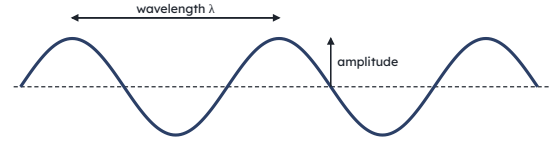
4.6 Waves

TRANSVERSE AND LONGITUDINAL



Transverse: oscillations perpendicular to the direction of energy transfer (e.g. light, water ripples)

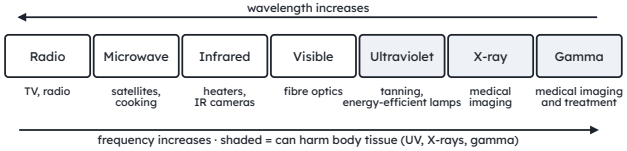


Longitudinal: oscillations parallel to the direction of energy transfer (e.g. sound)

WAVE PROPERTIES

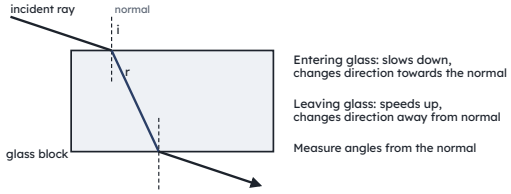
- **Amplitude:** maximum displacement of a point on a wave from its undisturbed position.
- **Wavelength:** distance from a point on one wave to the equivalent point on the adjacent wave.
- **Frequency:** number of waves passing a point each second (Hz). **Period** T = 1 ÷ f.
- Waves transfer energy, not matter (ripples move but the water doesn't travel).

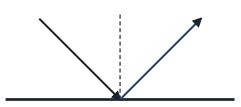
ELECTROMAGNETIC SPECTRUM



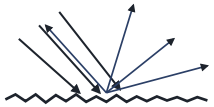
- Transverse; all travel at the same speed in a vacuum (3×10^8 m/s); transfer energy from source to absorber.
- UV: skin ageing and skin cancer risk. X-rays and gamma: ionising, can cause gene mutation and cancer. Dose in sieverts.
- (HT) Radio waves can induce an alternating current in a circuit (aerial).

REFRACTION AND REFLECTION



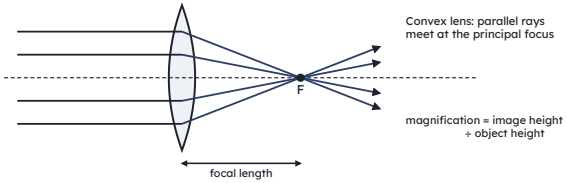


Specular: smooth surface, angle i = angle r



Diffuse: rough surface, light scattered in many directions

LENSES AND LIGHT (PO)

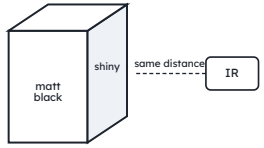


- Convex lens: real or virtual image. Concave lens: always virtual.
- An object's colour depends on which wavelengths it reflects most; filters transmit some colours and absorb the rest.

SOUND, ULTRASOUND, SEISMIC (PO, HT)

- Human hearing: 20 Hz to 20 kHz. Ultrasound is above 20 kHz: partially reflected at boundaries; echo timing gives depth (distance = speed × time ÷ 2).
- P-waves: longitudinal, through solids and liquids. S-waves: transverse, can't pass through liquids → evidence for a liquid outer core.

BLACK BODY RADIATION (RP10)



Leslie cube full of hot water: matt black emits most infrared, shiny silver emits least

Good emitters are good absorbers. Perfect black body absorbs all incident radiation (Physics only)

- All bodies emit and absorb infrared; the hotter, the more it emits.
- (PO) A perfect black body absorbs all radiation incident on it; it is the best emitter.

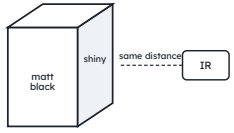
MODEL EXPLANATIONS (GRADE 7+ ANSWERS)

Explain why a ray of light changes direction when it enters a glass block at an angle.
Light slows down when it enters glass, so it changes direction, towards the normal. One side of each wavefront enters the glass first and slows down while the rest is still faster, so the wavefront changes direction.

Explain why a red object looks black in blue light. (Physics only)
A red object reflects red light and absorbs other colours, including blue. Blue light is all absorbed, so no light is reflected to the eye, so the object appears black.

Explain why the Earth's temperature stays roughly constant. (Higher)
The Earth absorbs radiation from the Sun and emits radiation into space. When the rate of absorption equals the rate of emission, the temperature stays constant (it also depends on the atmosphere).

