Waves

OxfordAQA International GCSE Physics 9203, topic 3.3: waves, EM spectrum, sound, reflection, refraction, (P) lenses

Energy without matter

> A wave moves energy from a source to a receiver; the matter stays put.

- OxfordAQA International GCSE Physics 9203, topic 3.3.
- (P) **ultrasound**, **refraction** calculations, lenses and the eye.

Transverse and longitudinal

> The direction of oscillation, compared with the direction of travel.

- Transverse: electromagnetic and water waves.
- Longitudinal: sound, as compressions and rarefactions.

Diffraction through a gap

> Waves spread most when the gap is about one wavelength wide.

- At a boundary waves are reflected, transmitted or absorbed.
- **Refraction** comes from a change of speed between media.

The wave equation

1. **Equation** $v = f \times \lambda$
2. **Water wave** $v = 2 \times 1.5 = 3$ m/s
3. **Radio, 100 MHz** $\lambda = 3.0 \times 10^8 \div 1.0 \times 10^8 = 3.0$ m

Decision

All electromagnetic waves travel at 3.0×10^8 m/s in air.

Reading a wave graph

$v = f\,\lambda = 2.5 \times 0.40 = 1.0$ m/s.

- Five waves pass a point every 2.0 s: $f = 2.5$ Hz.
- Amplitude is rest to crest, not crest to trough.

The electromagnetic spectrum

Radio to gamma: frequency rises as wavelength falls.

- All transverse, all at the same speed in a vacuum.
- Visible light: the narrow band our eyes detect.

Uses and hazards

Wave	Use	Hazard
radio	TV, radio, Bluetooth	—
microwave	phones, satellite TV	heats tissue
infrared	remotes, night vision	burns
ultraviolet	security marking	skin cancer, blindness
X-ray, gamma	imaging; sterilising	kill cells, mutations

(P) Infrared from hot objects

Dark, matt surface	Light, shiny surface
best absorber	poor absorber, poor emitter
best emitter	reflects infrared

X-rays: seeing inside

Bone absorbs X-rays; soft tissue lets them through.

- Very short wavelength, high energy, ionising.
- Monitor the doses of workers who use them.

Sound and the hearing range

We hear from 20 Hz to 20 000 Hz.

- Sound is longitudinal and needs a medium.
- It reflects (echoes) and diffracts.

(P) Sonar: timing an echo

> Halve the distance: the pulse goes down and back.

- $s = v \times t$; the time is there and back.
- **Ultrasound** also scans babies and breaks kidney stones.

The law of reflection

> Angle of incidence = angle of reflection.

- Angles are measured from the normal, not the surface.
- A plane-mirror image: virtual, upright, laterally inverted.

(P) Refraction into glass

n $=$ sin i $\div$ sin r $=$ 1.52; light in this glass travels at 2.0×10^8 m/s.

- Into a denser medium: slower, bends towards the normal.
- A prism disperses white light into a spectrum.

(P) Total internal reflection

> Inside the denser medium, beyond the critical angle, all light reflects.

- sin c = 1 / n: here c = 41°.
- Optical fibres carry light and infrared: endoscopes, communications.

(P) A convex lens

Two rays locate the image: parallel then through F, and through the centre.

- Magnification = image height ÷ object height (no unit).
- Held close, a convex lens magnifies: virtual, upright.

(P) The eye and its faults

Fault	Cause	Correction
long sight	eyeball too short	convex (converging) lens
short sight	eyeball too long	concave (diverging) lens

Common mistakes

Mistake	Fix
not halving an echo distance	the time is there and back
angles from the surface	measure from the normal
TIR as light enters glass	inside the denser medium only
convex lens for short sight	concave for short sight

Check yourself

Question	**Answer**
500 Hz, $\lambda = 0.68$ m: speed?	340 m/s
Diffraction strongest when?	gap $\approx$ one wavelength
Human hearing range?	20 Hz to 20 kHz
(P) n = 1.5: critical angle?	about 41.8°