody>
</table>

Switches that are too loud or malfunctioning in some way need to be replaced. Replacing a switch is a relatively simple procedure. Switches are standardized so they will fit all boxes and faceplates. It is critical that switches are replaced with the same type (not same brand). Check amperage ratings and wire type on the switch that is being replaced and make sure the new switch has U.L. approval.

Replacing Single Pole Switches with Terminal Screws

To remove the old switch from the wall:

1. Turn off power to the circuit containing the switch which you are about to replace. This can be done by flipping the correct breaker or removing the correct fuse. If in doubt, turn off all the power in the house.
2. After turning off power to the circuit, double-check that power is off by turning the light switch to the “on” position. If the light comes on, you have turned off the wrong circuit. You need to locate and turn off the correct breaker or remove the correct fuse and then re-test for the power being off.
3. Remove the screws holding the cover plate.
4. Remove the cover plate.
5. Remove the mounting screws attaching the switch to the box.
6. Pull the switch away from the box as far as the wires will easily allow.
7. Loosen the two brass-colored terminal screws and the grounding terminal screw and unhook the wires from the old receptacle.

Note: There are two black wires attached to the terminals; the grounding wire (green or bare copper) will be attached to the green screw on the new switch.

To install a new switch:

1. If needed, removed enough insulation from the wires so that they can wrap three-quarters of the way around the screw terminals. Clean the bare ends of the wires with fine sandpaper to remove dirt and corrosion. Bend the wires into little loops with the pliers so they can be hooked around the screws.
2. Fully loosen (but don’t remove) the screw terminals from the new switch.
3. Hold the switch so that the “OFF” marking on the toggle will be at the top.
4. Connect the wires to the screw terminals. The black wires can be placed under either screw. Be sure the end of the hook faces in the same direction that the terminal screw tightens (clockwise). Tighten the screws on the wires securely.
5. If the switch is grounded, connect the grounding wire to the green screw on the new switch. Be sure the end of the hook faces in the same direction that the terminal screw tightens (clockwise). Tighten the screws on the wires securely.
6. Recheck your connections. An error in your connection could cause the circuit breaker to trip or the fuse to blow.
7. With the switch in its off position, align the switch so that “OFF” is pointed toward the ceiling. Fold the wires as needed to get any excess length of wire back into the box, then push the switch into the electrical box. (NOTE: Make sure any grounding conductor(s) stay well clear of the hot terminals on the switch.)
8. Replace the mounting screws and secure the switch to the box.
9. Replace the cover plate and screws.
10. Turn on power to the circuit.
11. Test the switch by moving it on and off several times and observing the light.
Replacing Three-way Switches

To remove the old switch from the wall:

1. Turn off power to the circuit containing the switch which you are about to replace. This can be done by flipping the correct breaker or removing the correct fuse. If in doubt, turn off all the power in the house.
2. After turning off power to the circuit, double-check that power is off by turning the light switch to the “on” position. If the light comes on, you have turned off the wrong circuit. You need to locate and turn off the correct breaker or remove the correct fuse and then re-test for the power being off.
3. Remove the screws holding the cover plate.
4. Remove the cover plate.
5. Remove the mounting screws attaching the switch to the box.
6. Pull the switch away from the box as far as the wires will easily allow.
7. Loosen the two brass-colored terminal screws, the black or copper-colored common terminal screw, and the grounding terminal screw and unhook the wires from the old receptacle.

Note: there should be four wires connected to the old switch. Two of these wires will be connected to brass terminal screws while the third will be fastened to a black or copper colored terminal screw, and the last to the grounding terminal screw. Mark the wire connected to the black or copper-colored screw with a piece of “tan” masking tape so that you won’t lose track of where it goes. (Other wires may have colored tape on them.)

