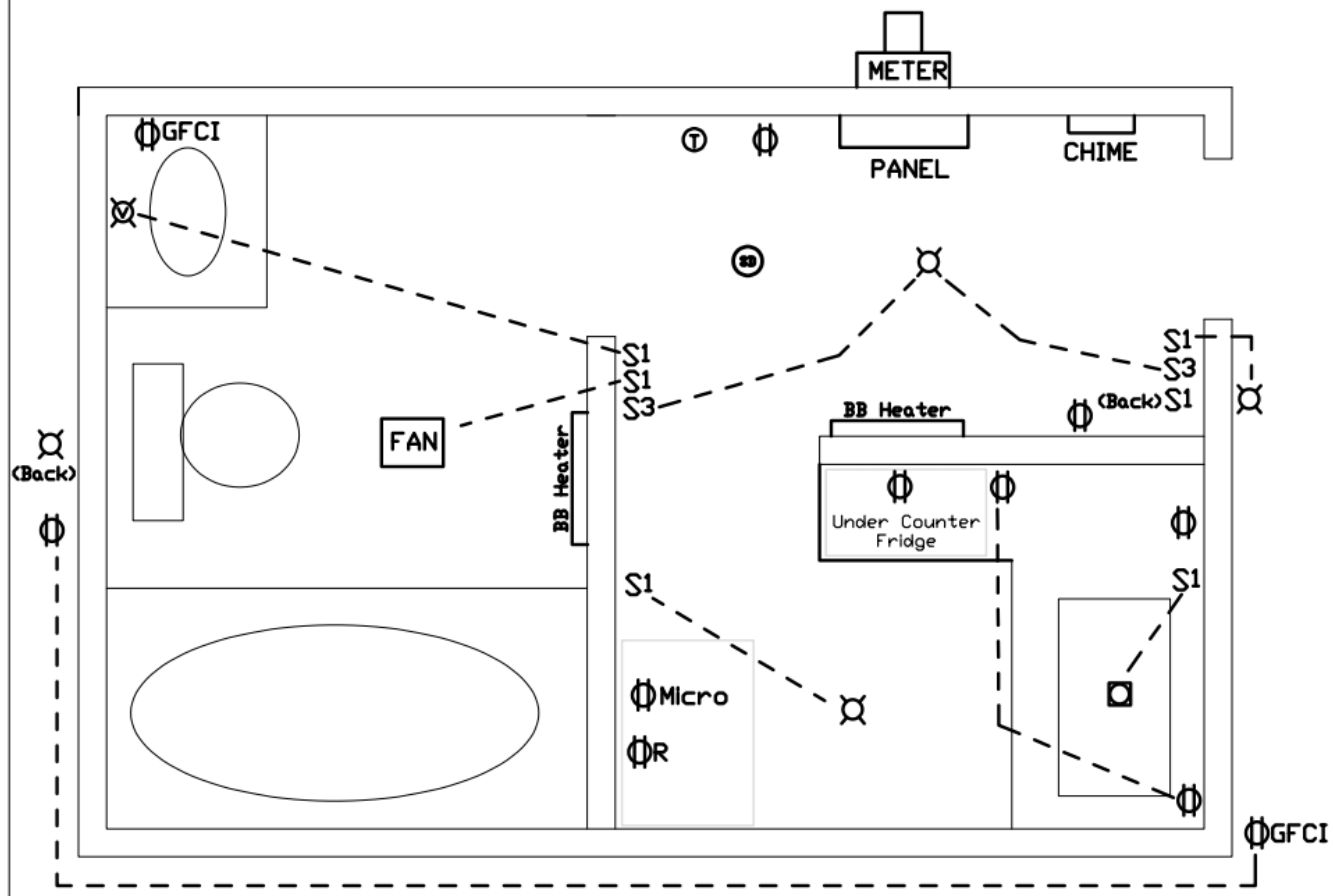
PART C

Project Pre-amble and Code Considerations



NOTES

All measurements to center of boxes

* Counter Plugs = 45.5"
* Switches = 48"
* Standard Plugs = 14"
* Microwave = 72"
* Vanity Light = 80"
* Range = Max 130mm to Center 26-744(6)
* Smoke Detector Interlocked with crawlspace SD

LEGEND

Single Switch.... S1
3 Way Switch.. S3
Receptacle.....
Light.....
Vanity Light....
Range..... R
Pot Light.....
Thermostat.....
Smoke Detector

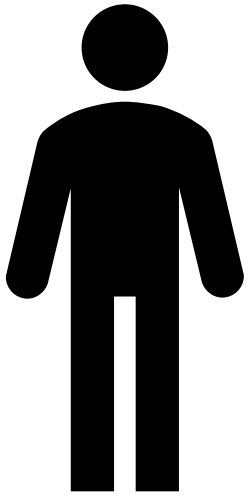
Device locations may need to be modified to suit your layout

NORKAM SHED ELECTRICAL LAYOUT - MAIN FLOOR

Grading Breakdown – Shed Project

Daily Individual Mark

70%



Group Mark

30%

Deductions

5-15% per missed day

Grading – Self-evaluated Daily Mark (70%)

Effort

- Are you on task?
- Are you engaged in the project?
- Are you helping your team?

- Are you engaging in non-classroom related activities?
- Are you consistently standing around talking to your friends?
- Are you taking “breaks” during class time?

Safety

- Are you wearing your PPE without needing reminders?
- Are you following safe work practices?

- Are you engaging in horseplay?
- Are you taking risks that you should not?

Professionalism

- Are you treating those around you with respect?
- Are you having appropriate conversations for a workplace?
- Are you pulling your weight on your team?

- Are you constantly swearing?
- Do you distract others from completing their work?

*Missed days are automatic zeros **in addition** to deductions

Grading – Group Mark (30%)

Completion

- Did your group get the project to completion in the allotted amount of time?
- Compared to other teams, how much work was completed?

Satisfaction

- Is the overall workmanship acceptable?
- Does the project meet all code considerations?
- Were instructor suggestions implemented?

Extras

- How many upgrades did your group accomplish?
- What is the complexity of the project enhancements?

Grading – Deductions for Attendance (–%)

First Day

- -5%

Second/Third Day

- -10% each day

Forth/Fifth Day

- -15% each day

Exceptions only apply under the two following conditions:

- You email me at enielsen@tru.ca with your reason **ahead of class time**
- You provide me with a **signed parent or coach note with a contact phone number**

Consequences for Bad/Unsafe Behaviours

Isolation Station

Including but not limited to:

- Cleaning or sorting tasks
- Shop maintenance tasks
- Writing a reflective paragraph on why you are engaging in bad behaviours
- Presenting to the class your reflective paragraph on why you are engaging in bad behaviours

Loss of Privileges

- Shop bay door stays closed
- No headphones in shop for entire group for the entirety of our class
- Loss of power tools for group for the week

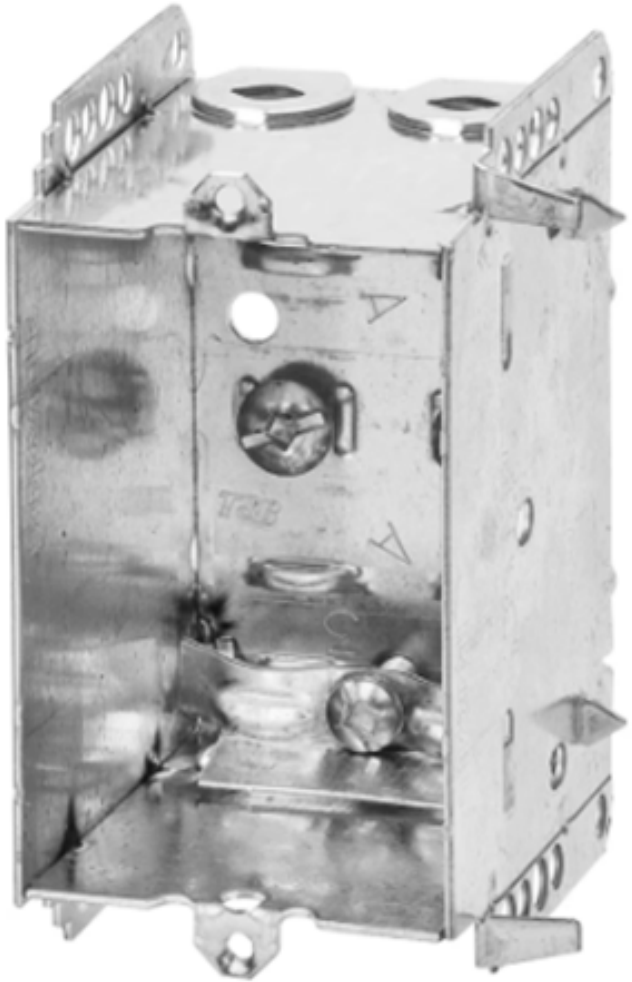
Not enough?

- Parent contact
- Behaviour contracts
- Guidance counsellor or principal referral

Give me your ideas and if appropriate we will add them to the bucket!

