RESIDENTIAL ELECTRICAL WIRING

GFCIs AND AFCIs

TEACHER’S GUIDE
INTRODUCTION

This Teacher’s Guide provides information to help you get the most out of Residential Electrical Wiring: GFCIs and AFCIs. The contents in this guide will allow you to prepare your students before using the program and present follow-up activities to reinforce the program’s key learning points.

This program is part of an eight-part video series titled Residential Electricity and Wiring. This series teaches the student step-by-step how to safely and effectively connect, install, and repair residential electrical wiring. Common aspects of residential wiring are explored including:

- Setting up the main panel
- Properly wiring appliances, fixtures, receptacles, and switches
- Ensuring safety through proper grounding and surge protection devices

In addition to procedures involved with new construction and wiring, examples of what an electrician might find when performing renovation work are also incorporated. Safe work practices and techniques are emphasized throughout the programs, and the importance of following the current National Electrical Code and local regulations is stressed.

Ground-fault and arc-fault circuit interrupters offer the peace of mind homeowners want—and the life-saving protection that building codes require. This topic is the focus of GFCIs and AFCIs. After explaining where GFCIs and AFCIs must be used, this video illustrates how to wire and test GFCI receptacles, GFCI circuit breakers, and AFCIs.

LEARNING OBJECTIVES

After viewing the program, students will be able to:

- Realize that the safety of people and property are an important part of the electrician's job.
- Identify the role of the National Fire Protection Association (NFPA) and the purpose of the National Electrical Code (NEC).
- Describe common types of ground-faults and their causes.
- Explain the purposes of GFCIs and AFCIs.
- Distinguish the difference between a GFCI and an AFCI.
- Provide examples of circumstances when a GFCI or an AFCI would be required.
- Explain how to install a GFCI and an AFCI.

EDUCATIONAL STANDARDS

National Standards

This program correlates with the National Competency Standards and Objectives from the National Center for Construction Education and Research. The content has been aligned with the following educational standards and benchmarks from this organization.
Describe the risks associated with working around electricity and high voltage.
Identify electrical hazards and how to avoid or minimize them in the workplace.
Define the units of measurement that are used to measure the properties of electricity.
Explain how voltage, current, and resistance are related to each other.
Explain the purpose of ground-fault circuit interrupters and tell where they must be installed.
Explain how ground-fault circuit interrupters (GFCIs) can save lives.
Explain the role of the NEC® in residential wiring.
Describe the purpose of the National Electrical Manufacturers’ Association (NEMA) and the National Fire Protection Association (NFPA).

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English Language Arts Standards
The activities in this Teacher’s Guide were created in compliance with the following National Standards for the English Language Arts from the National Council of Teachers of English.

Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.
Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

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Technology Standards
The activities in this Teacher’s Guide were created in compliance with the following National Education Technology Standards from the National Education Technology Standards Project.

Students demonstrate a sound understanding of the nature and operation of technology systems.
Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.
Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
Students employ technology in the development of strategies for solving problems in the real world.
Students use technology tools to enhance learning, increase productivity, and promote creativity.

The National Education Technology Standards reprinted with permission from the International Society of Technology Education.
PROGRAM OVERVIEW

Ground-fault and arc-fault circuit interrupters offer the peace of mind that homeowners want—and the life-saving protection that building codes require. After explaining where GFCIs and AFCIs must be used, this video illustrates how to wire GFCI receptacles, GFCI circuit breakers, and AFCIs and then how to test them.

MAIN TOPICS

Topic 1: Introduction to Ground-faults and GFCIs
The first segment explains how a ground-fault occurs and what a GFCI does in the event of a ground-fault. Situations where a GFCI is required are identified in accordance with the NEC code. The role of the NEC and the NFPA in developing standards and regulations is discussed.

Topic 2: GFCI Types and Devices
The second segment describes the types of GFCI devices and explains the difference between receptacles and circuit breakers. The advantages and disadvantages of each are outlined, including a discussion of “nuisance tripping.”

Topic 3: Installing GFCIs
This topic explains the importance of proper GFCI installation. Proper connection is discussed, including definitions of the line side and the load side of a GFCI receptacle, and identification of each color lead. Examples of correct and incorrect installations are provided, allowing the viewer to see the effects of each.

