



eduresourceza.com

PHYSICS ***

MOMENTUM

↳ The product of an object's mass and its velocity

$$\text{kg m s}^{-1} \leftarrow p = m \cdot v \rightarrow \text{m/s}$$

$$p \propto m \quad m \propto \frac{1}{v}$$

$$p \propto v$$

VECTOR NATURE OF "P"

$$\Delta p = p_f - p_i$$

change in momentum = $m(v_f - v_i)$

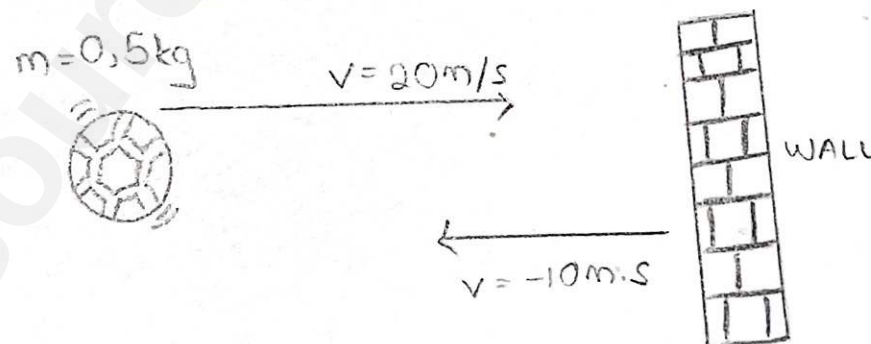
$$\Delta p = m(v_f - v_i)$$

$$= 0,5(-10 - 20)$$

$$= -15 \text{ kg m s}^{-1}$$

∴ Δp is 15 kg m s^{-1} to the left.

e.g. Zaakirah throws a 500g ball to a wall with a velocity of 20 m s^{-1} and it rebounds at 10 m/s . Calculate the change in momentum of the ball.



STEPS

1. Draw
2. Choose direction
3. Plug symbols on diagram using direction & conversions
4. Plug into $p = mv$ or $F_{\text{net}} \Delta t = \Delta p$ or $p_{\text{bef}} = p_{\text{after}}$ etc.

* Answer can't be negative & must have direction

IMPULSE

↳ The product of the resultant/net force acting on an object and the time the resultant/net force acts on the object.

↳ The resultant force that acts on an object is equal to the rate of change in momentum in the direction of the resultant force.

$$F_{\text{NET}} \Delta t = \Delta p \rightarrow \text{change in momentum}$$

IMPULSE (N.s)

$$F_{\text{net}} = m(v_f - v_i)$$

$$F_{\text{net}} = m \cdot a$$

$$m \cdot a \Delta t = m(v_f - v_i)$$

$$a \Delta t = v_f - v_i$$

$$v_f = v_i + a \Delta t$$

$$F_{\text{net}} \propto \frac{1}{\Delta t}$$

$$F_{\text{net}} = \frac{\Delta p}{\Delta t} \rightarrow \text{rate of change in momentum}$$

net force

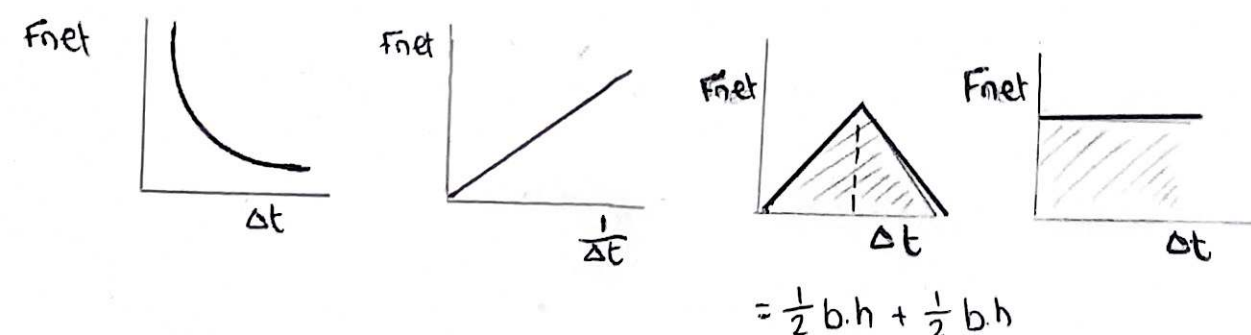
$$F_{\text{net}} \Delta t = m \Delta v$$

$$= F \Delta t$$

$$= \Delta p$$

NEWTON'S 2nd Law of motion

in terms of momentum: The resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force.