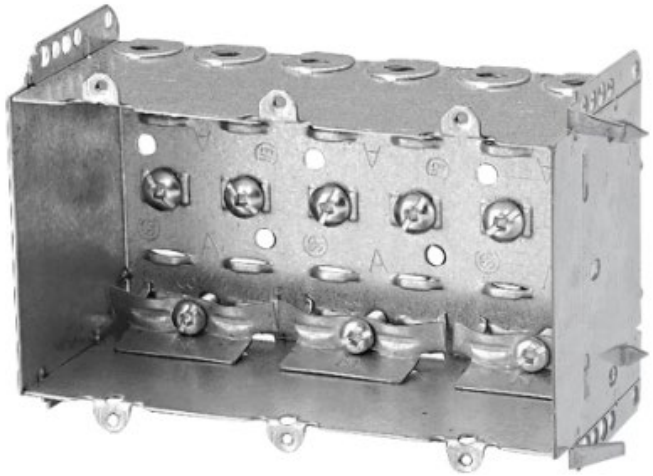
Phase 1 – Layout and mount boxes

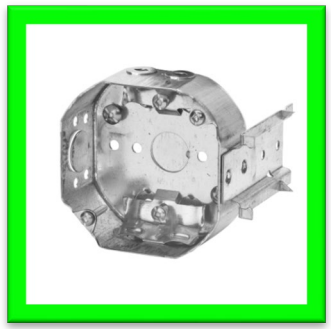
1. Review plans for box heights and locations
2. Mark studs out
3. Mount appropriate box type

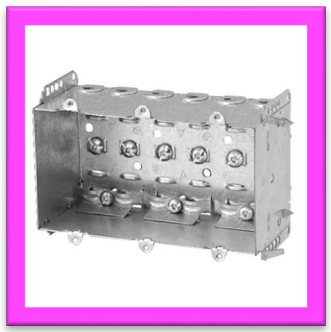


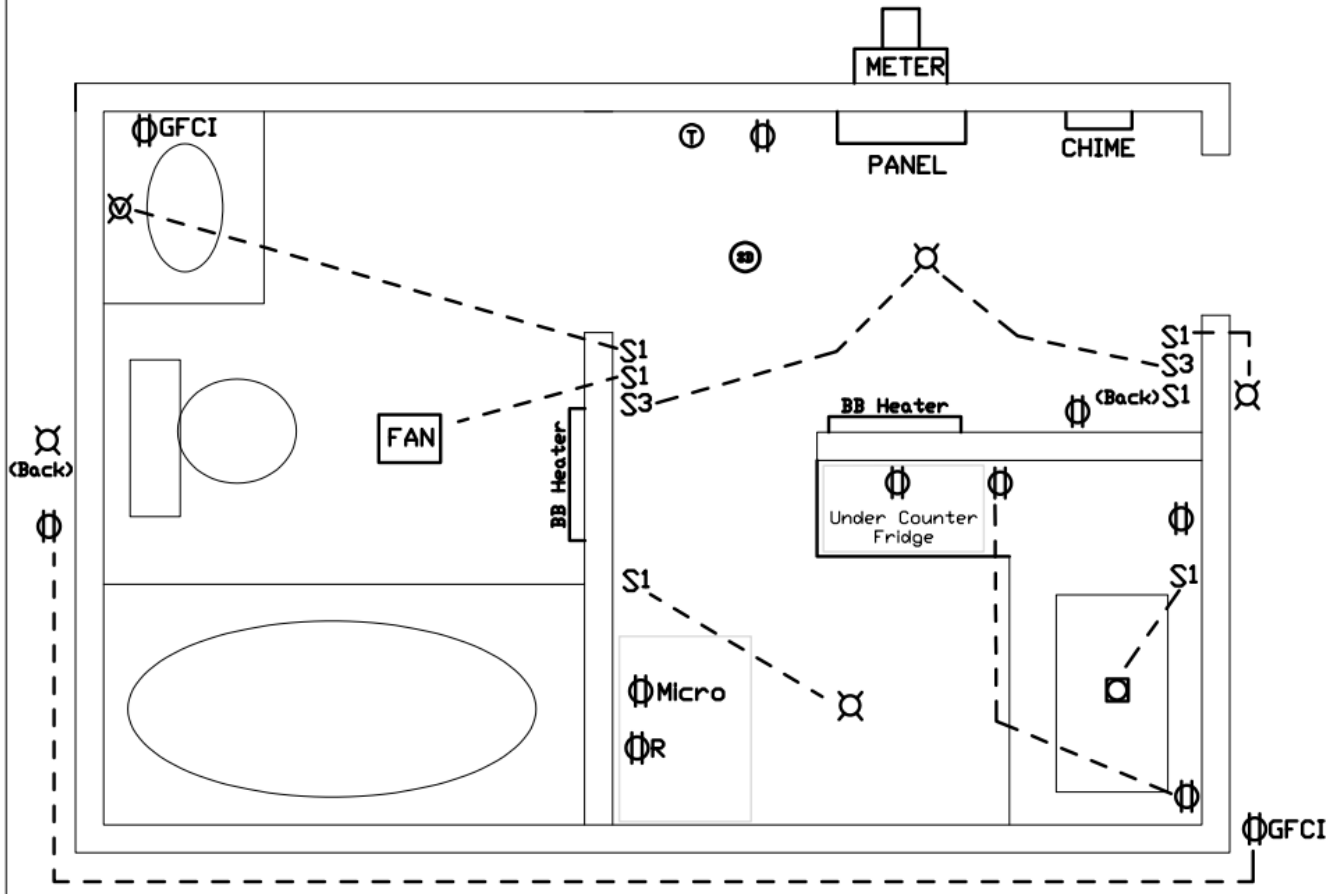
***Takes about 1.5 – 2.5 shop days**

Device Boxes









NOTES

All measurements to center of boxes

* Counter Plugs = 45.5"
* Switches = 48"
* Standard Plugs = 14"
* Microwave = 72"
* Vanity Light = 80"
* Range = Max 130mm to Center 26-744(6)
* Smoke Detector Interlocked with crawlspace SD

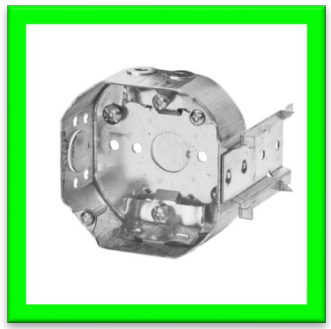
LEGEND

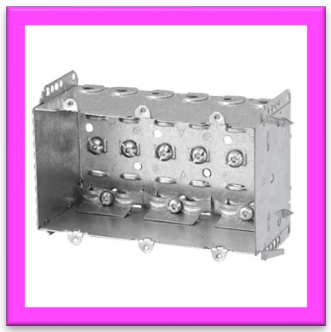
Single Switch.... S1
3 Way Switch.. S3
Receptacle.....
Light.....
Vanity Light....
Range.....R
Pot Light.....
Thermostat.....
Smoke Detector

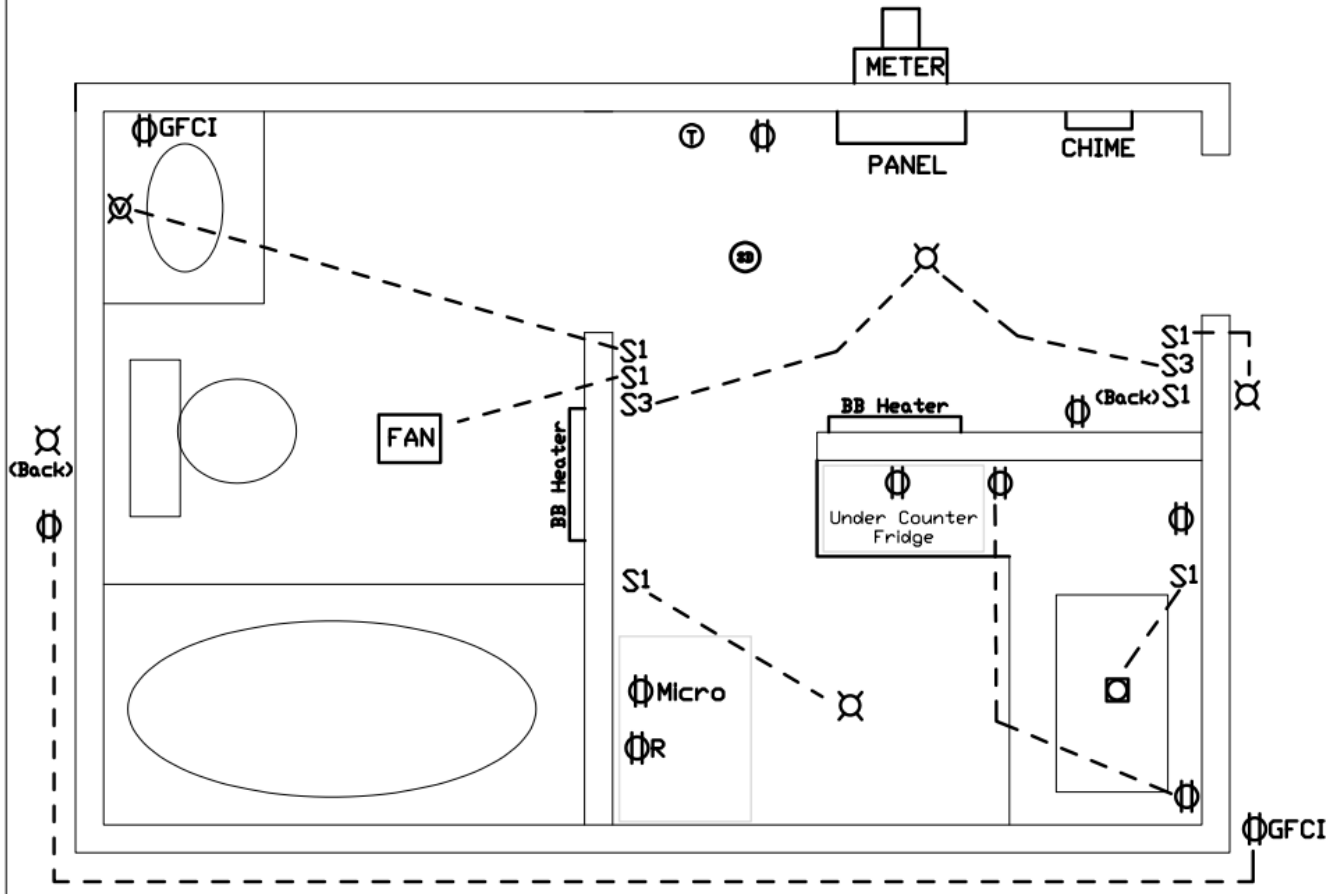
Device locations may need to be modified to suit your layout

NORKAM SHED ELECTRICAL LAYOUT - MAIN FLOOR

Range Equipment







NOTES

All measurements to center of boxes

* Counter Plugs = 45.5"
* Switches = 48"
* Standard Plugs = 14"
* Microwave = 72"
* Vanity Light = 80"
* Range = Max 130mm to Center 26-744(6)
* Smoke Detector Interlocked with crawlspace SD

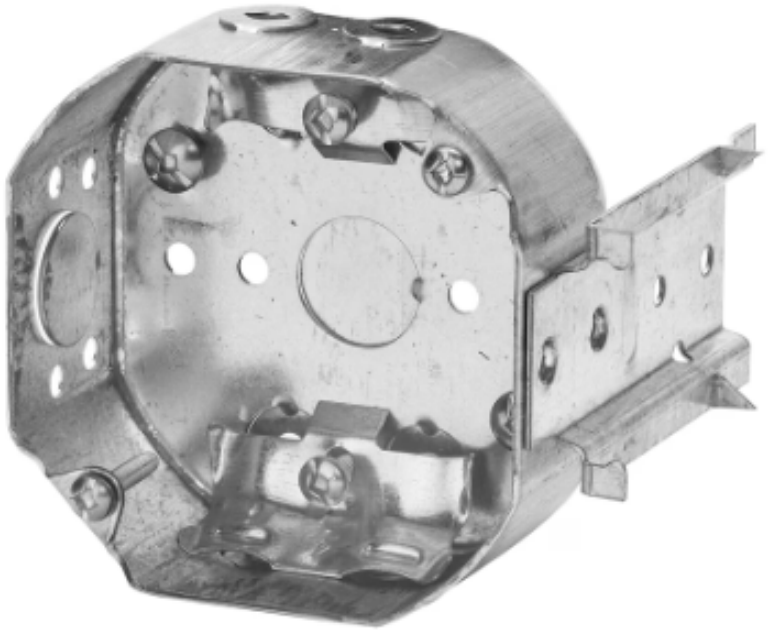
LEGEND

Single Switch.... S1
3 Way Switch.. S3
Receptacle.....
Light.....
Vanity Light....
Range.....R
Pot Light.....
Thermostat.....
Smoke Detector

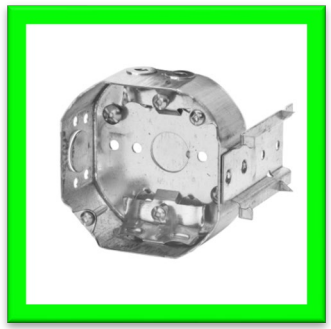
Device locations may need to be modified to suit your layout

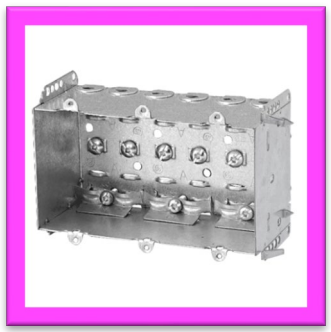
NORKAM SHED ELECTRICAL LAYOUT - MAIN FLOOR

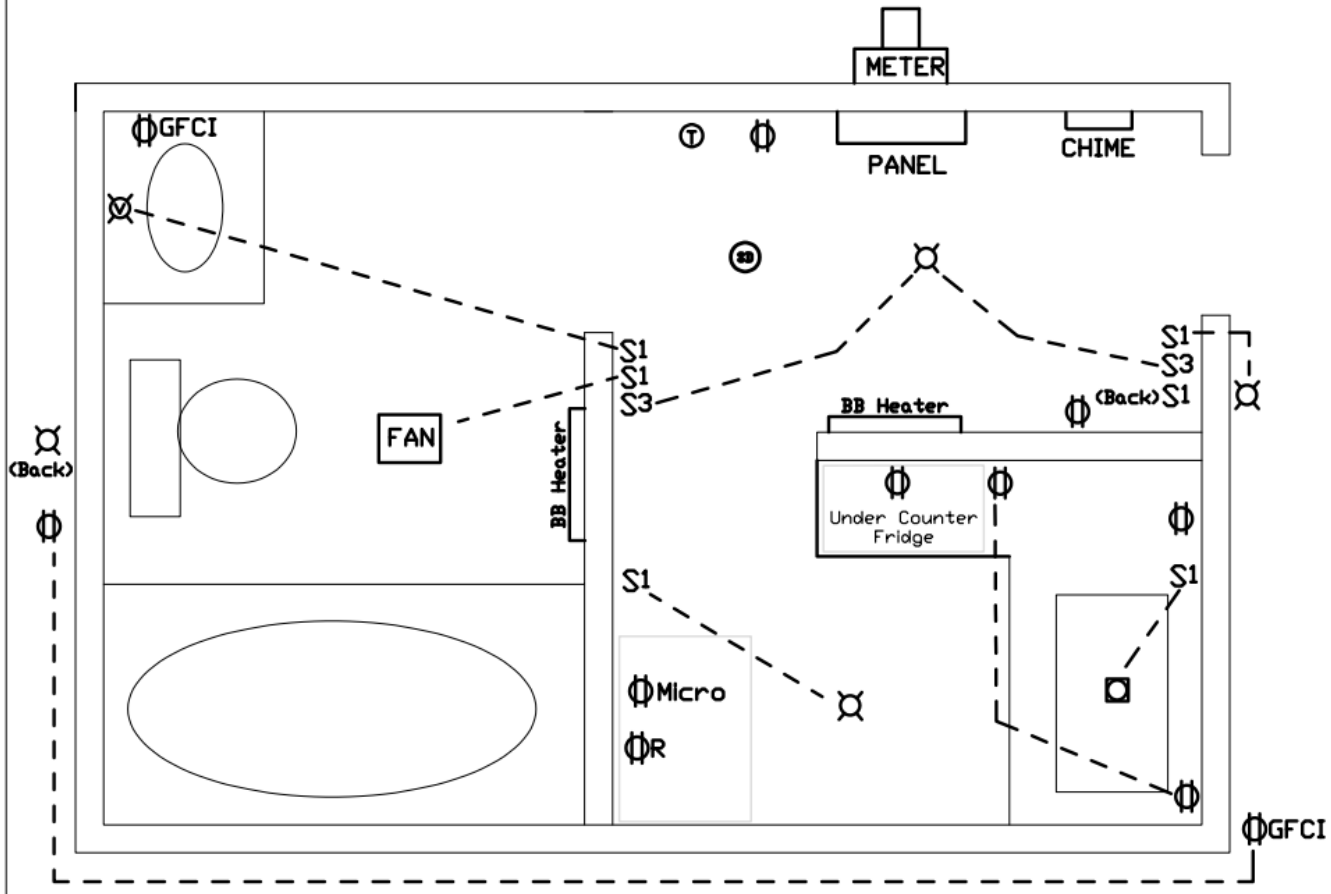
Octagon / Round Boxes



Doorbell Components







NOTES

All measurements to center of boxes

* Counter Plugs = 45.5"
* Switches = 48"
* Standard Plugs = 14"
* Microwave = 72"
* Vanity Light = 80"
* Range = Max 130mm to Center 26-744(6)
* Smoke Detector Interlocked with crawlspace SD

LEGEND

Single Switch.... S1
3 Way Switch.. S3
Receptacle.....
Light.....
Vanity Light....
Range.....R
Pot Light.....
Thermostat.....
Smoke Detector

Device locations may need to be modified to suit your layout

NORKAM SHED ELECTRICAL LAYOUT - MAIN FLOOR

Service Equipment

Heating Equipment

Recessed Lighting and Bathroom Fan

Installation of boxes, cabinets, outlets, and terminal fittings

12-3000 Outlet boxes (see Appendix B)

1) A box or an equivalent device shall be installed at every point of outlet, switch, or junction of conduit, raceways, armoured cable, or non-metallic-sheathed cable.
2) Non-metallic outlet boxes shall not be used in wiring methods using metal raceways or armoured or metal-sheathed cable, except where the boxes are provided with bonding connections between all cable entry openings.
3) Where metal fittings are used to terminate a non-metallic wiring method to a non-metallic outlet box, the metal fittings shall be bonded to ground.
4) Metal boxes embedded in parking lot slabs or pavement, road beds, and similar areas subject to vehicular traffic shall comply with the requirements of Rule 2-116 1).
5) The box shall be provided with a cover or luminaire canopy.
6) At least 150 mm of free insulated conductor shall be left at each outlet for making of joints or the connection of electrical equipment, unless the insulated conductors are intended to loop through lampholders, receptacles, or similar devices without joints.
7) Notwithstanding the requirements of Subrule 1), an outlet box shall not be required where provision for connection is integral to the equipment.
8) Notwithstanding the requirements of Subrule 1), an outlet box shall not be required for a switch or a receptacle conforming to Rule 12-3010 7).
9) Where a pendant ceiling fan and all possible accessories weigh less than 16 kg and are intended to be supported by a ceiling outlet box, the outlet box shall be marked for fan support.
10) Floor boxes shall be installed in accordance with the manufacturer's installation instructions for the type of floor intended.

