

How a House Is Wired

YES Electric • NEC 2026 with NEC 2023 numbers in parentheses

Draft 1 (October 2026). This chapter is under review. Code numbers are NEC 2026. Your local inspector may use an earlier edition, so ask your journeyman which one applies. Boxes marked "Picture coming" will get drawings and photos in a later version.

YES Electric Residential Course, Phase 1 (Installation).

Code edition. This chapter cites NEC 2026. Where NEC 2026 moved a section, the NEC 2023 number is in parentheses. The local inspector (the AHJ, "authority having jurisdiction") may still enforce an earlier edition, so ask your journeyman which one applies before your first inspection.

How to use this chapter. Read it once all the way through. Then take it to the job and work it section by section, in order. Sections 5 through 9 are written as steps. Do them in the order given. Every step that touches a live part has a warning at that step.

What this chapter does not cover in depth. Part 6A gives the short version of the service, meter base, and grounding electrodes for a new house; R-SERVICE, R1.5, and R1.6 teach them in full. The full load calculation is in R-LOAD. Cable methods in depth are in R1.3, devices in depth are in R1.4, and old houses are in R-OLDHOUSE. Low-voltage (data, coax, doorbell, thermostat) is in R-LOWVOLT. This chapter points to those modules where they go deeper.

Learning Objectives

When you finish this chapter, you can do the following:

1. Prove a house is dead before you work in it, using a non-contact tester and then a meter.
2. Trace power from the utility transformer through the service drop or lateral, the meter, the main disconnect, and the panel out to each circuit.
3. Explain 120/240 V split-phase power: two hots, one neutral, and why a 240 V-only load has no neutral.
4. Name every part inside a residential load center: main breaker, bus bars, neutral bar, ground bar, bonding screw or strap, and each breaker type.
5. Walk a framed house room by room and produce a circuit list and a marked-up layout that meets every NEC dwelling requirement for receptacles, lighting, GFCI, AFCI, and tamper-resistant devices.
6. Pick the right cable, breaker, and box for every circuit, and do a box-fill calculation.
7. Rough in a whole house: set boxes, drill, pull home runs, staple, protect, make up grounds, and label.
8. Pass a rough-in inspection.

9. Make up the panel, trim out every device, and power up the house in a safe order.
10. Test every outlet, GFCI, and AFCI, and pass final inspection.
11. Read a circuit directory and map an unlabeled panel with a circuit tracer.

Sources for this chapter

Source	What it gives you
Kuhlman, Residential Electrical Troubleshooting (2019), "Electrical Panels," pp. 40–47, plus pp. 11, 13, 20, 27, 34, 35–36 (page numbers, where the PDF page equals the book page)	Main panel vs subpanel, where neutrals and grounds land, how the service neutral carries the imbalance. Also his sections on backstabbing, 3-way switches, GFCI, AFCI, and tandem breakers.
Arc Workforce, Residential Electrical Field Guide, Part 2 (Component Encyclopedia), Part 3 (Box Fill Quick Reference), Part 10 (NM Cable rules, Box Fill), Job 10 (Panel Labeling and Load Survey)	Breaker types, panel anatomy, the box-fill method, NM rules inspectors catch, the panel-mapping procedure. Its code citations are NEC 2020. Use the numbers in this chapter instead.
NEC 2026,	Every code number in this chapter was checked against this text. Items that could not be checked are marked as still being checked against the printed code book.
Commercial Module 1.4 (Branch Circuits, Feeders and Panelboards)	The three-phase version of the panel material here. Read Part D (the service bond) after this chapter.

Kuhlman's photos and text are copyrighted. This chapter paraphrases him. Do not copy his photos into our materials.

PART 1: SAFETY. PROVE THE HOUSE IS DEAD

A house with the studs open can still have live wires in it. In a remodel the old service may still be on. In new construction the builder may have a temporary power pole with cords running into the house, and the panel may have been energized early for the HVAC contractor. Never assume. Prove it, every day, before you touch anything.

1.1 Know where the power comes from on this job

Before you start, find out which of these four situations you are in. Ask the journeyman or the builder.

Situation	What is live	What you do
New construction, no permanent power yet	The temporary pole and its cords and receptacles. The house panel is dead because the utility has not set the meter.	Work in the house. Keep temp cords off the floor and out of standing water. Never connect anything to the temp pole yourself.
New construction, permanent power on ("released early")	The house panel's line side is live. Any breaker that is on feeds its circuit.	Treat the panel as live. Lock out every circuit you work on (Step 1.3).
Remodel, meter pulled by the utility	The meter base line side may still be live (it comes from the utility). Everything after the meter is dead.	Do not open the meter base. Prove dead at the panel.
Remodel, main breaker off	The line side of the main breaker, the service conductors, and the meter base are live.	Treat the top of the panel as live. Never work above the main breaker.

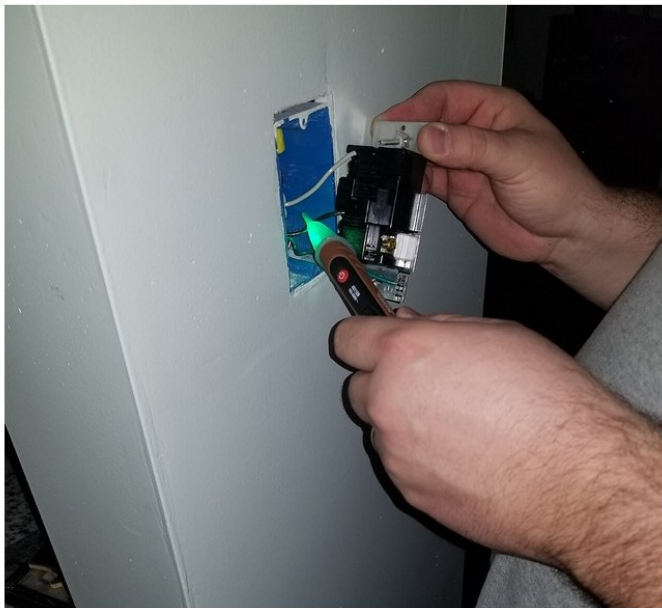
WARNING: Only the utility pulls a meter. In Alabama Power territory, pulling or cutting a meter seal yourself is against the utility's rules and is dangerous. A meter can arc when pulled under load. If the job needs the meter out, the journeyman calls the utility.

WARNING: The main breaker does not kill the main lugs. The conductors from the meter land on lugs above the main breaker. Those lugs are live whenever the meter is in, even with the main off. Plan your work so your hands never go near them.

1.2 Your test tools

You need two testers. They do different jobs.

1. **A non-contact voltage tester ("tick tracer," "volt stick").** It beeps near a live AC conductor. It is fast and good for a first check. It can miss a live wire when the wire is shielded, when the battery is low, or when you hold it wrong. It can also beep on a dead wire that runs next to a live one. A non-contact tester never proves a circuit dead by itself.
2. **A two-lead voltage tester or digital multimeter (DMM), rated CAT III 600 V or better.** This is the tool that proves dead. Set it to AC volts.



Non-contact voltage tester (glows and beeps near a live wire)



Two-lead digital multimeter with test leads, rated CAT III 600 V

On the left, a non-contact voltage tester glows near a live wire in an open switch box. On the right, a two-lead digital multimeter rated CAT III 600 V, the tool that proves a circuit dead.

Photo: Voltage Tester with green light.jpg by Bigmacthealmanac, CC BY-SA 4.0; Fluke 115 multimeter with case and leads.jpg by J.C. Fields, CC BY-SA 3.0.

Commercial Module 2.1 covers meter categories, PPE, and lockout/tagout in depth. R2.1 covers the residential version.

1.3 The prove-dead procedure (do this every time)

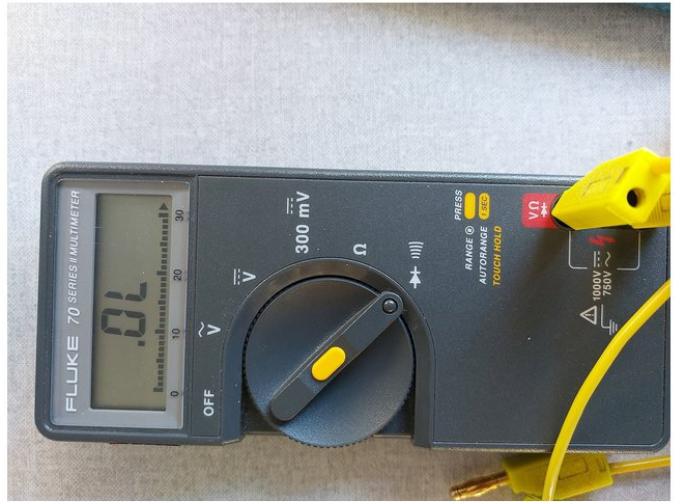
This is called "live-dead-live." Do all six steps.

1. **Turn off and lock out.** Turn off the breaker (or the main). Put a breaker lock on it and a tag with your name. If you have no lock, tape the breaker off and tell everyone on site. Why: a painter or another trade can flip a breaker back on while you work.
2. **Check your meter on a known live source.** Plug the leads into a receptacle you know is live (or the temp pole). It should read about 120 V. Why: this proves your meter and leads work. A meter with a dead battery or a broken lead reads 0 V on a live wire.
3. **Sweep with the non-contact tester.** Hold it against every cable and wire in the box or area you are about to touch. If it beeps, stop. Find out why.
4. **Measure with the meter.** At the box or wires you will touch, measure: - hot to neutral (black to white), - hot to ground (black to bare), - neutral to ground (white to bare), - and on a 240 V circuit, hot to hot (black to red, or black to the re-identified white). Every reading should be 0 V. A high-impedance digital meter can show a small "ghost voltage" on a dead wire that runs next to a live one. If you see any voltage you cannot explain, stop and ask the journeyman. A meter with a low-impedance (LoZ) setting drains ghost voltage and shows a true reading.

5. **Check your meter on the known live source again.** Why: if the meter died between Step 2 and Step 4, your 0 V reading meant nothing.
6. **Treat any wire you did not test as live.** If you open a new box or cut into a new cable, go back to Step 3.



Knob on AC volts (V~). Black lead in COM, red lead in V.

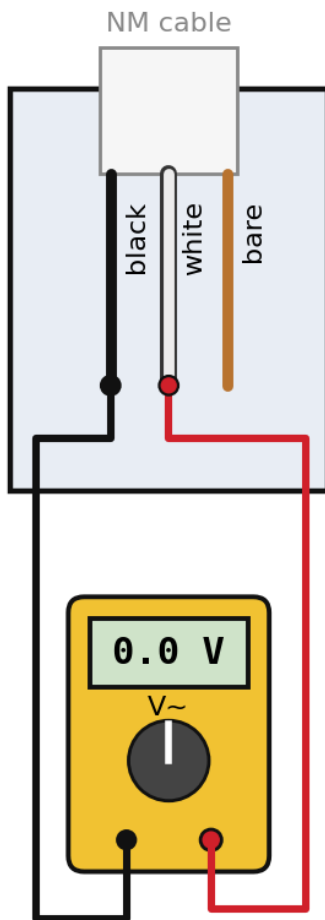


Knob on ohms. OL on the screen means an open circuit.

Left: the knob is on AC volts with the black lead in COM and the red lead in the V jack. Right: the knob is on ohms, and the screen reads OL because the leads are not touching anything.

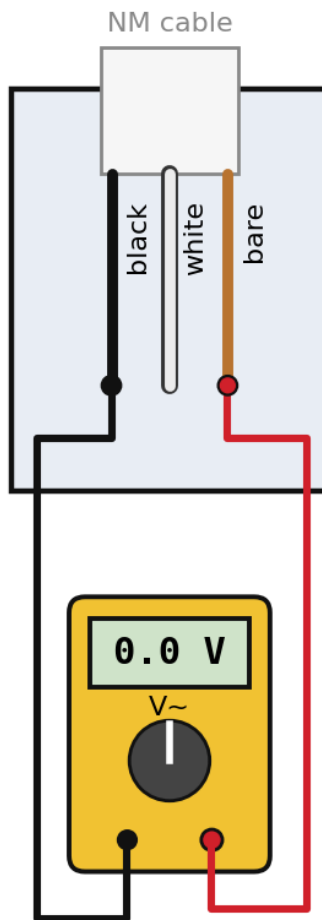
Photo: Aneng AN870 multimeter 02.jpg by Retired electrician, CC0; Fluke 70 series II multimeter (connected) 01.jpg by OliCol11, CC BY-SA 4.0.

**Hot to neutral
(black to white)**



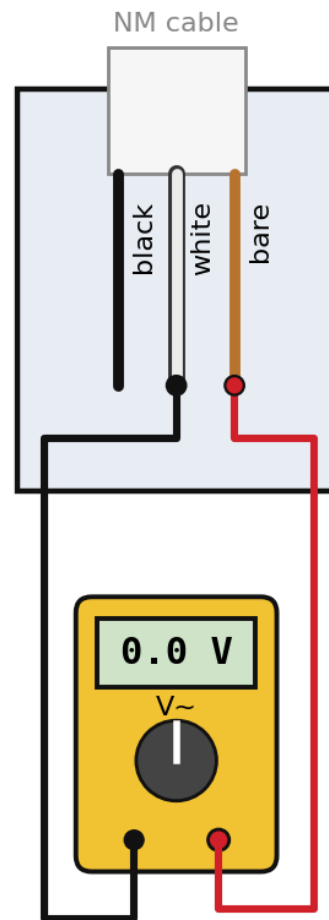
must read 0 V

**Hot to ground
(black to bare)**



must read 0 V

**Neutral to ground
(white to bare)**



must read 0 V

Front view of an open box. Meter on AC volts, leads in COM and V.
Check the meter on a known live source before and after these readings.
Any voltage you cannot explain: stop and ask the journeyman.

A meter set to AC volts, with its leads in COM and V, checks hot to neutral, hot to ground, and neutral to ground in an open box. Every reading must be 0 V before anyone touches the wires.

Drawing: YES Electric.

WARNING: Shared neutrals. In older houses and in kitchens wired with 12/3 cable, two circuits can share one neutral (a multiwire branch circuit). Turning off one breaker does not kill the shared neutral. It can carry current from the other circuit. Before you open a neutral splice, measure current on it with a clamp meter or turn off both breakers. NEC 2026

210.4(B) requires the two hots of a multiwire branch circuit to be on a two-pole breaker or handle-tied breakers so they shut off together. Older work often breaks this rule.

Picture coming: Four-panel illustration of live-dead-live. Panel 1: meter leads in a known-live receptacle reading 120.0 V. Panel 2: non-contact tester held against an NM cable entering a box, no light. Panel 3: meter leads on the black and white conductors in the box reading 0.0 V. Panel 4: meter back in the known-live receptacle reading 120.0 V. Caption: "Test, test, test again."

Field photo coming: A breaker lock and a handwritten tag ("DO NOT TURN ON, [name], [date]") installed on a single-pole breaker in a YES job panel.

1.4 Other site hazards in an open-stud house

Hazard	What to do
Drilling into hidden plumbing, gas line, or ductwork in a floor or top plate	Look on both sides before you drill. Gas lines and PEX run through the same plates you do.
Ladders on a subfloor with loose debris	Sweep the floor where the ladder feet go. Use a fiberglass ladder near any live work.
Attic heat	Work attics before 11 AM in summer. Bring water. Step only on joists or running boards.
Nail guns from other trades	Wear safety glasses all day. Framers and drywallers shoot into the same studs you are working near.
Cut sheath edges and staples	Wear gloves when pulling cable.

PART 2: HOW POWER MOVES THROUGH A HOUSE

2.1 The path from the pole to the receptacle

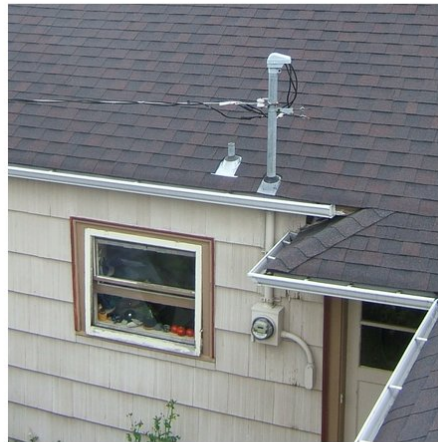
Power reaches the house in this order:

1. **The utility transformer.** On a pole (overhead service) or on a green pad in the yard (underground service). It steps the utility's distribution voltage (often 7,200 V or more in a rural or suburban line) down to 120/240 V for the house.
2. **The service drop or service lateral.** A drop is the overhead cable from the pole to the house. A lateral is the underground cable from the pad-mount to the meter. Both belong to the utility up to the "point of delivery," which the utility defines.

3. **The meter base and meter.** The meter measures energy. The meter base (socket) is usually owned by the homeowner and installed by the electrician, but the utility owns and seals the meter.
4. **The service disconnect (main breaker).** The one switch that turns off the whole house. It can be in the indoor panel, or outside in a meter-main combination. NEC 2026 225.41 (NEC 2023 230.85) requires an outdoor emergency disconnect for one- and two-family dwellings, which in new houses is usually met with a meter-main outside. R-SERVICE covers this.
5. **The panel (load center, panelboard).** It holds the breakers that split the power into branch circuits.
6. **Branch circuits.** The cable from each breaker out to the receptacles, lights, and appliances it serves.



Overhead service: transformer on the pole



Service drop to the mast, then the meter



Underground service: green pad-mount transformer

An overhead service starts at a transformer on the pole, and the service drop runs to the mast on the roof and down to the meter. An underground service starts at a green pad-mount transformer in the yard, and the lateral runs under the ground to the meter.

Photo: 412 DSP Hazard-Regulated 005 - DPLA - aa078f14771f3e698a93e741108312a6.jpg by U.S. Environmental Protection Agency (via National Archives), Public domain (US government work); Residence service drop.JPG by Chetvorno, CC0; Pad-mounted Transformer Photo 2024.jpg by Simon-says-elkay, CC BY-SA 4.0.

Some useful words (all defined in NEC Art. 100):

Word	Meaning
Service	The conductors and equipment that deliver power from the utility to the house wiring.
Feeder	The conductors between the service and a later overcurrent device, for example from the main panel to a subpanel in the garage.
Branch circuit	The wiring between the last breaker and the outlets. Almost everything you rough in is branch circuits.
Outlet	A point where current is taken to supply equipment: a receptacle, a light, or a hardwired appliance. A light box is a "lighting outlet."
Grounded conductor	The neutral, the white wire. It carries current.
Equipment grounding conductor (EGC)	The bare or green wire. It carries current only during a fault.

Picture coming: One-line of a house: pole transformer → service drop → meter → main breaker panel → three example circuits (120 V receptacle, 240 V range, 120 V lighting). Label each part with its NEC name (service drop, service-entrance conductors, service disconnect, panelboard, branch circuit). Show the grounding electrode conductor running from the panel to a ground rod and to the water pipe.

2.2 Split-phase 120/240 V

The utility transformer for a house has one primary winding and one secondary winding. The secondary is 240 V end to end, with a tap in the exact middle. Three wires come off it:

- **L1 (Line 1)**, one end of the winding. A hot.
- **L2 (Line 2)**, the other end. A hot.
- **N (Neutral)**, the center tap. The utility grounds it at the transformer, and you ground it again at the service.

Measured with a meter, you get:

Meter leads	Reading	Why
L1 to N	120 V	Half the winding.
L2 to N	120 V	The other half.
L1 to L2	240 V	The whole winding.
N to ground (at the main panel)	0 V	They are bonded together at the service.

People call this "split-phase" or "single-phase three-wire." It is not two phases. Measured from the neutral, L1 and L2 swing in opposite directions. When L1 is at +170 V peak, L2 is at −170 V peak. That is why they add to 240 V across the full winding.

Picture coming: Split-phase waveform diagram: L1 and L2 sine waves 180° apart drawn against a horizontal neutral line. Mark 120 V RMS from each to neutral and 240 V RMS between them. Beside it, a drawing of a center-tapped transformer secondary with L1, N, L2 labeled.

What the neutral carries. A 120 V load connects from one hot to neutral. Current flows out on the hot and back on the neutral. When there are 120 V loads on both legs, the neutral carries only the difference. Kuhlman gives the example of 20 A on L1 and 30 A on L2: the service neutral carries 10 A (Kuhlman, p. 45). This is why the panel alternates breakers between L1 and L2. It balances the load and keeps neutral current down.

Why a 240 V-only load has no neutral. A water heater element connects across L1 and L2. Current flows out one hot and back the other. Nothing returns on a neutral, so the circuit is two hots and a ground: 10/2 cable, with the white re-identified as a hot. A range or dryer is different. It has 240 V heating elements, but its clock, light, timer, and motor run on 120 V. Those need a neutral, so a range or dryer circuit is two hots, a neutral, and a ground: 6/3 or 10/3 cable.

What happens when the neutral is lost. If the service neutral opens, 120 V loads on L1 and L2 end up in series across 240 V. The leg with less load gets the higher voltage. The Arc Guide (Part 10, "Lost / Floating Neutral") describes legs reading 180 V and 60 V. Lights burn bright on one side of the house and dim on the other, and electronics burn up. Kuhlman describes the test for a deteriorated service neutral using current on the water pipe (p. 45). R2.x covers this fault.

2.3 Wire colors

Color	Job	Code basis
Black	Hot (ungrounded)	Convention. Any color except white, gray, or green may be a hot.
Red	Second hot: the other leg of a 240 V circuit, a 3-way traveler, or the switched leg	Convention.
Blue, yellow (in conduit)	Hots, used in multi-circuit conduit runs	Convention.
White or gray	Neutral (grounded conductor)	NEC 2026 200.7 identifies it and 200.8 (NEC 2023 200.7) says white or gray may be used only as the grounded conductor, with exceptions.
White re-marked with black or red tape	A hot, in a cable where the white is used as a hot (240 V circuits, switch loops)	NEC 2026 200.8(C)(1) (NEC 2023 200.7(C)(1)). The re-marking must go all the way around the insulation at every place the conductor is visible. In a switch loop, the re-identified white may only be the feed to the switch, never the return to the light.
Bare copper or green	Equipment ground	NEC 250.119. Green may never be used as a hot or a neutral.

Wire	Color	Job	Code basis
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	Red	Second hot: the other leg of a 240 V circuit, a 3-way traveler, or a switched leg	Convention.
	Blue, yellow (in conduit)	Hots in multi-circuit conduit runs	Convention.
	White or gray	Neutral (grounded conductor)	NEC 2026 200.7, 200.8 (NEC 2023 200.7)
	White, re-marked with black or red tape	A hot, where the white is used as a hot (240 V circuits, switch loops)	NEC 2026 200.8(C)(1) (NEC 2023 200.7(C)(1))
	Bare copper or green	Equipment ground	NEC 250.119. Green is never a hot or a neutral.

Tape re-marking goes all the way around the insulation at every place the conductor is visible. In a switch loop, the re-identified white may only be the feed to the switch, never the return to the light.

This chart shows what each wire color is used for in a house and the code basis for it. It includes a white wire re-marked with tape so it can be used as a hot.

Drawing: YES Electric.

2.4 What a circuit is, and why breakers trip

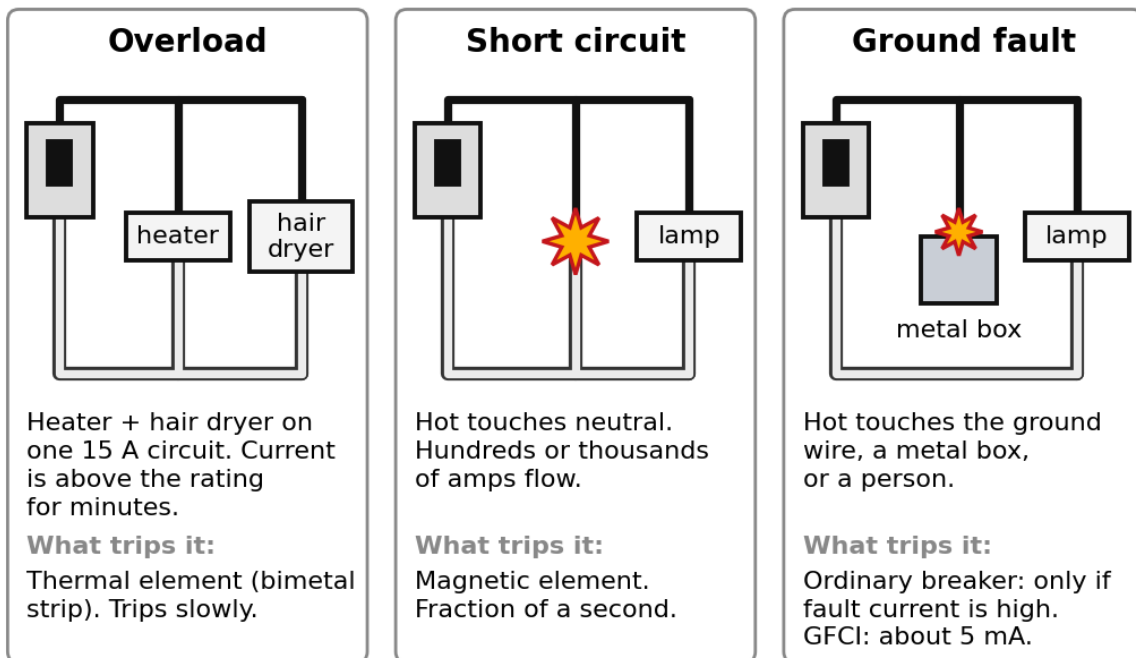
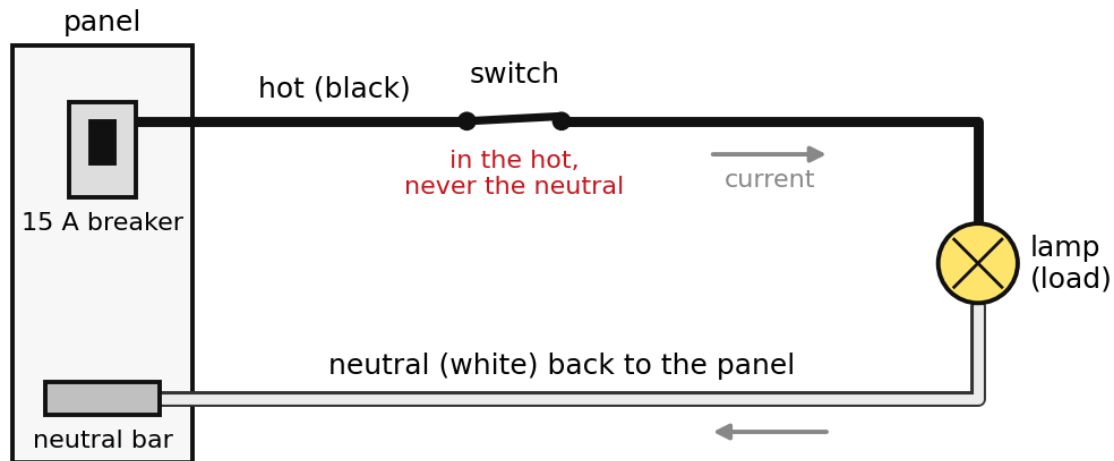
A circuit is a closed loop. Current leaves the panel on the hot, flows through the load (a lamp, a heater, a motor), and returns on the neutral (or the other hot, for 240 V). Break the loop anywhere and current stops. A switch breaks the loop on purpose. It must always break the hot, never the neutral (NEC 2026 406.30(B), NEC 2023 404.2(B)). Why: a switch in the neutral leaves the light socket hot when the switch is off, and someone changing a bulb gets shocked.

A breaker opens the circuit for four reasons:

Cause	What happened	What trips it
Overload	Too much load on the circuit, such as a space heater and a hair dryer on one 15 A circuit. Current is above the rating for minutes.	The thermal element (a bimetal strip that bends as it heats). It trips slowly.
Short circuit	Hot touches neutral. Hundreds or thousands of amps flow.	The magnetic element. It trips in a fraction of a second.
Ground fault	Hot touches the ground wire, a metal box, or a person.	Ordinary breakers trip only if the fault current is high enough. A GFCI trips at about 5 mA of imbalance, which protects people.
Arc fault	A loose terminal or a nail through a cable arcs. Current is too low to trip a normal breaker, but the arc can start a fire.	An AFCI watches the current waveform for the signature of arcing.

The breaker protects the wire. A 15 A breaker is on 14 AWG copper and a 20 A breaker is on 12 AWG because those wires can carry that current without overheating the insulation (NEC 2026 240.4(D)). Never put a bigger breaker on a wire to stop it tripping. The wire then overheats inside the wall before the breaker opens.

