This experiment was the hardest among the semester because I had to explain a lot of things plus do a power point presentation to give the students the minimum knowledge they need to finish the experiment. The hardness of this experience come from the equipments I used to measure the speed of light. It is known that the speed of light in vacuum is the maximum medium speed since it is index has a value of 1; any other materials will have a speed less than the speed of light. This phenomena will be used to measure the speed of light used a light kit.

The experiment launches with a brief presentation describing some properties of light, how it is move and whether the light has energy or not. In the middle of the presentation I showed the students the oscilloscope, defined the oscilloscope, and explained what some buttons of the oscilloscope do and I explained how to connect the oscilloscope to an experiment to measure data and actually see the shape of that data. Then explain the light kit, show them where the transmitter and the receiver on the kit is and how to connect the kit to the oscilloscope. I finally showed them the fiber optics and talk in a brief on what is a fiber optic, why it is used and introduces some real life applications on the fiber optics. I supervised the students on how to connect the experiment together then helped them troubleshoot the experiment and explained the mistakes they did. The results were very descent and close to the actual value of the speed of light.

This experiment was not easy on the students but they learned a lot of things. They learned that not everything can be easily measured used simple equipments like the timer that's why we have to use a more sophisticated and accurate measurement devices such as an oscilloscope. Another important thing they learned is how to troubleshoot to find what is working right and what is not.

Science Lesson Plan

Teacher:

Period: **Class:**
Date(s):

SETTING THE STAGE	
Essential Question	Is the light travels instantaneously or with finite speed?
Content Objective(s) (Student-friendly)	How fast light travel, behavior of the light (wave)
Connection to previous or future lessons	Connect what students learning in physics with my research. Measure how fast light travel; try to explain the energy of light.
Critical Thinking Questions	Does the light have energy? What is the energy for?
Key Vocabulary	Wave, energy.
Materials Needed/Safety	Oscilloscope, Optical Fiber, Laser kit, Ruler
ACTIVE INSTRUCTION	
• Launch (Engage)	Explain and demonstrate the experiment with students help. Measure the length of the fiber optic (do it several times with different students)
• Investigation (Explore)	How close the answer to the real value? Investigate the following formula: $\frac{Light\ speed\ in\ a\ vacuum}{Light\ speed\ in\ another\ medium} = Refractive\ Index$

Measurement of light speed

University of MASS LOWELL

Prof. Xuejun Lu

Modified by

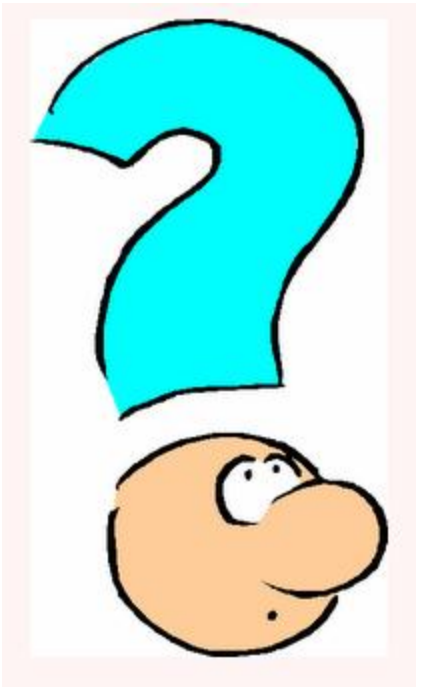
Ibrahim Alshawabkeh

Department of Electrical
& Computer Engineering

Speed of Light

- **The only thing we can really see is light. But the problem is:**

- whether light travels instantaneously or with finite speed



Speed of Light

- Speed of light is a physical constant.
- Speed of light is important for many applications such as fiber optic for sending/receiving information

Speed of Light

- We all know that :

$$S=D/T$$

S: Speed; D: Distance ; T: Time

If we can let the light travel a fixed length, and measure the time needed, then the whole problem can be figured out.

Speed of Light

But here comes new problems:

1. **How to let the light propagate in a fixed length?**
2. **How to measure the time?**

Since we all know that the light speed may be quite large, and the time needed may be quite tiny this will be hard to measure using regular timers.

Speed of Light

Solution:

1. **Light waves can propagate along optical fibers. If we know the length of the fiber, then we can know how long it takes light to travel from one end to the other.**
2. **We can change the light signal into an electric signal and then use an oscilloscope to measure the time delay precisely.**

Index of Refraction

- **When light passes through mediums other than a vacuum it slows down**
  - Water – 25% less than in a vacuum

- **Index of Refraction: ratio between the speed of light in a vacuum and its speed in some other medium**

$$\frac{Light\ speed\ in\ a\ vacuum}{Light\ speed\ in\ another\ medium} = Refractive\ Index$$

