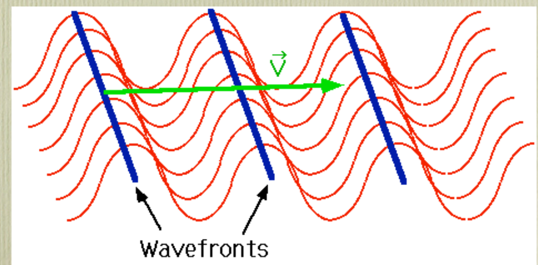
Radiation (again!)

Peter Watson

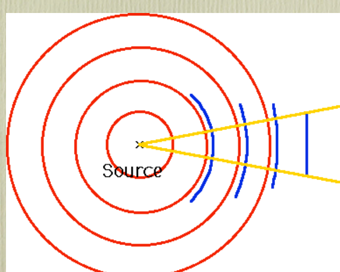
How do we know light is a wave?

- Need to be able to see waves in 2-D



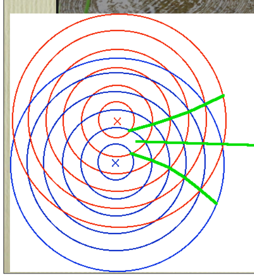
Text

- A point source of waves produces spherical waves.
- If we see them a long distance from the source, they look like plane waves.

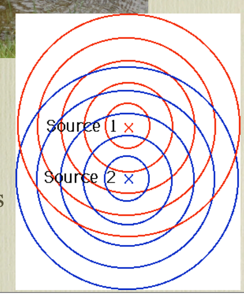


Text

PW,



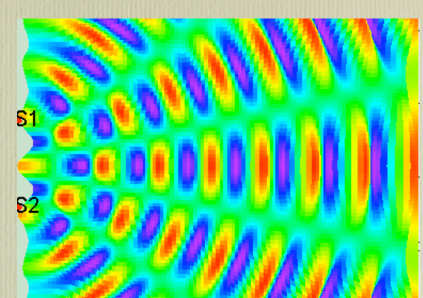
there are places where the crests add up



Ripple tank

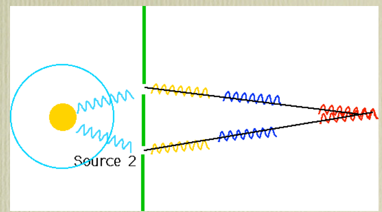
PW

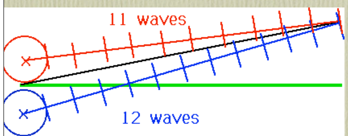
- Like this



Wikisource

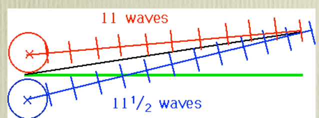
•Young's slits does this for light.
Instead of two sources, take light from one source and split it in two





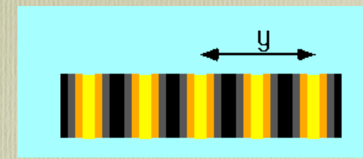
- Constructive (they add up)

- Destructive (they cancel out)



PW

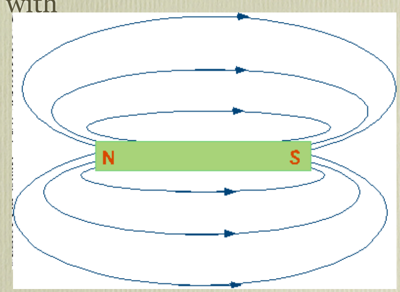
- When you do this for light, you get
- bright bands (adding up)
- dark bands (cancelling out)



Direct Demonstration that light is a wave (also lets you find λ)

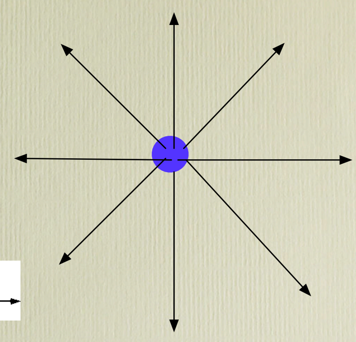
So what is it a wave in?

- Can map out magnetic field with iron filings
-

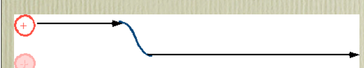


PW, Wikipedia

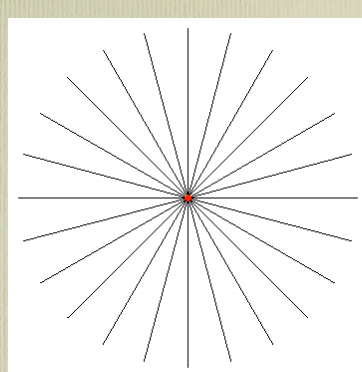
Charge (e.g. proton, electron) produces **electric** field



- Moving this charge changes field



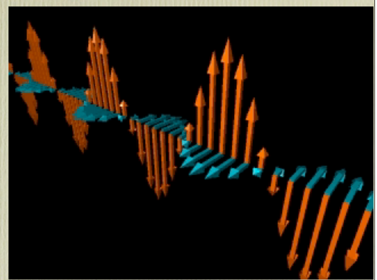
- “kink” in lines of forces travels out at speed of light



Maxwell

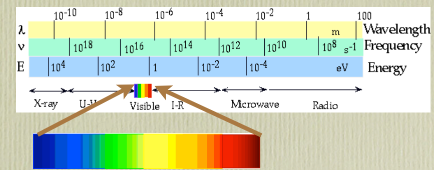
- Faraday’s law says
- Changing magnetic field ➟induced electric field
- Maxwell’s equations
- Changing electric field ➟induced magnetic field

- magnetic field is at right angle to electric.
- which is why it is **Electromagnetic Radiation**

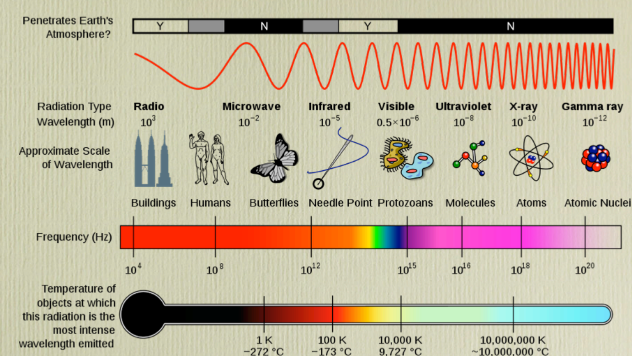


Hence Faraday + Maxwell predict light from induced fields

- Light is part of the whole electromagnetic spectrum

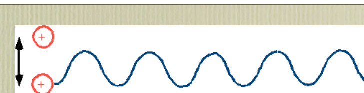


- All waves satisfy fλ=c
- (frequency ×wavelength = speed)

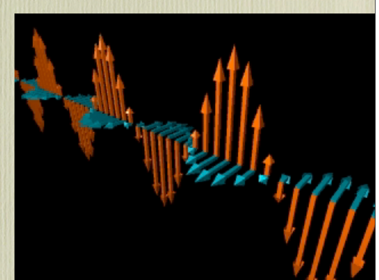


Text

- Need to oscillate charge to give periodic wave



- Wave is actually more complicated:
- magnetic field is at right angle to electric.
- which is why it is **Electromagnetic Radiation**



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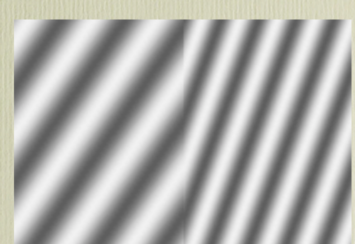
e.g X-rays

- Röntgen (1895)
- Very penetrating rays produced by vacuum tube
- passes through solids, fogs photographic plates
- very short-wave radiation (λ~1 nm)

Refraction and lenses

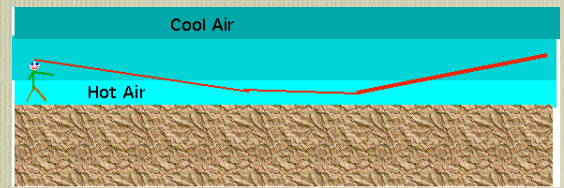
- All kinds of waves will change speed when the encounter a new medium



- Samir Tohme

1. Why do we see wavy liquid-like lines over asphalt and pavement during hot days?
2. How come it occurs only during days with high temperatures only? What are these wavy things we see anyways and what causes them?

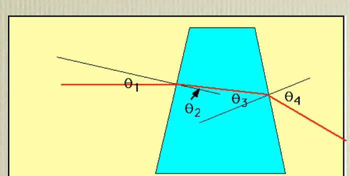
- Mirages: Hot air is less dense than cold air
- so light travels faster



So you see ima
of sky in directi
of ground

Wikimedia

- When light goes from air to glass, it gets bent closer to perpendicular to surface
- From glass to air, it gets bent away from perpendicular
- so effect of two surfaces at an angle is to deflect beam of light



PW

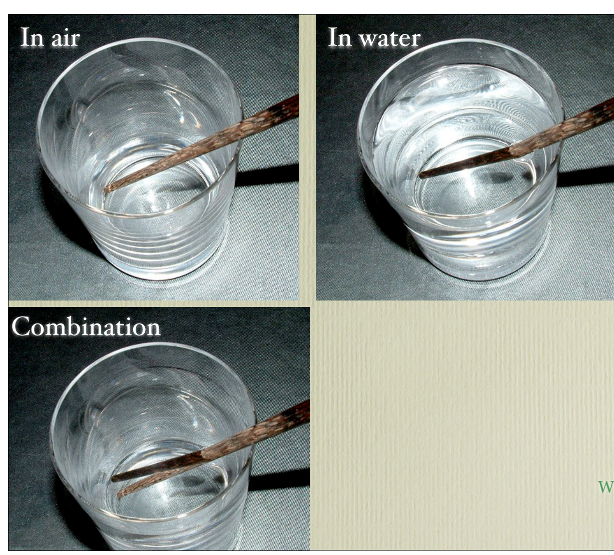
Light Box

Text

1. Christopher Canonaco

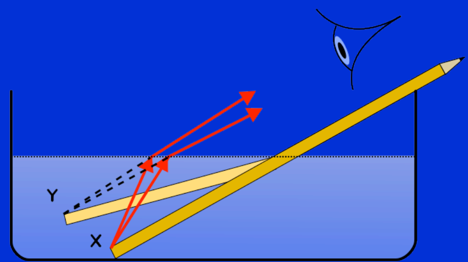
1. Why does my hand bend when I put it underwater?
2. When we place objects underwater, they appear to bend. Are there any objects that will not bend? Would different liquids cause objects to bend more or less?
3. 2 on a 5-point scale. I imagine the professor will know the answer to this question off the top of their head.

Text



Anton
Wikimedia

1. Light travelling upwards from object is refracted at surface
2. Object appears to be bent



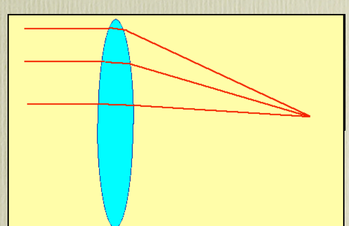
Wikimedia

Text

Lenses

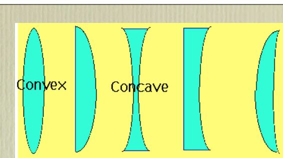
- All optical instruments have at least 2 surfaces.
- A prism deflects light via two successive refractions

