Lesson

Yellow highlight = required component

Subject Area(s) Physics & Physical Science

Associated Unit N/A

Lesson Title **Letters from Hogwarts**

Header Picture of water beads.

Image 1
Image file: ___?
ADA Description: ___?
Source/Rights: Copyright © ___?
Caption: ___?

Grade Level 11 (10-12)

Lesson # 1 of 1

Lesson Dependency

Time Required 40-50 Minutes

Summary

This lesson is meant to serve as a bridge between the lessons about how light behaves and how those laws are applied in an engineering sense. Students will be given a brief review over light, the laws of refraction (Snell's Law, Critical Angle, and Total Internal Reflection), and a brief history of fiber optics. Emphasis will then shift to how those Snell's Law is applied to fiber optics and how engineers make it work on a large scale. After the lesson is complete, the students will participate is a fiber optics demo where they send signals through a polymer rod.

Engineering Connection

Often in the classroom, students lose sight of why they are learning the material. With this lesson, the connection between the classroom and the engineering world is reinforced by showing how the simple idea of refractions has spawned a global market of fiber optics. Despite the simple principles behind fiber optics, its success did not happen overnight. Instead many areas of technological advancement (processing techniques, packaging, solid state physics for example) had to come together to make global communicate by fiber optics viable.

Engineering Category = 1

Choose the category that best describes this lesson's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering analysis or partial design
3. Engineering design process

Keywords

Snell's Law, Fiber Optics, Light, Morse Code

Educational Standards

National and State

Choose standards from http://asn.jesandco.org/resources/ASNJurisdiction or browse educational standards on TeachEngineering.

State/national science/math/technology (provide source, year, number[s] and text):

Chapter 112. Texas Essential Knowledge and Skills for Science
Subchapter C. High School

Statutory Authority: The provisions of this Subchapter C issued under the Texas Education Code, §§7.102(c)(4), 28.002, and 28.025, unless otherwise noted.

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§112.31. Implementation of Texas Essential Knowledge and Skills for Science, High School, Beginning with School Year 2010-2011.

The provisions of §§112.32-112.39 of this subchapter shall be implemented by school districts beginning with the 2010-2011 school year.

Source: The provisions of this §112.31 adopted to be effective August 4, 2009, 34 TexReg 5063; amended to be effective August 24, 2010, 35 TexReg 7230.

§112.39. Physics, Beginning with School Year 2010-2011 (One Credit).

(7) Science concepts. The student knows the characteristics and behavior of waves. The student is expected to:

(D) investigate behaviors of waves, including reflection, refraction, diffraction, interference, resonance, and the Doppler effect;

Source: The provisions of this §112.39 adopted to be effective August 4, 2009, 34 TexReg 5063.

http://www.teachengineering.org/browse_standards.php Year 2009

- ***----------***
- ***National Science Education Standards: Science [1995]***
- ***Current Standard***
  - ***Content Standard E: Science and Technology (Grades K - 12)***
- ***Standard's Subset***
  - ***key:***
  - ***Link to ALL information for a standard***
  - ***Standard has one or more explicit curriculum alignments***

- ***Content Standard E: As a result of activities in grades 9-12, all students should develop Abilities of technological design Understandings about science and technology***
  (Grades 9 - 12)

- ***----------***

ITEEA Educational Standard(s)

ITEEA (provide standard number, grade band, benchmark letter and text):

Standard 17. Students will develop an understanding of and be able to select and use information and communication technologies.
(Grades K – 12)

- ***L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.***
  (Grades 9 - 12)
- ***M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.***
  (Grades 9 - 12)
- ***N. Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.***
  (Grades 9 - 12)
- ***O. Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.***
  (Grades 9 - 12)
- ***P. There are many ways to communicate information, such as graphic and electronic means.***
  (Grades 9 - 12)
- ***Q. Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.***
  (Grades 9 - 12)

Pre-Requisite Knowledge

While it is encouraged to already have covered Snell's law at the time of this lesson, this lesson is self-sufficient if that is not the case.

