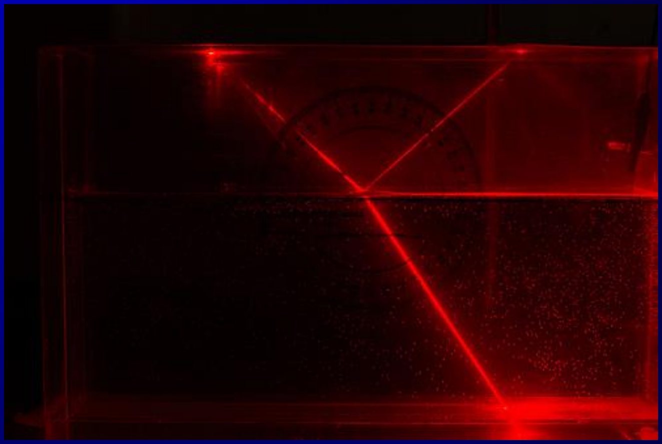
Science Activity & Video Series

Volume 7: LASER Edition

Includes detailed project steps, explanations and key concepts, tips & tricks, and access to instructional videos.

Designed by real scientists for our future generation.

A collection of quick and inexpensive science experiments that work you through lasers, introduce you to optics, and present project ideas guaranteed to get your kids excited to do real science.



Supercharged Science

www.SuperchargedScience.com

Thank You for purchasing the *Homeschool Science Activity & Video Series.*

I hope you will find it to be both helpful and insightful in sparking young minds in the field of science!

INTRODUCTION

Do you remember your first experience with *real* science? The thrill when something you built yourself actually *worked*? Can you recall a teacher that made a difference for you that changed your life?

First, let me thank you for caring enough about your child to be a homeschool parent. As you know, this is a huge commitment. While, you may not always get the credit you deserve, never doubt that it really does make a difference.

This book has free videos that go with it to show you step-by-step how to do each experiment. You can view the videos at: SuperchargedScience.com/savs7.htm

Access code: ESCI

Go to this page now so you can get a preview of the videos.

Think of this activity book as the "Idea Book", meaning that when you see an experiment you really like, just take it and run (along with all its variations).

For example, if you find yourself drawn to measuring refraction angles of a laser, our ideas are just the beginning. Try shining the laser through windows, eyeglasses, magnifiers, plastic containers, glasses of oil, and so forth. Does the temperature of a medium matter?

A Word About Safety… make sure you work with someone experienced when you're working with new stuff you're unsure about. Just use common sense—If it seems like it could be dangerous, ask for help.

Laser Safety The beam of laser pointers is so concentrated that it can cause real damage to your retina if you look into the beam either directly or by reflection from a shiny object. Do NOT shine them at others or yourself.

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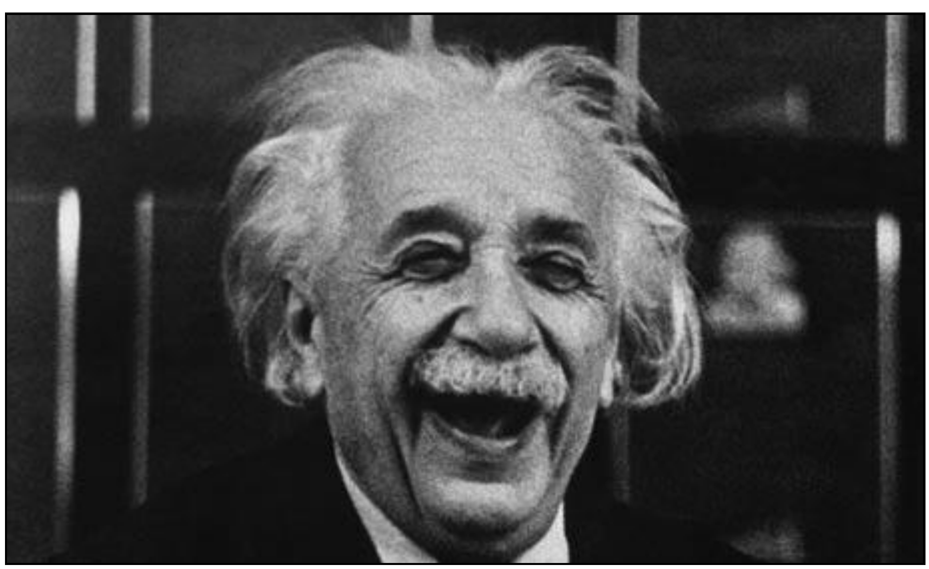
"Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand."

~Albert Einstein



What is a Laser?

Activity

This is a quick overview of what a laser is, and why you can't make a laser from a flashlight beam.

Materials

- Laser
- Flashlight
- Clear tape
- Red nail polish
- Ruler
- Pencil
- Paper
- Old CD

Experiment

To start with, watch the video for this experiment:

SuperchargedScience.com/savs7.htm

Access code: ESCI

1. Cover the end of the flashlight with clear tape. Paint the tape with red nail polish.

2. Stand close to the wall and shine both the laser and the flashlight at the wall.

3. Now slowly move backwards. What happens to the laser and the flashlight light on the wall?

The laser dot doesn't change size (or if it does, it's not much), but the pool of light from the flashlight increases in size. The light from the laser travels in the same direction in a straight line, called **collimated** light. The flashlight beam diverges, or spreads out.

4. Hold your flashlight very, very close to a sheet of paper at a small angle and look at the light on the paper. Do you see any dark spots, or is it all the same brightness? (It should be the same brightness.)

5. Now try this with a red laser (do NOT use a green laser). Hold it very close to the paper again at a small angle and look for tiny dark spots, like speckles. Those are coherent waves interfering with each other. It's really hard to see this, so you may not be able to find it with your eyes. (You can pass the light through a filter (like a gummy bear) to cut down on the intensity so the speckle pattern shows up better.)

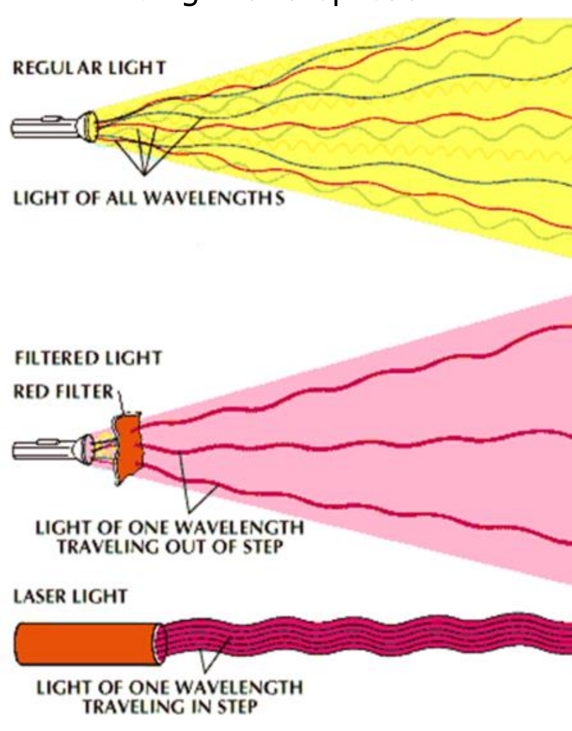
What's happening is this: light travels in waves, and when those waves are in phase (**coherent**) they interfere with each other in a special way. They cancel each other out (destructive interference) or amplify (constructive interference). This pattern isn't found with sunlight or light from a bulb because that kind of light all out of phase and doesn't have this kind of distinct interference pattern.

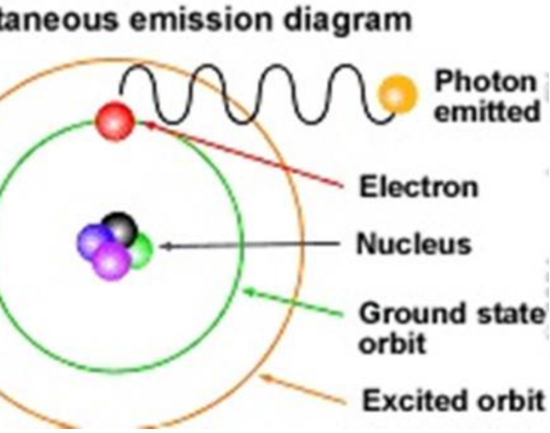
Okay, so now try this...

6. Shine the laser onto a CD and aim it so that the light bounces on the wall.

7. Now try it with a white flashlight or sunlight.

Did you notice any rainbows with the sunlight? Yes! That's because a CD is made up tiny little prisms that un-mix the light and spread it





out. For white light, you get a rainbow.

But what about the laser? How many colors did you get with the laser?

Just one. That's because a laser is **monochromatic.** It's only made up of one color, one wavelength. It is not a mix of different colors like light is.

Not all light is going to give the whole rainbow. It depends on the light source itself. Sometimes you'll only get red and green, sometimes you'll only see blue, red, and green. It depends on what colors make up the light.