so it will bend
a ray of light
Add a second prism
and a third

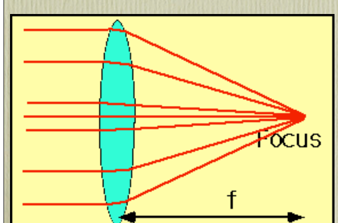


A lens is a “smoothed out” version of this

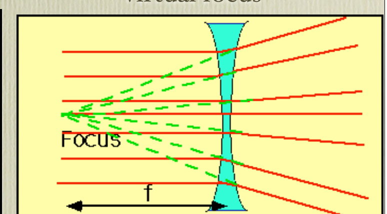
- Many different shapes of lenses



Convex:
converges light
to a focus

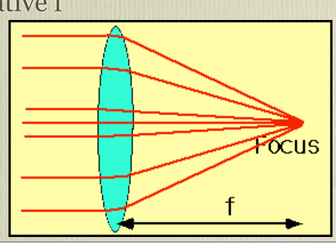


Concave:
diverges light
but leaves a
virtual focus

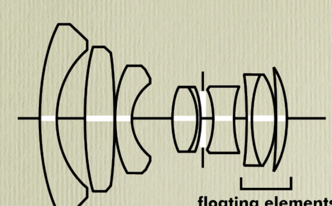


PW

- Most important parameter is focal length f
- “Strength” of lens
- Distance at which rays are brought to a focus for light from ∞
- so f = 40 cm means light is focussed 40 cm from lens
- diverging lenses have negative f



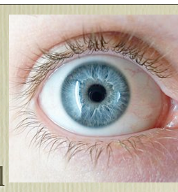
- Camera lenses have many components



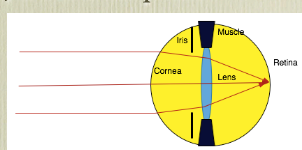
Nippon Kogaku (Nikon)
Nikkor-N Auto 24mm f/2.8
1967

Text

The most important lens system



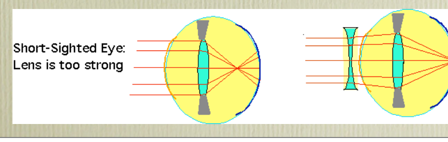
- Works differently from any other optical instrument (such as camera, telescope..) in that focussing is performed by deforming the lens by the eye muscles.
- Eye can be focussed (ideally) from a far point of ∞ to 20 cm
- Iris cuts down light
- Retina detects light
- Eye is filled with vitreous humour



PW, Wikisource

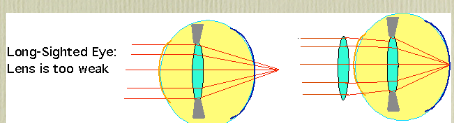
Common eye-problems:

- Short-sight/Near-sightedness/myopia: caused by too strong a lens, corrected by concave lens.
- Note opticians talk about strength of lens in diopters
- D = 1/f
- so -40 cm lens is -2.5 D



Text

- Long-sight/far-sightedness/hyperopia: caused by lens that is too weak
- corrected by convex lens



PW

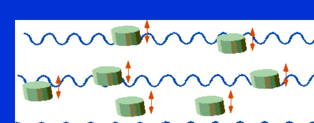
- Presbyopia: inability to focus, corrected by bi-focals
- Astigmatism: eye is not perfectly spherical, corrected by cylindrical lens.
- Other issues: usually retinal problems (light detecting system) e.g. glaucoma, macular degeneration

Michael Gora (Shahad Dalla, Tanvir Janmohamed)

1. Q- What are microwaves, how are they being used in technology today and is there any dangers associated with using microwaves?
2. This is a good question because microwaves are used for many applications on a day-to-day basis. If it is not the actual microwaves that are dangerous but a bi-product of microwaves that can cause danger is there a way to detach the two.
3. I assume this is an easy question to answer. However, there is always the possibility of microwaves having setbacks that the whole scientific community is blind to for reasons such as research equipment restrictions or intricacies that have gone overlooked.

