Formula Sheet of PHYSICS

Chapter – 1: Motion

1. Formula of Speed: -

$$\boldsymbol{Speed = \frac{Distance\ travelled}{Time\ taken}}$$

- The S.I unit of speed is ***meters per second*** or $\frac{m}{s}$ or ms^{-1}.
- The smaller speed values are ***centimeters per second***, or $\frac{cm}{s}$ or cm^{-1}.
- The higher speeds values, the unit of ***kilometers per hour*** or $\frac{km}{h}$ or kmh^{-1}.
- Speed is a scalar quantity.
- If a body travels a distance '*s*' in time '*t*', its speed v is:

$$\boldsymbol{v = \frac{s}{t}}$$

where,

$v = speed$

$s = distance\ travelled$

$t = time\ taken\ (to\ travel\ that\ distance)$

2. Formula of Average Speed: -

$$\boldsymbol{Average\ speed = \frac{Total\ distance\ travelled}{Total\ time\ taken}}$$

3. Formula of Velocity: -

$$\boldsymbol{Velocity = \frac{Distance}{Time\ taken}}$$

- The S.I unit of velocity = speed, meters per second ms^{-1}, smaller values of velocities unit is cm^{-1}, and for bigger values unit is $km\ h^{-1}$.

- Velocity is a vector quantity.

4. Formula of Acceleration: -

$$\boldsymbol{Acceleration = \frac{Final\ velocity - Initial\ velocity}{Time\ taken}}$$

- The S.I unit of acceleration is "meters per second per second" or "meters per second square" or $\frac{m}{s^2}$ ms^{-2}.

- The units of acceleration are "centimeters per second square" (cm^{-2}) and "kilometers per hour square" ($km\ h^{-2}$).

- The initial velocity of a body is u and it changes to a final velocity v in time t, then:

v = u + at

Where,

$a = acceleration\ of\ the\ body$

$v = final\ velocity\ of\ the\ body$

$u = initial\ velocity\ of\ the\ body$

$t = time\ taken\ for\ the\ change\ in\ the\ velocity$

5. Formula of Average Velocity: -

$$\boldsymbol{Average\ velocity = \frac{Initial\ velocity + Final\ velocity}{2}}$$

Or,

$$\boxed{\bar{v} = \frac{u+v}{2}}$$

where,

$\bar{v}$ *denotes the average velocity*

u *is the initial velocity*

v *is the final velocity*

6. Equations of Uniformly Accelerated Motion: -

i. **First equation of motion:** It gives the velocity acquired by a body in time t.

$$\boxed{v = u + at}$$

$v =$ *final velocity of the body*

$u =$ *initial velocity of the body*

$a =$ *acceleration*

$t =$ *time taken*

ii. **Second equation of motion:** It gives the distance travelled by a body in time t.

$$\boxed{s = ut + \frac{1}{2}at^2}$$

$s =$ *distance travelled by the body in time t*

$u =$ *initial velocity of the body*

$a =$ *acceleration*

iii. **Third equation of motion:** It gives the velocity acquired by a body in travelling a distance.

$$\boxed{v^2 = u^2 + 2as}$$

$v = final\ velocity$

$u = initial\ velocity$

$a = acceleration$

$s = distance\ travelled$

Chapter – 2: Force and Laws of Motion

1. Formula of Momentum: -

$$\boxed{\boldsymbol{Momentum = mass \times velocity}}$$

Mathematically, $$\boxed{\boldsymbol{p = m \times v}}$$

$$p = momentum$$

$$m = mass\ of\ the\ body$$

$$v = velocity\ (or\ speed) of\ the\ body$$

2. Equation of Newton's Second Law of Motion: -

$$\boxed{\boldsymbol{Force \propto \frac{Change\ in\ momentum}{Time\ taken}}}$$

The body of mass m having an initial velocity u and final velocity as v.

Force F acts on the body for time t. So:

i. Initial momentum of this body = mu.
ii. Final momentum of this body = mv.

So, The Newton's second law of motion becomes –

$$F \propto \frac{mu - mv}{t}$$

Or, $$F \propto \frac{m(u-v)}{t}$$

But, $\frac{v-u}{t}$ is changes in velocity with time, which is acceleration 'a'.

$$F \propto m \times a$$

Or, $$F = k \times m \times a$$ k is constant

The value of constant k in S.I unit is 1, so the equation is:

$$\boxed{\boldsymbol{F = m \times a}}$$

$$\boxed{\boldsymbol{Force = mass \times acceleration}}$$

The S.I unit of force is Newton, denoted by N.

A newton is a force which when acting on a body of mass 1 kg produces an acceleration of $1m/s^2$ in it.

Newtons Second law of motion:

$$\boxed{\boldsymbol{F = m \times a}}$$

$m = 1\,kg$ and $a = 1\,m/s^2$, so 1 newton.

$$\boxed{\boldsymbol{1\,newton = 1\,kg \times 1\,m/s^2}}$$

3. Formula of Conservation of Momentum: -

$$\boxed{\boldsymbol{m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2}}$$

$m_1 = mass\ of\ object\ 1$
$m_2 = mass\ of\ object\ 2$
$u_1 = initial\ velocity\ of\ object\ 1$
$u_2 = initial\ velocity\ of\ object\ 2$
$v_1 = final\ velocity\ of\ object\ 1$
$v_2 = final\ velocity\ of\ object\ 2$

Chapter – 3: Gravitation

1. Universal Law of Gravitation: -

i. Force between two bodies is directly proportional to the product of their masses.

$$\boxed{\boldsymbol{F \propto m_1 \times m_2}} \qquad \text{- - - - 1}$$

ii. Force between two bodies is inversely proportional to the square of the distance between them.

$$F \alpha \frac{1}{r2} \qquad \text{- - - 2}$$

Combining equation (1) and (2):

$$F \ \alpha \ \frac{m_1 \times m_2}{r^2}$$

$$\boxed{\boldsymbol{F = G \times \frac{m_1 \times m_2}{r^2}}}$$

G = Universal Gravitational Constant

2. S.I unit of Gravitational Constant, G:

- The unit of force F = Newton (N).
- The unit of distance r = meter (m).
- The unit of masses m_1 and m_2 = kilogram (kg).

$$\boxed{\boldsymbol{G = F \times \frac{r^2}{m_1 \times m_2}}}$$

- So, the S.I unit of gravitational constant G, so equation is:

$$\boxed{\boldsymbol{\frac{newton\,(meter)^2}{(kilogram)^2}}}$$

$$\boxed{\boldsymbol{Nm^2/kg^2}}$$

$$\boxed{\boldsymbol{Nm^2kg^{-2}}}$$

3. The value of Gravitational Constant, G is $\boxed{\mathbf{6.67 \times 10^{-11}\, Nm^2}}$

4. Formula of Kepler's Third Law: -

- The cube of the mean distance of a planet of a planet from the sun is directly proportional to the square of time it takes to move around the sun.

$$\boxed{\boldsymbol{r^3 \propto T^2}}$$

$$\boxed{\boldsymbol{T^2 = constant \times T^2}}$$

$$\boxed{\boldsymbol{\frac{r^3}{T^2} = constant}}$$

$r = mean\ distance\ of\ planet\ from\ the\ sun$

$T = time\ period\ of\ the\ planet\ (around\ the\ sun)$

5. Acceleration due to gravity, $\boxed{\boldsymbol{g = G \times \frac{M}{R^2}}}$

$G = gravitational\ constant$
$M = mass\ of\ the\ earth$
$R = radius\ of\ the\ earth$

$$\boxed{\boldsymbol{g = 9.8\, m/s^2}}$$

6. Radius of Earth, $\boxed{\boldsymbol{R = 6.4 \times 10^6\, kg}}$

7. Mass of Earth, $\boxed{\boldsymbol{M = 6 \times 10^{24}\, kg}}$

8. Equations of motions for freely falling bodies: -

S/No.	**General equations of motion**		**Equations of motion for freely falling bodies**
i.	$\boldsymbol{v = u + at}$	Changes to	$\boldsymbol{v = u + gt}$

ii.	$s = ut + \frac{1}{2}at^2$	Changes to	$h = ut + \frac{1}{2}gt^2$
iii.	$v^2 = u^2 + 2as$	Changes to	$v^2 = u^2 + 2gh$

9. When a body is falling vertically downwards, its velocity is increasing, so the acceleration due to gravity, g, is taken as positive.

$$\boxed{\text{Acceleration due to gravity} = +9.8\ m/s^2}$$

10. When a body is thrown vertically upwards, its velocity is decreasing, so the acceleration due to gravity, g, is taken as negative.

$$\boxed{\text{Acceleration due to gravity} = -9.8\ m/s^2}$$

11. Formula of Weight: -

Downward force acting on a body of mass ‘m’ is given by:

$$\boxed{\textbf{Force} = \textbf{mass} \times \textbf{acceleration due to gravity}}$$

$$\boxed{\textbf{Force} = m \times g}$$

The force of attraction of earth on a body is known as Weight W in place of force in the above equation:

$$\boxed{W = m \times g}$$

$$m = \text{mass of the body}$$

$$g = \text{acceleration due to gravity}$$

12. The weight of $1\ kilogram\ mass$ is $9.8\ newtons$.

13. Formula of Pressure: -

- Pressure is the force acting perpendicular on a unit area of the object.

$$\boxed{\textbf{Pressure} = \frac{\textbf{Force}}{\textbf{Area}}}$$

- The S.I unit of pressure is 'newton per square meter' (N/m^2 or Nm^{-2}), which is also called as Pascal (Pa).

$$1\ Pascal = 1\ newton\ per\ square\ meter$$
$$\mathbf{1\ Pa = 1\ N/m^2}$$

- The force acting on a body perpendicular to its surface is called thrust, or, thrust is the total force acting on the surface of a body. So, the pressure is defined as the thrust per unit area.

$$\boldsymbol{Pressure = \frac{Thrust}{Area}}$$

14. Archimedes' Principle: -

$$\boxed{\boldsymbol{Buoyant\ force\ (or\ Upthrust)\ acting\ on\ an\ object}} = \boxed{\boldsymbol{Weight\ of\ liquid\ displaced\ by\ that\ object}}$$

15. Formula of Density: -

- Density of a substance is defined as mass of the substance per unit volume.

$$\boldsymbol{Density = \frac{Mass\ of\ the\ substance}{Volume\ of\ the\ substance}}$$

Or,

$$\boldsymbol{Density = \frac{Mass}{Volume}}$$

- The S.I unit of mass = $kilogram\ (kg)$.
- The S.I unit of volume =$cubic\ meter\ (m^3)$.
- The S.I unit of density ='$kilogram\ per\ cubic\ meter'$ (kg/m^3 or kgm^{-3}).

Densities of some common substances in S.I units

S/No.	Substances	Density	Density can also be written as
1.	Cork	$240\ kg/m^3$	$0.24 \times 10^3\ kg/m^3$
2.	Wood	$800\ kg/m^3$	$0.8 \times 10^3\ kg/m^3$
3.	Ice	$920\ kg/m^3$	$0.92 \times 10^3\ kg/m^3$
4.	Water	$1000\ kg/m^3$	$1.0 \times 10^3\ kg/m^3$

5.	Glycerine	$1260 \quad kg/m^3$	$1.26 \times 10^3 \; kg/m^3$
6.	Glass	$2500 \quad kg/m^3$	$2.5 \times 10^3 \; kg/m^3$
7.	Aluminium	$2700 \quad kg/m^3$	$2.7 \times 10^3 \; kg/m^3$
8.	Iron	$7800 \quad kg/m^3$	$7.8 \times 10^3 \; kg/m^3$
9.	Mercury	$13600 \; kg/m^3$	$13.6 \times 10^3 \; kg/m^3$
10.	Gold	$19300 \; kg/m^3$	$19.3 \times 10^3 \; kg/m^3$