A circuit is a closed loop



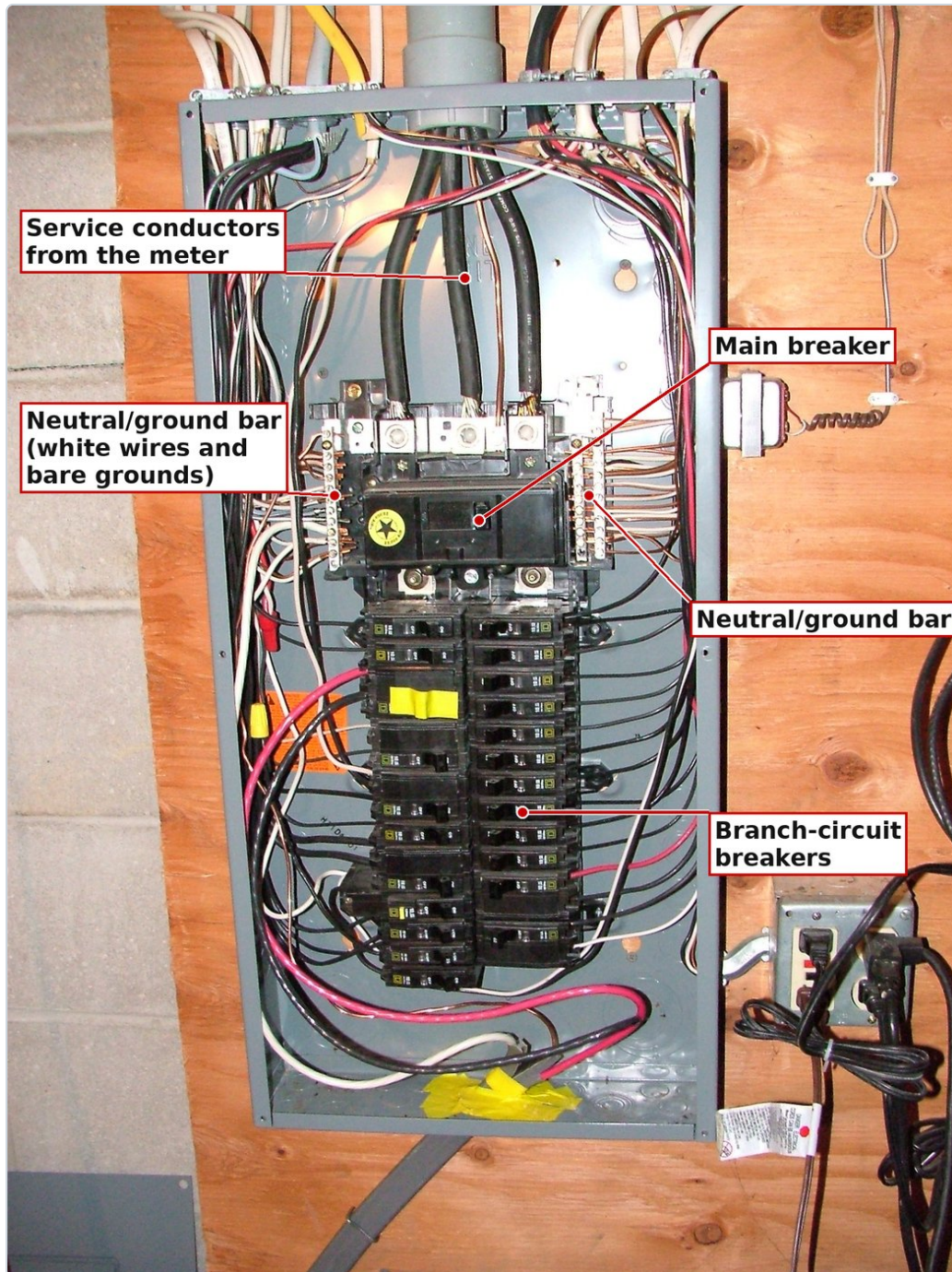
Current leaves the panel through a 15 A breaker on the black hot, passes through a switch in the hot and the lamp, and returns on the white neutral. The bottom row shows an overload, a short circuit, and a ground fault, and what trips the breaker in each case.

Drawing: YES Electric.

2.5 Panel anatomy

Open the cover of a residential load center and you see the following parts. Learn every one. The field exercise at the end of the chapter tests you on them.

Part	What it is	What to know
Enclosure (can, tub)	The steel box	Mounted to the studs or a backboard. It has knockouts for cables.
Dead front (cover)	The steel cover with slots for breaker handles	Never leave a panel energized without it.
Main lugs	Where the service conductors from the meter land	Live whenever the meter is in, even with the main off.
Main breaker	Two-pole breaker that turns off the whole panel	Its rating must not exceed the panel's bus rating (NEC 2026 408.36).
Hot buses (L1, L2)	Two copper or aluminum bars down the center	The breaker "stabs" alternate L1, L2, L1, L2 down each side. A two-pole breaker grabs one of each.
Neutral bar(s)	Terminal bar(s) where white wires land	In a main panel it is bonded to the can. One neutral per terminal hole (NEC 2026 408.41).
Ground bar	Terminal bar where bare and green wires land	Bolted to the can. Required whenever the panel has separate equipment grounds (408.40).
Main bonding jumper	A green screw or a metal strap that ties the neutral bar to the can	Installed in the main panel (service) only. Removed in a subpanel.
Grounding electrode conductor (GEC) terminal	Lug where the wire to the ground rods and water pipe lands	Main panel only. R-SERVICE covers sizing.
Breakers	Plug onto the bus	Must be the brand and type listed on the panel label.
Filler plates (blanks)	Close unused slots in the dead front	Required (408.7). An open slot lets a finger touch the bus.
Directory	Card on the door listing every circuit	Required (408.4).
Panel label	Sticker inside the door	Lists the rating, the breakers allowed, the number of circuits, the wire sizes for each terminal, and torque values. Read it before you install anything.



A residential load center with the dead front removed. The service conductors land on the main breaker, the branch breakers plug onto the hot buses behind them, and in this main panel the white neutrals and bare grounds share the two terminal bars.

Photo: US wiring basement-panel.jpg by davef3138, CC BY 2.0.

Breaker types you will see:

Type	Use
Single-pole, 15 A and 20 A	120 V circuits.
Two-pole, 20 A to 60 A	240 V and 120/240 V circuits: range, dryer, water heater, HVAC.
Tandem (twin, "cheater")	Two single-pole breakers in one slot. Only allowed where the panel label permits them and only in the positions it shows. Kuhlman explains that a panel labeled "30/40" has 30 full-size spaces and allows up to 40 circuits with tandems (Kuhlman, p. 34).
AFCI (combination type)	Arc-fault protection for bedroom, living, kitchen, hall, and laundry circuits. Has a test button.
GFCI breaker	Ground-fault protection for people. Has a test button.
Dual-function (DFCI, "AFCI/GFCI")	Both in one breaker. Used where a circuit needs both, such as kitchen and laundry receptacles.
Plug-on-neutral versions	AFCI, GFCI, and DF breakers that clip onto a neutral rail in the panel instead of using a coiled white pigtail. Only in panels built for them.



Single-pole breaker (one space)



Two-pole breaker (two spaces, common trip)



Tandem breaker (two circuits, one space)



AFCI breaker with coiled white pigtail

Four breaker types seen from the back: a single-pole breaker, a two-pole common-trip breaker, a tandem breaker that puts two circuits in one space, and an AFCI breaker with its coiled white pigtail. GFCI, dual-function, and plug-on-neutral breakers are not shown.

Photo: Cutler-Hammer ONE pole CTL circuit breaker LARGE.JPG by LP-mn, Public domain; Cutler-Hammer TWO pole CTL Circuit Breaker LARGE.JPG by LP-mn, Public domain; Cutler-Hammer CHEATER or Non-CTL Circuit Breaker LARGE.JPG by LP-mn, Public domain; AFCI.jpg by سید پارسا هدوی, CC BY-SA 4.0.

Main panel vs subpanel. In the main (service) panel, neutrals and grounds are tied together through the main bonding jumper. In a subpanel, the neutral bar floats: the bonding screw is removed, the grounds go on a separate ground bar bonded to the can, and the feeder has four wires (two hots, neutral, ground). NEC 2026 250.24(B) forbids connecting the

neutral to ground on the load side of the service disconnect. Kuhlman says he asks every job applicant this question because many electricians get it wrong (Kuhlman, p. 43). Part 7 of this chapter walks through both. Note that when the service disconnect is outside in a meter-main, the indoor panel is a subpanel and must be wired that way.

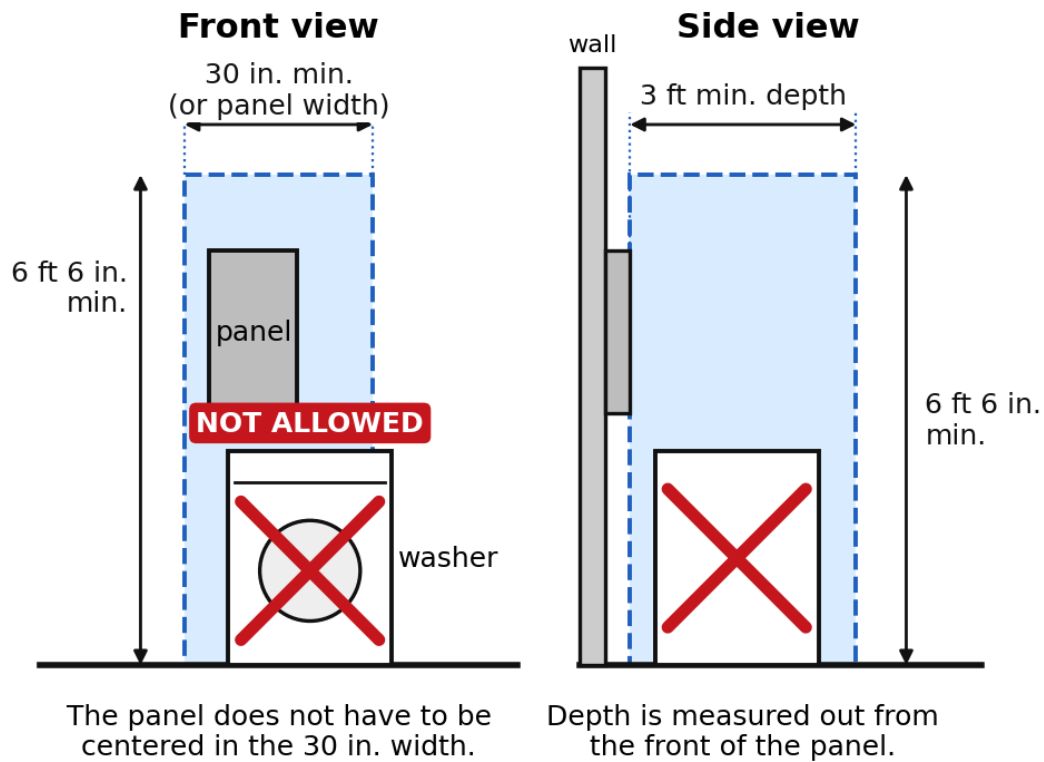
Picture coming: Cutaway of a 200 A, 40-space residential load center with every part labeled. Two versions side by side. Left: main panel, main breaker at top, green bonding screw installed through the neutral bar into the can, neutrals and grounds on the bonded bars, GEC landing on its lug. Right: subpanel fed from an outdoor meter-main, bonding screw removed and shown in a hand, separate ground bar screwed to the can, 4-wire feeder (L1 black, L2 red, N white, G bare) landing on the main lugs, neutral bar, and ground bar.

2.6 Working space in front of the panel

NEC 2026 110.26 requires clear working space in front of the panel so a person can work on it safely and get away from an arc. For a 120/240 V residential panel:

Dimension	Minimum
Depth, in front of the panel	3 ft (Table 110.26(A)(1), 0–150 V to ground)
Width	30 in. or the width of the panel, whichever is greater. The panel does not have to be centered in it.
Height	6 ft 6 in. or the height of the equipment, whichever is greater

The panel also may not go in a clothes closet (240.24(D)), in a bathroom (240.24), or over the steps of a stairway (240.24(F)). The handle of the highest breaker may be no more than 6 ft 7 in. above the floor (240.24(A)). These rules matter in the planning step, because the panel location is picked before rough-in starts. A washer, a water heater, or shelving in front of the panel violates the working-space rule, so check the plan.



Clear working space for a 120/240 V panel (NEC 2026 110.26). Keep it free of washers, water heaters, and shelving.

The clear working space in front of a 120/240 V panel, seen from the front and from the side, is at least 30 in. wide (or the panel width), 3 ft deep, and 6 ft 6 in. high. A washer standing in that space is marked not allowed.

Drawing: YES Electric.

PART 3: PLANNING THE HOUSE

Do not drill a hole until the plan is done. The plan is two things: a marked-up floor plan showing every box, and a circuit list showing every breaker. The plan takes 2 to 4 hours for a 1,800 sq ft house. It saves days of rework, because a box missed at rough means cutting drywall later.

3.1 What you need before you start

1. The floor plan, printed at 1/4 in. = 1 ft if possible. If there is no electrical plan (most production houses have none), you draw the layout yourself.
2. The appliance list from the builder: range (electric or gas), cooktop and wall oven, dryer (electric or gas), water heater (electric, gas, or tankless), HVAC equipment with model numbers, dishwasher, disposal, microwave (over-the-range or countertop), refrigerator (with ice maker?), and anything special (hot tub, EV charger, well pump, generator).
3. The owner's or builder's fixture choices: recessed lights or surface fixtures, ceiling fans, under-cabinet lights, exterior lights.

4. Colored markers or pencils. YES uses red for receptacles, blue for lights and switches, green for dedicated appliance circuits, and black for low-voltage.
5. A tape measure. Walk the actual framing. Plans and framing do not always match.

3.2 The planning walk, step by step

1. **Start at the panel location.** Confirm the working space from Section 2.6. Mark the panel on the plan.
2. **Walk each room in a fixed order.** YES order: kitchen, dining, living, hallways, bedrooms, bathrooms, laundry, garage, exterior, attic and crawl space. Use the rules in Sections 3.3 through 3.9 for each room.
3. **In each room, mark the walls first, then the counters, then the ceiling, then the switches.** Use these symbols on the plan:

Symbol	Meaning
⦿ (circle with two lines)	Duplex receptacle
⦿ GFCI	GFCI receptacle
⦿ WP	Weatherproof receptacle, with in-use cover
⦿ 240	240 V receptacle (range, dryer)
○ (circle)	Ceiling light
○ F	Ceiling fan (fan-rated box)
⊙	Recessed light
S	Single-pole switch
S3, S4	3-way, 4-way switch
SD	Smoke alarm
CO	Carbon monoxide alarm
J	Junction box or direct hardwire connection (water heater, dishwasher)

1. **Number every box with its circuit.** Write the circuit number next to each symbol.
2. **Fill in the circuit list as you go** (Section 3.11 shows the format).
3. **Have the journeyman check the plan before rough starts.** Then walk it with the builder or owner, because they decide fixture locations and switch sides.

Symbol	Meaning	Symbol	Meaning
	Duplex receptacle		Recessed light
	GFCI receptacle	S	Single-pole switch
	Weatherproof receptacle, with in-use cover	S3 S4	3-way, 4-way switch
	240 V receptacle (range, dryer)	SD	Smoke alarm
	Ceiling light	CO	Carbon monoxide alarm
	Ceiling fan (fan-rated box)	J	Junction box or direct hardwire (water heater, dishwasher)

Write the circuit number next to every symbol on the plan.

These are the plan symbols from Section 3.2 as they appear on a floor plan, each with its meaning.

Drawing: YES Electric.

Picture coming: A marked-up floor plan of a 3-bedroom, 2-bath ranch house drawn at 1/4 in. = 1 ft, with receptacles in red, lighting and switches in blue, dedicated circuits in green, smoke alarms marked SD, and a circuit number beside every symbol. Dimension lines show the 6 ft/12 ft receptacle spacing along one living room wall.

3.3 Required circuits

These circuits are required by NEC 2026 210.11(C) in every dwelling. Each one serves only the outlets named.

Circuit	Rule	Why
Kitchen small-appliance	Two or more 20 A circuits for the kitchen, pantry, breakfast room, and dining room receptacles, including the refrigerator receptacle. No other outlets. (210.11(C)(1), 210.52(B))	Toasters, coffee makers, and kettles draw 10 to 15 A each. Two circuits let two of them run at once.
Countertop receptacles	Must be fed by at least two small-appliance circuits. No small-appliance circuit may serve more than one kitchen. (210.52(B)(3))	Same reason.
Laundry	At least one 20 A, 120 V circuit for the laundry receptacle(s). No other outlets. (210.11(C)(2))	A washer motor plus an iron or a steamer.
Bathroom	At least one 20 A circuit for bathroom receptacles. It may serve receptacles in more than one bathroom and nothing else. Or, if it serves a single bathroom only, it may also feed other equipment in that bathroom such as the lights and fan. (210.11(C)(3) and its Exception)	Hair dryers draw 12 to 15 A.
Garage	At least one 20 A, 120 V circuit for garage receptacles, including the one required in each vehicle bay. No other outlets. (210.11(C)(4))	Shop tools, compressors, freezers.

3.4 Dedicated (individual) appliance circuits

These loads each get their own circuit. Some are code requirements. Some are good practice that YES does on every house.

Load	Typical breaker and cable	Basis
Electric range, 12 kW	50 A two-pole, 6/3 NM-B, 4-wire 14-50 receptacle	210.19(C): a range of 8¾ kW or more needs at least a 40 A circuit. Most 12 kW ranges call for 40 A or 50 A on the nameplate. Use what the installation manual says.
Wall oven or cooktop	Per nameplate, usually 30 A or 40 A two-pole	Nameplate and installation manual.
Electric dryer	30 A two-pole, 10/3 NM-B, 4-wire 14-30 receptacle	Dryer nameplate (usually 5,000 to 5,600 W).
Electric water heater, 4,500 W	30 A two-pole, 10/2 NM-B	422.13 treats a storage water heater of 120 gal or less as a continuous load, so you size at 125%: $4,500 \text{ W} \div 240 \text{ V} = 18.75 \text{ A} \times 1.25 = 23.4 \text{ A}$, round up to 25 A or 30 A. YES uses 30 A on 10 AWG.
HVAC air handler or furnace	Per nameplate MCA (minimum circuit ampacity) and MOCP (maximum overcurrent protection)	Article 440 and 422.12 (central heating equipment needs an individual branch circuit).
HVAC condenser (AC or heat pump)	Per nameplate MCA and MOCP, usually 20 A to 40 A two-pole	Article 440.
Dishwasher	20 A, 12/2	Good practice. The dishwasher installation manual usually calls for an individual circuit.
Disposal	20 A, 12/2 (some manuals allow 15 A)	Good practice and manufacturer instructions.
Over-the-range microwave	20 A, 12/2	422.16(B)(4) requires a receptacle on an individual branch circuit when a microwave/hood is cord-connected.
Refrigerator	20 A, 12/2	Allowed on a small-appliance circuit by 210.52(B)(1), but YES gives it its own circuit so a tripped countertop circuit does not spoil food. Exception No. 2 to 210.52(B)(1) permits this.
Gas furnace or gas water heater	15 A or 20 A, per manual	The igniter, blower, and controls need 120 V.

Rule for every appliance: the nameplate and the installation manual win. Read the manual before you rough in. It tells you the circuit size, where the receptacle or junction box goes, and how high. A dishwasher manual, for example, shows exactly which side of the sink base the cord comes through.

3.5 Receptacle spacing: walls in living areas

NEC 2026 210.52(A) applies to every kitchen, family room, dining room, living room, parlor, library, den, sunroom, bedroom, recreation room, and similar room.

The 6 ft rule (210.52(A)(1)). No point along the floor line of any wall space may be more than 6 ft from a receptacle. In practice:

1. Put a receptacle within 6 ft of each side of every doorway, fireplace, or other break in the wall.
2. Then put receptacles no more than 12 ft apart along the wall.

Why: appliance cords are about 6 ft long. The rule is meant to keep people from running extension cords across doorways and under rugs.

What counts as wall space (210.52(A)(2)). Any wall 2 ft wide or more, measured along the floor and around corners, unbroken by doors, fireplaces, stationary appliances, or fixed cabinets. It also includes fixed panels such as the fixed side of a sliding glass door, and fixed room dividers such as a bar-type counter or a railing.

Small wall spaces. A 2 ft piece of wall between two doors needs a receptacle. A 23 in. piece does not.

Floor receptacles count only if they are within 18 in. of the wall (210.52(A)(3)).

Countertop receptacles do not count toward the wall rule (210.52(A)(4)).

New in NEC 2026: no receptacles just below a counter. If you put a receptacle on a wall space that is below a countertop or work surface (such as a breakfast bar in the living room), it cannot be within 24 in. of the countertop (210.52(A)(5)). Why: a cord hanging from a receptacle just under a counter edge gets snagged and pulled.

Receptacles that do not count toward the required number (210.52): one that is part of a light fixture or appliance, one inside a cabinet, one more than 5½ ft above the floor, and a switched receptacle used as the room's required lighting outlet (unless it is a half-switched duplex, where the unswitched half counts).

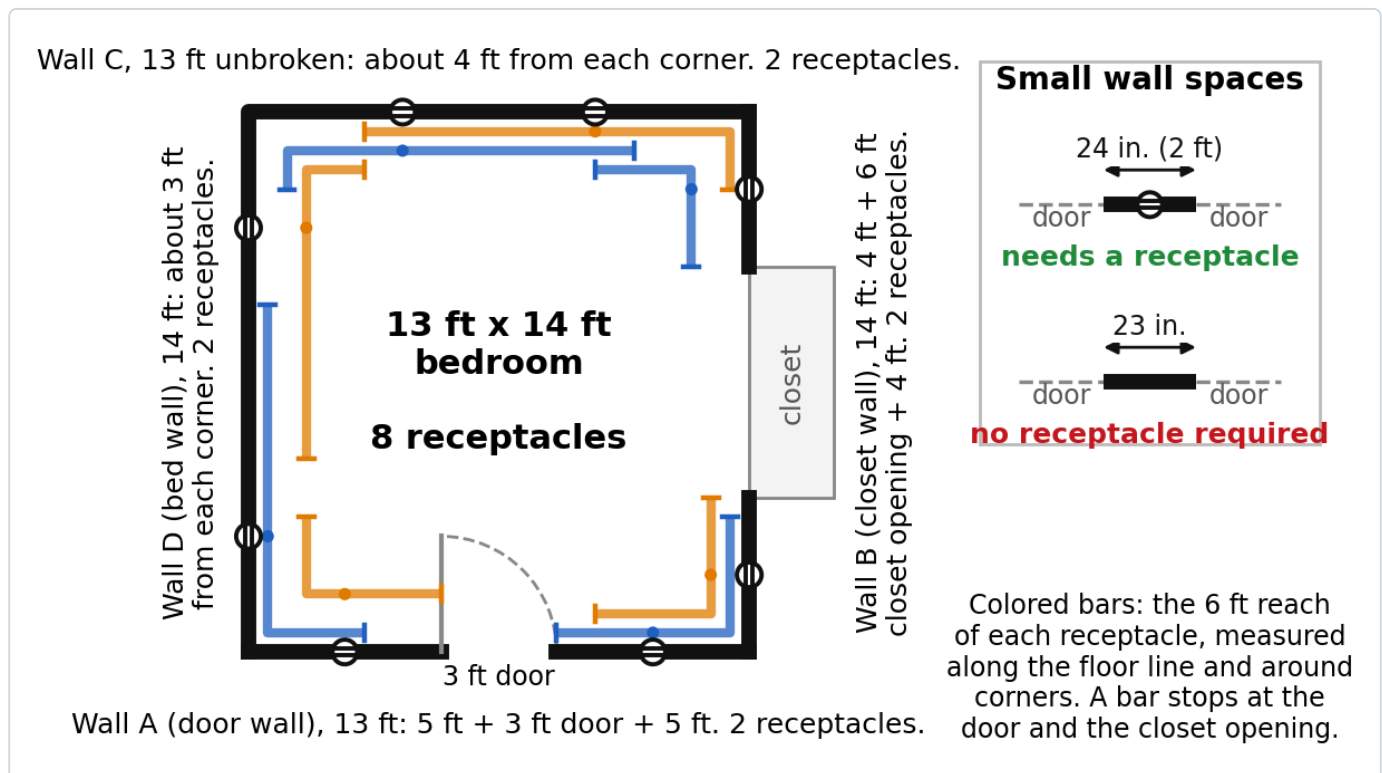
Worked example: a 13 ft × 14 ft bedroom

The bedroom has a 3 ft door in the middle of the 13 ft wall and a 6 ft closet opening on one 14 ft wall.

1. Wall A (door wall), 13 ft: the door splits it into 5 ft and 5 ft pieces. Each is a wall space over 2 ft. One receptacle near the middle of each piece puts every point within 6 ft. That is 2 receptacles.

2. Wall B (closet wall), 14 ft: the closet opening leaves 4 ft and 4 ft pieces. One receptacle in each. That is 2 receptacles. (A single receptacle could serve both if the measurement around the corner works, but separate receptacles are easier to check.)
3. Wall C, 13 ft unbroken: one receptacle in the middle covers 6.5 ft each way, which is 0.5 ft too far at the corners unless the corner receptacles on walls A and D are within 6 ft of the corner. Put two receptacles on wall C, about 4 ft from each corner. That is 2 receptacles.
4. Wall D, 14 ft unbroken (the bed wall): put a receptacle on each side of where the bed will go, about 3 ft from each corner. That is 2 receptacles.

The total is 8 receptacles. Code would allow fewer with careful corner measurements, but 8 is what an owner expects and what YES installs.



This plan view shows the 13 ft by 14 ft bedroom from Section 3.5 with its 8 receptacles. Colored bars show the 6 ft reach of each receptacle along the floor line, and an inset shows that a 24 in. wall between two doors needs a receptacle while a 23 in. wall does not.

Drawing: YES Electric.

3.6 Kitchen counters, islands, and peninsulas

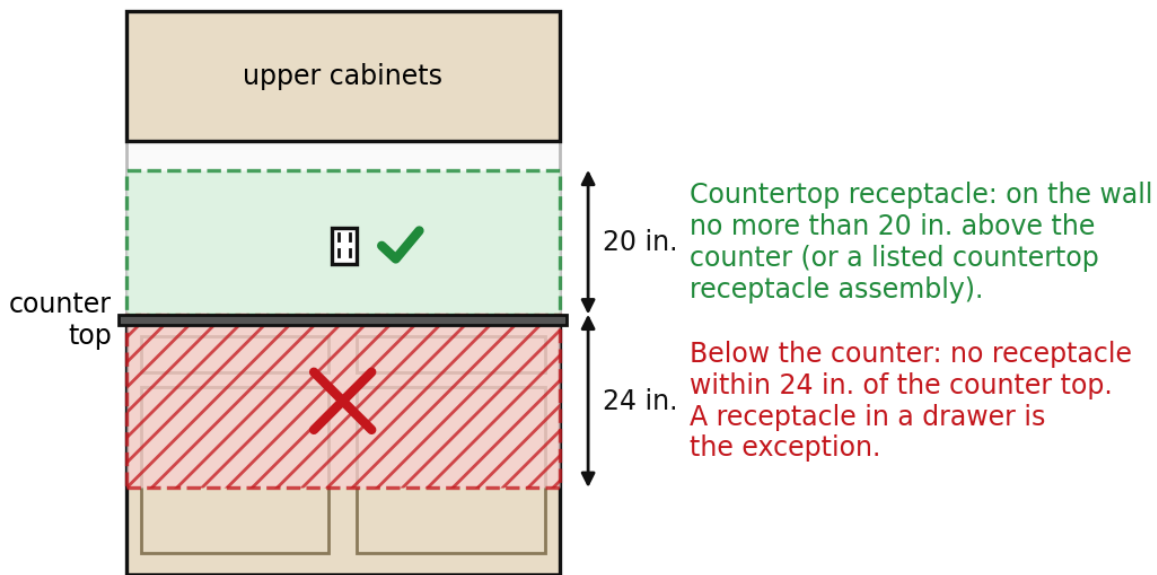
NEC 2026 210.52(C) covers countertops and work surfaces in kitchens, pantries, breakfast rooms, dining rooms, and similar areas.

1. **Every counter space 12 in. or wider gets a receptacle.**
2. **24 in. rule (210.52(C)(1)).** No point along the wall line of a counter may be more than 24 in. from a receptacle. In practice, put a receptacle within 24 in. of each end of each counter section and no more than 48 in. apart between.

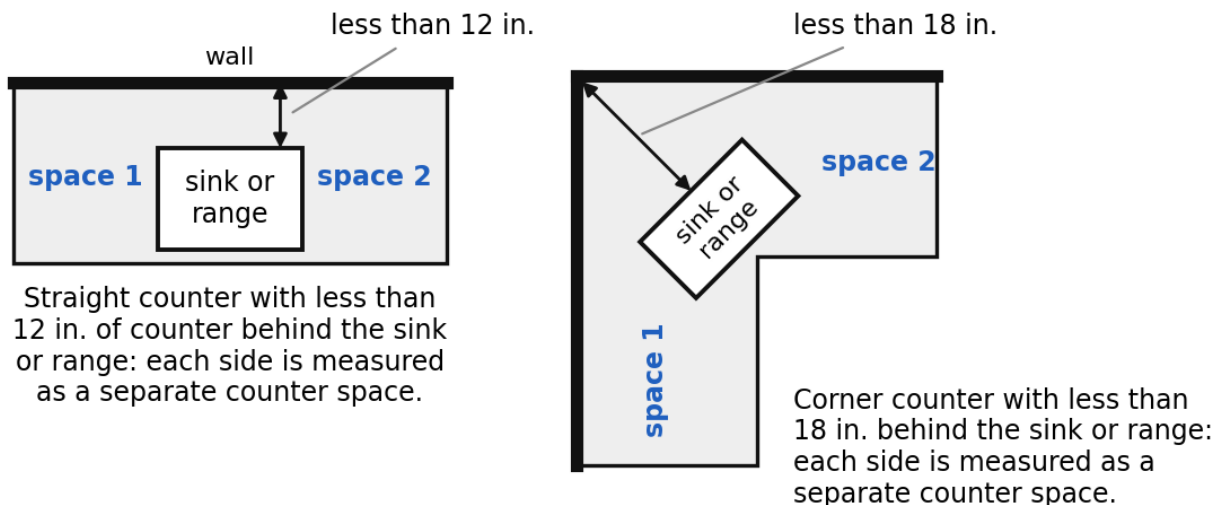
3. **Behind a sink or range.** You do not need a receptacle directly behind a sink or range. Figure 210.52(C)(1) shows when the space behind counts as a break: if the sink or range is set in a straight counter with less than 12 in. of counter behind it, or set across a corner with less than 18 in. behind it, the counter on each side is measured as a separate space.
4. **Height (210.52(C)(3)).** A countertop receptacle must be on the wall no more than 20 in. above the counter, or in the countertop using a receptacle assembly listed for countertops.
5. **Not behind appliances.** A receptacle hidden by an appliance garage, a fastened-in-place appliance, a sink, or a rangetop does not count.
6. **Below the counter (210.52(C)(4)).** A receptacle on the cabinet side or wall below a counter may not be within 24 in. of the counter top. A receptacle installed in a drawer is the exception.
7. **Islands and peninsulas (210.52(C)(2)), the NEC 2026 rule.** You are not required to put a receptacle on an island or peninsula. If you do put one there, it must meet the height and location rules in items 4 and 6. If you do not put one there, you must provide "electrical provisions" at the island or peninsula for a future receptacle. YES practice: run a 12/2 from a small-appliance circuit to a box or a coiled, labeled cable end inside the island base, so a receptacle can be added later. Ask the AHJ what they accept as a provision.

