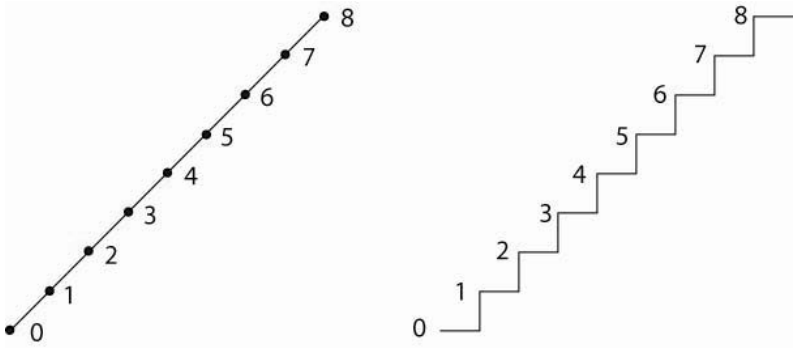
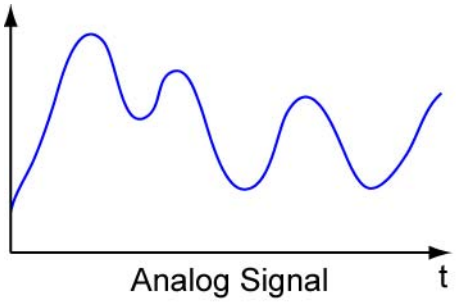
Basic Electrical Meters Tutorial
Cornerstone Electronics Technology and Robotics I Week 3

- Administration:
  - Prayer
  - Bible Verse
  - Turn in quiz
- Electricity and Electronics, **Chapter 2,** Meters:
  - Terms and Definitions:
    - Analog vs. Digital Displays: Analog displays have a continuous range of values while digital displays have discrete levels or integers.
    - Concept: If you were climbing a ramp as in the diagram below, you could stop at any level on the ramp; say 4.23' above the ground. The ramp has a continuous slope with an infinite number of possible levels in between each foot marker. However, if you climb the steps, you can only stop at the discrete levels of the foot markers. You could not stop at 4.23' above the ground; you could only stop at 4' or 5' above the ground.

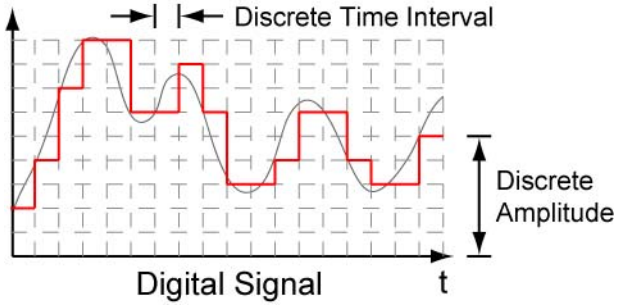


A Ramp (Analog) **Steps (Digital)**

- Analog vs. Digital Signals: Analog signals are continuous where a digital signal is a signal for which amplitude and time are discrete.

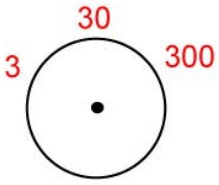


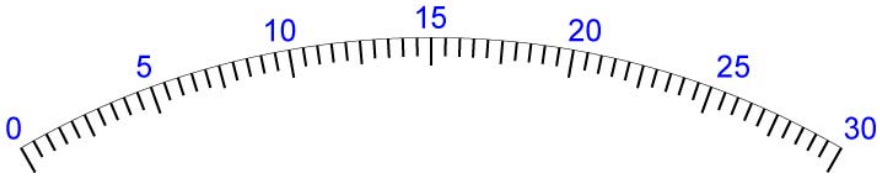
The amplitude of an analog signal changes continuously with time. An analog signal has a theoretically infinite resolution.

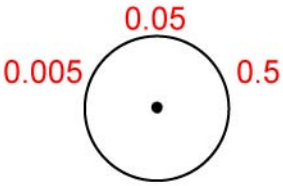


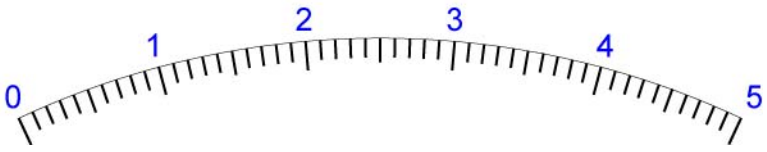
An analog signal may be converted to a digital signal by sampling the analog signal at discrete time intervals and converting the analog amplitude to a discrete digital amplitude.

