Waves Lesson 1: What is a Wave?!

Today's lesson will cover the following specification points:

Know that for a transverse wave, the direction of vibration is at right angles to the direction of propagation and understand that electromagnetic radiation, water waves and seismic S-waves (secondary) can be modelled as transverse

Know that for a longitudinal wave, the direction of vibration is parallel to the direction of propagation and understand that sound waves and seismic P-waves (primary) can be modelled as longitudinal

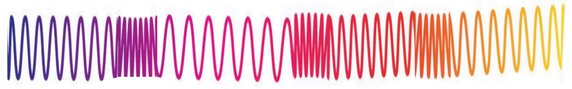
Describe the features of a wave in terms of wavefront, period, wavelength, frequency, crest (peak), trough, amplitude and wave speed

Know that waves transfer energy and information without transferring matter

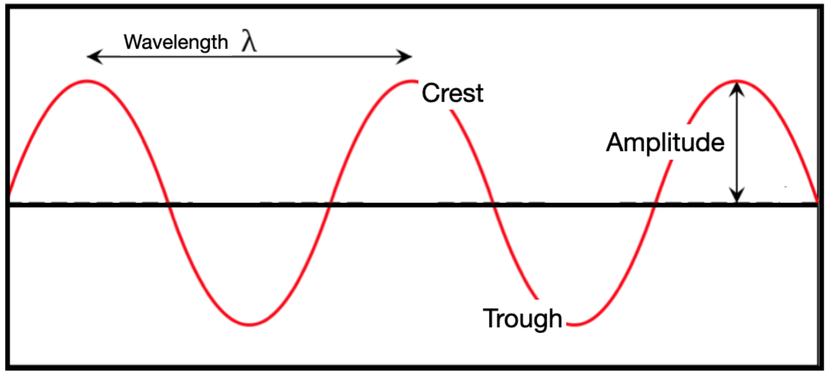
Describe what is meant by wave motion as illustrated by vibrations in ropes and springs,

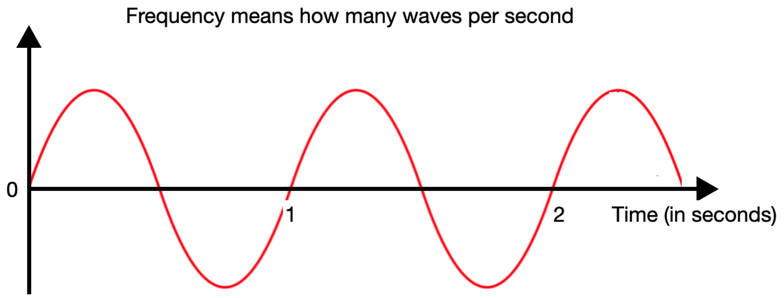
Useful diagrams:

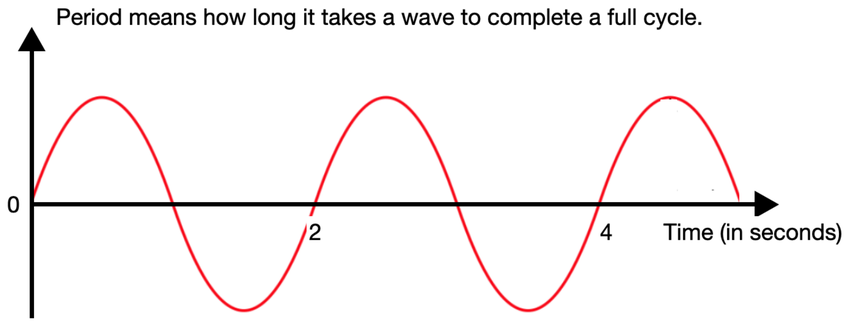
Transverse Wave



Longitudinal Wave





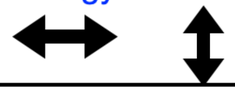


Doodle:

1) Listen to the ‘story’! How many waves do you see, or hear mentioned? Write them down here.

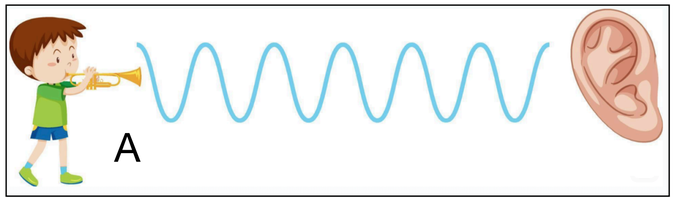
Tick the correct boxes!

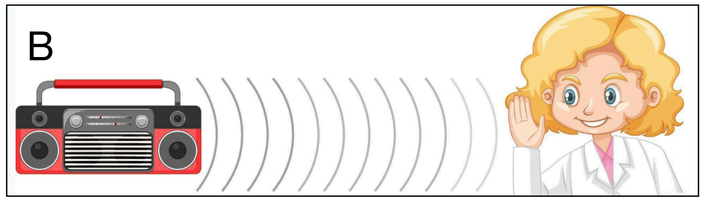
One has been done for you

	 Transverse Waves	 Longitudinal Waves
Do they transfer energy?	✓	
Do they transfer matter?		
Energy & vibrations are at right angles to each other 		
Energy & vibrations are parallel to each other 		
Write TWO examples of each!	....	....

Done? Are dominoes falling a wave? Explain your answer.

GCSE Questions!





1. Two illustrators draw images of sound waves for a children's text book. Explain which wave diagram, A or B, is more scientifically accurate and why.

_____

_____

_____

_____

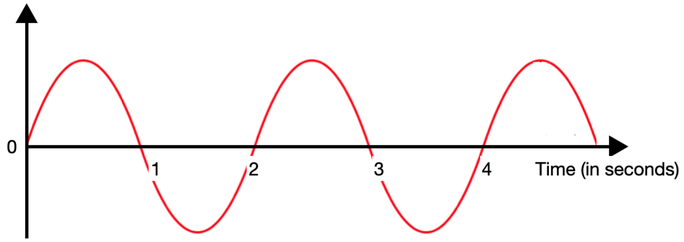
_____

2. Give an example of a transverse wave. (1 mark)

_____

3. What is the frequency of this wave?

_____



What is the period?

_____

4. Look at the diagram below. Which letter represents the wave's…

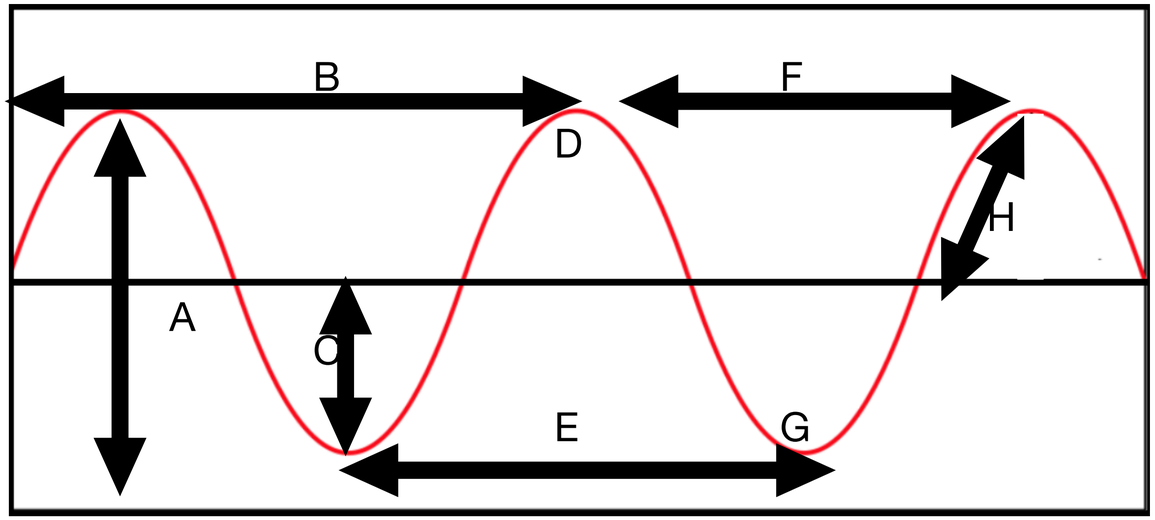
Amplitude ____

Wavelength ____

Crest ____

Peak ____

(4 marks)



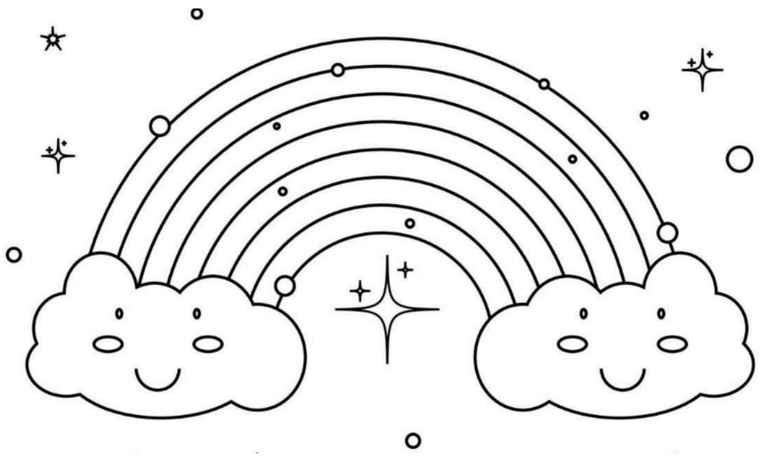
Waves Lesson 2:
Electromagnetic Waves

Today's lesson will cover the following specification points:

Know that light is part of a continuous electromagnetic spectrum that includes radio, microwave, infrared, visible, ultraviolet, x-ray and gamma ray radiations, and that all these waves travel at the same speed in free space

Know that the speed of electromagnetic waves in a vacuum is 3.0 × 108m/s and is approximately the same in air

know the order of the electromagnetic spectrum in terms of decreasing wavelength and increasing frequency, including the colours of the visible spectrum



Uses of EM waves!

(Those in italics are mentioned on the Cambridge Specification only).

Radio waves:
broadcasting and communications
astronomy, radio frequency identification (RFID)

Microwaves:
cooking and satellite transmissions
satellite television, mobile phones

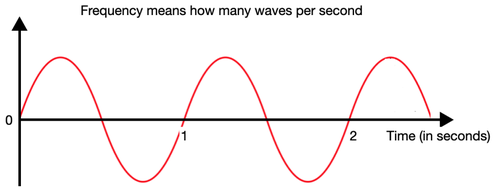
Infrared:
Heaters and night vision equipment
electric grills, short range communications such as remote controllers for televisions, intruder alarms, thermal imaging, optic fibres

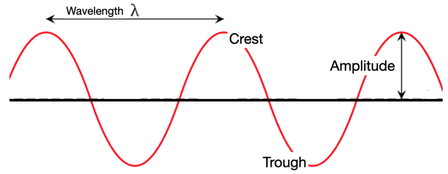
Visible light:
optic fibres and photography
vision, illumination

Ultraviolet:
fluorescent lamps (edexcel only)
security marking, detecting fake bank notes, sterilising water

x-rays:
observing the internal structure of objects and materials, including for medical applications

gamma rays:
sterilising food and medical equipment (e)
detection of cancer and its treatment





Dangers of EM waves!

(Those in italics are mentioned on the Cambridge Specification only).