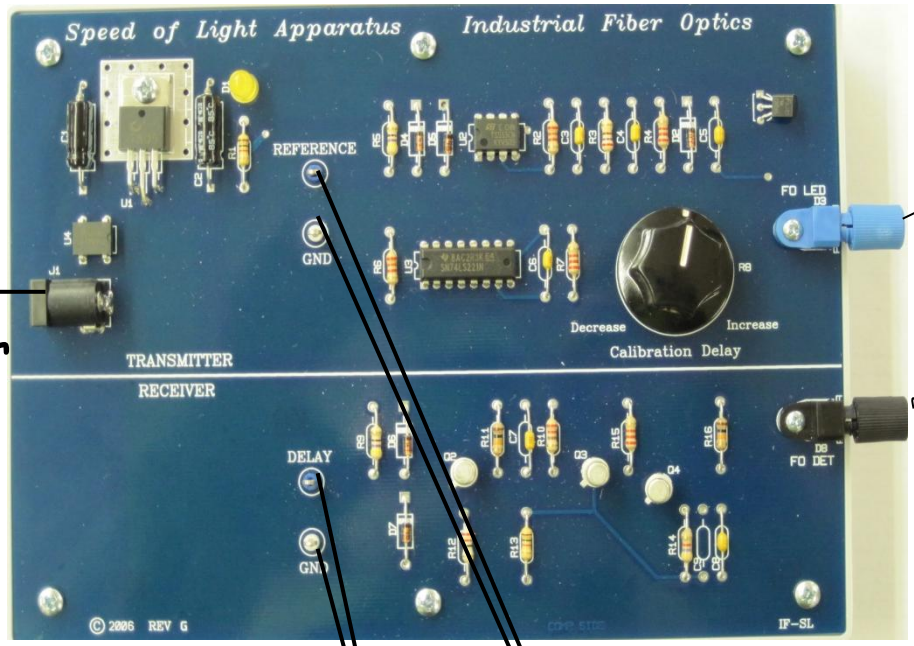
Index of Refraction

- Index of refraction is a measure of the speed of light in mediums
- Index of Refraction depends on the medium
- Index of refraction always greater than one (n>1)
- Why n>1?

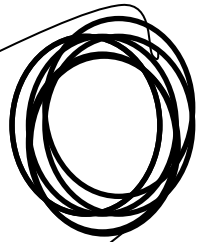
Speed of Light

- **Laser:** Generates a bundle of light: EM Wave
- **Optical Fiber:** Total length: 20m long
  - **Guides light by <u>total internal reflection</u>**
- **Oscilloscope:** Displays source waveform from signal generator (channel 1) and received signal after being transmitted through fiber (channel 2)

Speed of Light



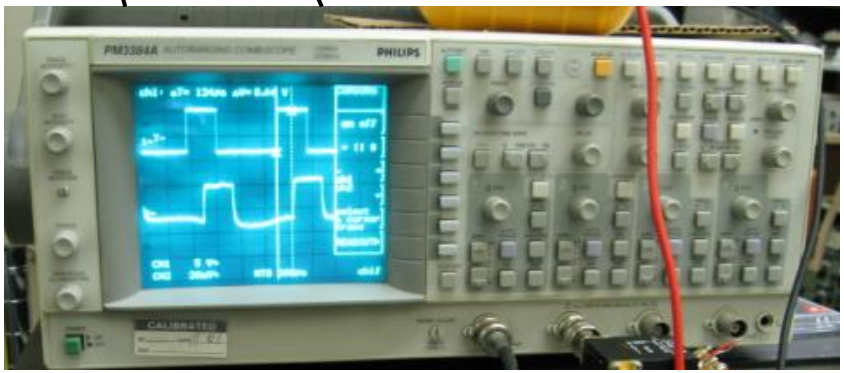
Optical fiber



To AC Power

To Channel 2

To Channel 3



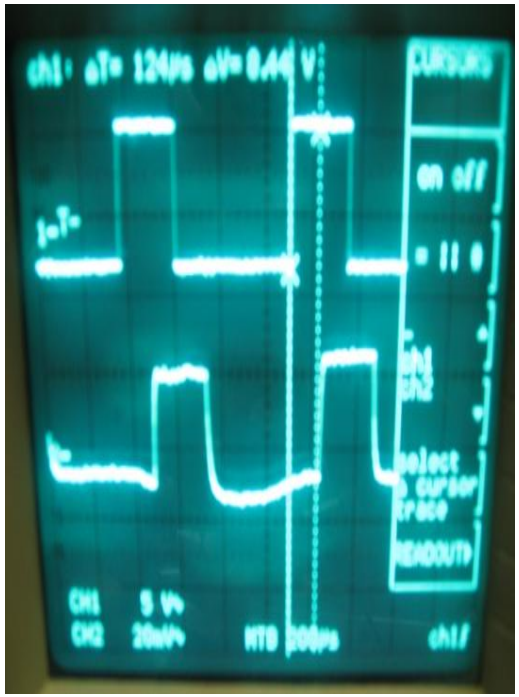
oscilloscope

Speed of Light

- From the oscilloscope, we can clearly see two signals.

The delay between the two signals the reference signal and the Detected signal.

The delay is in nano-sec.
What is Nano?



Thank You !

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