Island receptacle rule history. NEC 2020 and earlier required at least one receptacle on every island and peninsula. NEC 2023 dropped the requirement and added the "future provisions" language. If your AHJ still enforces NEC 2020, you must install the receptacle.

Elevation: the wall behind a counter



Plan views: when a sink or range breaks the counter



A countertop receptacle goes no more than 20 in. above the counter, and no receptacle may be within 24 in. below the counter top. Two plan views show that a sink or range with less than 12 in. behind it on a straight counter, or less than 18 in. behind it across a corner, splits the counter into two separate spaces.

Drawing: YES Electric.

Worked example: an L-shaped kitchen

The L has a 10 ft run with a sink in the middle and an 8 ft run with a 30 in. range in the middle. There is a 2 ft counter at the end of the 8 ft run, past the refrigerator.

Counter section	Length	Receptacles	How placed
Sink run, left of sink	4 ft 3 in.	2	12 in. from the corner and 12 in. from the sink edge. Each point is within 24 in.
Sink run, right of sink	3 ft 9 in.	1	Centered. 22½ in. to each end.
Range run, left of range	2 ft 9 in.	1	Centered.
Range run, right of range	2 ft 9 in.	1	Centered.
Short counter past the refrigerator	2 ft	1	Centered. Every counter space 12 in. or wider needs one.

The total is 6 countertop receptacles. Split them between small-appliance circuit 1 and circuit 2 so that adjacent receptacles are on different circuits.

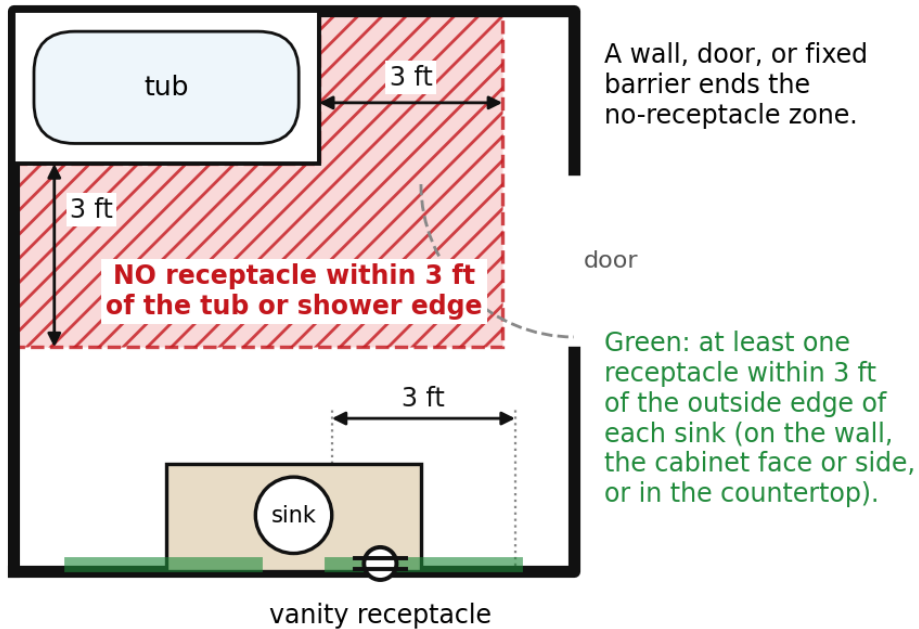
Picture coming: Plan view of the L-shaped kitchen above with dimension lines showing each countertop receptacle and a 24 in. radius drawn from each one along the wall line. Circuit numbers 1 and 2 alternate. The island shows a dashed box labeled "provision for future receptacle, 12/2 from SA-2."

3.7 Bathrooms, laundry, hallways, foyers, outdoors, garage, basement

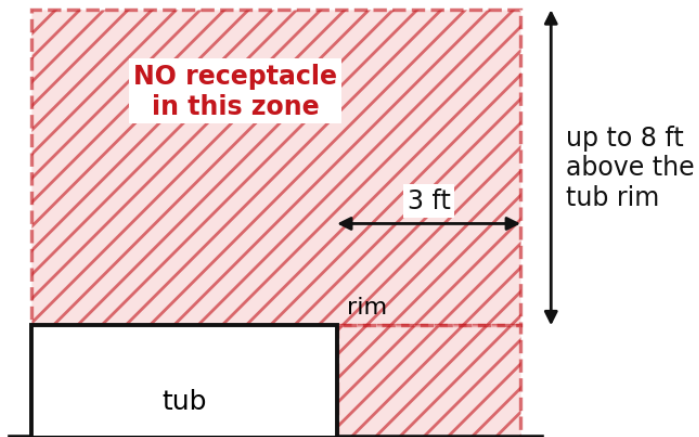
Area	Rule (NEC 2026)	YES practice
Bathroom	At least one receptacle within 3 ft of the outside edge of each sink, on the wall beside the sink, on the face or side of the sink cabinet, or in the countertop. Not more than 12 in. below the top of the sink or counter. (210.52(D))	One receptacle beside each sink, 42 in. to the bottom of the box (about 6 in. above a 36 in. vanity). Double vanity: one receptacle between or one at each sink.
Bathroom receptacle near tub	No receptacle inside a tub or shower, or within 3 ft horizontally of the outside edge of the tub or shower stall, from the floor up to 8 ft above the tub rim or shower threshold. A wall, door, or fixed barrier ends the zone. In a bathroom too small to meet this, the receptacle may go on the wall farthest from the tub or shower (Exception No. 2). (406.9(C)(1)) Switches cannot be in a tub or shower space unless part of a listed tub or shower assembly. (406.9(C)(2))	Plan the vanity receptacle first, then check its distance to the tub.
Laundry	At least one receptacle where laundry equipment goes (210.52(F)), within 6 ft of the appliance (210.50(C)).	Washer receptacle 42 in. to bottom, behind the washer location. Dryer receptacle per Section 3.4.
Hallway	A hallway 10 ft or longer, measured along its centerline without passing through a doorway, needs at least one receptacle. (210.52(H))	One receptacle per 10 ft of hall, for vacuums.
Foyer	A foyer over 60 sq ft that is not part of a hallway needs a receptacle in each wall space 3 ft or wider. (210.52(I))	
Outdoors, front and back	One-family house: at least one receptacle at the front and one at the back, readily accessible from grade and not more than 6½ ft above grade. (210.52(E)(1))	Weather-resistant (WR) receptacle in a box with an extra-duty in-use cover (406.9(B)).
Balcony, deck, porch	A balcony, deck, or porch within 4 in. of the house needs at least one receptacle reachable from it, not more than 6½ ft above its walking surface. (210.52(E)(3))	
HVAC equipment	A 120 V receptacle within 25 ft of heating, air-conditioning, and refrigeration equipment, on the same level, not on the load side of the equipment's disconnect. (210.63(A)) GFCI protected (210.8(E)).	Condenser: WR receptacle on the house wall near the unit. Attic air handler: receptacle in the attic near the unit.
Garage	At least one receptacle in each vehicle bay, not more than 5½ ft above the floor (210.52(G)(1)), on the 20 A garage circuit.	One per bay plus one on each side wall, 48 in. to bottom. A ceiling receptacle for each door

Area	Rule (NEC 2026)	YES practice
		opener (on a separate circuit, see Section 3.11).
Unfinished basement	At least one receptacle in each separate unfinished portion. (210.52(G)(3))	
Accessory building with power	At least one receptacle. (210.52(G)(2))	

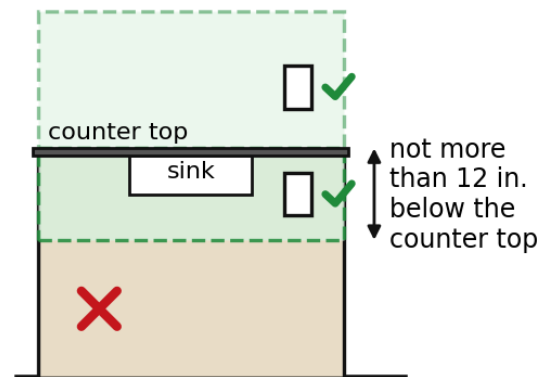
Plan view



Elevation at the tub



Elevation at the vanity



No receptacle may be within 3 ft horizontally of the tub edge, from the floor up to 8 ft above the tub rim. The vanity receptacle must be within 3 ft of the outside edge of the sink and not more than 12 in. below the counter top.

Drawing: YES Electric.

3.8 GFCI, AFCI, and tamper-resistant requirements

GFCI (ground-fault circuit interrupter): NEC 2026 210.8

A GFCI compares the current on the hot and the neutral. If they differ by about 5 mA, some current is leaking to ground, possibly through a person, and it trips. GFCI protection must be

"readily accessible," so a GFCI receptacle cannot be hidden behind a refrigerator or inside a ceiling. Use a GFCI breaker when the outlet itself is hard to reach.

210.8(A): dwelling unit receptacles. All 125 V through 250 V receptacles on single-phase circuits rated 150 V or less to ground and 50 A or less, in these locations, need GFCI protection:

#	Location
1	Bathrooms
2	Garages
3	Accessory buildings with floors at or below grade, used for storage or work
4	Outdoors
5	Crawl spaces at or below grade
6	Basements (finished and unfinished)
7	Kitchens (every receptacle, not only countertop ones)
8	Areas with sinks and permanent provisions for food or beverage preparation or cooking (wet bars)
9	Within 6 ft of the top inside edge of any sink bowl
10	Boathouses
11	Within 6 ft of the outside edge of a bathtub or shower stall
12	Laundry areas
13	Indoor damp locations
14	Indoor wet locations

Note what this includes. The 120/240 V dryer receptacle in a laundry area is a 250 V, 30 A receptacle, so it needs GFCI protection. So does a range receptacle in a kitchen. The refrigerator receptacle is in the kitchen, so it needs GFCI protection.

210.8(D): specific appliances (new and expanded in NEC 2026). The branch circuit or outlet for these appliances, rated 150 V or less to ground and 60 A or less, needs GFCI protection whether they are cord-connected or hardwired. The dwelling-relevant ones are:

Appliance
Dishwashers
Electric ranges
Wall-mounted ovens
Counter-mounted cooking units (cooktops)
Clothes dryers
Microwave ovens
Sump pumps

Why: listed appliances with metal frames have leaked current into people through failed elements and worn cords. A two-pole GFCI breaker is the usual way to protect a 240 V range or dryer.

210.8(E): the HVAC service receptacle required by 210.63 needs GFCI protection.

210.8(F): outdoor outlets. All outdoor outlets at dwellings, not only receptacles, on single-phase circuits of 150 V or less to ground and 60 A or less, need GFCI protection. Lighting outlets are exempt (Exception No. 1). Exception No. 2, which exempted listed HVAC equipment such as the condenser, **expired on September 1, 2026**. After that date, an outdoor condenser or heat pump needs GFCI protection, or a listed Class C SPGFCI (special-purpose GFCI) under Exception No. 3, with the disconnect marked "Warning: Class C SPGFCI Protection Provided for HVAC Unit." Some inverter-drive heat pumps nuisance-trip on a standard GFCI. Ask the journeyman and the HVAC contractor before rough, and ask the AHJ how they are enforcing this.

210.8(C): lighting outlets in crawl spaces need GFCI protection.

AFCI (arc-fault circuit interrupter): NEC 2026 210.12

An AFCI watches the current waveform for the pattern an arc makes: a loose screw terminal, a cable crushed by a staple, a nail through a cable. Those arcs can start fires at currents too low to trip a standard breaker.

210.12(B): all 120 V, 10 A, 15 A, and 20 A circuits supplying outlets or devices in these dwelling areas need AFCI protection:

#	Area
1	Kitchens
2	Family rooms
3	Dining rooms
4	Living rooms
5	Parlors
6	Libraries
7	Dens
8	Bedrooms
9	Sunrooms
10	Recreation rooms
11	Closets
12	Hallways
13	Laundry areas
14	Similar areas

The rule covers the whole circuit, lights and smoke alarms included. If a circuit serves a bedroom light and the hallway smoke alarm, it needs AFCI protection. Bathrooms, garages, outdoors, attics, and unfinished basements are not on the list.

How to provide it. In new construction, use a combination-type AFCI breaker (210.12(A)(1)) or a dual-function breaker where GFCI is also needed. 210.12(A) lists other methods (outlet-type AFCI at the first outlet with limits on the home-run length: 50 ft of 14 AWG or 70 ft of 12 AWG) that are mostly used in remodels. R1.4 covers them.

Where you need both. Kitchen receptacles, laundry receptacles, a dishwasher in a kitchen, and a disposal or microwave in a kitchen need both AFCI and GFCI. Use a dual-function (DF) breaker, or an AFCI breaker with a GFCI receptacle downstream.

Tamper-resistant receptacles: NEC 2026 406.26 (NEC 2023 406.12)

All 15 A and 20 A, 125 V and 250 V non-locking receptacles in dwelling units, including attached and detached garages and accessory buildings, must be listed tamper-resistant (TR). The face of the receptacle is marked "TR." Shutters behind the slots open only when both prongs push in at once. Why: children push keys and hairpins into receptacles.

Exceptions exist (receptacles more than 5½ ft above the floor, receptacles that are part of an appliance or luminaire, and a single receptacle or duplex for an appliance that is not easily moved, located in a dedicated space). The NEC 2026 text of the exceptions was not readable in

our copy, so it is still being checked against the printed code book. YES installs TR on every 15 A and 20 A receptacle in a house, which avoids the question.



Tamper-resistant (TR) receptacle: TR is molded into the face



Outdoor box with an in-use (bubble) cover

Left: a tamper-resistant receptacle has the letters TR molded into its face. Right: an outdoor box with an in-use (bubble) cover, which keeps rain out even while a cord is plugged in.

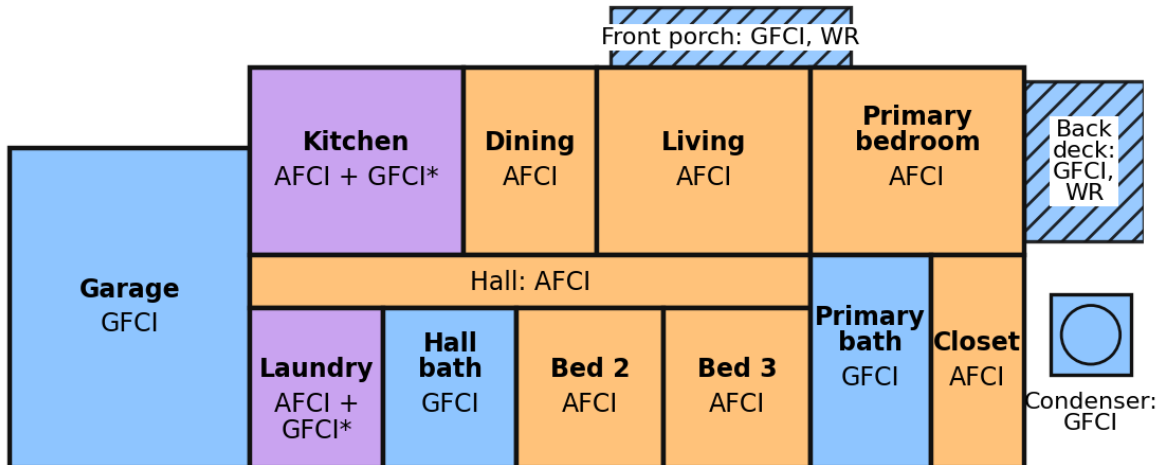
Photo: NEMA 5-20RA GFCI Tamper Resistant Receptacle.jpg by Wtshymanski, CC BY-SA 3.0; 20051008tub-panel03 by davef3138, CC BY 2.0.

Summary table: protection by location

Location	GFCI	AFCI	TR
Kitchen countertop and wall receptacles	Yes	Yes	Yes
Refrigerator, dishwasher, disposal, microwave (kitchen)	Yes	Yes	Yes (receptacles)
Range, cooktop, wall oven (240 V)	Yes (210.8(D))	No (240 V)	Not applicable to 50 A
Dryer receptacle (laundry)	Yes	No (240 V)	No (30 A)
Washer receptacle (laundry)	Yes	Yes	Yes
Bedrooms, living, dining, hall, closets	No*	Yes	Yes
Bathrooms	Yes	No	Yes
Garage receptacles	Yes	No	Yes
Outdoors, including the condenser	Yes	No	Yes, and WR
Attic HVAC service receptacle	Yes	No	Yes
Unfinished basement	Yes	No	Yes
Smoke alarms on a bedroom/hall circuit	No	Yes	Not applicable

*Unless within 6 ft of a sink, such as a wet bar.

Protection by location for the example house (Section 3.8 summary table)



GFCI
 AFCI
 Both (dual-function breaker)
 Neither

*The 240 V range (kitchen) and dryer (laundry) circuits get GFCI only, no AFCI.
 Smoke alarms are on the AFCI hall circuit (circuit 18). Attic HVAC receptacle and crawl space: GFCI.
 Neither (standard breaker): bathroom lights and exhaust fans (circuit 20), water heater (circuit 10), air handler (circuit 11). All 15 A and 20 A receptacles are tamper-resistant (TR); outdoor ones are also weather-resistant (WR).

This floor plan of the 3-bedroom, 2-bath example house is colored to show which rooms need GFCI protection, AFCI protection, or both, following the Section 3.8 summary table.

Drawing: YES Electric.

3.9 Required lighting outlets and switch locations: NEC 2026

210.70

Location	Requirement
Every habitable room, kitchen, laundry area, and bathroom	At least one lighting outlet controlled by a wall switch near an entrance to the room. (210.70(A)(1))
Switched receptacle instead of a light	Allowed in rooms other than kitchens, laundry areas, and bathrooms (Exception No. 1). Common in bedrooms and living rooms.
Hallways, stairways, attached and detached garages with power, accessory buildings with power	At least one wall-switched lighting outlet. (210.70(A)(2)(1))
Outdoor entrances with grade-level access	At least one wall-switched light on the outside of each entrance or exit. A garage vehicle door does not count as an entrance. (210.70(A)(2)(2))
Interior stairs with 6 or more risers	A switch at each floor level, and at each landing that has a stairway entry, controlling the stair light. This means 3-way switches top and bottom. (210.70(A)(2)(3)) Dimmers only if each location can bring the light to full brightness. (210.70(A)(2)(4))
Attics, crawl spaces, utility rooms, basements used for storage or containing equipment needing service	At least one lighting outlet with a switch at each point of entry, and the light at or near the equipment. (210.70(C)) An attic with an air handler always needs this.

Remote, central, or automatic control (motion sensors, smart systems) is allowed in hallways, stairways, and at outdoor entrances.

Neutral at the switch (NEC 2026 406.30(C), NEC 2023 404.2(C)). Bring a neutral to switch locations that control lighting in bathrooms, hallways, stairways, and habitable rooms. Why: smart switches, occupancy sensors, and timers need a neutral to power their electronics. YES practice: bring a neutral (a white conductor) into every switch box. It costs nothing at rough and saves a rewire later.

3.10 Smoke and carbon monoxide alarms

Smoke and CO alarm locations come from the building code (the IRC, Sections R314 and R315), not the NEC. The common requirements for new houses are:

1. A smoke alarm in each sleeping room.
2. A smoke alarm outside each separate sleeping area, in the hall near the bedrooms.
3. A smoke alarm on each story, including basements.

4. All alarms hardwired to 120 V with battery backup, and interconnected so that when one sounds, all sound.
5. A CO alarm outside each sleeping area when the house has a fuel-burning appliance (gas furnace, gas water heater, fireplace) or an attached garage.

Ask the AHJ for the local amendments. The IRC also sets distances from bathrooms, kitchens, and ceiling corners. R-LOWVOLT and R1.7 cover alarm details. In this chapter you wire them in Section 5.10.

Smoke alarms in bedrooms and halls are on circuits that need AFCI protection (210.12(B)). NFPA 72 asks that the alarm circuit not be on a GFCI. YES practice: put the alarms on the bedroom-hall lighting circuit. A lighting circuit gets used every day, so a tripped breaker is noticed quickly.

3.11 Worked example: 3-bedroom, 2-bath, 1,800 sq ft house

The house. One story on a crawl space, 1,800 sq ft of living area, plus an attached 2-car garage. Electric range (12 kW), electric dryer (5,000 W), electric water heater (4,500 W, 50 gal), heat pump (3-ton condenser outside, air handler with 10 kW heat strips in the attic). Over-the-range microwave, dishwasher, disposal, refrigerator with ice maker. One kitchen with an island, a dining room, a living room, a primary bedroom with its own bath, two more bedrooms, a hall bath, a laundry room, a front porch and a back deck.

Assumed equipment nameplates (change these to the real nameplates on your job):

Equipment	Nameplate assumption
Air handler with 10 kW strips	MCA 52 A, MOCP 60 A
Heat pump condenser	MCA 19 A, MOCP 30 A, about 4 kVA
Microwave	1,500 W
Dishwasher	1,200 W
Disposal	800 W (about $\frac{3}{4}$ hp)

The circuit schedule

Ckt	Serves	Breaker	Cable	Protection	Device notes
1	Kitchen small-appliance #1: countertops left of sink, dining room receptacles	20 A 1P	12/2	DF (AFCI+GFCI) breaker	TR receptacles
2	Kitchen small-appliance #2: countertops right of sink and range run, island provision, pantry	20 A 1P	12/2	DF breaker	TR
3	Refrigerator	20 A 1P	12/2	DF breaker	Single or duplex TR receptacle behind fridge, 48 in. to bottom
4	Dishwasher	20 A 1P	12/2	DF breaker	Receptacle in sink base, cord per 422.16(B)(2)
5	Disposal	20 A 1P	12/2	DF breaker	Switched receptacle in sink base; switch at counter by the sink
6	Over-the-range microwave	20 A 1P	12/2	DF breaker	Receptacle in the cabinet above the range
7	Range, 12 kW	50 A 2P	6/3 NM-B	2P GFCI breaker (210.8(D))	14-50R receptacle, 4-wire
8	Dryer, 5,000 W	30 A 2P	10/3 NM-B	2P GFCI breaker (210.8(A)(12), 210.8(D))	14-30R receptacle, 4-wire
9	Washer and laundry receptacles	20 A 1P	12/2	DF breaker	TR
10	Water heater, 4,500 W	30 A 2P	10/2 NM-B	Standard 2P	Hardwired. White re-identified black or red.
11	Air handler, 10 kW strips	60 A 2P	6/2 NM-B (55 A at 60°C, ≥ MCA 52 A)	Standard 2P	Hardwired to the unit's disconnect or terminal block
12	Heat pump condenser	30 A 2P	10/2 NM-B to the outdoor disconnect, then	2P GFCI or Class C SPGFCI per Section 3.8	Disconnect within sight of the unit (440.14)

Ckt	Serves	Breaker	Cable	Protection	Device notes
			10 AWG in liquidtight whip		
13	Bathroom receptacles, both baths	20 A 1P	12/2	GFCI receptacle at each vanity, or a GFCI breaker	TR
14	Primary bedroom and its closet: receptacles and lights	15 A 1P	14/2, 14/3 to fan	AFCI breaker	TR
15	Bedroom 2: receptacles and light	15 A 1P	14/2	AFCI breaker	TR
16	Bedroom 3: receptacles and light	15 A 1P	14/2	AFCI breaker	TR
17	Living room receptacles	20 A 1P	12/2	AFCI breaker	TR
18	Hall receptacle, hall lights, laundry light, all smoke alarms	15 A 1P	14/2, 14/3 between alarms	AFCI breaker	Interconnect on the red wire
19	Kitchen, dining, living, and foyer lights; porch and back-door lights	15 A 1P	14/2, 14/3 for 3-ways	AFCI breaker	
20	Both bathrooms: lights and exhaust fans	15 A 1P	14/2, 14/3 for fan/light	Standard	Not an AFCI area if the circuit serves only bathrooms
21	Garage receptacles, one per bay plus side walls	20 A 1P	12/2	GFCI breaker	TR
22	Garage lights, garage door opener receptacles (ceiling), garage-side exterior light	15 A 1P	14/2	GFCI breaker (opener receptacles are in the garage)	TR
23	Exterior receptacles: front, back, deck	20 A 1P	12/2	GFCI breaker	WR and TR, extra-duty in-use covers
24	Attic: HVAC service receptacle and attic light switched at the scuttle	15 A 1P	14/2	GFCI breaker	
25	Crawl space light switched at the access	15 A 1P	14/2	GFCI breaker (210.8(A)(5), 210.8(C))	

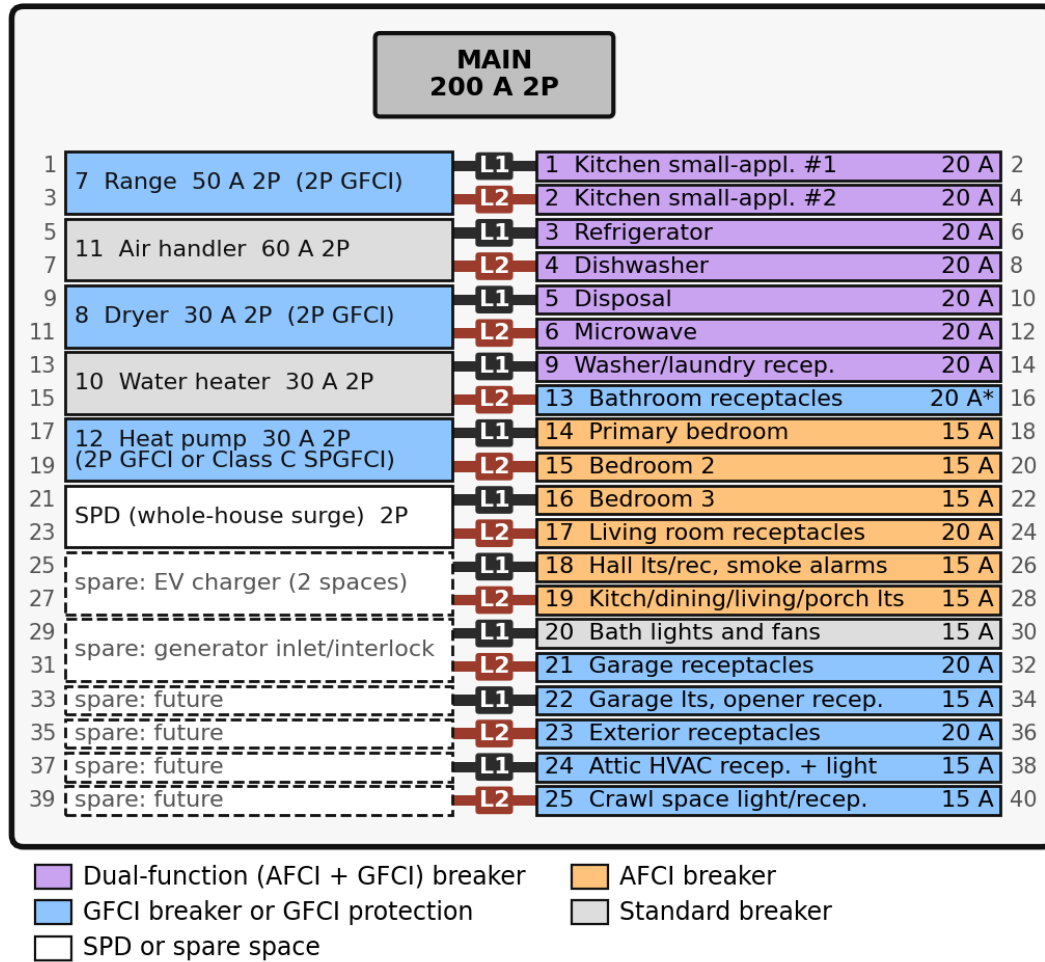
Ckt	Serves	Breaker	Cable	Protection	Device notes
	door, crawl space receptacle (if any)				

Counting the panel

Item	Count
Single-pole circuits	20 (circuits 1–6, 9, 13–25)
Two-pole circuits	5 (circuits 7, 8, 10, 11, 12), 10 spaces
Spaces used	30
Whole-house surge protective device (required for dwelling services by 230.67)	2 spaces if it is a breaker-type SPD
Spaces used with SPD	32

Panel choice: 200 A, 40-space. It leaves 8 spaces for an EV charger (2 spaces), a generator inlet and interlock (2 spaces), and 4 for future circuits. Do not fill a new panel more than about 80%. Every owner adds something later.

200 A, 40-space panel for the Section 3.11 example house



Single-pole breakers alternate L1, L2 down each side. Each two-pole breaker takes one L1 and one L2 space. Used: 20 single-pole + 5 two-pole (10 spaces) = 30, plus a 2-space SPD = 32. Spare: 8 of 40.

*Circuit 13: GFCI receptacle at each vanity, or a GFCI breaker. The placement shown is one workable layout.

This 40-space panel layout places circuits 1 to 25 of the example house, with single-pole breakers alternating between the L1 and L2 legs and each two-pole breaker using one space on each leg. It also shows the 2-space surge protective device and the 8 spare spaces.

Drawing: YES Electric.

Is 200 A enough? (Preview of R-LOAD)

R-LOAD teaches the full calculation. Here is the short version using the NEC 2026 optional method for one dwelling (120.82, NEC 2023 220.82), so you can see where the numbers come . Note that NEC 2026 changed this method: general lighting is now 2 VA per sq ft (it was 3), and the first block taken at 100% is now 8 kVA (it was 10).