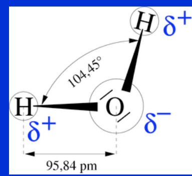
1. Just as moving charge produces EM waves
2. E.M waves move charges

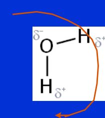
- just as corks bob up and down in water



PW

1. Water molecule consists of charges
2. E.M wave "spins" molecule
3. transfer heat to surroundings





Text

Why microwaves?

1. Visible & IR too strongly absorbed (that's how you grill meat!)
2. Need wavelengths short enough to fit inside oven
3. Fixed on 2.24 GHz (λ = 12.2 cm) produced by magnetron
4. heats water much more than fat or bone
5. microwaves are used for communication: e.g. GSM cell-phones use 900 MhZ & 1.8 GHz

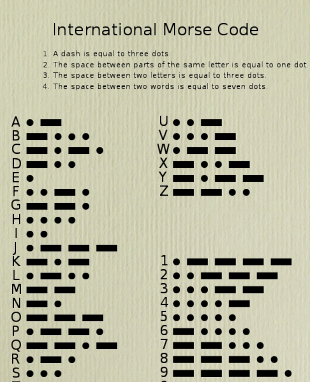
Text

Jennifer Macinsky

1. How do radio waves carry data and voices through the air? How can people from different locations tune into the same radio frequency and recieve the same information on that radio frequency, but no interference from information broadcasted on other frequencies?
2. This is a good question because it gets at the fundamental physical reason for how radio frequencies work. And I believe it relates well to this course, and can be explained at our level. Plus I want to know.

1. Actually it's three good questions!
2. How do the radio waves propagate?
3. How do we modify them?
4. How do we separate different frequencies?
5. Problem is that voice has frequencies of ~ 1 kHz,
6. Radio frequencies ~ 1 MHz

Oldest was Morse code



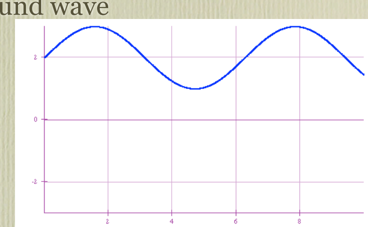
Text

Amplitude Modulation (A.M)

- "Carrier Wave" is high frequency: change the amplitude by the sound wave

Rectify it

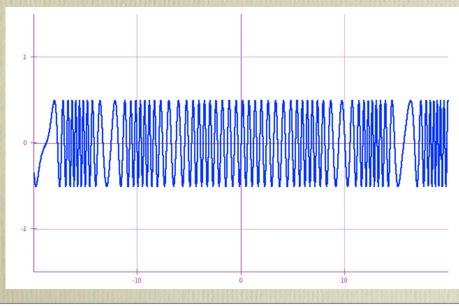
"average" it to get rid of high frequency



PW

Frequency Modulation (F.M.)

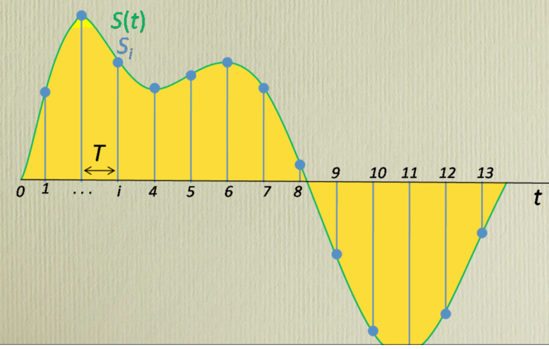
- Vary the frequency of the wave.
- Mush less prone to interference



Text

Digital methods

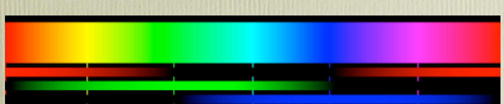
- Sample height of signal at discrete times



