UNIT 2

Physics at work

REVISION NOTES

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Density and Flotation

- Density = mass / volume kgm^{-3} gcm^{-3}
- kgm^{-3} to gcm^{-3} divide by 1000
- gcm^{-3} to kgm^{-3} multiply by 1000
- Density of water ≈ $1000kgm^{-3}$

- Upthrust = weight of fluid displaced.
- An object floats in a fluid if :-
  - the density of the object is less than that of the fluid,
  - the upthrust is greater than the weight.
  - Archimedes principle.

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Fluids and Pressure

- A fluid is any substance that flows.
- Pressure = force/area Nm^{-2} Pa
- Pressure in a fluid = h.ρ.g
- Terminal velocity
  - the maximum velocity an object can achieve when passing through a fluid,
  - when the weight = upthrust plus the viscous drag force.

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Fluid flow

- Streamline – the path taken by the fluid.
- Laminar flow – when the fluid flows smoothly around an object.
- Turbulent flow – when the fluid does not flow smoothly around an object.
- The rate of flow of a fluid is related to its viscosity. Units Pa.s
- Stokes' Law **$F= 6\pi\eta rv$**
- Viscosity depends on temperature.

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Elastic and Plastic

- After elastic deformation, the object returns to its original shape and size.
- After plastic deformation, the object does not returns to its original shape and size, but retains a permanent deformation.
- Hooke's law $F = k.\Delta x$ so long as the limit of proportionality is not exceeded.
  - i.e. graph remains straight
- Elastic limit – beyond this a permanent extension is produced.

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Stretching and squashing

- Beyond the yield point the material becomes plastic and does not return to its original shape.
- Stress = force/cross sectional area Pa
- Strain = $\Delta l/l_o$ no units
- Young's modulus = stress/strain Pa
- Tensile – stretching
- Compressive - squashing

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Material terms

- Malleable – can be hammered into sheets.
  - compression
- Ductile – can be drawn into wires.
  - tension
- Hard – difficult to indent the surface
- Brittle – little plastic deformation before fracture.
- Tough – large plastic region before fracture.
- Strong – high breaking stress.
- Stiff – large Young's modulus
- Flexible – small Young's modulus

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Elastic strain energy

- Energy stored in a material due to being deformed. E_{el}
- E_{el} = to the area under a force v extension graph
- $E_{el} = ½ F.x = ½ k.x^2$ Joules
- Energy/unit volume = ½stress.strain

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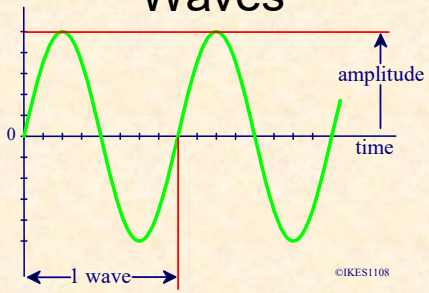
Waves



Amplitude – maximum displacement
Period – time taken for one wave
Frequency – the number of waves per second
Speed – how fast the wave travels
Wavelength – distance travelled by a wave in one time period

$V = f \times \lambda$

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Electromagnetic Spectrum

Name	Wavelength (m)	Production	Application
γ-rays	$10^{-16} – 10^{-11}$	Nucleus	X-ray shadow graphs, crystallography, radiotherapy
x-rays	$10^{-14} – 10^{-10}$	Atomic electrons	X-ray shadow graphs, crystallography, radiotherapy
Ultraviolet	$10^{-10} – 10^{-8}$	Discharge tubes	Sterilisation, fluorescence
Visible light	$4 – 7 \times 10^{-7}$	Hot objects. Discharge tubes.	Vision, astronomy,
Infrared	$10^{-7} – 10^{-3}$	Hot objects	Night vision, cooking, astronomy
Microwaves	$10^{-4} – 10^{-1}$	Oscillating electrical circuits	Communications, entertainment, television, radar, cooking
Radio	10^{-3} - 10^{5}	Oscillating electrical circuits	Communications, entertainment, television

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Types of waves

- Transverse – displacement at right angles to the direction of travel.
- Longitudinal – displacement parallel to the direction of travel.
- Progressive wave – wave is travelling
- Standing (stationary) wave – when two progressive waves meet travelling in opposite directions.
  - Nodes – minimum displacement
  - Antinodes – maximum displacement
  - Between node and antinode - λ/4
  - Resonance tube, Melde's experiment, spring, sonometer

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Sound

- Longitudinal pressure waves
  - pressure and displacement 90° phase shift
  - open tube, f_o $2f_o$ $3f_o$ $4f_o$ etc
  - closed tube, f_o $3f_o$ $5f_o$ etc
- Strings - wave velocity - tension and mass
  - frequency depends on length, tension and mass

$$v = \sqrt{\frac{T}{m_o}} \Rightarrow f = \frac{1}{2l}\sqrt{\frac{T}{m_o}}$$

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Wave terms

- Wavefront – the surface showing the position of the wave.
- Phase – the difference between two waves – usually expressed in degrees or radians.
- Coherence – when two waves of similar amplitude have a constant phase difference.
- Path difference – the difference between two waves – usually expressed in wavelengths
- Phase difference = $\lambda/2\pi$ × path difference