What's Going On?

The word LASER is an acronym for Light Amplification by Stimulated Emission of Radiation.

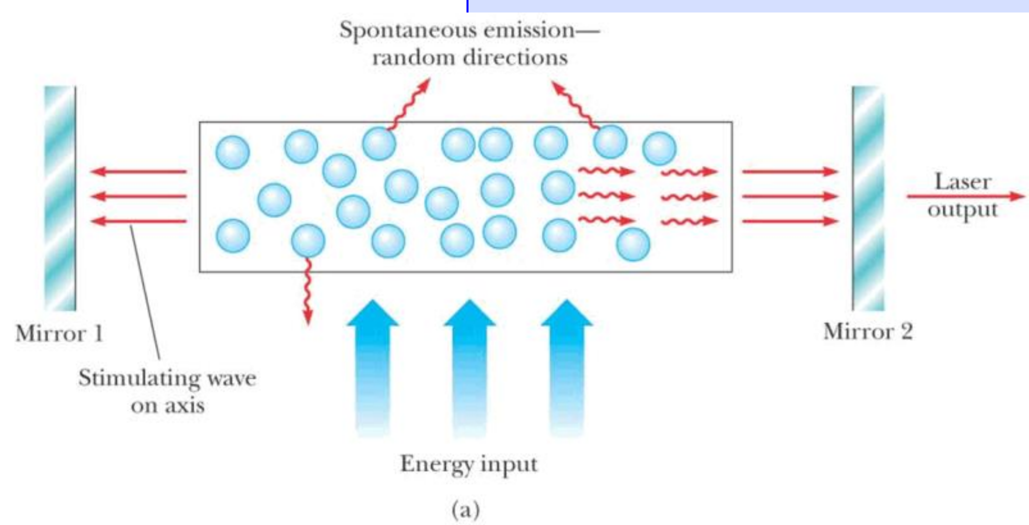
Lasers are optical light that is amplified, which means that you start with a single particle of light (called a photon) and you end up with a lot more than one after the laser process.

Stimulated emission means that the atom you're working with, which normally hangs out at lower energy levels, gets excited by the extra energy you're pumping in, so the electrons jump into a higher energy level. When a photon interacts with this atom, if the photon as the same exact energy as the jump the electron made to get to the higher level, the photon will cause the electron to jump back down to the lower level and simultaneously give off a photon in the same exact color of the photon that hit the atom in the first place.

The end result is that you have photons that are the same color (**monochromatic**) and in synch with each other (**coherent**). This is different from how a light bulb creates light, which generates photons that are scattered, multi-colored, and out of phase. The difference is how the light was generated in the first place.

Radiation refers to the incoming photon. It's a word that has a bad connotation to it (people tend to think all radiation is dangerous, when really it's only a small percentage that is).

In this case, it just means light in the laser. The incoming photon radiation that starts the process of **stimulated emission** (when the electron jumps between energy levels and generates another photon), and the **light amplification** means that you started with one photon, and you ended up with two. Put it all together and you have a LASER!



BENDING LIGHT

Activity

This simple activity has surprising results! We're going to bend light using plain water.

Materials

- Red and green laser
- Paperclip
- Index card
- Tape
- Rubber band
- Water glass

Experiment

To start with, watch the first video for this experiment at:

SuperchargedScience.com/savs7.htm

Access code: ESCI

1. Open the paperclip into an "L" shape, and tape it to an index card so the card stands up. This is your projection screen.
2. Use the rubber band to attach the laser pointers together. You'll want them very close and parallel to each other. Place the rubber band close to the ON button so the laser will stay on when you put the rubber band over it.
3. Place the laser pointers on a stack of books and put switch them on with the rubber band.
4. Shine the lasers through the middle of an empty glass jar and onto the screen.
5. Put a mark where the red and green laser dots are on the screen.
6. With the lasers still on, slowly fill the container with water. What happened to the dots?
7. You can add a couple of drops of milk or a tiny sprinkling of cornstarch to the water to see the beams in the water.

What's Going On?

Light bends when it travels from one medium to another, like going from air to a window, or from a window to water. Each time it travels to a new medium, it bends, or **refracts**. When light refracts, it changes speed and wavelength, which means it also changes direction.

Here's a quick activity you can do if the idea of refraction is new to you…

Take a perfectly healthy pencil and place it in a clear glass of water. Did you notice how your pencil is suddenly broken? What happened? Is it defective? Optical illusion?

Can you move your head around the glass in all directions and find the spot where the pencil gets fixed? Where do you need to look to see it broken?

