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CHAPTER 1 - PHYSICAL QUANTITIES AND UNITS

All physical quantities consist of a numerical magnitude and a unit and can be expressed in terms of the SI base units.

The base units are:
mass (Kg)
length (m)
time (s)
electric current (A)
temperature (K)
amount of substance (mol)

Expressing derived units as products of the base units:
F = ma   Kg x ms^{-2} = $Kgms^{-2}$

Homogeneity of physical equations:
v = u + at
$ms^{-1} = ms^{-1} + ms^{-2}s^{1}$
$ms^{-1} = ms^{-1} + ms^{-1}$

Results tables: include symbol and unit

Powers of ten:
pico (p) 10^{-12}
nano (n) 10^{-9}
micro (μ) 10^{-6}
milli (m) 10^{-3}
centi (c) 10^{-2}
deci (d) 10^{-1}
kilo (K) 10^{3}
mega (M) 10^{6}
giga (G) 10^{9}
tera (T) 10^{12}

The mole is the amount of substance containing the same number of atoms or molecules as the number of atoms in 0.012Kg of carbon-12. This number is called the Avogadro constant, L = 6.02 x $10^{23}mol^{-1}$.

The molar mass of a substance is the mass of one mole of that substance. Therefore one mole of any substance is the amount containing a number of particles equal to the Avogadro constant.

Scalars are quantities that have magnitude only:

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e.g. length, speed, mass, density, energy, power, temperature, charge and pd..

Vectors are quantities that have direction as well as magnitude:
e.g. displacement, force, torque, velocity, acceleration, momentum, electric current and electric field.

temp (K) = temp (°C) + 273

CHAPTER 2 - KINEMATICS

Displacement - The displacement of a body at position x from point 0 is a vector from 0 to x. The size of the vector indicates the magnitude and the direction of the vector indicates the direction of the displacement.

Speed - The rate of change of distance with respect to time.

Velocity - The rate of change of displacement with respect to time.

Acceleration - The rate of change of velocity with respect to time.

Derive from the definitions of velocity and acceleration:
velocity = displacement/time and acceleration = change in velocity/time

$$a = \frac{(v-u)}{t}$$

giving v-u = at
and then $v = u + at$

Distance moved = average velocity x time taken
Therefore $s = \frac{(u+v)}{2} t$

From the first equation

$$a = \frac{(v-u)}{t} \quad \text{so } t = \frac{(v-u)}{a}$$

substitute into $s = \frac{(u+v)}{2} t$ to get $s = \frac{(u+v)}{2} \frac{(v-u)}{a}$ which gives $s = \frac{v^2 - u^2}{2a}$

Following that $2as = v^2 - u^2$ and therefore $v^2 = u^2 + 2as$

$s = \frac{(u+v)}{2} t$ substitute v = u + at into the equation which gives $s = \frac{(u + u + at)t}{2}$ and so $s = \frac{2ut + at^2}{2}$

and this gives $s = ut + \frac{1}{2}at^2$

The gradient of a velocity-time graph gives the magnitude of the acceleration.

The gradient of a displacement-time graph gives the velocity.

The area underneath a velocity-time graph gives the distance.

The magnitude of air resistance depends on the density of the air and the speed of the object through the air.

Maximum velocity of fall is called the terminal velocity.

acceleration = $\frac{\text{change in velocity}}{\text{time}} = (v-u)/t$

CHAPTER 3 DYNAMICS

NEWTONS LAWS OF MOTION

1st Law - All bodies in the universe will remain at rest or continue to move with constant velocity unless there is a resultant force acting on the body.

2nd Law - The acceleration an object experiences multiplied by the mass of the object is equal to the net force acting on the object.
Therefore F = ma

3rd Law - If body A exerts a force on body B then body B exerts an equal and opposite force in body A.

Mass is the amount of matter that a body contains and is a measure of the inertial property of that body, that is, of its resistance to change motion.

Linear momentum = mass x velocity

Force is the rate of change of momentum.
A force is that which can change the state of rest of an object or its state of uniform motion in a straight line.

In the equation F = ma force and acceleration are always in the same direction.

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The law of conservation of energy states that the total momentum of an isolated system cannot be changed.

