

`Electrical Technology

Basic Electrical Shop EEL 1112

Revised 2/11

Job #1

Tapping and Drilling Metal

Objective:

Given the layout diagram, material, and proper tools, the student will construct a drill and tap gauge, as evidenced by scoring a minimum of 75% as a grade for the project.

Materials provided by the student	Materials provided by the department
Hammer	1½" x 6" Aluminum stock
Center punch	Number/Letter punches
Ruler & Straight edge	Drill Bits & Drill Press
Necessary Taps and handles	
Flat metal file (i.e., bastard file)	

Information:

Twist Drills

Twist drills are "end" cutting tools used to produce holes in most types of material. On standard drills, two helical grooves, or flutes, are cut lengthwise around the body of the drill. They provide cutting edges and space for the cuttings to escape in the drilling process. Most twist drills used today are made of high-speed steel. High-speed drills are always stamped with the letters "H.S." or "H.S.S." A drill bit is divided into three main parts: shank, body, and point.

Drills up to .5" in diameter have straight shanks, while those over this diameter usually have tapered shanks. Straight-shank drills are held in a drill chuck; tapered-shank drills fit into the internal taper of the drill press spindle.

The drill body is the portion of the drill between the shank and the point. It consists of a number of parts important to the efficiency of the cutting action.

1. The flutes are two or more helical grooves cut around the body of the drill. They form the cutting edges, admit cutting fluid, and allow the chips to escape from the hole.
2. The margin is the narrow, raised section on the body of the drill. It is immediately next to the flutes and extends along the entire length of the flutes. Its purpose is to provide a full size to the drill body and cutting edges.
3. The body clearance is the undercut portion of the body between the margin and the flutes. It is made smaller to reduce friction between the drill and the hole during the drilling operation.

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The point of a twist drill consists of the chisel edge, lips, lip clearance, and heel. The chisel edge is the chisel-shaped portion of the drill point. The lips (cutting edges) are formed by the intersection of the flutes. The lips must be of equal length and have the same angle so that the drill will run true and will not cut a hole larger than the size of the drill.

Drill sizes are designated under four systems: Fractional, Number, Letter, and Millimeter (metric) sizes.

The Fractional size drills range from 1/64" to 3.25" varying in steps of 1/64" from one size to the next.

The Number size drills range from #1, measuring 0.228" to the #97, which measure 0.0059".

The Letter size drills range from A to Z. Letter-A drill is the smallest in the set (.234") and Z is the largest (.413).

The Millimeter (metric) drills are produced in a variety of sizes. Miniature metric drills range from 0.04 to 0.09 mm in steps of 0.01 mm. Straight-shank standard metric drill are available in sizes from 0.5 to 20 mm. Taper-shank metric drills are manufactured in sizes from 8 up to 80 mm.

Taps

Taps are cutting tools used to cut *internal* threads inside of a drilled hole, whereas a Die cuts *external* threads on the outer surface of a rod. Taps are made from high-quality tool steel that has been hardened and ground.

NOTE: hardening of the metal results in a tool that is very brittle and is easily broken, especially when the Tap is NOT kept perpendicular to the metal being tapped and/or when the Tap is allowed "wobble" (even a very *small* amount of wobble will result in breakage). Depending on the size of the Tap, two, three or four flutes (grooves) are cut lengthwise *across* the threads to form cutting edges provide room for the chips, and to allow cutting fluid to be inserted for lubrication. The end of the shank is square so that a tap wrench can be used to turn the Tap into a hole. For inch Taps, the major diameter, number of threads per inch, and type of thread is usually found on the shank of a Tap.

For example: 6-32 UNC represents:

1. 6 = major diameter of the Tap.
2. 32 = number of threads per inch.
3. UNC = Unified National Coarse (a type of thread)

Hand Taps are usually made in sets of three: called *Taper*, *Plug*, and *Bottoming*.

A *Taper* Tap is tapered from the end. Approximately six threads are used to start a thread easily. It can be used for tapping a hole, which goes through the work, as well as starting a blind hole (a blind hole does not penetrate completely *through* the work).

A *Plug* Tap is tapered for approximately three threads. Sometime the Plug Tap is the only Tap used to thread a hole going through a piece of work.

A *Bottoming* Tap is not tapered but chamfered at the end of one thread. It is used for threading to the bottom of a blind hole. When tapping a blind hole, first use the Taper Tap, then the Plug Tap, and complete the hole with a Bottoming Tap.

Extreme care must be used when tapping a hole to prevent breakage (see the NOTE above). A broken tap in a hole is difficult (if not impossible) to remove and often results in scraping the work.

To tap a hole by hand:

1. Select the correct Tap and tap wrench for the job
2. Apply a suitable cutting fluid to the Tap
3. Place the Tap in the hole as vertically as possible (perpendicular), press downward on the wrench applying equal pressure on both handles, and turn clockwise for about two turns
4. Check the Tap to verify it is at the desired angle
5. When the Tap has been properly started, feed it into the hole by turning the tap wrench
6. Turn the Tap clockwise one-quarter turn and then turn it backward about ½ turn to break the chip. Repeat this process by using steady motion to prevent breakage
7. Once the Tap has exited the work, back the Tap out. Then *chase* the threads by running the Tap slowly all the way through the hole

The table below shows the correct size drill bit to use with the Taps common in the electrical field. This table gives the Number Drill and the **closest** usable Fractional Drill bit needed to do the job. The first choice is the Number Drill.

Tap Size	Number Drill	Fractional Drill
6-32	36	7/64
8-32	29	9/64
10-32	21	5/32
10-24	25	5/32
1/4-20	7	13/64

Types of Screws

Electricians must be familiar with the standard machine screws used with electrical devices, such as receptacles, switches, plates, boxes, and terminals. A terminal is the screw that is used to connect the conductor to the device.

Machine screws commonly used by the electrician are 6-32, 8-32, 10-24, 10-32, and the 1/4-20. The numbers have a specific designation. The first digit denotes the size as it is listed in the American Screw Gauge. The second and third digits indicate the number of threads per inch.

Example: 6-32; the number six (6) is the American Screw Gauge size; the second and third digits are the number thirty-two (32) which indicate there are 32-threads per inch cut into the shaft. It is important that the electrician be able to quickly identify *by sight* the various sizes of machine screws used.

A 6-32 screw is used to fasten electrical devices such as switches and receptacles to their outlet boxes. These boxes have their fastening holes tapped (threaded) to accept the 6-32 screw. Sizes 8-32 and 10-32 machine screws are used with fixture-mounting hardware and terminal screws. Sizes 10-24 and 1/4-20 are used with fastening other common electrical equipment such as beam clamps and covers.

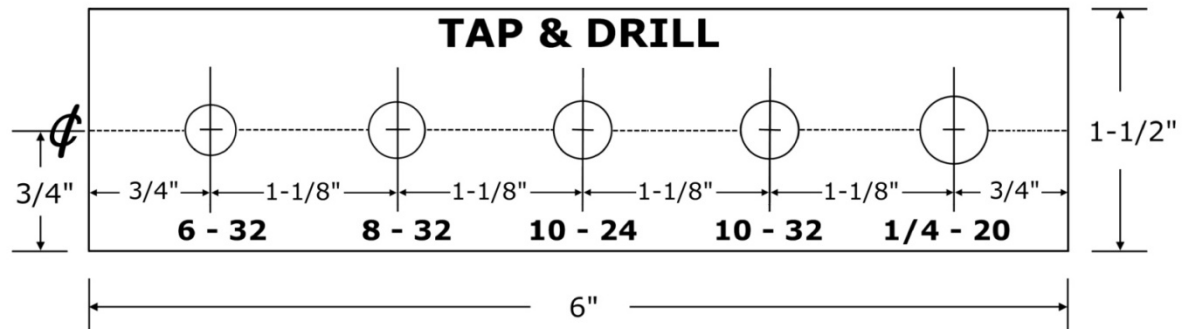
The types of machine screw heads are: Flat, Round, Oval, and Binder.

The *Flat head* screw is used to fasten the mounting ears of a switch or receptacle to its outlet box. The Flat head screw permits the decorative cover plate used with the device to make flush contact with the finished wall.

Binder head screws are used on electrical terminals to achieve a broader and better contact between the screw head and the wire to be fastened. The common *Round* head screw may be used in any situation where space is not a factor. By design, the Round head is a better screw to use where objects must be tightened to a maximum degree.

The threads on machine screws are rather fine and can be stripped if the newly made tapped hole is abused. The damaged threads will make it impossible to fully tighten it.

In the field, the tapped holes in electrical hardware are sometimes filled with plaster, concrete, or rust that has accumulated during construction. In these cases, the threads within the tapped hole must be chased (renewed) to accept the machine screw.



Procedure:

1. Using a piece of 1 1/2" x 6" aluminum stock (see diagram above), round the corners and smooth the edges using the flat file.
2. Using a pencil and straight edge, layout the aluminum to the specifications given on the diagram. The drawing on this page IS *very near* to scale; the dimensions are correct.
3. Center punch all drill locations using a hammer and center punch.
4. Using the drill press, drill all holes with specified drill bits as shown on the diagram.
5. Tap the bottom holes with tap specified on the diagram.
6. Use letter/number punches to stamp the words and numbers specified on the diagram. Stamp your name on the *back* of the project.
7. Clean your project and insert the proper screws into the tapped holes. (Do not tighten completely)
8. Turn your project in to the instructor for grading.

