

Optics Communications Project

The Lesson

My physics students will build a prototype telephone from individual components. The final project proceeds as follows. Students will take an audio signal from a microphone and amplify it with an OP amp so that it can drive an LED. The modulated LED signal will be carried by a optical fiber where it will be received by a phototransistor on the other end. The signal is amplified with an OP amp and used to drive an a speaker. The optical communications unit consists of a series of about eleven labs which will be done that investigate each component of the optical communications project and several components coupled together. These labs will cover the fundamentals of electronics and electrodynamics. Since the project is fairly complicated, students must become familiar with each individual component. Once students finish the preliminary labs, they will build the prototype telephone. The final project will bring meaning and purpose for each activity which addresses a teaching standard in physics.

DC Circuits

Students will build series an parallel circuits using resistors. They will measure voltages and currents across each resistor. They will repeat this for circuits made of light bulbs and circuits made of capacitors.

AC Circuits

Students will build a series LC circuit connected to a frequency generator. They will then measure the voltag of the output signal as a function of different capacitances.

Solenoid

In order for students to understand how a speaker works they need to observe that a current- carrying wire produces a magnetic field. Students will send a current through solenoid an plot the magnetic field around it using small compasses. They will then observe the magnetic force by projecting a metal ball with a current-carrying solenoid.

Motor

Students wind up magnetic wire into a loop and connected across a battery where the ends of the magnetic wire have had the enamel coating sanded off the lower half. The students will then place a magnet over the loop and observe as it oscillates. They will learn how a motor works by observing the interaction between electricity an magnetism.

Speaker

Students will be given a paper plate, foil, magnet wire and a magnet, the will assemble a speaker. Using a frequency generator, they will drive the speaker. The will write their observations on a piece of paper and discuss how it works. They will write a summary on how the speaker works.

OP AMPs

Students investigate a non-inverting operational amplifier. They will connect an AC source in series with a resistor. The output of this circuit will be connected to an inverting amplifier. Students will take voltage and current measurements of the input and output signal. They will do this for several values of the two resistors that drive the amplifier. Using experimental data, they will derive the relationship that governs the amplification of voltage.

OP AMP and Speaker

Students will take a sound source from an IPOD and amplify the current and voltage with an OP amp. The output of the OP AMP will be used to drive a speaker.

The sound from the speaker should be noisy and have low volume. The students will add three capacitors at three locations to improve the sound. In AP physics, we will draw a connection between resonant LC circuits and impedance matching.

LED

Students will use a frequency generator and a resistor to drive an LED. Students will make qualitative observations as the voltage and resistance is varied on the LED. They will then make a plot of current vs. voltage to show that there is a nonlinear relationship between the two.

Phototransistor

Students will measure the voltage across the phototransistor as a function of several light intensities. They will do this by varying the distance between the phototransistor and point source of light.

Optical Cable

Students will obtain an optical cable and move it across a page with images on it and make an observation of what they see on the other end of the optical cable. They will do this for a computer screen, light bulb, TV screen, projector and etc. Students will then guide the light from a laser onto an optical fiber using a convex lens. If properly done, light should exit the other end.

Microphone

Students will drive an electret microphone with a 5V power and a capacitor and connect the output to an oscilloscope. They will speak into the mic and observe the signal. They will produce three monotone sounds with their voice and measure the period of the sound.

Putting It All Together

Finally, I will give the students each of the components mentioned above, where they will be given a breadboard and instructions on where to wire each component. Students will work in groups of four, where two students will build the transmitter and two students will build the receiver. Once the receiver and transmitter are working, they will put them together through an optical fiber.