Text

Colour

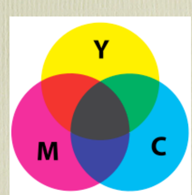
- is complicated!
- firstly perception: the retina consists of rods and cones
- three kinds of cones, respond (roughly) to red, green, blue light (RGB)
- e.g common color-blindness (in men) is lack of red sensors



Wikipedia

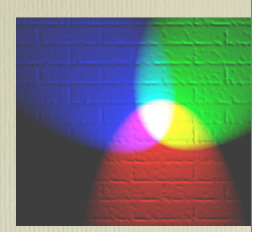
- Note that cones are less sensitive to light and are more concentrated near the centre of the eye
- Hence in low light we lose colour vision (can't see colours of dim stars)
- Also to see better in the dark, use peripheral vision (don't look directly at the object)
- Very bright light saturates all the cones, so we see it as white

- Colour is essentially defined by light reflected from a surface
- "subtractive" colour defined by removing a colour from spectrum
- e.g remove red from spectrum leaves cyan
- - green ➟ magenta
- -blue ➟ yellow
- CMYK printing includes black



Text

- "additive" colour starts with black
- add RGB to create white light



Text

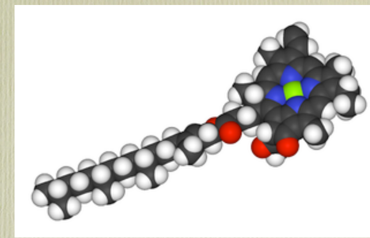
Brandon Keyes

1. Why is most (if not all) of Earth's vegetation green? Is this an Earth specific trait, or a vegetation specific trait? As in, if a green vegetable were taken to the moon, would it change colours? My guess is that it would not. It is relevant to science to understand why certain things take on certain colors, and if it is relative to Earth or not.
2. It involves many different scientific elements, and so I do think it is a rather difficult question to answer,although it may be something as simple as the gasses in our atmosphere reacting with the plants and light.

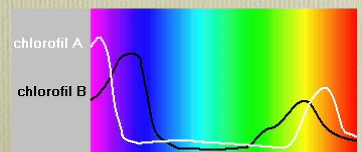
Text

•Chlorophyll

complex molecule, evolved in several forms



- Absorbs blue, yellow and red light, so looks green

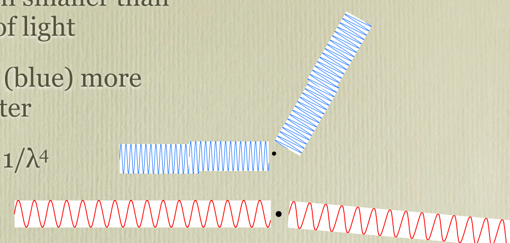


Wikipedia

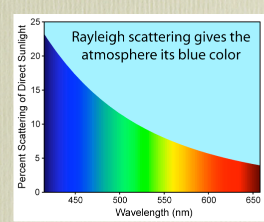
Why is the sky blue?

2. I've noticed the sky is bluest at midday on a cold day, but when it's smoggy it's whiter. Would it be blue on other planets? Is it blue on the moon?
3. I'd guess it's not simple, but I'm sure it can be explained.

- Atom is much smaller than wavelength of light
- Short λ light (blue) more likely to scatter
- Scattering ~ $1/\lambda^4$



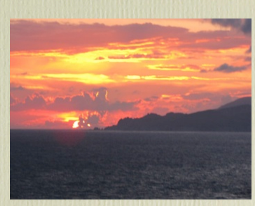
- Blue light has λ ~ 400 nm
- Red light has λ ~ 800 nm
- so blue will scatter 16 times more than red



PW.
Wikipedia

- Blue sky arises because blue light is removed from white
- red light is left

So your blue sky



Is someone else's sunset!

PW

Will revisit radiation once more

- Now we need to look at electricity