Job #1

Grading Sheet

Name _____ **Verified** by _____ Grade _____

- | | |
|---|-----------------|
| 1. Corners rounded, edges smooth | Yes / No |
| 2. Spacing of drilled holes is correct | Yes / No |
| 3. Holes tapped to diagram specifications | Yes / No |
| 4. Threads are square (perpendicular to surface) | Yes / No |
| 5. Screws can be threaded in by hand | Yes / No |
| 6. Words/numbers stamped to diagram specifications | Yes / No |
| 7. Letters/numbers are double struck | Yes / No |
| 8. The overall appearance of project is in a neat and workman like manner | Yes / No |

Instructor Comments:

Job #2

Splicing and Terminating Conductors

Name _____ Verified by _____ Grade _____

Objectives:

1. Splice conductors using a mechanical connector.
2. Splice conductors using wire nut connectors.
3. Splice grounding conductors using the "Greenie" wire nut.
4. Terminate conductors using a crimp connector.
5. Terminate conductors on a device screw.

Materials:

Provided by the student	Provided by the department
1. Splicing Kit	1. Scotch-Loc Connector
2. Necessary tools	2. Wire

Directions:

Obtain the necessary materials from the Instructor. Complete all five sections before having the Instructor check your work.

1. Mechanical Splice Connector Checked by: _____

- A. Scotch-Loc, 14AWG *stranded*, 14AWG *solid*
- B. Split-Bolt, 6AWG *stranded*

2. Wire Nut Splice Connectors Checked by: _____

- A. Two 14 AWG *solid*
- B. Three 14AWG *solid*
- C. Two 12AWG *stranded*
- D. One 18AWG *stranded* one 14AWG *solid*

3. Grounding Pigtail ("Greenie" Wire Nut) Checked by: _____

- A. One 14AWG bare *solid* (through the hole); two 14AWG *solid* green (pigtail)

4. Crimp Termination Checked by: _____

- A. One 14AWG *solid* conductor – Insulated Termination
- B. One 14AWG *solid* conductor – Non-Insulated Termination

5. Screw-type Termination Checked by: _____

- A. One 14AWG *solid* black on the brass screw and one 14AWG *solid* white on the silver screw of a receptacle.
- B. One 12AWG *stranded* black on the brass screw and one 12AWG *stranded* white on the silver screw of a receptacle.

Job #3

Construction of an Extension Cord

Name _____ **Verified by** _____ Grade _____

Objective: Given proper materials and equipment, the student will construct a six -foot extension cord, in accordance to National Electrical Code requirements and the listed procedure.

Materials:

Provided by the student	Provided by the department
Wire strippers	6' of type 14/3 SJO cord
Phillips head screwdriver	Cord Plug and Connector
Razor Knife, if needed	

Procedure:

1. Loosen the three face screws by using the Phillips head screwdriver and remove the front section of the connector.
2. Loosen the clamp screws on the bottom section of the connector. Feed the cord through this section of the connector.
3. Remove approximately 1" of cord insulation by using the wire strippers, exposing the three conductors. Trim the white nylon strings.
 - ✓ Check each conductor carefully to ensure that the conductors are not cut, nicked or sliced. If they are damaged, cut off the conductors and repeat step #3.
4. Remove no more than 1/4" of insulation from each conductor (or amount shown on the device)
5. Insert the stripped wires into the proper terminal clamps on the front section of the connector and tighten the screws.
 - ✓ Be aware that there are no loose strands around the terminals.
 - ✓ Do not assemble the bottom section of the connector.

6. Repeat steps one (1) through five (5) for the plug.

7. Have the Instructor check both the plug *and* connector for proper connections.

Instructor verification _____

8. Assemble the bottom section of the plug and connector.
9. Using a permanent marker, write your name on the yellow section on one of the ends.
10. Have completed cord checked for operation.

Questions to Ask Yourself after Completing a Wiring Project

The following projects in this book consist of wiring actual electrical circuits. It is essential that the electrician be very conscientious of the work that is being done. In the field, the electrician has only one chance to wire the circuit correctly. Once the circuits are "roughed-in", the drywall will cover all the work, leaving only the conductors accessible in the device box.

Fortunately, you have the opportunity now to correct any mistakes that might be made, especially before grading. Listed below are questions that you should ask yourself before committing your work to being graded. After awhile, you will turn these questions into good work habits that will come automatically.

The goals of completing these projects are to develop hands-on skills required in the field, learn to wire common circuits, connect devices, and develop designing and problem solving skills. Speed will come with time. Do not try to rush through these projects, you should **learn and understand** what you are doing (you will be tested over these projects).

Questions:

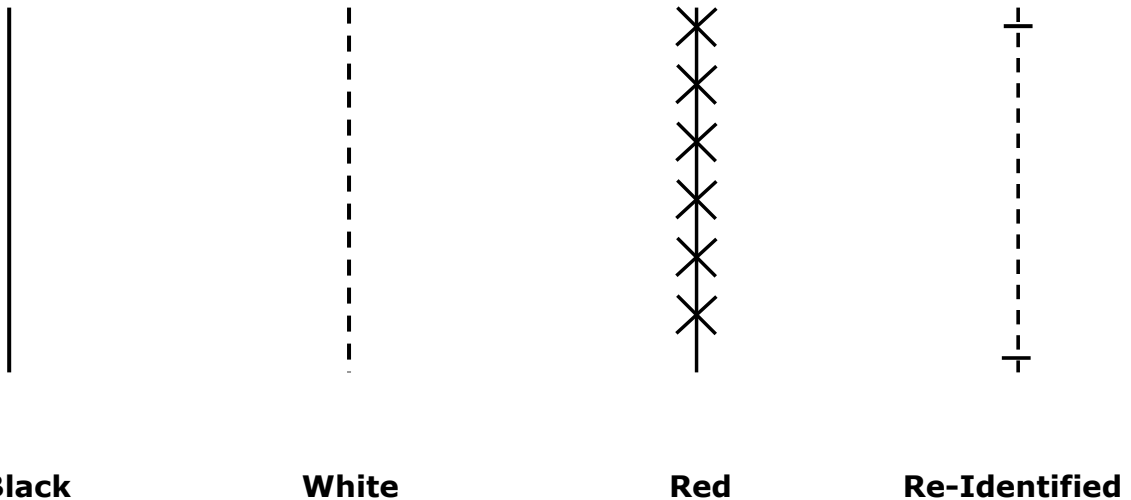
1. Is the circuit wired according to the description?
2. Does the circuit operate as described?
3. Do the wire nut splices meet requirements?
4. Are the screw terminations correct?
5. Is the grounded conductor re-identified when necessary?
6. Is there 6" of free conductor from the edge of the box?
7. Is there a 1/4" of cable sheathing showing inside the box?
8. Are the grounding conductors connected to the device and box?
9. Are you using NM-B cable clamps and are they tightened?
10. Is the device connected to the circuit correctly?
11. When MC-Cable is being used:
 - Are you using MC-cable clamps and are they tightened?
 - Did you use an anti-short bushing?
12. Overall, does the circuit meet National Electrical Code requirements?

Circuit Drawing

Circuits will have to be drawn out. This will help in designing the project prior to actually wiring the circuit and troubleshooting should the circuit not operate as expected. By drawing the circuit first, you can eliminate the chance of making errors in wiring. ***If the circuit does not work on paper, it will not work when wired per the drawing.***

These diagrams must be ***neatly*** drawn. The use of a straight edge is required.

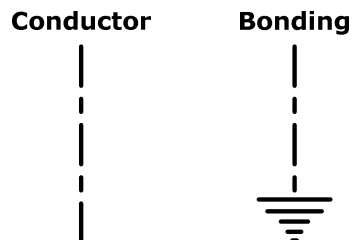
Since we will be using only a single color pencil, the following representations will be utilized to identify the different conductors:



White

Since it is a *given* that all circuits have EGCs and that all “equipment” is Bonded, it will *not* be necessary to draw the Equipment Grounding Conductor (EGC) for these projects.

Should you desire to include the EGC on your drawing, the *accepted* Equipment Grounding Conductor and Equipment Bonding (to metal) representation is:



Note to Equipment Grounding Conductor and Bonding usage: if you decide to utilize this in your drawings, you will be required to use it in ***ALL*** of your drawings.

Job #4**Voltage Measurements of the Work Station**Name _____ **Verified by** _____ Grade _____

Objective: Given necessary tools and instruction sheet, the student will verify voltages present at the Disconnect and load center, and verify the operation of the Disconnect and load center, as evidenced by completing this lab.

Materials:

Provided by the student	Provided by the department
1. Flat and Phillips head screwdrivers	1. The electricity
2. Fuse pullers	
3. Solenoid Voltage Tester	

Information: The most common electrical circuit measurement taken in the field is for voltage. Most voltage measurements are taken with reference to ground. The term ground can either be the equipment ground (bare or green) or the circuit grounded conductor (white or gray). The ground reference point is respect to the current carrying or "hot" conductor.

CAUTION: Extreme care must be used when taking measurements. You are working on a live circuit. **DO NOT** place any part of your body on the metal parts of the Disconnect or load center. **DO NOT** allow a path for current to inadvertently flow to ground through your body.