Learning Objectives

After this lesson, students should be able to:

- **Apply Snell's Law to an experimental set-up**
- **Apply Snell's Law and its derivatives (Critical Angle/Total Internal Reflection) to fiber optics**

- **Be able to identify various components of a simple fiber optics system**
- **Be able to give the human analogies to fiber optics components (Eye=Photodiode, Brain=Converter, etc)**

Introduction / Motivation

After centuries of relying on old owl technology, Hogwarts has finally to upgrade their communication system to fiber optics. Here we will explore what is the fundamental basis for fiber optics.

Teacher Notes:

There is a power point to follow for this lesson that includes the "script."

As an attention grabber demo, purchase dehydrated water gems and soak in a large beaker (Make sure the students do not see them in the unhydrated state yet). The water gems are a hydrophilic polymer that will absorb water. As the beads absorb water their index of refraction will begin to more closely resemble that of water until you can no long see the beads.

Take the beaker (will fully hydrated bead in it) and place in front of the class. Ask the students how many beads are in the beaker. Most will probably say zero. Take your hand and pull some of the beads out showing that the beaker is in fact full of beads. Show them the dehydrated bead and explain to them that it is a hydrophilic polymer that absorbs water. Drop a few dehydrated beads in the beaker to show that they can be seen in the water. Ask why you can see the dehydrated bead but not the hydrated bead (The index of refraction is different). Ask them what happens to the index of refraction as the bead absorbs more water (does it more closely resemble water?) Emphasis that this is due to how light behaves in different materials.

After the demo, explain that you wanted to take such concepts from the classroom and apply them to real world. A prime example of that is the development of fiber optics which relies on total internal reflections to work. To emphasis the concepts you are going to do a fiber optics activity using a plastic rod (hold up the rod) and morse code but in order to get to that point you need to discuss the history of FOs and how the classroom material is applied. You are now ready to Segway in to the power point. Comments can be found in the notes section of each slide that will help guide the lesson.

Lesson Background & Concepts for Teachers

Snell's law and it applications are basic stuff for a physics teacher. However, the principles and engineering behind fiber optics are not. The power point does a good job of guiding the lesson but will not give you comprehensive knowledge of the subject. When I created this lesson I found the following book chapter helpful

http://media.techtarget.com/searchNetworking/downloads/FiberOptic_ch3.pdf

Vocabulary / Definitions

Word	Definition
Electromagnetic Wave	A form of energy emitted and absorbed by charged particles which exhibits wave-like behavior as it travels through space
Refraction	The change in direct of a wave due to the transition from one medium to another
Reflection	The complement to the incident wave that is returned off the medium
Critical Angle	The angle at which total internal reflection takes place
Total Internal Reflection	The situation when no light is able to diffract out of a medium due to the critical angle being reached
Attenuation	The process of losing the intensity of a signal through such events as absorption, bending losses, and ablation of the material
Transmitter	In the context of fiber optics, a transmitter is the device that creates the light signal to be sent over the fiber optic cables
Receiver	The device, typically a photodiode, that receives the sent signal from the signal
Converter	The device that converts the digital light signal into a readable output.
Chromatic Dispersion	The refractive index is a function of wave length and as a result any signal that is a combination of wavelengths will refract to different degrees resulting in the separation of each individual wavelength
Bending Losses	When the angle of bending is significant enough to destroy total internal reflection
Ablation of Materials	When the material is damaged in such a way that total internal reflection is not maintained
Scattering	A general term referring to the interaction of waves with an object of the appropriate size scale (a house will scatter radio waves, electrons will scatter x-rays

Associated Activities

Sending a Message

Lesson Closure

Assessment

Please see the power point presentation for the assessing the students during the lesson. Questions and expected comments are listed in the notes.

For the post assessment, please see the worksheet for the accompanying activity, "Sending a Message."

Lesson Extension Activities

Additional Multimedia Support

Fiber Optics PowerPoint

References

http://media.techtarget.com/searchNetworking/downloads/FiberOptic_ch3.pdf

Attachments

Power Point

Worksheet

Other

Redirect URL

Contributors

Brian Rohde, Don McGowan

Supporting Program

NSF GK-12 University of Houston,

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Students in 1st, 2nd, 3rd, 4th, and 7th period Pre AP Physics at Friendswood ISD