12-3010 Outlet box supports (see Appendix B)

1) Except as permitted by Subrule 6), boxes and fittings shall be firmly secured to studs, joists, or similar fixed structural units other than wooden, metal, or composition lath, in accordance with this Rule.
2) Where ganged sectional boxes are used, they shall be secured to metal supports or to wooden boards at least 19 mm thick that are rigidly secured to the structural units.
3) Where boxes having any dimension greater than 100 mm are used, they shall be secured on at least two sides or shall be secured to metal supports or to wooden boards at least 19 mm thick that are rigidly secured to the structural units.
4) Where boxes are mounted on metal studs, additional support shall be provided to prevent movement of the box after the drywall is installed.
5) Mounting nails or screws shall not project into nor pass through the interior of an outlet box unless
   a) the nails or screws are located so as not to be more than 6.4 mm from the back or ends of the box; and
   b) the nails or screws are located so that they will not interfere with insulated conductors or connectors.
6) This Rule shall not apply to boxes and fittings installed after the studs, joists, or structural units have been concealed.
7) This Rule shall not apply to a switch or a receptacle with an integral enclosure for use with non-metallic-sheathed cable and having brackets that securely fasten the integral enclosure to walls or ceilings of conventional construction.
8) Where a ceiling outlet box marked for fan support is installed, the outlet box shall be
   a) securely attached directly to the building structure; or
   b) attached by a bar hanger securely attached directly to the building structure.
9) A pendant ceiling fan and all possible accessories weighing 16 kg or more shall be supported independently of the outlet box.

12-3014 Accessibility of junction boxes

1) Pull-in, junction, and outlet boxes, cabinets and gutters, and joints in conductors and cables shall be accessible.
2) A vertical space of 900 mm or more shall be required to provide ready access.

12-3016 Outlet boxes, cabinets, and fittings (see Appendix B)

1) The front edges of boxes, cabinets, and fittings installed in walls or ceilings shall not be set in more than 6 mm from the finished surface and, where the walls or ceilings are of wood or other combustible material, shall be flush with the finished surface or shall project from the surface.
2) Gaps or open spaces in plaster surfaces of walls or ceilings shall be filled in around the front edges of boxes, cabinets, and fittings.
3) Outlet boxes requiring wet location cover plates shall be installed in a manner that the intended seal between the outlet box and the cover is ensured.
4) Flush boxes, cabinets, and fittings shall be of a type suitable for the intended location of installation.

12-3024 Unused openings in boxes, cabinets, and fittings

Unused openings in boxes, cabinets, and fittings shall be effectively closed by plugs or plates affording protection substantially equivalent to that of the wall of the box, cabinet, or fitting.

12-3032 Wiring space in enclosures (see Appendix B)

1) Enclosures for overcurrent devices, controllers, and externally operated switches shall not be used as junction boxes, troughs, or raceways for insulated conductors feeding through to other apparatus.
2) Notwithstanding Subrule 1),
   a) enclosures for overcurrent devices, controllers, and externally operated switches shall be permitted to be used as junction boxes
      i) for all installations where a single feeder supplying another enclosure is tapped from it and the connectors used each provide an independent clamping means for each

Other considerations

Panelboards

26-600 Location of panelboards (see Appendices B and G)

1) Panelboards shall not be located in coal bins, clothes closets, bathrooms, stairways, rooms or spaces with high ambient temperatures, dangerous locations, nor in any similar undesirable places.
2) Panelboards in dwelling units shall be installed as high as possible, with no overcurrent device operating handle positioned more than 1.7 m above the finished floor level.

26-602 Panelboards in dwelling units (see Appendix B)

1) A panelboard shall be installed in every dwelling unit except for
   a) dwelling units in hotels and motels; and
   b) dwelling units that have been created by subdivision of a single dwelling and are not individually metered for electrical power consumption.
2) Every panelboard installed in accordance with Subrule 1) shall have a single supply protected by overcurrent devices, and this supply shall be capable of being disconnected without disconnecting the supply to any other dwelling unit.

Other considerations we will ignore this time

Rule 12-3000

Sealing around outlet boxes and cables to provide an air barrier may be required. Requirements for air and vapour barriers are in the *National Building Code of Canada*, Subsections 9.25.3 and 9.25.4.

VIDEO

Schulerruler. (October 27, 2020)

Sizing an electrical box. YouTube.

https://www.youtube.com/watch?v=F9Mm1ISYrkk

12-3034 Maximum number of insulated conductors in a box (see Appendix B)

1) Boxes shall be of sufficient size to provide usable space for all insulated conductors contained in the box, subject to the following:
   a) an insulated conductor running through a box with no connection therein shall be considered as one insulated conductor;
   b) each insulated conductor entering or leaving a box and connected to a terminal or connector within the box shall be considered as one insulated conductor;
   c) an insulated conductor of which no part leaves the box shall not be counted; and
   d) No. 18 and No. 16 AWG fixture-wires supplying a luminaire mounted on the box containing the fixture-wires shall not be counted.
2) Except as specified in Subrule 3) and subject to the details given in Subrule 1), boxes of the nominal dimensions given in Table 23 shall not contain more insulated conductors of a given size than permitted by the Table, and the number of conductors shall be reduced for each of the following conditions as applicable:
   a) one insulated conductor, of the largest size in the box, for each fixture stud or hickey within the box;
   b) one insulated conductor, of the largest size terminated under the conductor connector, for every pair of conductor connectors with insulating caps; and
   c) two insulated conductors for each flush-mounted device on a single strap within the box.
3) Where a box contains a device having a dimension greater than 2.54 cm between the mounting strap and the back of the device, the total usable space shall be reduced by the space occupied by the device, calculated as 32 cm^3 multiplied by the depth of the device in centimetres.

4) Subject to the details given in Subrules 1) and 3), boxes having nominal dimensions or volume other than those shown in Table 23, or any box containing insulated conductors of different sizes, shall have the amount of usable space per insulated conductor as specified in Table 22, but the number of insulated conductors so calculated shall be reduced for each of the conditions of Subrule 2) as applicable with the exception of Subrule 2) b), provided that such exception is based on the size of the largest insulated conductor that is included with every pair of conductor connectors.

5) The total usable space in a box considered under Table 22 shall be considered to be the internal volume of the box and shall disregard any space occupied by locknuts, bushings, box connectors, or clamps.

6) Where sectional boxes are ganged, or where plaster rings, extension rings, or raised covers are used in conjunction with boxes, ganged or otherwise, and are marked with their volume measurement, the space in the box shall be the total volume of the assembled sections.