The Law of conservation of momentum

↳ The total linear momentum of a closed system remains constant (is conserved).

Closed/isolated system: A system on which the resultant/net force is zero.

NO FRICTION

$$\sum P_{\text{BEFORE}} = \sum P_{\text{AFTER}}$$

$$m_1 v_1 = m_2 v_2$$

Elastic & Inelastic Collisions

$$K_{\text{before}} = K_{\text{AFTER}}$$

$$\sum P_{\text{before}} = \sum P_{\text{AFTER}}$$

P is conserved

$$K_{\text{before}} \neq K_{\text{AFTER}}$$

Falling Objects

$$v_i = 0 \text{ m/s}$$

$$K = \frac{1}{2} m v^2$$

STEPS

1. Draw a before & After scenario.
2. Plug in values with direction
3. Use $\sum P_{\text{before}} = \sum P_{\text{AFTER}}$
4. Solve for unknown

The Doppler Effect

↳ The change in frequency (or pitch) of the sound detected by a listener because the sound source & the listener have different velocities relative to the medium of sound propagation.

↳ change in frequency of a wave due to the relative movement between the source and the observer

$$f_L = \frac{v \pm v_L}{v \pm v_S} \cdot f_S$$

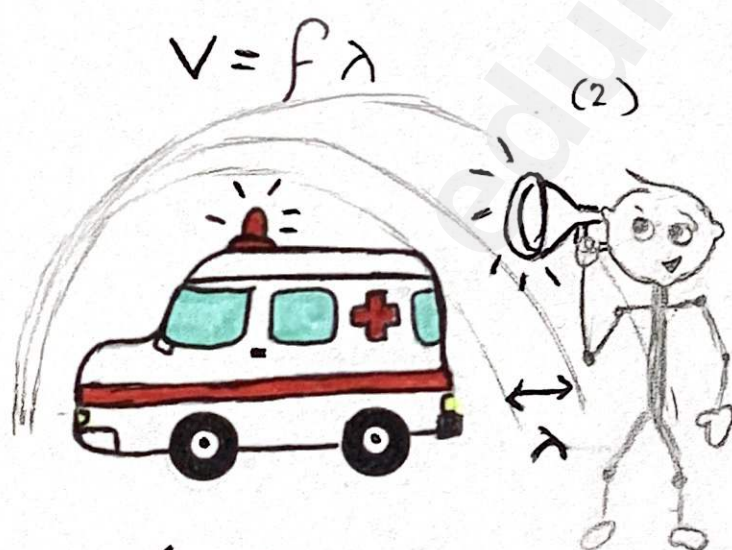
v_L : velocity of listener
 v_S : velocity of source

* Loud: $\lambda \downarrow f \uparrow$
Soft: $\lambda \uparrow f \downarrow$

$$v = \frac{\Delta x}{\Delta t} \text{ - displacement}$$

v : velocity of sound in air (340 m/s)

$f \propto \text{pitch} \propto \text{loudness}$
 $f \propto \frac{1}{\lambda}$



AWAY

$\lambda \uparrow f \downarrow$



Towards: compression of waves

$\lambda \downarrow f \uparrow$

Steps for Solving Doppler

- make a list by carefully reading
- make sure there's right units & stipulate listener & source.
- Decide away or towards scenario

1. S towards L ($v_S -$)
2. S Away L ($v_S +$)
3. L towards S ($v_L +$)
4. L Away S ($v_L -$)

→ Use appropriate formula

- Applications doppler flow meter.
- Medicine - fetus heart rate
blood flow rate
 - Maritime - SONAR positioning
under water
 - Law enforcement - radar
monitoring of speed-
ing cars

