

WIRING A WALL SECTION

Description

The activities that have led up to wiring a wall should have given students the skills and knowledge to culminate with this activity. This activity could be an opportunity to conduct a summative assessment of students' previous knowledge of theory, safety, code, and wiring methods. Wiring a wall section will introduce students to a few new CEC rules and wiring methods. Having a wall section is obviously a requirement for this activity. The wall section could be full scale or smaller; to make this activity relate to the real world, it's recommended that the wall section be at least 4' wide by 4' tall. The wall section shown in Figure 1 would be optimal, as it has some real (although scaled down to half size) features such as door and window openings, as well as a corner section, which will help students learn about routing wire and placement of device boxes in relation to these features.



Figure 1—Sample wall section

Building a wall section for a class requires a substantial amount of lumber and time. Optimally, this activity would work well with students having completed the carpentry portion of the course first. This activity is an opportunity for students to wire a wall to code specifications and with the teacher's supervision, energize and test their circuits. Students will likely work in small groups, depending on the availability of material and the number of walls available. The students should have the opportunity to wire their wall sections individually, to give the teacher a clear picture of each student's skills and competencies. The wire and boxes may be re-used for each student in order to reduce cost and waste.

Lesson Outcomes

The student will be able to:

- Correctly wire a wall section with a receptacle, switch, and light to CEC specifications
- With supervision, energize and test the circuit
- Understand the CEC requirements for wiring a wall
- Know where to place devices in relation to doors and windows

Assumptions

Students will be able to recognize electrical hazards and understand correct safety precautions and procedures. Students will also know:

- How to wire a basic circuit
- How to produce a wiring diagram for the circuit
- How to safely work with hand tools
- How to use a portable drill

Terminology

Auger bit: a drill bit that usually includes a rotating helical screw blade to act as a screw conveyor to remove the drilled-out material. The rotation of the blade causes the material to move out of the hole being drilled.



Figure 2—Wood auger bit

Bottom plate: the 2×4"s or 2×6"s that lie on the subfloor and upon which the vertical studs are installed. Also called the *sole plate*.

Cable strapping: attaching staples at predetermined distances to comply with Canadian Electrical Code.

Courtesy loop: a length of wire (usually 3–5") that is not strapped before entering a device box. This allows a box to be moved a few inches after wiring, or allows more wire to be pulled into a box for repair of a possible nick of a wire in a box by drywallers who might inadvertently cut a wire when installing drywall. This is not required by code, but it is best practice for residential electrical work. This may save time and money in the event of one of these situations, and may prevent needing to rewire a wall after drywall has been applied (see Figure 13).

Cripple studs: short wood members used above and below window and door openings to support the frame.

Protection plate: a steel or aluminum plate used to cover a stud section where an electrical wire runs. This is only required if the edge of the hole is drilled less than $1\frac{1}{4}$ " (32 mm) from the edge of the stud).

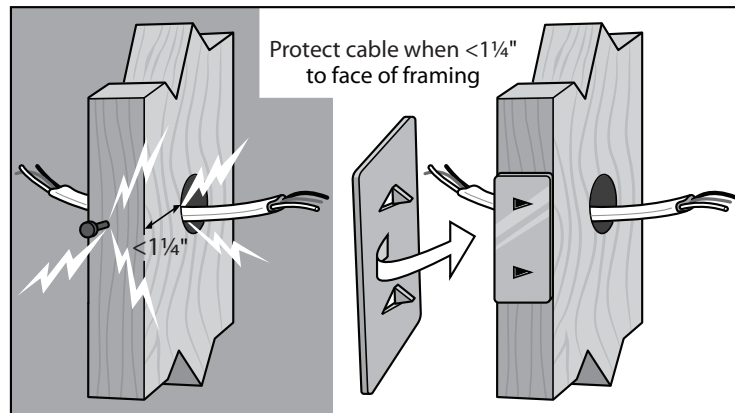


Figure 3—Protection plate

Stud: a wooden support member with 2×4 " nominal dimensions (accurately $1\frac{1}{2} \times 3\frac{1}{2}$ "). Studs are usually spaced 12–16" (30–41 cm) on centre.