ALL measurements are performed utilizing a Solenoid Voltage Tester

Colors listed below, refer to the Conductors that are attached to the Terminal and/or Lug where the measurement is being taken

Part I: Voltage measurements at the Fused Disconnect

1. Ensure the Fused Disconnect side-arm is open (**Off**).
2. Take these measurements from the Terminals/Lugs at the top of the fuse panel:

Black to Green _____ Black to the Metal (conduit) _____

Red to Green _____ Red to the Metal (conduit) _____

Black to Red _____

3. Take these measurements from the Terminals/Lugs at the bottom of the fuse panel:

Black to Green _____ Black to the Metal (conduit) _____

Red to Green _____ Red to the Metal (conduit) _____

Black to Red _____

4. Close the Fused Disconnect side-arm **(On)**

5. Take these measurements from the Terminals/Lugs at the top of the fuse panel:

Black to Green _____ Black to the Metal (conduit) _____

Red to Green _____ Red to the Metal (conduit) _____

Black to Red _____

6. Take these measurements from the Terminals/Lugs at the bottom of the fuse panel:

→Make sure both (2) fuses are inserted

Black to Green _____ Black to the Metal (conduit) _____

Red to Green _____ Red to the Metal (conduit) _____

Black to Red _____

7. Ensure the Fused Disconnect side-arm is open **(Off)**

→ Using the fuse pullers, remove both fuses

8. Close the Fused Disconnect side-arm **(On)**

9. Take these measurements from the Terminals/Lugs at the bottom of the fuse panel:

Black to Green _____ Black to the Metal (conduit) _____

Red to Green _____ Red to the Metal (conduit) _____

Black to Red _____

→Replace both fuses

Part II: Voltage measurements at the load center (breaker panel).

1. Ensure the Fused Disconnect side-arm is open **(Off)**
2. Take the following measurements at the lugs located above the top of each circuit breaker:

Black to Green _____ Black to the Metal (conduit) _____
Red to Green _____ Red to the Metal (conduit) _____
Black to Red _____

3. Close the Fused Disconnect side-arm **(On)**
4. Take the following measurements at the lugs located above the top of each circuit breaker:

Black to Green _____ Black to the Metal (conduit) _____
Red to Green _____ Red to the Metal (conduit) _____
Black to Red _____

5. Ensure both circuit breakers are open **(Off)**
6. Take the following measurements from the Terminal *on* the bottom of each circuit breaker:

<u>Black Conductor Breaker</u>	<u>Red Conductor Breaker</u>
Terminal to White _____	Terminal to White _____
Terminal to Green _____	Terminal to Green _____

7. Close both circuit breakers **(On)**
8. Take the following measurements from the Terminal *on* the bottom of each circuit breaker:

<u>Black Conductor Breaker</u>	<u>Red Conductor Breaker</u>
Terminal to White _____	Terminal to White _____
Terminal to Green _____	Terminal to Green _____

9. Open the Fused Disconnect side-arm **(Off)** and **remove both fuses**
10. Close the Fused Disconnect side-arm **(On)** and close both circuit breakers **(On)**

11. Take the following measurements from the Terminal *on* the bottom of each circuit breaker:

Black Conductor Breaker

Terminal to White _____

Terminal to Green _____

Red Conductor Breaker

Terminal to White _____

Terminal to Green _____

12. Open both circuit breakers **(Off)** and open the Fused Disconnect side-arm **(Off)**

→Replace both fuses

Job #5

Installation of a Duplex Receptacle

Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a duplex receptacle, as evidenced by scoring a minimum of 75% on this project.

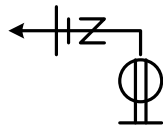
Circuit Description:

Using type NM-B cable, connect a duplex receptacle that is hot at all times. The receptacle is installed in a metal box.

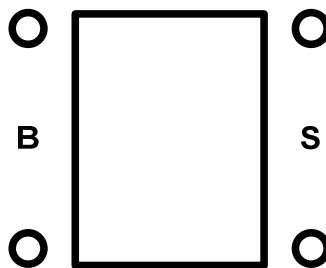
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint description:



Drawing:



Job #6

Installation of Duplex Receptacles

Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect duplex receptacles, as evidenced by scoring a minimum of 75% on this project.

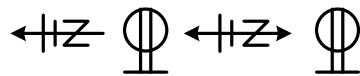
Circuit Description:

Using type NM-B cable, connect two duplex receptacles that are hot at all times. The receptacles are installed in separate metal boxes. The receptacles shall be connected by using the **pigtail** method.

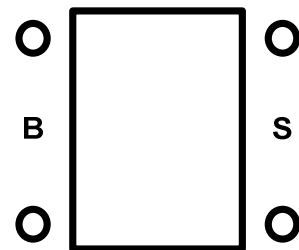
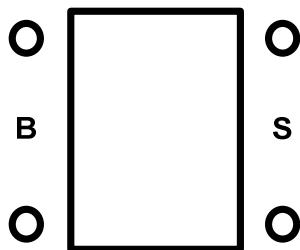
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint description:



Drawing:



Job #7

Installation of Switching Circuits

Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

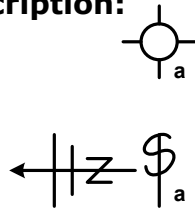
Circuit Description:

Using type NM-B cable, connect a single pole switch that controls one luminaire. The power is fed to the switch box. The switch and luminaire are installed in metal boxes.

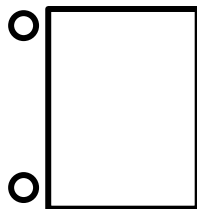
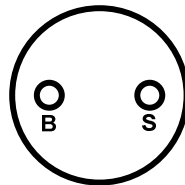
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint description:



Drawing:



Job #8

Installation of Switching Circuits

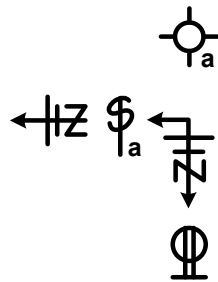
Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

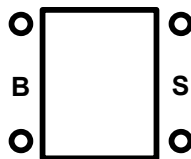
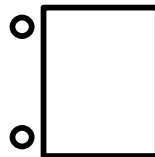
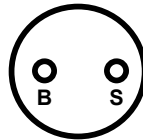
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: (Devices installed in metal boxes, type NM-B cable)



Drawing:



Job #9

Installation of Switching Circuits

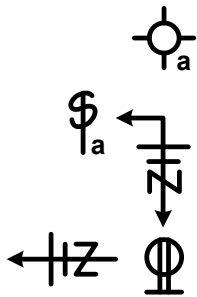
Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

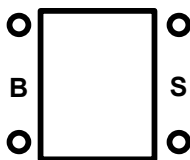
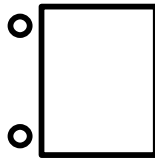
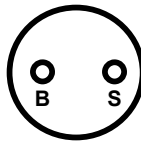
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: (Devices installed in metal boxes, type NM-B cable)



Drawing:



Job #10

Installation of Switching Circuits

Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

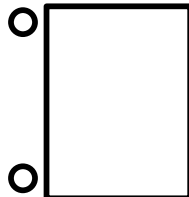
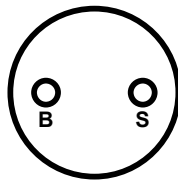
1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Description: Install a circuit that has a single pole switch controlling a luminaire. Power is fed to the luminaire box. (Devices installed in metal boxes.)

Art 200.7C2

Art 404.2C

Drawing:



Job #11 Installation of Switching Circuits

Name _____ **Verified** by _____ Grade _____

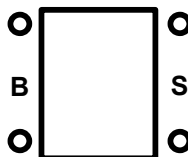
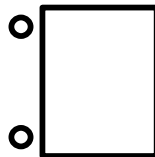
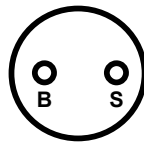
Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Description: Install a circuit that has a receptacle that is hot at all times and a luminaire that is controlled by a single pole switch. Home Run power is fed to the luminaire box. The receptacle is fed from the switch box. Use one cable between luminaire and the switch box, and one cable between switch box and receptacle. (Devices installed in metal boxes.)

Drawing:



Job #12 Installation of Switching Circuits

Name _____ Verified by _____ Grade _____

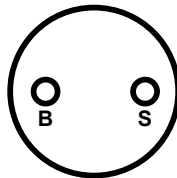
Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

Circuit Description: Using type NM-B cable, wire a circuit in which a single pole switch will control two luminaires. Power is fed into luminaire box #1. (Devices installed in metal boxes.)

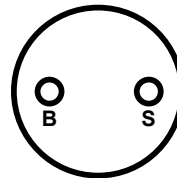
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

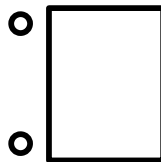
Drawing:



1



2



Job #13

Installation of Switching Circuits

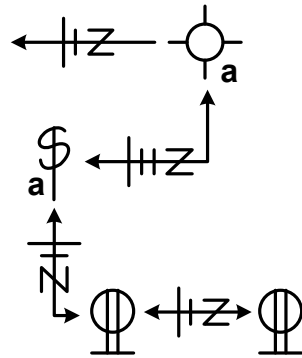
Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

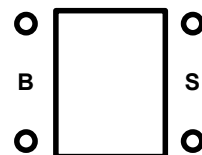
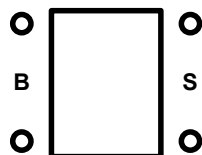
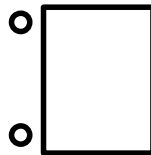
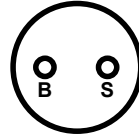
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: (Devices installed in metal boxes, use type NM-B cable)



Drawing:



Job #14

Installation of Switching Circuits

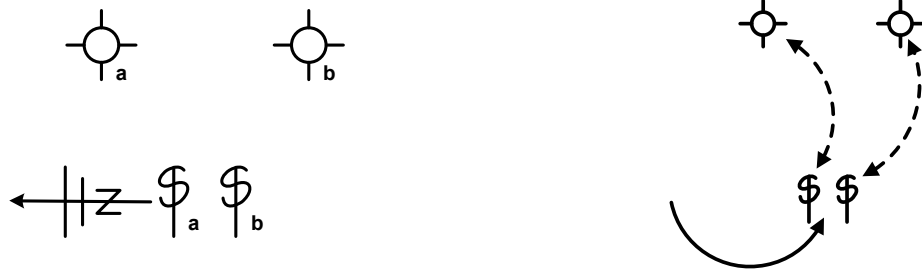
Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

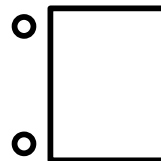
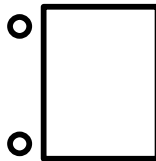
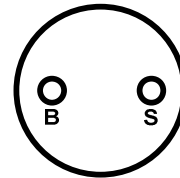
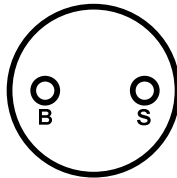
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: Devices installed in same metal box and luminaires are in separate boxes.