Topic 4: Testing and Limitations of GFCIs
The discussion of GFCIs ends with an overview of testing a GFCI device. Drawbacks and limitations of GFCI devices are also made clear.

Topic 5: Arc Faults and AFCIs
This segment explains how an arc fault occurs, emphasizing the dangers associated with this type of fault. Situations that call for an AFCI are identified. The advantages and disadvantages of circuit breakers and receptacles are discussed.

Topic 6: Installing an AFCI
The final segment of the program outlines proper installation of an AFCI device, pointing out similarities between AFCI and GFCI installation. Basic safety rules are reviewed.
FAST FACTS

- A ground-fault circuit interrupter, or GFCI, protects against electrical shock. An arc-fault circuit interrupter, or AFCI, protects against electrical fire.
- A ground-fault can occur if you touch a faulty electrical appliance. The shock you receive from this could cause serious injury or even electrocution.
- Quickness of response is why GFCI’s are used, even on grounded circuits. The GFCI device will open the circuit much faster than a standard circuit breaker.
- In wet or damp circumstances, a person’s body has less resistance to conducting electricity. This increases their risk of electrical shock.
- The National Fire Protection Association is responsible for ensuring that standards are established to safeguard persons and property from hazards arising from the use of electricity.
- The National Electrical Code is a document produced by a consensus process that is open to public comment and to proposals for changes.
- Class B GFCI devices were used only for underwater swimming pool lighting that was installed before the adoption of the 1965 National Electrical Code.
- Since GFCI’s are very sensitive, they can sometimes be tripped when a situation isn’t dangerous. This is referred to as “nuisance tripping.”
- It’s extremely important that you connect protected devices on the load side of a GFCI receptacle, so that it will operate correctly.
- You should never connect a GFCI or an AFCI to a multiwire branch circuit. This is a circuit where two circuits share a common neutral connection.
- Monthly testing of GFCI receptacles is recommended to make sure that the GFCI mechanism will operate properly.
- The temperature of an arc can reach 10,000 degrees Fahrenheit or more—easily hot enough to start a fire. Arc faults are a leading cause of residential fires.
- Conventional circuit breakers and fuses cannot detect arc faults because these faults are often intermittent rather than solid contacts. Also, the level of current is often too low to trip the breaker.

VOCABULARY TERMS

ampacity: Amperage capacity.
ampere: A unit of measurement related to current.
appliances: Any equipment made for a specific purpose that uses electricity to create light, heat, mechanical motion, etc.
arc fault: An unintentional electrical discharge characterized by low or inconsistent current; resulting sparks may cause a fire.
arc-fault circuit interrupter (AFCI): Protects against electrical fire by detecting an arc-fault and shutting off power to that circuit in a fraction of a second.
conductor: Anything that passes electricity from one point to another. Electrical wires and power lines are conductors.
continuity: Formed by a complete circuit of properly connected grounding conductors.
fixed appliance: An appliance, such as a dishwasher, that’s fastened at a specific location.
grounded: Connected to the earth or to something that conducts electricity to the earth, such as a water pipe.
**ground-fault**: When something or someone provides an unintentional path between a source of electrical current and the ground. This can happen if you touch a faulty electrical appliance, and it can cause electrocution. Ground-faults can also cause fires.

**ground-fault circuit interrupter (GFCI)**: Protects against electrical shock by detecting a ground-fault and shutting off power to that circuit in a fraction of a second.

**nuisance tripping**: Tripping that occurs in a GFCI when a situation isn’t dangerous.

**transformer**: A device used to change the levels of voltage and current, but not of power. Higher voltages result in lower current, and lower voltages result in higher current.

**tripping**: A temporary stop in current.

**voltage**: A unit of measure denoting the force, or pressure, that moves current through a conductor. Represented by the letter “E,” for electro-motive force.

**wattage**: A unit of measure denoting amount of usable power. Represented by the letter “P,” for power.

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**PRE-PROGRAM DISCUSSION QUESTIONS**

1. How is electricity generated?
2. What is a ground-fault?
3. What are the hazards of working with electricity?
4. What is the NEC? Why is it important?
5. What do you think are the pros and cons of working as an electrician?

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**POST-PROGRAM DISCUSSION QUESTIONS**

1. What challenges might you face when installing a new receptacle in an older home?
2. What factors might prompt an electrician to do work that exceeds or is “above code”?
3. Why is it important to follow the current NEC code?
4. What OSHA regulations might apply to your job as an electrician?
5. Based on the information learned in the video, what classes do you think you should take to prepare for a job as an electrician?

