

Resistance Lab Review

ENGR 112

Overview

- Review of the general description of the resistance of an element.
- Multi-meter fundamentals.
- Potentiometer construction.
- Lab review:
 - Part 1
 - Part 2
 - Part 3
 - Part 4

Resistance of an Element

- The resistance of a thin element is generally described in terms of material properties and geometry:

$$R = \rho \frac{L}{A} \quad R = \rho \frac{L}{A}$$

where: ρ -*resistivity of element*

A -*cross-sectional area of element*

L -*length of element*

Exercise

- A high voltage power line is 20 miles long and has a diameter of 1.5 inches. The power line is made with aluminum which has a resistivity of $0.0278 \Omega\text{mm}^2/\text{m}$. Note: The power line is actually a bundle of smaller wires, but it will be assumed that the bundle can be approximated by a single wire with a diameter equal to the bundle diameter. Calculate the overall resistance. (1 mi = 1.609 km)
- A lead to attach a chip to a semiconductor board is made of gold ($\rho=0.0222 \Omega\text{mm}^2/\text{m}$). The lead is 1 cm in length and has a diameter of 10 microns. Calculate the overall resistance. (1 micron = 10^{-6}m)

Multimeter Review

- Multimeters are instruments that are used to measure voltage, resistance, and currents.
 - Fancier models can also check chips, diodes, capacitors, continuity and measure temperature.
- Voltages: DC and AC (check ranges)

Multimeter Overview



Symbol for DC voltage
Note scales: 200 mV to 600 V



Symbol for AC voltage



Symbol for resistance
Note scales. 200 Ω to 20 M Ω



Symbol for DC amperage



Symbol for continuity checking



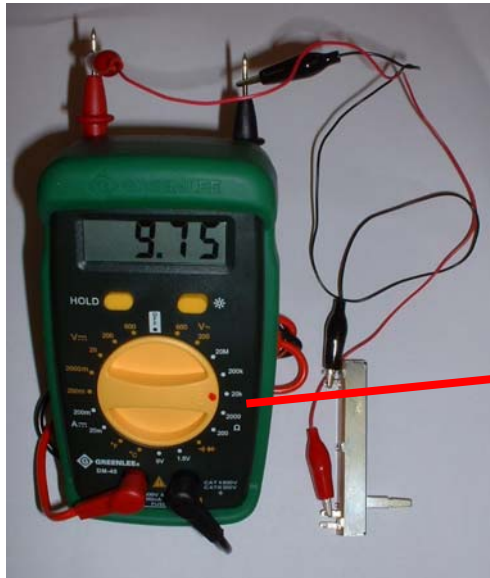
Symbol for + port



Symbol for - port

Using A Multimeter

- Voltage is measured **ACROSS** two points.
- Current is measured **THROUGH** a point.
 - Have to break the circuit.
- Resistance of an element has to be measured with nothing else attached to it



