

Course Outline

Introduction:

This is an Outline of a course of a Getting Started Lesson + 5 Science Lessons for 7 year old student and older.

This Document is for Teachers.

Lesson 1: Light

-What is light?

Light is a form of radiation emitted by most things in the universe, however, we cannot always see it. The light we can see is actually a very small portion of all of the light that's out there. (Teacher will show a diagram of the EM spectrum and explain it using the wave-theory of light. This is the simplest to grasp and the easiest to relate to these lessons.) All light waves are just a little different from one another, this is what makes color (Teacher explains wavelengths and color at a depth specific for his/her class).

-What does light do?

Sample explanation: Light waves are actually bouncing off of everything in this classroom right now. Every wall, every window, and even every person has tiny waves touching them right now. Some of those waves are absorbed, that's why you feel hot when the sun is out. Some of those waves get reflected, and that's what gives things their color. (The Teacher would then give examples of this like: the red box, the green tee-shirt, the blue rug etc... The Teacher can ask the students to identify what color light is bouncing off of objects to test students' understanding of the subject. The Teacher would then end on a white object and



explain that white light is a combination of all visible light. It is worth mentioning that white is not on the EM spectrum. This would lead the class to the hands-on activity)

-Extra experiment

Use a prism to refract white light onto a sheet of white paper and prove that white light is a combination of colors. This can sync nicely with the “red and blue makes purple, red and green make yellow” lesson.

Tokymaker Exercise

-Rainbow LED

Objective: Form the link between the theory of light and technology.

Method: Create all of the colors of the rainbow on the Tokymaker’s head LED. Explain that most screens use a combination of red, blue, and green light to create the other colors of the rainbow.

Explanation: Just like how white light is created when all visible light is mixed, other colors can be created when specific wavelengths interact.

Final Project

-Boulder Trap

Objective: Show how light can transmit energy in an extremely visual way.

Method: Using a servo, a light sensor, the Tokymaker, and cardboard, recreate the movie cliché of ‘hero steps into a trap and the wall opens to reveal a boulder rolling down at him/her.’

The teacher will construct a small cardboard ramp with a servo-driven door holding back a ball at the top. A light sensor will be placed at the base of the ramp on the ‘ground’. When the hero steps over the light sensor and casts a shadow, the boulder is



released and the hero must escape. Alternatively, two additional servo doors may be added around the base of the ramp. These can truly trap the hero.

Explanation: Light transmits energy to whatever it touches. When the light sensor no longer receives that energy, it tells the Tokymaker that the hero stepped over it.

Lesson 2 Sound

-What is sound?

Sample explanation: Sound, like light, is a wave. This means that instead of being a thing that you can touch and feel, its energy that can move very small things around. The air around us isn't empty. It's full of tiny moving particles which bounce around the room. These particles are what we breathe in. Oxygen is one of those particles, and so are nitrogen and carbon dioxide. Without the proper amounts of each element we can not breathe. That is why we can't breathe in space. What does this have to do with sound? When you make a noise, you actually force those tiny particles in the air to bump into each other a certain way. Our ears can pick up these vibrations and this is how we hear. The more energy you put into making a noise, the more those particles move around, and the louder the sound is. We call the strength of the particle bounding the "amplitude". Loud energetic waves have large amplitudes, while soft low-energy waves have small amplitudes.

-What is frequency?

Sound isn't all about how large vibrations are, that's just volume. We also need to understand how we make sounds distinct, and use it to create music or language.

Frequency is a measure of how fast the sound's vibrations are. Slower vibrations make deeper sounds and quicker vibrations make more high pitched sounds. (The teacher can have the kids place a finger on their throats and make sounds of various pitches. They should be able to feel the difference). By combining sounds of various frequencies and amplitudes we are able to create languages and music.

-Extra experiment

Get a glass of water and sing to it. The water should vibrate.

Tokymaker Exercise-TokyTunes:

Objective:

Learn about sound and vibrations using a hands-on exercise. Allow students to



hear what different vibrations sound like and associate changes in pitch with changes in frequency.

Method:

Students will use a set of buttons (Programmed so each button corresponds to a unique note) and a speaker to create their own musical compositions. Additionally, they can experiment with frequency settings on the speaker and play specific tones (ex: 450Hz, 1000Hz).

Explanation:

Speakers are actually vibrating membranes. By altering the speed a speaker membrane vibrates at, different tones can be created.

Final Project : Music Box

It is a cardboard structure with light sensors that detect dark shadows on a paper and translate the positions of the shadows into different notes.

<http://tokylabs.com/tokymusicbox/>

Lesson 3: Heat

-What is heat energy?

Every object is made up of tiny moving molecules. In some objects, like tables and people, those molecules don't move very much. They just jiggle around and bump into each other like they're on a packed train car. In others, like boiling water, they move around all over the place, and some even escape into the air. Heat energy and temperature are not the same thing. Temperature is the measure of the total heat energy of an object. Just like the energy of a sound wave is measured by the movement of air particles, the heat energy of an object is measured by the movement of all of its molecules.