Microwaves:
internal heating of body tissue

Infrared:
skin burns

Ultraviolet:
damage to surface cells and eyes, leading to skin cancer and eye conditions including blindness

X-rays and Gamma rays:
cancer, mutation

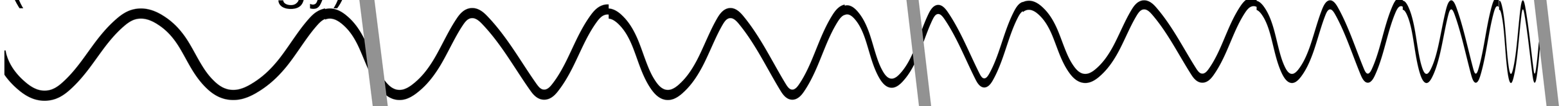
describe simple protective measures against the risks

You might want to use this page to make notes. Or you might want to just enjoy listening! Up to you.

Electromagnetic Waves

(Least energy)

(Most energy)



Radio Microwave Infrared Light Ultra-violet X-ray Gamma

Electromagnetic Waves

(Least energy) (Most energy)

Radio Microwave Infrared Light Ultra-violet X-ray Gamma

1) Which waves travel at the speed of light?

2) Which of the above waves can travel though space?

3) Which of these waves do <u>you</u> give off?!

4) Which three are most damaging to human cells?

5) Match the wave to the use

Used for cooking: penetrate deep into food, and are absorbed by water particles

Used to send mobile phone signals

Used in communications: they travel most easily through Earth's atmosphere (2)

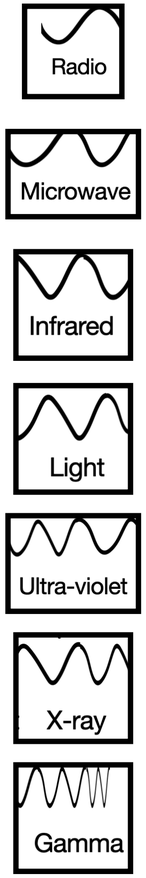
Used to sterilise water

Used for thermal imaging

Used to treat cancer

Used for grilling food

Travel through skin, absorbed by bone



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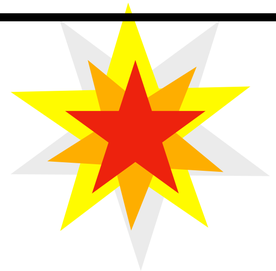
6) Puzzles!

You want to use a satellite to get images of clouds around Earth. At night! What kind of wave detector do you use?

Ice gives off far less IR radiation than water. What wave would you try to detect if you wanted to accurately map the ice on Earth's oceans?

You want to study bursts of the highest energy electromagnetic waves there are. What waves do you try and detect and where do you put the detector?

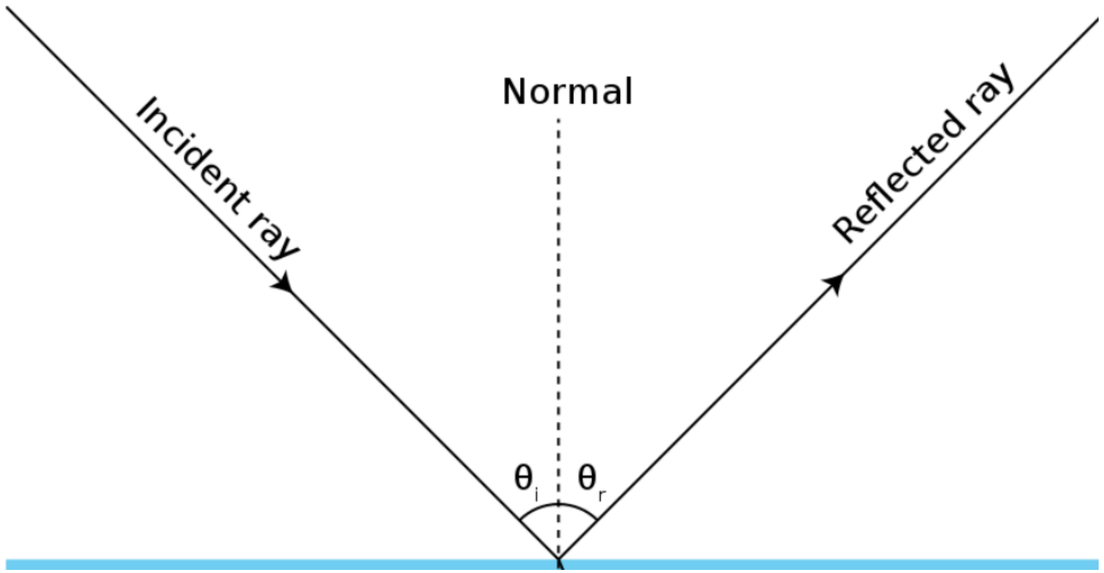


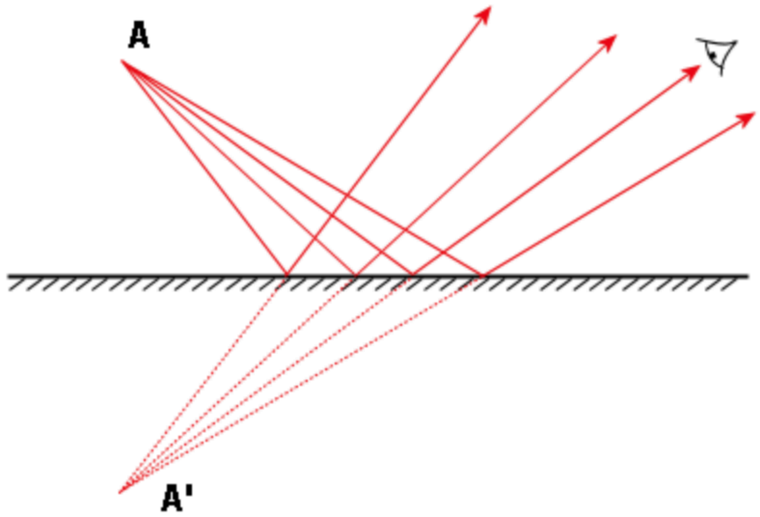
Waves Lesson 3: Reflection

Today's lesson will cover the following specification points:

Describe how waves can undergo: (a) reflection at a plane surface
Define and use the terms normal, angle of incidence and angle of reflection
Describe the formation of an optical image by a plane mirror, and give its characteristics, i.e. same size, same distance from mirror, virtual
State that for reflection, the angle of incidence is equal to the angle of reflection; recall and use this relationship
Use simple constructions, measurements and calculations for reflection by plane mirrors

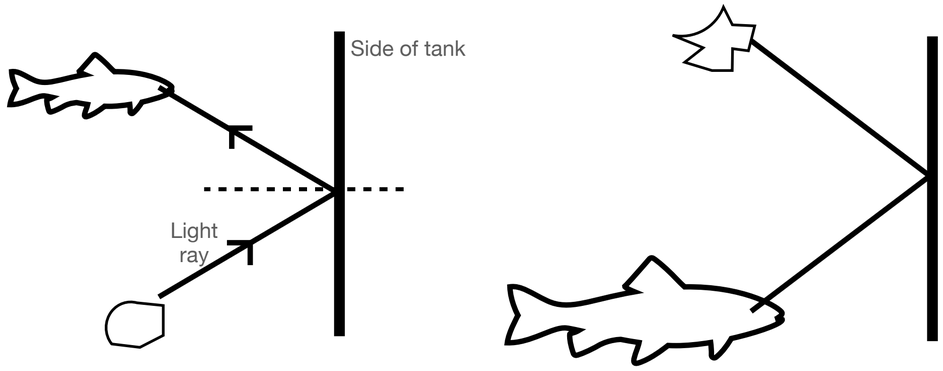
(This is Cambridge, but Edexcel is the same, the spec just goes into less detail so not as useful here!)

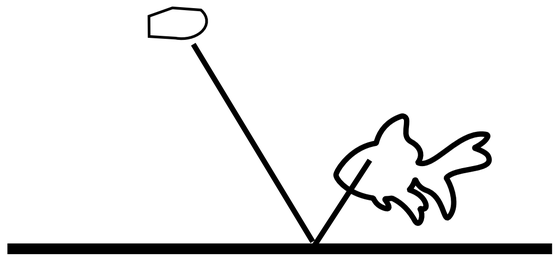




Ray Diagram Questions!

1. Draw arrows on the light rays to show how these fish see the food. One has been done for you.
(Hint, they are average fish, they can't shoot laser beams out of their eyes)



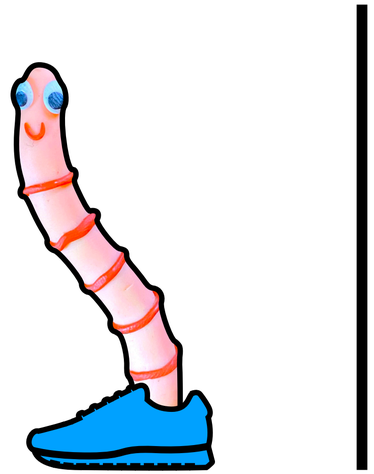


2. Label the reflected rays with an 'r' in each diagram

3. Label the incident rays with an 'i'.

4. Sketch the normals! The first has been done.

5. Wormy has a new shoe. Draw a normal in the middle of the mirror, then draw light rays to show how she can see her boss new footwear,



6. On the back of this page, draw a diagram showing how an ant sees their pants in a mirror.

7. Label the incident ray, reflected ray, angle of incidence and angle of reflection in the diagram.

GCSE Questions!

1. A woman looks at her reflection in a mirror. Draw a cross where the image of the bow on her head would be.
2 marks

2. Draw a ray from the bow that reflects off the mirror and into the woman's eye. Draw arrows to show what direction the ray is travelling in.
2 marks

3. Mark the angle of incidence with an i, and the angle of reflection with an r.
1 mark

4. A mug is placed 20cm in front of a flat mirror.

Is the image…

a) Bigger and 20cm away from the mug
b) Bigger and 40cm away from the mug
c) The same size and 20cm from the mug
d) The same size and 40cm from the mug

1 mark

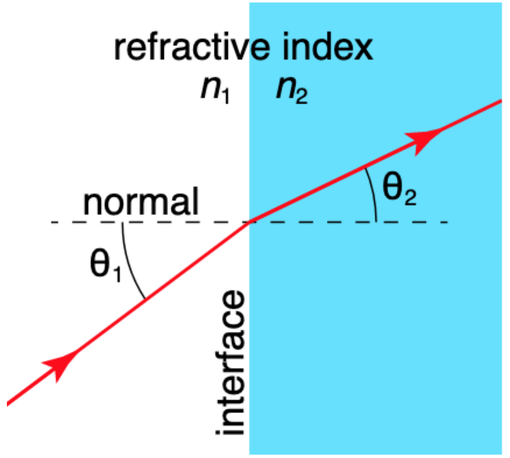
Waves Lesson 4: Refraction

Edexcel and Cambridge both write IGCSE exams. Today's lesson will cover the following specification points:

Edexcel:
Explain that all waves can be refracted
Draw ray diagrams to illustrate refraction
(Practical: investigate the refraction of light, using rectangular blocks, semi-circular blocks and triangular prisms.
Practical: investigate the refractive index of glass, using a glass block) You can look this up after the lesson!
Know and use the relationship between refractive index, angle of incidence and angle of refraction

Cambridge: All of the above and:
Describe the dispersion of light as illustrated by the refraction of white light by a glass prism

$$n = \frac{\sin i}{\sin r}$$



Notes: Anything you're unsure of that you need to look up after the lesson? Any questions you want to post in the Facebook group?

When each object hits the boundary…

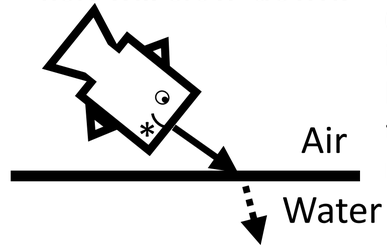
1) Will it speed up or slow down?

2) Which direction will it go in? ← Draw a line!