To install a new switch:

1. If needed, removed enough insulation from the wires so that they can wrap three-quarters of the way around the screw terminals. Clean the bare ends of the wires with fine sandpaper to remove dirt and corrosion. Bend the wires into little loops with the pliers so they can be hooked around the screws.
2. Fully loosen (but don’t remove) the terminal screws from the new switch.
3. Connect the wires to the screw terminals. Make sure that the wire you marked with the tape goes back on the terminal with the black or copper-colored screw. The other two wires go to either of the brass screws and the grounding wire goes to the green screw. Hook wires securely around the screws. Be sure the end of the hook faces in the same direction that the terminal screws tighten (clockwise). Tighten the screws on the wires securely.

![3-Way Switch – Middle of the Run](image-url)
Note: “Three-wire plus ground” type NM cable is often used for wiring three-way switches with the white and red wires in these cables being used in very specific ways. The wires going to the brass-colored screws may not both have black insulation; one could be black and another black but marked with a red “stripe” or else one could be red and another white but marked with a red “stripe.” It is OK to reverse either of the two wires going to the brass screw terminals without affecting the switch’s function.

4. If the switch is grounded, connect the grounding wire to the green screw on the new switch. Be sure the end of the hook faces in the same direction that the terminal screw tightens (clockwise). Tighten the screws on the wires securely.

5. Recheck your connections. An error in your connection could cause the circuit breaker to trip or the fuse to blow.

6. Fold the wires as needed to get any excess length of wire back into the box, then push the switch into the box. For a three-way switch, there is no need to orient the switch a certain direction when installing it in the box. If you look at the toggle, you will notice it does not even have “On” and “Off” markings.

(NOTE: Make sure any grounding conductor(s) stay well clear of the hot terminals on the switch.)

7. Replace the mounting screws and secure the switch to the box.

8. Replace the cover plate and screws.

9. Turn on the power to the circuit.

10. Test the switch by moving it on and off several times and observing the light. Go to the other three-way switch that controls the light and test the light from that switch as well.
Replacing Light-Dimmer Switches

Materials and Tools Needed

- screwdriver
- needle nose pliers
- new dimmer switch
- sandpaper
- wire stripper

Dimmer switches allow the intensity of the light to be controlled. This is desirable to save energy and to create moods.

To remove the old dimmer switch from the wall:

1. Turn off power to the circuit containing the switch which you are about to replace. This can be done by flipping the correct breaker or removing the correct fuse. If in doubt, turn off all the power in the house.
2. After turning off power to the circuit, double-check that power is off by turning the light switch to the “on” position. If the light comes on, you have turned off the wrong circuit. You need to locate and turn off the correct breaker or remove the correct fuse and then re-test for the power being off.
3. Remove the screws holding the cover plate.
4. Remove the cover plate.
5. Remove the mounting screws attaching the switch to the box.
6. Pull the switch away from the box as far as the wires will easily allow.
7. Loosen the two brass-colored terminal screws and the grounding terminal screw and unhook the wires from the old receptacle. If the dimmer switch does not have screw terminals but has leads instead, remove the wire nuts and disconnect the wires.

Note: there are two black wires attached to the terminals; the grounding wire (green or bare copper) should be connected to the green screw on the new switch. Some dimmer switches come with short black wires extending out from the body of the switch. In this case, the switch is connected into the circuit using wire nuts.

Note: Some dimmer switches may not use screw terminals but instead have two

To install a new dimmer switch:

1. If needed, removed enough insulation from the wires so that they can wrap three-quarters of the way around the screw terminals. Clean the bare ends of the wires with fine sandpaper to remove dirt and corrosion. Bend the wires into little loops with the pliers so they can be hooked around the screws.
2. If the dimmer switch has screw terminals, loosen (but don’t remove) the screws on the new switch.
3. Hook the wires securely around the screws. Be sure the end of the hook faces in the same direction that the terminal screws tighten (clockwise). Tighten the screws on the wires securely.
4. Most dimmer switches have two wires coming from them. These wires are connected to the permanent wires with wire nuts. Either wire coming from the switch can be connected to either of the permanent wires.
5. Recheck your connections. An error in your connection could cause the circuit breaker to trip or the fuse to blow.
6. Fold the wires as needed to get any excess length of wire back into the box, then push the switch into the box.
7. Replace the mounting screws and secure the switch to the box.
8. Replace the cover plate and screws.
9. Install the control knob.
10. Turn the power on to the circuit.
11. Test the dimmer knob by turning it on and off several times.
Appendix 3. **Wiring Around Your Home**