Doppler

Downloaded from eduresourceza.com

Light
 $c = f\lambda$

Sound

$$f_L = \frac{v \pm v_L}{v \pm v_S} \cdot f_s$$

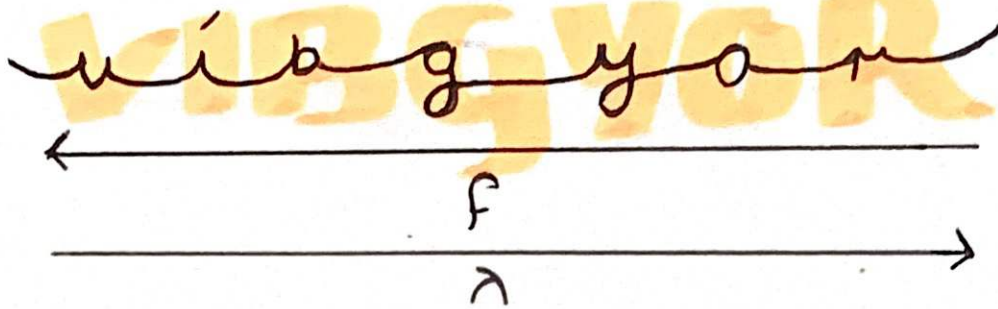
Blue - toward

Red - Away



Red shift occurs when the spectrum of a distant moving star moving away from earth is shifted toward the red end of the spectrum.

Doppler of light proves an expanding universe.



Photoelectric Effect

occurs when light is shined on a metal surface and this causes the metal to emit electrons
the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.

$f < f_0$ (NOTHING HAPPENS)

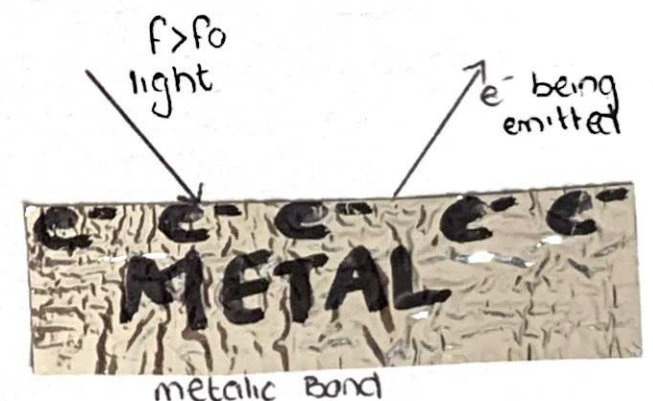
$f > f_0$ (PHOTOELECTRIC EFFECT OCCURS)
frequency of light

$f = f_0$ (METAL WILL BECOME HOT)

f_0 : Threshold frequency → The minimum frequency of light needed to emit electrons from a certain metal surface.
(minimum frequency of incident radiation at which electrons will be emitted from a particular metal).

* W_0 : Work function → The minimum energy that an electron in the metal needs to be emitted from the metal surface.
material specific

Formulae ♥♥♥		
$E = W_0 + E_{kmax}$	$E = hf = \Delta E$	$f_0 = \frac{c}{\lambda}$
$\frac{hc}{\lambda} = hf_0 + \frac{1}{2}mv^2$	$E = \frac{hc}{\lambda} = \Delta E$	$f_0 = \frac{1}{\lambda}(c)$
$hf = hf_0 + \frac{1}{2}mv^2$	$E_k = \frac{1}{2}mv^2$	$W_0 = hf_0$
$m_e = 9.11 \times 10^{-31} \text{ kg}$ $c = 3.0 \times 10^8 \text{ m.s}^{-1}$ $h = 6.63 \times 10^{-34} \text{ J.s}$		



(W_0) material specific

Described: metal specific

Energy of light $E = W_0 + E_k$
electrons are emitted

$$E_k = \frac{1}{2}mv^2$$

Increase INTENSITY at constant frequency = Increase AMOUNT of emitted electrons
Increase FREQUENCY at constant intensity = Increase KINETIC ENERGY of emitted electrons.