Question: Which has more heat energy:

Iceberg

Pot of boiling water

Answer:

Iceberg

-What is temperature?

Temperature is the measure of the average heat energy of each molecule.

Add an analogy:

-If heat is the measure of the total energy of molecular motion in an object, what does temperature do?

Temperature determines an object's state of matter. There are three states of matter: solid, liquid, and gas.

So what's the difference? Solids can be large or small. This means that they can have a lot of heat energy, or very little heat energy. What makes a solid a solid is that it has a low enough temperature for its molecules to stay together. Molecules in a solid don't



have enough energy to individually break apart. Molecules in a liquid have slightly more energy than molecules in a solid. They don't have enough to break away from each other and go bouncing around the room, but they do have enough energy to flow. Molecules in a liquid won't get stuck together in one shape like a solid will. Molecules in a gas have even more energy. In fact, they have enough energy to go flying around whatever container they're in. What all of this means is that the higher the temperature of a substance is, the more energetic its particles are, and the more they will move around freely. This all happens independent of heat energy.

Tokymaker Exercise

-Sound thermometer

Objective:

Relate temperature change with state change and connect this lesson to the previous lesson on sound and frequency for reinforcement.

Method:

Put a thermometer in a heat resistant plastic bag. Place the bag in freezing water, then heat that water up to boiling point. Observe the changes in state (ice to liquid to gas) and the temperatures they happen at. Students will use the Tokymaker for temperature readings. Then connect the Tokymaker to a speaker, which will increase in pitch as the temperature increases.

Explanation:

As the water is heated the temperature change will be recorded by the temperature sensor. At the same time a tone will be played reflecting how high or low the temperature is. As the water goes from freezing to boiling (a process which students understand) and the temperature increases from low to high (another process students intuitively understand), the sound frequency will increase. This can help reinforce previously learned concepts and cement students' understanding of temperature.

Lesson 4: Gravity

-What is a force?

A force is something that (when unopposed) will cause a change in the motion of an object. For example, if you push something you are exerting a force. There are two kinds of forces: contact forces and field forces. Contact forces require direct contact to work. You can't pull a door open if you're not touching it, therefore, your pull is a contact force. You must be touching what you're moving. Field forces don't need direct contact to work. The earth's gravity is a field force. You don't need to be touching the ground for gravity to pull you back down.

-What is gravity?

Gravity is what keeps the solar system together, the planets in their orbits, and your shoes on the ground. It is a field force and is proportional to an object's mass and your distance from it. If something is very large and close to you, its gravity will be stronger than something that is very small and very far away. Most importantly, the force gravity exerts on you does not rely on your mass, only the mass of the object you're falling towards.

-Extra experiment

Have the teacher hold a heavy textbook and a small notebook in the air. Have the students vote on which they think will hit the ground first.

Correct Answer: They hit the ground at the same time because acceleration due to gravity does not rely on the smaller object's mass.

Tokymaker Exercise

-*Sound of acceleration*

Objective: Reinforce previous lessons on frequency and combine that with a new conceptualization of acceleration.



Method: Attach the accelerometer to a glove and use the Tokymaker to convert the magnitude of that acceleration to a sound. The faster the hand accelerates, the higher the tone.

Explanation: The accelerometer measures acceleration. This includes acceleration due to gravity and acceleration due to physical movement. By attaching this to a glove, students can see the difference between acceleration and constant velocity movement.

Final Project

-Magic gloves

Use an accelerometer to control a pair of motors and drive a small robot around.

Lesson 5 Magnetism:

-What is Magnetism?

Magnetism, like gravity, is a field force. This means that a magnetized object doesn't need to touch what it's effecting (Teacher could demonstrate this by moving objects around with a strong bar magnet). Magnetic fields only effect charged particles. A charged particle is anything that is positively, or negatively charged. This means that it has too many, or too few, electrons in a certain area. This is why people aren't effected by magnets, but metal is.

-Extra experiment

Sample: We can actually forcibly charge certain areas of objects by moving electrons around. In fact, you (the students) have probably already done it yourselves. If you take a balloon and rub it on your shirt, it will stick to your body and make your hair stand up. By rubbing the balloon on your shirt, you transfer electrons to the balloon. This makes you positively charged and the balloon negatively charged. That's why it sticks!

Tokymaker Exercise

-Electromagnet

Objective:

Visualize magnetic fields and their effect on the objects around them

Method: Set the Tokymaker electromagnet in a plate of iron shavings and then change the strength of the magnetic field. Have the kids experiment with how they can make the metal shavings move.

Explanation:

Magnetic fields are commonly represented using field lines. These lines are not just



conceptual, they actually have physical properties. This is a great way to 'see' magnetic fields.

Final Project

-Magnet King

Have the students spread out various objects (paper clip, coins, eraser, etc.) on a table. With the Tokymaker contraption have the students hover around the objects and see what they can and cannot pick up. With a rotation sensor, the students can vary the strength of their magnetic attraction.