Meter reads 9.75 k Ω

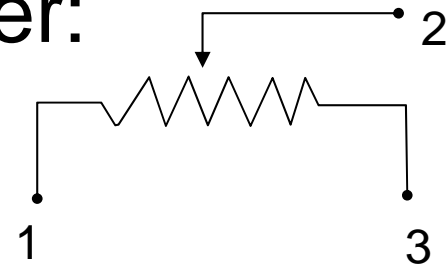
→ 20 k Ω scale

Potentiometer Construction

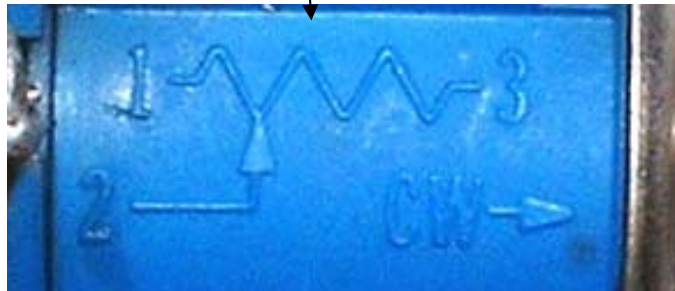
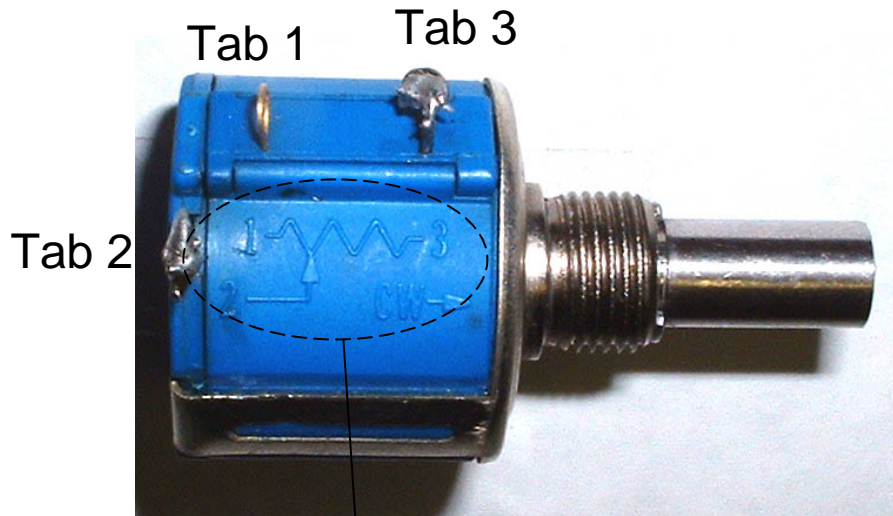
- Potentiometers are variable resistors.
- Most potentiometers are constructed such that the change in resistance occurs due to a change in geometry.
 - Primarily done by changing the length.
 - Easier to get a linear relationship between change in position and change in resistance.

$$R = \rho \frac{L}{A}$$

Schematic for a potentiometer:



Rotary Potentiometer



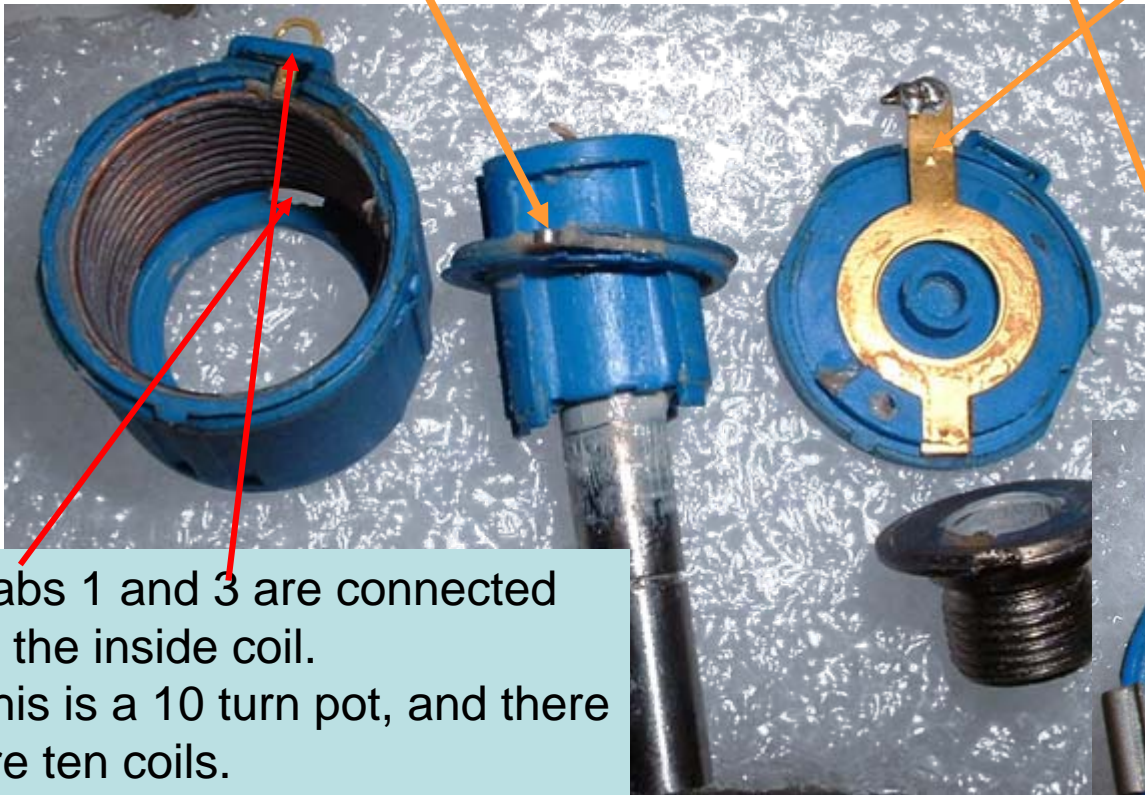
Measuring resistance across tabs 1 and 3 should yield the full resistance ($5\text{k}\Omega$). Measuring the resistance between tabs 1 and 2 will yield the resistance between tab 1 and the wiper connected to tab 2.