- **Analog Meter**: A meter that uses a scale with continuous range of values.
  - Practice reading analog scales:



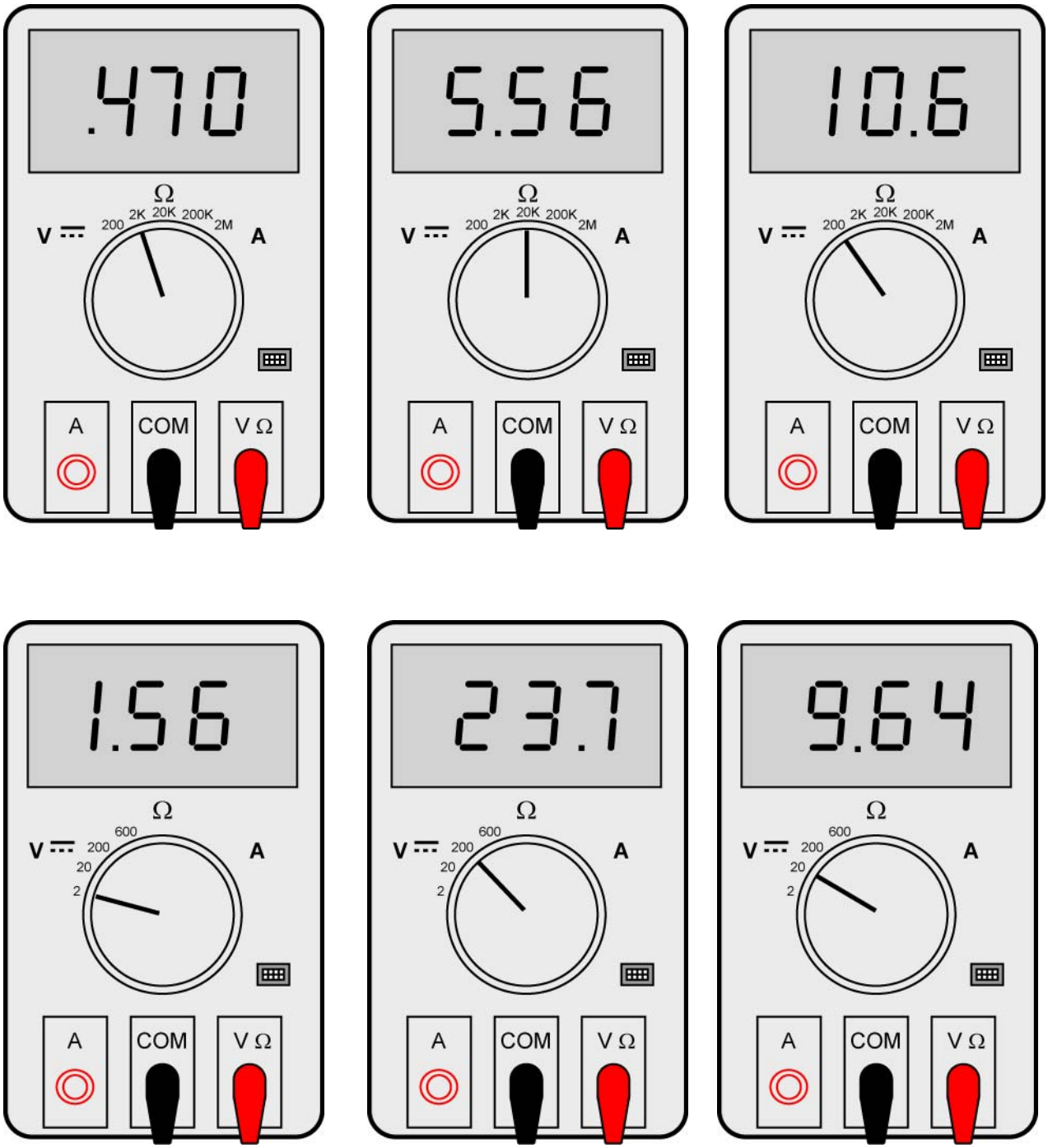






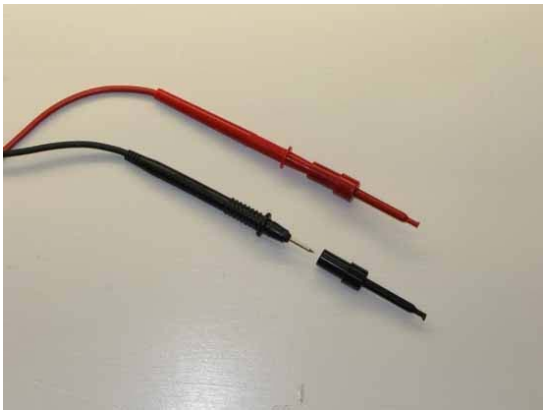
  - Read analog scale examples: vernier calipers, thermometer.
  - Student Activity Sheet 2-2

- **Digital Meter**: A meter that gives values only in discrete amounts.
    - Practice reading digital scales:

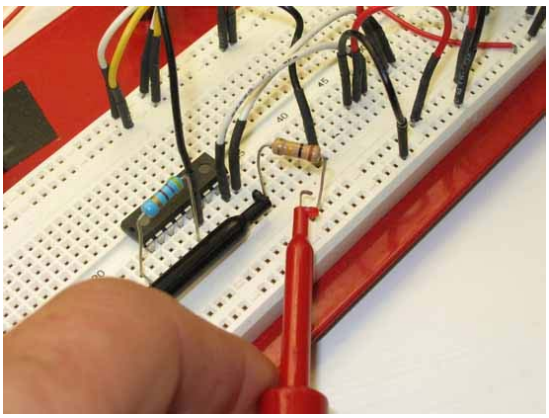


    - Read digital scale examples: calipers, micrometer, digital multimeter (DMM), and thermometer.
- See: http://pioneer.netserv.chula.ac.th/~tarporn/311/HandOut/DmmPPT.pdf

- Meter Probe Adapters: Attaches test probes to component and IC leads. See: http://www.radioshack.com/home/index.jsp Part #270-334
- When removing the adapter from the test probe, **push from the base** of the adapter.

