Quantity	Estimated Value
Mass of a car	900-2000kg
Volume of a person	0.1 m^3
Density of sand	1500kg/m^3
Quantity	**Estimated Value**
Mass of a Person	60 – 85 kg
Weight of a Person	600 – 850 N
Height of a Person	1.5 – 1.85 m
Walking Speed of a Person	1 – 2 $m\,s^{-1}$
Speed of a Car on the Motorway	30 – 65 $m\,s^{-1}$
Volume of a Can of a Drink	300 – 600 cm^3
Density of Water	1000 $kg\,m^{-3}$
Density of Air	0.5- 1.5 $kg\,m^{-3}$
Mass of an Apple	100 – 200 g
Weight of an Apple	1 – 3 N
Current in a Domestic Appliance	10 - 15 A
E.M.F of a Car Battery	12 V
Hearing Range of a Person	20 - 20,000 Hz
Young's Modulus of a Material	Value x 10^{10} - 10^{11} Pa
Power of a Hair Dryer	500 – 750 W
Energy Required to Boil Water	9.5 x 10^5 J
Resistance of a Filament Lamp	580 Ω
Wavelength of Visible Light	4.0 – 7.0 x 10^{-7} m
Pressure Due to a Depth of 10 m	1 x 10^5 Pa
Mass of a Protractor	5 – 50 g
Mass of a Meter Rule	10 – 25 g
Volume of a Human Head	2 – 9 x 10^3 cm^3
Speed of Sound in Air	100 – 900 $m\,s^{-1}$
Number of Joules of Energy in 1 kWhr	3.6 x 10^6 J
Speed of Sound in Water	1480 – 1500 $m\,s^{-1}$
Speed of Sound in Metal	4000 – 5000 $m\,s^{-1}$
Mass of a Scientific Calculator	80 – 150 g
Speed of an Athlete Running in a 100 m Race	8 – 10 $m\,s^{-1}$
Energy of an Athlete Running in a 100 m Race	3500 – 4500 J
Mass of an Atom of Carbon	2 x 10^{-26} kg
Diameter of a Nucleus	Value x 10^{-14} – 10^{-15} m
Diameter of an Atom	Value x 10^{-11} – 10^{-10} m
Density of Oil (Average)	750 – 850 kg m
Speed of Light in Vacuum	2.8 - 3.0 x 10^8 m s
Diameter of an Hair Strand	0.05 – 0.1 mm
Mass of 1 Liter of Water	0.9 – 1.1 kg
Amount of Particles in 1 Mole of a Substance	6.023 x 10^{23}
Mass of Cell Phone (Average)	80 – 450 g
Wavelength of Violet Light	3.5 – 4.5 x 10^{-7} m
Wavelength of Red Light	6.5 – 7.5 x 10^{-7} m
Refractive Index of Glass	1.5
Refractive Index of Diamond	2.0
Refractive Index of Water	1.33

AS Level subject content

1 Physical quantities and units

1.1 Physical quantities

Candidates should be able to:

1 understand that all physical quantities consist of a numerical magnitude and a unit

2 make reasonable estimates of physical quantities included within the syllabus

1.2 SI units

Candidates should be able to:

1 recall the following SI base quantities and their units: mass (kg), length (m), time (s), current (A), temperature (K)

2 express derived units as products or quotients of the SI base units and use the derived units for quantities listed in this syllabus as appropriate

3 use SI base units to check the homogeneity of physical equations

4 recall and use the following prefixes and their symbols to indicate decimal submultiples or multiples of both base and derived units: pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T)

1.3 Errors and uncertainties

Candidates should be able to:

1 understand and explain the effects of systematic errors (including zero errors) and random errors in measurements

2 understand the distinction between precision and accuracy

3 assess the uncertainty in a derived quantity by simple addition of absolute or percentage uncertainties

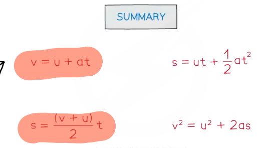
1.4 Scalars and vectors

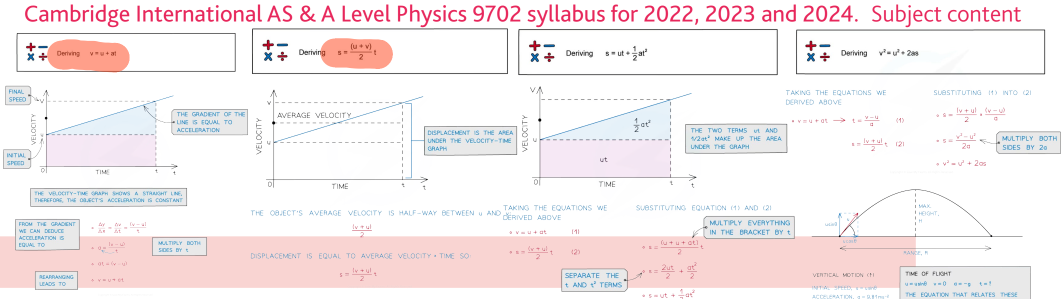
Candidates should be able to:

1 understand the difference between scalar and vector quantities and give examples of scalar and vector quantities included in the syllabus

2 add and subtract coplanar vectors

3 represent a vector as two perpendicular components





2 Kinematics

2.1 Equations of motion

Candidates should be able to:

1 define and use distance, displacement, speed, velocity and acceleration

2 use graphical methods to represent distance, displacement, speed, velocity and acceleration

3 determine displacement from the area under a velocity–time graph

4 determine velocity using the gradient of a displacement–time graph

5 determine acceleration using the gradient of a velocity–time graph

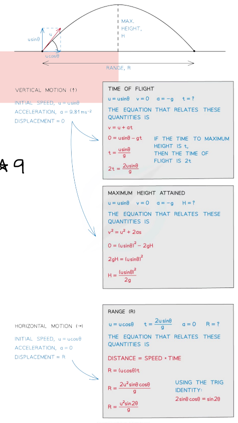
6 derive, from the definitions of velocity and acceleration, equations that represent uniformly accelerated motion in a straight line

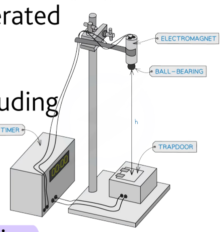
7 solve problems using equations that represent uniformly accelerated motion in a straight line, including the motion of bodies falling in a uniform gravitational field without air resistance

8 describe an experiment to determine the acceleration of free fall using a falling object

*9 describe and explain motion due to a uniform velocity in one direction and a uniform acceleration in a perpendicular direction

*9





3 Dynamics

An understanding of forces from Cambridge IGCSE/O Level Physics or equivalent is assumed.

3.1 Momentum and Newton's laws of motion

Candidates should be able to:

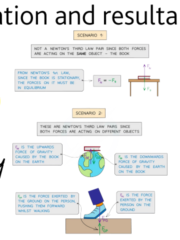
1 understand that mass is the property of an object that resists change in motion

2 recall *F* = *ma* and solve problems using it, understanding that acceleration and resultant force are always in the same direction

3 define and use linear momentum as the product of mass and velocity

4 define and use force as rate of change of momentum -ms

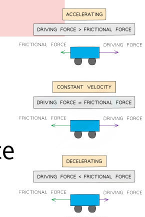
5 state and apply each of Newton's laws of motion



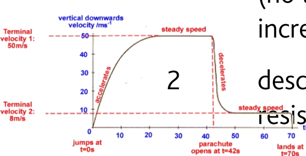
6 describe and use the concept of weight as the effect of a gravitational field on a mass and recall that the weight of an object is equal to the product of its mass and the acceleration of free fall

3.2 Non-uniform motion

Candidates should be able to:

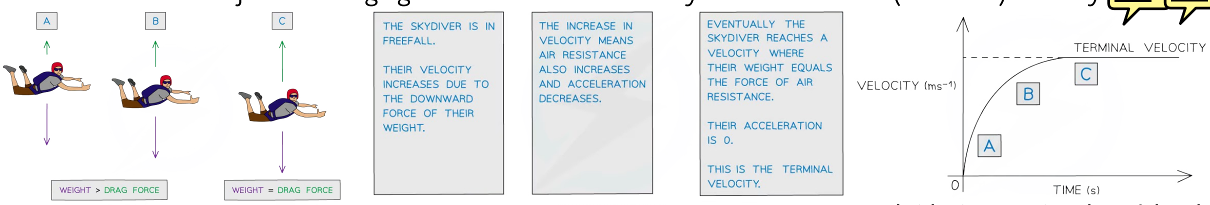


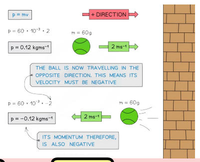
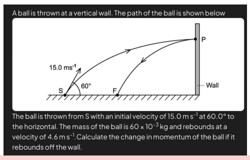
1 show a qualitative understanding of frictional forces and viscous/drag forces including air resistance (no treatment of the coefficients of friction and viscosity is required, and a simple model of drag force increasing as speed increases is sufficient)