Vapour barrier: any material used for damp proofing. Typically, vapour barrier is clear plastic sheathing placed between an insulated wall and a structural wall to control vapour flow within the interior space. The sheathing inhibits the movement of water vapour molecules through the wall. Polyethylene is often used as a vapour barrier, and is available in various thicknesses, e.g., 0.15 mm (6 mil) poly.

Vapour box: moisture resistant barrier surrounding an electrical box. According to the BC Building Code (not the Canadian Electrical Code), if the electrical box is located in an exterior wall or ceiling that requires a vapour barrier, then a vapour box is also required. The enclosure surrounding an electrical box is like a shroud. It consists of a separate plastic or fiberglass box with a wide gasketed flange and seal with a vapour barrier sheet that is normally fixed to the joist or studs.



Figure 4—Vapour barrier example

Wire staple: a staple used to secure electrical cable to studs.



Figure 5—Wire staple

Estimated Time

2–4 hours

Recommended Number of Students

20, based on *BC Technology Educators' Best Practice Guide*, small groups of 2–4 per wall, with the opportunity for individual assessment for wiring

Facilities

Technology education shop

Tools

- Cordless drill or portable power drill
- ½" to ¾" auger bit
- Robertson® #1 and #2 screwdrivers
- Wire strippers
- Lineman pliers
- Utility knife
- Hammer
- Pencil
- Tape measure

Optimally, each group will have all hand tools. The cordless or power drill with auger may be shared among the class.

Materials

- Wall section
- 14/2 Loomex cable
- S1 staples
- Wire connectors (yellow)
- Duplex receptacles (one per wall)

- Single-pole switch (one per wall)
- Keyless lamp holder (one per wall)
- 40 W light bulb (one per wall)
- 2 single device boxes and 1 octagon box (per wall)
- 1" #8 wood screws
- 1 power cord (4–6'); 14/3 gauge extension cord with male cord end at one end and bare conductors at the other end. To be used to energize circuit.

Optional

Students could wire a full-scale project such as a shed or small building. It is preferred they practise on a mock-up wall first to understand CEC requirements and wiring methods.

Resources

Electrical Code Simplified, House Wiring Guide, BC Book 1. P.S. Knight Co. Ltd.

ACTIVITY

The teacher should demonstrate how to wire a wall section. The students should draw a wiring diagram of a receptacle with incoming power feeding a light switch and a light. The students will have this to refer to before they start their wall sections. It is advised that students complete **Activity Plan 10: Wiring Devices** before doing this activity.

For the sake of explanation, this activity will be based on the wall section model shown in Figure 1. Teachers may not use the same scale wall section or door and window configuration and should adapt the rules used in this activity to their own wall section.

Marking Out Box Locations

1. Place the assembled wall section on the floor or bench with space around for students to see the demonstration clearly.
2. Using a tape measure, explain how to lay out the wall for boxes to be attached.
3. Show students the symbols for receptacle, switch, and light.

Note: All measurements will represent the bottom of the device boxes.

Receptacle Box

The receptacle will be marked at 6" (15 cm) from the floor at the end of the wall section with the window framed into it.