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**GROUP ACTIVITIES**

**On-the-Job Journal**

In this activity, students visit a new residential construction site to observe the location and installation of GFCIs and AFCIs at the site. They ask an on-site electrician to show them the various components of the electrical service installation and explain any factors affecting the wiring needs of the residence.

When students return to the classroom, ask them to write a one or two-page journal entry about their field trip. Students should discuss the location and installation of GFCIs and AFCIs, and note any special comments the electrician made during their visit. They should also include their thoughts about what they learned during their field trip and any questions they may have about GFCIs and AFCIs.
Who’s Using All the Electricity?
In this activity, students ask their parents for a statement from their electric provider. Then, students gather in groups of four to compare the amount of electricity each family used during a given period of time. While they review the statements, students should answer the following questions:

- Is there a great difference between the amount of electricity each home uses?
- If so, why do you think some families are using more electricity than others? Why do you think some families use less?
- Do you think the number of family members makes a difference in the amount of energy a home uses? Do you think the age of each family members affects energy usage? Why or why not?

Students should answer these questions and address any other points you feel are relevant in one or two paragraphs.

INDIVIDUAL STUDENT PROJECTS

Power to Your Home
In this activity, students write two to four paragraphs on how power is consumed in their home and how they think this usage can be modified. Students should keep the following questions in mind:

- Which appliances are used most often?
- Do students think certain appliances are used more often than they should be?
- How can students cut down on the amount of power they use at home?
- What are the benefits of cutting down on power usage at home?

What is the NEC?
In this activity, students use the Internet or your local library to obtain a current edition of the National Electrical Code. They write a one page paper that explains what the NEC is and why it is important, summarize the types of information that can be found in the NEC handbook, and explain why it is updated annually.

INTERNET ACTIVITIES

Tricks of the Trade
In this activity, students use the Internet to identify and explore trade organizations and on-line publications for electrical and construction professionals.
Occupational Outlook
In this activity, students visit the U.S. Department of Labor’s Bureau of Labor Statistics Web site (http://www.bls.gov/oco/home.htm) to explore the Occupational Outlook Handbook. They search the database to find out more about the job outlook for electricians over the next decade including salary ranges, work conditions and future industry trends.

What are the Electricity Needs of Your Area?
In this activity, students use Google (www.google.com) or a similar search engine to research the average energy needs versus the average energy usage of their area. When they have completed their research, they should answer the following questions:

• Does the average energy requirements of their area equal the average energy usage, or does their area use more or less energy than it actually needs?
• If their area is using more energy than it needs, what do students think that energy is being used on?
• If their area is using more energy than it needs, what can residents of that area do to conserve energy?

Students should present their answers in two-three written paragraphs.

ASSESSMENT QUESTIONS

Q: What is a ground-fault?
A: A ground-fault occurs when something or someone provides an unintentional path between a source of electrical current and the ground.
Feedback: This can happen if you touch a faulty electrical appliance, and it can cause electrocution. Ground-faults can also cause fires.

Q: What does a ground-fault circuit interrupter do?
A: A ground-fault circuit interrupter detects a ground-fault and shuts off power to that circuit in a fraction of a second.
Feedback: A ground-fault circuit interrupter (GFCI) is often built into a receptacle.

Q: When a ground-fault occurs, the current flowing to the load is higher than the current flowing from the load. (True or False)
A: True
Feedback: In a typical two-wire circuit, the current flowing to a load, meaning an appliance, is balanced. The current flowing to the load on the hot conductor is the same as the current flowing from the load on the grounded conductor. A ground-fault occurs when the load becomes unbalanced.
Q: According to the NEC code, which of the following new construction or remodeling 20-ampere receptacle outlets would NOT call for a GFCI?
   a. An outlet on a kitchen countertop surface
   b. A bar outlet that is 5 feet from a sink
   c. A living room receptacle that is 5 feet from the kitchen
   d. A receptacle that is 4 feet from a swimming pool

A: c
Feedback: If it detects an imbalance, the GFCI’s solid-state circuitry opens the circuit in a fraction of a second, interrupting the flow of current before it can cause harm.