Drawing:



Job #15

Installation of Switched Receptacles

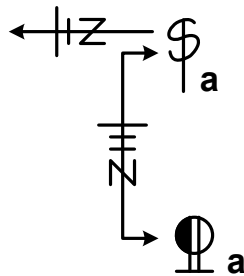
Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

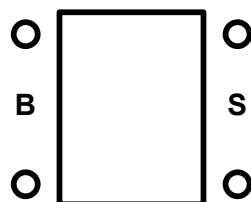
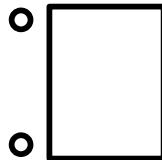
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: (Devices installed in metal boxes, bottom half of the receptacle is switched, top half in hot at all times, use type NM-B cable)



Drawing:



Job #16

Installation of Switched Receptacles

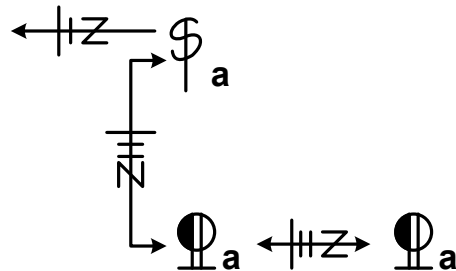
Name _____ Verified by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a single pole switching circuit according to the blue print below, as evidenced by scoring a minimum of 75% on this project.

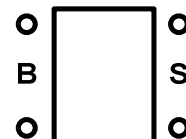
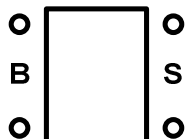
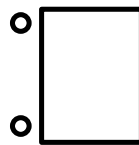
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: (Devices installed in metal boxes, bottom half of the receptacles are switched, top half in hot at all times, use type NM-B cable)



Drawing:



Job #17

Installation of Three-way Switching Circuits

Name _____ **Verified by** _____ Grade _____

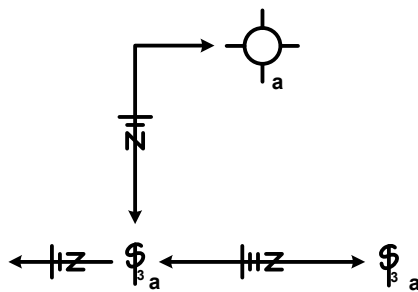
Objective: Given necessary equipment and tools, the student will connect a three way switching circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

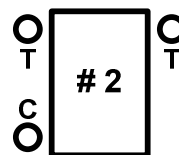
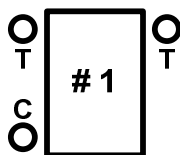
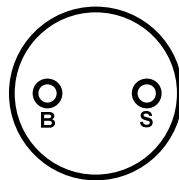
1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint:

Power (home run) is feed to Switch box #1. The Switch leg (*both* the grounded and ungrounded conductors) will be brought out of Switch box #1 to the Luminaire. Switches and luminaires are installed in *separate* metal boxes. Use type NM-B cable.



Drawing:



All jobs after #17 are wired in MC Cable

Job #18

Installation of Three-way Switching Circuits

Name _____ **Verified** by _____ Grade _____

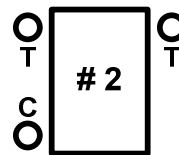
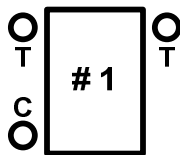
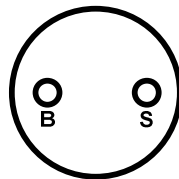
Objective: Given necessary equipment and tools, the student will connect a three way switching circuit according to the blueprint below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description in **MC** Cable.
3. Have the circuit checked by the instructor.

Description: Install a circuit that controls a Luminaire from two (2) different locations (switches are in separate boxes). Power will be brought into Switch box # 1 and the Switch leg (*both* the grounded and ungrounded conductors) will be brought out of switch box # 2 to the Luminaire. (Devices and luminaires are installed in separate metal boxes.)

Drawing:



Job #19

Installation of Three-way Switching Circuits

Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a three way switching circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

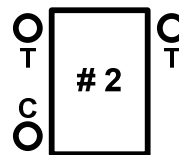
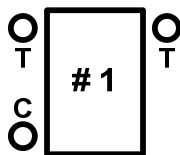
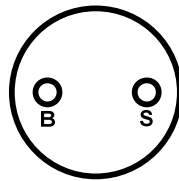
1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Description: Install a switching circuit in which one luminaire is controlled from two locations. Power is fed to the luminaire box. You may take the Switch leg to either Switch box. Use type **MC** cable. (Devices installed in *separate* metal boxes.)

ART. 404.2A

ART. 200.7C2

Drawing:



Job #20

Installation of Three-way Switching Circuits

Name _____ Verified by _____ Grade _____

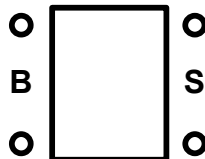
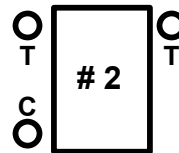
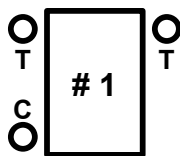
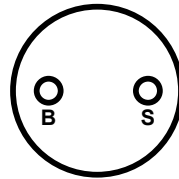
Objective: Given necessary equipment and tools, the student will connect a three way switching circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Description: Install a switching circuit in which one luminaire is controlled from two locations. Power is fed to the duplex receptacle box. The duplex receptacle is hot at all times. The fixture and devices are installed in *separate* metal boxes. Use type MC cable.

Drawing:



Job #21

Installation of Three-way Switching Circuits

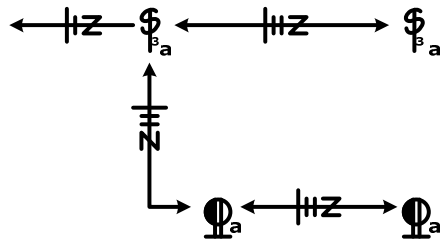
Name _____ Verified by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a three way switching circuit according to the blueprint below, as evidenced by scoring a minimum of 75% on this project.

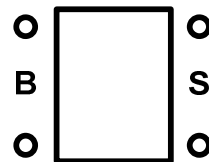
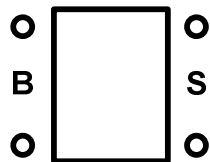
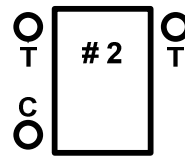
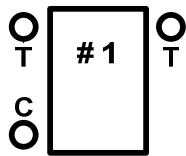
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: (Devices installed in metal boxes, top half of split receptacle switched, use type MC Cable).



Drawing:



Job #22

Installation of Four-way Switching Circuits

Name _____ Verified by _____ Grade _____

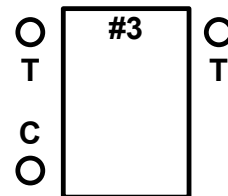
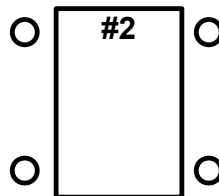
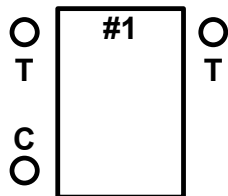
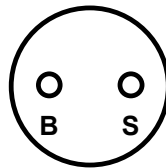
Objective: Given necessary equipment and tools, the student will connect a four way switching circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Description: Wire a circuit such that a luminaire is controlled from three separate locations. Power is fed into three-way switch box #1 and the switch leg (both the ungrounded and grounded conductors) are fed directly to the luminaire out of three-way switch box #2. Install all devices in metal boxes.