Step	Load	VA
1	General lighting and receptacles: 1,800 sq ft × 2 VA	3,600
2	Two small-appliance circuits × 1,500 VA	3,000
3	Laundry circuit × 1,500 VA	1,500
4	Range nameplate	12,000
5	Dryer nameplate	5,000
6	Water heater nameplate	4,500
7	Dishwasher, disposal, microwave nameplates	3,500
8	Subtotal, general loads	33,100
9	First 8,000 VA at 100%	8,000
10	Remainder (25,100 VA) at 40%	10,040
11	General load after demand	18,040
12	Heat pump: 100% of compressor (4,000 VA) + 65% of 10 kW strips (6,500 VA), per 120.82(C)(3)	10,500
13	Total	28,540 VA
14	Divide by 240 V	119 A

The calculated load is 119 A, so a 200 A service carries it with room for an EV charger. The refrigerator is not added separately in this method because it is served from a small-appliance or individual receptacle circuit whose load is already counted in the 1,500 VA blocks and the per-square-foot figure. R-LOAD shows each step and the cases where this changes.

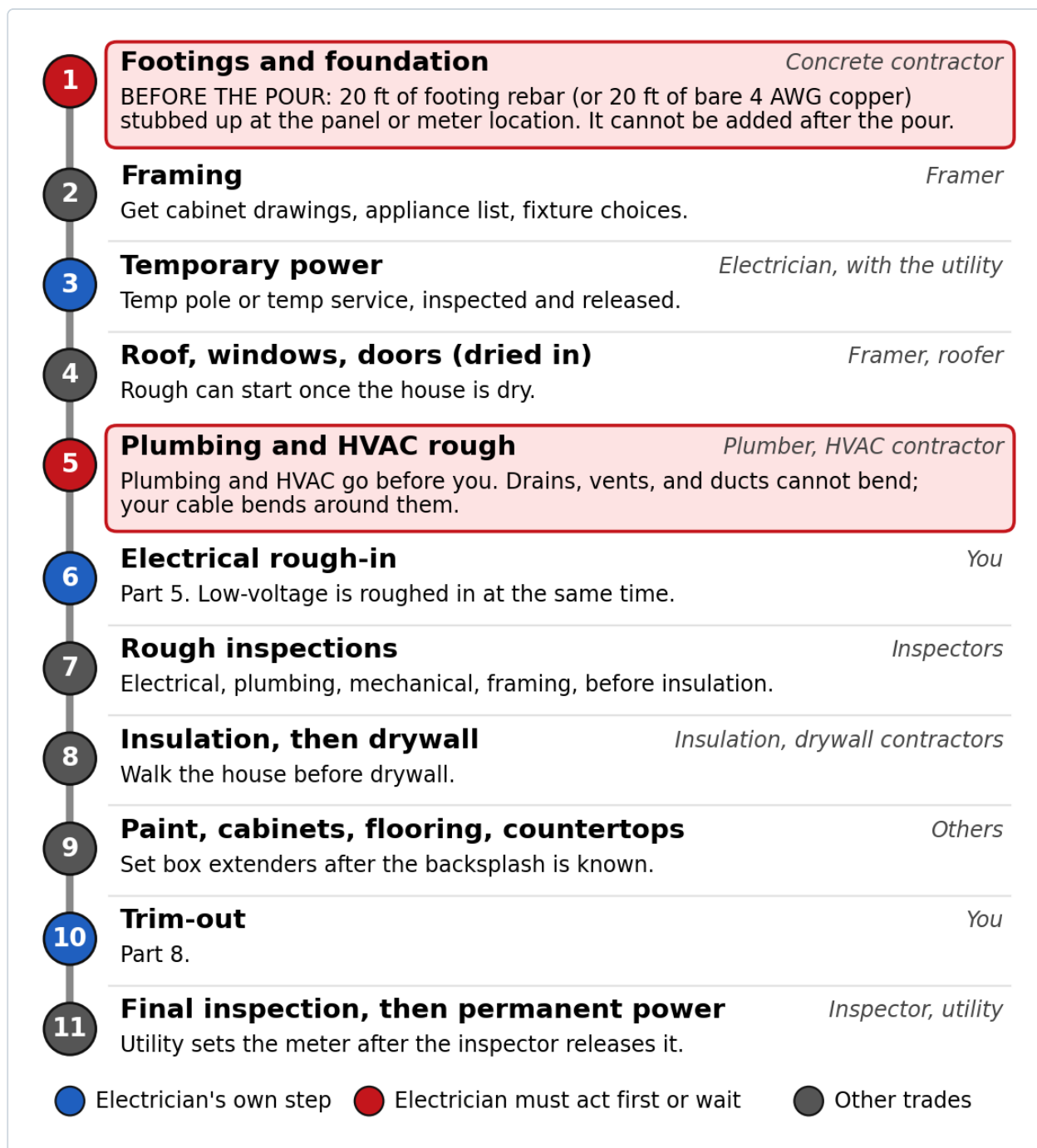
3.12 The permit, the other trades, and the order of work

A green helper does not pull permits or decide the schedule. You still need to know the order, because doing your part at the wrong time means tearing it out.

The permit. On YES jobs, YES pulls the electrical permit as the licensed electrical contractor, and all work is done under a licensed electrician's supervision. A helper wires the house under the journeyman. Never call for an inspection yourself unless the journeyman tells you to. The permit card has to be posted on site before rough-in starts.

The order of trades on a new house:

Step	Who	What the electrician does at this step
1. Footings and foundation	Concrete contractor	Before the footing is poured , make sure a 20 ft piece of the footing rebar (or 20 ft of bare 4 AWG copper) is stubbed up or reachable at the panel or meter location. This is the concrete-encased electrode (Part 6A). It cannot be added after the pour.
2. Framing	Framer	Nothing yet. Get the cabinet drawings, the appliance list, and the fixture choices.
3. Temporary power	Electrician, with the utility	A temp pole or a temp service on the meter base location, inspected and released.
4. Roof, windows, doors ("dried in")	Framer, roofer	You can start rough once the house is dry. Rain on open boxes and wet cable jackets is not allowed.
5. Plumbing and HVAC rough	Plumber, HVAC contractor	They go before you. Drains, vents, and ducts are large and cannot bend around your cable. Your cable bends around them. If you rough in first, expect to move cable.
6. Electrical rough-in	You	Part 5 of this chapter. Low-voltage (data, coax, doorbell, thermostat) is roughed in at the same time (R-LOWVOLT).
7. Rough inspections	Inspectors	Electrical, plumbing, mechanical, and framing are inspected before insulation.
8. Insulation, then drywall	Insulation, drywall contractors	Walk the house before drywall to confirm nothing got pulled loose.
9. Paint, cabinets, flooring, countertops	Others	Set kitchen and bath box extenders after the backsplash is known.
10. Trim-out	You	Part 8.
11. Final inspection, then permanent power	Inspector, utility	Part 9. The utility sets the meter after the inspector releases it.



The order of trades on a new house runs from footings to final inspection in 11 steps. Step 1 is flagged because 20 ft of footing rebar or bare 4 AWG copper must be stubbed up before the pour, and step 5 is flagged because plumbing and HVAC rough go before the electrician.

Drawing: YES Electric.

What to get from the builder before you plan:

1. The kitchen and bath cabinet drawings with dimensions. Countertop receptacles, the sink-base dishwasher and disposal boxes, the microwave receptacle, under-cabinet lights, and the island provision all come from this drawing.
2. The HVAC equipment locations: the air handler or furnace, the condenser pad, and the thermostat location.

3. The water heater location and type.
4. Window and door locations as framed. Receptacles and switches often move because a window ended up wider than the plan.
5. Where the meter goes. Alabama Power wants the meter socket 48 to 60 in. to the center above finished grade and, since January 1, 2022, an external disconnect on the load side of every new residential meter base (Alabama Power Builder's Guide, in). R-SERVICE covers the full utility rules.

PART 4: MATERIALS

4.1 Cable sizes

All the cable in a typical house is Type NM-B ("Romex" is one brand name). The "B" means the conductors are rated 90°C, but NEC 2020 334.80(A) limits NM cable to the 60°C ampacity column of Table 310.16. Why: NM cable is buried in insulation and bundled through holes, where it cannot shed heat, so the code uses the lowest temperature rating. The jacket colors are an industry convention (made by all major manufacturers so a crew can see wire size from across a room). The code does not require them.

Cable	Conductors inside	Ampacity, 60°C copper (Table 310.16)	Breaker	Jacket color	Typical use in a house
14/2 with ground	Black, white, bare	15 A	15 A (240.4(D))	White	Lighting, bedroom and general receptacle circuits, bath fans
14/3 with ground	Black, red, white, bare	15 A	15 A	White	3-way travelers, smoke alarm interconnect, fan/light with separate switches
12/2 with ground	Black, white, bare	20 A	20 A (240.4(D))	Yellow	Kitchen small-appliance, bath, laundry, garage, outdoor, dishwasher, disposal, microwave, refrigerator, living room receptacles
12/3 with ground	Black, red, white, bare	20 A	20 A	Yellow	3-ways on a 20 A circuit; 20 A multiwire circuits (two-pole breaker required)
10/2 with ground	Black, white, bare	30 A	30 A (240.4(D))	Orange	Water heater, condenser
10/3 with ground	Black, red, white, bare	30 A	30 A	Orange	Dryer, small wall oven or cooktop
8/3 with ground	Black, red, white, bare	40 A	40 A	Black	40 A range or cooktop
6/3 with ground	Black, red, white, bare	55 A	50 A (next standard size down is 50 A; 55 A is not a standard breaker)	Black	50 A range
6/2 with ground	Black, white, bare	55 A	Per HVAC nameplate MOCP	Black	Air handler with heat strips

Notes:

- 1. 14 AWG never goes on a 20 A breaker.** This is the most common rough-in mistake. A 20 A circuit needs 12 AWG from the breaker to the last outlet, including every pigtail.
- 2. 12 AWG on a 15 A breaker is allowed** but wastes copper and makes devices harder to fit. YES uses 14 AWG on 15 A circuits.
- 3. HVAC uses different rules.** Under Article 440, the wire is sized to the nameplate MCA and the breaker to the nameplate MOCP. A condenser with MCA 19 A and MOCP 30 A can

be on 12 AWG and a 30 A breaker. YES runs 10 AWG anyway so the circuit can carry a larger replacement unit later.

4. **Aluminum branch-circuit wiring** is not used for new 15 A and 20 A circuits. R-OLDHOUSE covers it.
5. **UF cable** (gray jacket) is for wet locations and direct burial. NM may not be used in wet or damp locations (334.12(A)(4)).

4.2 Boxes

Box	Where	Typical volume
Single-gang new-work plastic (nail-on)	Switches and receptacles in stud walls	18.0, 20.3, or 22.5 cu in (marked inside the box)
Two-gang new-work plastic	Two switches, or a switch and a receptacle	About 32 to 35 cu in
Three-gang and four-gang new-work plastic	Switch banks at entries	About 45 to 70 cu in
Round or octagon ceiling box, plastic, 50 lb rated	Ceiling lights	Marked
Fan-rated ceiling box or fan brace	Any ceiling location where a fan could go	Marked; must be listed and marked "for fan support" (314.27(B))
4 in. square metal, 2⅞ in. deep, with a mud ring	Kitchen, garage, and anywhere a box needs more room	30.3 cu in for the box (Table 314.16(A)), plus the ring's marked volume
Adjustable-depth box	Kitchen backsplash where tile thickness is unknown	Marked
Weatherproof box or siding mounting block	Exterior receptacles and lights	Marked
Old-work (remodel) box	Finished walls only (R1.3)	Marked

Fixture weight (314.27(A)). A ceiling box at a lighting outlet must support a fixture of at least 50 lb. A fixture heavier than 50 lb needs a box listed and marked for that weight, or support independent of the box. A wall fixture over 6 lb needs a box marked for it. A ceiling fan always needs a box listed for fan support. The box is marked with the maximum fan weight if it is over 35 lb, and no fan box may carry more than 70 lb.

4.3 Box fill: how to calculate it

NEC 2026 314.16 sets how many wires can go in a box. Too many wires overheat, damage insulation when the device is pushed in, and make loose connections. Inspectors check it on every job.

Step 1. Find the box volume. It is printed inside every plastic box. For a standard metal box, use Table 314.16(A). Add the marked volume of a mud ring or extension ring.

Step 2. Count the allowances. Each allowance uses the volume per conductor from Table 314.16(B)(4):

Wire size	Volume per allowance
14 AWG	2.00 cu in
12 AWG	2.25 cu in
10 AWG	2.50 cu in
8 AWG	3.00 cu in
6 AWG	5.00 cu in

What is in the box	Allowances	Rule
Each hot or neutral conductor that enters from outside and is spliced or terminated	1 each, at its own size	314.16(B)(1)
A conductor that passes through without a splice	1	314.16(B)(1)
A pigtail that never leaves the box	0	314.16(B)(1)
Internal cable clamps (any number)	1 total, at the largest conductor size	314.16(B)(2)
Fixture studs or hickey	1 each type, at the largest size	314.16(B)(3)
Each device yoke (a switch, a receptacle, a GFCI)	2, at the largest conductor connected to that device	314.16(B)(4)
Equipment grounding conductors, up to 4	1 total, at the largest ground size	314.16(B)(5)
Each equipment grounding conductor beyond 4	$\frac{1}{4}$ each	314.16(B)(5), new in NEC 2026

NEC 2026 change. Before NEC 2026, all the grounds in a box counted as one allowance no matter how many there were. Now the first four count as one, and each ground after that adds a quarter allowance. A box with six cables has six grounds, so you add $2 \times \frac{1}{4} = \frac{1}{2}$ allowance.

Step 3. Multiply and add. Compare the total to the box volume. The total must be less than or equal to the box volume.

Worked example 1: a receptacle in the middle of a 20 A run

A single-gang plastic box, 18.0 cu in, no internal clamps. Two 12/2 cables (one in, one out) and one duplex receptacle.

Item	Count	× size	Volume
Insulated conductors: 2 black, 2 white	4	× 2.25	9.00
Grounds: 2 (up to 4 = 1 allowance)	1	× 2.25	2.25
Device yoke	2	× 2.25	4.50
Clamps	0		0
Total			15.75 cu in

$15.75 \leq 18.0$, so the box passes.

Worked example 2: a GFCI with three 12/2 cables

Same 18.0 cu in box. Three 12/2 cables (feed in, LOAD out, and a second LINE-side branch), one GFCI receptacle.

Item	Count	× size	Volume
Insulated conductors: 3 black, 3 white	6	× 2.25	13.50
Grounds: 3	1	× 2.25	2.25
GFCI yoke	2	× 2.25	4.50
Total			20.25 cu in

$20.25 > 18.0$. The box fails. A 20.3 cu in box would pass by 0.05 cu in, which leaves no room for a deep GFCI body. Use a 22.5 cu in box. Plan GFCI boxes this way at rough, because the GFCI body is deeper than a standard receptacle.

Worked example 3: a two-gang switch box with a 3-way

A two-gang plastic box marked 32.0 cu in. Cables: 14/2 from the panel (power in), 14/2 to the room light, 14/3 to the 3-way at the other door. Devices: one single-pole switch for the room light, one 3-way switch.

Item	Count	× size	Volume
Insulated conductors: 14/2 (2) + 14/2 (2) + 14/3 (3)	7	× 2.00	14.00
Grounds: 3	1	× 2.00	2.00
Two device yokes	4	× 2.00	8.00
Total			24.00 cu in

$24.0 \leq 32.0$, so the box passes.

The Arc Guide's box-fill section (Part 10) says to count every conductor at the largest wire size when sizes are mixed. That is not what 314.16(B) says. Count each conductor at its own size. Only the clamp, fitting, device, and ground allowances use the largest size.

4.4 Staples, plates, bushings, and connectors

Item	Use	Rule
NM staples, listed	Secure cable to framing	334.2 requires them to be listed. Use the size marked for the cable. Do not overdrive. The staple should hold the cable without denting the jacket.
Stacker or "cable organizer" straps	Run 2 to 4 cables neatly along a stud	Listed for the number of cables. Flat cable is never stapled on edge (334.30).
Nail plates (steel, 1/16 in. thick)	Cover a cable that is less than 1¼ in. from the face of a stud, joist, or plate	300.6(A) and 300.6(D)
Plastic grommets or bushings	Line holes in metal studs before cable goes through	300.6(B)(1). Must stay in place and be listed.
Wire connectors (twist-on)	Splices	Use the size and wire combination printed on the box.
Push-in or lever connectors	Splices	Listed for the wire sizes. Lever types (such as Wago 221) also take stranded fixture leads.
Crimp sleeves and ground wire connectors with a hole	Ground make-up	Sized for the number and size of grounds.
Green ground screws (10-32)	Bond a ground to a metal box	250.148 requires grounds be connected to a metal box. Use the tapped hole in the box.
Cable connectors (clamps) for metal boxes and the panel	Secure cable where it enters a knockout	314.17(B)(2)

4.5 Material takeoff for the example house

A green helper is often sent to the supply house with a list. Here is how the list for the 1,800 sq ft house in Section 3.11 is built. The quantities are YES planning estimates. Count your own plan before ordering.

Step 1. Count the boxes from the marked-up plan.

Box	Count for the example house	Where they come from
Single-gang new-work, 20.3 or 22.5 cu in	About 75	Wall receptacles (about 45), single switches (about 20), sink-base, fridge, washer, garage
Two-gang new-work	About 10	Entry switch pairs, bath vanity light and fan, kitchen
Three-gang new-work	2 or 3	Front entry and kitchen switch banks
Ceiling box, 50 lb rated	About 15	Bedroom closets, halls, baths, laundry, garage, exterior wall lights
Fan-rated ceiling box or brace	4	Three bedrooms and the living room
Canless recessed lights (with their own junction box)	About 20	Kitchen, living, halls, per the fixture plan
4 in. square, 2 $\frac{1}{8}$ in. deep, with mud ring	3	Range receptacle, dryer receptacle, water heater junction if not hardwired at the tank
Weatherproof box or siding mounting block	6	Front, back, and deck receptacles, three door lights
Smoke and CO alarm boxes	6	Three bedrooms, hall, living area, one CO

Step 2. Estimate cable by measuring each circuit. For each circuit on the schedule:

1. Measure the route on the plan from the panel to the first box, through the attic or crawl space if that is how you will run it. Add the drop down the wall (about 8 ft for a ceiling-height run down to a receptacle).
2. Add the box-to-box lengths. Two receptacles 10 ft apart on one wall take about 12 ft of cable once you add the drop into each box.
3. Add 2 ft for each box (1 ft of tail out of each side) and 3 ft at the panel.
4. Add 15% for routing around things you cannot see on the plan.

For the example house, those steps come out near these totals:

Cable	Estimate	Buy
14/2 NM-B	About 1,100 ft	Five 250 ft coils
14/3 NM-B	About 200 ft	One 250 ft coil
12/2 NM-B	About 900 ft	Four 250 ft coils
10/2 NM-B	About 90 ft	Cut length (water heater and condenser)
10/3 NM-B	About 40 ft	Cut length (dryer)
6/3 NM-B	About 35 ft	Cut length (range)
6/2 NM-B	About 60 ft	Cut length (attic air handler)

Step 3. Small parts.

Item	Quantity	How it is figured
NM staples	About 1,000	2 per box plus 1 every 4 ft of run, plus waste
Stacker straps	About 50	Near the panel and at long vertical runs
Nail plates	About 75	Every top and bottom plate hole in a 2×4 wall, plus off-center holes
Grounding crimp sleeves or ground connectors	About 150	1 per box, plus extras
Twist-on or lever connectors	About 400	Count 2 to 4 per box, more at switch and fan boxes
Cable connectors for the panel	About 30	One per home run, sized for the cable
1×4 running boards and 1×2 guard strips	Per attic layout	Section 5.6
Fire-rated caulk or foam	4 to 6 tubes or cans	If sealing is your job (Section 5.7)

The devices (receptacles, switches, GFCIs, breakers) are ordered for trim-out after the rough inspection, from the same box count. The breaker list comes straight from the circuit schedule in Section 3.11.

PART 5: ROUGH-IN, STEP BY STEP

Rough-in is everything you install before insulation and drywall: boxes, cable, protection, and ground splices. For an 1,800 sq ft house, a journeyman and a helper typically take 3 to 5 days (Section 5.12 gives a day-by-day schedule). Work in this order:

1. Set the panel (or confirm where it goes).
2. Set every box in the house.
3. Drill every hole.
4. Pull the home runs and the box-to-box cable, one circuit at a time.
5. Staple and protect.
6. Make up grounds, strip sheaths, label, and fold conductors into boxes.
7. Do the pre-inspection checklist (Part 6).

Why boxes first: once every box is up, you can see the whole route of each circuit and drill straight lines, so you drill fewer holes and pull less cable.

5.0 Rough-in tool kit

Bring all of this on rough day. Commercial Module 1.1 and R1.1 cover tool use and safety in depth.

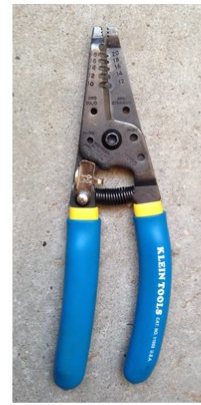
Tool	What it is for
Right-angle drill (corded or 18 V high-torque)	Drilling studs, plates, and joists. A regular drill cannot fit between studs 16 in. apart.
$\frac{3}{4}$ in. and $\frac{7}{8}$ in. self-feed or auger bits, plus an 18 in. extension	Holes for cable. The extension reaches top plates from below and through doubled studs.
Hammer, or a staple hammer listed for NM staples	Nailing boxes and driving staples
Cable ripper (sheath stripper)	Slitting the NM jacket without cutting the insulation inside
Wire strippers with 10–18 AWG holes	Stripping conductors to length
Lineman's pliers and diagonal cutters	Cutting cable, twisting grounds
Crimp tool for ground sleeves	Making up grounds
25 ft tape measure and a 4 ft level	Box heights and layout
Story poles cut to 16 in. and 44 in.	Setting box heights without measuring each one
Laser line or chalk line	Lining up holes
Fish tape (25 ft) or glow rods	Getting cable down a wall from the attic or through an insulated wall
Cable spinner (reel stand)	Lets the coil turn so the cable comes off without kinks
Markers (fine and wide) and colored tape	Labeling cables and boxes
Headlamp	Attics, crawl spaces, the inside of walls
Safety glasses, gloves, knee pads, dust mask	Daily PPE
Non-contact tester and a CAT III meter	Proving dead anywhere power might be on (Section 1.3)
The marked-up plan and circuit schedule, in a plastic sleeve	The whole job runs from it



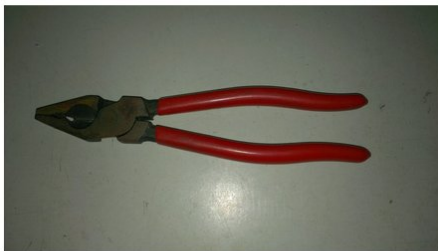
Right-angle drill boring a stud



Auger bit for wood



Wire strippers with AWG holes



Lineman's pliers



Fish tape



Headlamp

Six rough-in tools: a right-angle drill boring a stud, an auger bit, wire strippers with AWG holes, lineman's pliers, a fish tape, and a headlamp.

Photo: Dewalt DCD740C1 Angle Drill by Mark Hunter, CC BY 2.0; Drill auger.jpg by Emrys2 at en.wikipedia, CC BY-SA 3.0; Klein wire strippers.jpg by J.C. Fields, CC BY-SA 3.0; Lineman's Plier.jpg by Honmingjun, CC BY-SA 3.0; Fish tape.jpg by Lucius Kwok, CC BY-SA 2.0; Zebralight H600Fc Mk IV headlamp with its headband.jpg by Siarhei Besarab, CC BY-SA 4.0.

5.1 Box heights: code versus convention

Most box heights are trade convention. A few are code. Know which is which, because the builder or owner can change a convention but not a code rule.

Box	Height, YES default	Code or convention
Wall receptacle	16 in. from the subfloor to the bottom of the box	Convention. Code sets no minimum. Floor receptacles count only within 18 in. of the wall (210.52(A)(3)).
Switch	44 in. to the bottom of the box (top of box at about 48 in.)	Convention. Code sets a maximum: the switch handle at its highest position not more than 6 ft 7 in. above the floor (406.38(A)(2), NEC 2023 404.8(A)).
Countertop receptacle	42 to 44 in. to the bottom (6 to 8 in. above a 36 in. counter, above a 4 in. backsplash)	Code maximum: not more than 20 in. above the counter (210.52(C)(3)).
Bathroom vanity receptacle	42 in. to the bottom	Code: not more than 12 in. below the top of the sink or counter (210.52(D)(2)), within 3 ft of the sink edge (210.52(D)(1)).
Laundry (washer) receptacle	42 in. to the bottom, behind the washer	Convention. Within 6 ft of the appliance (210.50(C)).
Dryer receptacle (14-30R)	Per the dryer manual; commonly 28 to 36 in. to the center	Convention and manufacturer.
Range receptacle (14-50R)	Per the range manual's template, low on the wall behind the range	Manufacturer. The range must slide back over it.
Refrigerator receptacle	42 to 48 in. to the bottom, offset to one side	Convention. Above the water-line box, so the plug is reachable from the top.
Garage receptacle	48 in. to the bottom	Code maximum: not more than 5½ ft above the floor for the one required per bay (210.52(G)(1)).
Exterior receptacle	18 to 24 in. above finished grade or deck	Code maximum: not more than 6½ ft above grade or deck (210.52(E)).
Exterior wall light at a door	66 to 72 in. to the center, or centered on the door per the builder	Convention.
Bathroom vanity light	78 to 80 in. to the center, centered on the sink	Convention. Check the mirror height with the builder.
Smoke alarm (ceiling)	Center of the ceiling, at least 4 in. from the wall	Building code and NFPA 72 (still being checked against the printed code book).

How to set heights fast. Cut a 2×4 "story pole" to 16 in. and another to 44 in. Stand it on the subfloor next to the stud and set the bottom of the box on top of it. Every box comes out the same. If the floor will get a thick finish (¾ in. hardwood over the subfloor, or tile on a mortar

bed), ask whether to measure from subfloor or finished floor. YES measures from the subfloor unless the builder says otherwise.

5.2 Mounting boxes flush for the drywall

The front edge of the box must end up at the finished wall surface.

Wall surface	Code rule	What to do
Gypsum drywall, plaster, tile, concrete (noncombustible)	The front edge may be set back no more than $\frac{1}{4}$ in. from the finished surface (314.20(A))	Set the box to stick out from the stud face by the drywall thickness: $\frac{1}{2}$ in. for $\frac{1}{2}$ in. drywall, $\frac{5}{8}$ in. for $\frac{5}{8}$ in. drywall.
Wood paneling, wood wainscot, wood ceiling (combustible)	The box must be flush with the surface or stick out past it (314.20(B))	Set the box for the full paneling thickness. No setback allowed.
Kitchen backsplash tile	Drywall plus tile plus thinset	Set the box for the drywall only, then add a box extender at trim; or use an adjustable-depth box.

Why: a box set back too far leaves the device yoke floating, so the receptacle moves when a plug goes in, and the combustible wall behind is exposed to any arc in the box.

Steps for a nail-on plastic box:

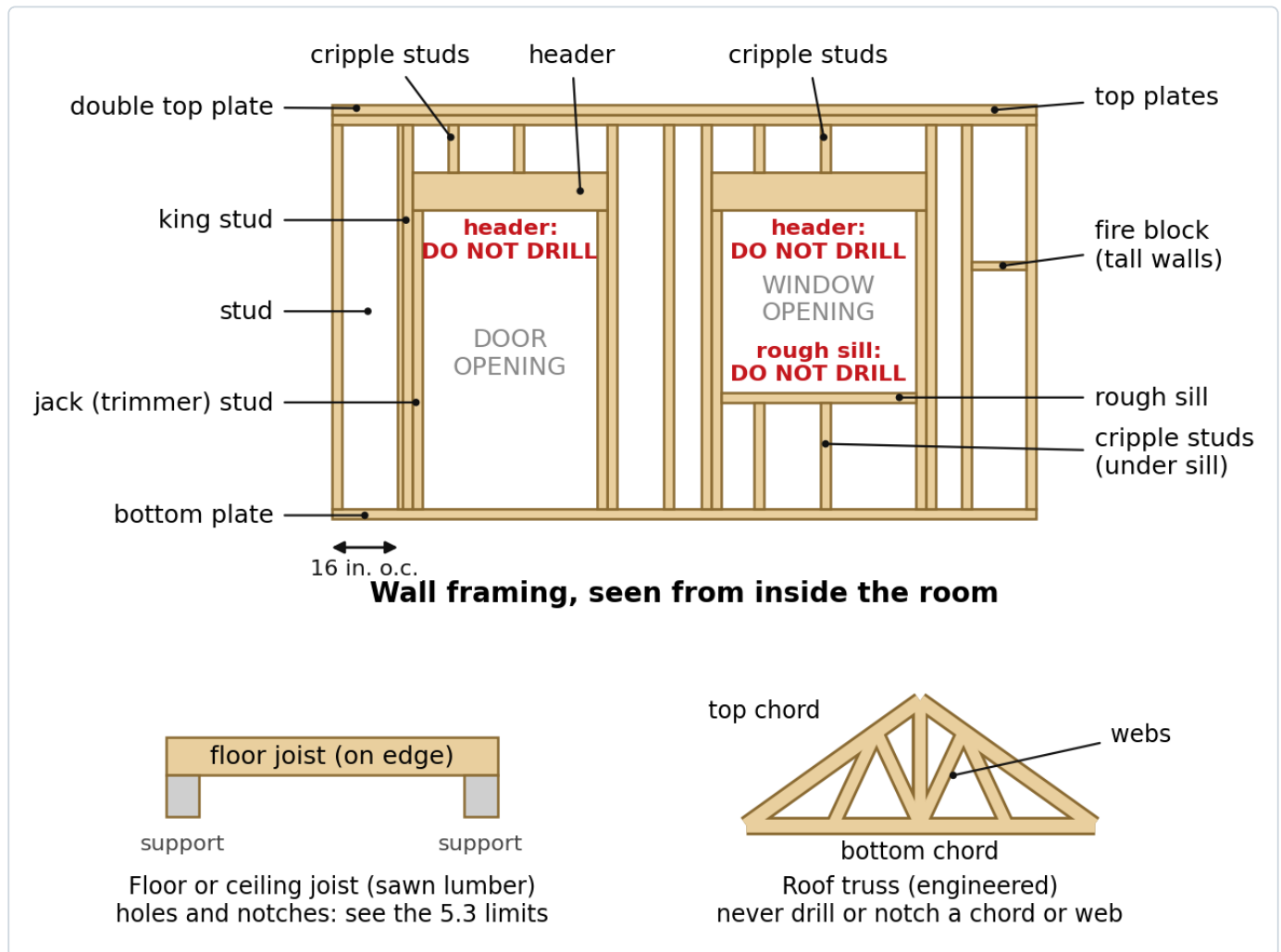
1. Read the depth gauge. Most new-work boxes have raised ribs or marks on the side for $\frac{1}{2}$ in. and $\frac{5}{8}$ in. drywall.
2. Hold the box against the side of the stud with the gauge mark lined up on the stud face.
3. Set the bottom at the height from Section 5.1.
4. Drive both captive nails fully. Check that the box does not rock.
5. Put receptacle boxes on the side of the stud that the plan shows. YES default: the side away from the door for switches, so the switch is not behind the door when it opens. Check the door swing on the plan.
6. Keep boxes off the stud next to a door frame by at least the width of the casing (about 3 in.), so the trim carpenter can install the casing.
7. On a ceiling, use a ceiling box with a bracket, or a box nailed to the side of a joist. For a fan, install a listed fan brace or nail the fan-rated box to 2× blocking between the joists.