Q: The ________________ is specifically responsible for ensuring that standards are established to safeguard persons and property from hazards arising from the use of electricity.
   a. National Fire Protection Association (NFPA)
   b. National Electrical Code (NEC)
   c. Occupational Safety and Health Administration (OSHA)
   d. Environmental Protection Associate (EPA)

Feedback: All electricians should be aware of and comply with the codes and standards set forth by all three of these organizations.

Q: What are the advantages of a GFCI in comparison to a standard circuit breaker?
A: If an imbalance is detected, the GFCI’s solid-state circuitry opens the circuit in a fraction of a second, interrupting the flow of current before it can cause harm. The GFCI device will open the circuit much faster than a standard circuit breaker.
Feedback: Quickness of response is why GFCI’s are used, even on grounded circuits.

Q: Every three years, the national standard for electrical wiring is revised to reflect changes required by the electrical industry. (True or False)
A: True
Feedback: The National Electrical Code is a document produced by a consensus process that is open to proposals for changes and to public comments. Technical committees review each proposal and vote on accepting or denying changing code standards.

Q: Which class of GFCI device is most commonly used today?
   a. Class A
   b. Class B
   c. Both A and B
   d. Neither A nor B

A: a
Feedback: A Class A GFCI device is designed to trip when it detects a ground-fault in the range of 4 to 6 milliamperes, meaning four-thousandths to six-thousandths of an ampere. Class B GFCI devices are essentially obsolete today.
Q: The black and white conductors on a GFCI device are the ___________.
   a. load leads
   b. useable leads
   c. free leads
   d. line leads
A: d
Feedback: The line leads are connected to the wires supplying power to the device. It’s extremely important that you connect protected devices on the load side of a GFCI receptacle, so that it will operate correctly.

Q: Describe an arc fault and provide an example.
A: An arc fault occurs when current flows across an insulating medium. For example, when an electrical cord becomes worn or damaged, current can arc momentarily, jumping from one conductor to another. Also, when there is a loose connection in a receptacle, and you plug something into it, an arc fault can occur.
Feedback: Arc faults can be line-to-neutral, meaning hot conductor to grounded conductor; line-to-line; or line-to-ground.

ADDITIONAL RESOURCES

WEB SITES

National Electrical Code
www.nfpa.org/nec

International Brotherhood Of Electrical Workers
www.ibew.org

National Electrical Safety Foundation
www.esfi.org

National Electrical Contractors Association
www.necanet.org

BOOKS

Wiring a House (For Pros by Pros) Revised and Updated edition
by Rex Cauldwell
The Taunton Press, August 2002, Paperback 256pp
ISBN: 1561585270

Residential Wiring
by Harry Sorge
Delmar Learning, December 26, 2002, Paperback 432pp
ISBN: 0766846962
**Electric Safety, VHS/DVD, Meridian Education Corporation**
Those who work with electricity encounter many hazards, including electric shock and electrical fires. This video details safety procedures for these hazards as well as protection of electrical instruments and solid-state devices. An excellent overview for those who work with electricity and as a general safety video for everyone. A Meridian Production. (21 min.)
Order #: 25284 www.meridianeducation.com, 1-800-727-5507

**Electrical Principles, VHS/DVD, Meridian Education Corporation**
This live-action video introduces the basics of electricity. Computer animation adds interest and excitement as the video comes to life in its coverage of atoms, conductors, insulators, free electrons, voltage, current, resistance, magnetism, attraction-repulsion, electromagnets, a simple circuit, and other electrical principles. Ideal for courses in electricity, physics, science, automotive, and technology. A Meridian Production. (19 min.)
Order #: 25282, www.meridianeducation.com, 1-800-727-5507

**Electrical Repairs, VHS/DVD, Meridian Education Corporation**
This video looks at common automotive electrical problems. It covers how to use a DVOM to check continuity, voltage, resistance, and amperage; inspect, test, and replace fusible links, circuit breakers, and fuses; and work on batteries and alternators. Don't get a shock—develop a well-grounded knowledge of electricity. Correlates to the standards for the Collision Repair and Refinish Technician Training Certification Program, from the National Institute for Automotive Service Excellence and the National Automotive Technicians Education Foundation. A Shopware Production. (20 min., includes teacher’s guide)
Order #: 32783, www.meridianeducation.com, 1-800-727-5507