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Refraction

- The change in direction of a wave due to a change in wave speed.

$$ {}_1\mu_2 = \frac{\sin i}{\sin r} = \frac{v_1}{v_2} $$

- Total Internal Reflection – light travelling from more dense to less dense medium.
- Critical angle ${}_1\mu_2 = 1/\sin c$
- Optical fibres - 45° prisms – periscopes, binoculars etc

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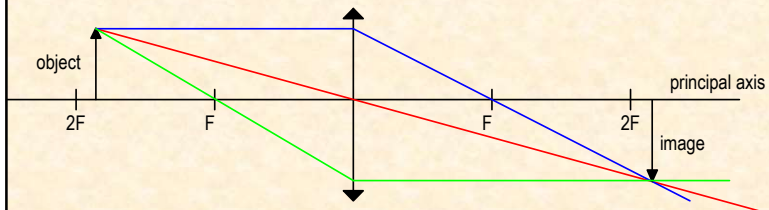
Lenses 1

- Converging - parallel light rays all made to pass through a point - the focus.

lens fatter in middle than edges



Measurement of focal length:-
distant object, lens formula, reflection at 2F

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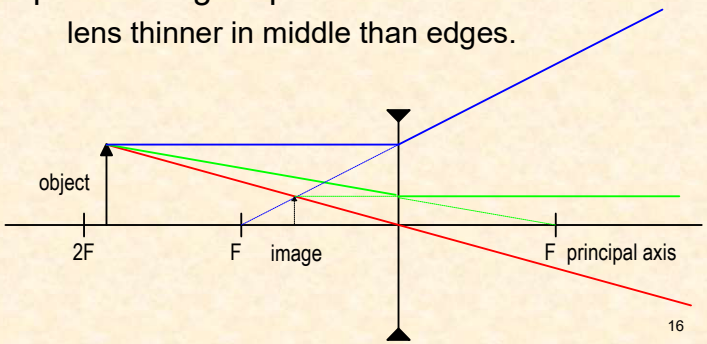
Lenses 2

- Diverging - parallel light rays all appear to pass through a point - the focus.

lens thinner in middle than edges.



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Lens formulae

u = distance of object from lens

v = distance of image from lens

f = focal length of lens

linear magnification = v/u

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

- Real is positive sign convention
- Power of a lens = 1/f Dioptres (f in m)
- For thin lenses, close together, $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + ...$

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Polarisation of light

- Em radiation vibrates in just one plane.
  - Polaroid – sun glasses – removes glare.
- Crossed polaroids stop light passing.
  - Stress analysis in plastics.
  - Concentration of (sugar) solutions.
  - LCD screens
- Longitudinal waves *cannot* be polarised.

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Reflection

- Angle of incidence = Angle of reflection
- Occurs at the boundary between materials.
- Some of the wave is refracted as well.
- Pulse echo techniques
  - Sonar (remember ÷ 2), ultrasound scans
  - Radar
  - Resolution limited by wavelength
  - Cannot resolve distances less than λ

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Light

- Particles or waves?
- Particles:-
  - Reflection, Photoelectric effect, atomic spectra
- Waves:-
  - Reflection, refraction, interference, diffraction
- Photons – packets of e-m energy (waves).
  - E = h×f
  - Transitions between discrete energy levels
- Radiant flux – Power per square metre

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Photoelectric effect

- Evidence for light as particles
- Electrons emitted from a metal surface when short wavelength light incident.
- $E = hf = \varphi + {}^{1}/_{2}mv^{2}_{max}$
- Threshold frequency – minimum frequency for photoelectrons to be emitted.
- Φ is the work function of the metal.
- $eV = 1.6 \times 10^{-19}J$

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Doppler effect

- Change of received frequency owing to movement of source or receiver.
- Wavelength changes owing to the motion.
- Sound – police car
- Light – red shift
  - Radar speed traps

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Diffraction

- Diffraction – the spreading of waves beyond the geometrical shadow
  - Evidence that light is a wave
  - Most noticeable when obstacle/gap is comparable to the wavelength
- Diffraction grating
- $d \times \sin\theta = n\lambda$
- Electron diffraction
- Waves as particles – particles as waves

$\lambda = h/p$

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Interference

- Waves must be coherent.
- Superposition (addition) of waves.
  - In phase, path difference {(nλ)}, constructive
  - Out of phase, {(n+½)λ}, destructive
- Ripple tanks
- Sound
- Young's double slit

$$\lambda = \frac{a \times d}{D}$$

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Prefixes

• tera	×1,000,000,000,000	(T)	TeV
• giga	×1,000,000,000	(G)	GeV
• mega	×1,000,000	(M)	MHz, M
• kilo	×1,000	(k)	kHz, k, kV
• milli	×0.001	(m)	mV, mA, mW
• micro	×0.000 001	(μ)	μV, μA, μW, μF
• nano	×0.000 000 001	(n)	nF
• pico	×0.000 000 000 001	(p)	pF

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Questions

- Set in context – read the context – underline relevant details.
- Look carefully at diagrams – circle and name relevant details.
- Focus on relevant bookwork descriptions and calculations – answer these.
- Attempt all sections – no credit can be given if there is no attempt at an answer!!!!!!!!
- *Estimate*, *Calculate* – show your working.
- *State and explain* – do both!

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