Table 23
Number of insulated conductors in boxes

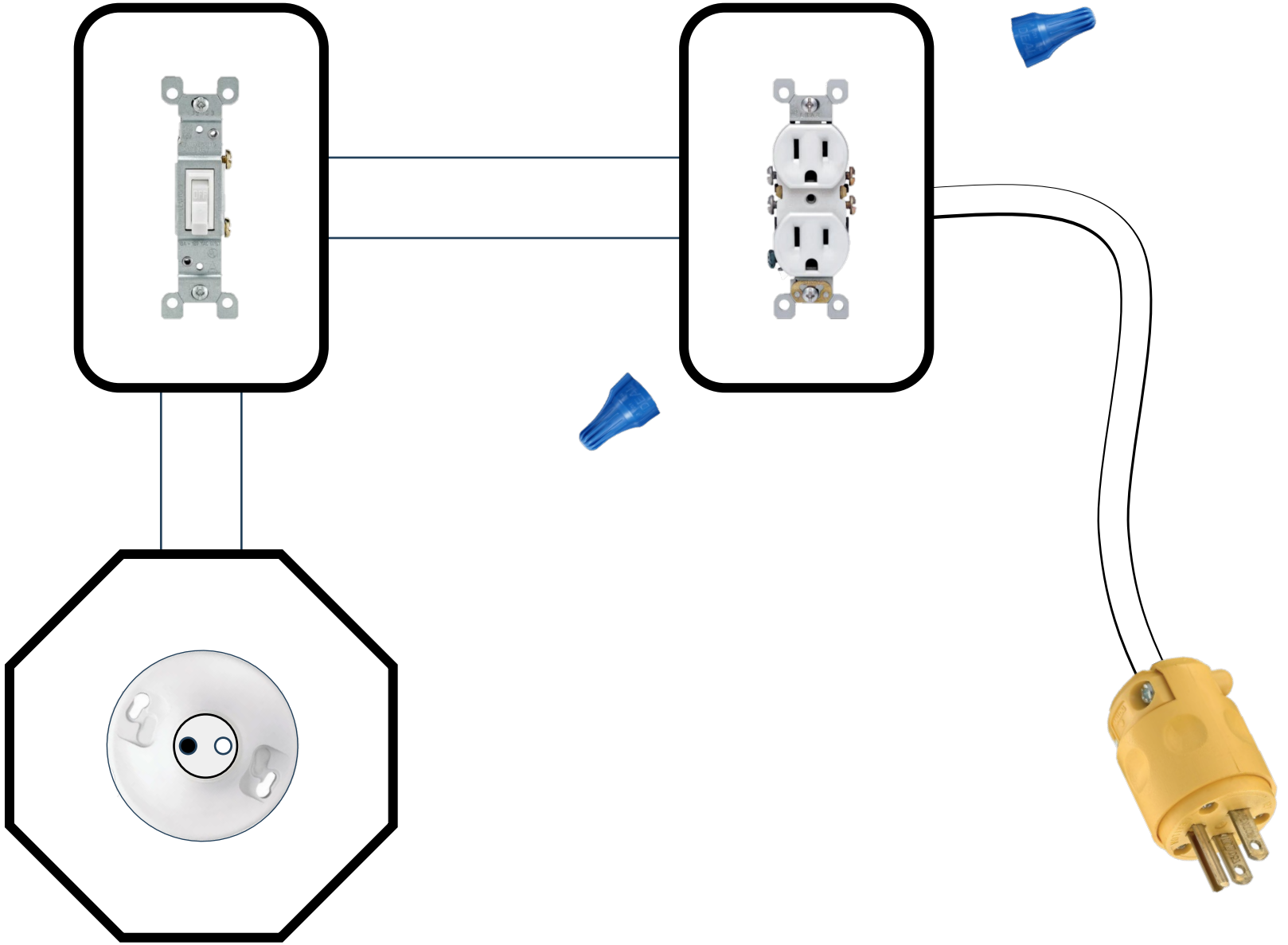
(See Rule 12-3034.)

Box dimensions trade size		Capacity, mL (in³)	Maximum number of conductors (per AWG size)				
			14	12	10	8	6
Octagonal	4 × 1-1/2	245 (15)	10	8	6	5	3
	4 × 2-1/8	344 (21)	14	12	9	7	4
Square	4 × 1-1/2	344 (21)	14	12	9	7	4
	4 × 2-1/8	491 (30)	20	17	13	10	6
	4-11/16 × 1-1/2	491 (30)	20	17	13	10	6
	4-11/16 × 2-1/8	688 (42)	28	24	18	15	9
Round	4 × 1/2	81 (5)	3	2	2	1	1
Device	3 × 2 × 1-1/2	131 (8)	5	4	3	2	1
	3 × 2 × 2	163 (10)	6	5	4	3	2
	3 × 2 × 2-1/4	163 (10)	6	5	4	3	2
	3 × 2 × 2-1/2	204 (12.5)	8	7	5	4	2
	3 × 2 × 3	245 (15)	10	8	6	5	3
	4 × 2 × 1-1/2	147 (9)	6	5	4	3	2
	4 × 2-1/8 × 1-7/8	229 (14)	9	8	6	5	3
	4 × 2-3/8 × 1-7/8	262 (16)	10	9	7	5	3

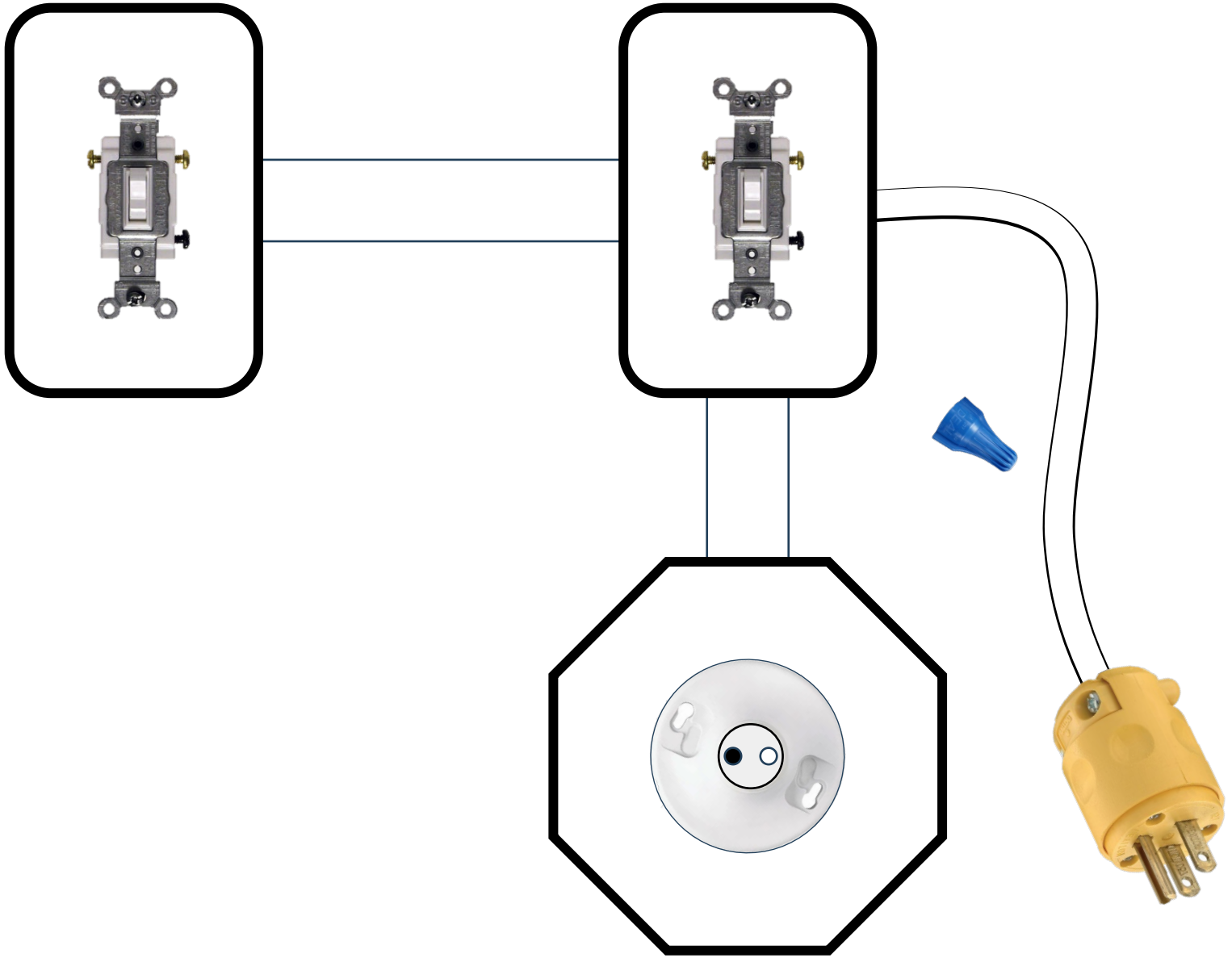
Table 22
Space for insulated conductors in boxes
(See Rule 12-3034.)

Size of conductor, AWG	Usable space required for each insulated conductor, mL
14	24.6
12	28.7
10	36.9
8	45.1
6	73.7