Example

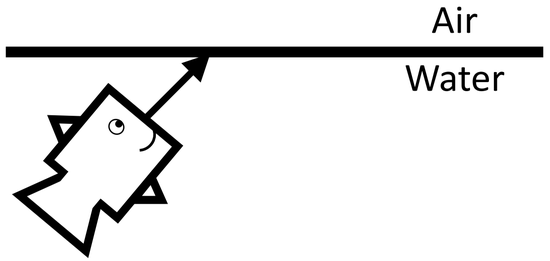
1) Going into water - fish will *slow down.*

2) Corner with a * will hit water first, so fish will change direction as shown

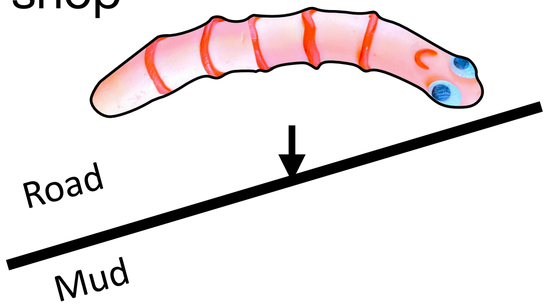


(Boundary is 'line' between the different materials)

1) Weirdly square fish leaping out of water

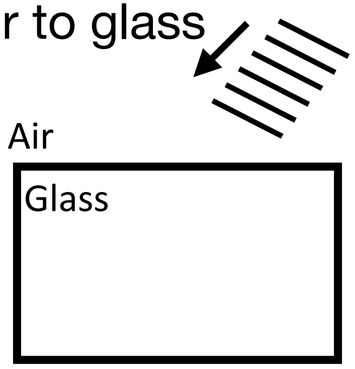


2) Wormy rolling to the shoe shop

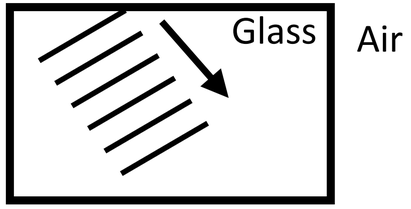


3) Steamroller hitting a square of glue it could happen physics is relevant

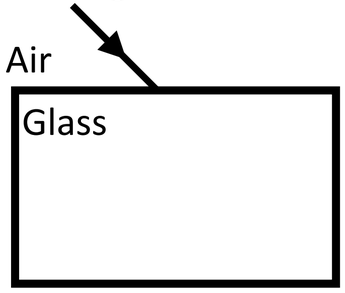
5) Light moving from air to glass



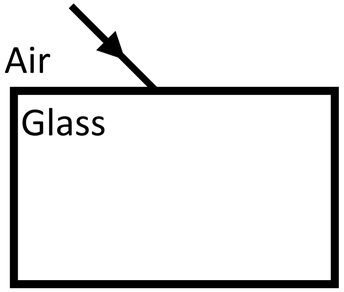
6) Light moving from glass to air



6) Light moving from glass to air



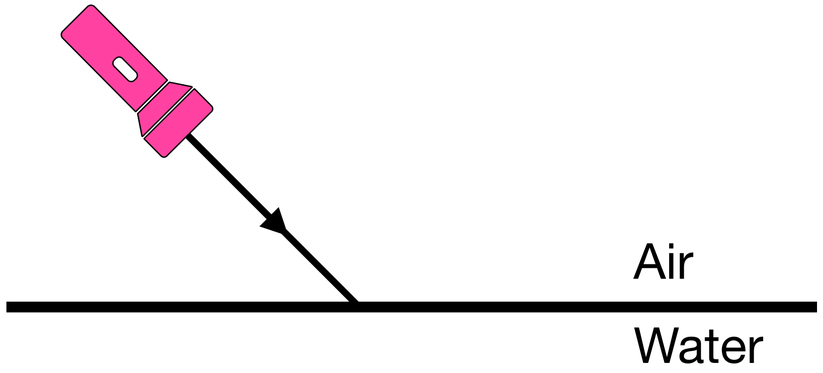
Done? Show how the light travels through the glass and out the other side!



I think…

GCSE Questions!

1. A laser is shone at the surface of a swimming pool. Draw a line to show the path of the ray of light. 2 marks

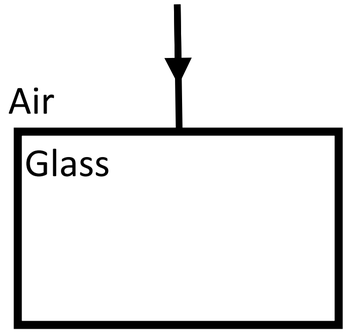


What is the name of this process?

_____ 1 mark

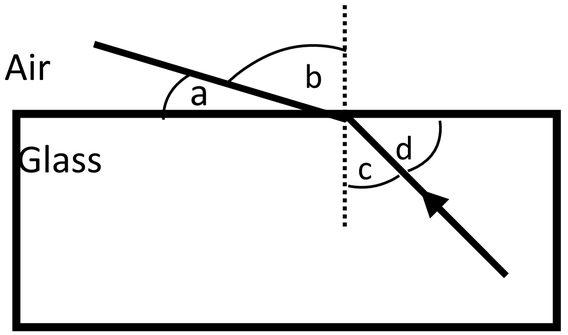
2. A ray of light passing into a glass block as shown. Describe what happens to the direction the light is travelling in.

1 mark



3) A ray of light refracts when leaving a piece of glass.

What letter shows the angle of refraction: a, b, c or d? 1 mark

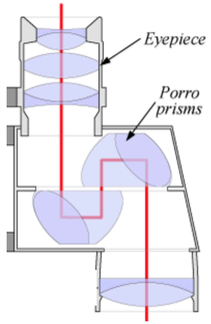


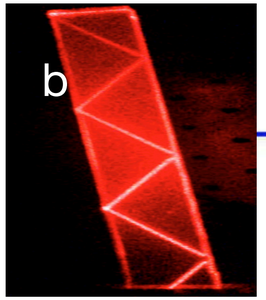
Waves Lesson 5: Total Internal Reflection

Thanks for supporting me on Kofi!

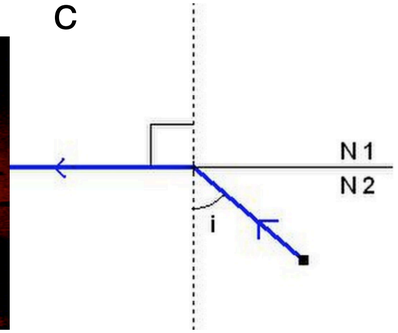
One of these is NOT an example of total internal reflection. Which one do you think? Explain your answer!

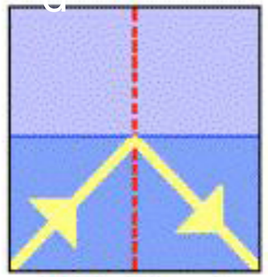
a*





c





I think…

Because…

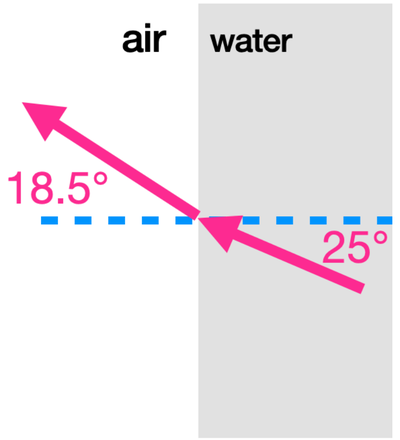
$$\sin c = \frac{1}{n} \qquad n = \frac{\sin i}{\sin r}$$

1) The refractive index of diamond is 2.4. Calculate the critical angle for light passing from diamond to air.

2) Calculate the critical angle for light passing from ruby to air. The refractive index of ruby is 1.8.

3) Jewels seem to sparkle more, the more the light shining on them is internally reflected. Which do you think would sparkle more, a jewel with a higher or lower critical angle?

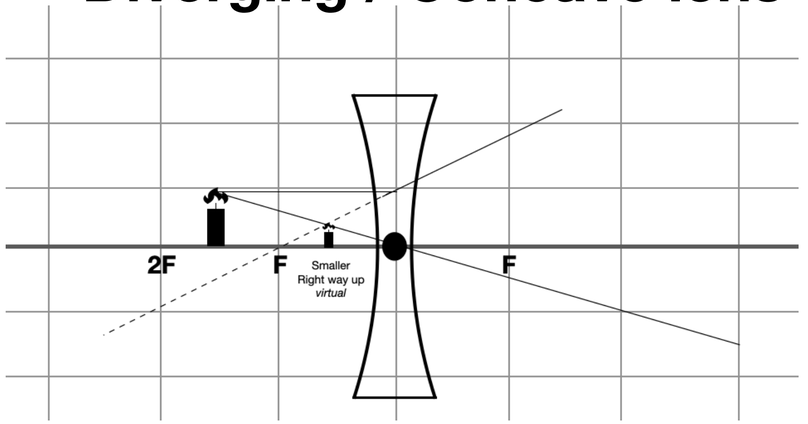
4) Light travels from water to air as shown. Calculate the critical angle of water.



*Huge thanks to DrBob for this image. License https://creativecommons.org/licenses/by-sa/3.0/legalcode Sourced via wikimedia commons.

Waves Lesson 6: Lenses

Diverging / Concave lens



Edexcel don't actually need you to learn about lenses! Cambridge want you to:

Describe the action of thin converging and thin diverging lenses on a parallel beam of light
Define and use the terms focal length, principal axis and principal focus (focal point)
Draw and use ray diagrams for the formation of a real image by a converging lens

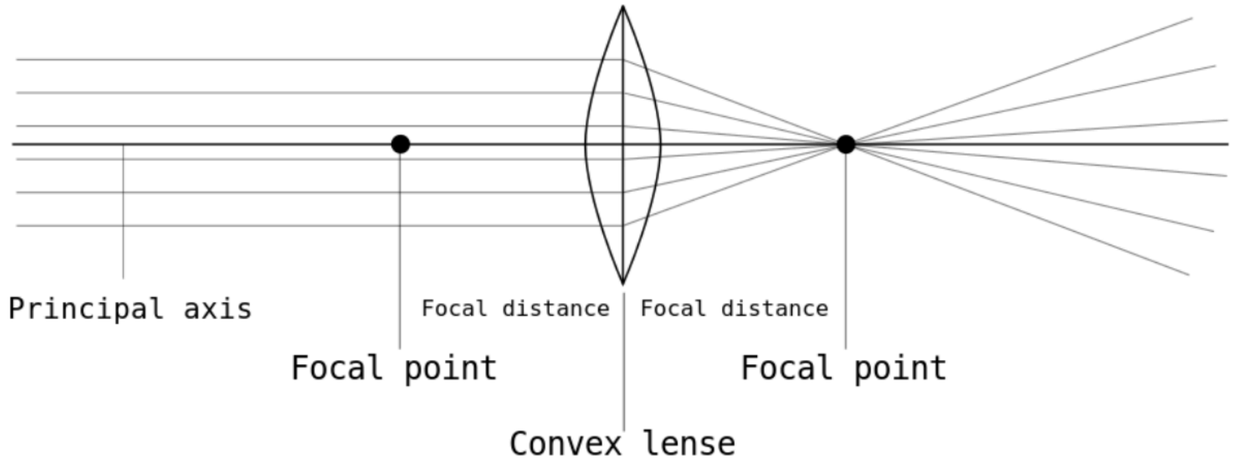
Describe the characteristics of an image using the terms
enlarged/same size/diminished **upright/inverted** **real/virtual**