↑ Intensity ↑ amount of electrons

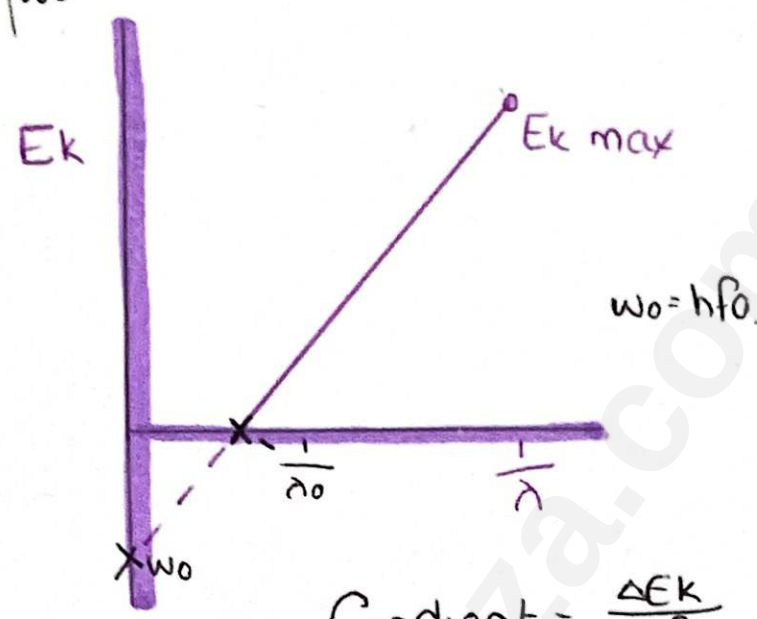
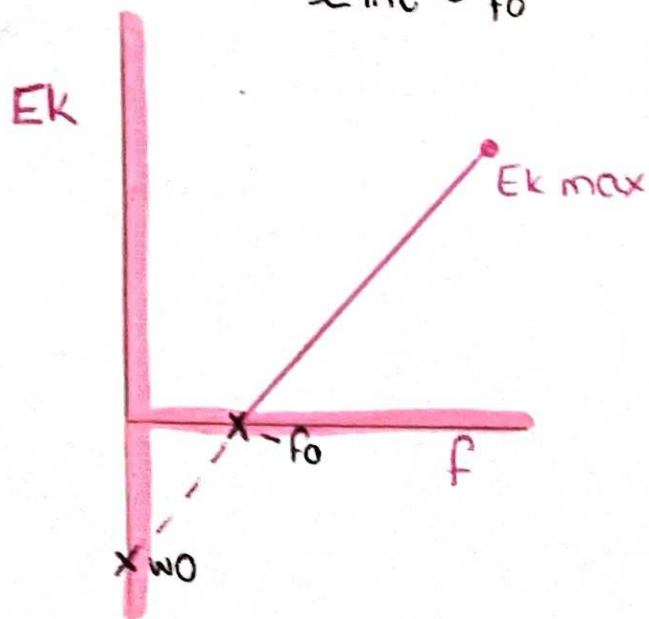
↑ Frequency ↑ E_k

$$f > f_0$$

$$E > W_0$$

Downloaded from eduresourceza.com

$$x \text{ int} = f_0 \quad y \text{ int} = w_0$$



Applications:

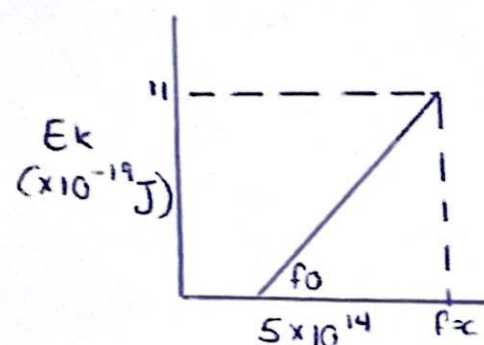
- Solar powered calculators
- light in camera meters

The photoelectric effect demonstrates the particle nature of light

$$\text{Gradient} = \frac{\Delta E_k}{\Delta f} = \frac{J}{Hz} = \frac{J}{s^{-1}} = Js$$

EXAM

In an experiment:



1) What does f_0 represent?

Threshold frequency

2) Calculate w_0 (work function) using above information

$$f_0 = \frac{c}{\lambda_0} = \frac{3 \times 10^8}{5 \times 10^{-14}} = 6 \times 10^{14} \text{ Hz}$$

$$w_0 = hf_0 = (6.63 \times 10^{-34})(6 \times 10^{14}) = 3.98 \times 10^{-19} \text{ J}$$

3) Calculate $f(x)$

$$hf = w_0 + E_k$$

$$6.63 \times 10^{-34} \cdot f = 3.98 \times 10^{-19} + 11 \times 10^{-19}$$

$$\therefore f =$$

ROYGBIV

Visible light in order of decreasing wavelength / increasing frequency.