Fan boxes in NEC 2026. 314.27(B)(2) addresses ceiling outlet boxes in habitable rooms at locations where a ceiling fan could be installed. The full text of the room list was not readable in our code copy (still being checked against the printed code book). YES practice: install a fan-rated box or a fan brace at the center of every bedroom, living room, and family room ceiling, and anywhere the plan shows a fan.

Recessed lights. Use IC-rated housings wherever insulation will touch them. In an insulated ceiling under an attic, that is every one. Use airtight (AT-rated) housings in any ceiling below an attic, for the energy code. Most new houses use "canless" wafer LEDs with a remote junction box, which are IC-rated. Follow the layout in the plan. Keep housings at least 3 in. from joists if the manufacturer requires it.

Field photo coming: A row of nail-on single-gang boxes on studs in an open wall, all at 16 in. to bottom, each projecting ½ in. from the stud face, with a 16 in. 2×4 story pole leaning against the wall.

5.3 Drilling



A framed wall with a door and a window is labeled with its studs, double top plate, bottom plate, king and jack studs, headers, cripple studs, rough sill, and fire block. A floor joist and a roof truss are shown below it.

Drawing: YES Electric.

The code rules

1. **The 1¼ in. rule for holes (300.6(A)(1), NEC 2023 300.4(A)(1)).** The edge of a bored hole must be at least 1¼ in. from the nearest edge of the wood member. Why: drywall screws and trim nails are about 1¼ in. long. A cable closer than that gets hit.
2. **If you cannot keep 1¼ in.,** cover the cable with a steel nail plate at least 1/16 in. thick, long and wide enough to cover the cable area (300.6(A)(1)).
3. **Cables running parallel to framing (300.6(D)).** A cable running along the face of a stud or joist must be at least 1¼ in. from the nearest edge where nails or screws are likely. Staple cables to the center of the wide side of a stud, not near its front edge.
4. **Notches (300.6(A)(2)).** If you notch a stud to lay a cable in it, the notch must be covered by a steel plate at least 1/16 in. thick, installed before the drywall goes up. Notching is only allowed where it does not weaken the structure. YES practice: drill, do not notch.
5. **Metal studs (300.6(B)(1)).** Put a listed plastic grommet or bushing in every hole before you pull cable through. Why: punched steel edges cut through the cable jacket.
6. **Under a roof deck (300.6(E)).** Keep cables at least 1½ in. below the bottom of the roof decking. Why: roofers shoot long nails and screws through the deck.

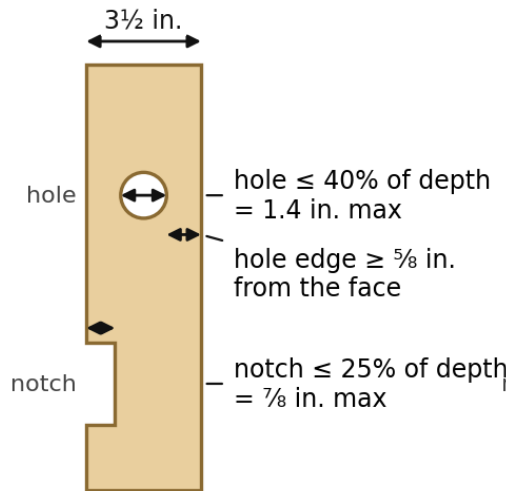
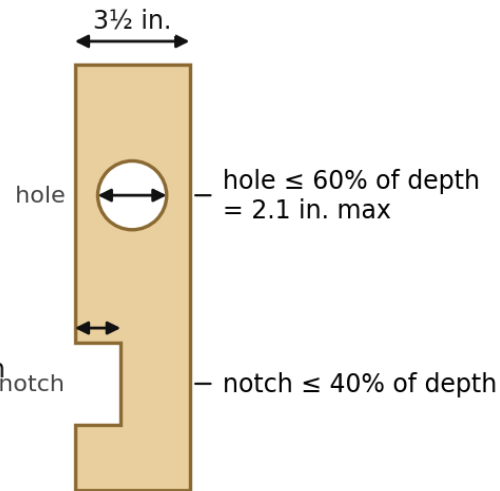
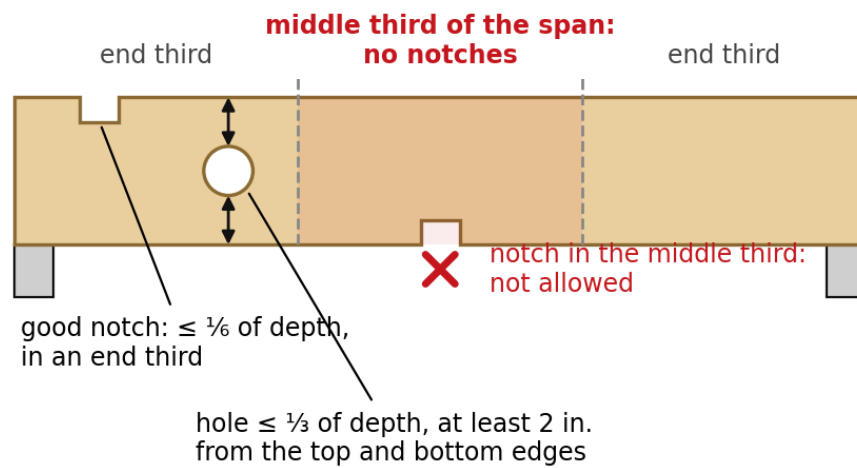
The math in a 2×4 wall

A 2×4 stud is 3½ in. deep. If you center a hole in it, the edge of the hole must be 1¼ in. from each face: $3\frac{1}{2} - 1\frac{1}{4} - 1\frac{1}{4} = 1$ in. A hole centered in a 2×4 can be at most 1 in. in diameter and still meet the 1¼ in. rule on both sides without a plate. A 2×6 stud is 5½ in. deep, so a centered hole can be up to 3 in.

The building-code rules (framing strength)

How big a hole and notch the framing can take is a building-code rule (IRC R602.6 for studs, R502.8 for joists), not an NEC rule. The framing inspector enforces it. The common limits are below, but verify them with the AHJ (still being checked against the printed code book).

Member	Bored hole	Notch
Stud in a bearing wall (exterior wall, or any wall carrying a floor or roof)	Diameter $\leq$ 40% of the stud depth (1.4 in. in a 2×4), edge at least $\frac{5}{8}$ in. from the face	$\leq$ 25% of the stud depth ($\frac{7}{8}$ in. in a 2×4)
Stud in a non-bearing wall	Diameter $\leq$ 60% of the stud depth (2.1 in. in a 2×4)	$\leq$ 40% of the stud depth
Floor or ceiling joist (sawn lumber)	Diameter $\leq$ $\frac{1}{3}$ of the joist depth, at least 2 in. from the top and bottom edges	$\leq$ $\frac{1}{6}$ of the depth; never in the middle third of the span
Top plate of a bearing wall	A hole or notch that leaves less than half the plate width needs a steel strap across it	
Engineered lumber (I-joists, LVL beams, trusses)	Only in the knockouts or locations the manufacturer allows	Never notch. Never cut a truss chord or web.

BEARING-wall stud (2×4)**NON-BEARING stud (2×4)****Floor or ceiling JOIST (sawn lumber), side view**

Building-code limits (IRC R602.6 studs, R502.8 joists); verify with the AHJ.
 The NEC 1¼ in. rule still applies: a hole edge closer than 1¼ in. to a face needs a steel nail plate.
 Engineered lumber (I-joists, LVL, trusses): only where the manufacturer allows. Never notch.

These are the building-code limits for holes and notches in a 2x4 stud in a bearing wall, a 2x4 stud in a non-bearing wall, and a floor or ceiling joist.

Drawing: YES Electric.

Drilling steps

1. **Pick your bit.** YES uses a 3/4 in. or 7/8 in. auger or self-feed bit in a right-angle drill. A 3/4 in. hole passes two 14/2 or 12/2 cables. A 1 in. hole passes three. Do not go over 1 in. in a 2×4.
2. **Pick the run height.** Drill horizontal runs through studs at about 12 in. above the receptacle boxes (about 28 to 32 in. above the subfloor). The cable then drops down into

the top of each box. Why: it keeps the cable above the baseboard nailing zone (the bottom 6 in.) and away from the box location, so the drywall crew's router does not hit it.

3. **Mark a line.** Snap a chalk line or use a laser along the run so the holes line up. Straight holes make pulling easy and keep the cable from rubbing.
4. **Center every hole in the stud depth.** Hold the drill square to the stud.
5. **Check for pipes and ducts on the far side before each hole.**
6. **Drill top plates for runs to the attic** and bottom plates for runs to a crawl space or basement. Center the hole in the plate. For the panel, drill one hole per two cables, or use a 2 in. hole with a nail plate on each face if the plate is 2×6.
7. **Plate every hole that ends up closer than 1¼ in. to a face.** Nail plates go on the face of the stud over the hole. Put them on at rough. The inspector looks for them.

WARNING: Drilling. A right-angle drill with a self-feed bit can twist your wrist or arm when the bit binds. Brace the handle against the stud, keep a firm grip on both handles, and use the clutch if the drill has one.

Picture coming: Cross-section of a 2×4 stud showing a centered 1 in. hole with 1¼ in. dimensioned to each face, and a second stud with an off-center hole only ¾ in. from the face, covered by a 1/16 in. steel nail plate. Caption: "Centered hole up to 1 in. needs no plate. Closer than 1¼ in. needs a plate."

5.4 Pulling cable: from the panel outward

Each circuit has a **home run**: the cable from the panel to the first box on the circuit. Then cable runs from box to box.

Before you pull

1. Mount the panel can (or have it mounted). Its knockouts are where every home run ends. R1.5 covers mounting the panel.
2. Set up a cable spinner or reel so the cable pays off without twisting. Kinked NM is damaged NM.
3. Have a marker ready to label every cable end.

Steps for one circuit

1. **Start at the panel.** Pull the end of the cable into the panel can through a knockout and connector. Leave a tail long enough to reach the bottom of the can plus 18 in. Why: you do not yet know which breaker slot this circuit gets, and the neutral and ground bars may be at the far end of the can.
2. **Label the panel end.** Write the circuit number and description on the sheath with a marker, about 6 in. from the end: "19 KIT/LIV LTS".

3. **Run the cable to the first box.** Go through the holes you drilled. Do not pull hard enough to burn or stretch the jacket on the edges of the holes. Keep bends gentle: the inside radius of a bend must be at least 5 times the cable diameter (334.24).
4. **At the box,** pull the cable so it extends 10 to 12 in. past the front of the box. Cut it.
5. **Start the next cable from the same box** to the next box on the circuit. Label which way it goes.
6. **Continue box to box** to the last box on the circuit.
7. **Do not mix circuits in one box** unless the plan calls for it (for example, a two-gang box with switches on two circuits). If two circuits share a box, label each cable with its circuit number.
8. **Never splice inside a wall.** Every splice must be in an accessible box.

How to route home runs

1. Run home runs through the attic or crawl space when you can. Those runs are short and straight, and it keeps walls near the panel from filling with holes.
2. Bring all home runs into the panel through the top or bottom plate directly above or below the panel. Space them so you can staple them flat on the studs beside the panel without stacking.
3. Do not put more than two cables through one hole that will be sealed with foam or caulk, and do not bundle more than two cables in contact with insulation (334.80(B) and (C)). If you do, you must derate the ampacity, which can make 12 AWG too small for a 20 A breaker.

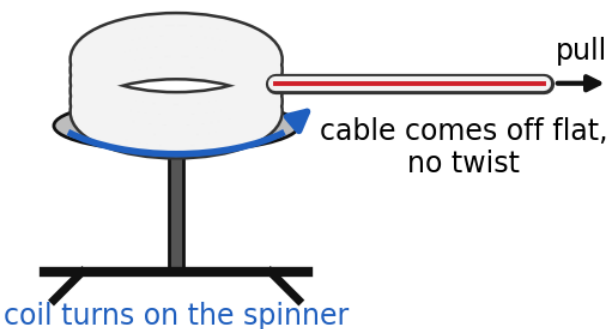
Picture coming: Simplified isometric of a ranch house framing showing the panel on the garage wall, home runs going up through the top plate into the attic, running across the attic on running boards, and dropping down through top plates into each room's wall to the first box. Each home run labeled with its circuit number.

5.4A Pulling technique

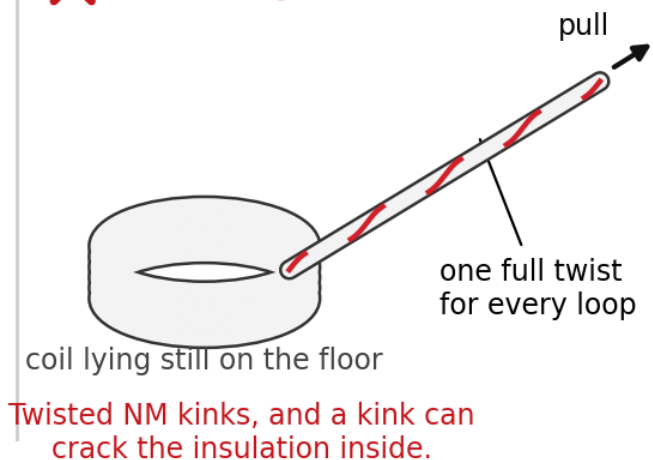
1. **Let the coil turn.** Put the coil on a cable spinner. If there is no spinner, stand the coil on edge and roll it along the floor like a tire as you pay cable out. Pulling cable off the side of a coil that is lying still puts one full twist in the cable for every loop. Twisted NM kinks, and a kink can crack the insulation inside.
2. **Pull a few studs at a time.** Push the end through the first two or three holes, walk ahead, and pull it through. Pull a loop of slack through each hole as you go rather than dragging 40 ft of cable through ten holes in one pull. Long dragging pulls burn the jacket on the hole edges.
3. **Work as a pair when you can.** One person feeds from the coil and keeps it from tangling. The other pulls through the holes. Call out "hold" and "pull" so the feeder does not let a loop pile up and kink.

4. **Down from the attic.** In new construction the ceiling has no drywall, so you can see the top plate from below. Drill up through the top plate from inside the room with the extension bit, centered in the wall. Push the cable up into the attic from below, or drop it down from above and catch it.
5. **Up from a crawl space.** Drill down through the bottom plate and subfloor from inside the wall, in the middle of the stud bay, centered in the plate. Before you drill, look at the floor from below or measure from an outside wall so you do not come out into a floor joist or a duct.
6. **Through an insulated or closed wall** (a remodel, or a wall the insulation crew filled early): use a fish tape or glow rods from the box opening up to the top plate hole, tape the cable to the end in a smooth taper, and pull it back. R1.12 covers fishing in depth.
7. **Leave the tail.** At every box, pull the cable 10 to 12 in. past the front of the box before you cut it (Section 5.4, step 4). Too short cannot be fixed without a splice box. Too long is just trimmed at make-up.

✓ **RIGHT: coil on a spinner**



✗ **WRONG: pulled off the side**



No spinner? Stand the coil on edge and roll it along the floor like a tire as you pay out cable. The red line is a mark along the jacket, drawn to show twist.

A coil on a spinner turns and pays the cable off flat with no twist. Pulling cable off the side of a coil that is lying still puts one full twist in the cable for every loop.

Drawing: YES Electric.

5.4B Routing around doors, windows, corners, and plumbing

A framed wall is not a clear path. These are the obstacles a beginner meets on the first day, and how YES routes around each one.

Obstacle	What it is	How to get past it
Door opening	A gap in the wall framed with a header (a beam, often a doubled 2×10 or 2×12) across the top, trimmer and king studs on each side	Never run cable across a doorway at floor level, and never drill through a header. The header carries the load over the opening, and the building inspector treats a hole in it like a hole in a beam. Go over it: up through the top plate into the attic, across, and down on the other side. Or go under it: down through the bottom plate into the crawl space or basement and back up. If there are short cripple studs between the header and the top plate, you may drill through the cripples, with the same 1¼ in. rule.
Window opening	A gap with a header on top, a rough sill (a flat 2×4) below it, and short cripple studs under the sill	Drill straight through the cripple studs under the sill at your normal run height if the sill is high enough. A receptacle under a window mounts on the side of a cripple stud. If the sill is too low to run under, go over through the attic or under through the floor, as with a door. Never drill the rough sill or the header.
Outside corner or a wall intersection	Two or three studs nailed together, or a stud plus blocking	Drill through each stud in line with a long bit, keeping the 1¼ in. rule on both faces. If the holes cannot line up, go up and over through the top plate. A nail plate goes on any corner stud where the hole ends up near a face.
Doubled studs at a beam pocket, or a post	A column of studs carrying a beam or a girder	Treat a post like a header. Do not drill it. Go over or under. Ask the journeyman if you are not sure what a stud cluster is carrying.
Plumbing wall ("wet wall")	The wall behind a toilet, tub, or sink with the drain and vent pipes	Stay out of the stud bays with drains and vents. Run over the top through the attic. A sink-base receptacle in a plumbing wall gets its cable from above, dropped straight down beside the pipes, not across them. Keep cable away from where the plumber will set the tub.
Ducts in the floor or ceiling	Supply and return ducts, often in a joist bay	Run along the side of a joist, not across the bottom of a duct. Never staple to a duct or run cable through a duct (NEC 2026 300.25, NEC 2023 300.22, governs ducts and plenums; NM may not run inside them).
Hold-down hardware and shear walls	Steel straps, bolts, or plywood nailing patterns the framer installed for wind or earthquake loads	Do not drill through a hold-down or a strap, and do not cut a strap. Ask the framer or the journeyman before you drill near one.
Fire blocking	Horizontal 2× blocks in tall walls, typically at ceiling height in walls over 10 ft and between floors	Drill through the block centered like a top plate. The hole gets sealed after the rough inspection (Section 5.7).

Obstacle	What it is	How to get past it
Trusses and I-joists	Engineered roof or floor framing	Never drill or notch a truss chord or web. Run cable across the top of the bottom chords on running boards, or along them. In I-joists, use only the manufacturer's knockouts or the hole chart.
Exterior wall	Wall with sheathing and house wrap behind the studs	Cable stays in the stud bays, stapled to the side of the stud at the center of its depth. Insulation fills the bay behind and around it.

Picture coming: Elevation of a framed exterior wall with a door and a window. Show the receptacle run as a red line through cripple studs under the window sill, and the run past the door going up through the top plate, across the attic, and back down the far side. Header and rough sill labeled "DO NOT DRILL." A plumbing wall to the right with drain and vent pipes and a cable dropping from the attic beside them to a sink-base box.

5.5 Securing the cable

1. **Staple within 12 in. of every box** (334.30). Measure along the cable from where it enters the box.
2. **Single-gang plastic boxes without cable clamps need the staple within 8 in.** of the box (314.17(B)(2) Exception). Why: the box has no clamp to hold the cable, so the staple does the job. Most nail-on single-gang boxes have no internal clamps, so YES staples within 8 in. on every single-gang box.
3. **Staple every 4½ ft along the run** (334.30). A cable running horizontally through bored holes counts as supported by the holes, as long as the holes are no more than 4½ ft apart and the cable is stapled within 12 in. of each box (334.30(A)). Studs at 16 in. centers meet this.
4. **Vertical runs** along a stud get stapled every 4½ ft, to the center of the wide side of the stud.
5. **The sheath must go at least ¼ in. into the box** past the knockout or clamp (314.17(B)(2), 334.19). Why: the sheath protects the insulation where it rubs on the box edge.
6. **One cable per staple** unless the staple is listed for two (it will say so on the box). Never staple flat cable on its edge (334.30).
7. **Do not overdrive staples.** A staple driven into the jacket can cut the insulation and cause a short or an arc fault later.

5.6 Attics, crawl spaces, and basements

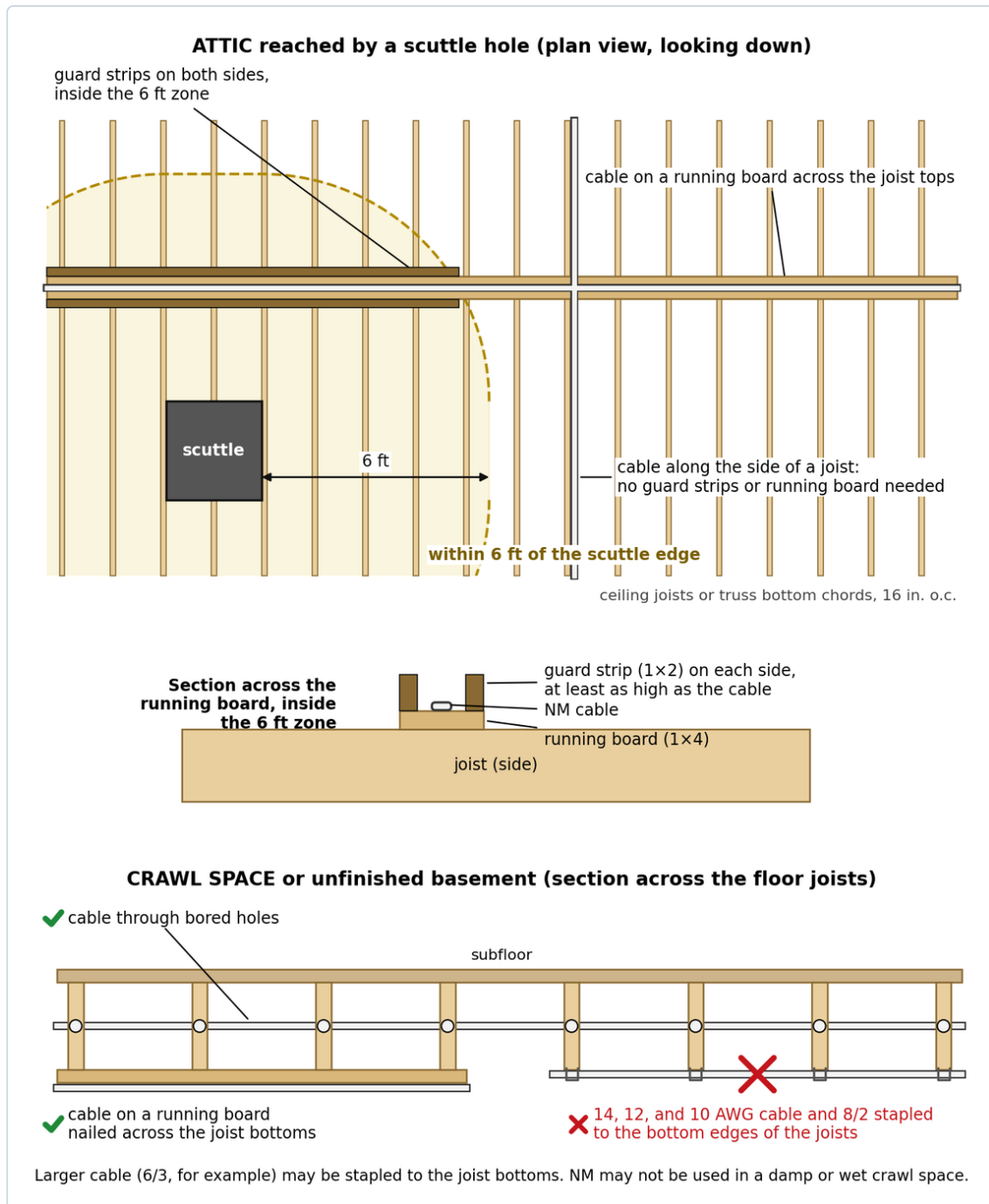
Attics (334.23 → 320.23)

Situation	Rule
Cable runs across the top of joists or the face of rafters, attic reached by permanent stairs or a pull-down ladder	Protect with guard strips at least as high as the cable, wherever the cable is within 7 ft of the floor (320.23(A)(1)).
Same, attic reached only by a scuttle hole	Guard strips only within 6 ft of the nearest edge of the scuttle or attic entrance (320.23(A)(2)).
Cable runs along the side of a joist or rafter	No guard strips or running boards needed (320.23(B)). Still keep 1¼ in. from the edge (300.6(D)).

YES practice in attics: run cable along the sides of joists or on a 1×4 running board nailed across the top of the joists, and add guard strips (1×2 on each side) within 6 ft of the scuttle. Stay out of the area right at the eaves, where the roof deck is low and the 1½ in. roof-deck rule is hard to meet.

Crawl spaces and unfinished basements (334.15(C))

1. Cables smaller than two 6 AWG or three 8 AWG conductors (that is, every 14, 12, and 10 AWG cable, and 8/2) must go through bored holes in the joists or on running boards when they run across the joists. They may not be stapled to the bottom edge of the joists. Why: the bottom edge is where people hang things, bump heads, and store lumber.
2. Larger cables (6/3, for example) may be stapled to the bottom edge of the joists.
3. Cable running along a basement wall must be in conduit or tubing, or otherwise protected (334.15(C)). The sheath runs through the conduit and at least ¼ in. into the box, with a bushing on the conduit end. Staple within 12 in. of where the cable enters the conduit.
4. Where cable goes through a floor in exposed work, sleeve it in conduit or EMT (334.15(B)).
5. NM may not be used in damp or wet locations (334.12(A)(4)). A wet or damp crawl space needs UF or a raceway wiring method. Ask the journeyman.



In an attic reached by a scuttle, cable running across the tops of the joists needs guard strips within 6 ft of the scuttle, and cable along the side of a joist needs none. In a crawl space, cable goes through bored holes or on a running board, and 14, 12, and 10 AWG cable may not be stapled to the bottom edges of the joists.

Drawing: YES Electric.

5.7 Insulation, fire blocking, and sealing penetrations

1. **Insulation.** The insulation contractor installs batts or blown insulation after your rough inspection. Keep cables tight to the framing and stapled so the batts fit behind or around them. Do not run cables through the middle of the cavity where they will be crushed by batts.

2. **Bundling.** More than two NM cables run together without spacing, in contact with insulation, need the conductor ampacity derated (334.80(C)). This is why home runs should be spread out, not bundled in a fat bunch near the panel.
3. **Fire blocking.** Holes through top plates and bottom plates break the fire blocking between floors and between the wall cavity and the attic. The building code requires those holes to be sealed with an approved material, usually fire-rated caulk or fire-rated foam. Who seals them varies by builder (some have the insulation contractor do it). Ask, and if it is your job, do it after the rough inspection.
4. **Fire-rated walls.** Openings around electrical penetrations into or through fire-resistance-rated walls, floors, or ceilings must be firestopped by approved methods (300.23). In a house, the common rated assembly is the wall and ceiling between the attached garage and the house. Boxes in that wall have size and spacing limits under the building code. Use steel boxes in the garage-house wall if the AHJ requires it, and seal around them. Ask the AHJ (still being checked against the printed code book).
5. **Air sealing.** The energy code requires the building to be air-sealed. Recessed lights in an insulated ceiling must be airtight-rated, and penetrations through the top plates into the attic must be sealed.

5.8 Labeling and grounds at rough

At each box, do these steps after every cable is in and stapled:

1. **Strip the sheath.** Slit the sheath with a cable ripper, starting at the end and stopping about $\frac{1}{2}$ in. inside the box. Pull back the sheath and paper and cut them off, leaving at least $\frac{3}{4}$ in. of sheath inside the box (314.17(B)(2)).
2. **Check the free length.** Each conductor must have at least 6 in. of free conductor measured from where it leaves the sheath (300.16(A), NEC 2023 300.14). Because the box opening is less than 8 in., each conductor must also reach at least 3 in. past the front of the box (300.16(B)). Cut the conductors to about 8 in. past the sheath. Why: devices are installed and replaced from the front, and short wires break.
3. **Make up the grounds.** Twist all the bare grounds in the box together with one extra 8 in. bare pigtail. Crimp them with a crimp sleeve, or use a ground wire connector with a hole for the pigtail. In a metal box, add a second pigtail to the green 10-32 ground screw in the box (250.148). Why at rough: the inspector checks grounds at rough, and the drywall crew sometimes cuts loose grounds.
4. **Label each cable** at the box with a marker on the sheath or a tape tag: where it goes ("FROM PANEL," "TO LIGHT," "TO S3 HALL"). This saves an hour at trim.
5. **Fold the conductors neatly into the back of the box.** Hots and neutrals stay separate and unspliced at rough, except where your journeyman wants neutrals spliced at rough too. Do not leave wires hanging out. The drywall crew will cut them with a router.
6. **Mark switch boxes** with which switch controls which light, if there is more than one switch.