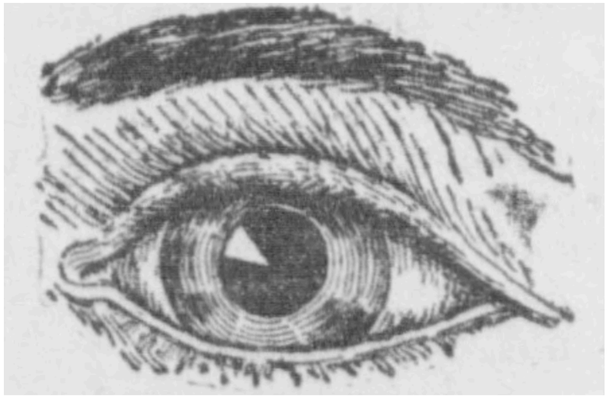
Know that virtual images are formed when diverging rays are extrapolated backwards and do not form visible projections on a screen

Draw and use ray diagrams for the formation of a virtual image by a converging lens

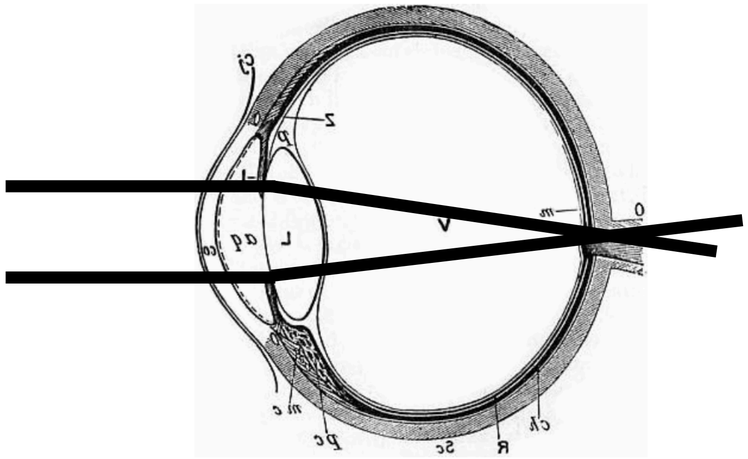
Describe the use of a single lens as a magnifying glass

Describe the use of converging and diverging lenses to correct long-sightedness and shortsightedness





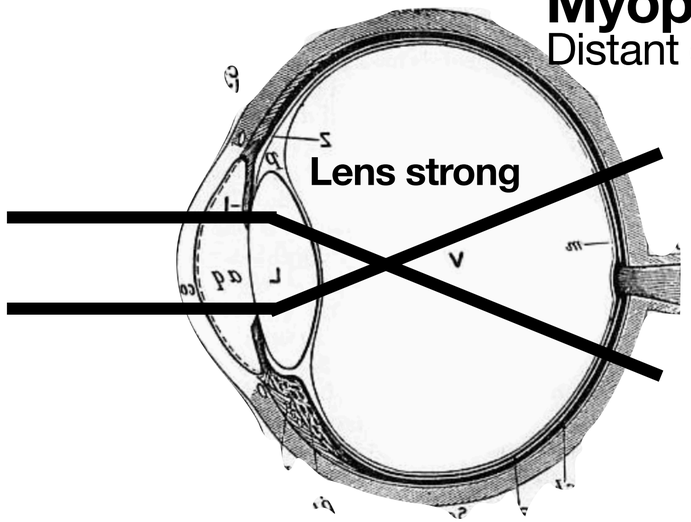
Typical Eye

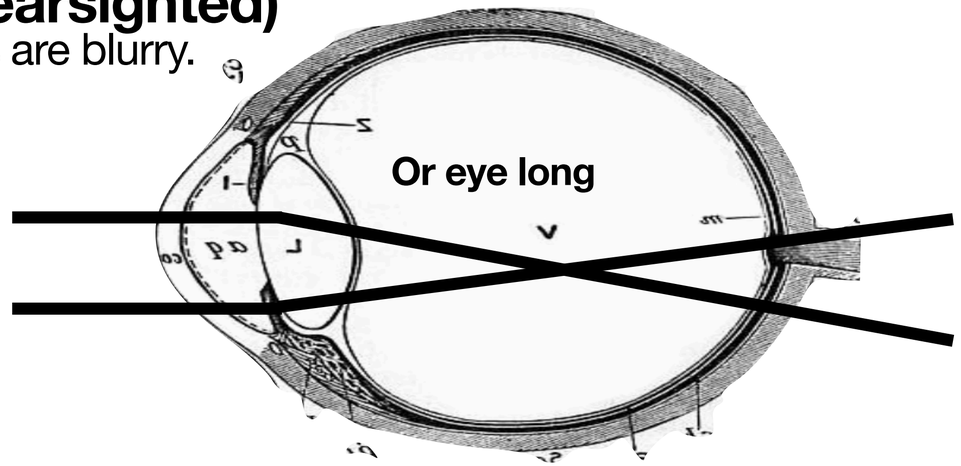


(Image focussed at back of eye)

Myopia (Nearsighted)

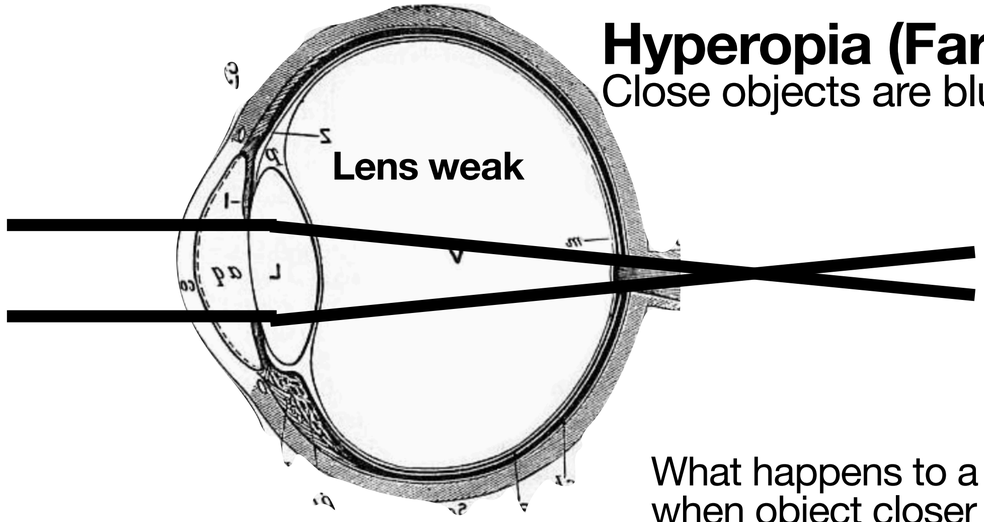
Distant objects are blurry.

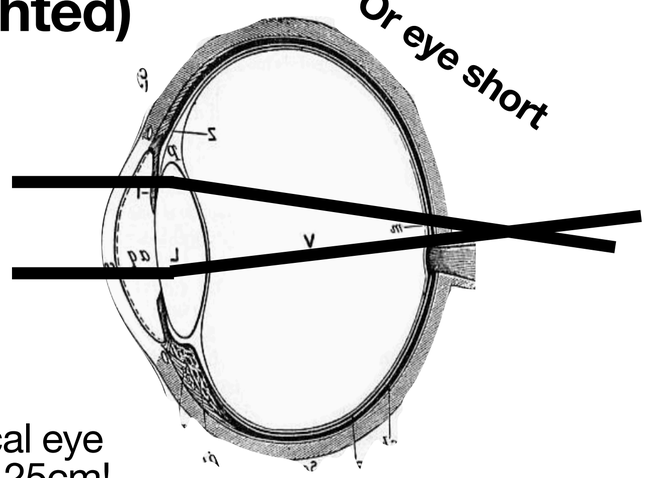




Hyperopia (Farsighted)

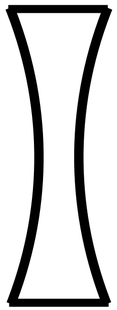
Close objects are blurry.



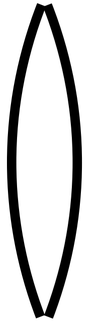


What happens to a typical eye when object closer than 25cm!

1) Which lens would you put in front of these eyes help them see in focus?
2) Sketch how they work!

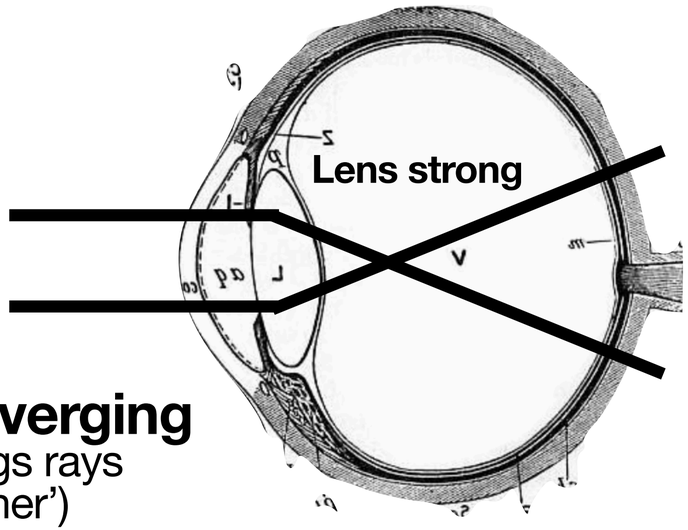


Diverging
('Spreads rays out')

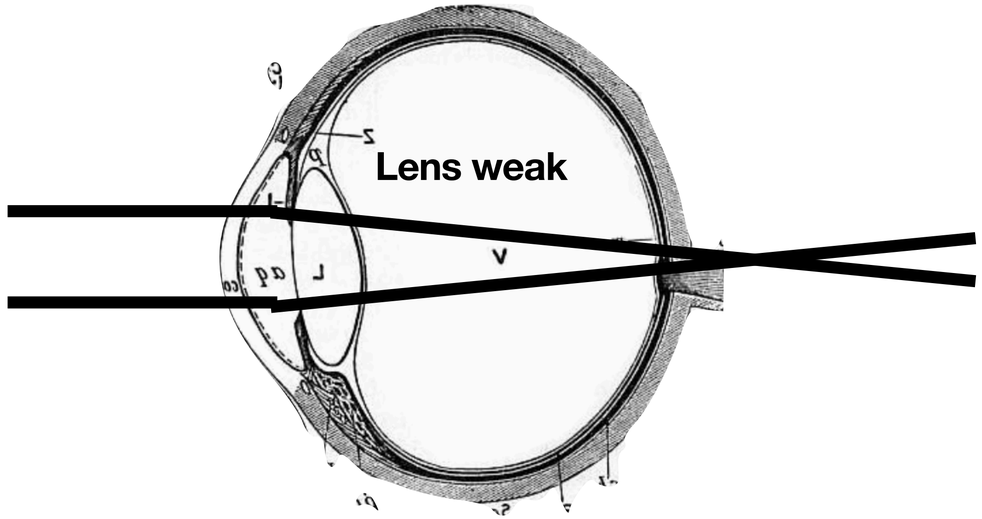


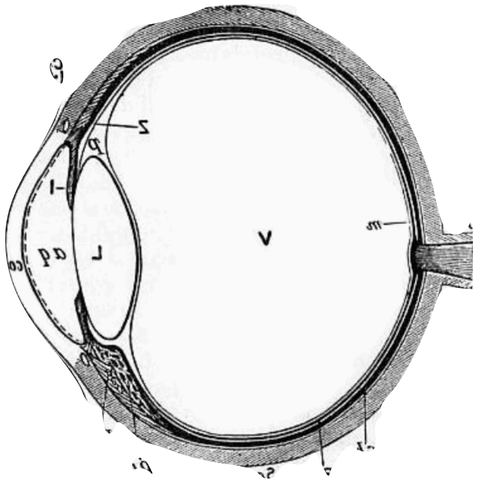
Converging
('Brings rays together')

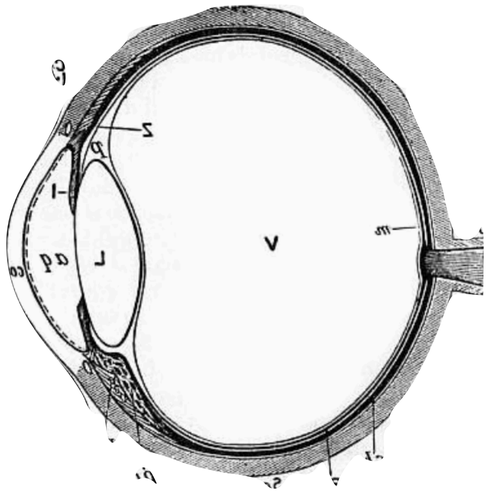
Myopia (Nearsighted)
Distant objects are blurry.