RMIVUXG

(UWUW mnemonic)

EM radiation in order of decreasing wavelength / increasing frequency

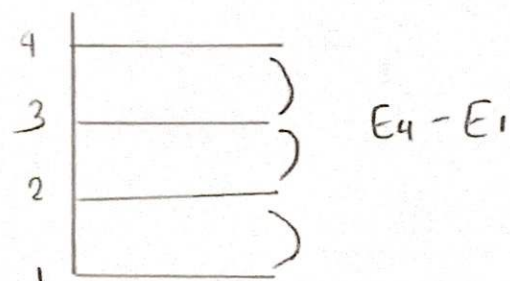
Atomic absorption spectrum: formed when certain frequencies of electromagnetic radiation that passes through a medium

e.g. cold gas - is absorbed

electrons make a transition from a low energy level to a high energy level.

Atomic emission spectrum: formed when certain frequencies of electromagnetic radiation are emitted due to an atom's electrons making a transition from a high energy state to a lower energy state.

3 photons = 3 jumps



WORK: the product of the magnitude of the force, the magnitude of the displacement & the $\angle$ between the force & the displacement.
Product of the displacement & the component of the force // to the displacement.

$$W = F \Delta x \cos \theta$$

θ in direction of motion $\cos 0 = 1$

NO WORK IS DONE IF $\angle$ object does not move
force is at right $\angle$ to displacement.

POWER: the rate at which work is done

$$P = \frac{W}{\Delta t} \quad (\text{power in watts/W})$$

$$P = \frac{E}{t}$$

$P_{avg} = F v_{avg}$ (use constant velocity/average only)

$$P = F v$$

$$P = F \frac{\Delta x}{t}$$

WORK-ENERGY THEOREM: the work done by a net force on an object is equal to the change in the object's kinetic energy

$$W_{net} = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$W_{net} = \Delta E_K = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$W_{nc} = \Delta K + \Delta U = (\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2) + (mgh_f - mgh_i)$$

• Constant velocity
 $\rightarrow f_{net} = 0$
 $\rightarrow \Delta E_K = 0$
 $\rightarrow W_{net} = 0$
 $\rightarrow \Delta K = 0$

• If friction is the only non-conservative force, then
 $W_{fr} = \Delta K + \Delta U$
 a law of E_K is generated heat energy.

• 2 non conservative forces such as friction & f_{app} are present
 $W_{fr} + W_{fapp} = \Delta K + \Delta U$

WORK, ENERGY & POWER

Kinetic energy: energy due to motion of an object

Gravitational potential energy: energy due to an object's height above the ground.

Conservation of MECH: the total mechanical energy in an isolated system remains constant.

• $E_{mech A} = E_{mech B}$ (when there is a height difference).

$E_{pa} + E_{ka} = E_{pb} + E_{kb}$

$$mgh + \frac{1}{2} m v^2 = mgh + \frac{1}{2} m v^2$$

• $E_{p \text{ before}} = E_{p \text{ after}}$ (no height difference)

Friction

$E_{p \text{ before}} = E_{p \text{ after}}$

Straight or

$E_{mech T} = E_{mech B}$ Height difference

Straight:

$$W_{net} = \Delta K$$

Inclined

$$W_{fr} = mg \sin \alpha$$

$$W_{fr} = mg \cos \alpha$$

NON-CONSERVATIVE FORCE: a force for which the work done in moving an object between 2 points depends on the path taken.
 eg: frictional force, air resistance, chord, tension in a chord.

CONSERVATIVE FORCE: a force for which the work done in moving an object between 2 points is independent of the path taken.
 eg: gravitational force, elastic force in a spring & electrostatic forces, coulombs forces.

