What is a wave?

Waves are vibrations that transfer energy from place to place without matter (solid, liquid or gas) being transferred.

Some waves must travel through a substance - the medium - can be solid, liquid or gas e.g. sound & water waves. Other waves can travel through empty space e.g. visible light.

All waves reflect - bounce off; refract – change direction; diffract – bend around.

Types of waves

Transverse: Remember ss.

Transver**s**e is easy to draw. The oscillations are at 90° to the direction of energy transfer.

Longitudinal: The **l**ongitudina**l** wave is harder to draw. Remember ll

C   R   C   R   C   R

Compression - particles are forced/move together and takes place when the pressure is higher. Rarefaction - particles move apart and takes place when pressure is lower.

Types of Wave

Longitudinal: particles of the medium vibrate / oscillate <u>parallel</u> to the direction of energy transfer. E.g. sound waves, P waves of earthquake.

Transverse: particles of the medium vibrate / oscillate <u>at right angles</u> to the direction of energy transfer. E.g. water waves, waves on strings, S waves of earthquake, light.

AS 90938
WAVE BEHAVIOUR
SURVIVAL SHEETS

Comparing light and sound

<u>Light</u>: transverse wave ● speed $\approx 3 \times 10^8$ ms^{-1} in air ● can travel through a vacuum
<u>Sound</u>: longitudinal wave ● speed ≈ 330 ms^{-1} in air ● source is a vibrating object e.g. loud speaker cone ● transmitted by vibration of air particles ● speed of travel in solids > in liquids > in air (in solids the particles are closest so the energy transfer is fastest) ● pitch of sound = frequency (high pitch = more waves/second) ● loudness of sound depends on the amplitude (loud sound = greater amplitude) ● audible frequency of humans is 20Hz to 20 kHz ● ultrasonic > 20 kHz ––high frequency sound beyond range of our audible frequency.

Properties

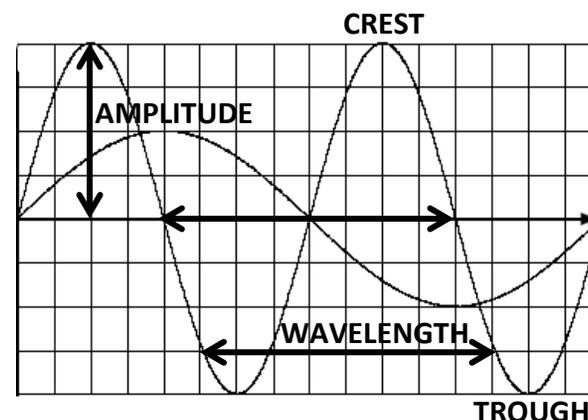<u>Wavelength</u>, λ: distance between any 2 corresponding points on a wave. Units: m
<u>Frequency</u>, **f**: number of waves passing a point every second. Units: Hz
<u>Amplitude</u>, **A**: maximum displacement from equilibrium position. Units: m
<u>Period</u>, **T**: Time for one complete wave to pass a point. Units: s

Also remember that velocity = distance/time.

$$v = f\,\lambda \qquad v = d/t \qquad T = 1/f$$

The other wave shown has
- *half the amplitude and*
- *double the wavelength.*

How we hear sounds.

Loud speaker: The speaker / speaker cone vibrates and the air particles near the cone vibrate at the same frequency. This sets up compressions and rarefactions in the air, which carry the sound energy / wave through the air to the ear.

Guitar string: The vibrating string causes the air molecules near the string to vibrate back and forth with the same frequency and hence creating compressions and rarefactions in air which spread out as sound waves to the ear.

Reflection of light

Smooth surfaces reflect evenly: Reflection is regular. Uneven / rough surfaces reflect unevenly: Reflection is irregular or diffuse – appears blurred.
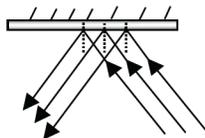
Plane mirror: flat mirror
Incident ray: ray that collides with mirror
Reflected ray: ray that bounces off mirror
Normal: ray drawn at 90° to the surface of medium
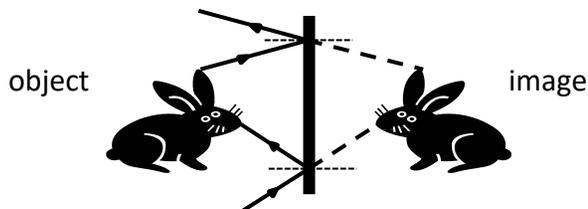Angle of incidence, i° = angle of reflection, r°.

object   image

Image: is same size as object ● appears as far behind mirror as object is in front ● is virtual - can't be projected onto a screen / rays of light don't actually go there. ● is laterally inverted (back to front)

W A V E S   ƨ Ǝ V A W

Reflection of sound

Reflection of sound off a hard surface is called an echo. Remember in calculations for an echo it has to go there AND back! E.g. a ship using sonar to find the depth of the sea floor.
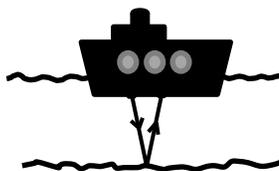
The speed of sound in water is 1300 ms⁻¹. If it takes 0.2s for the SONAR to return to the boat, the distance is 1300 x 0.2 = 260 m, so the sea is 130 m
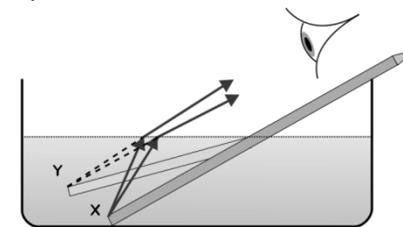
Refraction of light