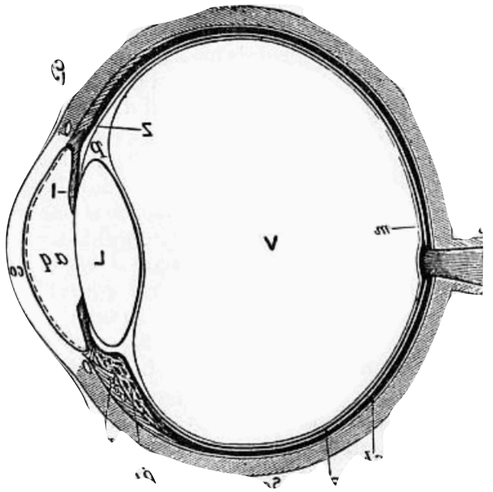


Hyperopia (Farsighted)
Close objects are blurry.



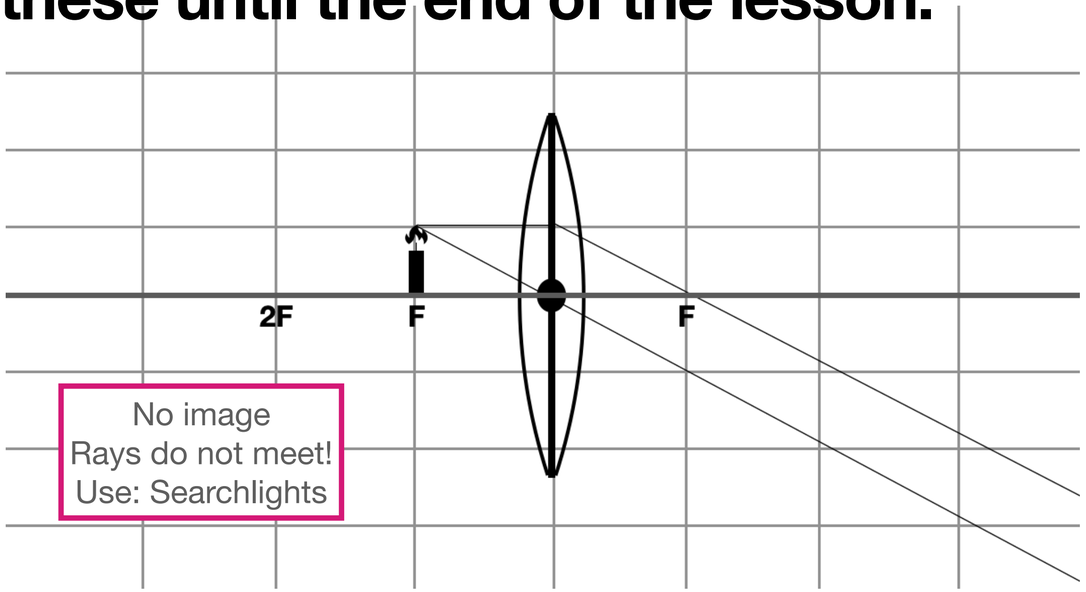


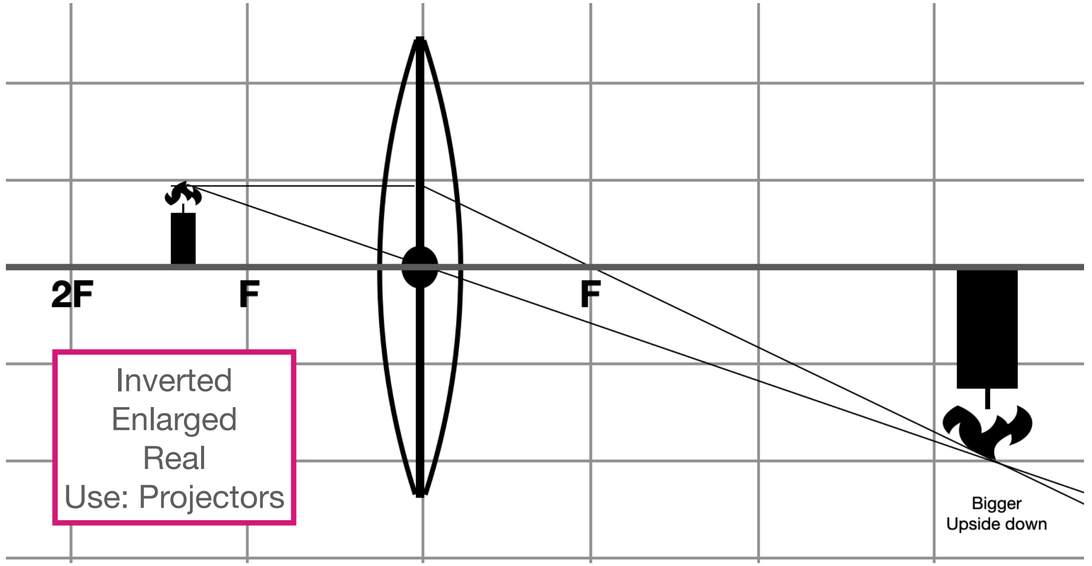


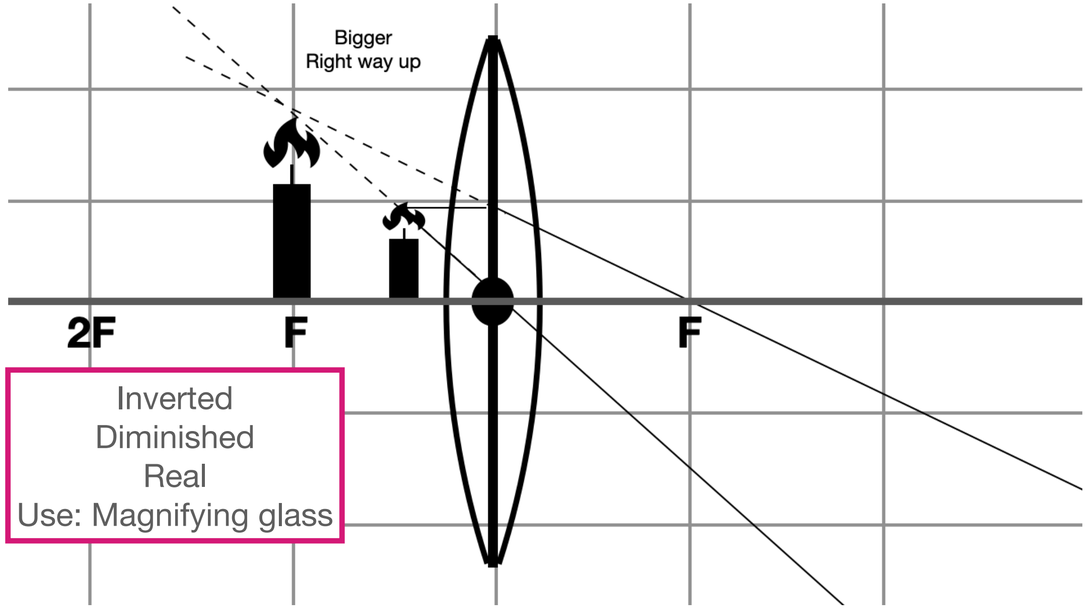


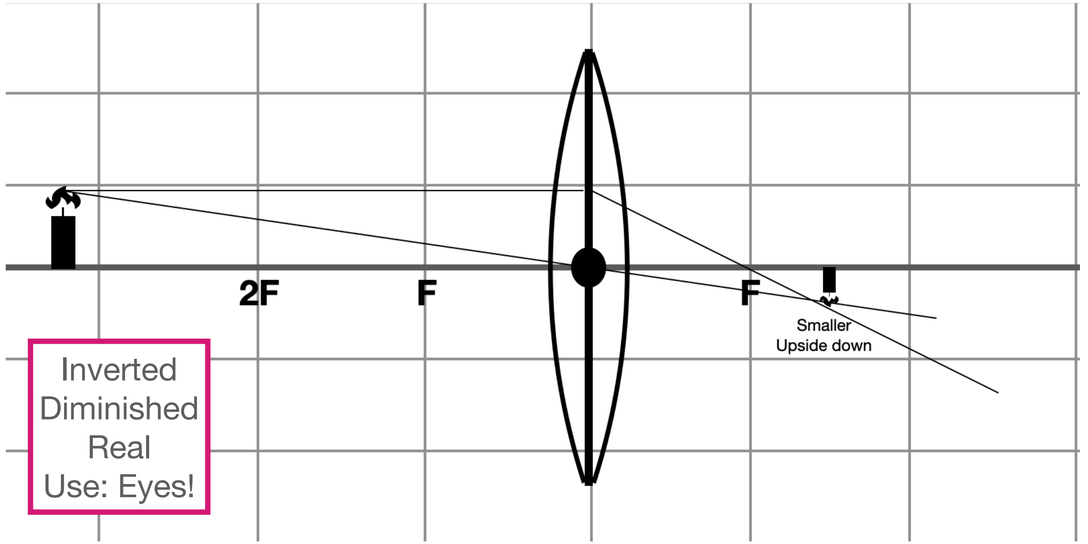
(Spare eye for sketching!)

Answers! To be used for checking / revision! I'd really like you to not use these until the end of the lesson.