When light travels from water to air, it bends. The amount it bends is measured by scientists and called the **index of refraction**, and it depends on the optical density of the material. The more dense the water, the slower the light moves,

and the greater the light gets bent. What do you think will happen if you use cooking oil instead of water?

Light can slows way, way down to a baby's crawl when you shine it through rubidium in the BEC state (the fifth state of matter... solids, liquids and gases are three states, and plasma and BEC are states four and five.)

So the idea is that light can change speeds, and depending on if the light is going from a lighter to an optically denser material (or vice versa), it will bend different amounts.

Glass is optically denser than water, which is denser than air.

Here's a couple of values for you to think about:

Vacuum	1.0000
Air	1.0003
Ice	1.3100
Water	1.3333
Pyrex	1.4740
Cooking Oil	1.4740
Diamond	2.4170

This means if you place a Pyrex container inside a beaker of vegetable oil, it will disappear, because it's got the same index of refraction! This also works for some mineral oils and Karo syrup. Note however that the optical densities of liquids vary with temperature and concentration, and manufacturers are not perfectly consistent when they whip up a batch of this stuff, so some adjustments are needed.

Questions to Ask

1. Is there a viewing angle that makes the pencil whole?
2. Can we see light waves?
3. Why did the green and red laser dots move?
4. What happens if you use an optically denser material, like oil?

What IS Science?

Science is more than a classroom… it's actually pretty difficult to define. Science is not about what we know, but rather about how we face what we *don't* know.

It's not a textbook of principles, set of rules, or collection of factoids. It's a process, a *thing* you do.

Science is what happens when you ask questions, get back answers, and try to figure out and make sense of it all. There are many different ways to do this, the *Scientific Method* is only one of the ways of sorting and sifting through the information as you go along.

Believe it or not, there's a straightforward method to doing science. You can't just sit around and argue about how things work, but you actually have to do experiments and be able to measure your results.

And other people have to be able to get those same results on their own, too!

Learn more about how to do real science with the e-Science Online Program: www.SuperchargedScience.com

MATH, JELL-O, AND LASERS

Activity

If you've ever scratched your head during a math class, wondering what you'll ever use *that* for, this is a great experiment to do! This teaches kids how to calculate the optical density of materials using a laser and some triangle math.

NOTE: Be sure to do the previous experiment on *Bending Light* on page 6 before trying this activity.

Materials

- Paper
- Laser
- Pencil
- Protractor
- Ruler
- Gelatin (1 box)
- 1/2 cup sugar
- 2 containers
- Hot (boiling) water and knife with adult help

Experiment

To start with, watch the video for this experiment:

SuperchargedScience.com/savs7.htm

Access code: ESCI

1. Mix two packets of gelatin with one cup of boiling water and stir well.
2. To one of the containers, add 1/2 cup sugar. Label this one as "sugar" and put the lid on and store it in the fridge.
3. Label the other as "plain" and also store it in the fridge. It takes about 2 hours to solidify. Wait, and then:
4. Cut out a 3"x3" piece of gelatin from the plain container.
5. On your sheet of paper, mark a long line across the horizontal, and then another line across the vertical (the "**normal**" line) as shown in the video.
6. Mark the **angle of incidence** of 40°. This is the path your laser is going to travel on.
7. Lay down the gelatin so the bottom part is aligned with the horizontal line.
8. Shine your laser along the 40° angle of incidence. Make sure it intersects the origin.
9. Measure the **angle of refraction** as the angle between the bent light in the gelatin and the normal line. (It's 32° in the video.)
10. Use Snell's Law to determine the index of refraction of the gelatin like this:

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

where: $n_1 = 1.0029$

$\theta_1 = 40°$

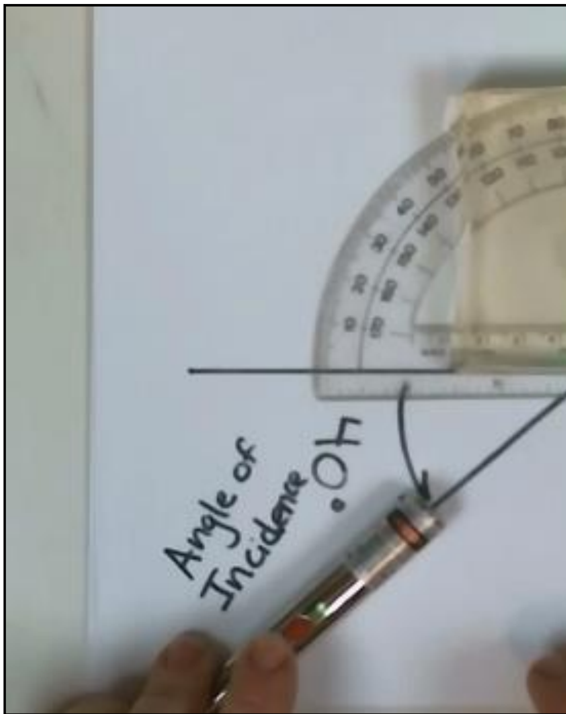
$\theta_2 = 32°$

Solve the equation for n_2:

$$n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2}$$

$$n_2 = \frac{(1.0029) \sin (40°)}{\sin (38°)}$$

$$n_2 = 1.217$$

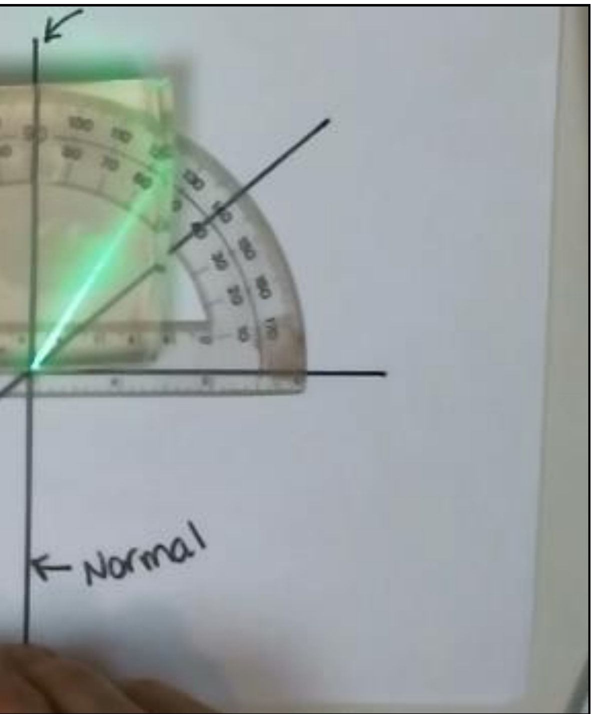


11. Repeat steps 4-10 with the sugar gelatin. Did you expect the index of refraction to be greater or less than the plain version, and why?

What's Going On?

How much light bends as it goes through one medium to another depends on the index of refraction (refractive index) of the substances.

There are lots of examples of devices that use the index of refraction, including fiber optics. Fiber optic cables are made out of a transparent material that has a higher index of refraction than the material around it (like air), so the waves stay trapped inside the cable and travel along it, bouncing internally along its length.



Magicians make tricky use out of refraction to do their tricks with illusions.

Experienced spear fisherman have to know where that fish really is, because it's not where it appears to be when they look at it from the top surface of the water.

Eyeglasses use lenses that bend and distort the light to make images appear closer than they really are.

Questions to Ask:

1. Does reflection or refraction occur when light bounces off an object?
2. Does reflection or refraction occur when light is bent?
3. What type of material is used in a lens?
4. What would happen if light goes from air to clear oil?

What is Math?

Math can be compared to a very useful tool, like a hammer, or a collection of tools like a set of screwdrivers.

A lot of kids get frustrated and bored with math, because many textbooks concentrate a lot on teaching the small, meticulous details of each and every type of tool. That's one of the fastest ways to kill your passion for something that could have otherwise been really useful!

Don't get me wrong – you do need to know how to tell a hammer apart from a screwdriver. But can you tell me *when* to use the hammer instead of the screwdriver?

It's really important to focus on how and when to use the different tools. This is my practical approach to teaching the subject.

Most kids think math just means numbers, when the truth is that math is much more than just numbers and being good at multiplying!

There are three main areas in math (at least when you first start out). Some kids enjoy adding and dividing, and for them, math is all about numbers. However, if you're really good with shapes and how they relate, then you might enjoy geometry. And if you are good at solving puzzles and people think you're unbeatable at certain games, chances are that logic will be a great match for your skills.

Gummy Bear Absorption

Activity

Gummy bears are a great way to bust one of the common misconceptions about light reflection. Let's find out how…

Materials

- Laser
- Flashlight
- Clear tape
- Red nail polish
- Red and green gummy bears

Experiment

To start with, watch the video for this experiment:

SuperchargedScience.com/savs7.htm

Access code: ESCI

What's the Misconception?

The misconception is this: most students think that color is a property of matter.