Drawing:



Job #23

Installation of Four-way Switching Circuits

Name _____ **Verified** by _____ Grade _____

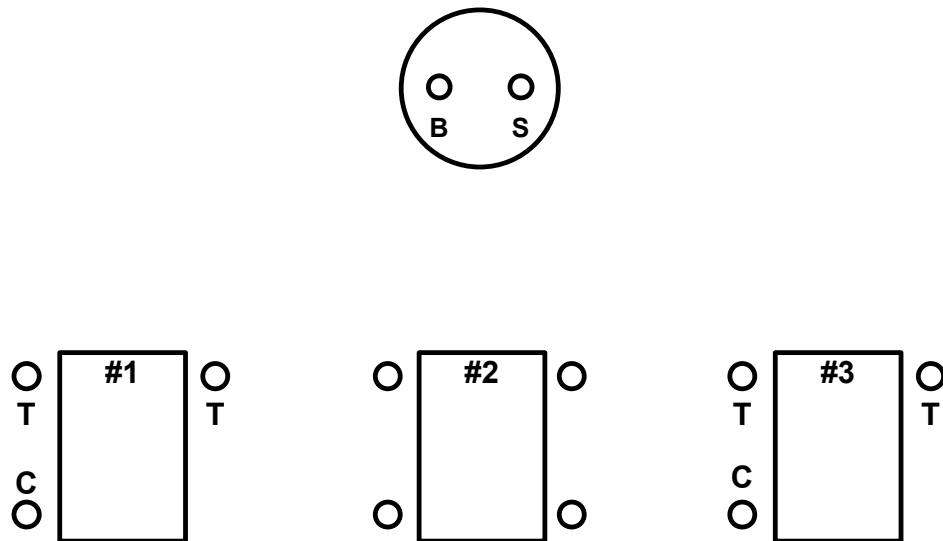
Objective: Given necessary equipment and tools, the student will connect a four way switching circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Description: Wire a circuit such that a luminaire is controlled from three separate locations. The power is fed into one of the three-way switch boxes. The switch leg (both the ungrounded and grounded conductors) are fed directly to the luminaire from the three-way switch box that contains the home run. All devices are installed in metal boxes.

Drawing:



Job #25

Installation of Four-way Switching Circuits

Name _____ Verified by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a four way switching circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Description: Install a circuit that has three (3) split duplex receptacles controlled from five (5) separate switches. The top half of the receptacles is switched and the bottom half is hot at all times. Power and switch leg (both the ungrounded and grounded conductors) are fed out of the first three-way switch box. **Obtain extra devices from the instructor.** (Devices installed in metal boxes.)

Drawing:

Provide your own drawing for this circuit.

Job #26

Installation of Ground Fault Circuit Interrupter Circuits

Name _____ Verified by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a ground fault circuit interrupter circuit according to the blueprint below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: (Install the GFCI and receptacle in metal boxes.)



Drawing:



Job #27

Installation of Ground Fault Circuit Interrupter Circuits

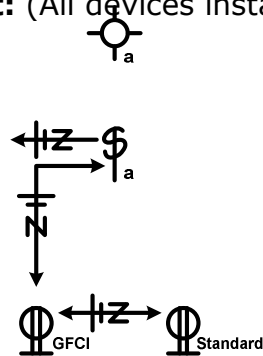
Name _____ Verified by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a ground fault circuit interrupter circuit according to the blueprint below, as evidenced by scoring a minimum of 75% on this project.

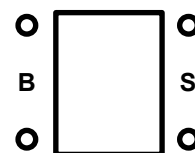
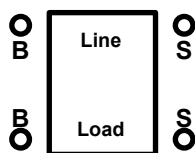
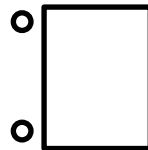
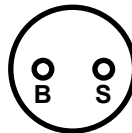
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Blueprint: (All devices installed in metal boxes)



Drawing:



Job #28

Installation of Special Circuits and Devices

Name _____ **Verified by** _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor.

Description: Install a circuit that has two luminaires controlled from one location. When luminaire # 1 is on, luminaire # 2 is off. When luminaire # 2 is on, luminaire # 1 is off. Power is fed to the switch box. Install all devices in metal boxes.

Drawing:

Provide your own drawing for this circuit. **Verified By:** _____

PPJob #29, #30

Installation of Special Circuits and Devices

Name _____ **Verified by** _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a circuit according to the description below, as evidenced by scoring a minimum of 75% on these projects.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor

Job #29 Description: Install a circuit that has a switch/receptacle (combo) device.

The switch controls the receptacle. (Devices installed in metal boxes)

Drawing:

Provide your own drawing for this circuit. Verified By: _____

Job #30 Description: Install a circuit that has a switch/receptacle (combo) device.

The switch controls a luminaire and the receptacle is hot at all times.
(Devices installed in boxes)

Drawing:

Provide your own drawing for this circuit. Verified By: _____

Job #31, #32
Installation of Special Circuits and Devices

Name _____ **Verified by** _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a circuit according to the description below, as evidenced by scoring a minimum of 75% on these projects.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to the description.
3. Have the circuit checked by the Instructor.

Job #31 Description: Install a circuit that has a switch/pilot luminaire (combo) device.

The switch will control a luminaire, and the pilot luminaire will be on at all times.

(Devices installed in metal boxes)

Drawing:

Provide your own drawing for this circuit. Verified By: _____

Job #32 Description: Install a circuit that has a switch/pilot luminaire (combo) device.

The switch controls a luminaire and the pilot luminaire is on **only** when the luminaire is on. (Devices installed in metal boxes)

Drawing:

Provide your own drawing for this circuit. Verified By: _____

Job #33

Installation of Special Circuits and Devices

Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor

Description: Install a circuit that has two switches on the same yoke (i.e. "stack switch"). Each switch will control a separate luminaire. Luminaires and switch (es) are mounted in separate boxes.

Job #34
Installation of 240-Volt Devices

Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

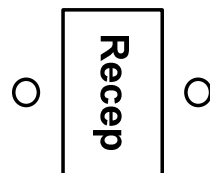
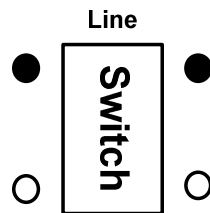
Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor

Description: Install a **double pole switch** that controls a **240V/20A receptacle**.

You will need to get the switch and receptacle from the instructor.
(Devices installed in metal boxes)

Drawing:



Job #35
Installation of 240-Volt Devices

Name _____ **Verified** by _____ Grade _____

Objective: Given necessary equipment and tools, the student will connect a circuit according to the description below, as evidenced by scoring a minimum of 75% on this project.

Procedure:

1. Using a straight edge, draw how this circuit will be wired.
2. Wire the circuit according to description.
3. Have the circuit checked by the instructor

Description: Install a 240 V/30A (or 50A) receptacle.

You will need to get the receptacle from the instructor. (Device installed in metal box)

Drawing: Draw two (2) Line Conductors and One (1) Grounded Conductor

Job #36

Bending Electrical Metallic Tubing

Name _____ **Verified** by _____ Grade _____

Objectives:

1. Make 90° stub-up bends to various heights.
2. Make back-to-back bends to various distances.
3. Make 30° offset bends to various heights.
4. Make 45° offsets bend to various heights.
5. Make four-bend saddles over various objects.
6. Make three-bend saddles over various objects.

Material:

Material you provide	Material provided by the department
1/2" E.M.T. Bender	40" lengths of 1/2" E.M.T.
Torpedo Level	60" lengths of 1/2" E.M.T.
Tape Measure	
Conduit Reamer/Hacksaw	

Tolerances for Grading:

All the grades for the individual bends will be averaged together for an overall job grade.

The tolerances are as follows:

"A" the height must be within $\pm 1/8"$, the dogleg must not exceed $1/8"$ and the degrees are $\pm 2^\circ$.

"B" the height must be within $\pm 1/4"$, the dogleg must not exceed $1/4"$, and the degrees are $\pm 4^\circ$.

"C" the height must be within $\pm 1/2"$, the dogleg must not exceed $1/2"$, and the degrees are $\pm 6^\circ$.

The student must obtain a minimum grade of a "C" for the bend.

Flattened, kinked, or otherwise damaged conduit will not be accepted under any circumstance.

Conduit that is not reamed will result in a letter grade deduction for the bend.

90° Stub-up bend:

Using information sheet (and/or classroom demonstration), make the following bends.

Do not use a hacksaw to adjust the finished height or length of the bend.

Use one stick of conduit (cut in half or thirds) to make two bends when possible.

1. 7" Stub-up **Verified by:** _____ **Grade:** _____
2. 8 1/2" Stub-up **Verified by:** _____ **Grade:** _____
3. 12 3/4" Stub-up **Verified by:** _____ **Grade:** _____

Back-to-Back bend:

Using information sheet (and/or classroom demonstration), make the following bends.

Do not use a hacksaw to adjust the finished height or length of the bend.

Use one stick of conduit (cut in half or thirds) to make two bends when possible.

1. 7 1/4" stub-up one end, 21" span
 Verified by: _____ **Grade:** _____
2. 6 3/4" stub-up on one end, 22" span
 Verified by: _____ **Grade:** _____

30° Offset Bends

Using information sheet (and/or classroom demonstration), make the following bends.

Do not use a hacksaw to adjust the finished height or length of the bend.

Use one stick of conduit to make two bends when possible.

1. 6" true offset **Verified by:** _____ **Grade:** _____
2. 8" true offset **Verified by:** _____ **Grade:** _____

45° Offset Bends

Using information sheet (and/or classroom demonstration), make the following bends.

Do not use a hacksaw to adjust the finished height or length of the bend.

Use one stick of conduit (cut in half or thirds) to make two bends when possible.

1. 7" true offset **Verified by:** _____ **Grade:** _____

2. 9" true offset **Verified by:** _____ **Grade:** _____

Box offsets

Using information sheet (and/or classroom demonstration), make the following bends.

Do not use a hacksaw to adjust the finished height or length of the bend.

Use one stick of conduit (cut in half or thirds) to make two bends when possible. **(Use 4" square box to check offset).**

1. Box offset on one (1) end of conduit, only.

Verified by: _____ **Grade:** _____

2. Using the bend in #1 above, place a box offset on the other end of the conduit. The conduit must properly fit into two 4" square boxes at the same time.

Verified by: _____ **Grade:** _____

3-Bend Saddles

Using information sheet (and/or classroom demonstration), make the following bends.

Do not use a hacksaw to adjust the finished height or length of the bend.