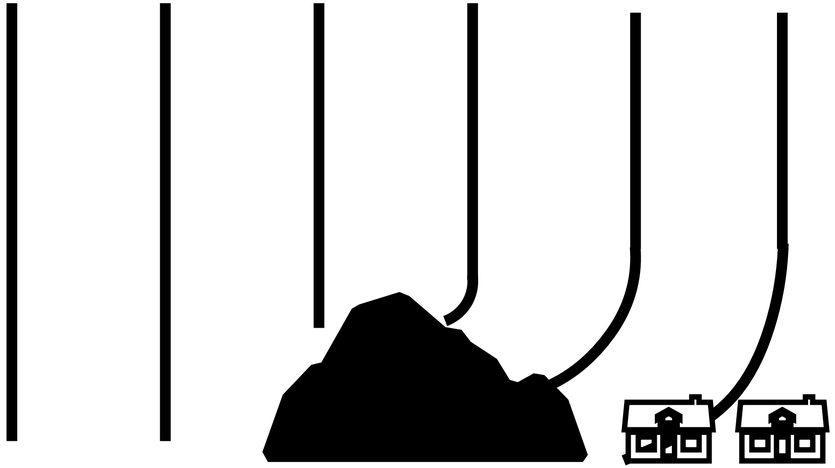
Waves Lesson 7: Diffraction

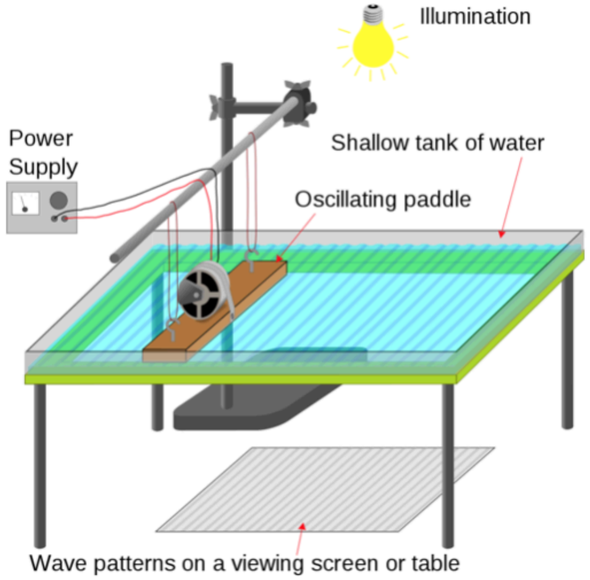
Specification points covered this lesson:

Describe how waves can undergo: (c) diffraction through a narrow gap
Describe how wavelength and gap size affects diffraction through a gap
Describe how wavelength affects diffraction at an edge

Describe the use of a ripple tank to show: diffraction due to a gap and diffraction due to an edge

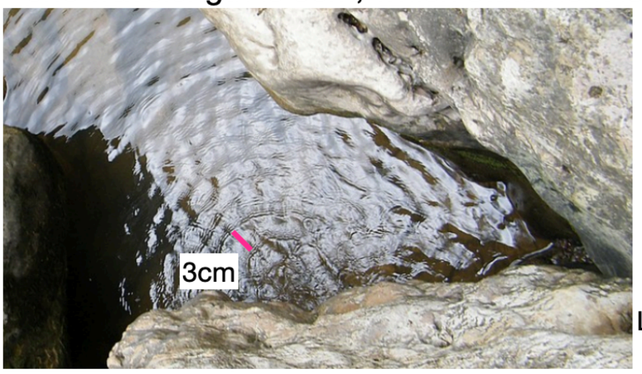
Thank you for paying my wages by supporting me on Kofi!





Ripple Tank

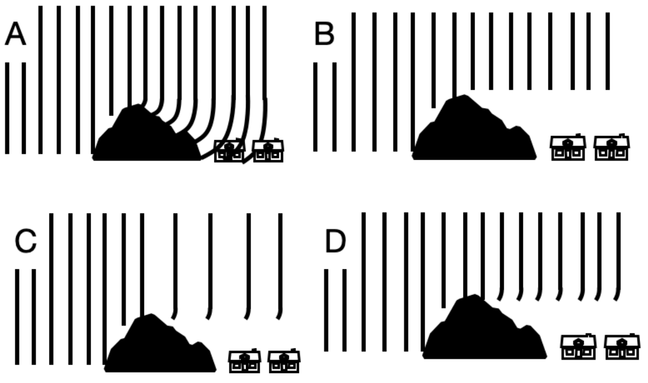
Water waves travel through a hole in a rock and make the pattern shown. Mark a cross on the photograph where the hole must be. If one wavelength is 3cm, which statement is correct?



The hole is three cm or smaller

The hole is 3cm or larger

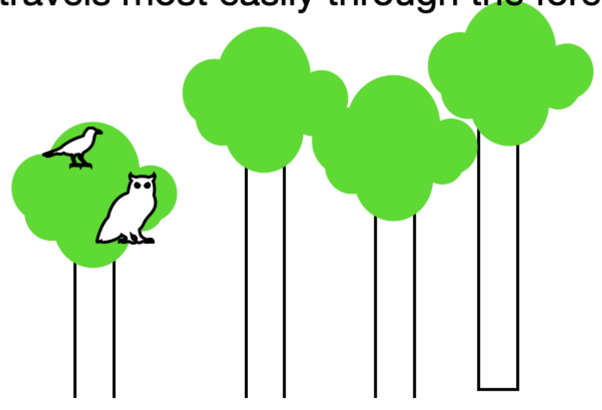
Explain your answer!



Which diagram shows how microwaves (of wavelength 1 metre) behave when they hit a 100m high mountain?

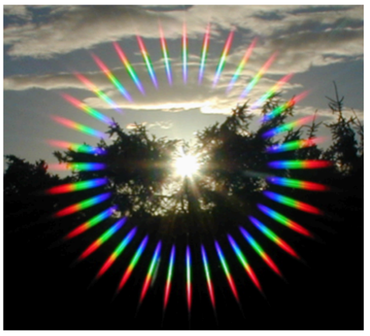
Explain why each of the others are wrong.

The sound of an owl's hoot has a wavelength of 43cm. A sparrow's tweet has a wavelength of 14cm. Both birds sing in a forest where the trees are over 30cm wide on average. Which bird's sound travels most easily through the forest, and why?



(NEVER LOOK AT THE SUN, DIFFRACTION GRATING OR NOT!)

A scientist takes a photo of the Sun through a diffraction grating. Why does the wavelength of red light mean it spreads out the most?

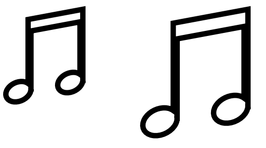


Waves Lesson 8: Sound

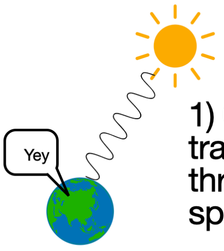
Thank you for paying my wages by supporting me on Kofi!

Starter Question: Which of these is ESSENTIAL, for a sound to be made?

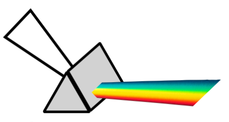
Echo chamber Waves Particles Vibrations Air



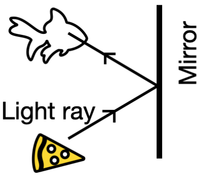
Light waves…



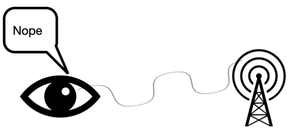
1) Can travel through space



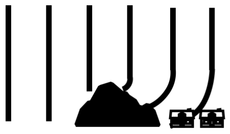
2) Travel slower through glass than air



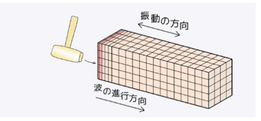
3. Can be reflected



4. Exist that can't be detected by humans



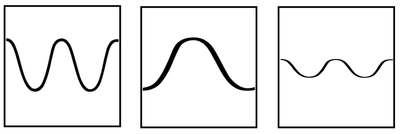
5. Can be diffracted



6. Are not pressure waves

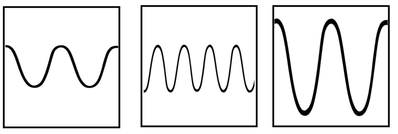
Can the same be said for sound waves? Write yes or no next to each case.

1. First Sound **Second Sound?**



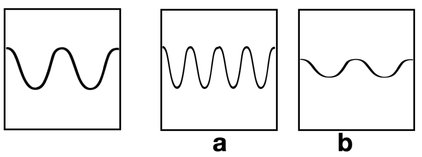
a b

2. First Sound **Second Sound?**



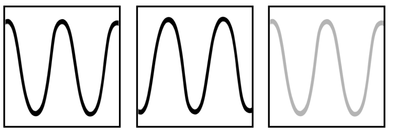
a b

3. First Sound **Second Sound?**



a b

4. First Sound **Second Sound?**



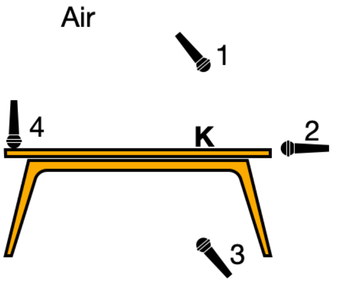
a b

Sketches **Louder**

Higher

GCSE questions!

1) A hand knocks on a table at K. Four microphones surround the table. Which microphone will pick up the sound first?



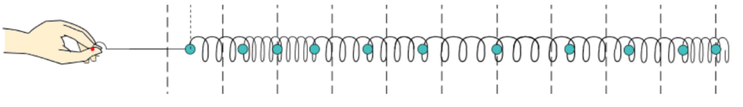
2) This picture represents a sound wave. Which sentence is correct?

a. The sound is getting higher
b. The sound is getting louder
c. The amplitude of the wave is decreasing
d. The frequency of the wave is decreasing.

3) Which of these sound waves could not be heard by a human?

a. Frequency of 2 kHz
b. Frequency of 20 kHz
c. Frequency of 200 Hz
d. Frequency of 200 000Hz

4) A person pulls on a slinky and produces a wave as shown. Label an area of compression and an area of rarefaction.



IGCSE Waves

Lesson 9: UltraSound

Thank you for paying my wages by supporting me on Kofi! xxx

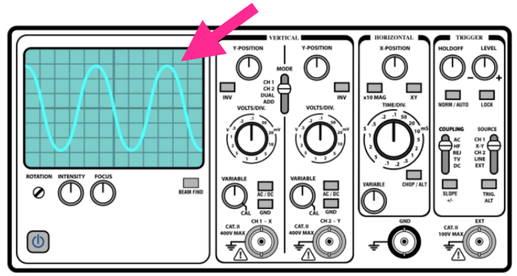
So you have a sound. You want to display it.

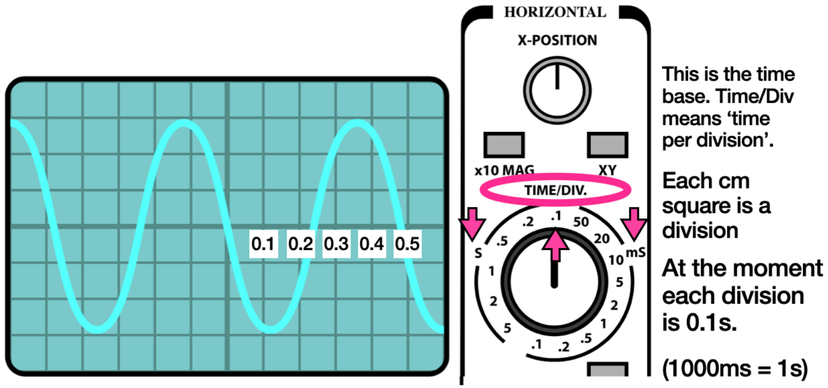
What equipment do you need?

Oscilloscope ✓

Wires ✓

_____?



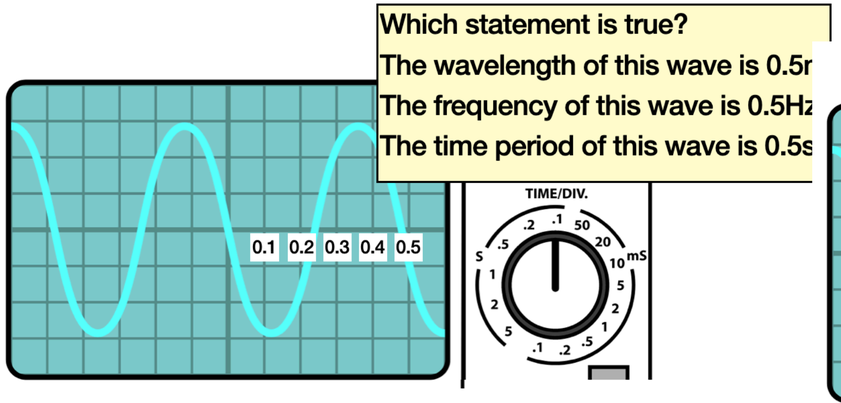


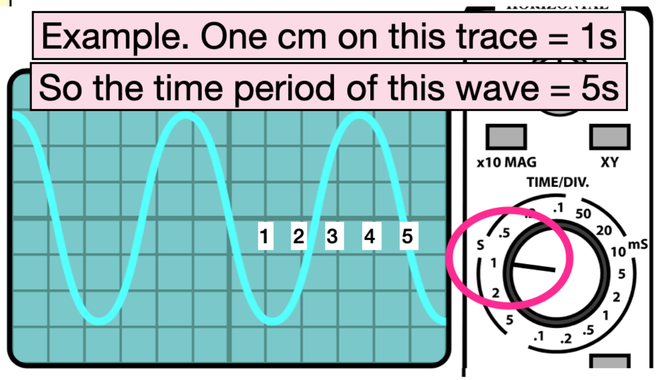
This is the time base. Time/Div means 'time per division'.