For example, if I place shiny red apple of a sheet of paper in the sun, you'll see a red glow on the paper around the apple. (Try this if you haven't!)

Where did the red light come from? Did the apple add color to the otherwise clear sunlight?

No. That's the problem. Well, actually that's the idea that leads to big problems later on down the road. So let's get this idea straightened out.

It's really hard to understand that when you see a red apple, what's really happening is that most of the wavelengths that make up white light (which is the whole rainbow) are absorbed by the apple, and only the red one is reflected. That's why the apple is red.

When the light hits something, it gets absorbed and either converted to heat, reflected back like on a mirror, or transmitted through like through a window.

Okay so let's try an experiment to see how many colors our laser is made up of. Here's what you do:

1. Take out your flashlight and aim it at each of the gummy bears. Notice that you're taking white light (which is made up of all the colors) and passing it through a filter (the gummy bear). What color comes out the back of the bear?

2. Now cover the flashlight with clear tape, and paint nail polish over the tape. You now have a red flashlight. Use this to point it at the gummy bears. Is there any difference in how the light passes through each gummy bear?

3. Take out your laser. There should only be one color in your laser, right? Let's find out.

4. Shine the laser at each

of the gummy bears.

5. Which gummy bear blocks the light, and which lets it pass through? Why is that?

Do you see how the light passes through both gummy bears, but the laser doesn't? What does that tell you about light and how it gets transmitted through an object?

When you shine your white flashlight light through the red gummy bear, the red gummy is acting like a filter and only allowing red light to pass through, and it absorbs all the other colors. The light coming from out the back end of the gummy bear is monochromatic, but it's not coherent, not all lined up or in synch with each other.

What happens if you shine your flashlight through a green gummy bear? Which color is being absorbed or not absorbed now?

Remember, the gummy bear does NOT color the light, since white light is made up of all visible colors, red and green light were already in there.

The red gummy bear only let red through and absorbed the rest. The green gummy bear let green through and absorbed the rest.

Questions to Ask:

1. What would you expect to happen if you used a blue gummy bear? Yellow?
2. What might happen if you try a green flashlight instead of a red one?
3. What's the difference between the red laser and the red flashlight?
4. What other objects can you use as a filter instead of gummy bears?
5. Which light source is monochromatic?
6. What other light sources could you test that might give interesting results?

FLUORESCENCE

Activity

If you've ever wondered how glow in the dark toys stay bright even in the dark, this activity is just for you!

Materials

- Laser (green)
- Highlighter (pink or orange)
- Diffraction grating
- White paper

Experiment

To start with, watch the video for this experiment:

SuperchargedScience.com/savs7.htm

Access code: ESCI

When light hits a material, it's either reflected, transmitted, or absorbed as we discovered with the gummy bear activity earlier.

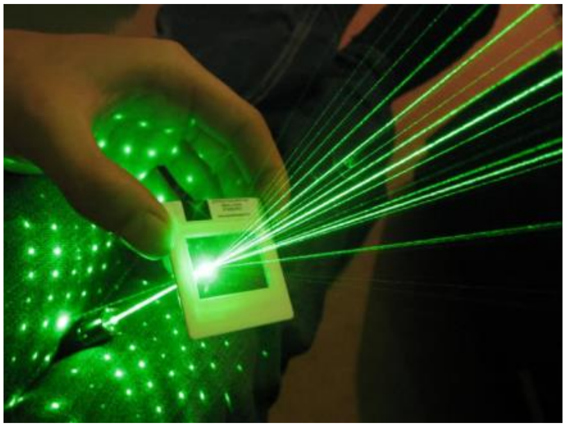
However, certain materials will absorb one wavelength and emit an entirely different wavelength, and when this happens it's called "**fluorescence**".

Let's do an experiment first, and then we'll go over why it does what it does. Here's what you do:

1. Point your laser at the wall, making a bright green dot. (Red lasers won't work with this experiment.)
2. Look at the dot through the diffraction grating. What do you see? How many different colors are there?

(If you don't have a diffraction grating, then simply shine your laser onto a CD and look at the reflected beams.)

We'll do more on diffraction another time, but just note that a diffraction grating is made up of a lot of tiny prisms that un-mix light into its different colors. That's why you see several different dots coming from the laser when you pass it through the diffraction grating.

