Unit Plan: Ohm’s Law – Current, voltage and resistance
Content Standard: Physics SP4 -
Students will evaluate relationships between electrical and magnetic forces.
a. Describe the transformation of mechanical energy into electrical energy and the transmission of electrical energy.

Electricity is a difficult subject for student’s to grasp. A student cannot see an electron move. A student does not feel voltage unlike a force. Electricity is an abstract concept that must be explored by observing its effects. Analogies are useful in this topic, and there are many useful ones to use.

Key concepts: Voltage, Resistance, Current, Metals, Semiconductors, Insulators, Diodes, Transistors, Doping,

Voltage can be introduced by using an analogy of BB’s to represent units of charge. The more BB’s raised to a certain height, the more energy the group has. The amount of energy in the system due to gravity is the weight of the BB’s multiplied by the height of the BB’s. The amount of energy per BB is the gravitational equivalent of voltage.

Current is easier to get across to students. It is a rate, and an analogy of students passing in the hall during the class change can be used. The number of students per minute is like the amount of gallons of water per minute in a pipe, is like the number of coulombs per second in a wire.

Next, I use a lab to introduce resistance. I give the students a variable power supply, two digital multimeters, resistors of unknown values and a 6V light bulb in a socket. I have the students find the voltage and current in the resistors and light bulbs for a range of voltages 0-20V for the resistors and 0-6V for the light bulb. The students plot the voltage versus the current and find that the resistors have constant slopes and the light bulb does not. I can then explain that the ratio of the voltage to the current is resistance. Some materials have constant resistances in a given range and others do not. This can lead into a discussion of Ohm’s Law and the difference between Ohmic and non-Ohmic materials.

I would then discuss the change in resistance for the light bulb and show how temperature affects the resistance. The class would be assigned a second lab, this one using a water bath to change the temperature of the metal, an insulator, and a semiconductor. As the temperature of the materials is raised from 0°C to 100°C, the resistance is measured. It is usually best to measure these with a digital multimeter set to measure resistance directly. As the temperature rises, the resistance will increase for the metal, but decrease in the semiconductor.

After these labs, I would then explain the concept of valance and conduction bands in a solid material and the location of the electrons in the conduction bands gives rise to the metal being a good conductor, but that the electrons completely fill the valance band and the gap is too large in the insulator and the semiconductor for these electrons to get to the conduction band.
Four variables determine the resistance of an object. The length of the object, the cross section of the object, the temperature and the material it is made of. I would explain to the students how the number of free charge carriers increases as the material gets thicker. As the object gets longer, the probability of a charge carrier being absorbed by the vibrating lattice, in other words, falling back into the potential well of an atom. I would assign problems involving Ohm’s Law. I would then assess the students at this point. A summative exam of the unit would be a unit test consisting of multiple choice, short answer and problems.