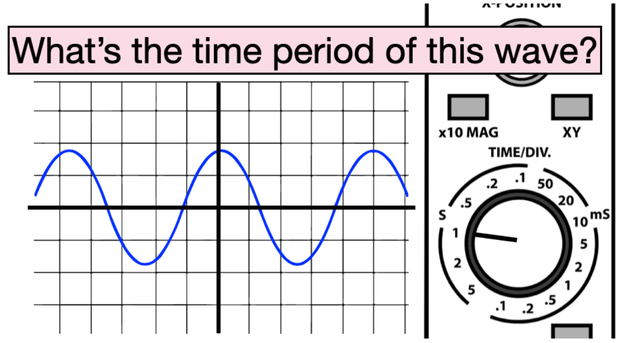
Each cm square is a division

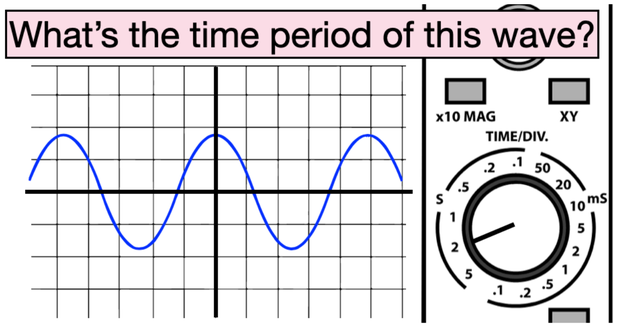
At the moment each division is 0.1s.

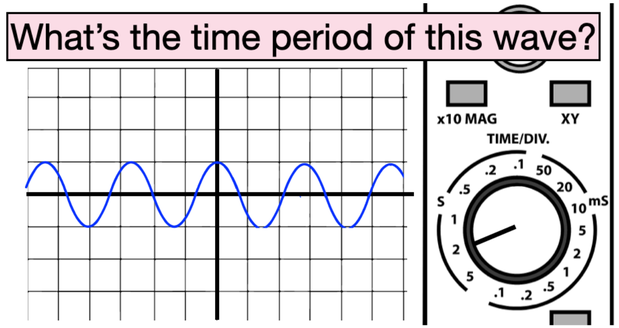
(1000ms = 1s)

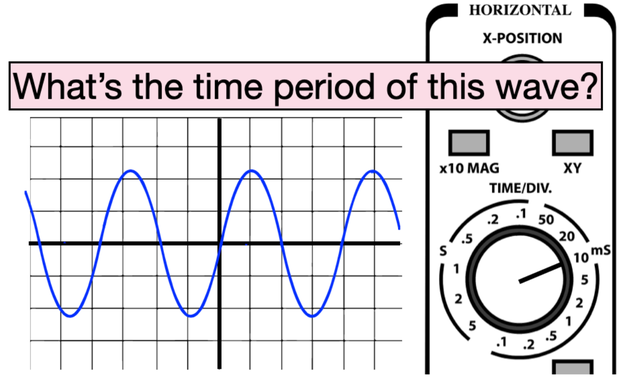












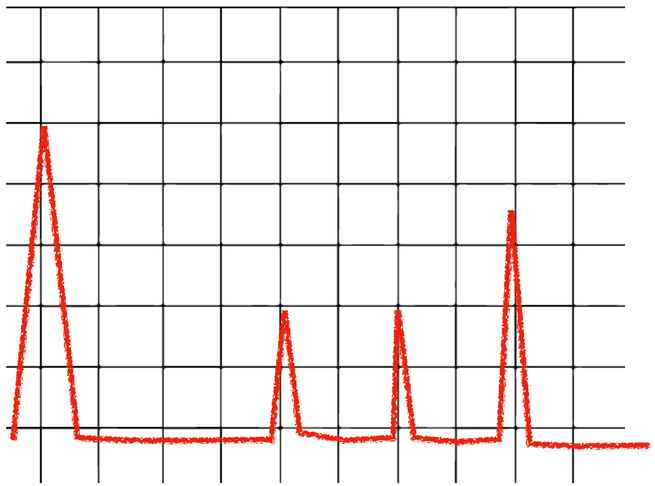
A boat sends an ultrasonic wave towards a shoal of fish and after 4 seconds receives a signal back. How far away from the boat are the fish?

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$ (So distance = speed x time)

Speed of sound in seawater = 1500 m/s

It takes 1 second for a bat to detect the reflection of its ultrasound emission. How far away is the moth it is hunting?

Speed of sound in air = 340 m/s

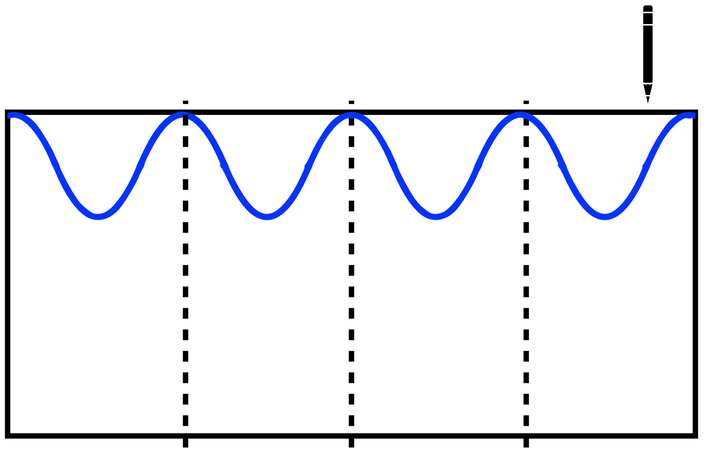


An ultrasound pulse was sent through the casing of a solid rocket booster. The trace shows there is a crack in the case. If 1cm = 1 second:

1) How far into the case does the crack occur?

2) How wide is the crack?

IGCSE Waves Lesson 10: Speed, Wavelength and Frequency



Fold a piece of paper twice and then draw a wave as shown.

Label the wavelength as 2m.

Move the paper so it travels past the pen in 1 second.

How many wavelengths are on your paper?

What is the frequency of the wave? (How many waves per second)

What is the wavelength?

What is the period?

What is the speed of the wave?

Finished?

If we double the frequency but keep the speed the same, what happens to the wavelength?

What changes in your model if the wave travels half as fast?

Can you write an equation linking wavelength, speed and frequency by thinking about the answers?

A water ripple has a wavelength of 2m and a frequency of 6Hz. How fast is it travelling?

The ripple slows down to 9m/s. Its frequency doesn't change. What is its new wavelength?

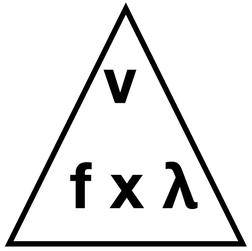
The speed of sound in air is 340m/s. What is the wavelength of a sound wave with a frequency of 200Hz?

Light travels at 300 000 000m/s in a vacuum. What is the frequency of a radio wave with a wavelength of 2000m?

Give your answer in kHz.

Wave speed = frequency x wavelength

$$v = f \times \lambda$$

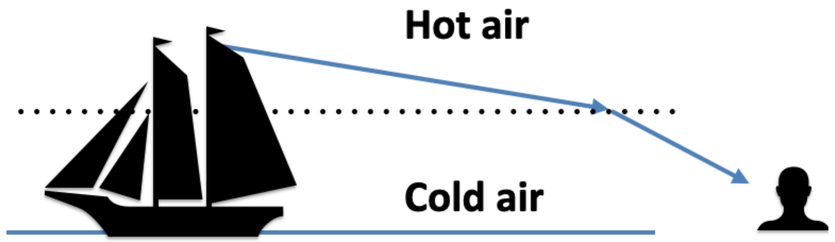


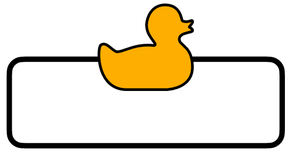
Finished?

Sound travels 340m in one second. How long does it take to travel 34m?

Now give your answer in milliseconds. (1 second = 1000 milliseconds)

What causes speed, wavelength and frequency to change?!



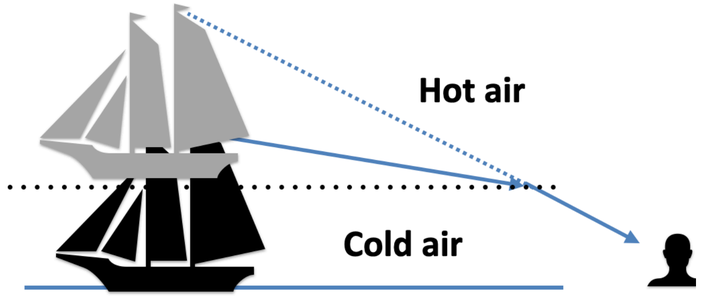


You bob a toy duck up and down in a bath and ripples are produced. What could you do to change..?

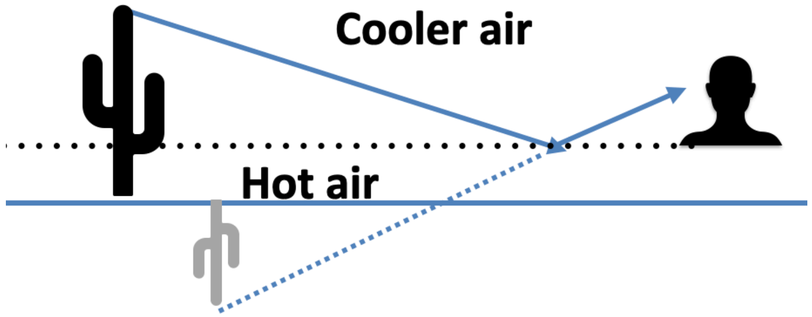
The frequency of the ripples?

The wavelength of the ripples?

The speed of the ripples?



A high note and a low note travel through water. What do they have in common; speed, frequency or wavelength?

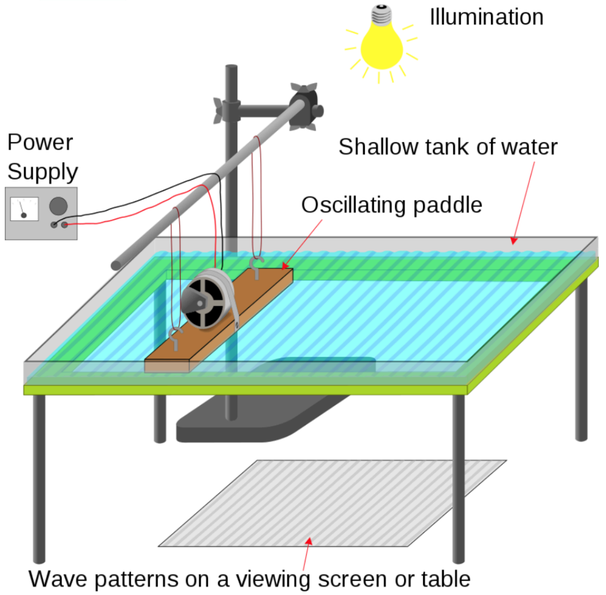


What is changing in these mirage examples?

We fill a wineglass with water and run a hand over the top. We hear a note. We fill the glass with water and hear a lower note. What has changed; speed, frequency or wavelength?

