Creating Science – Lasers.

Almost exclusively the great accomplishment and driving force behind the modern computer era, how can lasers help us personally? **#CreatingScienceLasers**

Suggested outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science Understanding

Physical sciences 1: Light and sound are produced by a range of sources and can be sensed (ACSSU020) – As we play with lasers and learn about safely using them.

Physical sciences 5: Light from a source forms shadows and can be absorbed, reflected and refracted (ACSSU080) – Experimenting with mirrors and our clothing demonstrates reflection, and water and lenses are used to illustrate refraction.

Science Inquiry Skills

Communicating 5: Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS093) – as we develop a "Laser Lesson" to share what we've learnt.

Warning

- Do not allow students to handle anything above a 1mw laser – legally and for their own safety!
- While all the lasers in stores for children are not dangerous to stare at, we discourage this simply out of safe practice and respect for very, very, bright light!

Preparation

- Make sure every student has access to a cheap laser, usually available online in bulk. You need a CLASS 1 LASER PRODUCT, or in other words, a really, really safe one.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students questions can and should guide student learning, more material is presented for you convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

Some of the activities are more appropriate as a demonstration. Use judgement and wisdom when working with lasers and young children.

Laser are generally fragile if dropped. Please warn students and work over carpet if possible.

Most students will encounter dangers at this level by accident (one student avoiding a laser light into his eyes by another student might potentially walk his head backwards into a pole, for instance).

Middle:

This activity is well suited to this age group. Most students will try to see how much damage they can do to the world with lasers at this point, so use judgement and wisdom when deciding who to hand a laser to.

Teen:

Now it is time to add measurements! Make sure you give the laser rating in nanometres each time one is used. Red lasers are usually ~700nm

Engage

Lasers, lasers, lasers. What do you know about lasers, and what would you like to know about them?

Play laser catch, as if you're a cat.

Animals love lasers too!

https://www.youtube.com/watch?v=rDRZAbA-nn0

Question Quest!

Write down what students would like to learn more about lasers

- ⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

Explore

- ⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Laser maze!

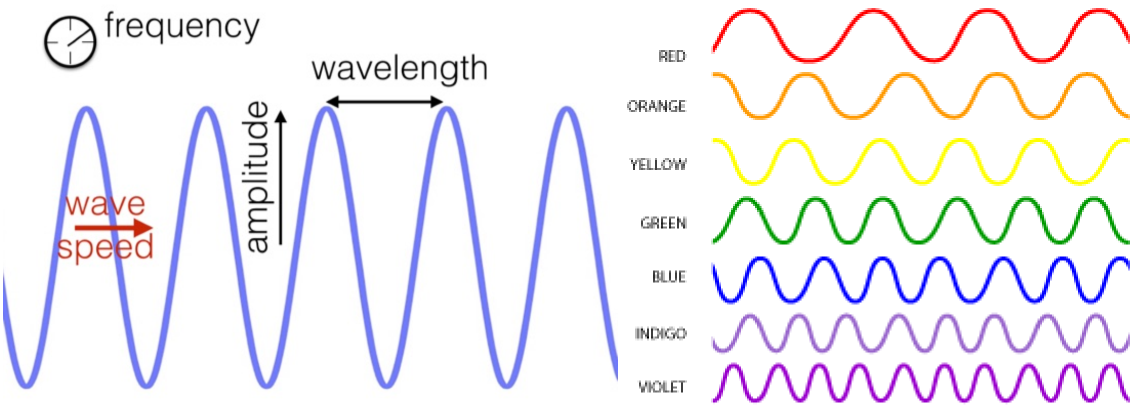
1. Can you make your laser bounce back and hit your hand?
2. Can you make your laser go around a block, and still hit your hand?
3. Can you get your laser to spread out so much that it disappears?
4. Can you get your laser to shrink down even smaller?
5. Can you get your laser light dot to move left to right, by moving your actual laser right to left?

This can be used to explain the 'dance moves of light'

Explain

Lasers are almost always only one colour. Exactly one colour! It makes them able to amplify their power enormously. Lasers can help us illustrate a few of the cool tricks of light.

Anatomy of light



Light travels like a wave.

Light has amplitude (brightness) and frequency (colour) just like sound waves do!

The carrier of light energy is known as the photon.

The dance moves of light

Reflection

As light bounces off different surfaces it can take on different qualities. Usually it just picks up the colour and bounces in all directions, and that's why we can see things in the room. If it gets to bounce off at the exact angle it came in on (i.e., with a mirror) we can create what we call a reflection. Demonstrate reflection with some of the following toys

- Spread out beam and put smoke/ chalk dust through it.
- Sound tube (a cup with the bottom replaced with a balloon, and a mirror stuck to the balloon.) shout into the cup, the deeper the better. What happens to the image in the mirror?
- Build a laser dance machine with 3 mirrors attached to motors.

- Measure the angel of incidence and the angle of reflection. (see activity)

Refraction

Light not only bounces, it can also bend. As light enters of leaves difference substances it can change speed, making it change its direction as well.

Demonstrate with;

- Reversing arrow behind a cup (see end of document)
- ‘breaking’ a pencil as it enters a cup of water.
- Get a spherical cup/bowl, and it makes the image though the other side back to front AND upside down (just like in our eyeball!)

Elaborate

Collimation

Lasers have a special trick. Spatial coherence also allows a laser beam to stay narrow over great distances (collimation), enabling applications such as laser pointers and lidar.

Other uses of lasers

From Wikipedia, 27 April 2021

Lasers are used in optical disk drives, laser printers, barcode scanners, DNA sequencing instruments, fiber-optic, semiconducting chip manufacturing (photolithography), and free-space optical communication, laser surgery and skin treatments, cutting and welding materials, military and law enforcement devices for marking targets and measuring range and speed, and in laser lighting displays for entertainment. They have been used for car headlamps on luxury cars, by using a blue laser and a phosphor to produce highly directional white light.[4][5][6][7]

History of the laser

From Wikipedia, 27 April 2021

Foundations

In 1917, Albert Einstein established the theoretical foundations for the laser and the maser in the paper *Zur Quantentheorie der Strahlung* (On the Quantum Theory of Radiation) via a re-derivation of Max Planck's law of radiation, conceptually based upon probability coefficients (Einstein coefficients) for the absorption, spontaneous emission, and stimulated emission of electromagnetic radiation.[23] In 1928, Rudolf W. Ladenburg confirmed the existence of the phenomena of stimulated emission and negative absorption.[24] In 1939, Valentin A. Fabrikant predicted the use of stimulated emission to amplify "short" waves.[25] In 1947, Willis E. Lamb and R.C. Retherford found apparent stimulated emission in hydrogen spectra and effected the first demonstration of stimulated emission.[24] In 1950, Alfred Kastler (Nobel Prize for Physics 1966) proposed the method of optical pumping, experimentally confirmed, two years later, by Brossel, Kastler, and Winter.[26]

…

and this research continues to this day.

In 2015, researchers made a white laser, whose light is modulated by a synthetic nanosheet made out of zinc, cadmium, sulphur, and selenium that can emit red, green, and blue light in varying proportions, with each wavelength spanning 191 nm.[37][38][39]

Evaluate

Diagnostic:

Take time to focus on planned content material during the engage phase, for example;

- Why can we see things that are out of reach? How does light get to us from way over there?
- Why are some things red, and other things blue?
- Why can't we see around corners, but we can hear around corners?
- How do mirrors work? Why can they make a perfect reverse image of what we see?
- Why is everything not where it looks like it should be when viewed through water?
- Do you think it's true that everything is back to front and upside down in our eyes?

Formative:

Try some challenges:

1. Can you make your laser bounce back and hit your hand?
2. Can you make your laser go around a block, and still hit your hand?
3. Can you get your laser to spread out so much that it disappears?
4. Can you get your laser to shrink down even smaller?
5. Can you get your laser light dot to move left to right, by moving your actual laser right to left?

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do by providing a "Laser Lesson"

Make a brief oral presentation on the 5 formative assessments above. Be sure to explain the ideas of;

- Reflection
- Refraction

Appendix: how lasers can kill you

Taken 18 may 19 from https://www.quora.com/How-could-a-laser-kill-someone

How could a laser kill someone?

3 Answers

By David Kitson (I develop military technology from time to time.)

Answered Dec 12

Some lasers are big and heavy, and could easily be used as a bludgeon to beat somebody to death, but generally lasers are more likely to cause serious non-lethal injuries.

To kill someone is a different matter. A UV laser could cause death by resulting in cancer if exposed to the output for a significant period certainly.

Also a laser might cause death simply by distracting someone at an inappropriate time, or causing other injury leading to distraction - such as an aircraft approaching a landing and the pilot being lazed, which does happen and is why there are such severe penalties for shining a laser at an aircraft.

It's even possible that a laser "scalpel" might cut deep enough and lack cauterization sufficient to result in bleeding to death, especially if not treated.

But if you wanted to kill someone outright, and cause a lethal injury, then you either need to expose them to sufficient laser radiation to cause flash burns to enough of their body to result in death from that injury, or you need to hit someone with sufficient power that the part exposed literally explodes from the vaporization of flesh. Of course, that kind of power is a problem.

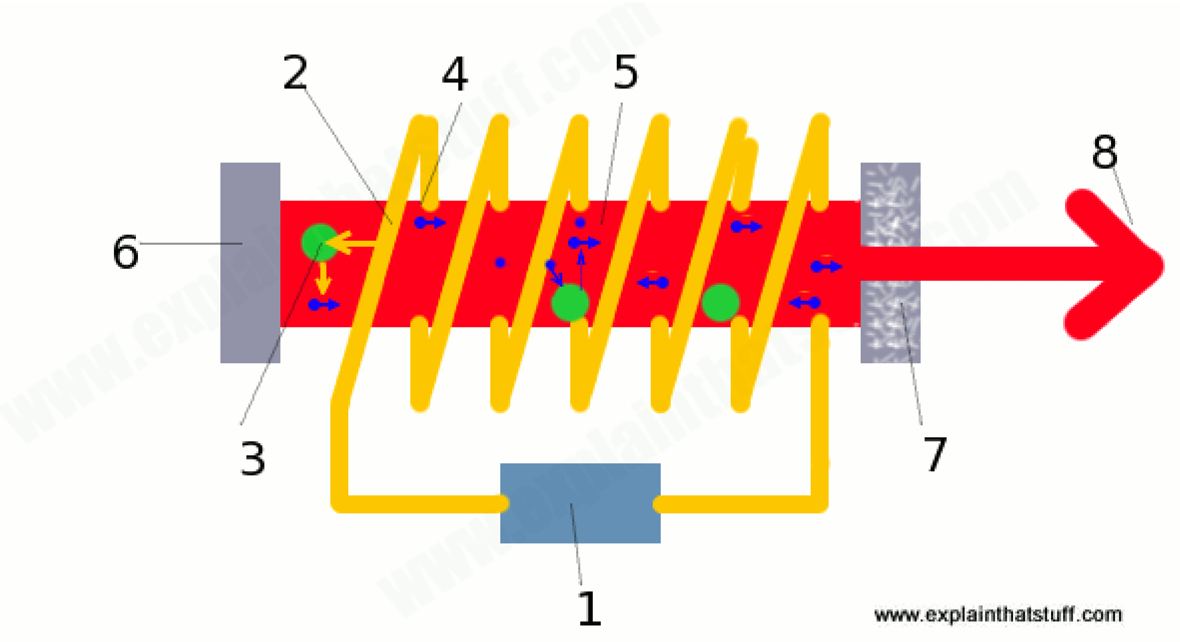
Now, if you specifically wanted to kill someone with a laser, but without all the hassles, then we get into the realm of fictional weapons that have existed, but are not all that practical.

Under such circumstances, the best I can come up with is to use a UV laser to open an ionized path to a victim, over considerable distance, and then use a high-powered tesla coil to discharge a significant voltage into that person such that the combination of the two causes the death, but that's not purely a laser, and if that's acceptable, then you might as well just go with a laser-sighted rifle, which combines a laser with a bullet.

All about lasers

Great stuff at https://www.explainthatstuff.com/lasers.html

How do the flash tube and the crystal make a laser beam?



1. A high-voltage electric supply makes the tube flash on and off.
2. Every time the tube flashes, it "pumps" energy into the ruby crystal. The flashes it makes inject energy into the crystal in the form of photons.
3. Atoms in the ruby crystal (large green blobs) soak up this energy in a process called **absorption**. Atoms absorb energy when their electrons jump to a higher energy level. After a few milliseconds, the electrons return to their original energy level (ground state) by giving off a photon of light (small blue blobs). This is called **spontaneous emission**.
4. The photons that atoms give off zoom up and down inside the ruby crystal, traveling at the speed of light.
5. Every so often, one of these photons stimulates an already excited atom. When this happens, the excited atom gives off a photon and we get our original photon back as well. This is called **stimulated emission**. Now one photon of light has produced two, so the light has been amplified (increased in strength). In other words, "**l**ight **a**mplification"(an increase in the amount of light) has been caused by "**s**timulated **e**mission of **r**adiation" (hence the name "laser", because that's exactly how a laser works!)
6. A mirror at one end of the laser tube keeps the photons bouncing back and forth inside the crystal.
7. A partial mirror at the other end of the tube bounces some photons back into the crystal but lets some escape.
8. The escaping photons form a very concentrated beam of powerful laser light.

Arrows