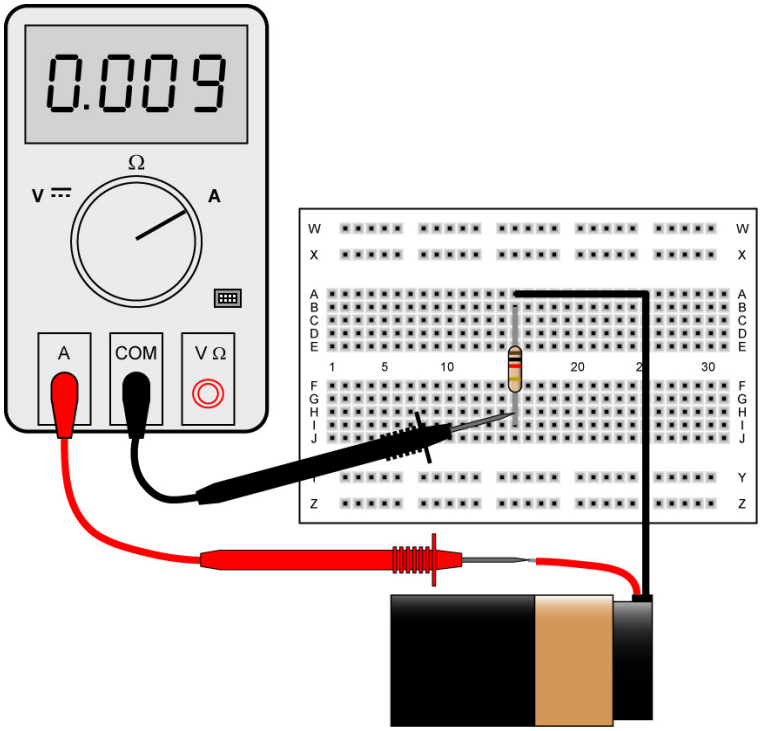


Attach Adapters to Test Probes



Attach Adapter to Component Lead

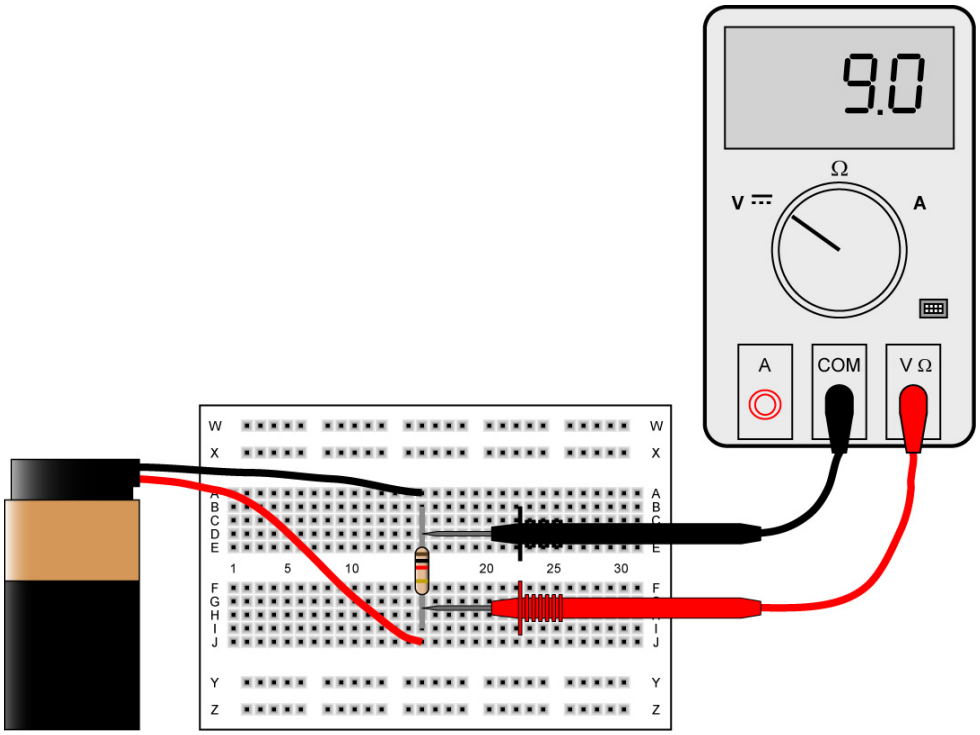
- Electricity and Electronics, **Section 2.2**, Ammeter:
  - Terms and Definitions:
    - **Ammeter**: An ammeter measures electrical current in a circuit.
  - Using an ammeter to measure current:
    - An ammeter must always be connected in series (in line) with a circuit component. In other words, the circuit must be broken at the point of measurement and the ammeter inserted.
    - When a current value is unknown, begin with the highest meter range.
    - **Never** connect an ammeter to a power source.
    - In dc circuits, the polarity of the meter must match the battery polarity; the positive (+) terminal of the ammeter connects toward the positive (+) side of the battery and the negative (-) terminal of the ammeter connects toward the negative (-) terminal of the ammeter connects toward the negative (-) side of the battery.
    - Sample reading:



Ammeter Inserted into a Circuit

  - Perform Basic Electrical Meters Lab 1 – Ammeter

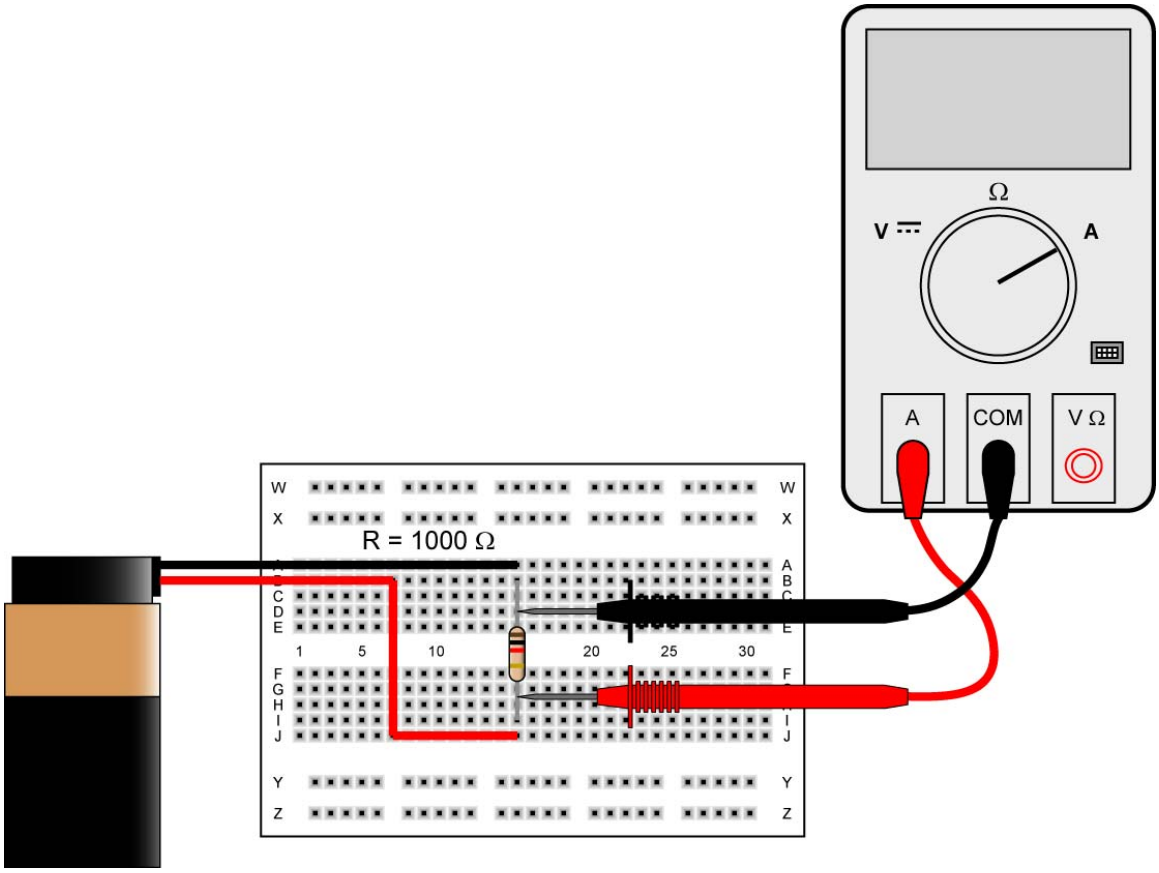
- Electricity and Electronics, **Section 2.3**, Voltmeter:
  - Terms and definitions:
    - **Voltmeter**: A voltmeter measures voltage in an electrical circuit. Voltage is *always relative between two points*. There is no such thing as voltage "on" or "at" a single point in the circuit. The voltage reading on a voltmeter is the voltage at one point in the circuit compared to another point in the circuit.
  - Using a voltmeter to measure voltage:
    - Voltmeters <u>are always</u> connected <u>in parallel</u> with the component (across the component); the circuit is not broken as with the ammeter.
    - When the voltage is unknown, <u>start with the highest</u> meter range.
    - In dc circuits, the <u>polarity of the meter must match the battery polarity</u>; the positive (+) terminal of the voltmeter connects toward the positive (+) side of the battery and the negative (-) terminal of the voltmeter connects toward the negative (-) side of the battery.
    - Sample reading:



Voltmeter Connected in Parallel with the Component

  - Complete Basic Electrical Meters Lab 2 – Voltmeter
  - See:
    - http://micro.magnet.fsu.edu/electromag/java/ohmslaw/
    - http://www.ngsir.netfirms.com/englishhtm/Circuit.htm

- Electricity and Electronics, **Section 2.4,** Ohmmeter:
  - Terms and definitions:
    - **Ohmmeter**: An ohmmeter measures electrical resistance which is the opposition to the flow of an electric current.
    - Always make sure that the power is off to the circuit.
    - When measuring resistance, the resistor must be disconnected from the circuit.
    - When the resistance is unknown, as usual, <u>start with the highest</u> meter range.
  - Special Readings for an Ohmmeter:
    - A reading of zero indicates a short circuit.
    - A reading of infinity indicates an open circuit.
  - Perform Basic Electrical Meters Lab 3 – Ohmmeter