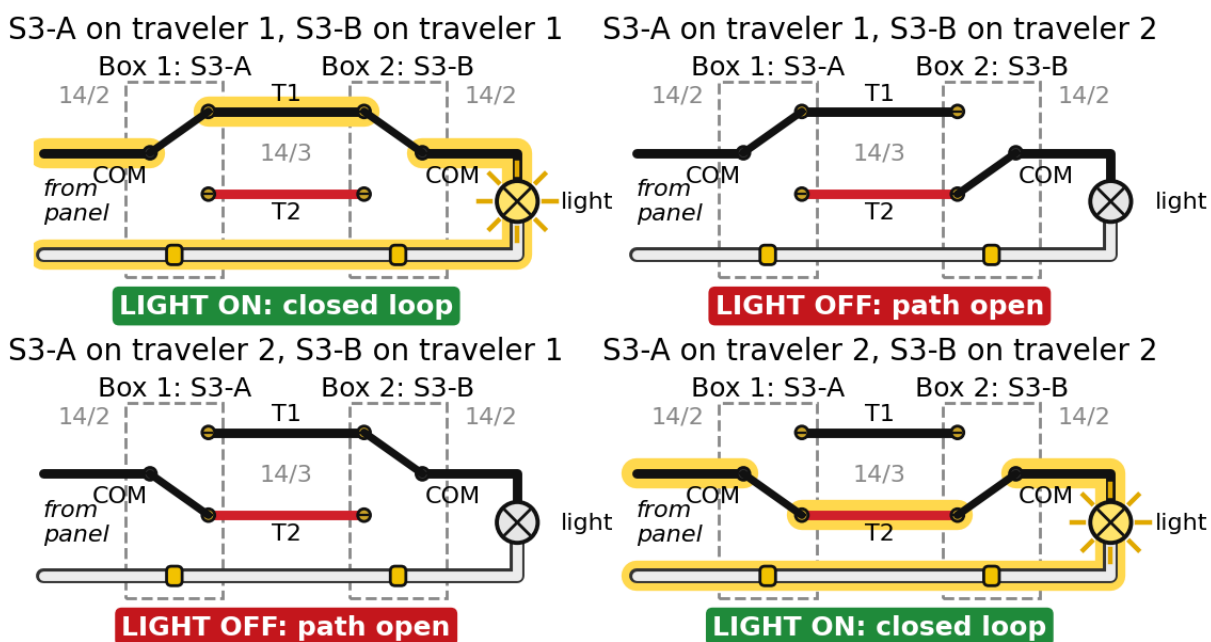
Field photo coming: A single-gang box at rough-in: two 12/2 cables entering from the top with ¼ in. of sheath visible inside, grounds twisted and crimped with a bare pigtail, hots and neutrals folded into the back, and "FROM PANEL 17" and "TO NEXT REC" written on the sheaths.

5.9 3-way and 4-way switching

A 3-way switch has three terminals: a **common** (usually a dark or black screw, marked COM) and two **travelers** (brass or light-colored screws). It connects the common to one traveler or the other. Two 3-way switches together let you control a light from two places. Add a 4-way switch between them for each additional location. A 4-way has four traveler terminals and swaps which traveler connects to which.

The rules:

1. All switching is done in the hot (ungrounded) conductors only (406.30(A), NEC 2023 404.2(A)).
2. The switches never interrupt the neutral (406.30(B)).
3. A neutral must be available at the switch location (406.30(C)). When several switches control one lighting load and the whole room can be seen from one location, the neutral is required at one location only. YES brings it to all of them.



From the panel: black = hot, white = neutral. In the 14/3: black = traveler 1 (T1), red = traveler 2 (T2). Switching is in the hot only. The white neutral is spliced through both boxes and never touches a switch. Yellow glow = current path. Grounds not shown.

Two 3-way switches are shown in all four toggle positions. The light is on when both switches connect their COM terminal to the same traveler, and the neutral passes through both boxes without touching a switch.

Drawing: YES Electric.

Method A: power enters at the first switch (YES default)

PANEL —14/2→ [S3-A] —14/3→ [S3-B] —14/2→ (LIGHT)
 box 1 box 2 box 3

Box 1 (S3-A): - 14/2 black from the panel → COMMON screw. - 14/3 black → traveler screw 1. 14/3 red → traveler screw 2. - 14/2 white from the panel + 14/3 white → spliced together (neutral passes through). - All grounds spliced with a pigtail → green screw on the switch.

Box 2 (S3-B): - 14/3 black → traveler screw 1. 14/3 red → traveler screw 2. - 14/2 black to the light → COMMON screw. - 14/3 white + 14/2 white to the light → spliced together. - All grounds spliced with a pigtail → green screw on the switch.

Box 3 (light): - 14/2 black → fixture hot (black). 14/2 white → fixture neutral (white). Ground → fixture ground and metal box if any.

Why this is the YES default: the neutral reaches both switch boxes, so a smart switch or occupancy sensor can be installed at either location later.

Other layouts you will see

Some electricians bring power to the light first and run cable from the light down to the switches. With only 14/3 cable that layout uses a white conductor as a hot (re-identified per 200.8(C)(1)) and leaves no neutral at the switch boxes. NEC 2026 406.30(C) now requires a neutral at switch locations, so the light-first layout needs 4-conductor cable (14/4 or 12/4) or an extra cable to comply. You will meet the old versions in existing houses. YES installs Method A in new work. R1.4 covers switch loops and other 3-way layouts in remodels.

4-way: three or more locations

PANEL —14/2→ [S3-A] —14/3→ [S4] —14/3→ [S3-B] —14/2→ (LIGHT)

S4 box: the 14/3 from S3-A brings two travelers (black, red). The 14/3 to S3-B carries two travelers (black, red). - Incoming travelers → the pair of terminals marked "IN" or "LINE" (on most 4-way switches, the two screws of the same color on one end, or on one side; read the device). - Outgoing travelers → the other pair, marked "OUT" or "LOAD." - Whites spliced (neutral passes through). Grounds spliced to the switch.

If the light works from the 3-ways but the 4-way only works in some positions, the travelers are crossed on the 4-way. Swap one pair.

Kuhlman notes that splicing the neutrals of two different cables from the same feed between two boxes creates a parallel neutral, which is a code violation (Kuhlman, p. 20). Each neutral splice should join only neutrals of the same circuit and path.

Picture coming: Wiring diagram for Method A 3-way and for a 4-way between two 3-ways: boxes drawn as rectangles, cables as bundles with color-coded conductors, travelers in black and red, commons marked COM, neutrals passing through each box with wire nuts, grounds in green.

5.10 Room-by-room rough-in notes

Smoke alarms (interconnected)

1. Run 14/2 from the bedroom-hall lighting circuit to the first alarm box.
2. Run 14/3 from alarm to alarm. The red conductor is the interconnect signal wire. The black is the hot, the white the neutral.
3. Use the box type the alarm manufacturer specifies (usually a single-gang or 4 in. round ceiling box, or a pancake box).
4. Every alarm in the house must be the same brand or a compatible system, because the interconnect signal is not standardized between brands.
5. Do not put a switch on the alarm circuit. Alarm power must be continuous.
6. Carbon monoxide alarms, or combination smoke/CO alarms, go on the same interconnect if the brand supports it.

Bathrooms

1. Vanity receptacle (circuit 13 in the example) on the 20 A bathroom circuit.
2. Vanity light above the mirror. Exhaust fan in the ceiling, in or near the tub or shower area.
3. Switches at the door. YES default: one switch for the vanity light and one for the fan. If the fan has a light, run 14/3 from the switch box to the fan so the fan and its light are on separate switches.
4. A fan or light over a tub or shower must be listed for that location. A fan in that location may need GFCI protection per its instructions. Read the fan's installation manual.
5. The fan's duct goes to the outside, not into the attic (mechanical code). The HVAC or general contractor usually installs the duct. Make sure it gets done before insulation.

Kitchen

1. Countertop receptacles at 42 to 44 in. to bottom, alternating circuits 1 and 2.
2. Refrigerator receptacle on circuit 3.
3. **Dishwasher (circuit 4):** a receptacle in the sink base cabinet on the side next to the dishwasher, about 12 in. above the floor, or a hardwire stub per the manual. If it is cord-and-plug connected, the cord must be 3 to 6½ ft long measured from the face of the plug to the plane of the back of the dishwasher (422.16(B)(2)). Leave enough cable to reach either location.
4. **Disposal (circuit 5):** a receptacle in the sink base, under the sink. The disposal's cord must be 18 to 36 in. long (422.16(B)(1)). Run the cable to the switch box first, at countertop height beside the sink, then down to the receptacle. Put the disposal switch

where a person cannot reach it from inside the sink basin, and away from the dishwasher door.

5. **Over-the-range microwave (circuit 6):** a single receptacle inside the upper cabinet above the range, per the microwave's template. The cord must be 18 in. to 4 ft and the receptacle on an individual circuit (422.16(B)(4)).
6. **Range (circuit 7):** 6/3 to a 14-50R receptacle in a 4 in. square box or a surface 50 A receptacle, low on the wall in the area the range manual shows. Leave 18 in. of cable at the box.
7. **Island:** run the provision from Section 3.6 and any pendant lights over the island. Pendants get a ceiling box each, switched at the kitchen entry.
8. **Under-cabinet lights:** a box or a cable stub at 54 in. under the wall cabinets, per the fixture, switched by the counter. If hardwired LED tape is planned, find out where its driver goes.
9. **Range hood (if not a microwave/hood):** a box or receptacle in the cabinet above, per the hood manual.

Laundry

1. Washer receptacle (circuit 9), 20 A, behind the washer location at 42 in.
2. Dryer receptacle (circuit 8), 30 A, 14-30R, at the height the dryer manual shows. 10/3 cable, 4-wire.
3. Laundry light with a switch at the laundry door (210.70(A)(1)).
4. If the laundry is in a closet, the light and switch may be outside the closet (210.70(A)(1) Exception No. 3).

Exterior

1. Receptacles at the front and back (circuit 23), plus the deck and porch. Use a siding mounting block or a weatherproof box. Set it flush with the siding plane, not the sheathing. Find out the siding thickness from the builder.
2. Lights at every door with grade-level access, switched from inside the door (circuit 19, and circuit 22 at the garage side door).
3. **Condenser:** run 10/2 (circuit 12) to the outdoor location of the disconnect, within sight of the condenser and not mounted on a panel of the unit designed for service access (440.14). Mount the disconnect box at about 48 in. to the bottom, on the house wall beside the pad. The HVAC service receptacle (circuit 23, or another GFCI-protected receptacle) must be within 25 ft of the condenser on the same level (210.63).
4. Flash or seal every penetration through the sheathing and house wrap. Coordinate with the siding installer.

Garage

1. Receptacles in each bay at 48 in. (circuit 21).

2. A ceiling receptacle at each garage door opener location (circuit 22), within reach of the opener's cord, typically 1 to 2 ft behind the motor location. Find the opener location from the door installer's specs: the motor is usually about 10 to 12 ft back from the door for a 7 ft door.
3. Garage lights switched at the house door and at the side service door (3-way if two doors).
4. Exterior light at the side service door.
5. The garage-house wall and ceiling below living space are fire separations (Section 5.7, item 4).

HVAC

1. **Air handler in the attic:** run 6/2 (circuit 11) to the air handler location. Leave 4 ft of cable coiled and labeled. The air handler usually has a built-in disconnect or breaker. If not, install a disconnect within sight.
2. **Service receptacle:** a receptacle within 25 ft of the air handler, at the same level, i.e., in the attic (210.63(A)), GFCI-protected (circuit 24).
3. **Attic light:** a light at or near the air handler, with a switch at the scuttle or attic stairs (210.70(C)) (circuit 24).
4. **Thermostat and control wiring** belong to the HVAC contractor or R-LOWVOLT. Do not run them in the same hole as power cable without checking with the journeyman.

Water heater

1. Run 10/2 (circuit 10) to the water heater location. Leave 3 ft of cable coiled.
2. The water heater's disconnect: the breaker can serve as the disconnect if it is within sight of the water heater, or if it is lockable in the open position (422.31(A), 110.25). YES installs a permanent breaker lock-off kit on the water heater breaker at trim.

Crawl space

1. Light at the crawl space access, switched at the access (210.70(C)). GFCI-protected (210.8(C)).
2. A receptacle if equipment in the crawl needs service (for example, a sump pump, a condensate pump, or a dehumidifier). GFCI-protected (210.8(A)(5)).

5.11 Box-by-box make-up guide

Every box in a house is one of about a dozen types. This table shows what goes where in each one. "At rough" is what you do before the inspection. "At trim" is the device connection after drywall. In every box, the grounds are spliced together with a pigtail at rough (Section 5.8), and the pigtail goes to the device's green screw at trim. The ground is left out of the rows below to keep them short.

Rule for every box: a neutral is only ever spliced to the neutral that came in the same cable path as its circuit's hot. Never splice the white from circuit 14 to the white from circuit 15, even

when both cables are in one box. That makes a shared neutral. It trips AFCI and GFCI breakers and can overload the neutral (Kuhlman, p. 20).

Receptacles

Box	Cables	At rough	At trim
R1. End of run	1 cable (in)	Grounds made up. Black and white folded in.	Black to brass, white to silver, ground to green.
R2. Middle of run	2 cables (in, out)	Grounds made up. Optional: splice blacks with a 6 in. black pigtail and whites with a 6 in. white pigtail now.	Black pigtail to brass, white pigtail to silver. The device does not carry current to the next box (Section 8.3).
R3. Half-switched (the room's required light is a switched receptacle)	14/3 (or 12/3 on a 20 A circuit) from the switch box	Grounds made up. Label the red "SW."	Break off the brass tab between the two brass screws. Leave the silver tab on. Black (always hot) to the bottom brass screw, red (switched) to the top brass screw, white to silver. The top half is switched. If the circuit continues to more receptacles, pigtail the black.
R4. GFCI with protected receptacles after it	2 cables (feed in, load out)	Grounds made up. Label the feed "LINE" and the other "LOAD." Use a 22.5 cu in box (Section 4.3, Example 2).	Feed black and white to LINE, load black and white to LOAD. Sticker each downstream receptacle "GFCI Protected" (Section 8.4).
R5. Two receptacles in a two-gang box, same circuit	2 cables	Grounds made up with two pigtails.	Splice blacks with two black pigtails, whites with two white pigtails. One pigtail pair to each receptacle.

Switches and lights

Box	Cables	At rough	At trim
S1. Single-pole, power comes to the switch first	14/2 in from the panel or the previous box, 14/2 out to the light	Splice the two whites together (with a pigtail if more cables continue on). Grounds made up. Label "LINE" and "TO LIGHT."	Feed black to one brass screw, the light's black to the other. The neutrals stay spliced in the back and never touch the switch.
S2. Single-pole, power also continues to receptacles	14/2 in, 14/2 to the light, 14/2 or 12/2 on to the next receptacle	Splice all three whites. Splice the feed black, the black going on to the receptacles, and a 6 in. black pigtail.	Pigtail to one brass screw, light black to the other.
L1. Light box with power in first, switch loop with a neutral (allowed, meets 406.30(C))	14/2 in from the panel, 14/3 down to the switch	At the light box: splice the feed black to the 14/3 black (this is the always-hot going down to the switch). Splice the feed white, the 14/3 white, and a 6 in. white pigtail for the fixture. Label the 14/3 red "SW LEG." At the switch box: grounds made up, white capped by itself and folded in, labeled "NEUTRAL."	At the light: fixture black to the 14/3 red, fixture white to the white pigtail. At the switch: black to one brass, red to the other. The white stays capped at the switch so a smart switch can use it later.
L2. Fan with separate switches for the motor and the light kit	14/2 in to the switch box, 14/3 from the switch box to the fan box	At the switch box: splice the feed black with two 6 in. black pigtails. Splice the whites. Label the 14/3 "TO FAN."	Pigtail 1 to the fan switch, the other side of that switch to the 14/3 black. Pigtail 2 to the light switch, the other side to the 14/3 red. At the fan: 14/3 black to the fan's black (motor), red to the fan's blue (light kit), white to white.
L3. 3-way, Method A	See Section 5.9	See Section 5.9	See Section 5.9
L4. Bath fan and vanity light from one two-gang box, power in	14/2 in, 14/2 to the vanity light, 14/2 (or 14/3 for a fan with a light) to the fan	Splice all whites. Splice the feed black with one black pigtail per switch.	One pigtail to each switch. Each switch's other screw to the black going to its load.
L5. Ceiling light at the end of a run	1 cable (the switched leg from the switch)	Grounds made up.	Fixture black to black, white to white, ground to the fixture's ground and the box.

Dedicated circuits and alarms

Box	Cables	At rough	At trim
D1. 240 V water heater junction	10/2	Leave 3 ft coiled at the tank location. Mark the white with black tape at both ends now so nobody mistakes it for a neutral.	Black to one element lead, taped white to the other, ground to the green screw (Section 8.9).
D2. Range or dryer receptacle	6/3 or 10/3	4 in. square box with a ring, or the surface receptacle's base. Leave 12 to 18 in. of cable.	Black to X, red to Y, white to W, ground to G. Torque each screw to the value on the device.
D3. Smoke alarm, first in the chain	14/2 in from the lighting circuit, 14/3 out to the next alarm	Splice the blacks, splice the whites. Fold the 14/3 red into the box, labeled "INTERCONNECT."	Harness black to the spliced blacks, harness white to the spliced whites, harness red to the 14/3 red.
D4. Smoke alarm, middle of the chain	14/3 in, 14/3 out	Leave the conductors loose and labeled.	Splice black, black, and harness black. White, white, and harness white. Red, red, and harness red.
D5. Smoke alarm, last in the chain	14/3 in	Leave loose and labeled.	Black, white, and red to the matching harness wires.

Picture coming: A grid of the twelve most common boxes (R1-R5, S1, S2, L1, L2, L4, D3, D4), each drawn as a box outline with the cables entering, conductors color-coded (black, red, white, bare green), splices shown as wire connectors, and device terminals labeled brass, silver, green. One box per tile, with its table code in the corner.

5.12 Day-by-day schedule for the example house

This is how a journeyman and a helper rough in the 1,800 sq ft house in Section 3.11 in five working days. Larger houses take longer. A first-time helper should expect to be slower and should spend the first two days mostly setting boxes and pulling cable.

Day	Work	Done when
Day 0 (half day, before rough)	The planning walk (Section 3.2). Circuit schedule written. Material counted and ordered (Section 4.5). Plan checked by the journeyman and walked with the builder.	Plan approved. Material on site.
Day 1	Panel can mounted. Every box in the house set to height and depth (Sections 5.1 and 5.2): about 115 boxes, plus the canless light junction boxes. Fan braces installed.	Every box on the plan is on the wall or ceiling. Count them.
Day 2	Every hole drilled (Section 5.3), by room, following the planned routes. Running boards in the attic.	You can see a clear path for every circuit on the schedule.
Day 3	Pull the home runs and box-to-box cable, kitchen first, then baths, laundry, and dedicated circuits (the 12 AWG and larger circuits).	Every 20 A and 240 V circuit is pulled and labeled at both ends.
Day 4	Pull the 15 A lighting and bedroom circuits, the 3-ways, the smoke alarm interconnect, the exterior, garage, attic, and crawl space circuits.	Every circuit on the schedule is pulled.
Day 5	Staple check, nail plates, guard strips. Strip sheaths, make up grounds, label, fold in (Section 5.8). Box fill checked. Pre-inspection checklist (Section 6.2). Photos of every wall. Call for the inspection.	Checklist complete. Inspection requested.

PART 6: THE ROUGH-IN INSPECTION

The rough-in inspection ("rough," "cover inspection") happens after rough-in and before insulation. The inspector must see every cable, box, and hole before the walls close. Nothing gets covered until the inspection passes. The permit card must be posted on site where the inspector can find it.

6.1 What the inspector checks

Item	What they look for	Code
Boxes	Secure, at the right depth for the finish, not overfilled, right type (fan-rated where needed)	314.16, 314.20, 314.23, 314.27
Cable sizes	12 AWG on all 20 A circuits; kitchen, bath, laundry, and garage circuits present and dedicated	210.11(C), 240.4(D)
Receptacle layout	6 ft/12 ft spacing, countertop 24 in. rule, bathroom, hallway, outdoor, garage, laundry, HVAC receptacles	210.52, 210.63
Lighting outlets	Every required room, stair, attic, crawl, exterior door	210.70
Securing	Staples within 12 in. of boxes (8 in. at clampless single-gang boxes), every 4½ ft; sheath ¼ in. into the box	334.30, 314.17
Protection	1¼ in. setback or nail plates; grommets in metal studs; guard strips in attics; running boards in crawl spaces	300.6, 320.23, 334.15
Grounds	Made up in every box	250.148
Free conductor length	6 in. free, 3 in. past the box face	300.16
Panel	Location, working space, height; cables entering with connectors; panel matches the plan	110.26, 240.24, 408
Smoke alarm locations	Boxes at every required location; interconnect cable	Building code
Fire and air sealing	Penetrations sealed, or ready to be sealed per the local practice	300.23, building and energy codes
Bathroom zones	No receptacle within the tub/shower zone; vanity receptacle within 3 ft of each sink	406.9(C), 210.52(D)

6.2 Pre-inspection checklist (do this the day before)

Walk every room with this list and a flashlight. Fix anything that fails before you call for the inspection.

1. Every box on the plan is installed. Count them against the plan.
2. Every box is nailed tight and set to the drywall depth.
3. Every ceiling box where a fan is planned is fan-rated or on a fan brace.
4. Every 20 A circuit is 12 AWG from the panel to the last box. Read the jacket color: yellow.
5. Every cable is stapled within 12 in. of each box (8 in. at clampless single-gang boxes) and every 4½ ft.
6. The sheath goes at least ¼ in. into every box.
7. Every cable within 1¼ in. of a stud, joist, or plate face has a nail plate.

8. Every metal-stud hole has a grommet.
9. Attic cables have guard strips within 6 ft of the scuttle, or run along the joist sides.
10. Crawl space and basement cables run through bored holes or on running boards.
11. Every box has grounds made up with a pigtail.
12. Every conductor has at least 6 in. free and reaches 3 in. past the box face.
13. Every cable is labeled at both ends.
14. Box fill checked in every GFCI box, every box with three or more cables, and every two-gang or larger box.
15. Panel working space is clear: 36 in. deep, 30 in. wide.
16. Smoke alarm boxes are at every required location with 14/3 interconnect.
17. The HVAC service receptacle box is within 25 ft of each piece of HVAC equipment.
18. The permit card is posted.
19. Take photos of every wall before insulation. Store them in the job folder. Why: when the owner wants a TV mount or a shelf later, the photos show where the cables are.

Field photo coming: A complete rough-in wall photographed for the job folder: a kitchen wall showing countertop boxes, refrigerator box, nail plates, staples, and labeled cables, with a tape measure hung on the wall for scale.

PART 6A: SERVICE EQUIPMENT AND THE GROUNDING ELECTRODE SYSTEM

R-SERVICE and R1.5 teach the service and grounding in full. A green helper on a new house still needs to know what gets built and in what order, because some of it has to happen weeks before rough-in. This part is the short version. Do all of it with the journeyman.

WARNING: Utility side. Everything on the line side of the meter belongs to the utility once it is energized. You never connect to or work on the service drop, the lateral, or a live meter socket. Only the utility sets and pulls meters (Section 1.1).

6A.1 What gets installed outside

For the example house, a new 200 A underground service in Alabama Power territory:

Part	What it is	Notes
Service conduit	A 3 in. conduit from the meter location down and out to the utility's transformer or pedestal	Alabama Power's builder diagram shows 3 in. service conduit, three conduit straps, and a footing notch at the meter location, all builder responsibility. The utility pulls its own cable in it. R-SERVICE covers the depth and the overhead version.
Meter socket	The base the utility's meter plugs into	Center 48 to 60 in. above finished grade (Alabama Power). The socket must be one the utility accepts.
External service disconnect	A 200 A main breaker, either built into a meter-main combination or in its own enclosure next to the meter	Required by Alabama Power on new residential meter bases since January 1, 2022. It also meets the NEC 2026 225.41 (NEC 2023 230.85) outdoor emergency disconnect for one- and two-family dwellings.
Service-entrance conductors	The conductors from the meter-main to the indoor panel. With the disconnect outside, these are now a feeder	4 wires: two hots, a neutral, and an equipment ground. Sized from Table 310.12(A) for a 200 A dwelling feeder: 2/0 AWG copper or 4/0 AWG aluminum. Because the disconnect is outside, the indoor panel is a subpanel (Section 2.5 and Part 7): neutral bar isolated, bonding screw out.
Surge protective device (SPD)	Type 1 or Type 2 SPD at the service	Required for dwelling services by 230.67. R1.9 covers it.

6A.2 The grounding electrode system

The grounding electrode system connects the electrical system to the earth. It limits voltage from lightning and from a utility fault. It does not trip breakers. The equipment grounding conductors do that (Section 2.4).

NEC 2026 250.50 says every one of these electrodes that is present at the house must be bonded together. If none is present, you install one or more:

Electrode	What it is	Rule	Conductor to it (GEC)
Concrete-encased electrode ("Ufer")	At least 20 ft of ½ in. or larger rebar (or 20 ft of bare 4 AWG copper) in the bottom of a footing in direct contact with the earth, with at least 2 in. of concrete around it	250.52(A)(3). If the new footing has rebar, it is "present" and must be used (250.50). That is why the rebar stub has to be planned before the pour (Section 3.12).	Not required to be larger than 4 AWG copper (250.66(B))
Ground rods	Rods at least 8 ft long, driven full length into the earth, top flush with or below grade unless protected	250.52(A)(5), 250.53(A)(4). One rod must be supplemented by a second electrode unless the single rod measures 25 ohms or less to earth (250.53(A)(2) and its Exception). YES drives two rods instead of testing. Space them at least 6 ft apart (250.53(A)(3)).	Not required to be larger than 6 AWG copper (250.66(A))
Metal underground water pipe	A metal water service pipe in contact with the earth for 10 ft or more	250.52(A)(1). It must always be supplemented by another electrode. Most new houses have plastic water service, so this electrode is usually not present.	Per Table 250.66 for the service size

Steps for the example house (with the journeyman):

1. Confirm the rebar stub or 4 AWG copper from the footing is at the meter location. Clean it of concrete.
2. Land a 4 AWG copper GEC on the rebar stub with a listed clamp rated for concrete-encased and direct-burial use.
3. Drive two 8 ft rods at least 6 ft apart near the meter location. Bond them with 6 AWG copper using listed clamps.
4. Run the GECs to the service disconnect's grounding terminal (the outside meter-main in this house). The GEC connects at the service, not at the indoor subpanel.
5. Protect the GEC where it could be damaged (250.64).
6. Leave every clamp at a rod and at the rebar accessible where 250.68 requires it. A buried or concrete-encased connection made with a listed clamp or an exothermic weld does not have to be accessible.

6A.3 Bonding the piping and the other systems

Item	Rule	What you do
Metal water piping inside the house	250.104(A): bond it to the service	Run a bonding jumper from the service to the metal water piping. With plastic supply piping, there may be nothing to bond. Ask the journeyman.
Gas piping	250.104(B): metal piping likely to become energized is bonded. Gas pipe may never be used as an electrode (250.52(B))	The gas pipe gets bonded by the equipment ground of the circuit feeding the furnace or water heater. Yellow CSST (flexible gas tubing) usually needs a separate bonding jumper per its manufacturer's instructions. R1.6 covers CSST.
Intersystem bonding termination (IBT)	250.94: a terminal outside at the service for the phone, cable TV, and satellite grounds	Mount a listed IBT bar near the meter and bond it to the service. R-LOWVOLT covers who lands on it.

Picture coming: Side view of a new house foundation showing the footing with a rebar stub coming up at the meter location, a meter-main on the wall with a 3 in. conduit going down and out to a pad-mount transformer, two 8 ft ground rods 6 ft apart, a 4 AWG GEC to the rebar stub and 6 AWG to the rods, an IBT bar beside the meter, and a 4-wire feeder going through the wall to the indoor panel with "BONDING SCREW REMOVED" called out.

PART 7: PANEL MAKE-UP

"Making up" the panel means landing every circuit on its breaker and bars. It is usually done after drywall, before trim-out, or the same day as trim. R1.5 covers setting the panel and landing the service or feeder conductors. This part covers the branch circuits.

WARNING: Is the panel live? If the meter is set and the main is on, the panel is live. The main lugs are live even with the main off. Do the prove-dead procedure (Section 1.3) on the panel bus before you put your hands in. Work with the main off whenever possible. Never work above the main breaker while the meter is in.