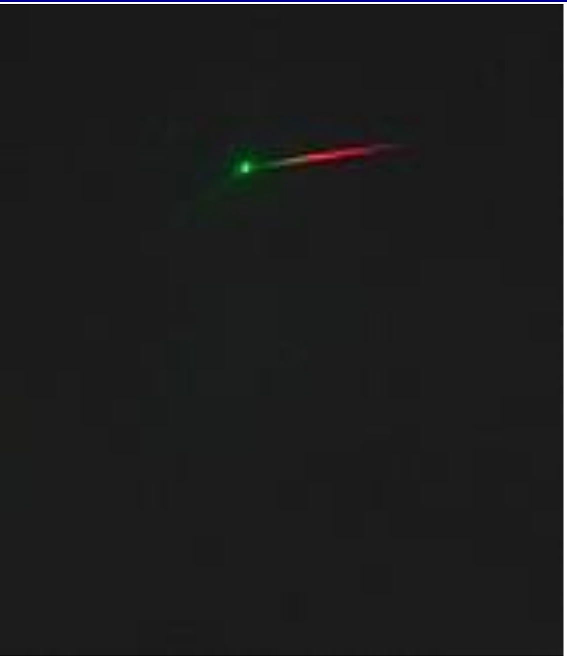


If you look at a candle flame through a diffraction grating, you'll see a whole rainbow, since the white light from a candle is made up of the rainbow. (Image below is a laser through a diffraction grating.)

A laser is one color, **monochromatic ,** so you should expect to see only one color through the diffraction grating.

Now let's try something else...

1. On your white sheet of paper, color an area with your marker.
2. Hold the paper against the wall. You can tape it into place if that makes it easier.
3. Turn off the lights



and point a green laser at the highlighter area you colored in.

4. Look at the dot next to the main dot through the diffraction grating.

5. Do you see more than one color now? Whoa!

What's Going On?

This is a fantastic experiment because it gives you totally unexpected results!

Where did the colors come from when you shined your laser on the highlighter area? And why weren't they present when you just used a plain white wall?

It has to do with something called **fluorescence.** When the green laser hits the orange square, the electrons are excited by the laser and jump up to a higher energy state, and then relax back down.

When they relax down, they release **photons** (light particles) that are made up of several different wavelengths. The diffraction grating makes it possible to see those wavelengths individually as a **spectrum**.

What kind of light is it?

Light bulbs use **incandescence**, meaning that the tungsten wire inside a light bulb gets so hot that it gives of light. Unfortunately, bulbs also give off a lot of heat, too. Incandescence happens when your electric stove glows cherry red-hot. Our sun gives off energy through incandescence also - a lot of it.

On the other end of things, *cold light* refers to the light from a glow stick, called **luminescence**. A chemical reaction (chemiluminescence) starts between two liquids, and the energy is released in the form of light. On the atomic scale, the energy from the reaction bumps the electron to a higher shell, and when it relaxes back down it emits a photon of light.

Phosphorescence light is the 'glow-in-the-dark' kind you have to 'charge up' with a light source. This delayed afterglow happens because the electron gets stuck in a higher energy state. Lots of toys and stick-on stars are coated with phosphorescent paints.

Triboluminescence is the spark you see when you smack two quartz crystals together in the dark. Other minerals spark when struck together, but you don't have to be a rock hound to see this one in action - just take a Wint-O-Green lifesaver in a dark closet with a mirror and you'll get your own spark show. The spark is basically light from friction.

Fluorescence is what you see on those dark amusement-park rides that have UV lights all around to make objects glow. The object (like a rock) will absorb the UV light and remit a completely different color. The light strikes the electron and bumps it up a level, and when the electron relaxed back down, emits a photon (particle of light).

TEACHING SCIENCE RIGHT

Hopefully these activities have given you a small taste of how science can be totally cool AND educational.

But teaching homeschool science isn't always easy.

You see, there's a lot more to it than most traditional science books and programs accomplish. If your kid doesn't remember the science they learned last year, you have a problem.

What do kids really need to know when it comes to science?

Kids who have a solid science and technology background are better equipped to go to college, and will have many more choices once they get out into the real world.

Learning science isn't just a matter of memorizing facts and theories. On the contrary, it's developing a deep curiosity about the world around us, AND having a set of tools that lets kids explore that curiosity to answer their questions.

Teaching science in this kind of way isn't just a matter of putting together a textbook with a few science experiments and kits.

Science education is a three-step process (and I mean teaching science in a way that your kids will really understand and remember). Here are the steps:

1. Get kids genuinely interested and excited about a topic.
2. Give them hands-on activities and experiments to make the topic meaningful.
3. Teach the supporting academics and theory.

Most science books and programs just focus on the third step and may throw in some experiments as an afterthought. This just isn't how kids learn.