1. 2 1/2" saddle, 18" from one end
Verified by: _____ **Grade:** _____

2. 3 1/2" saddle, 24" from one end
Verified by: _____ **Grade:** _____

3. 3" saddle, 21" from one end
Verified by: _____ **Grade:** _____

4-Bend Saddles

Using information sheet (and/or classroom demonstration), make the following bends.

Do not use a hacksaw to adjust the finished height or length of the bend

1. Make a 4-bend saddle to the following requirements:
Must be able to clear an object that is 8" wide and 5" tall. Use 30-degree offsets.

Verified by: _____ **Grade:** _____

2. Make a 4-bend saddle to the following requirements:
Must be able to clear an object that is 8" tall, 6" wide. Use 45 degree offsets.

Verified by: _____ **Grade:** _____

Job #37
Installing a Residential Service

Name _____ Verified by _____ Grade _____

Objective: Given necessary instruction install a 240/120V single phase, 100A, single phase service.

Procedure:

1. Wire the circuit according to description.
2. Have the circuit checked by the instructor.

Description: Install a 240V/120V 1Ø 100A overhead electrical service. There will be three circuits run from the electrical panel. There will be two 120V 20A receptacles mounted in the same box on separate circuits. There will be a 240/120V 30A receptacle mounted in a separate box. The boxes will be mounted 24" above the floor, and the circuit will be run in EMT.

Drawing:

No Drawing required.

Job #38

Getting to Know Your Transformer: Winding Resistance

Name _____ Date _____ Verified: _____

Objective:

Given an isolation transformer, determine which winding (high voltage or low voltage) has the most resistance.

Theory

A transformer changes voltage according to a turn's ratio. It is not possible to determine the turn's ratio solely on resistance alone. There are many factors that influence the resistance of the windings. These factors can include not only how many turns of wire but also the wire size and wire material.

Materials Required:

Materials the department provides:	Materials provided by you:
1 KVA Transformer(s)	Multimeter
.5 KVA Transformer(s)	

Procedure:

Answer the following questions, and then you take the resistance measurements

Before You Begin, Answer These Questions:

1. Which windings have the most turns?
 - a. H windings
 - b. X windings
2. Which windings use the larger wire size?
 - a. H windings
 - b. X windings
3. Based on what you know, which windings have the most resistance?
 - a. H windings
 - b. X windings

Steps:

1. Use one of the **1 kVA** transformers mounted in the booth.
2. Measure the resistance of both **H** windings and record your readings:

H1-H2 _____; **H3-H4** _____

4. Measure the resistance of both **X** windings and record your readings:

X1-X2 _____; **X3-X4** _____

6. Use one of the **.5 kVA** transformers mounted in the booth.

7. Measure the resistance of both **H** windings and record your readings:

H1-H2 _____; **H3-H4** _____

9. Measure the resistance of both **X** windings and record your readings:

X1-X2 _____; **X3-X4** _____

11. Measure the resistance between the following points:

A. **H1-X1** _____

B. **H2-X2** _____

C. **H3-X3** _____

D. **H4-X4** _____

E. **H2-H3** _____

F. **X2-X3** _____

Job #39**Calculating Transformer Voltage and Current Ratios**

Name _____ Date _____ Verified: _____

Objective:

Given a voltage source, transformer, loads, voltmeter and ammeter; calculate the voltage and current ratios. Verify that the primary VA is nearly equal to the secondary VA in a transformer.

Theory:

In this job you will be calculating voltage and current ratios. You need to express these ratios in a specified way, a transformer either steps the voltage up or it steps the voltage down. For example, a step down transformer has a primary voltage of 480 volts and a secondary voltage of 240 volts. This is expressed as a 2:1 ratio. For every 2 primary volts there is one secondary volt. Therefore, the one appears on the right side of the expression. Another example would be stepping the voltage down from 277 volts to 240 volts. This is 1.15:1 ratio ($277/240 = 1.15$).

If the transformer steps the voltage up, the one appears on the left side of the expression. For example if a transformer steps the voltage up from 150 to 300 volts, the ratio is 1:2.

Or if you step the voltage up from 208 to 380 volts, the ratio is 1.83:1

Materials Required:

Materials the department provides:	Materials provided by you:
1 KVA Transformer(s)	Multimeter
Lamp Bank	Amp Clamp
Light Bulbs, various wattages	Calculator
Wire	

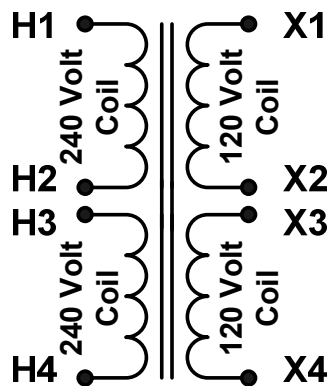
Procedure:

This job consists of four parts. In the first part of this job you will energize specified coils of a 1 KVA transformer and take voltage readings across the remaining coils of the transformer. In the second part of this job you will connect the 1 KVA transformer as a step down transformer and calculate the voltage and current ratios. In the next part of this job you will connect the 1 KVA transformer as a step up transformer and calculate voltage and current ratios.

Part I: You need a 1 KVA double wound transformer. Refer to *Diagram #1* below. This transformer has two high voltage windings (H1-H2 and H3-H4) and two low voltage coils (X1-X2 and X3-X4).

Be aware that the ratio between the H coils and the X coils is a *little* less than 2:1 for smaller transformers (1 KVA and below). Therefore, when you energize H1 – H2 with 240 volts you will have a little more than 120 volts across X1 – X2 and X3 – X4. There are extra turns in the secondary to compensate for voltage drop when you connect a load to the secondary of the transformer.

Diagram #1



Steps:

1. Refer to the nameplate.
2. Record the maximum voltage rating of the **H** windings.

3. Record the maximum voltage ratings of the **X** windings.

4. *Energize* the **H1-H2** winding with 240V.
5. Record the following voltages:

X1-X2 _____; **X3-X4** _____; **H3-H4** _____

Part II: In this part of the job you use the 1 KVA transformer as a **step down** transformer. Be sure to *parallel* both sets of windings.

Diagram #2.

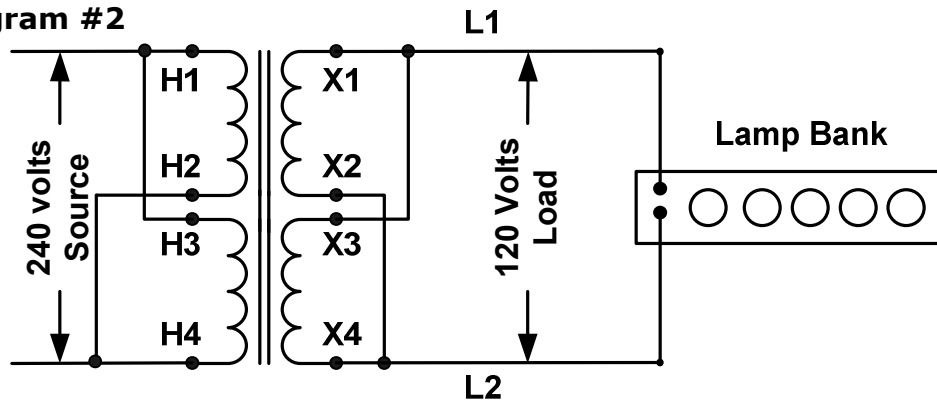
Using all the windings enables the transformer to carry 1 KVA of load.

Calculate the voltage and current ratios as you were instructed in the Theory part of this job.

Before You Begin, Answer These Questions:

Assume the secondary voltage is 120 volts. How much current will the load draw when the transformer is loaded to its nameplate capacity? Show your calculations.

Diagram #2



Steps:

1. Connect the transformer as a 2:1 transformer. Refer to *Diagram #2*.
2. Energize and verify that you get *about* 120 volts across the secondary.
3. De-energize and connect 300 watts of load across the secondary.
This is **load 1**.
4. Energize the transformer. Take voltage and current readings and record them in *Table #1* directly below.
5. De-energize and connect 600 watts of load across the secondary.
This is **load 2**.
6. Energize the transformer. Take voltage and current readings and record them in *Table #1* directly below.
7. De-energize and connect 900 watts of load across the secondary.
This is **load 3**.

8. Energize the transformer. Take voltage and current readings and record them in *Table #1* directly below.

Table #1

	Pri Volts	Sec Volts	Voltage Ratio	Pri Ampere	Sec Ampere	Ampere Ratio
Load 1						
Load 2						
Load 3						

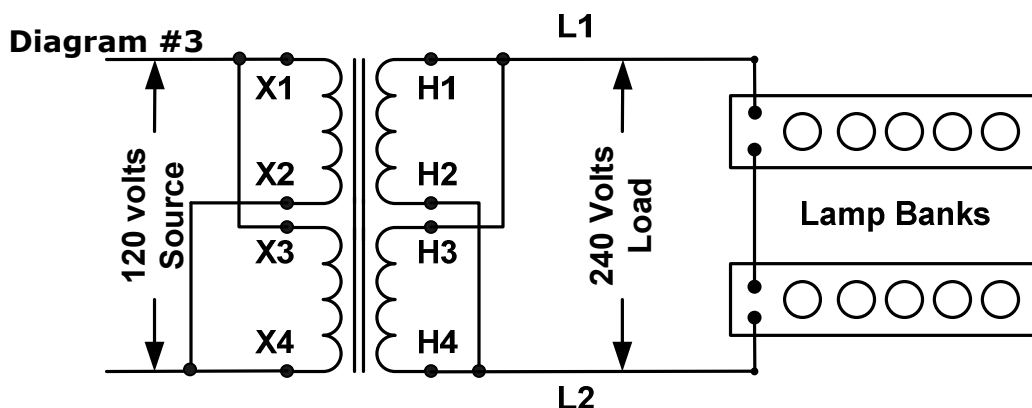
9. De-energize the transformer.