Occurs when light moves from one medium to another e.g. air into glass, or water into air etc. The higher the optical density of the medium, the slower it travels. When light passes *from less to more* optically dense medium it *slows down and refracts towards* the normal; when it passes from *more to less* optically dense medium it *speeds up and refracts away* from the normal.

water   glass
                        air
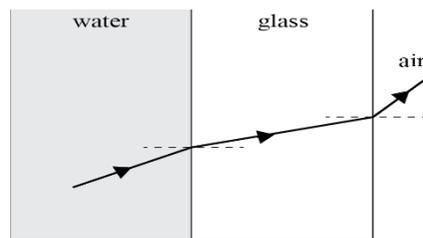
The rays from the bottom of the pencil refract away from the normal because it is travelling faster in air compared to water / water is more optically dense than air.
The human eye projects the image in a straight line and "sees" the end of the pencil where it is not and the pencil looks bent. (Avoid saying light / ray "bends" – use refracts instead). The image of pencil is virtual.

Critical angle

When light travels from a medium to a less dense medium, a certain angle of incidence will produce an angle of refraction of 90°. This angle of incidence is the critical angle for this material. If the angle of incidence > critical angle, then total internal reflection occurs.

- Less than the critical angle; Some reflected, most refracted
- Equal to the critical angle. Some reflected, ray refracted at 90°
- Greater than the critical angle. Total internal reflection
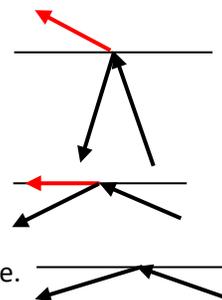
If rays meet the water surface at an angle greater than the critical angle the water surface behave like a mirror. i° = r°.

Dispersion

The splitting up of light into colours of spectrum ROYGBIV.

white light   prism   R
                                          V
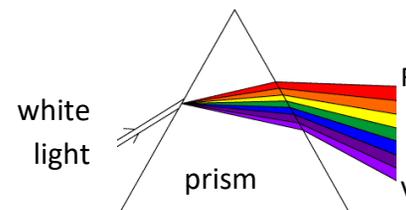
White light is made up of light of different colours/wavelengths. Light bends as it passes from air to the prism. Each colour/wavelength is refracted by a different amount, 'splitting' the white light into its constituent colours. This effect is repeated as the now dispersed colours exits the prism, giving further dispersion between each wavelength.
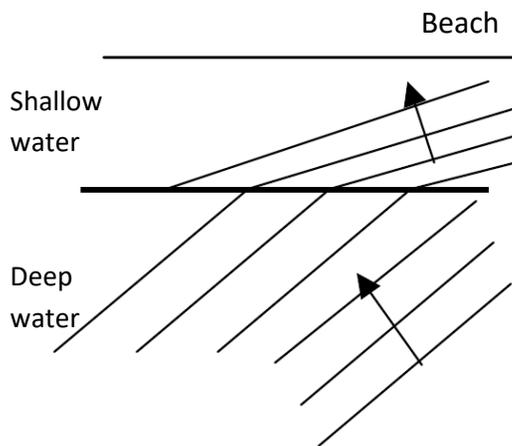Red is bent the least, violet the most. (Remember, violet is most violently bent!)

No Brain Too Small ● PHYSICS
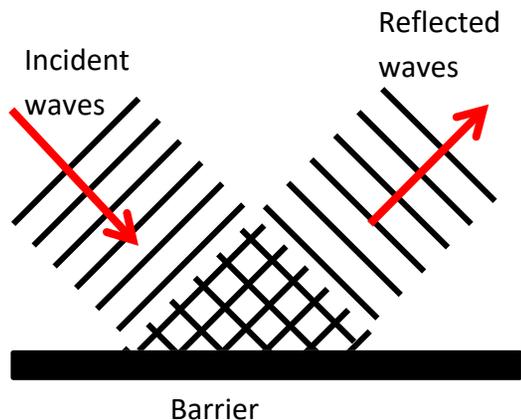
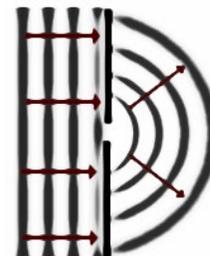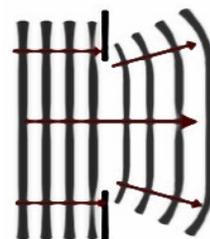| Reflection of water	Refraction of water	Diffraction of water
Incident waves — Reflected waves Barrier Water waves are reflected from hard flat surfaces. The length of the line representing the wave peak stays the same where it is being reflected. After reflection, a wave has the same speed, frequency and wavelength. Only the direction of the wave that has changed.	The waves' speed (v) reduces as they go into the shallower water. Their frequency is unchanged. Since v = f λ, λ also decreases. The direction of travel of wave fronts bends towards normal, wavelength decreases. Beach Shallow water Deep water Since the wavelength has decreased but there is still the same volume of water, the waves get higher (amplitude increases).	If a barrier with a small gap is placed in the tank the ripples emerge in an almost semicircular pattern. Small means the gap is about the same size as the wavelength of the ripples. If the gap is large however, the diffraction is much more limited. Note: there is no change in wavelength

Notes: