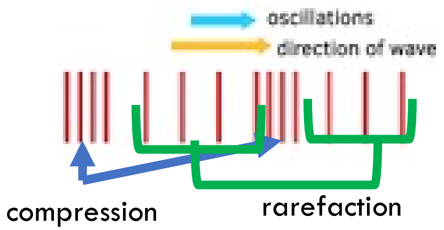
Synergy Science Knowledge Organiser
4 Waves

Transverse Waves

- In a transverse wave the oscillations are perpendicular to the direction of energy transfer.
- Ripples on water surfaces are examples of transverse waves

Longitudinal Waves

- In a longitudinal wave the oscillations are parallel to the direction of energy transfer.
- Longitudinal waves show areas of compression and rarefaction.
- Sound waves in air are longitudinal waves



Time period equation

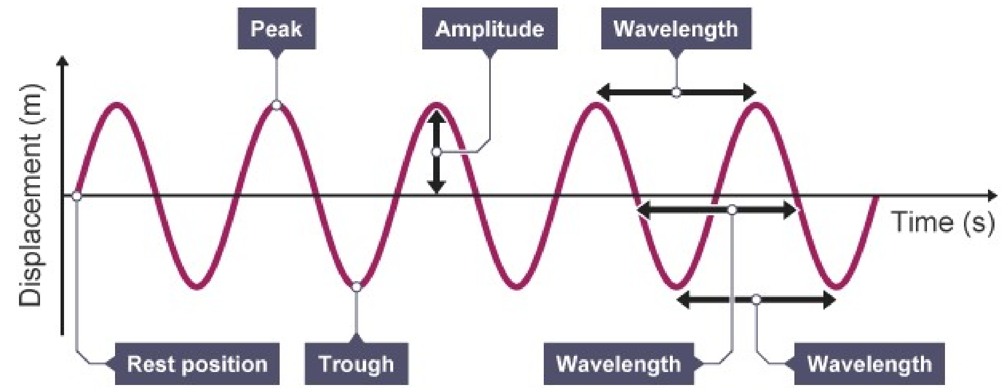
Time period is the time to complete one wave in seconds, s.

$$period = \frac{1}{frequency}$$

period, T, in seconds, s
frequency, f, in hertz, Hz

$$\left[T = \frac{1}{f} \right]$$

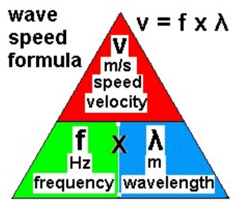
Wave motion



- Amplitude of a wave is the maximum displacement of a point on a wave away from its undisturbed position.
- Wavelength of a wave is the distance from a point on one wave to the equivalent point on the next wave.
- Frequency of a wave is the number of waves passing a point each second.

Wave Equation

- Wave speed is the speed at which the energy is transferred (or the wave moves) through the medium.
- All waves obey the wave equation:



$$wave\ speed = frequency \times wavelength$$

wave speed, v, in metres per second, m/s
frequency, f, in hertz, Hz
wavelength, λ, in metres, m

The microwaves transmitted by the speed gun have a frequency of 24 000 000 000 Hz and travel through the air at 300 000 000 m/s. Calculate the wavelength of the microwaves emitted from the speed gun.

E: Wavelength = $\frac{\text{speed}}{\text{frequency}}$

S: Wavelength = $\frac{300\ 000\ 000}{24\ 000\ 000\ 000}$

A: Wavelength = 0.0125

U: Wavelength = 0.0125 m

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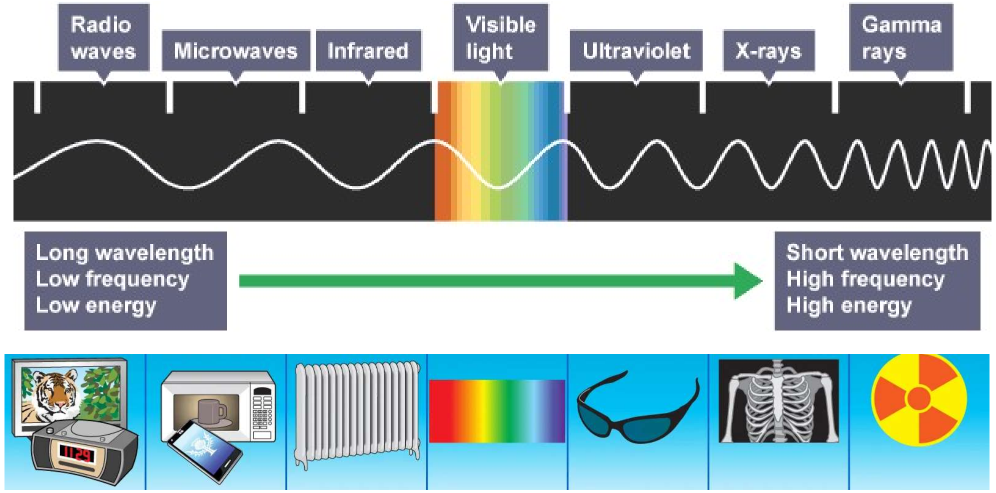
Electromagnetic Spectrum

- Electromagnetic waves are a continuous spectrum of transverse waves which all travel at the speed of light



Television
Radio
Telescopes

Satellite
communications
Cooking food
Mobile phones

Heaters,
Cooking
food
Infrared
cameras

Fibre
optic
cables

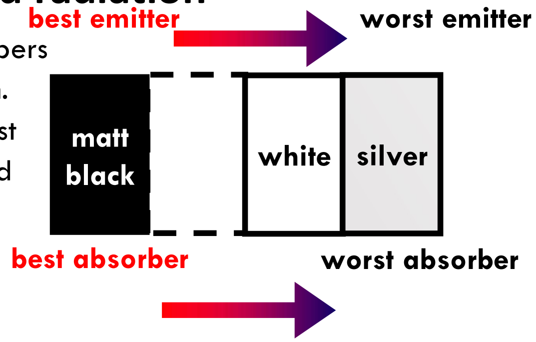
Fluorescent
lamps
Sun
tanning

Medical
imaging
and
treatments

Sterilising
surgical
instruments
Treatment
of cancer

Required Practical: Infrared radiation

- Black surfaces are the best absorbers and emitters of infrared radiation.
- Silver (shiny) surfaces are the worst absorbers and emitters of infrared radiation.



Infrared Radiation Practical

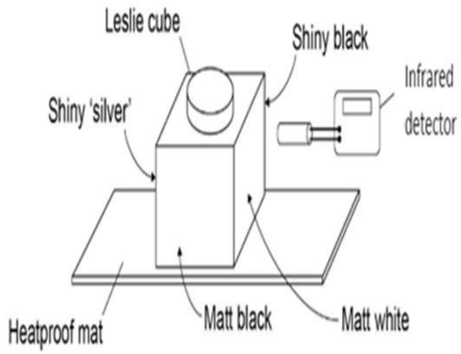


Figure 1: Practical Setup

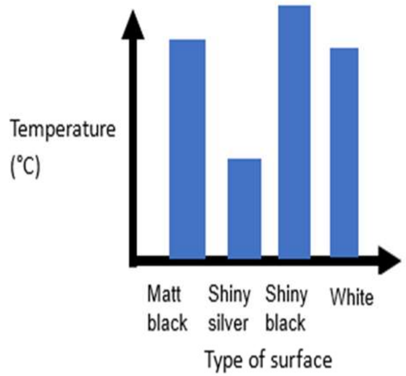


Figure 2: Experimental results

Method

1) Place the Leslie cube on to a heat proof mat.
2) Fill the cube with very hot water and replace the lid of the cube.
3) Mark a distance of 5cm using a ruler from each surface where measurements will be taken.
4) Use an infrared detector to measure the temperature of each surface.
5) Draw a bar chart to show the temperature of the surface against the type of surface.

The black surface should show the most infrared radiated and the shiny silver surface should show the least.

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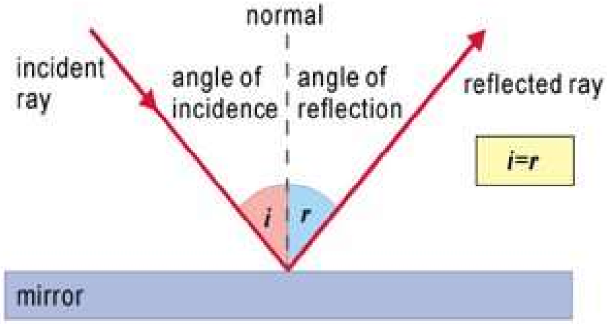
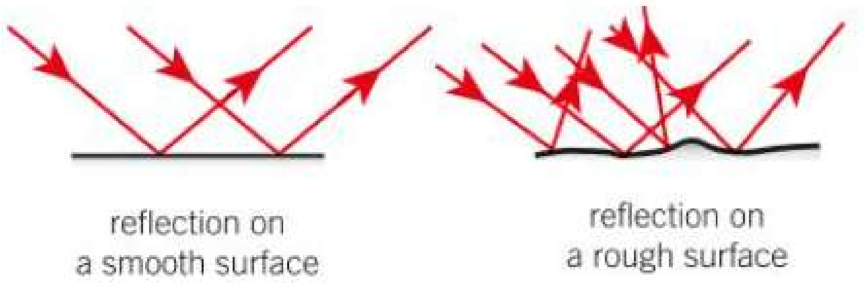
Reflection