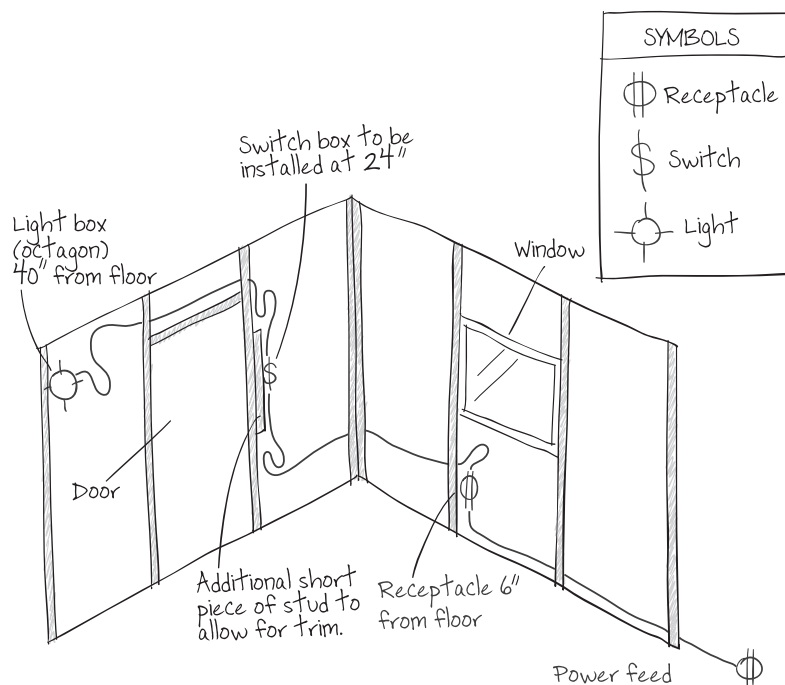


Figure 6—Sketch of wired wall section



Figure 7—6" (15 cm) mark and a receptacle symbol

Switch Box

The light switch should be marked at 24" (60 cm) from the floor on the wall section with the door framed into it. Mark the switch on the side of the door closest to the corner.



Figure 8—Light switch measurement at 24" and a switch symbol

Light Box

The light box should be marked at 40" (100 cm) from the floor at the end of the wall with the door frame.

Note: These measurements are to the scale of the demonstration wall section. A full-scale wall would be different (receptacles usually at 12" or 30 cm from floor, switches 46–52" or 115–130 cm, and light box locations will vary).

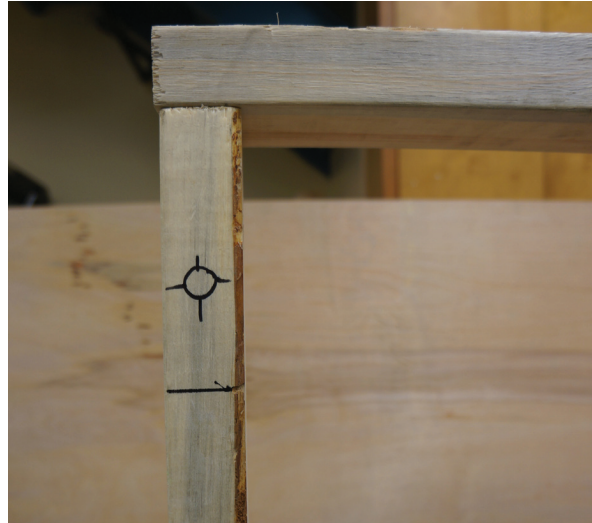


Figure 9—Light box at 40" (100 cm) from the floor with light symbol

Note: A wall section with a window will be an outside wall and according to the building code will require a vapour box. This activity will not use vapour boxes, but the students should be made aware of the building code requirement.

Mount Boxes

Outlet Box

With all devices marked out, attach the receptacle box using 1" (2.5 cm) wood screws. The measurement of 6" (15 cm) should be marked horizontally on the stud as a visual reference to place the bottom of the box.



Figure 10—Placement of box in relation to mark on stud

Switch Box

The switch will be placed on the outside of the door frame. An 8–10" (20–25 cm) long piece of stud should be cut and attached at the point where the light switch box will be placed (Figure 10). This is to allow for trim around the door. This is an error that occurs in residential wiring, and it should be noted to students that adding a piece of stud to bring the switch box further away from the door frame will prevent this problem. Adding a short piece of stud moves the box 3" away from the door frame. If the trim was going to be wider, then the box would have to be moved away further from the door frame.