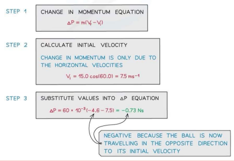


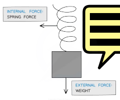
2 describe and explain qualitatively the motion of objects in a uniform gravitational field with air resistance

3 understand that objects moving against a resistive force may reach a terminal (constant) velocity



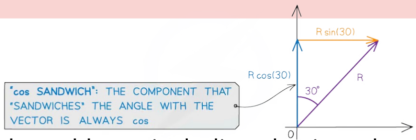




3.3 Linear momentum and its conservation

Candidates should be able to:

1 state the principle of conservation of momentum



2 apply the principle of conservation of momentum to solve simple problems, including elastic and inelastic interactions between objects in both one and two dimensions (knowledge of the concept of coefficient of restitution is not required)

3 recall that, for a perfectly elastic collision, the relative speed of approach is equal to the relative speed of separation

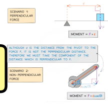
4 understand that, while momentum of a system is always conserved in interactions between objects, some change in kinetic energy may take place

4 Forces, density and pressure

4.1 Turning effects of forces

Candidates should be able to:

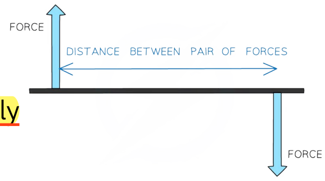
1 understand that the weight of an object may be taken as acting at a single point known as its centre of gravity



2 define and apply the moment of a force

3 understand that a couple is a pair of forces that acts to produce rotation only

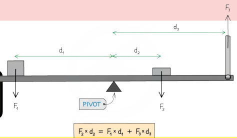
4 define and apply the torque of a couple



4.2 Equilibrium of forces

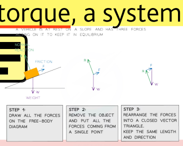
Candidates should be able to:

1 state and apply the principle of moments

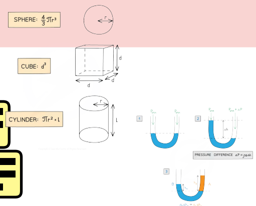


2 understand that, when there is no resultant force and no resultant torque, a system is in equilibrium

3 use a vector triangle to represent coplanar forces in equilibrium



4.3 Density and pressure



Candidates should be able to:

1 define and use density

2 define and use pressure

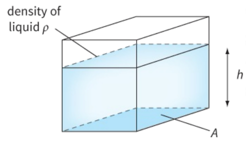
3 derive, from the definitions of pressure and density, the equation for hydrostatic pressure $\Delta p = \rho g \Delta h$

4 use the equation $\Delta p = \rho g \Delta h$

5 understand that the upthrust acting on an object in a fluid is due to a difference in hydrostatic pressure

6 calculate the upthrust acting on an object in a fluid using the equation $F = \rho g V$ (Archimedes' principle)

The force acting on the shaded area A on the bottom of the tank is caused by the weight of water above it, pressing downwards. We can calculate this force and hence the pressure as follows:



volume of water $= A \times h$

mass of water $=$ density $\times$ volume $= \rho \times A \times h$

weight of water $=$ mass $\times g = \rho \times A \times h \times g$

change in pressure $= \frac{\text{force}}{\text{area}}$

$= \rho \times A \times h \times \frac{g}{A}$

$= \rho \times g \times h$

The equation is written as $\Delta p = \rho g h$ because this formula calculates the *difference* in pressure between the top and bottom of the water in the tank. There is, of course, atmospheric pressure acting on the water at the top of the tank. The total pressure at the bottom of the tank is atmospheric pressure + Δp.

To calculate this upthrust:

The force due to water on the top surface $F_1 = \rho \times g \times h_1 \times A$

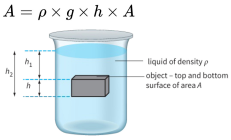
Similarly, the force due to the water on the bottom surface is $F_2 = \rho \times g \times h_2 \times A$

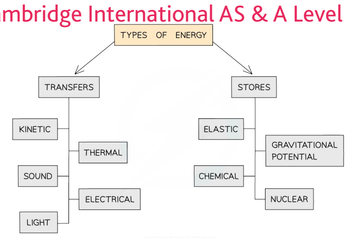
upthrust $= F_2 - F_1 = \rho \times g \times (h_2 - h_1) \times A = \rho \times g \times h \times A$

$= \rho \times g \times V$

where the volume of the object $V = h \times A$

$=$ the weight of the liquid displaced





Type of energy	Description
Kinetic	The ability to do work due to the movement of a body
Gravitational potential	The ability to do work due to the position of a body in a gravitational field
Elastic potential	The ability to do work due to the deformation of a body (e.g. a compressed or extended spring)
Sound	The ability to do work due to the kinetic and potential energy of the vibrating particles in a sound wave
Internal	The sum of the random kinetic and potential energies of the molecules in a body.
Electrical potential	The ability to do work due to the position of a charged particle in an electric field
Chemical potential	The ability to do work due to potential energy of the particles making up substances
Nuclear potential	The ability to do work due to the potential energy of the subatomic particles in the nuclei of atoms

5 Work, energy and power

An understanding of the forms of energy and energy transfers from Cambridge IGCSE/O Level Physics or equivalent is assumed.

5.1 Energy conservation

Candidates should be able to:

1. understand the concept of work, and recall and use *work done = force × displacement* in the direction of the force
2. recall and apply the principle of conservation of energy
3. recall and understand that the efficiency of a system is the ratio of useful energy output from the system to the total energy input $\text{EFFICIENCY} = \frac{\text{USEFUL ENERGY OUTPUT}}{\text{TOTAL ENERGY INPUT}} \times 100\%$ $\text{EFFICIENCY} = \frac{\text{USEFUL POWER OUTPUT}}{\text{TOTAL POWER INPUT}} \times 100\%$
4. use the concept of efficiency to solve problems
5. define power as work done per unit time
6. solve problems using $P = W/t$
7. derive $P = Fv$ and use it to solve problems

Derivation of $P = F \times v$

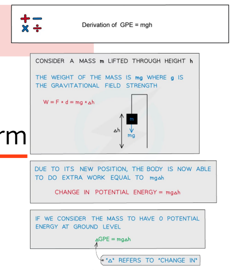
POWER IS THE RATE OF CHANGE OF WORK
$\text{POWER} = \frac{W}{t}$

WORK DONE = FORCE × DISTANCE
$W = F \times d$

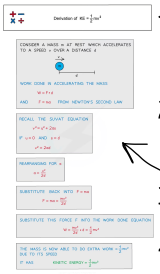
AT CONSTANT VELOCITY, $d = v \times t$ THEREFORE
$W = F \times v \times t$
$P = \frac{W}{t} = \frac{F \times v \times t}{t}$

CANCELLING t
$P = F \times v$

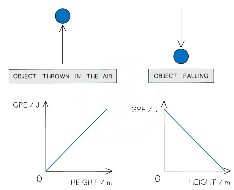
5.2 Gravitational potential energy and kinetic energy



Candidates should be able to:



1. derive, using $W = Fs$, the formula $\Delta E_P = mg\Delta h$ for gravitational potential energy changes in a uniform gravitational field
2. recall and use the formula $\Delta E_P = mg\Delta h$ for gravitational potential energy changes in a uniform gravitational field
3. derive, using the equations of motion, the formula for kinetic energy $E_K = \frac{1}{2}mv^2$
4. recall and use $E_K = \frac{1}{2}mv^2$

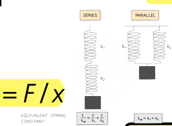


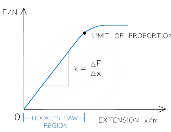
6 Deformation of solids

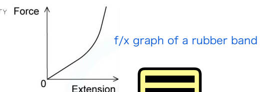
6.1 Stress and strain

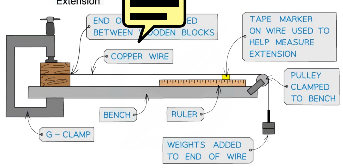
Candidates should be able to:

1. understand that deformation is caused by tensile or compressive forces (forces and deformations will be assumed to be in one dimension only)
2. understand and use the terms load, extension, compression and limit of proportionality
3. recall and use Hooke's law
4. recall and use the formula for the spring constant $k = F/x$
5. define and use the terms stress, strain and the Young modulus
6. describe an experiment to determine the Young modulus of a metal in the form of a wire





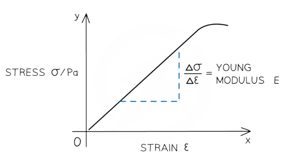




$\sigma = \frac{F}{A}$ — STRESS (Pa); FORCE (N); CROSS-SECTIONAL AREA (m²)

$\varepsilon = \frac{x}{L}$ — STRAIN; EXTENSION (m); LENGTH (m)

YOUNG MODULUS $E = \frac{\text{STRESS } \sigma}{\text{STRAIN } \varepsilon} = \frac{FL}{Ax}$ — (Pa)



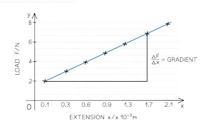
Material	Youngs Modulus /GPa
Mild Steel	210
Copper	120
Bone	18
Plastic	2
Rubber	0.02

Young's modulus

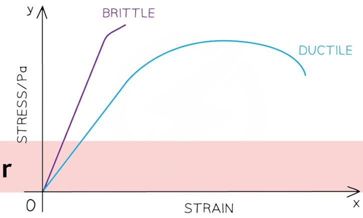
- Measures resistance of material to change its shape when a force is applied to it
- Related to atomic bonding
- *Stiff* - high Young's modulus
- *Flexible* - low Young's modulus

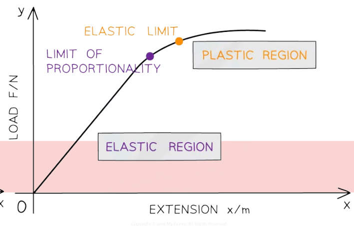
	Young's Modulus ($\times 10^9$ Pa)
cotton	5
leather	0.22
brass	110
copper	130
lead	14
nylon	1.8
Brick	28
Concrete	24
Diamond	11,000
Pine	13, 1.2
natural rubber	0.0019

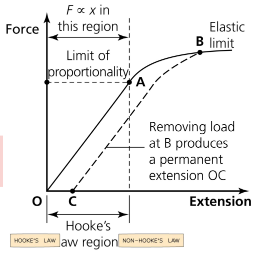
Mass m / g	Load F / N	Initial length / mm	Final length / mm	Extension x ($\times 10^{-3}$) / m
200	2.0	500	500.1	0.1
300	2.9	500.1	500.4	0.3
400	3.9	500.4	501.0	0.6
500	4.9	501.0	501.9	0.9
600	5.9	501.9	503.2	1.3
700	6.9	503.2	504.9	1.7
800	7.8	504.9	507.0	2.1



YOUNG'S MODULUS $E = \frac{\text{STRESS}}{\text{STRAIN}} = \frac{FL}{Ax} = \text{GRADIENT} \times \frac{L}{A}$ — FORCE / LOAD (N); LENGTH OF WIRE (m); CROSS-SECTIONAL AREA (m²); EXTENSION (m)





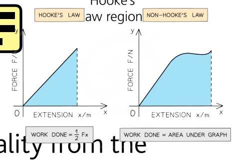


6.2 Elastic and plastic behaviour

Candidates should be able to:

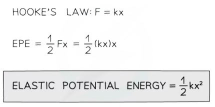
1 understand and use the terms elastic deformation, plastic deformation and elastic limit

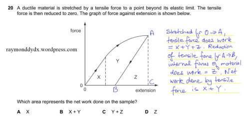
2 understand that the area under the force–extension graph represents the work done

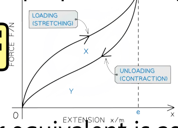


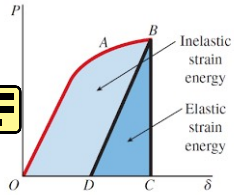
3 determine the elastic potential energy of a material deformed within its limit of proportionality from the area under the force–extension graph

4 recall and use $E_P = \frac{1}{2}Fx = \frac{1}{2}kx^2$ for a material deformed within its limit of proportionality









EPE when the object plastically deformed

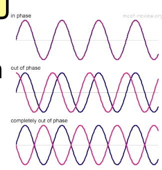
7 Waves

An understanding of colour from Cambridge IGCSE/O Level Physics or equivalent is assumed.

