Guitar Electronics

This activity will engage students in the design and function of an electric guitar control circuit. Students will learn about individual electronic components, and understand how to assemble an electric guitar control circuit according to a circuit diagram. Proper wire stripping, grounding and soldering techniques will also be highlighted.

Learning Objectives:

1. Students will plan the assembly of components according to a wiring diagram.
2. Students will properly solder components together into a wiring harness.
3. Students will use Ohm's law to quantify the effect of a resistor on voltage and current within a circuit.
4. Students will use Ohm's Law to estimate values in a voltage divider circuit using a potentiometer.
5. Students will utilize proper wire stripping, soldering and grounding techniques.

Standards:

HS-PS3-3 Energy

Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

CCSS.Math.Content.HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales

CCSS.Math.Content.HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance, R*

SME Skill Gaps
Oral communication and listening
Specific manufacturing processes

Materials Required:

1. Pencil and calculator to complete Ohm's Law calculations
2. Digital Multimeter with leads
3. Two (2) .022µF capacitors
4. Two pickups (neck and bridge)
5. One (1) 3 way toggle switch
6. Four (4) potentiometers (500kΩ)
7. Jumper wires (18 AWG)
8. One (1) ¼ inch female jack

Safety:

When soldering, wear eye protection and work in a well ventilated area. Be careful to avoid inhaling fumes/smoke. Wash your hands immediately after soldering.

References:

1. Electrical/ Electronic Schematic Symbols - www.rapidtables.com/electric/electrical_symbols.htm
2. Wiring a Guitar - www.stewmac.com/freeinfo/i-4000.html
3. Wiring Diagrams - www.stewmac.com/freeinfo/i-1217.html
4. Linear vs. Audio Pots - www.fretnotguitarrepair.com/repair/electric-guitar/electronics.php
5. Ohm's Law - www.hamuniverse.com/ohmslaw.html
6. Ohm's Law - www.allaboutcircuits.com/vol_6/chpt_2/5.html
7. Guitar Pickups - www.wisegeek.com/what-are-guitar-pickups.htm
8. Soldering - www.americanautowire.com/view-faq/guide-to-proper-soldering-of-terminals/
9. Google Slide Presentation: Electric Guitar Controls by D. Hunt (guitarbuilding.org) https://docs.google.com/presentation/d/1Fb7aqZRs7mpcUFopm5DSWB_OQ66e1rERqQ_6nWmPofQ/edit#slide=id.p17

Activity:

This two-part activity is designed to teach the design and function of an electric guitar control circuit. In part one, you will learn about individual electronic components and Ohm's law for Voltage, Resistance and Current. In part two, you will learn how to assemble an electric guitar control circuit according to a circuit diagram, write a circuit diagram of your own, and demonstrate proper soldering and grounding techniques for an electric guitar control circuit.

Name _____

Guitar Electronics

Part One: Electrical Circuit Terminology and Ohm's Law Basics

Define the related terminology for this lesson:

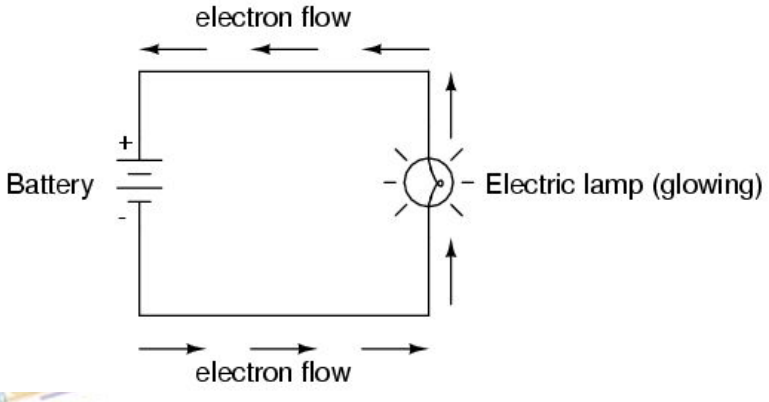
1. Volts _____
2. Ohms _____
3. Amps _____
4. Ground _____
5. Conductor _____
6. Insulator _____
7. Potentiometer _____
8. Capacitor _____
9. Pickup _____
10. Ohm's Law _____

Ohm's Law explained: In this algebraic expression, voltage (E) is equal to current (I) multiplied by resistance (R). Using algebra techniques, we can manipulate the equation, E = IR into two variations, solving for I and for R, respectively:

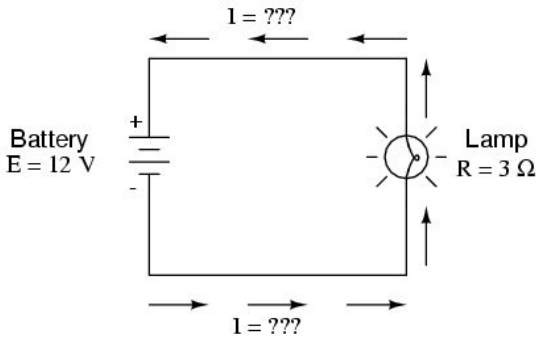
$$I = \frac{E}{R} \qquad R = \frac{E}{I}$$

Let's see how these equations might work to help us analyze simple circuits:

In this circuit, there is only one source of voltage (the battery, on the left) and only one source of resistance to current (the lamp, on the right). This makes it very easy to apply Ohm's Law. If we know the values of any two of the three quantities (voltage, current, and resistance) in this circuit, we can use Ohm's Law to determine the third.



In this example, we will calculate the amount of current (I) in a circuit, given values of voltage (E) and resistance (R):

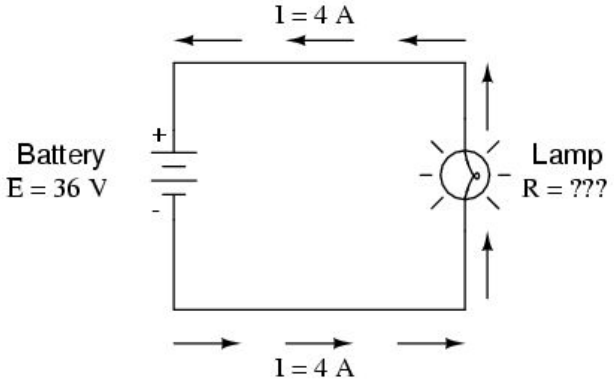


What is the amount of current (I) in this circuit?

$$I = \frac{E}{R} = \frac{12\ V}{3\ \Omega} = 4\ A$$

In this second example, we will calculate the amount of resistance (R) in a circuit, given values of voltage (E) and current (I):

What is the amount of resistance (R) offered by the lamp?

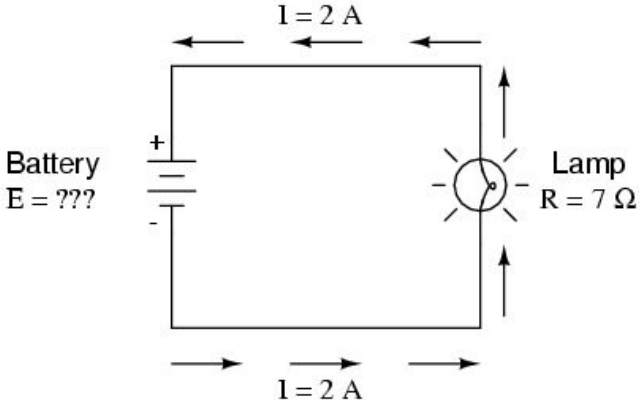


$$R = \frac{E}{I} = \frac{36\ V}{4\ A} = 9\ \Omega$$

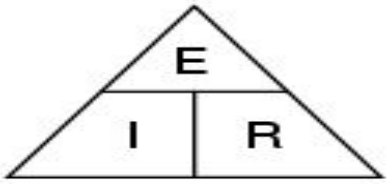
In the last example, we will calculate the amount of voltage supplied by a battery, given values of current (I) and resistance (R):

What is the amount of voltage provided by the battery?

