Lesson Title	Construction of an Ammeter and a Voltmeter from a Galvanometer
Length of Lesson	1 day
Created By	Jed Leggett, William Funderburk
Subject	Physics
Grade Level	11-12
State Standards	Physics 5b
DOK Level	3
DOK Application	Investigate, Compare, Hypothesize
National Standards	9-12: B (Physical)
Graduate Research Element	Input and Output Impedance

Student Learning Goal: Students will use their understanding of parallel and series circuits to calculate the resistance needed to turn a galvanometer into either an ammeter or Voltmeter.

Physics: 5. Apply understanding of magnetism, electric fields, and electricity: (b) Use schematic diagrams to analyze the current flow in series and parallel electric circuits, given the component resistances and the imposed electric potential.

National Science Education Standards of Content 9-12
B (Physical): Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students understand electric motors and generators.

Materials Needed (supplies, hand-outs, resources): galvanometer, 2 resistor decade boxes, voltmeter, small copper wire (18-24 gauge), voltage source (i.e. battery, DC power supply)

Lesson Performance Task/Assessment:
In this lesson, students will first construct simple circuits to determine the resistance and maximum current of an ammeter. They will then use these measured values to construct both an ammeter and a voltmeter to operate within a specified range.

Lesson Relevance to Performance Task and Students:
This lesson will deepen students understanding of the difference between series and parallel circuits, which are often employed in electrical devices. This lesson will also make students aware that all meters are constructed by humans and thus have certain limitations.

Anticipatory Set/Capture Interest:
The teacher will begin class by applying an excess voltage to a small resistor, causing it to burn up. The teacher will then lead a discussion on the necessity of accurate meters to prevent the overloading of circuits.

Guided Practice:
The teacher will explain the procedure for measuring the resistance and current at maximum deflection in the galvanometer. The teacher will then explain why a voltmeter uses a large resistor in series with the galvanometer, why an ammeter uses a small resistor in parallel with the galvanometer, and how to calculate the size of the resistors needed for particular voltage and current ranges.

Independent Practice:
Students will first measure the resistance of the galvanometer using the following procedure: 1.) Construct a series circuit containing the voltage source, the galvanometer, and the decade box set to maximum, 2.) Reduce the resistance of the decade box until the galvanometer reads full deflection, 3.) Hook up the second decade box in parallel to the galvanometer, 4) Reduce the resistance in the second box until the galvanometer drops to half deflection. Since the resistance of the second box is much smaller than the first, the resistance of the second box is approximately equal to the resistance of the galvanometer.

Students will then measure the current needed to produce full scale deflection in the galvanometer by removing the second decade box and using ohm's law to calculate the current in the galvanometer at full deflection (applied voltage divided by the sum of the resistance in the first box plus the resistance of the galvanometer).

Students will then be given particular voltage and current ranges for their devices (say 3V and 3 amps) and asked to construct a voltmeter and an ammeter that operate in the specified range.

Remediation and/or Enrichment:
R: individual IEP; partner help throughout lesson

E: The teacher can construct a complicated combination of resistors in series and parallel, and have students measure the total resistance using the procedure used on the galvanometer.

Check(s) for Understanding:
*****Why should a voltmeter have a large resistance?
* Why should an ammeter have a small resistance?

Closure:
Students will compare the readings on their devices will commercial multi-meters.

Possible Alternate Subject Integrations:
* Math – Students can be asked to find the resistance of a complicated combination of resistors in series and parallel. Such a task requires a lot of algebra.

Teacher Notes: