Internet of Things (IoT) at UCF

UNIVERSITY OF CENTRAL FLORIDA

UCF RET Site: Collaborative Multidisciplinary Engineering Design Experiences for Teachers

Investigating Modern Materials

Terry Barchfeld

AP Physics Year 2

6/26/2018

RET Site: CoMET Lesson/Unit Plan

Course(s): AP Physics Year 2, AP Physics C: Electricity and Magnetism
Grade Level: 11, 12
Suggested Length of Lesson: Three days

Materials/Technology Needed

- Power Source, Batteries are fine
- Variety of Wire Materials: carbon fiber yarns, copper wires, 'alligator clips', nichrome wire
- Multimeters, Thermometers
- Beakers with water
- Steel marbles and superballs
- Impact Plates: carbon fiber, 'cellphone' glass
- Meter sticks
- Speaker with sound source
- Cellphone with app to measure decibels
- Box configured for 'soundproof' study
- Nitrile gloves for handling yarns

Where this Fits

- AP Physics Year 2 has a section on thermodynamics and a section on circuitry. This lesson would be a cumulative activity that ideally occurs after those two sections have been covered.
- Any physics classes that have covered conservation of energy and circuits could do most of this activity

Lesson Objective(s)/Learning Goal(s)

- Compare and contrast electrical conductivity of carbon nanotube embedded materials and traditional materials.
- Compare and contrast thermal conductivity of carbon nanotube embedded materials and traditional materials
- Investigate the energy transfer properties of carbon fiber plates for both physical impact and sound waves.
- Design uses for these new materials
- Report on ways the materials are already being used.

Standard(s)/Benchmark(s) Addressed

- *Standards from AP Physics Year 2*
  - Matter has a property called thermal conductivity that measures its ability to conduct thermal energy
  - A force exerted on an object is always due to interaction with another object
  - Energy is transmitted spontaneously from a higher temperature to a lower temperature. The process through which energy is transferred between systems is called heat.
  - Matter has a property called resistivity. The resistivity depends on the molecular and atomic structure as well as the temperature of the material.
  - Energy conservation can be applied to a wide variety of physical systems.

Standards for Mathematical Practice

-

Instructional Strategies

- Students will generate and test hypothesis through ranking tasks for two of the lab activities.
- Lab groups will be used to perform the investigations.

Evidence of Learning (Assessment Plan)

- First students will perform four investigations. The results of those will be discussed.
- Students will research current uses of carbon nanotubes and carbon fiber
- Finally each group will present an 'elevator pitch' of a device that they design.

Description of Lesson Activity/Experiences

Day #1

- Brief introduction to carbon nanotubes, graphene, carbon fiber, and materials made from carbon fiber
- Students perform four brief lab investigations studying electrical conductivity, thermal conductivity, sound transmittance, and kinetic energy transfer via 'bounce' test.
- Without any further research students propose uses for these materials.

Day #2

- Students share results from the lab activities from the previous day including their suggestions about how to use those materials
- "Five minutes of research". Students look up the current uses of carbon nanotubes, graphene, and all of the carbon-embedded materials that they worked with in class. These speedy research results are also shared with the entire class.
- Lab groups create an 'elevator pitch' for a device that they invent based on using these new materials. Students spend the rest of the day on inventing a device and putting together their presentation. The device design should be supported by articles they've found and their own hands-on investigation.

Day #3

The final product from the students is the elevator pitch. Each group will make their presentation to the class.

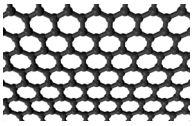
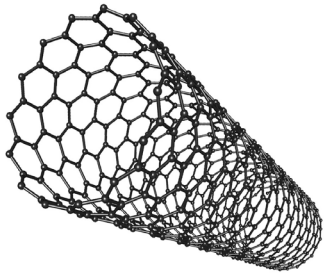
Recommended Assessment(s) and Steps

- Most assessments on this are formative.
- In the lab performance section, students show predictions before performing certain sections. Overall results are shared with the class.
- The elevator pitch will be presented and submitted in writing.

List of Materials/Resources Used

- Power Source, Batteries are fine
- Variety of Wire Materials: carbon fiber yarns, copper wires, 'alligator clips', nichrome wire
- Multimeters, Thermometers
- Beakers with water
- Steel marbles and superballs
- Impact Plates: carbon fiber, 'cellphone' glass
- Meter sticks
- Speaker with sound source
- Cellphone with app to measure decibels
- Box configured for 'soundproof' study
- Each student has their own laptop issued by the school.

Important Vocabulary

Term	Definition
Carbon 60, also called Buckyballs	Originally discovered in 1985 this particularly strong form of carbon atoms is shaped like a soccer ball. 
Graphene	Single layer of carbon atoms laid out in a hexagonal matrix 
Carbon nanotubes	Imagine rolling graphene into a cylinder and you have carbon nanotubes. They can be one cylinder (single walled) or many cylinders layered within each other (multiwalled). 
Carbon fiber	The longer version of carbon nanotubes, usually woven together with other materials.
Conductivity	A measure of how easily anything passes through a material.
Soundproofing	Method of preventing the transfer of sound energy from one area to another area.

Troubleshooting Tips

It is worth mentioning that this is a brand-new lesson. Even though there are elements that are familiar (basic circuit construction) or rather simple (testing materials by dropping a ball on them) I have yet to try these out with students in combination. There are new materials like electro-yarn and carbon fiber plates. I expect 'troubles' that will need fixing! Students may only be able to finish three investigations in a day instead of four. They may need more than 10 minutes to perform some quick research. Be ready to be flexible.

Other Helpful Information

The activities depend on having specific gear. Electro-Yarn (https://www.electro-yarn.com/) sells both kinds of the conductive yarns. You may need to look at amazon to purchase this in small classroom quantities. Carbon fiber scraps can be purchased from Protech Composites (http://www.protechcomposites.com) in half-pound lots at a reasonable price. Both companies were kind and helpful when I explained to them that I was a teacher putting together lessons on carbon materials for my high school physics classes.

Attachments

- Power point slides that act as directions for the lab activity
- Outline and script for teachers

References

AP Physics Year 2 Course Description,
https://apstudent.collegeboard.org/apcourse/ap-physics-2

AP Physics Year 2 Equation Sheet
https://secure-media.collegeboard.org/digitalServices/pdf/ap/ap-physics-2-equations-table.pdf

Carbon Fiber 101 Whitepaper
http://www.protechcomposites.com/download-white-paper/

Electro-Yarn Composites information regarding each type of yarn
https://www.electro-yarn.com/products.html

Acknowledgements

Authors

Terry Barchfeld, Timber Creek High School
Dr. Jan Gou, Professor, Composite Materials and Structures Laboratory
Dr. Joe Cho, Professor and Associate Chair, Nano fab and BioMEMS lab
Chad Hobby, returning RET teacher, Timber Creek High School
Jim Ebert, returning RET teacher, Deland High School

Supporting Program

RET Site: COMET Program, College of Engineering and Computer Science, University of Central Florida. This content was developed under National Science Foundation grant #EEC-1611019.

Contact information

Terry Barchfeld, terry.barchfeld@ocps.net