Note: The teacher will have to explain to students about the placement of a light switch around a door. The door swing must be taken into account so that the door will not cover the switch when being opened. If the door covers the switch, the switch must be outside the swing, or on the other side of the door frame. For this demonstration it is assumed the door will open to the outside, so it will not affect this application. Attach the light switch box at 24" (60 cm) to the bottom of the box.

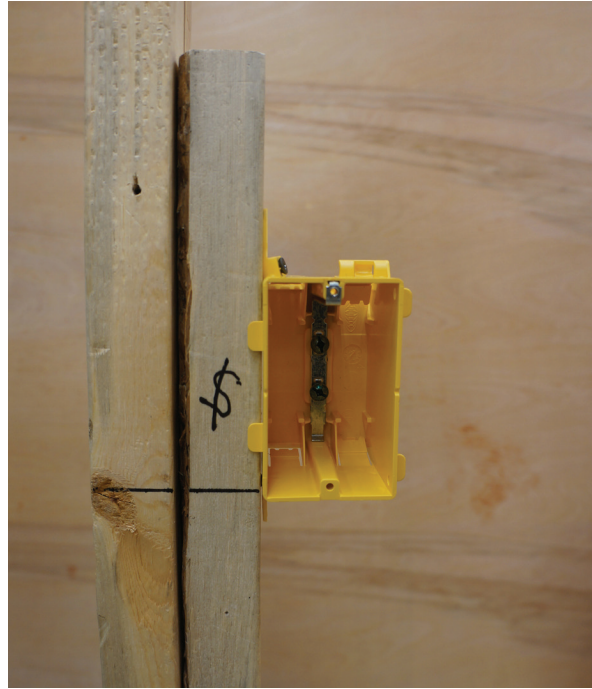


Figure 11—Switch box installed with an extra piece of stud

Light Box

Attach the octagon light box at 40" (100 cm) to the bottom with screws.

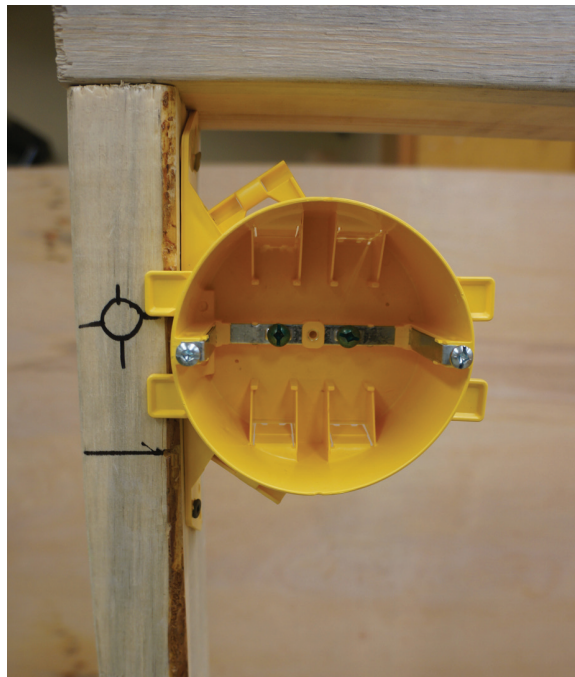


Figure 12—Octagon box attached to stud

Drill Studs

Install the auger bit into a cordless drill or a portable drill. Starting at the window, carefully drill a hole in the centre of the stud, about midway between the window sill and the bottom plate.

Note: All holes must be drilled in the centre of the stud to allow 1¼" (3 cm) clearance on either side of the hole to prevent drywall screws from penetrating the cable.

If the hole does not have 1¼" (3 cm) clearance on both sides, then a protection plate must be used. Continue to drill holes along the cable's path to the light switch at the same height as the first hole drilled. Two holes will have to be drilled through the cripple studs above the door frame for the cable to reach the light.

Install Cabling

1. Bring a short piece of 14/2 cable (24", or 60 cm) into the receptacle box to represent incoming power.

Note: All wiring will be done according to [Activity Plan 10: Wiring Devices](#). The wiring diagram from that activity may be used for reference.

2. Allow for a 3–5" (7.5–12.5 cm) courtesy loop (teacher should explain why a courtesy loop is used, see definitions) for incoming power and staple the cable within 12" of the receptacle box.

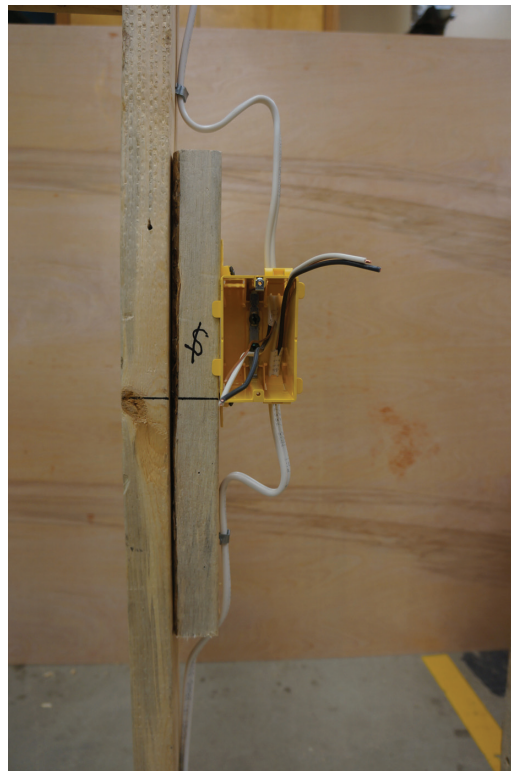


Figure 13—Cable stapled and with courtesy loop

Note: When stapling cable, the staple should not pinch the sheathing of the 14/2 cable. The code for strapping wire is not more than 12" (300 mm) from a box and every 59" (1.5 m) on a run. Cables run through studs are considered sufficiently supported.

3. Run the cable from the receptacle box to the switch box. Remember to measure enough cable for courtesy loops. Strap the cable.
4. Run the cable from the switch box to the light box. Remember to add a courtesy loop and strap.
5. The wiring method is the same as that in **Activity Plan 10: Wiring Devices**. The students will have their wiring diagrams to refer to when they do their walls.

Grounding the Boxes

The next step is to bond the boxes to ground, starting at the first single device box.

The first single gang box is going to be a receptacle with incoming power, the second single gang box will be a single-pole switch, and the octagon box will be a light.

1. Starting at the receptacle box, loosen the grounding screw in the box (counter-clockwise), loop one ground wire around the grounding screw (clockwise) and tighten the screw.
2. Make black, white, and bare pigtail wires for splicing outlets. Cut a piece of 14/2 Loomex 6" (15 cm) long and strip off the jacket. Scrap wire could be used for this task. Save the black and white pigtails for later splicing.
3. Join the two ground wires along with a pigtail grounding wire, twist, and put a wire connector on them. If the receptacle was the last device in a wiring configuration and there was only one 14/2 cable entering the box, the ground wire could simply loop from the ground screw to the receptacle without making a pigtail.
4. Now run the ground wire around the grounding screw in the single-pole switch box. Switches are not connected to the grounding wires, so join the two grounding wires and put on a wire connector.

Note: The switch will be bonded to the ground when the device is secured to the box.

5. The octagon box has only one 14/2 cable entering it, so in this case the grounding wire gets wrapped around the grounding screw and pushed into the box.

The grounding is now complete.

Splicing and Pigtailing

Outlet Box

1. Match up the white (neutral) wires in the box and cut them to the same length.
2. Leave 4" (10 cm) protruding, measured from the front edge of the box.
3. Strip the white wires, attach a 4" (10 cm) white pigtail to the other two white wires, twist, and put a wire connector on them.

Note: A pigtail is required by code for the white (neutral) cable with three conductors (14/3, 12/3, etc.), but not for two-wire cables. However, most electricians will use a pigtail for all receptacles and lamp holders, as it will reduce the strain on receptacle and lamp holder termination points and a spliced connection will carry current more reliably.

4. Cut and strip the black (hot) conductors in the receptacle box and make a pigtail connection for them as was done for the white wires.

Switch Box

Cut, strip, and twist the two white conductors and join with a wire connector in the switch box.

Light Box

No splices required.

Terminating and Mounting Devices

Outlet Box

The devices are now ready to be installed to the wires.

1. Starting at the receptacle, strip the pigtail's insulation on the neutral (white) and hot (black) wires to $\frac{5}{8}$ " (roughly 1 cm) for termination.
2. Make hooks with the ground, white, and black wires. The receptacle will have two silver terminal screws (neutral wire), two brass terminal screws (hot wire), and one green (ground wire) terminal screw. When looking at the receptacle from the front view:
 - The green terminal screw should be positioned at the bottom left.
 - The silver (neutral) terminal screws should be positioned to the left (longer knife blade shape).
 - The brass (hot) terminal screw should be positioned to the right with a smaller knife blade shape.

The receptacle should always be aligned this way when installed.

3. Attach the ground wire to the green screw with the hook in proper arrangement and tighten.
4. Attach the neutral wire to the proper terminal screw (silver) and tighten.
5. Attach the hot wire to the terminal screw (brass) and tighten. The two terminal screws that are not being used may be tightened so they do not protrude.

Switch Box

1. Cut, strip, and make a hook on the two black wires in the switch box (constant power coming from the receptacle) and switch leg (going to the light).

There are only two terminals on a single-pole switch. Most switches will have TOP written on the front and On and Off on the toggle, or a small raised dot on the toggle switch that indicates the On (up) position. Another way to configure a single-pole switch is to have the terminal screws to the right when looking at the switch from the front view when installing. The switch will work regardless of which terminal screws the two wires are connected

2. Attach the wires to the switch and tighten the terminal screws.

Octagon (Light) Box

The last device to be wired is the light.

1. Strip the ends of the black and white wires and put a hook on each.
2. Connect the white wire to the silver (neutral) terminal screw and the black wire to the brass (hot) terminal screw.

Since there are only two wires to be connected, no pigtail is needed. If there were two lights, a pigtail would be used at the first box. The two terminal screws not being used should be tightened.

3. The teacher should visually inspect the circuit to make sure the wiring is done according to the wiring diagram. Make sure there are no short circuit hazards such as exposed wire or bad wire connections. When inspection is complete, wrap electrical tape around the terminal screws on the switch and receptacle and secure them to the boxes with the screws on the devices.
4. Carefully bend the wires on the keyless lamp holder into the octagon box without putting pressure on the terminal screws, and then secure the fixture to the box.
5. Install a bulb.
6. Connect the temporary connection from the extension cord to the incoming power wire **without the cord plugged in.**
7. The last thing to do is energize the circuit. Make sure the light switch is in the OFF position. Make sure all students are clear of devices, and then energize.
8. Plug the extension cord into a wall outlet and turn the light switch ON.
9. When the light turns on, use the plug tester to test proper wiring on the receptacle.
10. After testing, de-energize the circuit.



Figure 14—Completed circuit with light on

Check for understanding and disperse the students into groups to commence wiring their wall sections.

Evaluation Guidelines

- Students work safely and responsibly with tools and equipment.
- Wiring is done according to demonstration standards.
- The circuit is checked for safety with the teacher before energizing individual wall sections.
- Students understand and execute wiring to CEC standards.
- Devices are placed accurately according to specified dimensions.
- Wiring and strapping are done neatly.
- Students should wire the circuit successfully by themselves and be assessed on workmanship and knowledge.