Rotary Potentiometer cont.

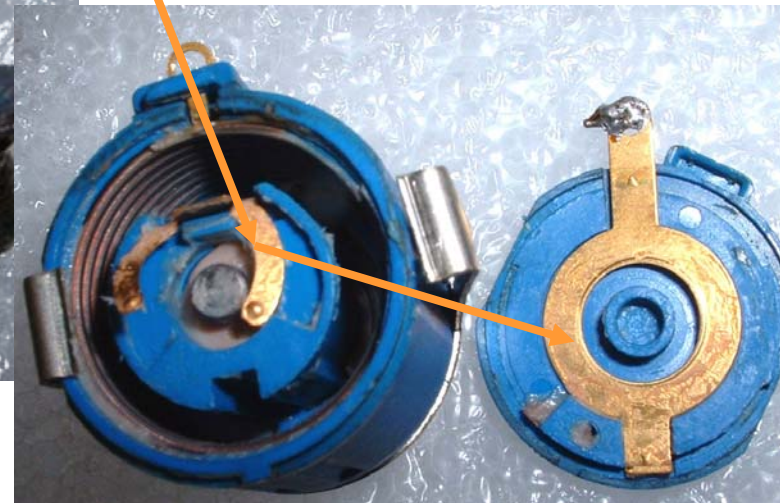
Wiper 1 contacts the coil is connected to tab 2 by a contact strip and an additional wiper 2.

Wiper 1 travels similar to a bolt in a nut as the edge of the wiper holder travels between the grooves of the coil.