RP10: RADIATION AND ABSORPTION



Leslie cube full of hot water: matt black emits most infrared, shiny silver emits least

Good emitters are good absorbers. Perfect black body absorbs all incident radiation (Physics only)

Aim: Investigate how the amount of infrared radiation absorbed or radiated by a surface depends on the nature of that surface.

Change	Type of surface
Measure	Infrared emitted (detector reading)
Control	Water temperature, distance from detector

Must include:

- Investigate absorption as well as emission
- Same water temperature for all faces
- Same distance from the detector
- Record a reading for each surface
- Conclude which surface emits most and least

Common mistake: Drawing a line graph for categoric data.

4.6 Waves

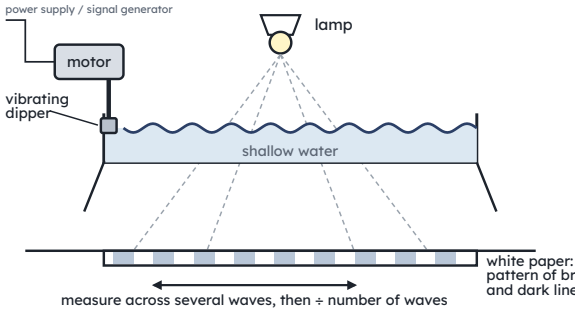
KEY EQUATIONS (ALL ON THE PHYSICS EQUATIONS SHEET)

Equation	Quantities (units)	Watch out
v = f λ	wave speed (m/s), frequency (Hz), wavelength (m)	MHz → Hz: × 10^6
T = 1 ÷ f	period (s), frequency (Hz)	Period: time for one wave
magnification = image height ÷ object height	no units (Physics only)	Same units top and bottom

KEY WORDS

Transverse: oscillations are perpendicular to the direction of energy transfer.
Longitudinal: oscillations are parallel to the direction of energy transfer; compressions and rarefactions.
Amplitude: the maximum displacement of a point on a wave away from its undisturbed position.
Wavelength: the distance from a point on one wave to the equivalent point on the adjacent wave.
Frequency: the number of waves passing a point each second (Hz).
Refraction: a change in direction when a wave changes speed crossing a boundary.
Perfect black body (PO): an object that absorbs all of the radiation incident on it; the best possible emitter.

RP8: WAVES



Aim: Make observations to identify suitable apparatus to measure the frequency, wavelength and speed of waves in a ripple tank and waves in a solid (a stretched string), and take appropriate measurements.

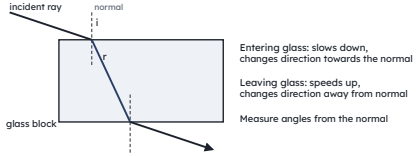
Change	Frequency (string)
Measure	Wavelength
Control	Water depth (ripple tank), tension and string length

Must include:

- Take measurements for both the ripple tank and waves in a solid (string)
- Justify why the apparatus is suitable
- Measure across several wavelengths and divide
- Determine frequency by counting over a set time or from the signal generator
- Calculate v = fλ

Common mistake: Measuring one wavelength only.

RP9: LIGHT (REFLECTION AND REFRACTION) (PO)



Aim: Investigate the reflection of light by different types of surface and the refraction of light by different substances.

Change	Angle of incidence
Measure	Angle of reflection or refraction
Control	Ray box, block material, width of ray

Must include:

- Test reflection from different types of surface
- Test refraction in different substances
- Draw a normal
- Measure angles from the normal with a protractor
- Use a thin ray

Common mistake: Measuring angles from the surface instead of the normal.

MISCONCEPTIONS

× **Water travels along with the wave.**	✓ Waves transfer energy, not matter.
× **Sound travels through a vacuum.**	✓ Sound needs particles to vibrate.
× **All EM waves are dangerous.**	✓ Only UV, X-rays and gamma rays harm body tissue; X-rays and gamma rays are ionising.
× **Light bends when it goes into glass.**	✓ Light travels in straight lines. It changes direction at the boundary because its speed changes.

AIM FOR GRADE 7+

- Standard form and unit prefixes in v = fλ (MHz, kHz, 3 × 10^8 m/s).
- Explain refraction using wavefronts (Higher).
- Echo questions: halve the total distance (Physics only, Higher).

COMMAND WORDS

State	a short answer, no explanation
Describe	say what happens, in order
Explain	say what and why: use "because" and "so"
Calculate	equation, substitution, answer, unit
Evaluate	both sides, then a justified conclusion

QUICK-FIRE QUIZ: COVER THE ANSWERS

Unit of frequency?	**Hertz (Hz)**
Fastest EM wave?	**All the same speed in a vacuum**
Human hearing range?	**20 Hz – 20 kHz**
Best emitter of infrared?	**Matt black surface**
EM wave used in fibre optics?	**Visible light**
Waves that can't pass through liquids?	**S-waves**