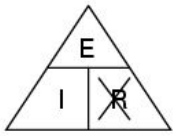
$$E = IR = (2\ A)(7\ \Omega) = 14\ V$$



Ohm's Law is a very simple and useful tool for analyzing electric circuits. It is used so often in the study of electricity and electronics that it needs to be committed to memory by the serious student. For those who are not yet comfortable with algebra, there's a trick to remembering how to solve for any one quantity, given the other two. First, arrange the letters E, I, and R in a triangle like this:

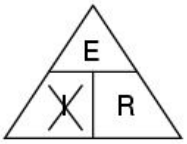


If you know E and I, and wish to determine R, just eliminate R from the picture and see what's left:



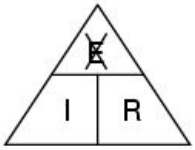
$$R = \frac{E}{I}$$

If you know E and R, and wish to determine I, eliminate I and see what's left:



$$I = \frac{E}{R}$$

Lastly, if you know I and R, and wish to determine E, eliminate E and see what's left:



$$E = I\,R$$

Now solve the equations below using Ohm's Law

	Solve	**Formula: Derive from Ohm's Law**	**Equation: Insert actual values**	**Answer: Be sure to label V, A, or Ω**
1	E = 8 V I = 1mA (.001 A) R =?			
2	R=2.5 k Ω (2,500 Ω) E = 12.5 V I = ?			
3	I = 1.5 A (1,500 Ω) R = 900 Ω E = ?			
4	E = 8 V I = 3 mA (.003 A or $3x10^{-3}$ A) R =?			
5	R= 5k Ω (5,000k Ω) E = 12.5 V I = ?			
6	I = .75 A or 750 mA R = 900 Ω E = ?			
7	**Analyze** your data. What happens to R when I increases?			
8	**Predict.** What will happen to I (current) when E increases? Why?			

