Internet of Things (IoT) at UCF

UNIVERSITY OF CENTRAL FLORIDA

UCF RET Site: Collaborative Multidisciplinary Engineering Design Experiences for Teachers

AP Physics C: Electricity and Magnetism

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RET Site: CoMET Lesson/Unit Plan

Course(s): AP Physics C: Electricity and Magnetism
Grade Level: 11&12
Suggested Length of Lesson: 1 40-minute class period and 2 50-minute class periods

Materials/Technology Needed	Where this Fits
▪ 100 Ω resistor (or similar resistor) ▪ Multimeter ▪ 1 F capacitor (or similar capacitor) *note: the larger the capacitance, the easier it is to measure and record data. Small capacitances run very fast and are difficult to record* ▪ Wires ▪ Adafruit conductive rubber cord stretch sensor ▪ Digital Calipers ▪ Meter Stick/Ruler ▪ 9 V battery or a power supply ▪ Single pole double throw switch ▪ Graphing Software or Data Analysis Software	▪ This lesson will be used at the end of the circuits unit in AP Physics C: Electricity and Magnetism. ▪ This lab activity is a synthesis of multiple topics covered throughout the unit and is very inquiry-based and provides students with an opportunity to design and perform an experiment. ▪ *Note: This lesson can be done without a capacitor for courses that cover resistance and resistivity but do not cover RC Circuits. This lesson can also be adapted to measure the current using an ammeter rather than the potential across the capacitor.

Lesson Objective(s)/Learning Goal(s)
▪ Students will be able to determine the capacitance of a capacitor and compare the measured capacitance to the labeled capacitance.
▪ Students will determine the resistivity of an unknown substance.
▪ Students will determine the time constant of an RC circuit.
▪ Students will be able to explain the purpose of a flexible strain sensor and explain how they work.
	Standard(s)/Benchmark(s) Addressed
	▪ *AP Physics C: Electricity and Magnetism*
	  ▪ *C.3.b.1- Calculate and interpret the time constant of the circuit*
	  ▪ *C.3.b.2- sketch or identify graphs of stored charge or voltage for the capacitor, or of current or voltage for the resistor, and indicate on the graph the significance of the time constant.*
	  ▪ *C.3.b.3- write expressions to describe the time dependence of the stored charge or voltage for the capacitor, or of the current or voltage for the resistor.*
	  ▪ *C.1.b.4- derive an expression for the resistance of a resistor of uniform cross-section in terms of its dimensions and the resistivity of the material from which it is constructed.*

Standards for Mathematical Practice ▪ MAFS.912.S-IC.2.6- Evaluate reports based on data ▪ MAFS.912.S-ID.3.7- Interpret the slope and intercept of a linear model in the context of the data ▪ MAFS.912.S-ID.3.8- Compute and interpret the correlation coefficient of a linear fit. ▪ MAFS.912.S-ID.2.6.a- Represent data on two quantitative variables on a scatter plot, and describe how the variables are related o Fit a function to the data; use functions fitted to data to solve problems in the context of the data	**Instructional Strategies** ▪ Guided Inquiry ▪ Cooperative Learning ▪ Experimental Reasoning ▪ Mathematical Modeling ▪ Experimental Error Analysis

Evidence of Learning (Assessment Plan) ▪ Students will submit a lab report including the following information: o Materials o Procedures o Data/Calculations o Error Analysis o Description of how flexible strain sensors work and how the lab represents a flexible strain sensor.	

Description of Lesson Activity/Experiences

- On day 1, students will be asked to research strain, strain gauges, and flexible strain sensors.
- After about 20-25 minutes of research, I will give a presentation on flexible strain sensors and their uses.
- On the second day, students will complete the guided inquiry lab activity in groups and analyze their data. After completing the activity and analyzing data, students will begin working to design their experimental procedure for the inquiry investigation portion of the lab.
- On the third day, students will complete the inquiry portion of the lab. For homework, students will complete their lab report for submission.
- Throughout all 3 days, the teacher will circulate the room to answer additional questions that students may have. The main goal of inquiry based learning is to have students design and learn with minimal assistance from teacher so they will not be given much assistance other than just direction.

Recommended Assessment(s) and Steps

- Students should know the general concepts of resistance, resistivity, and capacitance.
- Students should know the formulas associated with RC circuits and the relationships between the resistance, capacitance, and voltage in an RC circuit.
- Students will complete multiple lab activities before the implementation of this unit. This lab activity is a synthesis of multiple topics from the electrical circuits unit.
- Students will complete research on flexible strain sensors on day 1 and will learn about their uses.
- Students will complete the guided inquiry activity on day 2 and will plan out an experiment for the independent inquiry activity for day 3. Both days will be completed in groups.
- Students will submit a lab report and will be graded on the following criteria:
    - Experimental Procedure Design
    - Analysis of collected data
    - Analysis for experimental errors based on results and expected results
    - Explanation of how flexible strain sensors work and their uses. Explanation of how this lab corresponds to a flexible strain sensor.

Important Vocabulary

Term	Definition
• Strain Gauge	• A device that changes resistance when a force is applied.
• Resistance	• A measurement of the difficulty to pass an electrical current through a conductor.
• Resistivity	• A quantity that indicates how strongly a material will oppose the flow of electrical current.
• Voltage	• The amount of work required to move a positive charge from a reference point to a specific point inside the field without producing any acceleration.
• Capacitance	• The ability of a system to store an electrical charge. The ratio of the change in an electrical charge in a system to the corresponding change in its electric potential.
• RC Circuit	• A complete circuit that contains both a resistor and a capacitor.
• Time Constant	• For an RC Circuit, the time constant τ of the circuit is the product of the total resistance and the capacitance of the circuit. The time constant indicates the amount of time required for the exponential term to drop to 1/e or 37% of its original value. After 1 τ, the capacitor will have 63% (1-1/e) of the total charge if charging or will have discharged 63% of the total charge if discharging (37% remaining). Capacitors require 5τ to fully charge or discharge.

Troubleshooting Tips

- Ensure that students do not touch the switch or exposed metal while the capacitor is charging or discharging.
- Make sure that all wires are in proper working conditions without any internal wiring exposed.
- Make sure that the multimeter is hooked across the capacitor in parallel. If the reading of the voltage comes out negative, switch the leads of the multimeter.
- Make sure students are analyzing data with a best fit curve rather than using direct data points. Additional instruction on graphing and analyzing data may be required.

Attachments

- PowerPoints for lecture
- Strain Sensors and RC Circuits Lab Handout

References

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