Glossary of Electrical Terms related to Residential Wiring

**Ampacity**: The current in Amperes that a conductor can carry continuously under the conditions of use without exceeding the conductor’s temperature rating.

**Ampere**: The measurement of the rate of flow of current in an electrical circuit. One Ampere is the measurement of the rate at which current that will flow through a resistance of 1 Ohm when an electrical potential of 1 Volt is applied across that resistance. Sometimes this term is shortened to the word “Amp.”

**Arc-Fault Circuit Interrupter (AFCI)**: A device that is able to sense when an electrical arc occurs somewhere in a circuit and acts to de-energize the circuit connected to it.

**AWG (American Wire Gauge)**: This is the industry standard used to specify the size of electrical conductors. There are 40 different electrical conductor sizes ranging from 36 AGW (smallest) to 0000 AWG (largest). Each consecutive AGW size is 1.26 times smaller or bigger in diameter than the next. The larger the diameter, the greater the conductor’s current carrying capacity (ampacity).

**Ballast**: A device that is an integral part of a fluorescent light. It is used to regulate the amount of current which is allowed to flow though the light.

**Bonding**: Connecting the metal parts of electrical components together to assure electrical conductivity between them. It is the practice of intentionally electrically connecting all exposed metallic items not designed to carry electricity in a room or building as protection from electric shock.

**Bonding Jumper, Main**: This is a connection made between the grounded circuit conductor (Neutral) and the equipment grounding conductor inside the service entrance panel.

**Branch Circuit**: Consists of the circuit conductors that are between the final overcurrent device (fuse/circuit breaker) protecting the circuit and the outlet(s) which are part of that circuit. There are three types of branch circuits – General Purpose, Small Appliance, and Individual.

**Circuit Breaker**: A circuit protection device that is designed to either be 1) manually operated to open or close a circuit; or 2) automatically open a circuit when a predetermined overcurrent flows through the circuit. These are most often used inside the service entrance panel.

**Continuous Load**: An electrical load where the maximum current in a circuit is expected to continue for a period of 3 hours or longer. A continuous load shall not exceed 80% of the rating of the branch circuit.

**CU**: A marking on wire connectors, lugs and device terminals that indicates they are suitable for use with Copper conductors only.

**Current**: The flow of electricity (electrons) through an electrical circuit. Current is measured in Amperes.

**Dedicated Circuit**: See Individual Branch Circuit.

**Duplex Receptacle**: An electrical outlet that allows two plug-and-cord-connected devices to be connected to the house wiring system and receive power at the same time.

**Floor Plan**: A scale diagram of a room or building drawn as if seen from above. Floor plans show construction details such as placement of plumbing, the electrical system, and doors and windows.

**Fuse**: An overcurrent protection device with a fusible link which melts during an overcurrent condition in a circuit in order to stop the flow of electricity. Fuses can often be found in older service entrances panels and come in various ratings and form-factors.

**Ground**: The earth. It is used as the “common reference point” for measuring electrical potential (voltages) within an electrical system.
**Grounded (Grounding):** Connected to the ground or connected to an electrically conductive item that physically extends the connection to the ground.

**Grounded Conductor:** (Not to be confused with Grounding conductor.) For residential wiring, this is the “Neutral” wire which is the one with the white insulation.

**Ground Fault:** An unintentional, connection between a current carrying conductor and non-current carrying (grounded) parts of an electrical system (other conductors, metal enclosures, conduit, earth, etc.) causing current to flow on an unintended path (Ground-Fault Current Path).