Vertical Projectile Motion (VPM)

Equations of motion

$$v_f = v_i + a \Delta t$$

$$v_f^2 = v_i^2 + 2a \Delta x$$

$$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Delta x = \left(\frac{v_i + v_f}{2} \right) \Delta t$$

↳ a **projectile** is an object in free fall (no forces except F_g (force of gravity))

1-D MOTION = linear motion = motion in one line

Acceleration: rate of change of velocity $\frac{\Delta v}{\Delta t}$ (m.s^{-2}) 9.8 m.s^{-2} down

Gravitational acceleration: acceleration of a body due to the force of attraction of the earth

*MOTION DEPENDS ON INITIAL VELOCITY & NOT HEIGHT OF BUILDING

STEPS

① Draw & choose **scenario**

② Choose direction +up: $g = -9.8$
+down: $g = 9.8$

③ Read with **B** words:

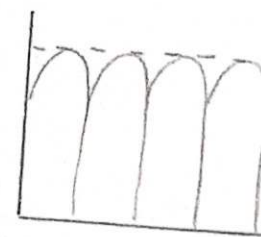
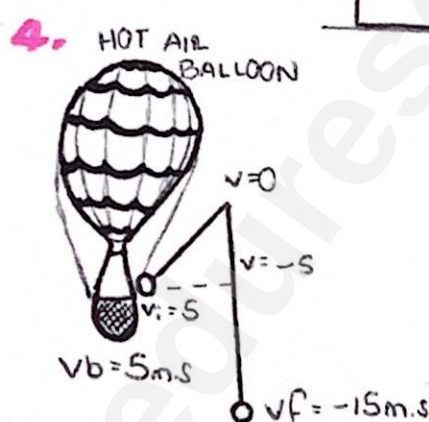
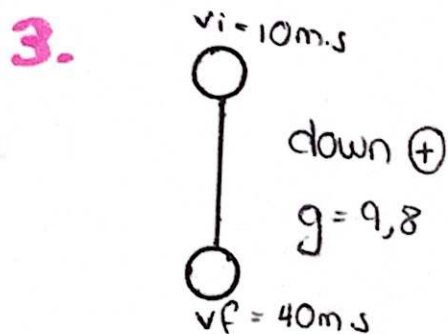
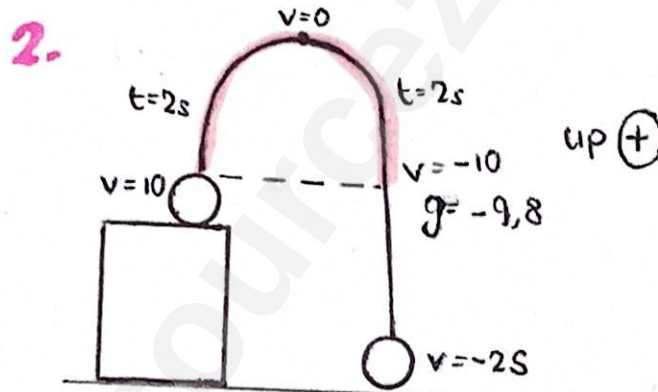
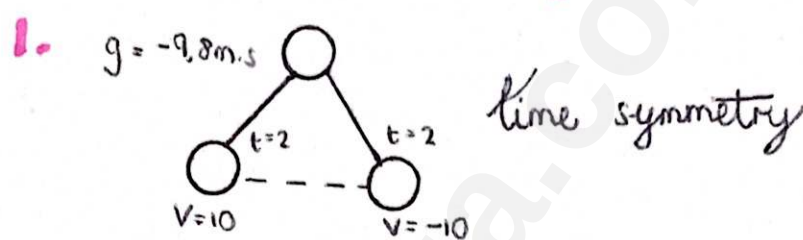
- ↳ Dropped: $v_i = 0$ (exception: takes v of balloon moving object)
- ↳ Rest / stop: $v_f = 0$
- ↳ constant velocity: $a = 0$
- ↳ released: $v_i = 0$
- ↳ throw: $v_i \neq 0$
- ↳ constant a : $g = 9.8 \text{ m.s}^{-2}$

④ Select equations

⑤ Put direction in answer

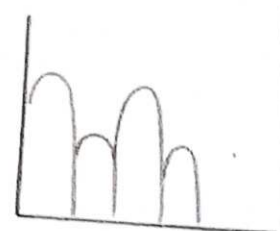
Scenarios:

- goes up: v - smaller
- goes down: v - bigger



elastic

* dotted line drop



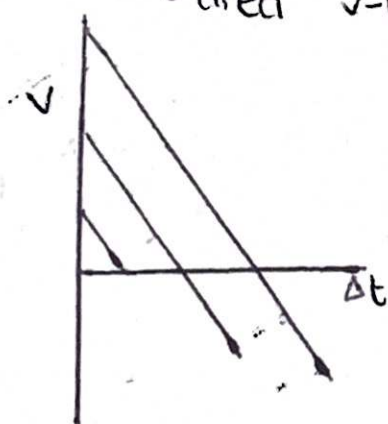
inelastic
line indicates another

VPM GRAPHS:

- if up is (+), start from y-axis
- ALWAYS do a drawing.