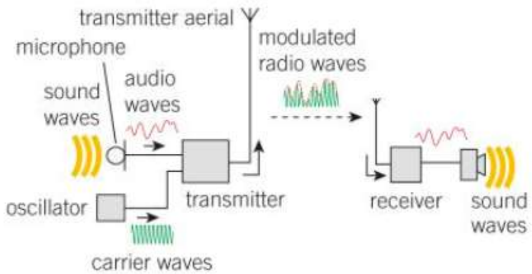
- The angle of incidence (i) is always the same as the angle of reflection (r)
- Shiny surfaces act as mirrors when they reflect waves.
- Rough surfaces **scatter** waves in all directions.



1. Draw a normal line (at 90°) through the middle of the mirror outline.
2. Use a ray box to shine an incident ray at the mirror - draw the incident and reflected rays.
3. Measure the angles of incidence (i) and reflection (r)

Higher Tier Only - Radio waves

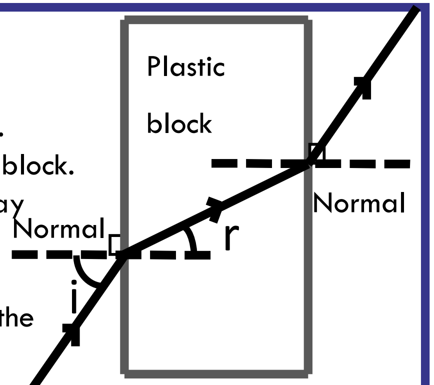
- When radio waves are absorbed, they may create an alternating current with the same frequency as the radio wave itself, so radio waves can themselves induce oscillations in an electrical circuit
- Radio waves are produced by vibrating long wires in a circuit.
- When the radio waves reach a receiver, the energy from the wave is absorbed.
- This causes electrons in the wire to vibrate back and forth producing an alternating current.



- The frequency of the current is the same as the original radio wave.

Refraction

1. Place the block on the rectangle.
2. Shine the light ray along the incident line.
3. Mark the position the light ray leaves the block.
4. Draw a new normal line where the light ray exits the block.
5. Draw a line between the two normal lines representing the ray as it passes through the block.
6. Measure the angle of incidence (i)
7. Measure the angle of refraction (r)



i = angle of incidence
r = angle of refraction

- The direction that the light bends in depends on the relative density of the two media.
- Going into a denser material: Light slows down and bends towards the normal.
- Going to a less dense material: Light speeds up and bends away from the normal.

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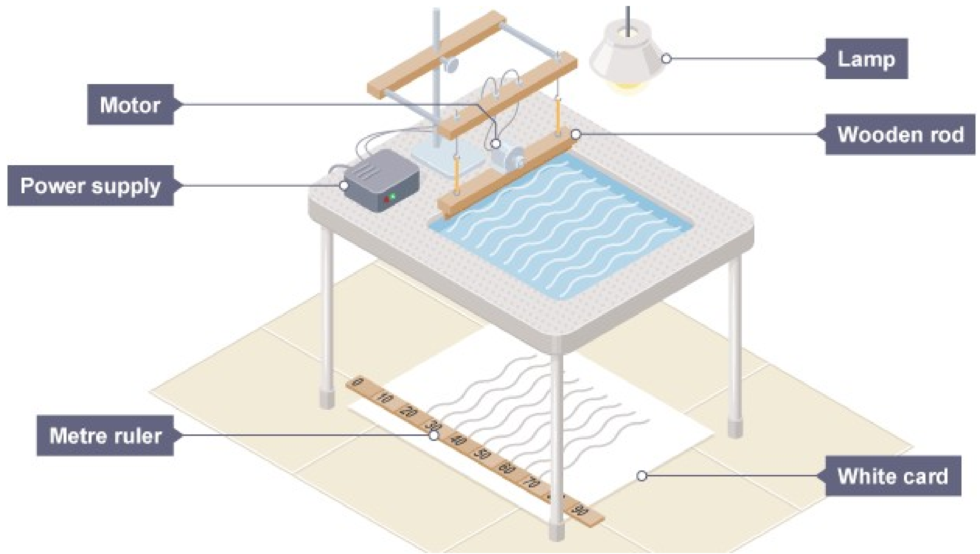
Required Practical: Ripple Tank

- Make observations to identify the suitability of apparatus to measure the frequency, wavelength and speed of waves in a **ripple tank** and waves in a solid and take appropriate measurements.



