Connecting Wires

Description

All lights in a house must have proper wire connections in order to work. Residential electrical work requires electricians to join wires together in junction boxes and electrical outlet boxes. It is very important that wire connections are done properly so that no short circuit, fire, or shock hazards occur.

Lesson Outcomes

The student will be able to:

• Use proper technique with tools
• Strip wire and use lineman pliers more proficiently
• Join wires together with lineman pliers (2 wire, 3 wire)
• Join wire using wire connectors
• Select the proper connector for the number of conductors that will be joined together

Assumptions

The students will:

• Have knowledge and understanding of basic electrical theory
• Have had an introduction to electrical hazards, safety, and electrical code
• Understand electrical circuits, drawings, and diagrams
• Have knowledge of electrical terminology and equipment
• Have practised stripping wire and using lineman pliers from Use of Hand Tools

Terminology

American Wire Gauge (AWG): a standardized wire gauge system used since 1857 predominantly in the United States and Canada for the diameter of round, solid, non-ferrous, electrically conducting wire.

Braid: to form into a braid; to weave together three or more strands or parts of something.

Conductor: a material or an object that conducts heat, electricity, light, or sound.

Insulation: a material that reduces or prevents the transmission of heat, sound, or electricity.

Splice: to join ropes, wires, etc., by weaving or twisting them together.

Wire connector: a twist-on cap made of a durable, thermoplastic polymer used to connect two or more aluminum or copper wires together in a box or enclosure. Also known as marrette, wire nut, and marr connectors in North America.
Connecting Wires

Electrician

Estimated Time
1–2 hours

Recommended Number of Students
Individual work

Facilities
Technology education shop with benches

Tools
• Good insulated lineman pliers
• Wire strippers
• Utility knife

Materials
• #14 gauge wire, could be scrap wire (minimum 6” in length)
• Yellow, red, and orange wire connectors
### Common Wire Connectors and Their Uses

<table>
<thead>
<tr>
<th>Wire Nuts and Wire Connectors</th>
<th>Colour &amp; Type</th>
<th>Connector Capacity</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>#14 to #6 AWG</td>
</tr>
<tr>
<td>Large Blue Wire Nut</td>
<td></td>
<td>Min. 3 #12</td>
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<tr>
<td></td>
<td></td>
<td>Max. 2 #6 w/ 1 #12</td>
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<tr>
<td>Large Grey Wire Nut</td>
<td></td>
<td>#18 to #6 AWG</td>
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<tr>
<td></td>
<td></td>
<td>Min. 2 #12</td>
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<tr>
<td></td>
<td></td>
<td>Max. 6 #12</td>
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<tr>
<td>Red Wire Nut</td>
<td></td>
<td>#18 to #8 AWG</td>
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<tr>
<td></td>
<td></td>
<td>Min. 2 #18</td>
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<td></td>
<td></td>
<td>Max. 4 #10</td>
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<tr>
<td>Yellow Wire Nut</td>
<td></td>
<td>#18 to #10 AWG</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Min. 2 #18</td>
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<td></td>
<td></td>
<td>Max. 3 #12</td>
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<tr>
<td>Orange Wire Nut</td>
<td></td>
<td>#22 to #14 AWG</td>
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<td></td>
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<td>Min. 1 #18 w/ 1 #20</td>
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<tr>
<td></td>
<td></td>
<td>Max. 4 #16 w/ 1 #20</td>
</tr>
</tbody>
</table>

**Note:** The most commonly used wire connectors in residential wiring are red, yellow, and orange. The table above shows acceptable wire sizes for wire nuts.
Activity 1: Connect Two Wires Together

The teacher will demonstrate proper technique for stripping insulation from conductors and for twisting wires together before installing wire connectors. Students will practise connecting two wires together using the proper method. Once students become competent, they will practise connecting three wires together.

1. Obtain appropriate tools.
2. Strip all insulated wires to expose 1" of copper (Figure 1).
3. Be sure not to nick or score the conductors.
4. Position the black and white wires so the insulations are even.
5. Hold the insulation of the two wires firmly.
   
   **Note:** Insulation is stripped to 1" to allow the student to cut a clean end on the connection at $\frac{5}{8}"$ so the connector will thread on easily and not leave any copper exposed. As students get more practice they might be able to strip the wire to $\frac{5}{8}"$ and get a clean enough end to thread the wire connector on.

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**Figure 1**—Connector and stripped wire

**Figure 2**—Twist the two wires together
6. Grasp the ends of the wires with lineman pliers and twist clockwise to join the wires together.

   **Note:** Pliers should be in line with wires with all wire connections facing them head on and not at 90° (Figure 2).

7. Trim the twisted ends of the exposed wires to \(\frac{5}{8}\)". (Figure 3).

8. Select the appropriate wire connector and twist it on in a clockwise direction (clockwise is commonly used to tighten, counter-clockwise to loosen).

   ![Exposed wires twisted together](image1)

   **Figure 3**—Exposed wires twisted together

9. When complete, no copper conductor should be exposed past the wire connector (Figure 4).

10. The insulations of the two wires should start to braid together.

   Students should do the same procedure again at the opposite end of the two wires.

   ![Completed connection](image2)

   **Figure 4**—Completed connection
Most Importantly: No bare copper should be exposed at the bottom of the wire connector.

• Figure 5 shows an example of poorly connected wires.  
  Note: The insulations are not aligned and the insulation has not started to twist together which makes the connection less stable.

Figure 5—Poorly connected wires

• Figure 6 shows a wire connector installed on the wires in Figure 5.  
  Note: The exposed copper conductor makes this VERY DANGEROUS.

Figure 6—Bare conductors, exposed
Activity 2: Connect Three Wires Together

1. Strip the wires to 1” (Figure 7).
2. Grip the insulation firmly with the thumb and finger close to the conductors (about ½”).
3. Gently squeeze the wires with the pliers while turning the pliers clockwise.
4. When the conductors start to braid, increase the pressure on the pliers until tight.
   **Note:** Some students might be more comfortable starting with two wires and adding the third after. Practise both ways.

5. Cut the exposed part of the wire to ⅜”.
6. Make sure the insulation has started to braid (Figure 8).
7. Select the appropriate wire connector and tighten.
8. Make sure no exposed conductor is visible past the wire connector (Figure 9).

Students should do the same procedure again at the opposite end of the wires.
Evaluation Guidelines

- The student uses tools appropriately and safely.
- The student removes insulation without nicking or scoring the conductor.
- Wires and insulation are braided together tightly.
- Wire connector is tight.
- There is no exposed copper beyond the wire connector.
- When the teacher removes the wire connector, the connection of the wires should still be stable.
- Three-wire connections should follow the same guidelines as above.
- The student is responsible for a tidy work environment.

Note: Three-wire connections are more difficult and should require more time for the students to perfect.

Optional Activities

Practice is key for students to become more proficient with pliers and wire strippers.

- Have students add more wires to the connection.
- Start with four wires (all wire from the previous exercises can be reused).
- Have students experiment by using smaller wire connectors (orange) in a four-wire splice to show them that the wire connector is too small and they must select the appropriate size to make a safe connection.
- Make a five- or six-wire splice to see if students can still produce quality splices.
- Have students attempt to strip wires using pliers instead of wire strippers.
- Many electricians use their pliers to strip wire to be more efficient. Students can practise getting a feel for the pliers by trying this. The students must be aware not to nick or score the wire when stripping insulation. If the wire is nicked or scored it will likely break when connecting it to other wires.

Optional Extension Activity

The teacher could do a class demonstration with a pre-assembled set of device boxes representing a receptacle, a switch, and a light. The teacher could make the appropriate wire connections and turn on the light to show the students a working circuit made possible by connecting wires using the methods from the activity. This activity could also work into the introduction of Wiring Devices.