

Wave Properties of Light:
Reflection – light reflects towards the normal and the distance between waves decreases when velocity decreases.
Refraction – the bending of the direction of travel of light after passing through a gap or around an obstacle to produce dark and bright areas.

Angle of refraction = i vs r
 $n = \frac{\sin i}{\sin r}$ – ratio of the gap or obstacle (or interference) – Young's double slit experiment produces a series of bright and dark areas depending on the path difference. Dark areas are nodes – destructive interference occurs all out of phase.

Path difference = $n\lambda$, $2n\lambda$, $3n\lambda$
 Bright areas are **antinodes** – constructive interference occurs in phase.

Path difference = $n\lambda/2$, $3\lambda/2$
 Dark – the distance (or difference) here dark or bright areas.
 $n\lambda = \frac{m\lambda}{2}$ ($m = 0, 1, 2, \dots$)

$d =$ distance (or difference) between slits and $x =$ distance (or difference) on the screen.

PARTICLE Properties of Light:
 Photoelectric effect (threshold) – ejection of electrons from a metal surface when light of a frequency greater than a threshold frequency (f_0) strikes it.

$E_{\text{photon}} = hf = hf_0 + KE_{\text{max}}$
 $h =$ Planck's constant
 $f =$ frequency of light
 $f_0 =$ threshold frequency
 $KE_{\text{max}} =$ maximum kinetic energy of electrons
 $W = hf_0$

$W =$ work function of an (f_0) is different for every metal.
 Ejected photoelectrons have a maximum kinetic energy.

$E_{\text{photon}} = hf = W + KE_{\text{max}} = W + \frac{1}{2}mv_{\text{max}}^2$
 $W = hf_0 = \phi$

$e =$ charge on an electron ($1.6 \times 10^{-19} \text{ C}$)
 $V_0 =$ stopping voltage (V) where no photoelectrons reach anode in photoelectric cell.



Maximum – photons can impart their energy to metal as free electrons.

$E = \frac{hc}{\lambda} = \frac{hc}{\lambda_0 + \Delta\lambda} = \frac{hc}{\lambda_0} \left(1 + \frac{\Delta\lambda}{\lambda_0} \right)^{-1}$ $E = \frac{hc}{\lambda_0} \left(1 - \frac{\Delta\lambda}{\lambda_0} \right)$

De Broglie Wavelength:
 $\lambda = \frac{h}{mv} = \frac{h}{p}$ $f = \frac{v}{\lambda} = \frac{E}{h} = \frac{hf_0 + KE_{\text{max}}}{h}$

Photons are only seen if λ and ν are small and h is large.
 Electrons have stable orbits as their wave circumference = whole no. of λ .

Energy levels:
 Electrons in atoms occupy energy levels, which they can jump between.
 1. Electrons drop levels, photon emitted with energy = difference in energy levels.
 2. Electrons absorb levels, photon absorbed with energy = difference in energy levels.
 3. Electron absorbs photon absorbed with energy \geq energy needed to ionise. The emitted electron carries extra energy away.
 $E_2 - E_1 = hf = hc/\lambda$ E_1 and $E_2 =$ different energy levels (J)

Electric Fields:

Particle	Charge (C)	Mass (kg)
Proton	$+1.6 \times 10^{-19}$	1.67×10^{-27}
Electron	-1.6×10^{-19}	9.11×10^{-31}

$E = \frac{F}{Q} = \frac{kQq}{r^2}$ (between parallel plates)

$E =$ electric field strength (V m⁻¹ or N C⁻¹)
 $q =$ unit positive charge (C)
 $Q =$ voltage across plates (V)
 $d =$ distance between plates (m)
 $E =$ force (N) on unit charge

$E = \frac{F_{\text{elec}}}{q} = \frac{Eq_{\text{test}}}{q_{\text{test}}}$ $a =$ acceleration (m s⁻²) of charged particle in electric field

$W = \Delta E = \Delta U = qV = \int \mathbf{F} \cdot d\mathbf{s}$

$W =$ work (J) on a charged particle in an electric field – $W = qV = \int \mathbf{F} \cdot d\mathbf{s}$
 $d =$ distance (m) moved parallel to field
 $E =$ electric field strength

A beam of electrons moving at right angles through a uniform electric field moves in a parabolic path (eg cathode ray).

$F_e =$ force (N) in magnetic field $F_e = qvB$
 $F =$ field strength (T)
 $v =$ particle velocity (m s⁻¹) $r = \frac{mv}{qB}$
 $E =$ electric field strength

STRUCTURES AND MATERIALS

Elastic – returns to original shape after deformation (energy returned as E_p)

Plastic – deformation is permanent (energy used to deform)

Hooke's law: $F = kx$
 $k =$ force constant (N) which measures stiffness
 $x =$ extension (m)
 Proportional limit point on F vs x graph where F and x are longer proportional.
 Elastic limit point after which deformation permanent.

Area under $F = kx$ is $\frac{1}{2}Fx = \frac{1}{2}kx^2$ is E_p (extension x and area under F vs x graph)

$\sigma =$ Stress (N m⁻²) or $F/A =$ load force (F) per area, perpendicular unit area (A)
 $\epsilon = \Delta L/L_0$

Tensile/Compressive strength, tensile and compressive stress respectively at point of failure. Fracture or breaking.

Shear stress – a torque in a material causes adjacent sections to slide across each other.

$E =$ Stress – extension or compression (or unit length) expressed as a percentage or fractional quantity.

$E = \frac{FL}{A\Delta L}$ $L =$ initial length (m)

$E =$ Young's Modulus (N m⁻²) = stress per unit strain, the stiffness of the material independent of dimensions.

$E = \frac{F/A}{\Delta L/L_0} = \frac{FL_0}{A\Delta L}$ (stress vs strain graph)

Strain energy – work done to change the length of a material. Area under F vs x graph is the strain energy (J) whereas the area under a stress vs. strain graph is the strain energy per unit volume (J m⁻³).



Stiff – small amount of plastic deformation (eg steel)

Tough – ability to absorb strain energy. Toughness is measured by area beneath stress vs. strain graph.

Strength – determined by maximum stress before fracture.

Centre of Mass (CM) – point used to simplify motion of a body.

$x_{CM} = \frac{m_1x_1 + m_2x_2 + \dots + m_nx_n}{m_1 + m_2 + \dots + m_n}$

$x_1 =$ distance of mass 1 (m) from one end. Similarly, centre of mass of mass is not above the base of support.

$\tau =$ Torque (Nm) – a turning effect dependent on the perpendicular force (F) and the distance (r) it is applied from the axis of rotation.

$\tau = Fr$

Translational equilibrium – when all forces acting on an object sum to zero. The object can be at rest or moving with constant speed.

$\sum F_x = 0$ $\sum F_y = 0$ and $\sum F_{\text{net}} = 0$

Rotational equilibrium – when all torque acting sum to zero.

$\sum \tau_x = 0$ or $\sum \tau_{\text{net}} = 0$

Stable – when it rotational and translational equilibrium.



Collarless beam – extending past its support structure.

Arch/Keystone – all stones are under compression.

Concrete – strong under compression, weak under tension.

Reinforced concrete – contains steel rods (tensile) to support under tension and it is strong under compression and tensile.

Pre-stressed concrete – under compression when formed. This means when it undergoes tension it is stronger as it is actually just less compressed.

Vce Physics Key Card

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