10. Calculate Primary and Secondary **VA** and fill in *Table #2*, directly below.

Table #2

	Pri VA	Sec VA
Load 1		
Load 2		
Load 3		

Part III: Now you will connect the 1 KVA transformer as a **step up** transformer. Be sure to parallel the windings. Refer to *Diagram #3*.



****Loads must be arranged for a *maximum* of 120V across each lamp bank****

Before You Begin, Answer These Questions:

1. If you connected the H windings in series (jumper H2-H3 together) instead of in parallel as you have it *Diagram #3* (with no load on H1 and H4), what would you expect the secondary voltage to be?

2. Why do you need to series the lamp banks in this part of the job?

3. Why is it important to have equal wattages in each lamp bank?

Steps:

1. Connect the transformer as a 1:2 transformer. Refer to *Diagram #3*.
2. Energize and verify that you get about 240 volts across the secondary.
3. De-energize and connect 300 watts of load across the secondary.
This is **load 1**.
4. Energize the transformer. Take voltage and current readings and record them in *Table #3* directly below.
5. De-energize and connect 600 watts of load across the secondary.
This is **load 2**.
6. Energize the transformer. Take voltage and current readings and record them in *Table #3* directly below.
7. De-energize and connect 900 watts of load across the secondary.
This is **load 3**.
8. Energize the transformer. Take voltage and current readings and record them in *Table #3* directly below.

Table #3

	Pri Volts	Sec Volts	Voltage Ratio	Pri Ampere	Sec Ampere	Ampere Ratio
Load 1						
Load 2						
Load 3						

9. De-energize the transformer.
10. Calculate Primary and Secondary **VA** and fill in *Table #4*, directly below.

Table #4

	Pri VA	Sec VA
Load 1		
Load 2		
Load 3		

Answer the following Four Questions:

1. For a step down transformer why is the primary current always less than the secondary current?
2. When you did your VA calculations you should have noticed that primary VA was slightly more than secondary VA. Why?
3. The 1 KVA transformers are capable of being used as 240V – 120V step down transformer and a 240 to 480 volt step up transformer. In both of these cases is it possible for these transformers to carry 1 KVA of load?
4. Refer to Part II of this job. Notice that the primary and secondary transformer windings are paralleled. What would the KVA rating of the transformer be if you connect H1 – H2 to the voltage source and did not use the H3 – H4 windings?

Job# 40
Measuring Currents & Voltages in a 3-Wire Single Φ System

Name _____ **Date** _____ **Verified:** _____

Objective:
Given the loading (120 volt and 240 volt) of a 3-wire single-phase system; calculate the amps on L1 and L2 and calculate the voltage drop across each 120-volt load when the neutral is disconnected.

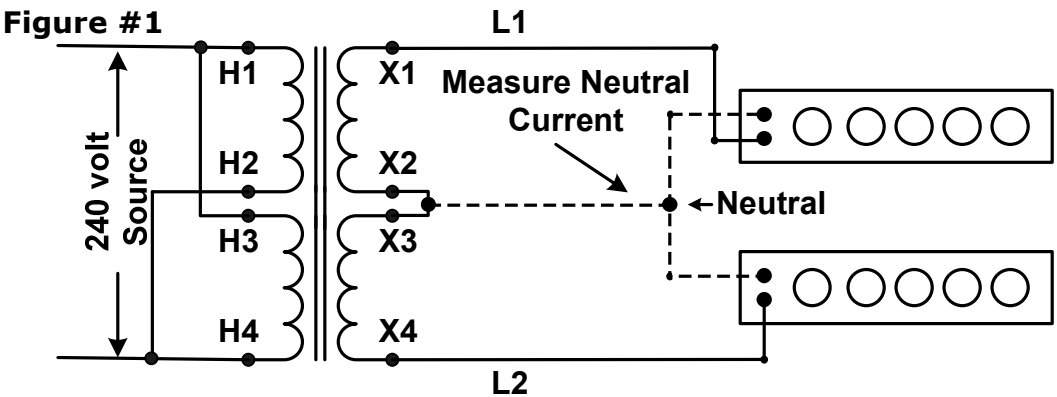
Materials Required:

Materials the department provides:	Materials provided by you:
1 KVA Transformer	Multimeter
Lamp Banks	Amp Clamp
120 Volt Bulbs, various watts	
250 Volt Bulbs, various watts	

Procedure:
This job consists of two parts. In the first part you will work with only 120V loads and see what role the neutral plays in this system. In the second part of this job you connect both 120V and 240V loads and observe what impact this has on the system.

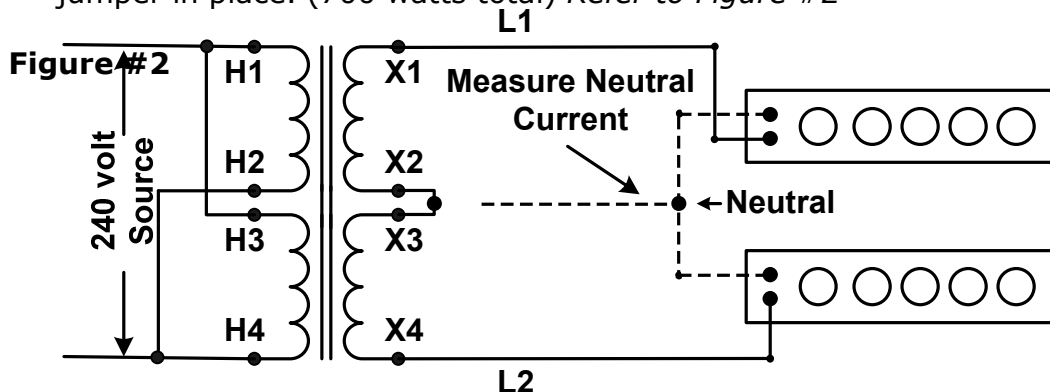
Part I:
In a single phase 3-wire system the neutral serves two purposes. First, it carries any unbalanced current if the two 120 volt loads are not equal. Second, it stabilizes the voltage. You will notice that as the imbalance between the two 120V circuits becomes greater, the neutral current also becomes greater.

Before You Begin, Answer These Questions:
Assume the current in L1 is 10 amps and the current in L2 is 15 amps.
What is the Neutral current? *Figure #1* below, represents the circuit.



Steps:

1. Parallel the H windings and connect them to the 240V source. *Figure #1*
2. Jumper X2 and X3 on the low voltage side. Connect the neutral to this point.
3. Terminal X1 feeds L1 and terminal X4 feeds L2.
4. Connect 300 watts each of load across **L1 – Neutral** and across **L2 – Neutral**. (600 watt total)
5. Energize and record volts and amps.
6. Record amps: L1 _____; **N** _____; **L2** _____
7. Record volts: L1 – N _____; **L2** – N _____
8. De-energize and connect an additional 100 watts across **L2 – Neutral**. (700 watts total)
9. Energize and record volts and amps.
10. Record amps: L1 _____; **N** _____; **L2** _____
11. Record volts: L1-N _____; **L2**-N _____
12. De-energize and connect an additional 100 watts across **L2 – Neutral**. (800 watts total).
13. Energize and record volts and amps.
14. Record amps: L1 _____; **N** _____; **L2** _____
15. Record volts: L1-N _____; **L2**-N _____
16. De-energize and remove 100 watts from **L2 – Neutral** and disconnect the Neutral at the X2-X3 connection but leave the X2-to-X3 jumper in place. (700 watts total) *Refer to Figure #2*

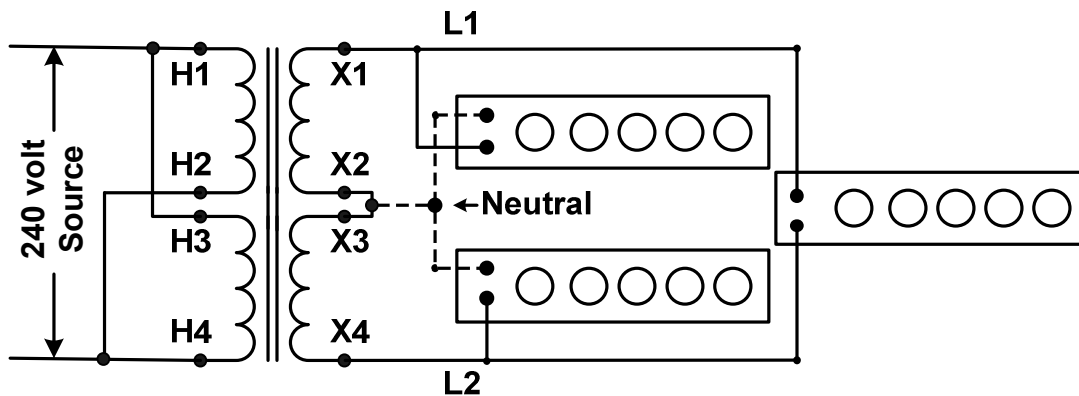


17. Energize and record volts and amps.
18. Record amps: L1 _____; **N** _____; **L2** _____
19. Record volts: L1-N _____; **L2-N** _____
20. De-energize and go to Part II.

Part II: In this portion of the job, you will see the effect of adding 240V loads

Refer to Fig #3

Figure #3



Before You Begin, Answer These Questions:

1. In an existing single-phase system you make the following measurement:
L1 = 3 amps, L2 = 5 amps and N = 2 amps.
What is the total current on L1 and L2 if you add 6 amps of 240 volt load to this system?
2. As you add more 240 volt load what will happen to the neutral current? Increase, decrease or stay the same?

Steps:

1. Connect 150 watts of load across L1-Neutral and connect 250 watts of load across L2-Neutral.
2. Energize and record volts and amps.
3. Record amps: L1 _____; **N** _____; **L2** _____
4. Record volts: L1-N _____; **L2-N** _____; **L1-L2** _____

5. De-energize and connect 200 watts of load across L1-L2 (250 Volt light bulbs).
6. Energize and record volts and amps.
7. Record amps: L1 _____; **N** _____; **L2** _____
8. Record volts: L1-N _____; **L2-N** _____; **L1-L2** _____
9. De-energize and connect another 100 watts of load across L1-L2 (a total of 300 watts).
10. Energize and record volts and amps.
11. Record amps: L1 _____; **N** _____; **L2** _____
12. Record volts: L1-N _____; **L2-N** _____; **L1-L2** _____
13. De-energize and connect another 100 watts of load across L1-L2 (a total of 400 watts).
14. Energize and record volts and amps.
15. Record amps: L1 _____; **N** _____; **L2** _____
16. Record volts: L1-N _____; **L2-N** _____; **L1-L2** _____
17. De-energize and put the equipment away.

Questions:

1. What is the total load on winding X1-X2 in Part II, step 14?
2. What is the total load on winding X3-X4 in Part II, step 14?
3. If you added another 100 watts of load across X3-X4, would you overload the transformer?

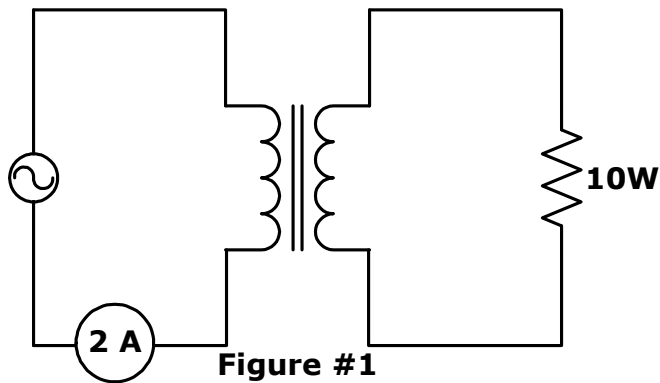
Single Phase Transformers Worksheet

Name _____ Date _____ Grade _____

Circle the correct answer for each question.

1. Increasing the turns ratio in the secondary of a transformer will:
 - A. Increase the power in the primary
 - B. Increase the current in the secondary
 - C. Increase the voltage in the secondary
 - D. Decrease resistance in the secondary
2. Increasing the turns ratio in the secondary of a transformer will:
 - A. Decrease the power in the secondary
 - B. Decrease the current in the secondary
 - C. Decrease the voltage in the secondary
 - D. Increase the permeability in the secondary
3. A transformer has a turns ratio of 4:1; the current in the secondary is 12.5 mA, what is the primary current?
 - A. 39.063 mA
 - B. 3.125 mA
 - C. .78125 mA
 - D. .320 mA
4. A transformer has a turns ratio of 1:5; the primary voltage is 4.6 V, what is the secondary voltage?
 - A. 23 V
 - B. 920 mV
 - C. 1.087 V
 - D. 5.435 V
5. Transformers operate by the principle of:
 - A. Mutual magnetism
 - B. Mutual inductance
 - C. Coefficient of coupling
 - D. Inductive reactance
6. The transformer has which type of connection between the primary and the secondary?
 - A. Electric
 - B. Magnetic
 - C. Electronic
 - D. Unlisted

Questions 7-9 refer to figure #1



7. What is the impedance (total resistance = W/I^2) of the primary?
- A. 2.5 Ω
 - B. 5 Ω
 - C. 200 m Ω
 - D. 400 m Ω
8. If the secondary voltage is 1 volt, what is the turns ratio?
- A. 2:1
 - B. 5:1
 - C. 1:2
 - D. 1:5
9. If the secondary impedance is 100 ohms, what is the turns ratio?
- A. 1:20
 - B. 1:6.325
 - C. 20:1
 - D. 6.325:1
10. A step-down transformer could have which type of turns ratio?
- A. 1:10
 - B. 10:1
 - C. 1:1
 - D. .1:10
11. A step-up transformer has 100 primary turns and 600 secondary turns. If the primary voltage is 50 V and the secondary current is 20 mA, what is the amount of primary current?
- A. 300 mA
 - B. 120 mA
 - C. 3.33 mA

D. 2.5 mA

12. A step-down transformer has a ratio of 8:1 and the primary voltage is 120 V. The secondary is rated at 240 VA. What is the primary VA?

- A. 9.6 VA
- B. 240 VA
- C. 960 VA
- D. 30 VA

13. The actual number of turns of a transformer is 1600 on the primary and 400 on the secondary. This type of transformer will:

- A. Increase the amount of secondary voltage.
- B. Decrease the amount of secondary current.
- C. Increase the amount of secondary current.
- D. Decrease the amount of secondary power.

14. A transformer has the primary voltage of 240 V and a secondary voltage of 24 V. This transformer is known as a/an:

- A. Step-up transformer
- B. Step-down transformer
- C. Isolation transformer
- D. Autotransformer.

15. Which of the listed is a power loss caused by changing magnetic fields inducing a voltage that produces short spirals of circular current in the core of the coil?

- A. Eddy Current
- B. Hysteresis
- C. Permeability
- D. Leakage Flux

16. The load is connected to the _____ and the input voltage is connected to the _____ of a step-down transformer.

- A. Primary/secondary
- B. Secondary/primary
- C. Secondary/secondary
- D. It does not matter.

17. A transformer has a primary voltage of 12.8 kV and a secondary voltage of 240 V. The transformer is rated at 150 kVA. What is the primary current?

- A. 1.172 kA
- B. 117.188 mA
- C. 625 A
- D. 11.719 A

18. A step-down transformer has a ratio of 10:1 and the primary voltage is 12 V. The secondary current is 8A. What is the secondary VA?

- A. 9.6 VA
- B. 240 VA
- C. 960 VA
- D. 30 VA

19. A step up transformer has 1000 turns to 6000 turns. The primary current is 50mA, the secondary current is:

- A. 300 mA
- B. 120 mA
- C. 8.33 mA
- D. 2.5 mA

20. The primary voltage is 100v; the secondary current is 6mA at 50mVA. This transformer has a ratio of

- A. 12:1
- B. 1:12
- C. 6:1
- D. 1:6

21 A transformer with a ratio of 8:1 has a primary current of 75mA, the secondary power is 10VA the primary voltage is

- A. 120V
- B. 133.333V
- C. 16.667V
- D. 7.5V

Single-Phase Transformer Connections

Name _____

Score _____

Theory:

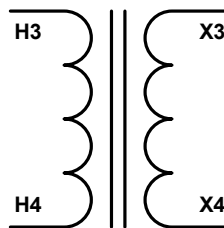
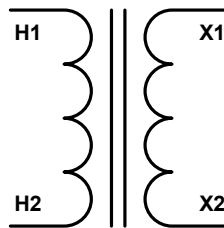
The standard stock single-phase transformer with a dual wound primary rated 240 x 480 volts, and a secondary rated 120/240 volts is a very versatile transformer. The primary and secondary sides of the transformer can be connected in series or parallel. If the primary side is connected in series, then the connection is for the high voltage (480 V). If the primary is connected in parallel, then the connection is for the low voltage (240 V). The same applies with the secondary. If the secondary is connected in series, then only 240 V will be available. If the secondary is connected in parallel, then only 120 V will be available.

Directions:

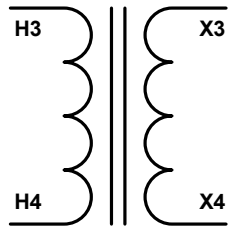
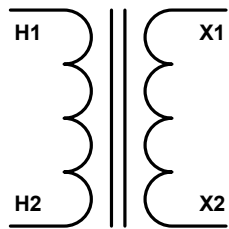
Connect the transformer diagrams for the voltages listed below. Calculate the turns ration for each.

1. 480 V Primary, 120 V Secondary

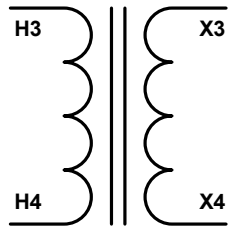
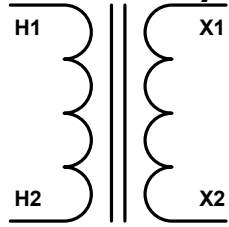
Turns Ratio



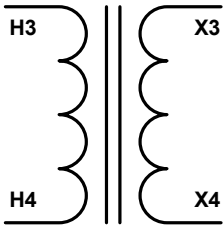
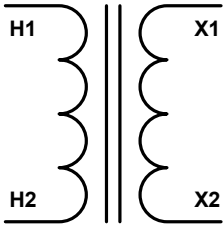
2. 480 V Primary, 240 V Secondary Turns Ratio = _____



3. 480 V Primary, 240/120 V Secondary Turns Ratio _____



4. 240 V Primary, 120 V Secondary **Turns Ratio** _____



5. 240 V Primary, 240 V Secondary **Turns Ratio** _____