Velocity Vs Time Graph:

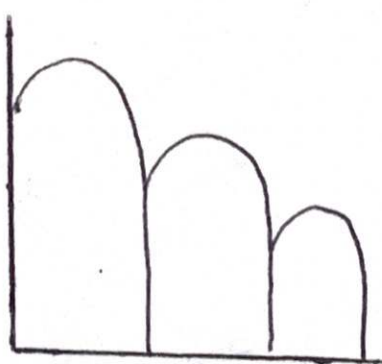
- gradient $v-t = a$
- area $v-t = \Delta y$



Slanted lines

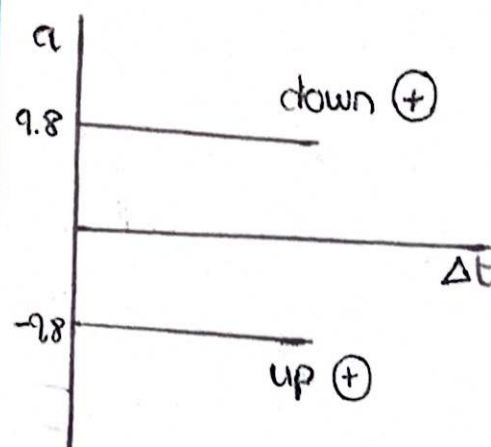
Displacement Vs Time:

- Same as drawing



Curves

Acceleration Vs Time



ELECTRODYNAMICS

Motor

- BATTERY
- Electrical → mechanical
- ♥ Principle: motor effect

Left

Generator

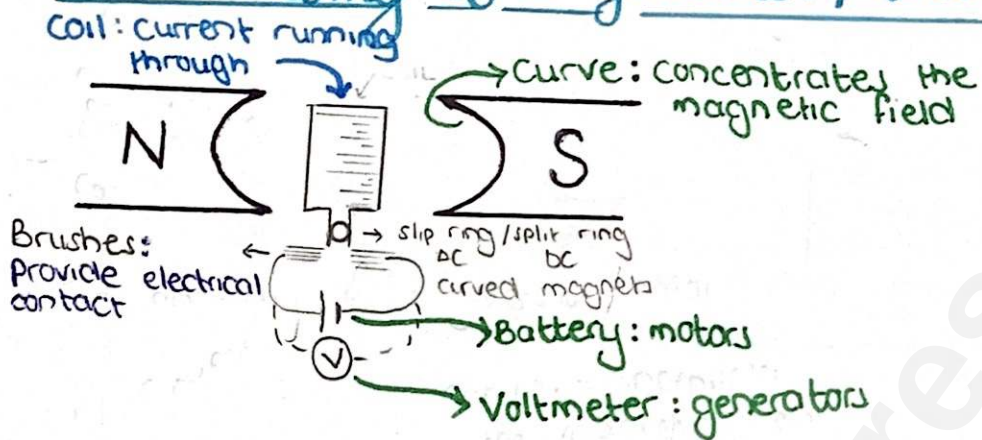
- NO BATTERY (bulb, galvanometer, ammeter, voltmeter)
- Mechanical → Electrical
- ♥ Principle: Law of electromagnetic induction

Right hand

$\mathcal{E} = \frac{-N \Delta \Phi}{\Delta t}$	$\cos 0^\circ = 1$
$\Phi = BA \cos \theta$	$\cos 90^\circ = 0$
$\mathcal{E} \propto I$	$\cos 180^\circ = -1$
	$\cos 270^\circ = 0$

*Voltage & current graph is the same
Induced emf drives current through a conductor, such that the EMF & current are in phase
∴ graphs are the same

The anatomy of a generator/motor



Formulae:

Average = $\frac{1}{2} P_{\max}$
$V_{\text{rms}} = \frac{V_{\max}}{\sqrt{2}}$
$I_{\text{rms}} = \frac{I_{\max}}{\sqrt{2}}$
Average = $V_{\text{rms}} \times I_{\text{rms}}$
$P_{\max} = V_{\max} \times I_{\max}$
Average = $\frac{V^2_{\text{rms}}}{R}$
Average = $\frac{W}{\Delta t}$
$W = \frac{V^2_{\text{rms}}}{R} \times \Delta t$

Household appliances:

Average / V_{rms} / I_{rms}

Power station:

$P_{\max}$ / $V_{\max}$ / $I_{\max}$

* $V_{\max}/I_{\max}$ is the highest point on the graph irrespective of type

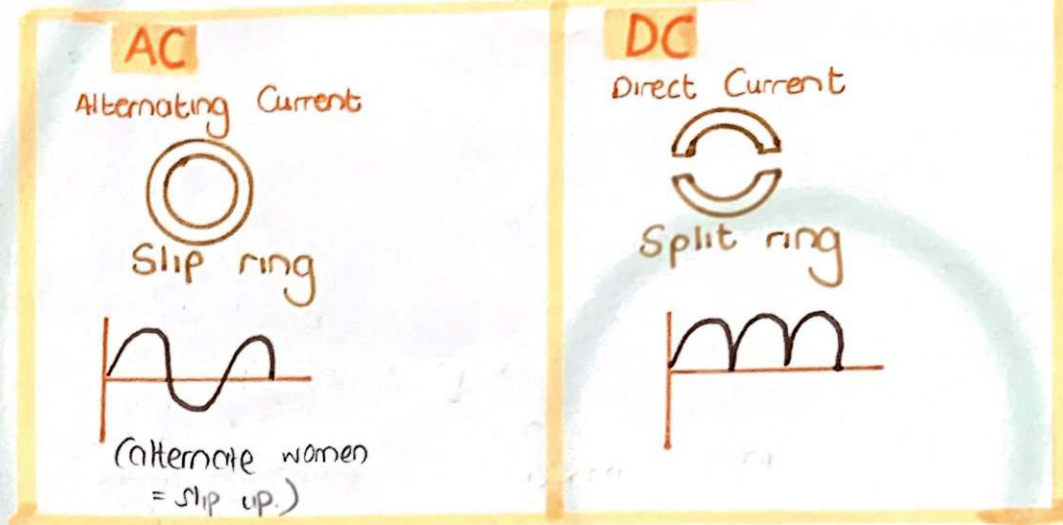
Thumb - movement (up or down)

1st (index) - field (N → S)

2nd - Current

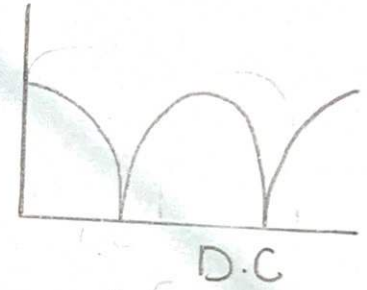
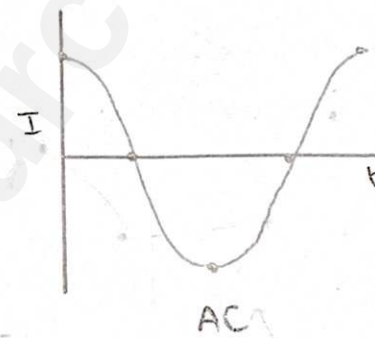
RHR
generators

LHR
Motors

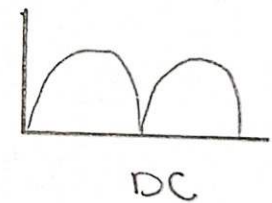
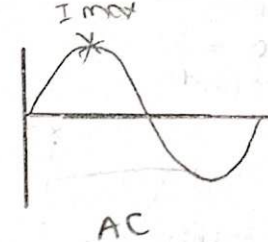


speed $f = \frac{1}{t}$ (eg. double speed, half time)
frequency is time for one egg.
eg. If 100 rotations take 1s. How long does 1 rotation take?
 $100:1 \rightarrow x = \frac{1}{100}$
 $x = 0.01$

Graph starting from 0 or horizontal



Graph starting from 90° or vertical



DC → car alternators ; fans

AC → Electricity generator

Advantages of AC over DC

- AC can be stepped up or down
- Easier to generate
- Can be transmitted at high voltages & low currents over long distances