IGCSE Waves Lesson 11: Practicals

Frequency = 1 / Period!



Ripple Tank

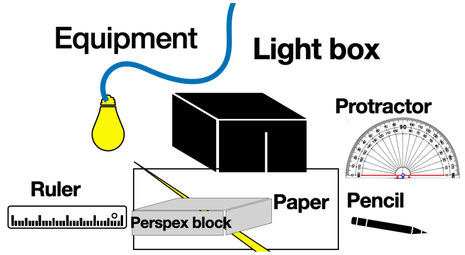
What are some dangers to look out for?!

What would you keep the same in this experiment?

A student wants to find the period of the waves. They put a mark on the side of the tank and start a timer when the crest of a wave passes it, then stop the timer when the next crest passes it.

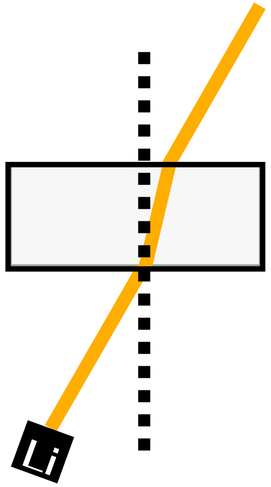
Why is this not going to give a very accurate result? How could we improve it?

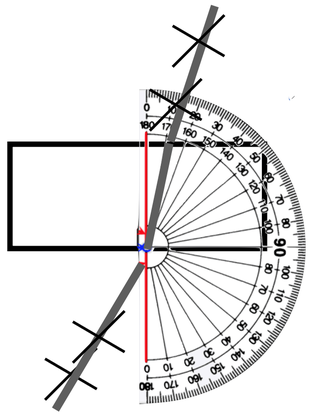
Practical: Investigate the refraction of light using different shaped blocks



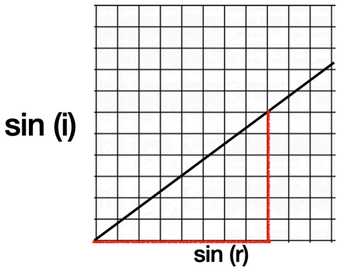
What are some dangers to look out for?!

What would you keep the same in this experiment?





Investigate the refractive index of glass, using a glass block.

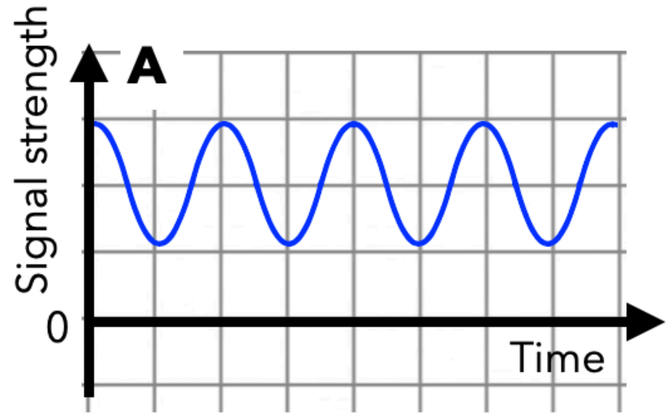


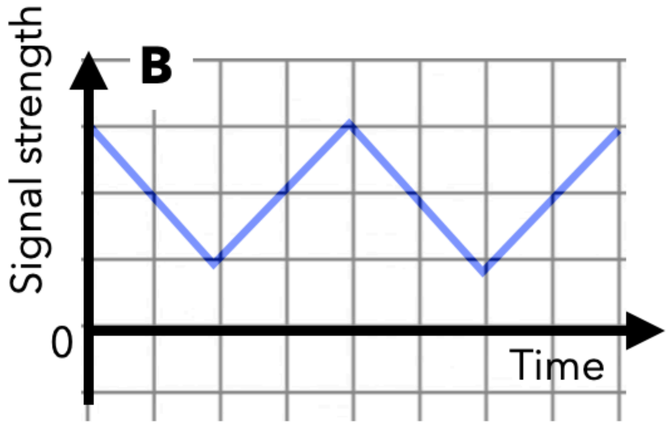
The gradient would give you n.

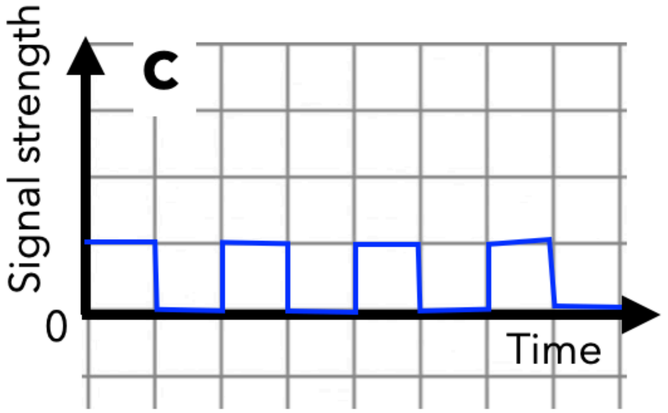
$$n = \frac{\sin i}{\sin r}$$

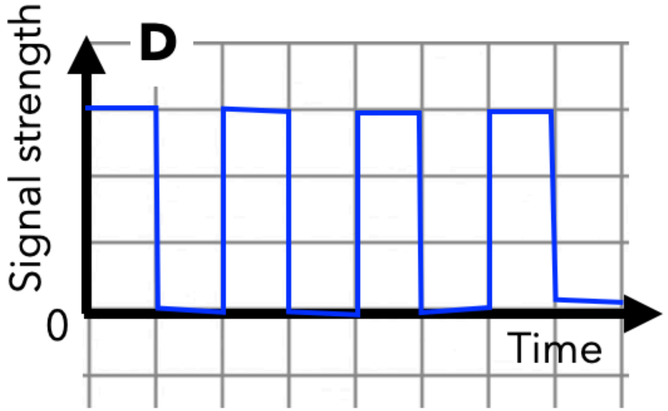
IGCSE Waves Lesson 12: Signals

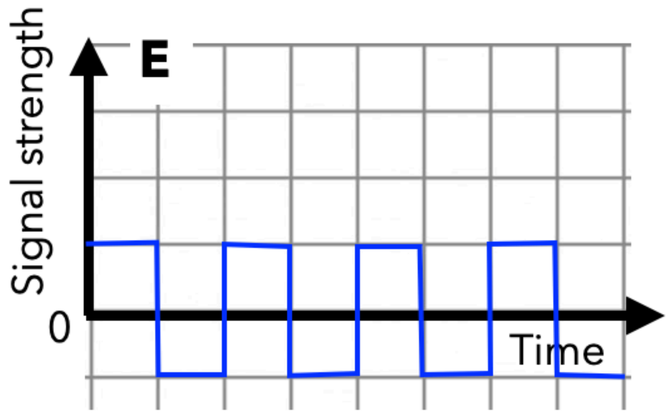
Which of these could be a digital signal? Explain your answer!

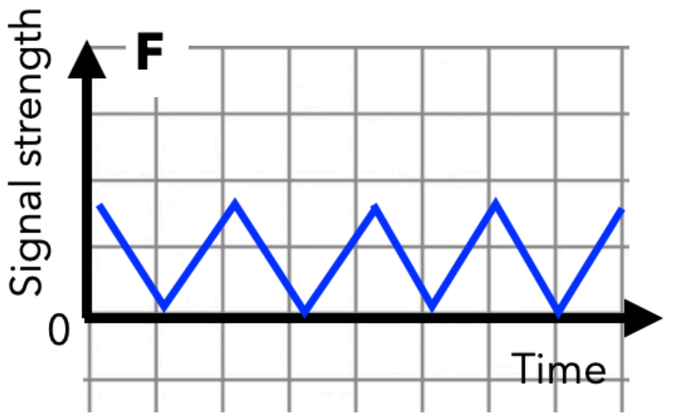




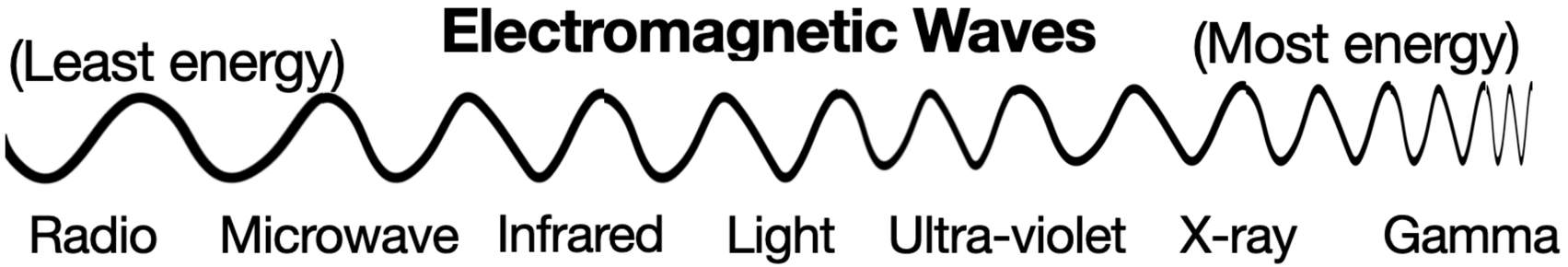








Fully describe the difference between a digital and analogue signal (2)



Why are microwaves used for mobile phone and wifi signals? (2)

Optic fibres are used for high speed broadband. Light or some infrared waves are reflected along glass (or glass-like!) tubes. Why could UV or X-rays not be used? (1)

Why are radio and microwaves not used? (1)

Waves Lesson 13: Doppler Effect and Recap

Say ‘Bingo’ when you've got 4 in a row!
Across, up and down or diagonal counts.

Thank you for paying my wages by supporting me on Kofi!

Radio	Speed	Transverse	Wood
Amplitude	Longitudinal	Microwave	One
Sound	Vacuum	Energy	Two
Matter	Glass	Four	Light

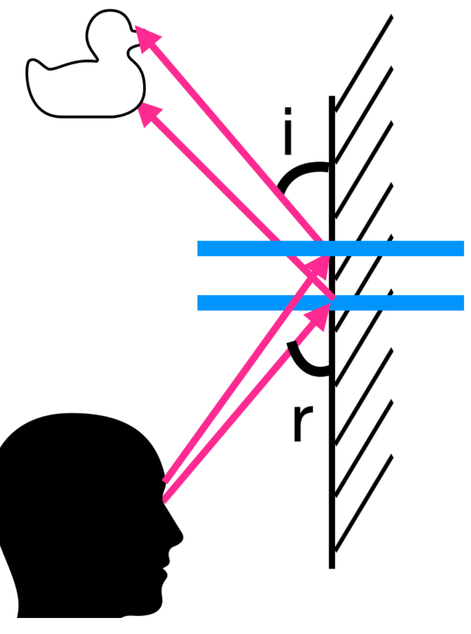
Electromagnetic Waves

Radio	Microwave	Infrared	Light	Ultra-violet	X-ray	Gamma
R	H	T	I	E	D	S

	Carries the most energy	Carries mobile phone signals	Not X-ray or Gamma, but ionising	Slightly higher frequency than light you can see	You give off mainly these waves
First word	☐	☐	☐	☐	☐

	Used for detecting and treating cancer	Slightly longer wavelength than Infrared	Used in photography	Carry the least energy	Used for TV remote controls
Second word	☐	☐	☐	☐	☐

Circle the mistakes in this reflection diagram. Draw the image in the right place, at the right size.



A ship is measuring the depth of the ocean floor. It emits a sound wave which returns in 4 seconds. How deep is the ocean below the ship? (3)

Suggest a suitable frequency for the sound wave the ship used. (2)