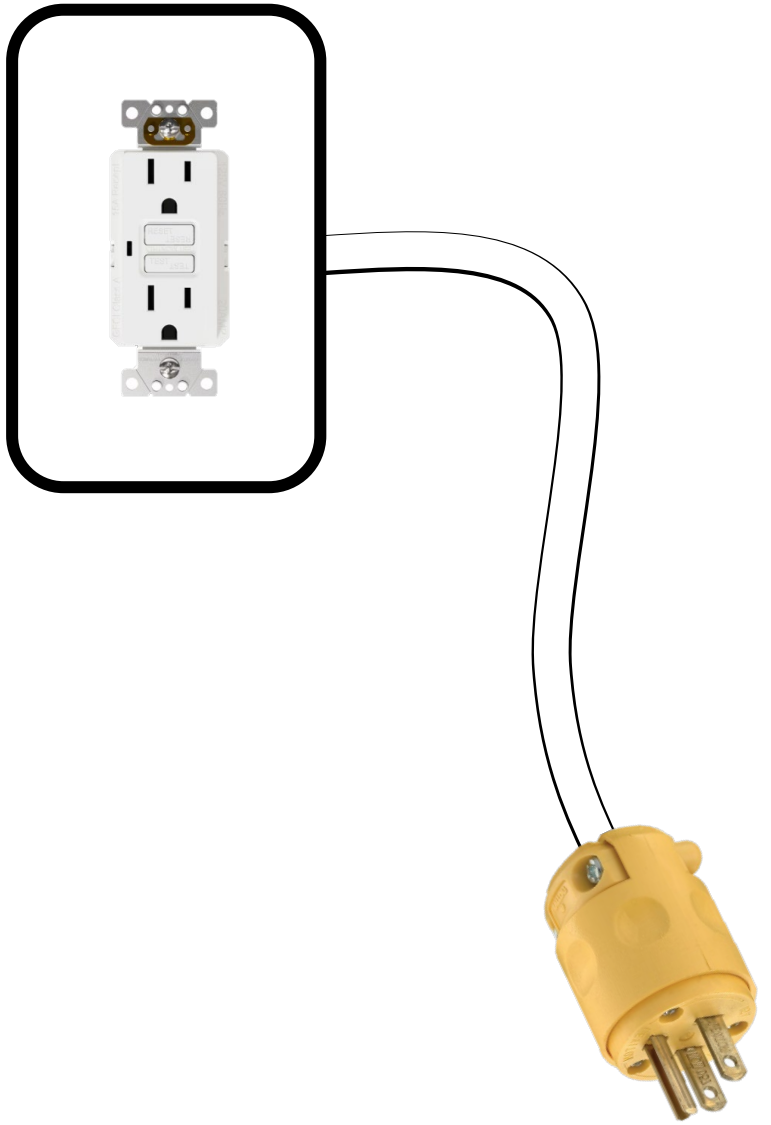
Board Example 1



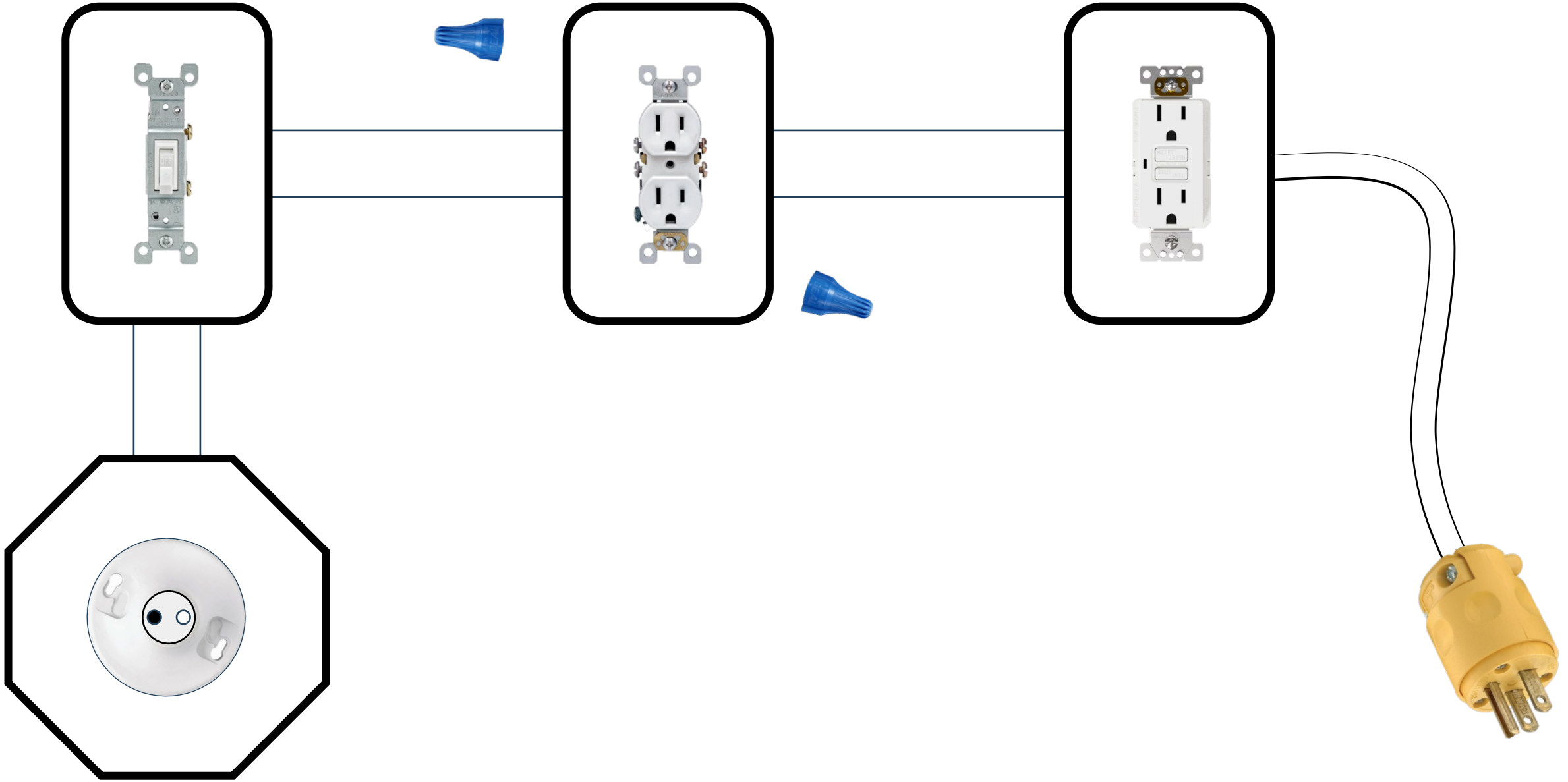
Board Example 2



Board Example 3



Board Example 4



C.1 Box Fill

VIDEO

Engineering Mindset. (May 24, 2019)

Ground Neutral and Hot Wires Explained. YouTube.

https://www.youtube.com/watch?v=P-W42tk-fWc&t=129s

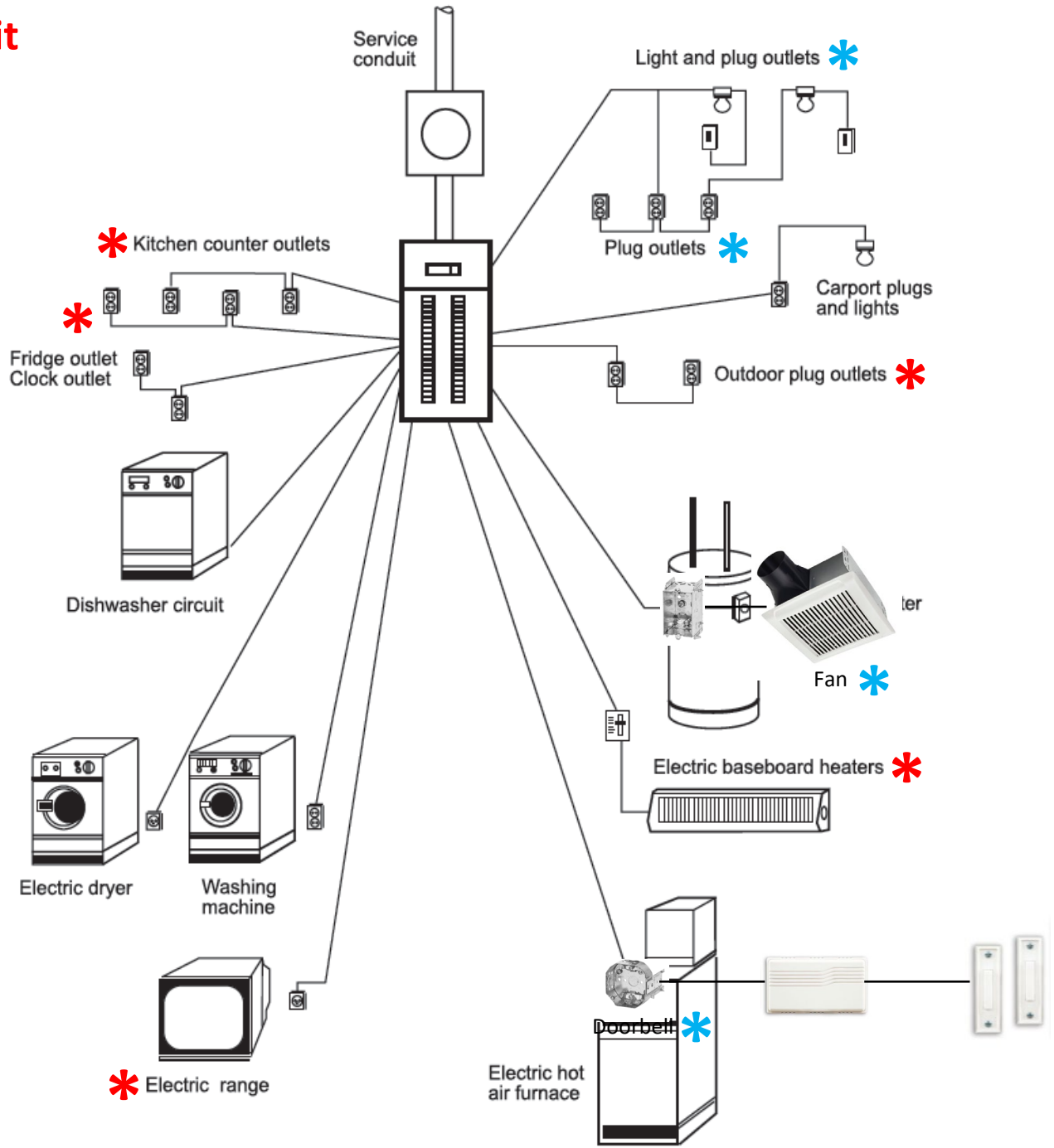
Phase 2 – Run cable to all boxes

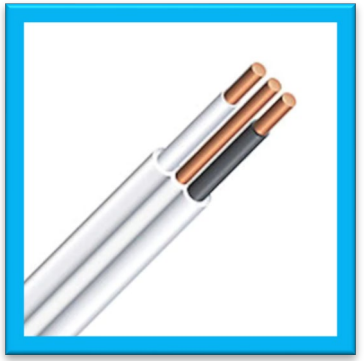
1. Plan out individual branch circuits (wire size and code requirements)
2. Drill holes (2 wires per ¾” hole)
3. Run cabling between boxes with 12-15” of extra cable at each box to account for loop and 8” of wire inside box.
4. Any wires run back to the panel should be run with enough length to reach anywhere in the panel