There is a better way. When you provide your kids with these three keys (in order), you can give your kids the kind of science education that not only excites them, but that they remember for many years to come.

Don't let this happen to you… you buy science books that were never really used and now your kids are filling out college applications and realizing they're missing a piece of their education—a REALLY big piece. Now *that's* a setback.

So what do you do?

First, don't worry. It's not something that takes years and years to do. It just takes commitment.

What if you don't have time? What I'm about to describe can take a bit of time as a parent, but it doesn't have to. There is a way to shortcut the process and get the same results! But I'll tell you more about that later.

Putting It Into Action

Step one: Get kids genuinely interested and excited about a topic.

Start by deciding what topic you want your kids to learn. Then, you're going to get them really interested in it.

For example, suppose I want my 10-year old son to learn about aerodynamics. I'll arrange for him to go up in a small plane with a friend who is a pilot. This is the kind of experience that will really excite him.

Step two: Give them hands-on activities and experiments to make the topic meaningful.

This is where I take that excitement and let him explore it. I have him ask my friend for other chances to go flying. I'll also have my friend show him how he plans for a flight. My son will learn about navigation, figuring out how much fuel is needed for the flight, how the weight the plane carries affects the aerodynamics of it, and so much more.

I'll use pilot training videos to help us figure this out (short of a live demo, video is incredibly powerful for learning).

My son is incredibly excited at this point about anything that has to do with airplanes and flying. He's sure he wants to be a pilot someday and is already wanting flying lessons (he's only 10 now).

Step three: Teach the supporting academics and theory.

Now it's time to introduce academics. Honestly, I have my pick of so many topics, because flying includes so many different fields. I mean he's using angles and math in flight planning, mechanics and energy in how the engine works, electricity in all the equipment on board the plane, and of course, aerodynamics in keeping the plane in the air (to name just a few).

I'm going to use this as the foundation to teach the academic side of all the topics that are appropriate.

We start with aerodynamics. He learns about lift and drag, makes his own balsa-wood gliders and experiments by changing different parts. He calculates how big the wings need to be to carry more weight and then tries his model with bigger wings. (By the way, I got a video on model planes so I could understand this well enough to work with him on it).

Then we move on to the geometry used in navigation. Instead of drawing angles on a blank sheet of paper, our workspace is made of airplane maps.

We're actually planning part of the next flight my son and my pilot buddy will take. Suddenly angles are a lot more interesting. In fact, it turns out that we need a bit of trigonometry to figure out some things.

Of course, a 10-year old can't do trigonometry, right? Wrong! He has no idea that it's usually for high school and learns about cosines and tangents.

Throughout this, I'm giving him chances to get together with my pilot friend, share what he's learned, and even use it on real flights. How cool is that to a kid?!

You get the idea. The key is to focus on building interest and excitement first, then the academics are easy to get a kid to learn.

Try starting with the academics and...well, we've all had the experience of trying to get kids do something they don't really want to do.

The Shortcut

Okay, so this might sound like it's time-intensive. If you're thinking "I just don't have the time to do this!" or maybe "I just don't understand science well enough myself to teach it to my kid." If this is you, you're not alone.

The good news is, you don't have to. The shortcut is to find someone who already specializes in the area you want your kids to learn about and expose them to the excitement that persons gets from the field.

Then, instead of you being the one to take them through the hands-on part and the academics, use a solid video-based homeschool science

program or curriculum (live videos, not cartoons).

This will provide them with both the hands-on experiments and the academic background they need. If you use a program that is self-guided (that is, it guides your kinds through it step-by-step), you don't need to be involved unless you want to be.

I'm partial to the "e-Science" program from SuperchargedScience.com (after all, I'm in it), but honestly, as long as a program uses these components and matches your educational goals, it should be fine.

Your next Step should be to take a look at how you're teaching science now and simply ask "Is my kid getting the results I want from his or her science education?"

After this, consider how you can implement the three key steps we just talked about. Either go through the steps yourself, or use a program that does this for you.

If you want to learn more about how to teach science this way, we regularly give free online tele-seminars for parents. To learn more about them, visit:

SuperchargedScience.com/freeteleclass.htm

My hope is that you have some new tools in your homeschool parent toolbox to give your kids the best start you can in life.

Again, I want to thank you for taking the kind of interest in your child that it takes to homeschool. I know it's like a wild roller coaster ride some days, but I also know it's worth it. Have no doubt that the caring and attention you give to your child's education today will pay off many fold in the future.

My best wishes to you and your family.

Warmly,

Aurora