An isolated system is any object or collection of objects on which no force is exerted by any external object.

For a perfectly elastic collision the relative speed of approach is equal to the relative speed of separation.

Although momentum of a system is always conserved in interaction between bodies, some change in kinetic energy usually takes place.

Mass remains constant anywhere in the universe.

Weight is a force which varies from place to place.

Inertia is the reluctance of an object to change velocity.

The Newton is the force necessary to give a mass of 1kg an acceleration of $1ms^{-2}$.

$ft = mv - mu$ The change in momentum which is measured in the unit Newton second. It is called the impulse of the force.

CHAPTER 4 FORCES

The centre of gravity of an object is a point through which the entire weight of the object is considered to act.

A couple is a pair of forces tending to produce rotation.

The turning effect of a force about a pivot is called its moment and is defined by the equation:
Moment of a force = force x perpendicular distance of pivot from the line of action of the force.

A pair of equal and opposite forces not acting in the same straight line is called a couple and the turning effect that they cause is called a torque.
Torque of a couple = one of the forces x perpendicular distance between the forces.

Complete equilibrium of a body is achieved when there is no resultant force and no resultant torque acting on the body.

The principle of moments states that for any object that is in equilibrium, the sum of the clockwise moments about any point provided by the forces acting on the object equals the sum of anticlockwise moments about that point.

If the resultant force on a point object is zero, the object is said to be in equilibrium.

If two equal and opposite forces act on a body, the resultant force on the body is zero and it will not accelerate.

CHAPTER 5 WORK, ENERGY AND POWER

Examples of energy in different forms: chemical energy in fuels such as oil and coal, kinetic energy in a moving train, potential energy and internal energy.

The conservation of energy states that energy cannot be created or destroyed, but can be converted from one form into another.

When a force moves in the direction of the force, work has been done:
Work = force x displacement in the direction of the force

Derive from the equations of motion, the formula ½ mv^2
Consider a body of mass m has a force f acting on it, changes from an initial velocity u and ends up with velocity v.
Work done = f x s = Gain in KE
Force = ma, so w = m x a x s
Using $v^2 = u^2 + 2as$ as = $\frac{(v^2 - u^2)}{2}$

we get w = $m\frac{(v^2 - u^2)}{2}$

= gain in KE
= $m(v^2 - u^2)/2$
If u = 0 then K.E.
= $\frac{1}{2}mv^2$

Derive from the defining equation W= Fs, the formula PE = mgh for potential energy changes near the Earth's surface:
Force required to lift a body of mass m = weight, which = mg
Work done = gain in PE
W = f x h
= mg x h
PE = mgh

Internal energy is the sum of the kinetic and potential energies of all the atoms within a body.

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One joule is the work done when a force of one Newton moves one metre in the direction of the force.

Energy is the stored ability to do work.

Energy is stored in the movement of individual atoms and molecules in a form of energy called internal energy.

Elastic collision - Momentum is conserved and the total kinetic energy of bodies is conserved.

Inelastic collision - Momentum is conserved, but the total kinetic energy after is less than the total kinetic energy before, because some energy has been transferred into other forms.

Perfectly inelastic implies that the two colliding objects stick together and if one if them is the ground hen no bouncing takes place.

The law of conservation of momentum to the collision:
$M_1U_1 + M_2U_2 = M_1V_1 + M_2V_2$

Power is the rate of doing work and it is also the rate at which the energy is transferred.

$$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$

$$\text{Power} = \frac{\text{force x distance}}{\text{time}}$$

$$= \text{force x } \frac{\text{distance}}{\text{time}}$$

So power = force x velocity

1kwh = 3600 000J

$$\text{Efficiency of a system} = \frac{\text{energy from the system}}{\text{energy supplied to the system}}$$

CHAPTER 6 WAVES

The laws of reflection of light:
The angle of incidence is equal to the angle of reflection
The incident ray, normal ray and the reflected ray are all in the same plane.

Properties of an image seen in a plane mirror:
It is virtual.
It is the size as the object.

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The image is laterally inverted.
Image distance from mirror = object distance from mirror.

Laws of refraction of light:
For an angle of incidence and an angle of refraction the refractive index

$$n = \frac{\sin(i)}{\sin(r)}$$

Refraction of light:
When light waves pass from air into a more dense medium such as water, they slow down, but their frequency remains constant.