7.1 Main panel versus subpanel

	Main (service) panel	Subpanel
Example	Indoor panel with the main breaker in it, fed directly from the meter	Indoor panel fed from an outdoor meter-main, or a garage panel fed from the house panel
Main bonding jumper (green screw or strap)	Installed (250.24(C))	Removed. Neutral bar is isolated from the can.
Neutral bar	Bonded to the can	Isolated (floating)
Ground bar	Bonded to the can; may be the same bar as the neutral if the panel label allows	Separate bar, screwed to the can (408.40)
Grounds and neutrals on the same bar?	Allowed where the panel is listed for it	Never (250.24(B), 250.142, 408.40)
Feeder	Service conductors: two hots and the neutral	Four wires: two hots, a neutral, and a ground
Grounding electrode conductor	Lands here	Not here (unless it is a separate building, which R-SERVICE covers)

Why the subpanel neutral must float: if the neutral is bonded to the can in a subpanel, normal neutral current splits between the neutral and the ground wire back to the main panel. The ground wire then carries current all the time, and every metal box and appliance frame on that feeder has a small voltage on it. A second bond also defeats GFCI protection on the feeder. The Arc Guide (Part 2, Panels) and Kuhlman (p. 43) both warn that this is one of the most common panel errors.

7.2 Order of work

1. **Prove dead.** Main off (or meter not set). Test the bus with the meter, live-dead-live.
2. **Read the panel label.** Find: the breaker types listed for this panel, which slots accept tandem breakers (if any), the wire size range and torque for each terminal (breaker lugs, neutral bar, ground bar), and how many conductors each neutral and ground terminal accepts.
3. **Check the bonding.** Main panel: bonding screw or strap installed. Subpanel: removed, separate ground bar installed.
4. **Plan the breaker layout.** Two-pole breakers for big loads near the top (closest to the main) is common. Spread single-pole circuits so the expected load is about equal on L1 and L2. Put the kitchen small-appliance circuits on opposite legs.
5. **Bring each cable in.** Remove the knockout, install a listed cable connector, and push the cable through so the sheath extends about $\frac{1}{2}$ in. past the connector inside the can. Tighten the connector screws until the cable cannot be pulled, without crushing the sheath.

6. **Strip the sheath back** inside the can. Route the conductors neatly along the side gutters, not across the breakers.

7.3 Landing a standard breaker circuit

1. **Ground first.** Route the bare ground to the ground bar (or the combined bar in a main panel where allowed). Cut it to length and land it under its own screw unless the panel label allows two or three of the same size under one screw. Torque the screw.
2. **Neutral second.** Route the white to the neutral bar. Land it in its own terminal. One neutral per terminal (408.41). Why: if two neutrals share a screw and one loosens during service work, the other circuit loses its neutral.
3. **Hot last.** Route the black to the breaker location. Strip to the length on the breaker's strip gauge (usually about $\frac{1}{2}$ in.). Insert it fully into the breaker lug and torque.
4. **Install the breaker** on the bus with it in the OFF position. Hook the breaker's back clip on the mounting rail, then press it firmly onto the bus stab until it seats.
5. **Write the circuit number** next to the breaker on the dead front with a marker, temporarily, until the directory is done.

7.4 Landing AFCI, GFCI, and dual-function breakers

These breakers watch the neutral current, so the circuit's neutral lands on the breaker, not the bar.

Pigtail type:

1. Land the circuit's white wire on the breaker terminal marked "LOAD NEUTRAL." Read the markings printed on the breaker body, because brands label the terminals differently.
2. Land the circuit's black wire on the terminal marked "LOAD POWER" or "LOAD HOT."
3. Land the breaker's coiled white pigtail on the panel's neutral bar.
4. Land the ground on the ground bar as usual.

Plug-on-neutral type:

1. The breaker clips onto a neutral rail in the panel. There is no pigtail.
2. Land the circuit's white and black on the breaker's marked terminals.

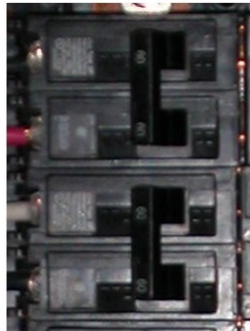
Two-pole GFCI (range, dryer, condenser):

1. Land the two hots on the two breaker lugs.
2. If the circuit has a neutral (range, dryer), land it on the breaker's load neutral terminal.
3. Land the pigtail on the neutral bar even when the circuit has no neutral (water heater, condenser). The GFCI electronics and test circuit need it. Read the instructions printed on the breaker.

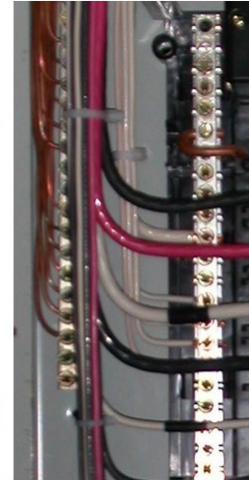
Common mistake: neutral on the bar instead of the AFCI. If you land the circuit neutral on the neutral bar instead of the AFCI or GFCI breaker, the breaker sees all the circuit's current leaving on the hot and none returning, and trips the instant there is load. Kuhlman notes that sharing a neutral between two AFCI circuits also causes trips (Kuhlman, pp. 35–36).



AFCI breakers: each white pigtail lands on the neutral bar



Two-pole breakers with tied handles



Ground bar (bare copper, left) and neutral bar (white wires, right)

Panel make-up in a new panel. Left: AFCI breakers with their white pigtails run to the neutral bar. Middle: two-pole breakers with tied handles. Right: a ground bar with bare copper wires next to a neutral bar with white wires.

Photo: Electrical closeup by scottbb, CC BY-SA 2.0.

7.5 Two-pole breakers and 240 V circuits

1. A two-pole breaker takes two adjacent slots on opposite legs (L1 and L2). It trips both hots together.
2. For a 240 V-only load (water heater, 10/2): black to one pole, re-identified white (wrap black or red tape around it for a few inches at each end) to the other pole, ground to the ground bar.
3. For a 120/240 V load (range 6/3, dryer 10/3): black and red to the two poles, white to the neutral bar (or the GFCI breaker's neutral terminal), ground to the ground bar.
4. For a multiwire branch circuit (12/3 serving two kitchen circuits): black and red on a two-pole breaker or two single-poles with a listed handle tie, on opposite legs (210.4(B)). If both hots were on the same leg, the shared neutral would carry the sum of their currents instead of the difference, and overheat. Group the neutral with its hots using a wire tie (200.6(B), 210.4(D)). With GFCI or AFCI protection, a multiwire circuit needs a two-pole GFCI or AFCI breaker. YES avoids multiwire circuits in new houses.

7.6 Torque

NEC 2026 110.14(D) requires that terminal connections with a marked torque value be tightened to that value with an approved means, such as a torque screwdriver or torque wrench. The torque values are printed on the panel label, the breaker, and the ground and neutral bars. They differ by brand and wire size.

1. Use a torque screwdriver set in inch-pounds (lb-in).
2. Set it to the value printed for that terminal and that wire size.
3. Tighten until it clicks or breaks over. Do not tighten past it.
4. Do not "re-tighten" a terminal later by feel. Use the tool again.

Why: a loose lug heats, oxidizes, and fails. An over-tightened lug cuts the conductor or cracks the breaker body. The Arc Guide (Part 10, Lost Neutral) describes a neutral screw that bottomed out without gripping the wire, which only a correct torque procedure and a tug test would have caught.

7.7 Finishing the panel

1. **Tug test** every conductor after torquing.
2. **Filler plates** in every unused dead-front opening (408.7). Use the panel manufacturer's plates.
3. **Neatness.** Conductors run along the gutters, bent at square corners, not draped across breakers. Grounds and neutrals do not cross over breakers to reach their bars.
4. **Directory (408.4(A)).** Every circuit gets a legible, permanent description that is clear and specific enough that circuits cannot be confused, including spare positions with a breaker in them. "Bedroom" is not specific enough when there are three. Write "Bedroom 2 (front left), receptacles and light." Type or print it neatly. The directory goes on the panel door or inside it.
5. **Dead front.** Install it with all its screws, using the screws that came with the panel. Do not use drywall screws: they are pointed and can pierce a conductor in the gutter.

Picture coming: A neatly made-up 40-space main panel with the dead front removed: grounds on the ground bar, neutrals on the neutral bar, AFCI breakers with coiled white pigtails going to the neutral bar, a two-pole GFCI for the range with black, red, and white landed, a two-pole for the water heater with black and taped white, filler plates in the unused slots, and the green bonding screw labeled.

Field photo coming: A completed typed circuit directory taped inside a YES panel door, with each circuit's room and loads written out.

PART 8: TRIM-OUT

Trim-out happens after drywall, paint, and usually flooring and cabinets. You install every device, fixture, appliance connection, and cover plate.

WARNING: Is anything live? On trim day the meter is often set and some circuits are on for the painters or HVAC. Before you open any box, check with the non-contact tester, then prove dead with the meter at the conductors you will touch (Section 1.3). Turn off and lock out the breaker for the circuit you are working on.

8.0 Trim-out order for a whole house

Trim-out on the example house takes a journeyman and a helper about 3 days. Work in this order so nothing gets energized before it is ready:

1. **Day 1: panel.** Make up the panel completely (Part 7) with every breaker OFF. Check bonding.
2. **Day 1 and 2: devices, room by room.** Start at the kitchen, then baths and laundry (the GFCI and dual-function circuits), then bedrooms and living areas. In each room: receptacles, then switches, then plates. Finish each room completely before the next one so nothing is left half-done.
3. **Day 2: fixtures, fans, and smoke alarms.** Fixtures go up after the devices so you are not working around hanging fixtures.
4. **Day 3: appliances and equipment.** Range and dryer receptacles, the water heater, the dishwasher, disposal, microwave, air handler, condenser, and the exterior.
5. **Day 3: test before power** (Section 9.1), then power-up (Section 9.2) and test every outlet (Section 9.3).
6. **Call for final inspection.**

8.1 Before you start

1. Clean out each box. Drywall mud and paint in the box get into terminals.
2. Pull the conductors out and check them for router or saw damage. A nicked conductor gets cut back and re-stripped, or spliced with a pigtail.
3. Check box depth now that the drywall is up. If a box is set back more than $\frac{1}{4}$ in. in drywall (314.20(A)), install a listed box extender.
4. Find your labels from rough.

8.2 Terminations

Screw terminals (wire-binding screws). NEC 2026 110.14(A) permits wire-binding screws for 10 AWG and smaller.

1. Strip $\frac{3}{4}$ in. of insulation (use the strip gauge on the back of the device).
2. Bend a hook with needle-nose pliers or the hole in your wire strippers.
3. Wrap the hook **clockwise** around the screw, about $\frac{3}{4}$ of a turn. Why: turning the screw clockwise to tighten it pulls the loop tighter. A counterclockwise loop gets pushed out from under the screw head.
4. Tighten the screw so the wire is held flat. Use the torque value on the device package if one is given.
5. **One wire under each screw.** If you need to connect two wires to one point, splice them with a pigtail.
6. No bare copper showing past the screw head, and insulation not pinched under it.

Back-wire (screw-clamp) terminals. These have a hole in the back with a clamp plate tightened by the side screw. They are made for straight, stripped wire and hold well. They are not the same as backstab terminals.

Backstab (push-in) terminals. The wire pushes into a hole and a spring holds it. NEC 2026 406.10(3) allows push-in terminals only on 15 A or smaller branch circuits with 14 AWG solid copper. YES does not use backstab terminals. Kuhlman reports that they fail often and that a backstabbed device is the usual cause when part of a room goes dead (Kuhlman, pp. 13 and 27).

Twist-on wire connectors.

1. Strip the wires to the length on the connector package (about $\frac{5}{8}$ in.).
2. Hold the wires parallel with the ends even. Twisting them together first with lineman's pliers is common practice and helps with stranded fixture leads.
3. Screw the connector on clockwise until the wires twist together below it and it is tight.
4. Tug each wire. None may pull out.
5. No bare copper showing below the skirt.
6. Use the color/size that is listed for the number and size of wires.

Lever and push-in splice connectors. Strip to the length on the connector, insert fully, close the lever (if lever type), and tug.

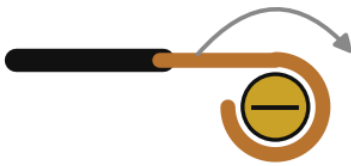
RIGHT

WRONG

Screw terminal



screw turns clockwise to tighten



Hook wrapped clockwise, about 3/4 turn.
Tightening pulls the loop in.



screw turns clockwise to tighten

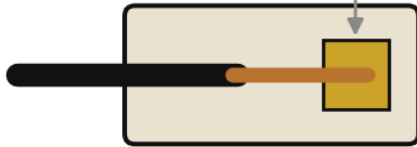


Hook wrapped counterclockwise.
Tightening pushes the wire out.

Back of the device



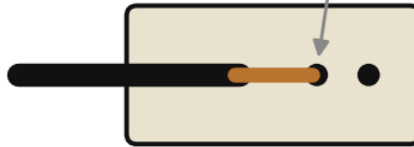
clamp plate,
tightened by side screw



Back-wire (screw-clamp) terminal:
straight stripped wire, held by a clamp.

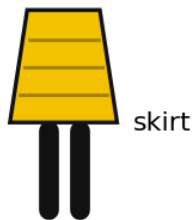


push-in holes
(spring inside)

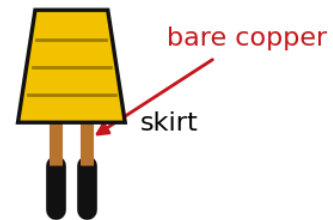


Backstab (push-in): allowed only on 15 A
with 14 AWG solid. YES does not use them.

Twist-on connector



Connector screwed on tight.
No bare copper below the skirt.



Bare copper showing below the skirt.

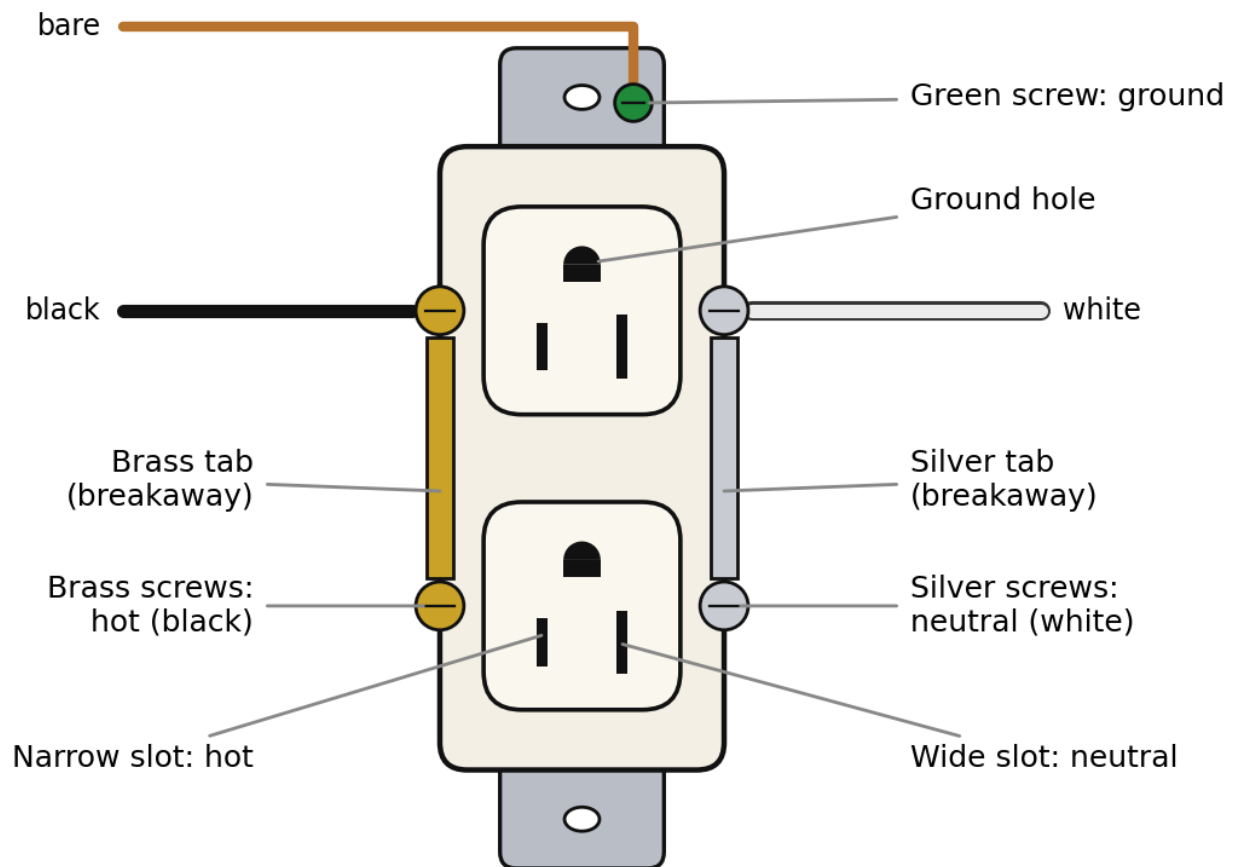
This shows the right and wrong way to make three connections: a wire hooked clockwise versus counterclockwise under a screw, a back-wire clamp versus a backstab hole, and a wire connector with no bare copper showing versus copper showing below the skirt.

Drawing: YES Electric.

8.3 Receptacles

1. Turn off and prove dead.
2. Ground pigtail → green screw.

3. White → silver screw. Black → brass screw. Why: the silver (neutral) side connects to the wide slot. A polarized plug puts the lamp's screw shell on the neutral, so a person touching the shell while changing a bulb touches a neutral, not a hot.
4. For a through-feed receptacle (cable in and cable out), pigtail the hots and neutrals instead of using the receptacle's two sets of screws to carry current downstream. Why: the device then is not part of the path to the next receptacle, and a loose device does not kill everything after it. In a multiwire circuit, pigtail the neutral is required (300.15(B)).
5. Fold the wires into the box in an accordion fold, push the receptacle in straight, and screw it to the box. Make the yoke sit flat against the box or the drywall ears flat against the wall (406.12).
6. Ground pin up or down: the code does not set an orientation. YES installs ground hole up on new work, so a loose metal plate that falls onto a half-pulled plug hits the ground blade first (R1.4). Match the existing devices on replacements.
7. TR receptacles everywhere (406.26). WR and TR outdoors.



Shown with the ground hole up, which is YES practice.
The code does not set an orientation.

A duplex receptacle has brass screws for the hot (black) wire, silver screws for the neutral (white) wire, and a green screw for the ground. The narrow slot is hot, the wide slot is neutral, and the round hole is ground.

Drawing: YES Electric.

8.4 GFCI receptacles: line and load

A GFCI receptacle has two pairs of terminals:

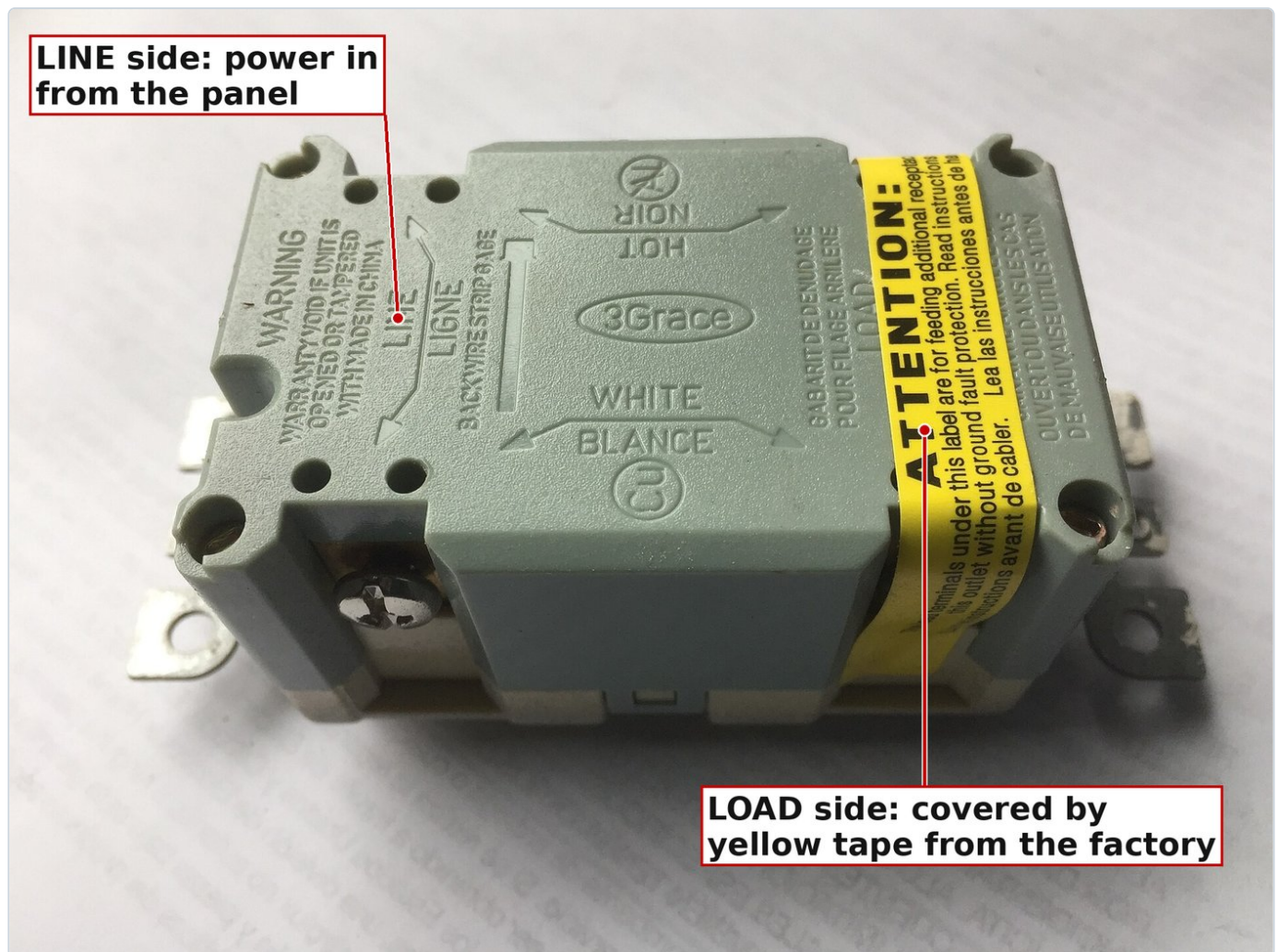
Terminals	Connect	Result
LINE	The cable from the panel (the feed)	Powers the GFCI
LOAD	The cable to downstream receptacles, if you want them protected	Downstream receptacles become GFCI-protected

Steps:

1. Find which cable is the feed. With the breaker on, carefully measure each black to ground. The live one is the feed. Turn the breaker back off and prove dead before connecting.

2. Feed → LINE terminals. Most GFCIs ship with tape over the LOAD terminals. Leave it there if you are not using LOAD.
3. If you protect downstream receptacles through LOAD, put a "GFCI Protected" sticker (included in the box) on each downstream receptacle.
4. If you reverse line and load, a modern GFCI will not reset and will not power the face. Fix the wiring.
5. Never land two circuits on one GFCI's LOAD. Kuhlman notes that a neutral from another circuit landed downstream causes the GFCI to trip (Kuhlman, p. 27).

YES practice for the kitchen: when the circuit is already on a dual-function breaker, the receptacles downstream are standard TR receptacles. Do not put a GFCI receptacle downstream of a GFCI breaker. It adds cost and confuses the owner about which device to reset.



The back of a GFCI receptacle. The LINE terminals take the cable coming from the panel; the LOAD terminals are covered by yellow tape from the factory and are used only to protect receptacles further down the circuit.

Photo: GFCI, img2.jpg by Steven Pavlov, CC BY-SA 4.0.

8.5 Switches

Single-pole:

1. Ground → green screw.
2. Feed hot (black from the panel side) → one brass screw. Switched hot (black to the light) → the other brass screw.
3. Neutrals spliced together in the back of the box. Not on the switch.
4. A switch is mounted with ON up. The words on the toggle tell you.

3-way and 4-way: wire them as in Section 5.9. Identify the COMMON screw on each 3-way before you connect anything. It is a different color (usually black) and marked COM.

Dimmers:

1. Use a dimmer rated for the load type. For LED fixtures, the fixture or lamp package lists compatible dimmers. A dimmer not matched to LED loads causes flicker and buzz.
2. Most smart dimmers and many LED dimmers need a neutral. The neutral you brought to every switch box at rough connects here.
3. Check the dimmer's wattage rating. When dimmers are ganged side by side in a multi-gang box, the side fins are broken off and the rating drops. The dimmer's instructions give the derated value.
4. Stairs: dimmers on stair lights must allow full brightness from each control location (210.70(A)(2)(4)). Use a multi-location dimmer system made for it.

Device plates. When switches and receptacles are in one box, the voltage between adjacent devices matters. 406.38(B) restricts grouping snap switches with devices where the voltage between them exceeds 300 V unless barriers are installed. This only comes up with 240 V devices in a box, which is rare in a house.

8.6 Light fixtures

1. Read the fixture instructions.
2. Mount the crossbar or bracket to the box with the box screws (8-32 or 10-32).
3. Connect: fixture ground to the box ground pigtail. Fixture white (the ribbed or marked wire on a lamp cord-type lead) to the circuit white. Fixture black to the switched hot.
4. Support the fixture weight on the box, which is rated for 50 lb at a ceiling outlet (314.27(A)(2)). Heavier fixtures need independent support.
5. In a closet, a fixture must keep its required clearances from storage space. Use enclosed LED or surface-mounted fluorescent/LED types listed for closets. R1.4 covers closet clearances (410.16).
6. Recessed and canless lights: follow the manufacturer's connection box instructions. Keep insulation off non-IC fixtures.

8.7 Ceiling fans

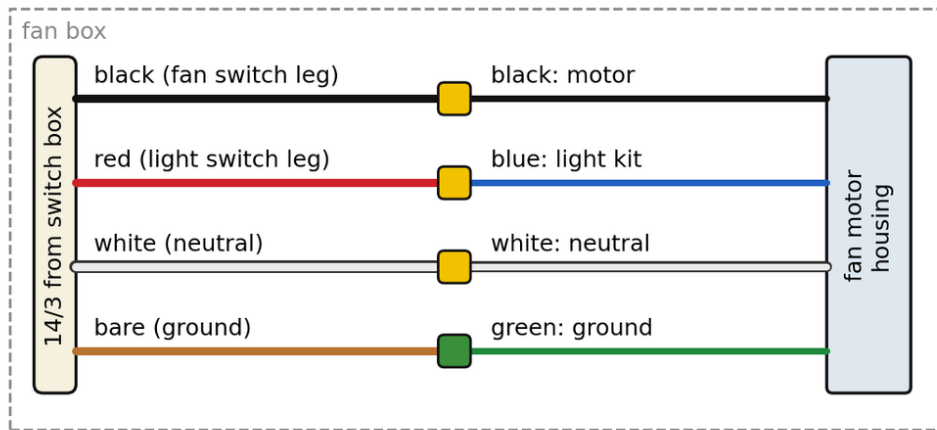
1. Confirm the box is listed and marked for fan support (314.27(B)). If it is not, replace it with a fan brace from below.
2. Mount the fan bracket to the box with the screws that came with the box (not the fixture screws). Fan boxes use 10-32 screws.
3. Hang the motor on the bracket hook while you connect.
4. Connect: ground to ground; white to white; black (fan) to the fan switch leg; blue (light kit) to the light switch leg if there are two switches (14/3 from rough). If there is one switch, tie black and blue together to the switched hot.
5. Balance the blades with the kit included. A wobbling fan loosens its own mounting.

8.8 Smoke alarms

1. Install the mounting plate on the box.
2. Connect the alarm's harness: black to black, white to white, red (interconnect) to red. Cap any unused red at the last alarm.
3. Plug the harness into the alarm, install the battery or pull the battery tab, and twist the alarm onto the plate.
4. Test after power-up (Section 9.4).

Ceiling fan with separate fan and light switches

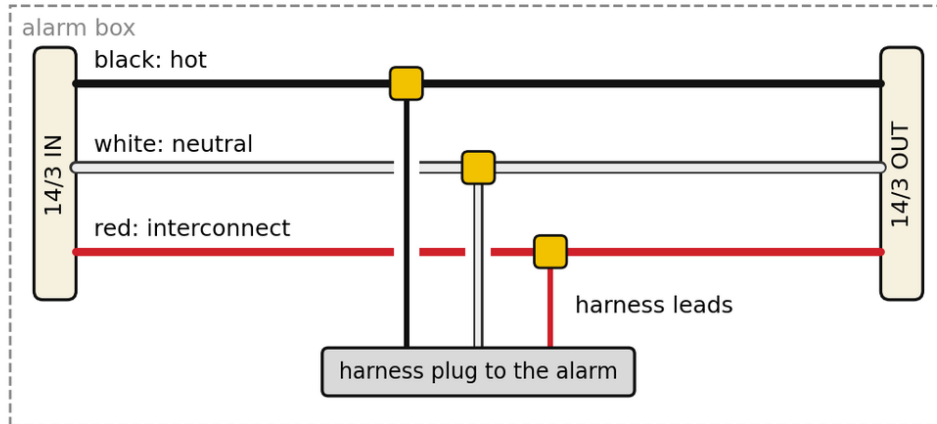
14/3 from the switch box to the fan box (Sections 8.7 and 5.11, box L2)



One switch only: tie fan black and blue together to the switched hot. Ground also goes to the fan bracket and a metal box.