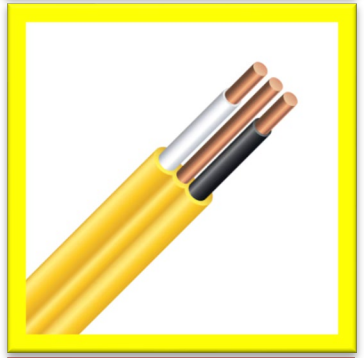
***Takes about 3 – 4 shop days (Guesstimate)**

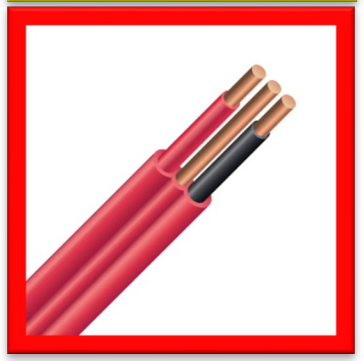
* Dedicated circuit

* General circuit



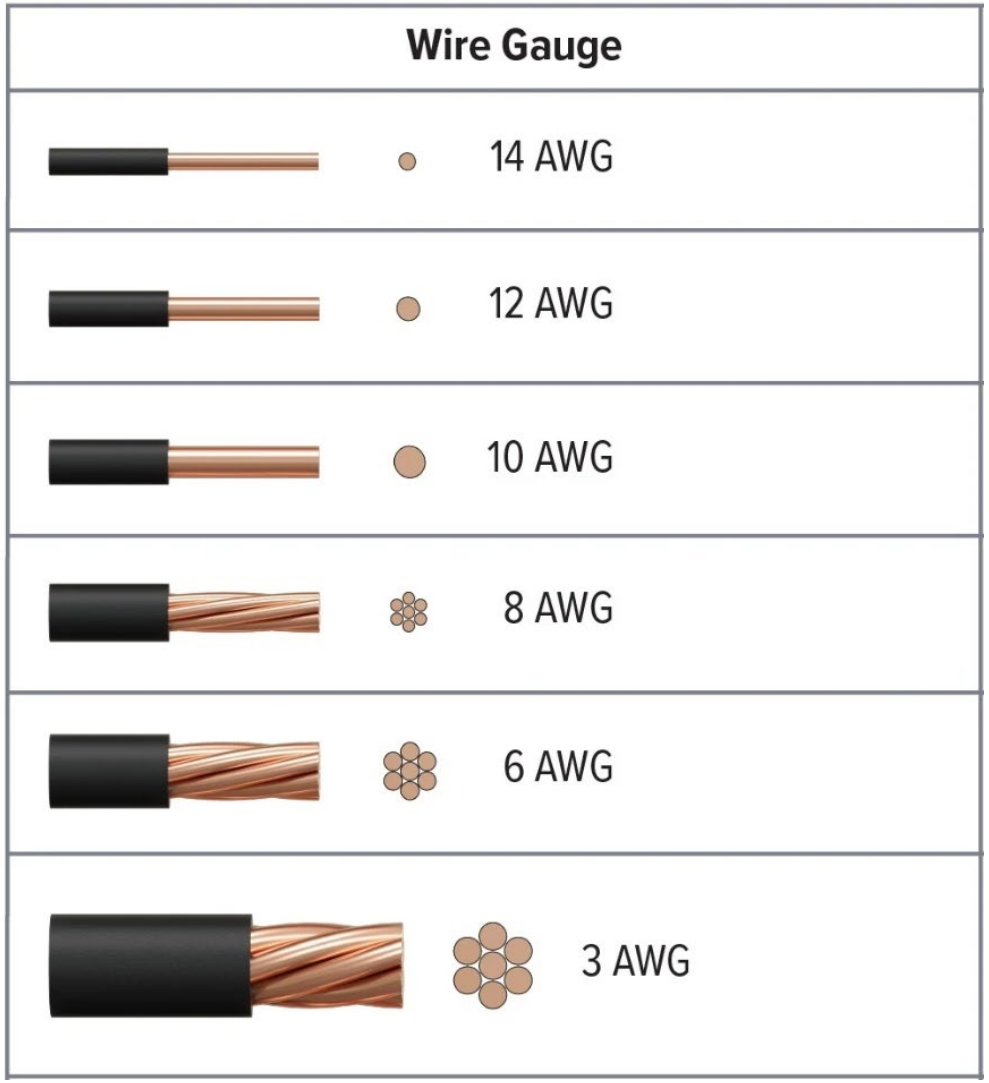






Doorbell Components

Code Considerations – Wire Ampacities



Code Considerations – Wire Ampacities

Table 2

Ampacities for not more than three insulated copper conductors, rated not more than 5000 V and unshielded, in raceway or cable (based on an ambient temperature of 30 °C*)

(See Rules 4-004, 26-142, 42-008, and 42-016, and Tables 5A, 5C, 19, and D3.)

Size, AWG or kcmil	Ampacity†,††					
	60 °C‡	75 °C‡	90 °C‡**	110 °C‡ See Note	125 °C‡ See Note	200 °C‡ See Note
14§	15	20	25	25	30	35
12§	20	25	30	30	35	40
10§	30	35	40	45	45	60
8	40	50	55	65	65	80
6	55	65	75	80	90	110
4	70	85	95	105	115	140
3	85	100	115	125	135	165
2	95	115	130	145	155	190
1	110	130	145	165	175	215
0	125	150	170	190	200	245
00	145	175	195	220	235	290
000	165	200	225	255	270	330
0000	195	230	260	290	310	380
250	215	255	290	320	345	—
300	240	285	320	360	385	—
350	260	310	350	390	420	—
400	280	335	380	425	450	—
500	320	380	430	480	510	—

Table 4

Ampacities for not more than three insulated aluminum conductors, rated not more than 5000 V and unshielded, in raceway or cable (based on an ambient temperature of 30 °C*)

(See Rules 4-004, 26-142, 42-008, and 42-016, and Tables 5A and 5C.)

Size, AWG or kcmil	Ampacity†,§					
	60 °C‡	75 °C‡	90 °C‡	110 °C‡ See Note	125 °C‡ See Note	200 °C‡ See Note
12**	15	20	25	25	25	35
10**	25	30	35	40	40	50
8	35	40	45	50	55	65
6	40	50	55	65	70	80
4	55	65	75	80	90	105
3	65	75	85	95	100	125
2	75	90	100	115	120	150
1	85	100	115	125	135	165
0	100	120	135	150	160	195
00	115	135	150	170	180	220
000	130	155	175	195	210	255
0000	150	180	205	225	245	295
250	170	205	230	260	275	—
300	195	230	260	290	310	—
350	210	250	280	315	335	—
400	225	270	305	340	365	—
500	260	310	350	390	420	—

Code Considerations – However…

14-104 Rating of overcurrent devices (see Appendix B)

1) The rating or setting of overcurrent devices shall not exceed the ampacity of the conductors that they protect, except
   a) where a fuse or circuit breaker having a rating or setting of the same value as the ampacity of the conductor is not available, and the maximum calculated or known load is in accordance with the Rules of Section 8, the ratings or settings given in Table 13 shall be permitted to be used within the maximum value of 800 A;
   b) in the case of equipment wire, flexible cord in sizes Nos. 16, 18, and 20 AWG copper, and tinsel cord, which are considered protected by 15 A or 20 A overcurrent devices; or
   c) as provided for by other Rules of this Code.
2) Except as provided for by Subrule 1) c), the rating of overcurrent protection shall not exceed
   a) 15 A for No. 14 AWG copper conductors;
   b) 20 A for No. 12 AWG copper conductors;
   c) 30 A for No. 10 AWG copper conductors;
   d) 15 A for No. 12 AWG aluminum conductors; and
   e) 25 A for No. 10 AWG aluminum conductors.