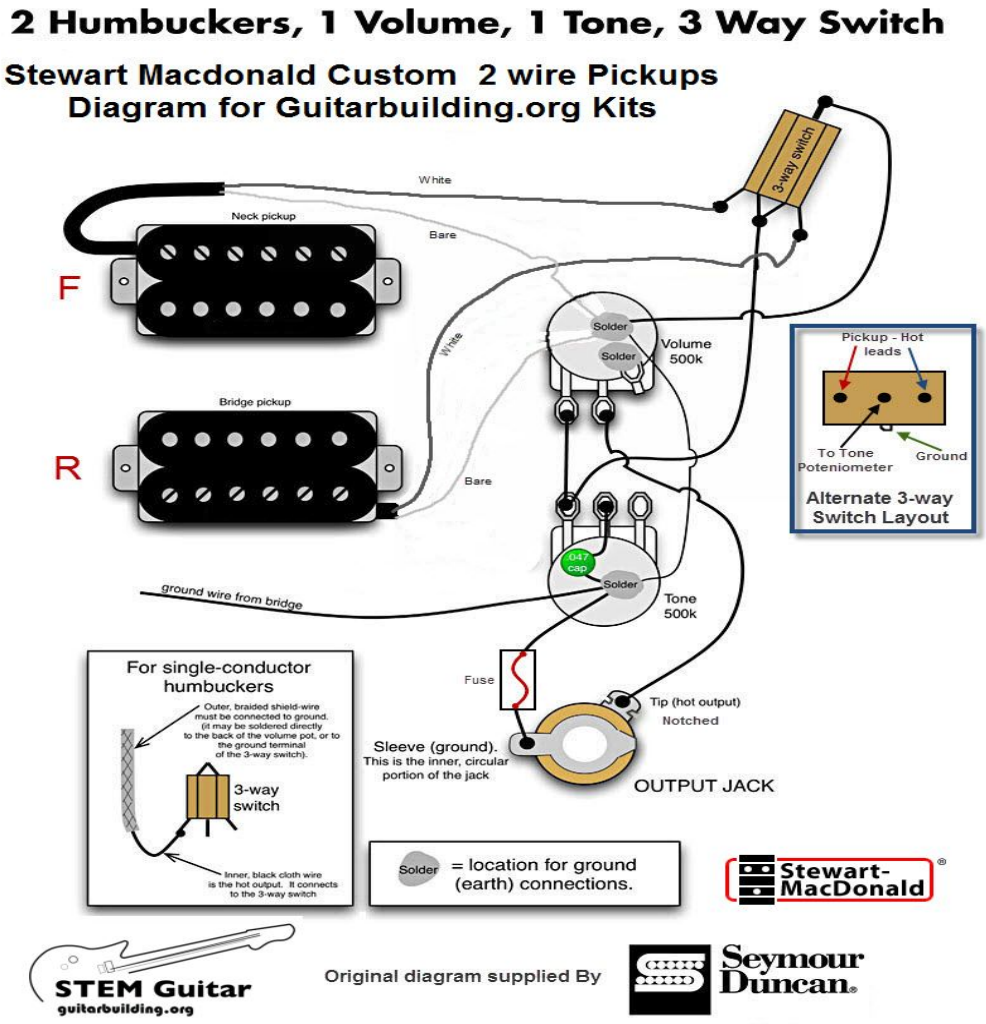
Name _____

Guitar Electronics

Part One: Assembling and Testing Electrical Circuits

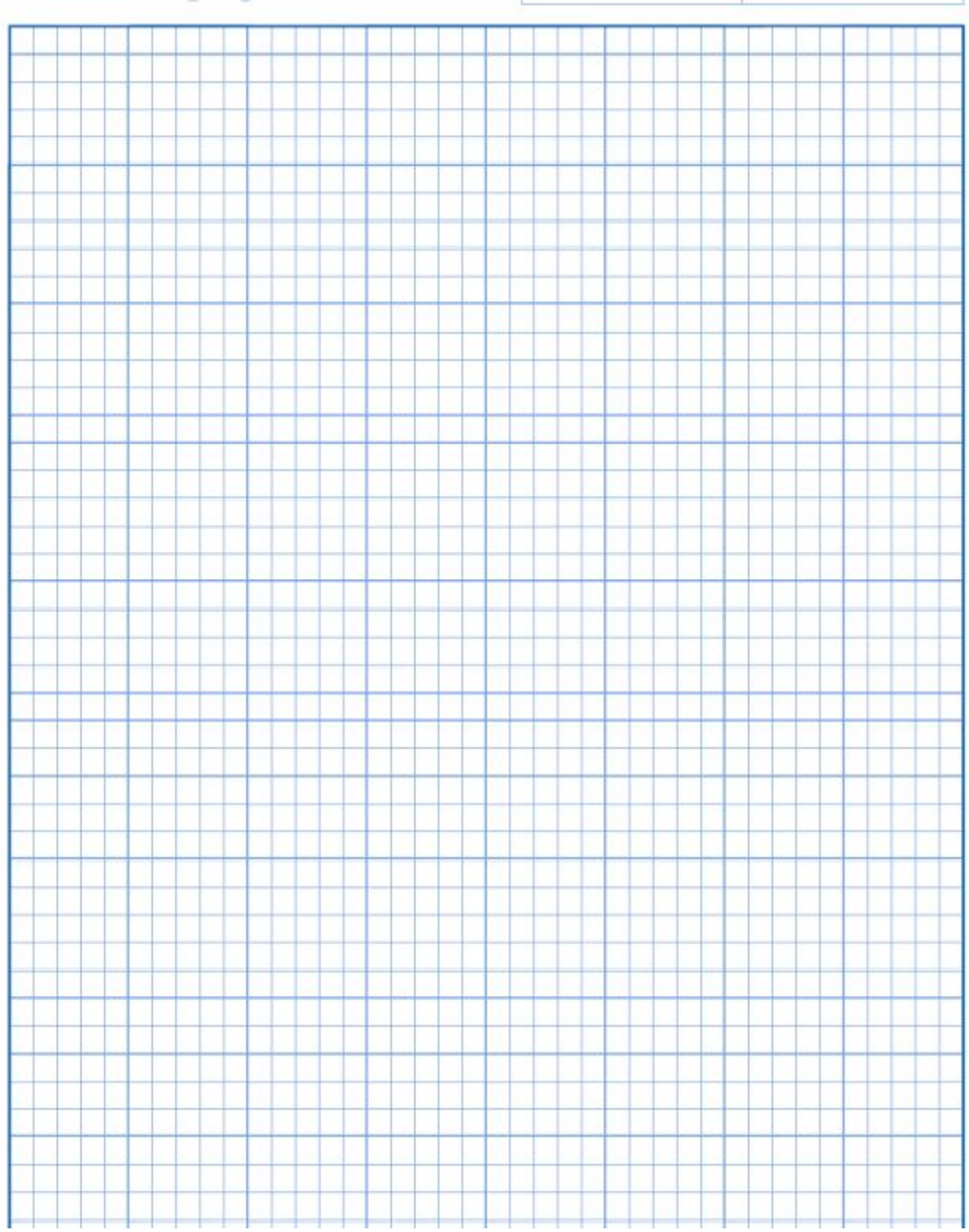
To begin, review the PowerPoint Presentation: *Electric Guitar Controls by D. Hunt*