**Ground Fault Circuit-Interruption (GFCI):** A device used to protect persons from the risk of bodily injury by de-energizing a circuit within a very short period of time when the current flowing to ground exceeds .006 amperes.

**Ground-Fault Current Path:** The path on which fault current flows beginning at the point of the ground fault and flowing through normally non-current carrying parts of the electrical system back to the electrical supply source.

**Grounding Conductor:** A conductor that is used to connect equipment or the grounded circuit of a wiring system to the grounding electrode or electrodes. In residential wiring, this is typically a 4 AWG – 8 AWG bare copper wire.

**Grounding Electrode:** A conducting material making a direct connection to the earth. This could be a metal water pipe, concrete-encased bare copper conductor, or a ground rod. Ground rods must be at least 0.5” in diameter and at least 8’ long.

**Individual Branch Circuit:** A branch circuit that supplies only one piece of utilization equipment (such as an electric range). Typically, a single receptacle (not a Duplex receptacle).

**Insulated/Insulation:** A non-conductive covering applied to wires or placed between conductive materials to prevent current from leaving a conductor and flowing on an unintended path.

**Lighting Outlet:** An outlet intended for the direct connection of a lamp holder or luminaire.

**Load:** The electrical power consumed by the devices attached to an electrical system. Loads can be of several types, the main ones being – Continuous, Non-Continuous, and Intermittent.

**Load Balancing:** The arrangement or sequence of attaching conductors to the panelboard (service entrance panel) in order to balance the anticipated loads on the phase conductors. With a balanced load, the connected equipment would draw an equal current through each 120-volt leg of a 120V/240V electrical system. Generally speaking, the simplest way to balance the load on a panelboard is to connect an equal number of branch circuits to each phase conductor.

**Load Center:** Also known as a Service Entrance Panel or Residential Panel Board. Circuit breakers typically “plug-in” to load centers whereas they “bolt-in” to panel boards.

**Location Damp:** An exterior or interior location that is normally or periodically subject to condensation of moisture in, on, or adjacent to, electrical equipment, and includes partially protected locations.

**Location Dry:** A location not normally subject to dampness, but may include a location subject to temporary dampness, as in the case of a building under construction, provided ventilation is adequate to prevent an accumulation of moisture.

**Location Wet:** A location in which water or other liquid can drip, splash, or flow on or against electrical equipment.

**Luminaire:** A complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light source and connect it to a power supply. Prior to the National Electrical Code adopting this term, “lighting fixture” was the commonly used term. This term is still used more often than luminaire.
**Maximum Continuous Load**: Defined to be 80% of the circuit rating (protection device). Any electrical load that operates for a period of 3 hours or more on a branch circuit shall not exceed 80% of the circuit rating (protection device).

**National Electrical Code (NEC)**: The electrical code published by the National Fire Protection Association. This code provides for practical safeguarding of persons and property from hazards arising from the use of electricity. It does not become law until adopted by federal, state, and local laws and regulations.

**Neutral Conductor**: The conductor connected to the neutral point of an electrical system that is intended to carry current under normal conditions.

**Ohm**: A unit of measure for electrical resistance. One Ohm is the amount of resistance that will permit one Ampere of current to flow when one Volt is applied across the resistance.

**Open Circuit**: A circuit that does not have a continuous path over which current can flow. Turning off a switch creates an open circuit (good), while a loose connection also can create an open circuit (bad).

**Outlet**: A point on the wiring system at which current is taken to supply utilization equipment.

**Overcurrent**: Any current is excess of the rated current of the equipment or the ampacity of a conductor.

**Overcurrent Device**: Also referred to as an Overcurrent Protection Device and is a form of protection that operates when current exceeds a pre-determined value. These devices are primarily consist of circuit breakers and fuses.