The ratio of their speed in air to their speed in the medium is called the refractive index of the medium: refractive index = $\frac{\text{speed in free space}}{\text{speed in the medium}}$

Refractive index: = $\frac{\sin i}{\sin r}$ or $\frac{C_1}{C_2}$,where c refers to the speed waves in mediums 1 & 2.

At a certain angle of incidence, called the critical angle, the angle of refraction is 90°.

If the angle of incidence in the more dense medium is increased past the critical angle, all of the light is reflected back and this is known as total internal reflection.

Refractive index is related to critical angle by the equation:

$$n_{12} = \frac{\sin i}{\sin r}$$

where n = refractive index from 1 to 2
but sin r = 90° = 1
so $n_{12} = \frac{\sin C}{1}$

therefore $n_{21} = \frac{1}{\sin C}$

Applications of total internal reflection:
The transmission of light through a glass fibre is one of the most important applications of total internal reflection and is known as fibre optics.
To see inside the human body and keyhole surgery.
for lighting roads signs or models.
In security fences.
For telephone calls and cable TV.

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Fibre optic cables advantages:
small
low mass
quite flexible
can carry more information than a conventional copper cable.

Longitudinal waves have vibrations along the wave direction.

Transverse waves have vibrations across the wave direction.

Frequency (F) (Hz) is the number of waves passing a point each second.

Period (T) (s) is the time for one wave to completely pass a point. (inverse of frequency $T = \frac{1}{F}$).

Amplitude (m) is the maximum displacement from the undisturbed position.

Wavelength (λ) (m) is the distance from one point on a wave to the corresponding point on the next wave.

Speed is the rate at which the wave front propagates.

Displacement - The displacement of a particle caused by the disturbance of a wave is the vector from its undisturbed position to its actual position.

The phase of the wave motion at any point is related to the displacement of the wave at zero time. Any two points on the wave will have a phase difference between them and this will be anything from 0° to 360°.

e.g. a pendulum swinging over a ball on a turntable.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

but a wave will travel a distance of one wavelength in a time equal to one period (T), so

$$\text{wave speed} = \frac{\text{wavelength}}{\text{period}}$$

However, $T = \frac{1}{f}$, where f is the frequency of the wave and so:

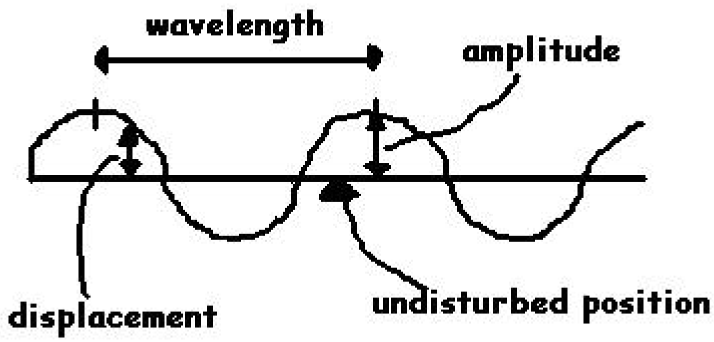
$v = f\lambda$

Waves that move through a material (or vacuum) are called progressive waves.
A wave in which the plane of vibration is constantly changing is called an unpolarised wave. If the

waves of a transverse wave are in one plane only, then the wave is said to be polarised.

Longitudinal waves cannot be polarised, because they vibrate only along the direction of motion of the wave.

Vibration - An object or particle is said to be vibrating when it moves backwards and forwards around a fixed point e.g. air moving from a loud speaker, a string on a violin or a shock wave through the ground produced by an explosion.



Waves are called mechanical waves if the waves need a substance (medium) through which to travel. e.g. sound.

When waves pass from deep to shallow water:
There is a decrease in wave speed and wavelength.
The frequency remains constant.
The ratio of the speed of the waves in deep water to that in shallow water is equal to that of their wavelengths.

An oscilloscope describes the shape of the sound waves and this property is known as their quality or timbre.

Noise is a mixture of many different frequencies.