7.1 Progressive waves

Candidates should be able to:

1 describe what is meant by wave motion as illustrated by vibration in ropes, springs and ripple tanks

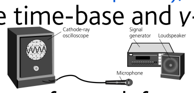


2 understand and use the terms displacement, amplitude, phase difference, period, frequency, wavelength and speed

$\phi = \frac{x}{\lambda} \times 360^\circ$ phase difference=((distance between the two points)/wavelength) x 360°

Points	Phase difference/ degrees	Phase difference/ radians	Common terms used to describe the phase difference
P and R	360 or 0	2π or 0	In phase
P and Q	180	π	Exactly out of phase (antiphase)
R and S	90	½π	90° or ½π out of phase

3 understand the use of the time-base and y-gain of a cathode-ray oscilloscope (CRO) to determine frequency and amplitude



4 derive, using the definitions of speed, frequency and wavelength, the wave equation $v = f\lambda$

wave speed = $\frac{\text{distance travelled by the wave}}{\text{time}}$

In time T, the period of oscillation, the wave travels one wavelength. Hence:

$c = \frac{\lambda}{T}$

but:

$f = \frac{1}{T}$

hence:

$c = \lambda f$

5 recall and use $v = f\lambda$

6 understand that energy is transferred by a progressive wave

7 recall and use $intensity = power/area$ and $intensity \propto (amplitude)^2$ for a progressive wave

$I = \frac{P}{A}$

$I = \frac{P}{4\pi r^2}$, where r is the distance moved by the wave.

$I \propto \frac{1}{r^2}$

$Ir^2 = \text{constant}$

$I_1 r_1^2 = I_2 r_2^2$

Intensity ∝ (Amplitude)^2

$I \propto A^2$

$\frac{I}{A^2} = \text{constant}$

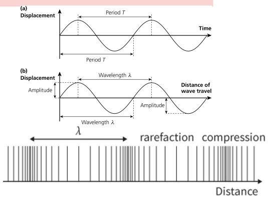
$\frac{I_1}{A_1^2} = \frac{I_2}{A_2^2}$

7.2 Transverse and longitudinal waves

Candidates should be able to:

1 compare transverse and longitudinal waves

2 analyse and interpret graphical representations of transverse and longitudinal waves

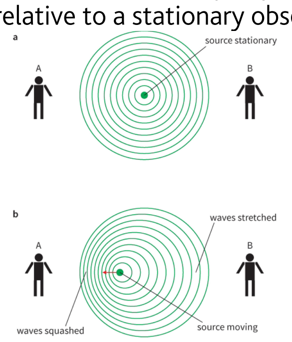


7.3 Doppler effect for sound waves

Candidates should be able to:

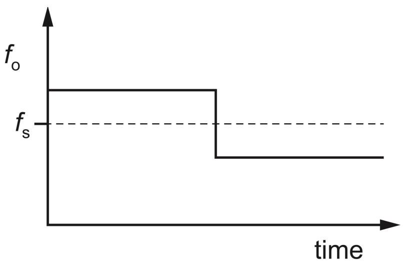
1 understand that when a source of sound waves moves relative to a stationary observer, the observed frequency is different from the source frequency (understanding of the Doppler effect for a stationary source and a moving observer is not required)

2 use the expression $f_o = f_s v / (v \pm v_s)$ for the observed frequency when a source of sound waves moves relative to a stationary observer



$f_o = \frac{f_s v}{v \pm v_s}$

where f_o is the observed frequency, f_s is the source frequency, v is the velocity of the waves and v_s is the relative velocity of the source and observer.



Observed frequency as a sound source moves directly towards and past an observer at constant velocity