Smoke alarm in the middle of an interconnected chain

14/3 in, 14/3 out (Sections 8.8 and 5.11, box D4)



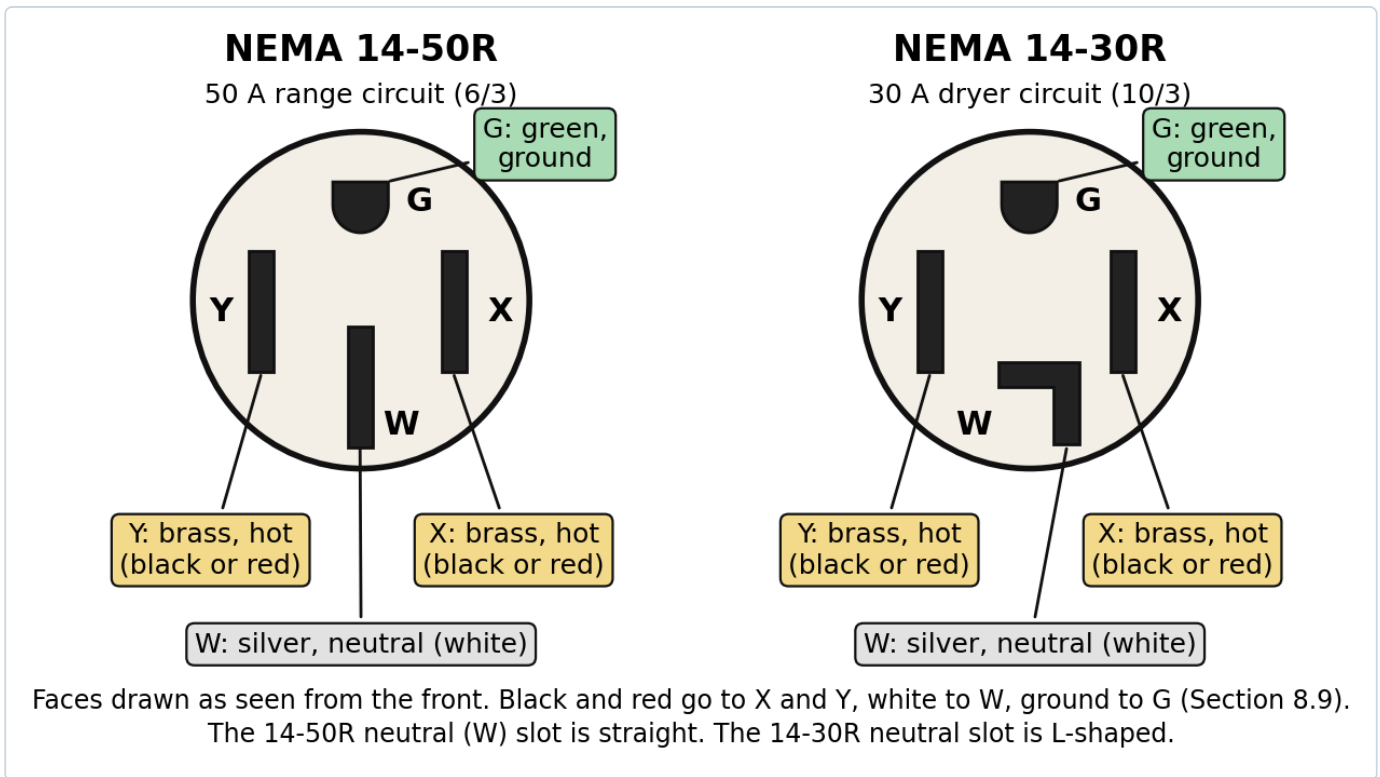
Black to black, white to white, red to red. Cap any unused red at the last alarm.
Grounds are spliced in the box (not shown). No switch on the alarm circuit.

A ceiling fan with separate fan and light switches connects its black motor lead to the 14/3 black, its blue light-kit lead to the red, white to white, and green to the bare ground. A smoke alarm in the middle of an interconnected chain splices black to black, white to white, and red to red with its harness.

Drawing: YES Electric.

8.9 Appliance connections

Appliance	Steps
Range (14-50R)	Install the receptacle in its box. Black and red to the X and Y brass terminals, white to the W (silver) terminal, ground to G (green). Torque per the device. At the range, use a 4-wire cord. Remove the range's factory bonding strap between neutral and frame (new installations must use the equipment grounding conductor, 250.140(A)).
Dryer (14-30R)	Same as the range. 4-wire cord. Remove the dryer's bonding strap or jumper per the dryer manual.
Water heater	Turn off and prove dead. At the water heater junction box: black to one element lead, re-identified white (taped black or red) to the other, ground to the green screw. Do not energize until the tank is full of water. A dry element burns out in seconds. Install the breaker lock-off kit.
Dishwasher	If cord-connected: plug in (cord length 3 to 6½ ft, 422.16(B)(2)). If hardwired: connect in the dishwasher's junction box with a listed cable connector, and the breaker must be within sight or lockable (422.31).
Disposal	Install the cord kit on the disposal (18 to 36 in., 422.16(B)(1)) and plug into the switched receptacle.
Microwave/hood	Plug into the cabinet receptacle once the installer hangs it.
Air handler and condenser	Land the circuit in the unit's disconnect or terminal block per the nameplate and manual. Condenser: a liquidtight whip from the disconnect to the unit. Do not land control wiring on power terminals.



These are the faces of a NEMA 14-50R range receptacle and a NEMA 14-30R dryer receptacle. Black and red connect to the X and Y terminals, white to W, and the ground to G.

Drawing: YES Electric.

8.10 Cover plates

1. Install all cover plates after paint.
2. Use plates that sit flat on the wall. A plate that rocks means the box is set back or the device is crooked. Fix the cause.
3. Exterior receptacles in wet locations get an extra-duty in-use (bubble) cover (406.9(B)(1)).
4. Do not overtighten plastic plate screws. They crack.

PART 9: TESTING AND ENERGIZING

9.1 Before you energize: check for shorts

Do this with the main off and every breaker off, after the panel is made up and all devices are installed.

1. Turn every wall switch OFF. Unplug everything. Remove lamps from any fixture you are unsure of.
2. At the panel, set your meter to ohms (Ω) or continuity.
3. For each circuit, measure at the breaker terminal and the bars (the breaker is off, so its terminal is isolated from the bus): - Hot to neutral: should read open (OL). A reading near 0

Ω means a short. A reading of a few ohms to a few hundred ohms means a load is connected, such as a light whose switch is on. - Hot to ground: should read open (OL). Any reading means a ground fault. - On AFCI and GFCI breakers, the neutral is on the breaker. Measure the circuit at the breaker's load terminals.

4. For a subpanel only: with all circuits landed, measure from the neutral bar to the ground bar. It must read open. A reading near 0 Ω means a neutral is touching a ground somewhere, or the bonding screw is still in.
5. Find and fix every short or ground fault before you energize. Common causes: a drywall screw through a cable, a staple through a cable, a ground wire touching a hot terminal in a box.

9.2 Power-up sequence

WARNING: Energizing. Stand to the side of the panel, not in front of it, when you close the main. Wear safety glasses. Keep the dead front on. If the journeyman is not present for your first power-up, do not do it.

1. The meter is set and the utility has released power.
2. All branch breakers are off. The main is off. The dead front is on.
3. Turn the main ON.
4. Measure at the panel (on the main breaker load terminals or the first breaker position, with the journeyman):

Measurement	Expected
L1 to L2	About 240 V
L1 to N	About 120 V
L2 to N	About 120 V
N to G	About 0 V

If L1-N and L2-N are not about equal (for example 95 V and 145 V), stop. The service neutral may be open or loose. Turn the main off and call the journeyman. The Arc Guide (Part 1, Symptom 9) and Kuhlman (p. 45) both describe this reading as a neutral problem. 5. Turn on the branch breakers **one at a time**, starting at the top. After each one, wait a few seconds and listen. If it trips, leave it off, note the circuit, and go on. 6. Do not turn on the water heater breaker until the tank is full. 7. Do not turn on HVAC breakers until the HVAC contractor is ready to start up the equipment. 8. Go back to any breaker that tripped and find the fault (R2.3 covers troubleshooting).

9.3 Test every outlet

Carry a plug-in receptacle tester with a GFCI test button, and your meter.

1. **Every receptacle:** plug in the tester. It shows correct wiring, open ground, open neutral, open hot, hot/ground reversed, or hot/neutral reversed. Fix anything other than "correct."
2. **Voltage spot checks:** at the farthest receptacle on each circuit, measure hot to neutral. Expect about 120 V with no load. A reading several volts lower than at the panel, with no load, points to a bad connection.
3. **Every switch:** operate it. The right light comes on. 3-ways and 4-ways work from every location in every combination.
4. **Every GFCI receptacle:** press TEST. Power goes off at the receptacle and every downstream receptacle. Press RESET. Power comes back. Then use the plug-in tester's GFCI button. It should trip.
5. **Every GFCI breaker:** press TEST at the panel. The breaker trips. Reset it. Use the plug-in tester at a receptacle on the circuit to confirm it trips.
6. **Every AFCI and dual-function breaker:** press TEST. The breaker trips. Reset it.
7. **240 V receptacles:** measure X to Y (240 V), X to W (120 V), Y to W (120 V), W to G (0 V).
8. **Fans and fixtures:** every one works and the fan does not wobble.
9. **Record** each circuit tested, the readings, and any problems on the job checklist.



A plug-in receptacle tester. The chart on top shows which pattern of the three lights means correct wiring and which means open ground, open neutral, open hot, or reversed hot and neutral.

Photo: USA receptacle tester.jpg by Demi, CC BY-SA 3.0.

9.4 Smoke alarm test

1. Each alarm shows a green power light.
2. Press TEST on one alarm. Every alarm in the house sounds. If one does not sound, the interconnect is open at that alarm or between it and the last working one.
3. Repeat from a second alarm at the other end of the house.

9.5 Final inspection checklist

1. Every device, fixture, and plate is installed. No open boxes, no missing plates.
2. Every receptacle tests correct. Every GFCI and AFCI trips and resets.
3. TR receptacles everywhere; WR outdoors; extra-duty in-use covers on wet-location receptacles.
4. All required lights work with their switches; stair switches work at both levels.

5. Smoke alarms work and are interconnected.
 6. Panel: directory complete and specific, filler plates installed, dead front on with its own screws, working space clear, nothing stored in front of it.
 7. Appliance circuits connected: range, dryer, water heater, dishwasher, disposal, microwave, HVAC.
 8. HVAC disconnects within sight, service receptacles within 25 ft.
 9. Water heater breaker lockable.
 10. Surge protective device installed (230.67).
 11. Outdoor emergency disconnect, if this house has one, labeled (225.41, R-SERVICE).
 12. Grounding electrode system and bonding complete (R-SERVICE).
 13. Every cover plate straight and every device level.
 14. Job photos of the finished panel and the directory in the job folder.
-

PART 10: WRAP-UP

10.1 Mistakes green helpers make

Mistake	What happens	How to avoid it
14 AWG on a 20 A circuit, even one pigtail	Fails inspection. The 14 AWG section can overheat.	Use yellow jacket on every 20 A circuit. Use 12 AWG pigtails.
Missing staples within 8 or 12 in. of a box	Fails rough inspection	Staple as you go, not at the end.
Sheath stops at the knockout instead of ¼ in. inside	Fails inspection; insulation chafes	Check every box at strip time.
Hole closer than 1¼ in. to the face, no nail plate	A drywall screw goes through the cable later	Center holes. Carry nail plates in your pouch.
Box set back from the wall	Device loose, plate rocks, fails inspection	Use the depth gauge on the box.
Grounds not made up at rough	Fails rough inspection	Make up grounds before you leave each box.
Forgetting a required receptacle (hallway, island provision, HVAC, deck)	Cut-in after drywall	Do the planning walk with the table in Section 3.7.
Neutral of an AFCI/GFCI circuit on the bar	Breaker trips under load	Land the circuit neutral on the breaker.
Bonding screw left in a subpanel	Objectionable current on grounds; fails inspection	Check bonding on every panel.
Backstabbing devices	Loose connections, dead outlets later	YES does not use backstab terminals.
Wire wrapped counterclockwise	Wire squeezes out from under the screw	Wrap clockwise.
GFCI LINE and LOAD reversed	GFCI will not reset	Find the feed with a meter first.
Too many wires in a box	Device will not fit; fails inspection	Calculate box fill at rough.
Two neutrals under one terminal	Fails inspection; a loose screw drops two circuits	One neutral per terminal (408.41).
Energizing the water heater dry	Element burns out	Confirm the tank is full first.
Shared neutral on single-pole breakers on the same leg	Neutral overheats	Two-pole or handle-tied breaker, opposite legs (210.4(B)).
Splicing in a wall without a box	Hidden splice can fail and start a fire	Every splice in an accessible box.
Generic directory ("bedroom," "lights")	Fails 408.4; useless to the owner	Write room, location, and loads for each circuit.

10.2 One-page master checklist

Plan - [] Panel location: working space 36 in. deep, 30 in. wide; not in a closet, bathroom, or over stairs. - [] Circuit list complete with breaker, cable, protection, and device for every circuit. - [] Two kitchen small-appliance circuits, laundry, bathroom, and garage 20 A circuits. - [] Dedicated circuits for every appliance per its nameplate. - [] Receptacles: 6 ft/12 ft, 2 ft wall spaces, 24 in. countertop rule, island provision, bathroom, hallway, foyer, front and back outdoor, deck, garage bays, basement, laundry, HVAC within 25 ft. - [] Lighting: every room, hall, stair (switch each level), garage, exterior doors, attic/crawl with equipment. - [] GFCI, AFCI, and TR marked for every circuit. - [] Smoke and CO alarm locations. - [] Cabinet drawings, HVAC and water heater locations, and window sizes confirmed against the framing. - [] Concrete-encased electrode (rebar stub) confirmed at the meter location before the footing pour.

Rough - [] Boxes set to height and drywall depth; fan-rated boxes where needed. - [] Holes centered; nail plates where under 1¼ in.; grommets in metal studs. - [] Home runs from the panel; tails labeled. - [] No cable across a doorway; no holes in headers, posts, rough sills, trusses, or hold-downs. - [] Every box matches its type in the make-up guide (Section 5.11); no neutrals from two circuits spliced together. - [] Staples within 12 in. (8 in. at clampless single-gang) and every 4½ ft. - [] Attic guard strips; crawl space running boards. - [] Sheath ¼ in. into boxes; 6 in. free conductor, 3 in. past the face. - [] Grounds made up; cables labeled; box fill checked. - [] Fire and air sealing done or scheduled. - [] Photos of every wall. - [] Rough inspection passed before insulation.

Service and grounding - [] External disconnect at the meter; indoor panel wired as a subpanel. - [] Concrete-encased electrode, two rods 6 ft apart, GECs landed at the service disconnect. - [] Water and gas piping bonded; IBT installed; SPD installed.

Panel - [] Bonding correct for main or subpanel. - [] One neutral per terminal; grounds per the label. - [] AFCI/GFCI neutrals on the breaker; pigtails on the bar. - [] Every terminal torqued with a torque tool. - [] Filler plates; directory specific; dead front with its own screws.

Trim - [] Clockwise wraps, one wire per screw, no backstabs. - [] GFCI line/load correct; downstream stickers. - [] 3-ways and 4-ways work from every location. - [] LED-rated dimmers; fans on fan-rated boxes, balanced. - [] Appliances connected per manuals; range and dryer 4-wire with bonding strap removed. - [] Plates straight; extra-duty covers outside.

Test and energize - [] Ohms test every circuit before energizing: no shorts, no ground faults. - [] Main on: 240/120/120/0 V. - [] Breakers on one at a time. - [] Every receptacle tested; every GFCI and AFCI tripped and reset; smoke alarms interconnected. - [] Final inspection passed.

FIELD EXERCISE

This is the outline's field exercise for R1.2, written out in full. Do all three parts with a journeyman. Allow one full day.

Part A: Name every part of a panel (1 hour)

Setup: a training panel, or a real panel with the main OFF, proved dead on the load side, and the dead front removed by the journeyman. If the meter is in, the main lugs are live. Keep your hands out of the panel. Point with a non-conductive pointer (a wooden pencil or a plastic probe).

1. Point to and name each of these. The journeyman checks each one. - Main lugs (or service conductors landing on the main breaker) - Main breaker, and read its rating - L1 bus and L2 bus - Neutral bar(s) - Ground bar - Main bonding jumper (screw or strap), and say whether this panel is a main panel or a subpanel and how you can tell - Grounding electrode conductor and where it goes - One single-pole breaker, one two-pole breaker, one AFCI, one GFCI or dual-function (if present), one tandem (if present) - AFCI/GFCI pigtail and where it lands - Filler plates - The panel label: read aloud the panel rating, the breaker types allowed, the maximum number of circuits, and one torque value
2. Explain to the journeyman, in your own words, why the bonding screw is in a main panel and out of a subpanel.

Part B: Measure split-phase voltage (30 minutes)

Setup: the same panel energized, with the journeyman present and directing. Wear safety glasses. Use a CAT III meter with probe tips no longer than needed.

WARNING: This part is done on live parts. The journeyman holds or watches the test, chooses the test points, and decides whether you take the readings or watch. Do not do Part B without a journeyman present.

1. Test your meter on a known live receptacle.
2. Measure at the main breaker load terminals, or the terminal of a two-pole breaker: - L1 to L2 - L1 to N - L2 to N - N to G
3. Write down the readings.
4. Explain each reading: why L1-L2 is about twice L1-N, and why N-G is about 0 V in a main panel.
5. If L1-N and L2-N differ by more than a few volts, tell the journeyman and explain what it could mean (Section 2.2, "What happens when the neutral is lost").

Part C: Map an unlabeled panel and write a directory (4 to 6 hours)

Setup: a house with a missing, wrong, or vague directory. Two people: one at the panel and one walking the house. Tools: circuit breaker tracer (transmitter and receiver), plug-in receptacle

tester, a lamp or night-light, a clipboard with a floor plan sketch, painter's tape, a marker, and a phone or radio. This follows the Arc Guide's Job 10 procedure with a tracer step added.

1. **Photograph the existing directory** and the panel before you change anything.
2. **Sketch the floor plan.** Draw every room. Number every receptacle, switch, light, and appliance on the sketch.
3. **Tell the owner** that power will go off room by room for short periods. Ask about anything that should not lose power (a medical device, a freezer, a computer). Save those for last and coordinate with the owner.
4. **Fast pass with the tracer.** Plug the tracer transmitter into a receptacle. At the panel, sweep the receiver down the breakers. The breaker with the strongest signal is that receptacle's circuit. Write the breaker number on a piece of painter's tape on the receptacle. Repeat at each receptacle. For a light or a hardwired appliance, connect the transmitter with the clip adapter at a lampholder adapter or have the journeyman connect it. The tracer is fastest when you are working alone (Kuhlman, p. 11).
5. **Confirm by switching off.** Working from breaker 1 down, the panel person turns one breaker off. The walker checks every outlet in the house with the plug-in tester or lamp and records what went dead. Turn it back on. Repeat for every breaker (Arc Guide, Job 10, steps 2 and 3).
6. **Flag problems.** Mark any breaker where nothing went dead (spare, or something missed). Mark any outlet that never went dead (it may be on a subpanel or a breaker you did not test). Also note double-tapped breakers, 15 A breakers on kitchen counters, and any breaker larger than its wire (Arc Guide, Job 10, load survey).
7. **Record two-pole breakers** with both numbers (for example, "7/9 Range").
8. **Write the directory.** One line per breaker, with breaker number, rating, and a specific description. Meet 408.4(A): clear, specific, unlikely to be confused. Example:

Breaker	Rating	Description
1	20 A DF	Kitchen counters left of sink, dining room receptacles
2	20 A DF	Kitchen counters right of sink, range wall, island
3	20 A DF	Refrigerator
5/7	50 A 2P GFCI	Range
14	15 A AFCI	Bedroom 2 (front left): receptacles and ceiling light
20	—	Spare (breaker installed, no load)

1. **Post the directory** on the panel door. Type or print it.
2. **Turn in** the photo of the old directory, your sketch, your notes, and the new directory to the journeyman.
3. **Remove all painter's tape** from the owner's walls.

Done when: every breaker has a specific description, every outlet in the house is on the sketch with a breaker number, and the journeyman has spot-checked five circuits and found them correct.

Optional Part D: Build a training wall

If YES has a training wall (two 8 ft wall sections framed with 2×4 studs), rough in and trim out this layout under supervision, then test it: one 15 A circuit with a 3-way pair and a ceiling light, one 20 A circuit with two receptacles fed through a GFCI on LINE with the second receptacle on LOAD, and one ceiling fan box with a 14/3 to a two-switch box. Run all the checks in Parts 6 and 9.

NEC CROSS-REFERENCES

All numbers are NEC 2026. NEC 2023 numbers are in parentheses where the section moved.

Section	Topic
Art. 100	Definitions: service, feeder, branch circuit, grounded conductor, equipment grounding conductor, outlet
110.14(A)	Wire-binding screws allowed for 10 AWG and smaller
110.14(D)	Torque connections to the marked value with an approved means
110.26	Working space about electrical equipment
120.82 (220.82)	Optional load calculation for a dwelling
200.6(B)	Group neutrals with their circuit conductors
200.7	Identifying the grounded conductor
200.8(C)(1) (200.7(C)(1))	Re-identifying a white conductor in a cable as a hot
210.4(B), 210.4(D)	Multiwire branch circuits: simultaneous disconnect, grouping
210.8(A), (C), (D), (E), (F)	GFCI: dwelling receptacles, crawl space lighting, specific appliances, HVAC service receptacles, outdoor outlets
210.11(C)(1)–(4)	Required kitchen, laundry, bathroom, garage circuits
210.12(A), (B)	AFCI methods and dwelling locations
210.19(C)	Range circuit minimum 40 A for ranges 8¾ kW and up
210.50(C)	Appliance receptacle within 6 ft of the appliance
210.52(A)–(I)	Dwelling receptacle outlet requirements
210.63	Equipment requiring servicing (HVAC receptacle within 25 ft)
210.70(A), (C)	Required lighting outlets and switch locations
225.41 (230.85)	Emergency disconnect for one- and two-family dwellings
230.67	Surge protection for dwelling services
240.4(D)	Small conductor overcurrent protection: 14 AWG 15 A, 12 AWG 20 A, 10 AWG 30 A
240.24	Location of overcurrent devices: accessibility, closets, bathrooms, over steps
250.24(B), (C)	No neutral-ground connection on the load side; main bonding jumper
250.119	Equipment grounding conductor identification
250.140	Frames of ranges and dryers
250.142	Use of the grounded conductor for grounding equipment
250.148	Grounds connected in boxes
250.50	All electrodes present are bonded into one grounding electrode system
250.52(A)(1), (3), (5); 250.52(B)	Water pipe, concrete-encased, and rod electrodes; gas pipe not an electrode

Section	Topic
250.53(A)(2), (A)(3), (A)(4)	Supplemental electrode (25 ohm exception), 6 ft rod spacing, 8 ft driven depth
250.64, 250.66, 250.68	GEC installation, sizing (6 AWG Cu to rods, 4 AWG Cu to concrete-encased), accessibility
250.94	Intersystem bonding termination
250.104(A), (B)	Bonding metal water and other metal piping
300.25 (300.22)	Wiring in ducts and plenums
310.12(A)	Dwelling service and feeder conductor sizes (200 A: 2/0 Cu, 4/0 Al)
300.6 (300.4)	Protection against physical damage: 1¼ in., nail plates, metal studs, roof decking
300.15(B)	Neutral continuity in multiwire circuits
300.16 (300.14)	Free conductor length at boxes
300.23 (300.21)	Firestopping penetrations
310.16	Ampacity table
314.16	Box fill (new ¼ allowance for each ground beyond four)
314.17(B)(2)	Cable sheath ¼ in. into box; 8 in. stapling at clampless single-gang boxes
314.20	Box setback in finished surfaces
314.27(A), (B)	Luminaire and fan boxes
320.23 (via 334.23)	Cable in accessible attics
334.10, 334.12	NM uses permitted and not permitted
334.15	NM in exposed work, basements, crawl spaces
334.24	Bending radius
334.30	Securing and supporting NM
334.80	NM ampacity (60°C column, bundling)
406.9(B), (C)	Wet-location receptacle covers; receptacles and switches near tubs and showers
406.10(3)	Push-in terminals limited to 15 A circuits and 14 AWG solid copper
406.12 (406.4)	Receptacle installation
406.26 (406.12)	Tamper-resistant receptacles
406.30 (404.2)	Switch connections: 3-way and 4-way, no switching the neutral, neutral at switch locations
406.38 (404.8)	Switch accessibility and maximum height
406.46 (404.14)	Switch ratings

Section	Topic
408.4(A)	Circuit directory
408.7	Unused openings closed
408.36	Panelboard overcurrent protection
408.40	Panelboard grounding; equipment grounds not on the neutral bar except where permitted
408.41	One grounded conductor per terminal
422.12	Central heating equipment on an individual circuit
422.13	Storage water heaters are continuous loads
422.16(B)	Cord lengths for disposals, dishwashers, microwave/hood combinations
422.31	Disconnects for permanently connected appliances
440.14	AC equipment disconnect within sight

END-OF-CHAPTER CHECKLIST

You are ready to move on when you can do each of these without the book:

- ☐ Prove a circuit dead with live-dead-live.
- ☐ Explain 120/240 V split-phase and why a water heater has no neutral but a range does.
- ☐ Name every part of a panel and tell a main panel from a subpanel.
- ☐ List the four required dwelling circuits from 210.11(C).
- ☐ Lay out the receptacles for a bedroom and an L-shaped kitchen.
- ☐ List where GFCI and AFCI are required in a dwelling under NEC 2026.
- ☐ Pick the cable and breaker for every circuit in the 1,800 sq ft example.
- ☐ Do a box-fill calculation, including the NEC 2026 rule for more than four grounds.
- ☐ Rough in a room: boxes at height and depth, holes, staples, plates, grounds, labels.
- ☐ Wire a 3-way and a 4-way.
- ☐ Land AFCI, GFCI, and two-pole breakers correctly and torque them.
- ☐ Trim out receptacles, a GFCI on line and load, switches, a fan, and smoke alarms.
- ☐ Test a house before and after energizing.
- ☐ Map a panel and write a 408.4 directory.

Videos to watch

These videos are made by other electricians and companies, not YES Electric. Watch each one after you read the section it goes with. Where a video does something differently from this module, the caution line says so. Follow this module and your journeyman, not the video. Click a title to open it on YouTube.

Section	Video
§1.2 Your test tools and §2.2 Split-phase 120/240 V (Field Exercise Part B)	How To Use A Multimeter - USING THE FLUKE T5-600 TESTER Electrician U • 14:08 In a live panel he measures hot to hot (about 240 V), each hot to neutral (about 120 V), each hot to ground, and neutral to ground (0 V), the same readings the helper takes in Field Exercise Part B. Caution: Sponsored intro by a contractor. He does not show the live-dead-live check; prove dead using R1.2 §1.3 every time. Panel measurements are for a journeyman-supervised exercise.
§2.5 Panel anatomy	How Do Electrical Panels Work - An Explanation of All the Parts! Electrician U • 10:05 Walks through the main lugs, main breaker vs main-lug-only, the neutral bar (isolated) vs ground bar (bonded to the can), and how the bus fingers alternate so stacked breakers land on opposite legs. Caution: He also covers three-phase panels and calls the legs 'A phase' and 'B phase'. Houses are single-phase 120/240 V; R1.2 calls them L1 and L2.
§5.2 to §5.5 Boxes, drilling, pulling, and securing cable	How to Install Rough Electricity in New Construction Ask This Old House This Old House • 7:23 A master electrician lays out receptacles, nails new-work boxes flush for drywall, drills every stud, unrolls cable flat, staples near boxes, strips 8 in. of sheath, and splices grounds at rough. Caution: Boxes go 18 in. to center for receptacles and 48 in. to center for switches. Use the YES box heights in R1.2 §5.1, not the video's. The fixtures shown use push-in connectors, which are part of the fixture; YES never backstabs devices.
§5.11 Box-by-box make-up guide (receptacles)	How Electricians MAKE-READY a Receptacle Electrician U • 3:26 Short clip of making up a receptacle box at rough: grounds twisted and pigtailed through a ground wire nut, then hots and neutrals cut to the same length and folded neatly into the back. Caution: He leaves about 4 to 5 in. outside the box; R1.2 calls for an 8 in. bare ground pigtail and labeling the sheaths ('FROM PANEL 17', 'TO NEXT REC'), which he does not show.
§5.9 3-way and 4-way switching	BEST EXPLANATION OF 3WAY SWITCHING - in under 3 minutes! Electrician U • 2:30 Whiteboard explanation of the common (black) screw, the two traveler screws, the hot side and leg side, and why a 3-way has no 'on' or 'off' position. Caution: Theory only, no hands-on wiring. He uses 12-3 as his example; a 15 A lighting circuit uses 14-3. Use R1.2 Method A (power enters at the first switch) and keep a neutral in each switch box.

Part 7 Panel make-up (\$7.2 to §7.7)	How to Wire an Electrical Panel - Good Workmanship Electrician U • 27:38 Full make-up of a 200 A panel: laying out AFCI/dual-function and 240 V breakers, stripping cable at the connector, dressing grounds and neutrals, one wire per terminal, anti-oxidant on aluminum feeders, and what makes an inspector fail a panel. Caution: Uses Square D QO plug-on-neutral breakers (no white pigtails) and an ABB cable-tie sponsor segment. Torque every terminal to the label value per R1.2 §7.6.
§8.2 and §8.3 Terminations and receptacles	Electrical 101: Wire an OUTLET Make a PERFECT J-Hook! Handyman Hertz • 2:55 Close-up of using the strip gauge, forming a small hook, wrapping it clockwise under the screw, insulation stopping at the screw, and tightening the unused screws. Caution: He says backstabbing is 'still code'. NEC 2026 406.10(3) limits push-in terminals to 15 A circuits with 14 AWG solid, and YES never uses them. Handyman channel, not a licensed electrician.
§8.4 GFCI receptacles: line and load	Watch a Pro Wire a 20A GFCI and 20A Receptacle, Any Code Violations? Sparky Channel • 9:24 A competition-winning electrician pigtails grounds, lands the LINE cable on the GFCI's LINE terminals and the downstream receptacle on LOAD, and the narrator explains the weather-resistant and 'GFCI Protected' label rules he missed. Caution: Uses back-wire clamp terminals (allowed; these are screw terminals, not push-ins). Code sections are quoted from NEC 2020; use the numbers in R1.2.

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