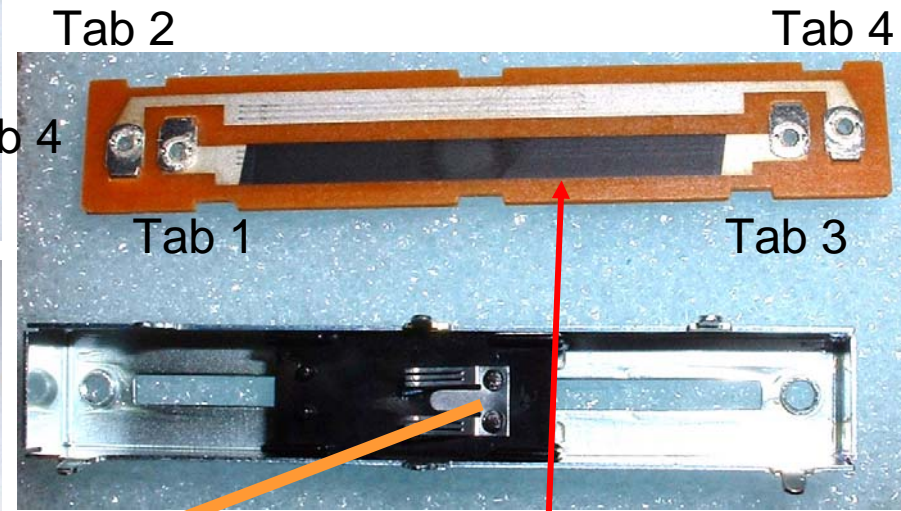
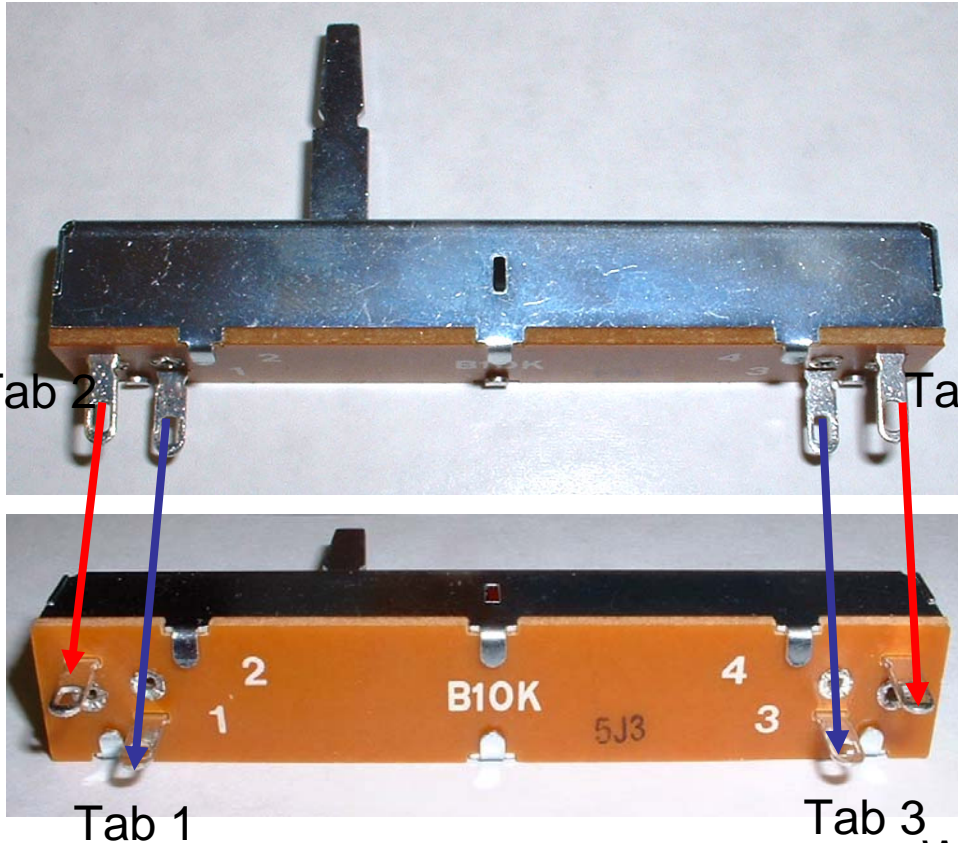
The goey stuff is a combination lubricant and conductive paste.



Tabs 1 and 3 are connected to the inside coil. This is a 10 turn pot, and there are ten coils.



Linear Potentiometer



Wiper to bridge from carbon strip between tabs 1 and 3 to tabs 2 and 4.

Carbon Black

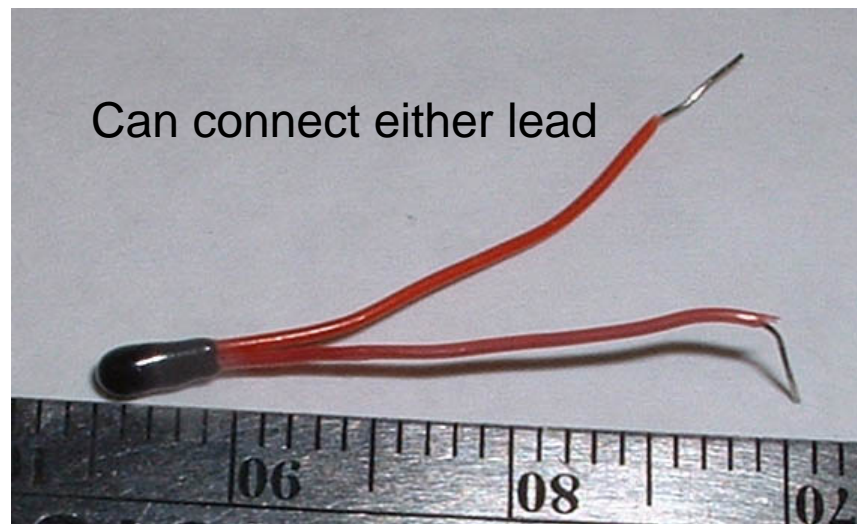
- The resistance of the carbon black can vary by:
 - Changing the geometry
 - By allowing it to absorb moisture.
- Resistance and moisture absorption ability is controlled by the percent carbon black present by weight



Material is made using Carbon black (printer toner) And a binder (glue, epoxy). It can be fairly brittle.