<u>Method</u>

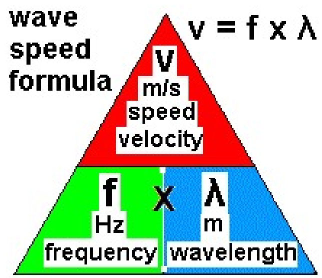
1) Use a stop watch or stop clock to measure how many waves pass in a given time.

2) Divide the number of waves in this time to find the frequency of the waves.

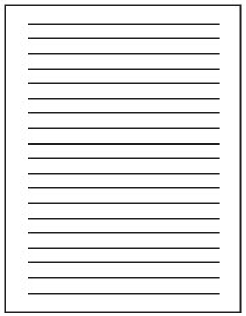
3) Measure the wavelength of the 3 or more waves using a ruler placed at a right angle to the waves.

4) Divide by the number of waves to get the wavelength of 1 wave.

5) Use the wave equation, wave speed = frequency x wavelength, to calculate the wave speed.



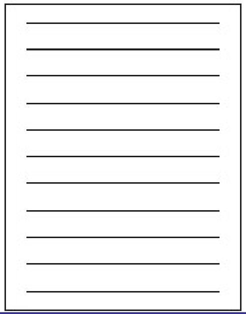
B



frequency of 19 hertz
wavelength of 0.5 cm.

E: wave speed = frequency x wavelength
S: wave speed = 19 x 0.5
A: wave speed = 9.5
U: wave speed = 9.5 cm/s

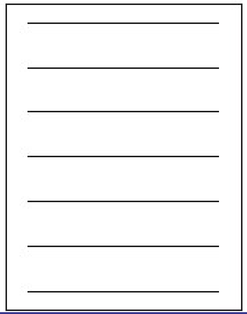
A



frequency of 11 hertz
wavelength of 1.0cm.

E: wave speed = frequency x wavelength
S: wave speed = 11 x 1.0
A: wave speed = 11
U: wave speed = 11 cm/s

C



frequency of 7 hertz
wavelength of 1.5 cm.

E: wave speed = frequency x wavelength
S: wave speed = 7 x 1.5
A: wave speed = 10.5
U: wave speed = 10.5 cm/s

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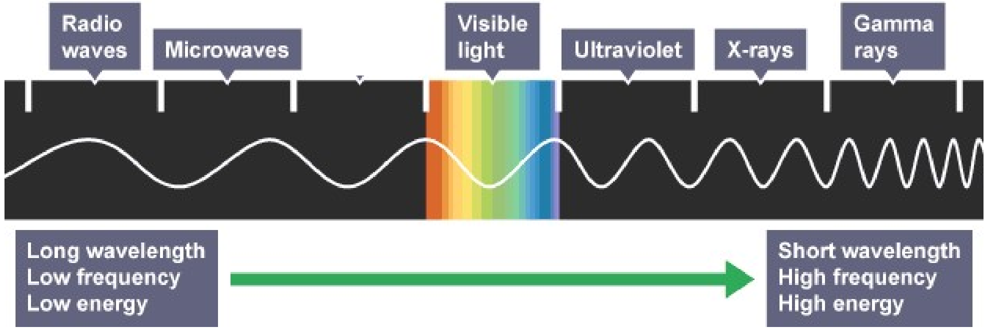
Electromagnetic Spectrum

Task: What is missing from the electromagnetic spectrum



Task: Complete the sentences

The part with the longest wavelength is ______________________________

As the wavelength gets shorter the frequency and energy ___________________

Humans can only detect ____

Gamma rays are used for ____

Microwaves are used for cooking food and ________________________________

Reflection

Task: Complete the table

Angle of incidence	Angle of reflection
30	
	65
18	

Wave Equation

Task: Calculate the speed of a wave

A student uses a ripple tank where all the water is the same depth.

She measures the wavelength of each wave as 0.34 m.

The period of each wave is 0.42 s.

Calculate the speed of the wave.

E:

S:

A:

U:

Highlight the keywords:

Transverse, longitudinal, perpendicular, parallel, oscillations, amplitude, wavelength, frequency, spectrum, absorbers, emitters, angle of incidence, angle of reflection, normal