- ✓ Carefully lay out all components as shown in the powerpoint and on the graphic below
- ✓ Double check layout and component location
- ✓ Strip jumper wire insulation ¼ inch for all wires and some will be completely bare
- ✓ Lay stripped wires on nodes and component terminals as per drawing
- ✓ Review techniques for soldering components
- ✓ Solder items to nodes or terminals



✓

Review Schematic Symbols. Draw the circuit schematic Diagram here (use pencil). Be sure to draw carefully and use a straight edge (ruler).



Name _____

Assessment
Guitar Electronics

1. When measuring continuity, which value is being tested?

   A. Volts
   B. Ohms
   C. Amps
   D. Watts

2. Continuity is directional; be careful when placing the leads as it will affect the outcome of the test.

   True -or- False

3. After connecting the electrical system you notice a hum. This is likely due to:

   A. The wrong size capacitor was in the circuit
   B. The pickup connection is loose
   C. The ground wire(s) are not connected properly
   D. The selector switch is stuck in the wrong position

4. The ground wire should be connected to the exposed metal case of the potentiometer.

   True -or- False

5. The capacitors being used with the potentiometers are set up to create a(n) _____.

   A. Hi pass filter
   B. Equalizer
   C. Low pass filter
   D. None of the above

6. Potentiometer + capacitor = _____

A. Volume
B. Vibrato
C. Tone
D. None of the above

7. The ¼" jack has two leads. One lead is the ground and the other lead is the signal out. The sleeve or inner cylinder of the jack is the ground.

True -or- False

8. What type of pickups are installed in our electric guitar?

A. Contact ribbon
B. Electromagnetic
C. Piezoelectric
D. Dynamic condenser

9. A common term for a poor solder joint a _____

A. Grounded Solder Joint
B. Slipped Solder Joint
C. Cold Solder Joint
D. None of the above

10. This term refers to melting solder on both contacts before you attempt to solder them. This coats or fills the wires or connector contacts with solder so you can easily melt them together.

A. Brazing
B. Tinning
C. Grounding
D. Desoldering

Assessment Key:

1. B - Ohms
2. False
3. C - The ground wire(s) are not connected properly
4. True
5. C - Low pass filter
6. C - Tone
7. True
8. B - Electromagnetic
9. C - Cold Solder Joint
10. B - Tinning

Reviewing Faculty Cohort Members:

Alex Moll, Lake Stevens Middle School (11/2017)
Chad McCormack, Wells High School, Wells, ME (3/2018)
Dave Parker, Noble High School, North Berwick, ME (3/18)