Code Considerations

12-3000 Outlet boxes (see Appendix B)

1) A box or an equivalent device shall be installed at every point of outlet, switch, or junction of conduit, raceways, armoured cable, or non-metallic-sheathed cable.
2) Non-metallic outlet boxes shall not be used in wiring methods using metal raceways or armoured or metal-sheathed cable, except where the boxes are provided with bonding connections between all cable entry openings.
3) Where metal fittings are used to terminate a non-metallic wiring method to a non-metallic outlet box, the metal fittings shall be bonded to ground.
4) Metal boxes embedded in parking lot slabs or pavement, road beds, and similar areas subject to vehicular traffic shall comply with the requirements of Rule 2-116 1).
5) The box shall be provided with a cover or luminaire canopy.
6) At least 150 mm of free insulated conductor shall be left at each outlet for making of joints or the connection of electrical equipment, unless the insulated conductors are intended to loop through lampholders, receptacles, or similar devices without joints.
7) Notwithstanding the requirements of Subrule 1), an outlet box shall not be required where provision for connection is integral to the equipment.
8) Notwithstanding the requirements of Subrule 1), an outlet box shall not be required for a switch or a receptacle conforming to Rule 12-3010 7).
9) Where a pendant ceiling fan and all possible accessories weigh less than 16 kg and are intended to be supported by a ceiling outlet box, the outlet box shall be marked for fan support.
10) Floor boxes shall be installed in accordance with the manufacturer's installation instructions for the type of floor intended.

Non-metallic-sheathed cable Types NMD90 and NMWU

12-550 Rules for cable Types NMD90 and NMWU (see Appendix B)
Rules 12-552 to 12-576 apply only to cable Types NMD90 and NMWU.

C.2 Non-metallic Sheathed Cable

What rules can you find?

VIDEO

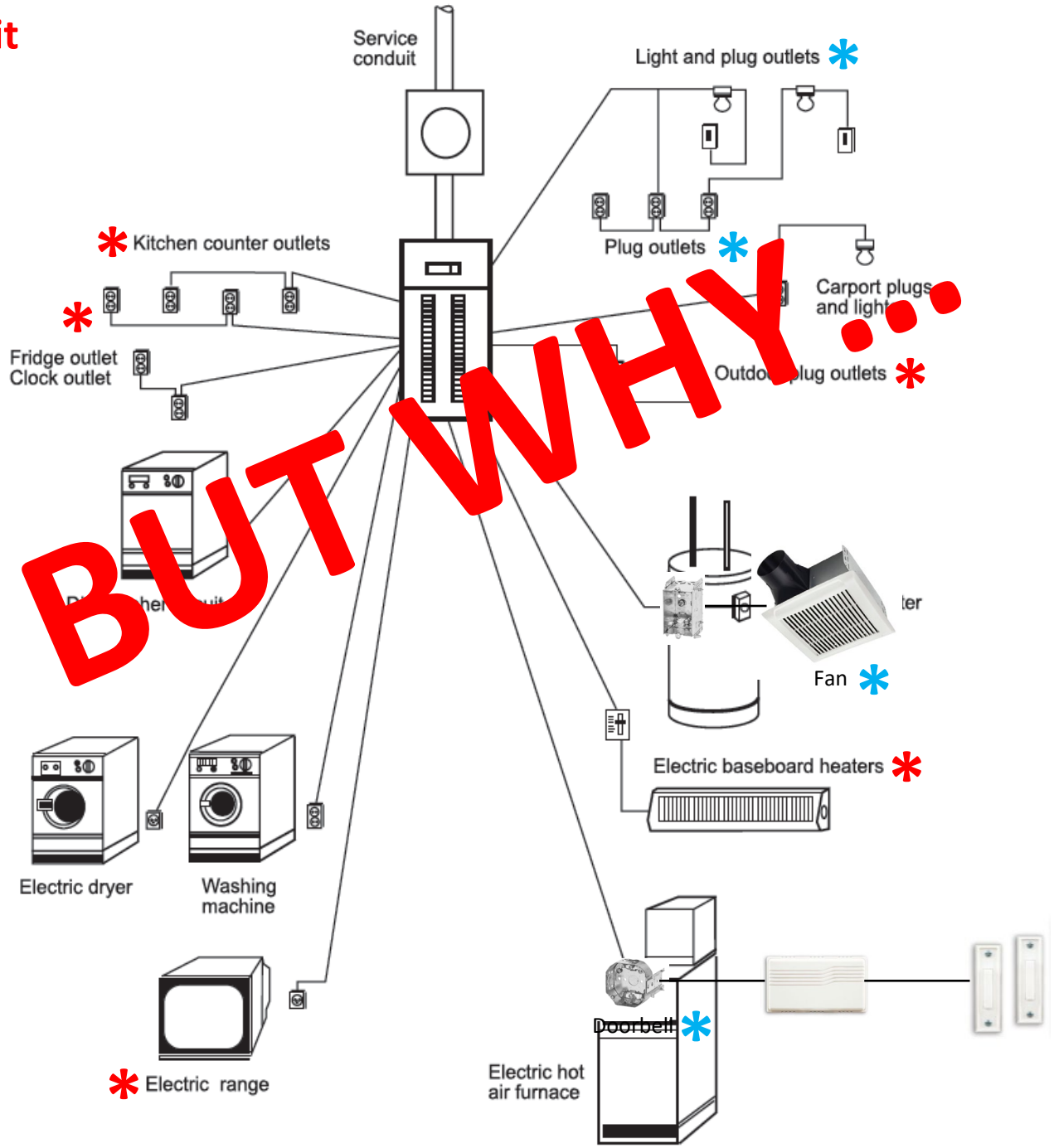
Electrical Safety Foundation International. (April 15, 2010)

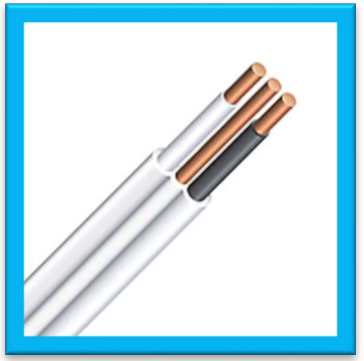
Arc Fault Circuit Interrupter (AFCI) Virtual Demonstration. YouTube.

https://www.youtube.com/watch?v=C-SBly_2bPQ

* Dedicated circuit

* General circuit





C.3 Branch Circuits

What rules can you find?

Phase 3 – Cut in boxes and prep for devices

1. Provide service loop at each box location
2. Strip back enough cable sheath to have 8” of wire inside your box (6” of **insulated** wire is absolute minimum)
3. Bond every box
4. Make any splices/pigtails needed at each location
5. Pack all wires to the back of the box

Code Considerations

- 12 – 3000 (6)
- 12 - 3010 (3)

12-110 Radii of bends in insulated conductors and cables

The radii of bends in insulated conductors and cables shall be sufficiently large to ensure that no damage is done to the conductors or cables or to their insulation, covering, or sheathing.

12-112 Conductor joints and splices (see Appendix B)

1) Conductors shall be spliced or joined with splicing devices or by brazing, welding, or soldering with a fusible metal or alloy.
2) Soldered splices shall first be spliced or joined so as to be mechanically and electrically secure without solder and then be soldered.
3) Joints or splices shall be covered with an insulation equivalent to that on the conductors being joined.
4) Joints or splices in conductors and cables shall be accessible.

12-114 Ends of insulated conductors

When the ends of insulated conductors at switches, outlets, and in similar places are not in use, they shall be insulated in the manner prescribed for joints and splices.

12-116 Termination of conductors (see Appendix B)

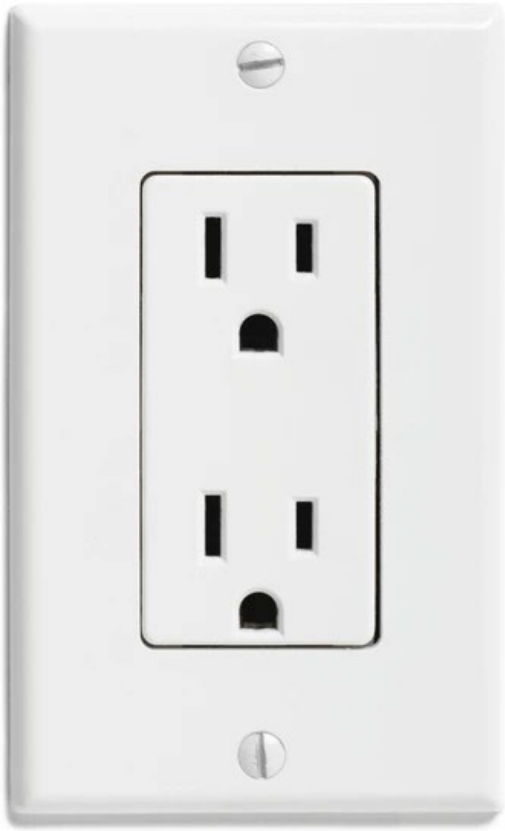
1) Connection of conductors to terminal parts shall be made by means of pressure connectors, solder lugs, or splices to flexible leads.
2) The portion of stranded conductors to be held by binding-screw terminals or solderless wire connectors shall have the strands confined so that there will be no stray strands to cause either short-circuits or grounds.

1.4 Receptacles?

What rules can you find?

Phase 4 – Mount devices and fixtures

1. Determine appropriate device to be mounted at each box location
2. Strip wire, making hooks where needed, and terminate devices
3. Level and mount all devices
4. Install appropriate cover plates



Add slide for different types of devices, etc.

- 15A rec
- 20A rec
- 15 switch single pole
- Etc.

Code Considerations

1.5 Diagrams / Services?

What rules can you find?