**Overload**: Operation of equipment in excess of the normal full-load rating, or of a conductor in excess of its rated ampacity, that over time, would cause damage or dangerous overheating.

**Receptacle**: A receptacle is a contact device at the outlet for the connection of an attachment plug.

**Receptacle Outlet**: An outlet where one or more receptacles are attached.

**Romex**: A trade name for Nonmetallic Sheathed Cable (NM).

**Service**: The conductors and equipment for delivering energy from the servicing utility to the wiring system of the premises served.

**Service Conductors**: The conductors running from the service point to the service disconnecting device.

**Service Drop**: The overhead service conductors from the last pole or other aerial support that connect to the service-entrance conductors at the building.

**Service Entrance Panel (SEP)**: A metal enclosure that houses circuit protection devices (circuit breakers or fuses) and provides the means by which power is divided up to be distributed to the individual circuits. It contains a “Main” breaker that allows the power from the utility company to be disconnected from the entire building.

**Service Equipment**: The equipment intended to be the main control and means of cutting off of the supply of electricity to a building. This usually consists of a circuit breaker or switch and fuse and their accessories.

**Short Circuit**: A connection between any two or more conductors of an electrical system in such a way as to significantly reduce the resistance of the circuit. This situation causes the current to flow outside of the intended path, hence the term “Short Circuit.” A short circuit is referred to as a “Fault.”

**Split-Circuit Receptacle**: A standard duplex receptacle whose “break-away” tabs have been removed and is connected such that one half of the receptacle supplies power all the time while power to the other half is controlled by a switch.

**Surface-Mounted Luminaire**: A luminaire mount directly on (surface of) the ceiling or a wall.

**Switch**: A device use to control (enable or disable) the flow of electricity in a circuit or portion of a circuit.

**Terminal**: A screw or quick-connect device where a conductor is intended to be connected.
**Three-way Switch**: A type of switch that is used in pairs to allow you to control the power supplied to a light or receptacle from two different locations.

**UL**: Underwriters Laboratories (UL) is an independent not-for-profit organization that develops standards and tests electrical equipment to those standards.

**UL-Listed**: Indicates that an item has been tested and approved to the standards established by the UL for that particular item.

**Ungrounded**: Not connected to ground or a conductive body that extends to the ground connection.

**Volt**: A measurement of electrical potential energy. It is the difference in electrical potential between two points of a conductor carrying one Ampere when the power being dissipated between those two points is one Watt.

**Voltage (nominal)**: A value assigned to a circuit or system for the purpose of specifying its (nominal) operating voltage. In residential systems the nominal voltage would be specified as 120/240 Volts. In practice, the actual voltages can vary slightly around the specified nominal voltages.

**Voltage Drop**: A reduction in voltage (difference in electrical potential energy) at a given point in a circuit due to current flowing through a resistance (typically the conductors in a circuit). The voltage drop across any given length of conductor can be calculated by “Ohm’s Law”: \( E = I \times R \) (voltage = current x resistance).

**Watt**: A unit of power. It is equal to: \( W = E \times I \) (energy = voltage x current).

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**Answers to Questions in Activity #1** (correct answer highlighted)

1. **Why do two switches connect to the paddle fan?**
   - Slow/Fast Speeds  **One for Light/One for Fan**

2. **How many lights are connected to 3-way switches?**
   - 1  4  5

3. **Where are multiple lights controlled by one switch?**
   - **Garage Exterior, Bath, Bedroom 2**

4. **What two appliances are shown using 240 Volts?**
   - **Clothes Dryer, Range**

5. **Which five areas use GFCI-protected receptacles?**
   - **Bath, ½ Bath, Kitchen, Garage, Front Porch**

6. **Which room makes use of Split-Circuit receptacles?**
   - **Bedroom 1**

7. **Where is the Service Entrance Panel located?**
   - **In the Garage**

8. **What does WP stand for on an outdoor receptacle?**
   - **Weatherproof**