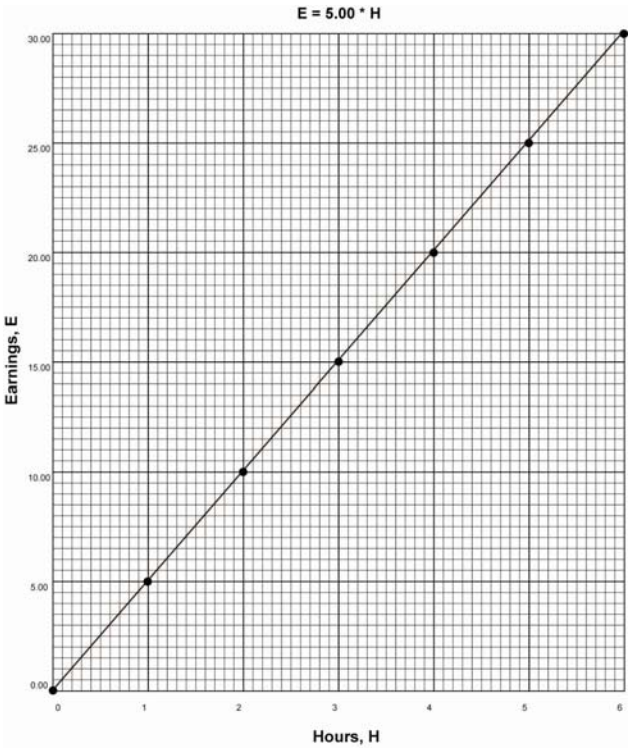


Is There Anything Wrong with This Meter Setup?

- Electricity and Electronics, **Section 2.5**, Digital Multimeters (DMM):
    - Digital multimeters are so named because they have the ability to measure a multiple of variables: voltage, current, resistance, transistors, and often many others.
    - Additional practices when making electrical measurements:
        - Make a touch test first. Clip the ground lead first, and then touch the red lead to the measuring point before clipping the lead to that point in the circuit.
        - Make sure the leads do not cross over or come in contact with other connection points, causing a possible short circuit.
        - Always check the selector mode and meter jacks before connecting the leads. This is especially true when measuring voltage after you have measured current or resistance.

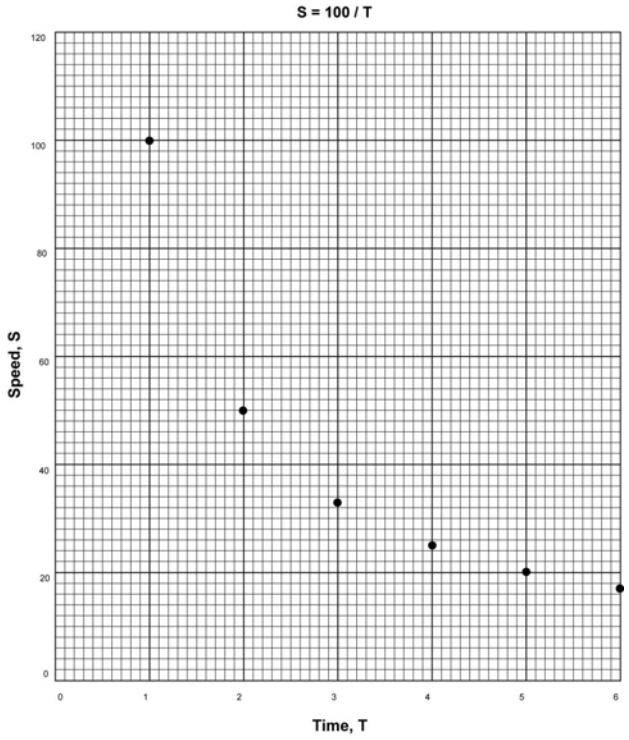
  Electricity and Electronics, **Section 1.4,** Ohm's Law (Introduction):
    - Review relevant algebra
    - Terms and Definitions:
        - **Directly Related:** Two terms, A and B, are directly related if as A is increased, B increases and B's increase is proportional to A's increase. For example, let's say you are paid a wage of $5.00/hour. Then your earnings (E) are equal to your wage times your hours (H) worked, or E = 5.00 H. The terms E and H are directly related since E increases in proportion to an increase in H. If H is doubled, E is doubled; if H is tripled, E is tripled, etc. See the table and graph below:

E = 5.00 H	
Hours, H	**Earnings, E**
1	$5.00
2	$10.00
3	$15.00
4	$20.00
5	$25.00
6	$30.00



- **Inversely Related:** Two terms, X and Y, are inversely related if as Y is increased, X decreases and X's decrease is proportional to Y's increase. For example, assume you have to travel a distance of 100 miles. Your speed (S) is equal to the distance divided by the time (T) it takes you to travel the 100 miles, S = 100 / T. So if your travel time, T, is 1 hour, then your speed, S, is 100 miles/hour. If you double T, (2 hours), then your speed is halved, (50 miles/hour), and if you triple T, (3 hours), then your speed is one third, (33.3 miles/hour), etc. The terms S and T are inversely related since S decreases in inverse proportion to an increase in T. See the table and graph below:

S = 100/T	
Time, T (In Hours)	Speed, S (In mph)
1	100
2	50
3	33.33333
4	25
5	20
6	16.66667



- Suggested Activity Sheets 2-2, 2-3

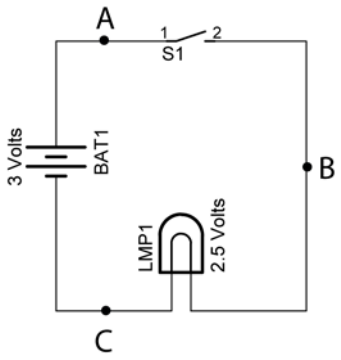
Electronics Technology and Robotics I Week 3
Basic Electrical Meters Lab 1 – Ammeter

- **Purpose:** The purpose of this lab is to acquaint the student with measuring current using an ammeter and to become acquainted with current relationships in a series circuit.

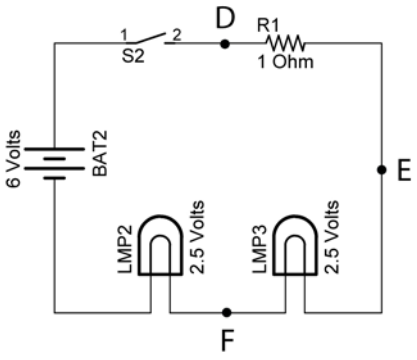
- **Apparatus and Materials:**

  - 1 – Digital Multimeter (DMM)
  - 1 – Battery Holder and Battery
  - 1 – SPST Switch
  - 1 – 1 Ohm Resistor
  - 2 – Lamp Holders
  - 2 – 2.5 V Lamps
  - Alligator Clips

- **Procedure:**
  - Wire the following circuits and then use your ammeter to measure the current at each point labeled.
  - Record your results in the tables below.
  - Write your conclusions regarding your results.



Circuit 1



Circuit 2

- **Results:**

Point	Current in mA
A	
B	
C	

Circuit 1

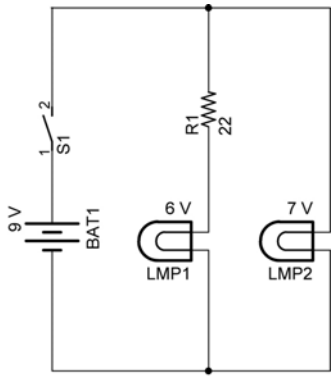
Point	Current in mA
D	
E	
F	

Circuit 2

- **Conclusions:**

Electronics Technology and Robotics I Week 3
Basic Electrical Meters Lab 2 – Voltmeter

- **Purpose:** The purpose of this lab is to acquaint the student with measuring voltage using a voltmeter.
- **Apparatus and Materials:**
  - 1 – Digital Multimeter (DMM)
  - 1 – Battery Snap and 9 V Battery
  - 1 – SPST Switch
  - 1 – 22 Ohm Resistor (Red, Red, Black)
  - 2 – Lamp Holders
  - 1 – 6 V Lamp and 1 – 7.5 V Lamp
  - Alligator Clips
- **Procedure:**
  - In the Circuit 3 below, close the switch then measure and record the voltage:
    - Across the battery terminals
    - Across the resistor
    - Across the 6 volt lamp. Add the voltage drops across the resistor and the 6 volt lamp, then compare the sum with the voltage drop across the battery.
    - Across the 7.5 volt lamp. Compare this reading with the voltage drop across the battery.
    - In the conclusions, describe how the sum of the voltage drops across the 6 V lamp and the resistor compare to the battery.



Circuit 3

- **Results:**

Component	Voltage in Volts
Battery	
Resistor	
6 V Lamp	
7.5 V Lamp	

- **Conclusions:**

Electronics Technology and Robotics I Week 3
Basic Electrical Meters Lab 3 – Ohmmeter

- **Purpose:** The purpose of this lab is to acquaint the student with measuring resistance using an ohmmeter.

- **Apparatus and Materials:**

    - 1 – Digital Multimeter (DMM)
    - Assortment of Resistors

- **Procedure:**
    - Measure and record the value of each resistor.

- **Results:**

Resistor	Resistance in Ohms
A	
B	
C	
D	
E	
F	
G	
H	