White noise is sound that contains a large number of frequencies in a particular range. Sounds like a hiss e.g. it can be an annoying background to weak radio signals.

A real image is one through which the light rays actually pass and which can be formed on a screen.

a virtual image is one through which the light rays do not pass, they only appear to come from it. For an object, the image produced by a plane mirror is virtual and the same distance behind the mirror as the object is in front of it.

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Uses of plane mirrors:
kaleidoscope.
overhead projector.
dental mirror.

The change of speed when light moves from one medium to another gives a change of direction when the beam hits the boundary at an angle.

When the light travels from a less dense medium such as air into a more dense medium such as glass, it bends towards the normal, bending away from the normal when its direction is reversed.

Real and apparent depth:

$$\text{refractive index} = \frac{\text{real depth}}{\text{apparent depth}}$$

When light passes from a medium (e.g. glass) to a less dense medium (e.g. air) there is an angle of incidence where the angle of refraction is 90 degrees.

CHAPTER 7 ELECTRICITY

Electric current is the flow of charged particles.

The quantity of charge which flows past a point depends upon the amount of current which flows in a certain amount of time.

Charge - One coulomb of charge passes a point in a circuit if one amp flows for one second.

Current is the rate of flow of charge and $Q = It$

Potential difference - A P.D exists between two points in a circuit if electrical energy is converted into other forms when energy flows between these points. The size of the P.D is equal to the ratio of energy converted to charge flow.

Volt - A P.D of 1 volt exists between two points in a circuit if 1 joule of electrical energy is converted into other forms of energy, when 1 coulomb of charge flows between the points.

$V = \frac{W}{Q}$, where w = energy converted, Q = charge and v = volts.

$P = VI$ and $P = I^2R$

Resistance - The size of the resistance is equal to the ratio of the P.D across the components to the current flowing through the component.

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The ohm - A resistance of 1 ohm exists between two points in a circuit if one ampere of current flows between the points when a P.D of 1 volt exists across the points.

$V = IR$

Ohms law states that for a metallic conductor the current flowing through it is directionally proportional to the potential difference across the conductor provided that temperature and other physical conditions remain constant.

$$R = \frac{\rho L}{A}$$

Kirchoffs first law states that the algebraic sum of currents leaving a junction equals the algebraic sum of currents entering a junction.

Kirchoffs first law follows from the principal of conservation of charge (charge is never created or destroyed). The charge entering a junction each second must leave the junction .

Resistors in series: $R_T = R_1 + R_2$

Resistors in parallel: $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$

Electricity is already in a wire in the form of electrically charged particles. It simply requires energy to make it flow.

A cell is a device containing chemicals that react together to release electrical energy.

The electrical charge passing any point in a circuit in one second is called the electric current (A).

A current of one ampere is flowing in a circuit if one coulomb passes any point in that circuit in one second.

Current is the same at any point in a circuit - conservation of charge. A circuit must be formed for a current to flow.
Voltage is the P.D across a resistor and I is the current flowing through it.

The P.D between two points is a measure of the difference in the energy of the electrons at these points.

Deriving:
$W = VI$ and $V = IR$

So W = IRI which means that $W = I^2R$

and when W = VI and V = IR

then $I = \frac{V}{R}$ and so $W = V \times \frac{V}{R}$ so $W = \frac{V^2}{R}$

CHAPTER 8 ATOMIC STRUCTURE

In the α-particle scattering experiment, α-particles were fired at a thin piece of gold foil. Most of the α-particles went straight through with little deviation, some were deflected slightly, but every now and again they were deflected through an angle of more than 90 degrees, so they appeared to bounce back off the foil. This gave Rutherford the idea that contains consist largely of empty space with a central nucleus that only affected the α-particles when they came close to it. The large deflections of an α-particle near a nucleus are due to a very small positively charged nucleus with a very large electric field near its surface. The closer the path of the α-particle gets to the nucleus, the greater this repulsion will be.

The nucleon number is the same as the mass number and it is the number of protons and neutrons that are in nucleus of an atom.

Proton number is the number of protons in an atom. The number of electrons in an atom equals the number of protons in an atom.

The isotopes of an element are atoms with the same proton number, but different nucleon numbers. If neutral, they have the same number of protons and electrons, but different numbers of neutrons.