Thermistor

- The resistance of a thermistor changes due to a change in resistivity since the geometry of the thermistor doesn't change. Semiconductor properties govern the resulting behavior.
- Often used as a temperature regulator in clothes dryers.



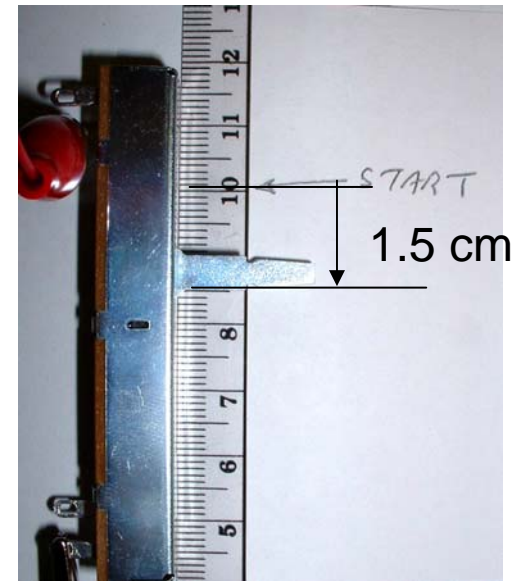
Physics Lab: Part 1-Rotary Potentiometer

- 1) Connect the leads to pins 1 and 3 on the potentiometer and measure the full resistance.
- 2) Connect the leads to pins 2 and 3. Turn the pot CCW till it stops. Record the resistance for each turn CW (clockwise).



Physics Lab: Part 2-Linear Potentiometer

- Connect multimeter to tabs 1 and 3 and record the resistance.
- Slide the stem all the way toward tab 1. Connect the lead on tab 3 to tab 4. Advance the stem in 0.5 cm increments and record the resistance.



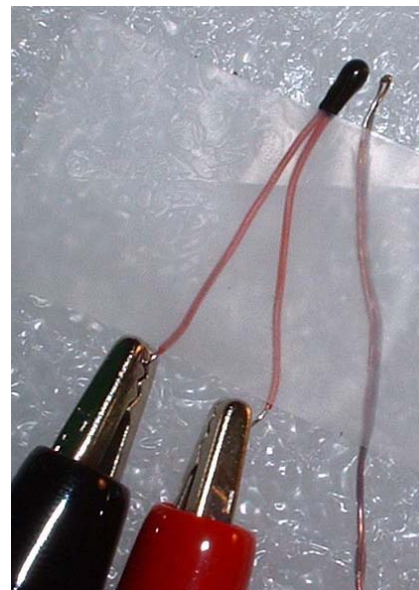
Physics Lab: Part 3- Carbon Black

- Handle the Carbon Black strip very carefully as it is fairly brittle.
- Connect the leads so that they are separated by 4 cm. Record this resistance.
- Fold a piece towel so that it is about 1.5 to 2 cm wide and wet it. Place the wet area on top of the carbon black between the two clips. Record the resistance value every 30 seconds, for 5 minutes.



Physics Lab: Part 4-Thermistor

- The leads for the thermistor are very small. Handle with care.
- Connect a multimeter lead to each leg of the thermistor. Make sure the thermistor and temperature probe are next to each other. Record the resistance value and room temperature. Be sure to note the units.
- Pinch the temperature probe and thermistor between the thumb and forefinger. Record the temperature and resistance when the temperature stabilizes.
- Repeat for other temperature sources.



Wrap Up

- Variable resistance components either vary geometry or resistivity.
- Multimeters are instruments to measure electrical properties.
- The equipment you use may be different, but the principles of operation are essentially the same.