- The S.I unit of smaller unit of density = ‘$grams\ per\ cubic\ centimeter$’ $g/cm^3\ or\ g\ cm^{-3}$.
- When mass of substance is taken in $grams\ (g)$, its volume is taken as ‘$cubic\ centimeters\ (cm^3)$’

Densities of some common substances in common units in ***$cubic\ centimeters\ (cm^3)$***

S/No.	Substance	Density
1.	Cork	$0.24 \quad g/cm^3$
2.	Wood	$0.8 \quad g/cm^3$
3.	Ice	$0.92 \quad g/cm^3$
4.	Water	$1.0 \quad g/cm^3$
5.	Glycerine	$1.26 \; g/cm^3$
6.	Glass	$2.5 \quad g/cm^3$
7.	Aluminium	$2.7 \quad g/cm^3$
8.	Iron	$7.8 \quad g/cm^3$
9.	Mercury	$13.6 \quad g/cm^3$
10.	Gold	$19.3 \; g/cm^3$

16. Formula of Density: -

- The relative density of a substance = the ratio of its density to that of water.

$$\boldsymbol{Relative\ density\ of\ a\ susbstance} = \frac{\boldsymbol{Density\ of\ the\ substance}}{\boldsymbol{Density\ of\ water}}$$

Relative Densities of some common substances

S/No.	Substance	Relative density
1.	Cork	0.24
2.	Wood	0.8
3.	Ice	0.92

4.	Water	1
5.	Glycerine	1.26
6.	Glass	2.5
7.	Aluminium	2.7
8.	Iron	7.8
9.	Mercury	13.6
10.	Gold	19.3

Chapter – 4: Work and Energy

1. **Formula of Work: -**

$$\boxed{\boldsymbol{Work = Force \times Displacement}}$$

$$\boxed{\boldsymbol{W = F \times s}}$$

- The S.I unit of Work is '$Joule$'.
- When a force of one newton moves a body through a distance of one metre, then the work done is known as 1 joule.

$$\boldsymbol{1\, joule = 1\, newton \times 1\, metre}$$

$$\boldsymbol{1\, J = 1\, Nm}$$

2. **Work done against gravity: -**

$$\boxed{\boldsymbol{Work\ done\ in\ lifting\ a\ body = Weight\ of\ body \times Vertical\ distance}}$$

$$\boxed{\boldsymbol{W = m \times g \times h}}$$

$W = Work\ done$

$m = mass\ of\ the\ body$

$g = acceleration\ due\ tp\ gravity$

$h = height\ through\ which\ the\ body\ is\ lifted$

3. **Formula for Work done when a body moves at an angle to the direction of force: -**

$$\boxed{W = F\cos\theta \times s}$$

$F = force\ applied$

$\theta = angle\ between\ the\ direction\ of\ force\ and\ direction\ of\ motion$

$s = distance\ moved$

i. When the force acts at right angles to the direction of motion of a body, then the $angle\ \theta$ between the direction of motion and direction of force is 90^o. So, $\cos 90^o = 0$, so work done is equal to zero.

Work done, $W = F\ \cos 90^o\ \times s$

$= F\ \times 0\ \times s$ (Because $\cos 90^o = 0$)

$$\boxed{W = 0}$$

ii. When the force acts opposite to the direction of motion of a body, the $angle\ \theta$ between the direction of motion and the direction of force is 180^o. The force F acting in the direction of motion of the body becomes, $-F$ (minus F).

$$\boxed{Work\ done = -F\ \times s}$$

4. Formula of Kinetic Energy: -

- The kinetic energy of a moving body is measured by the amount of work it can do before coming to rest.

$$\boxed{Kinetic\ Energy = \frac{1}{2}\ mv^2}$$

$m = mass\ of\ the\ body$

$v = velocity\ of\ the\ body$

5. Formula of Potential Energy: -

- The potential energy of a body is equal to the work done on the body, against the gravity.

$$Work\ done = Force\ \times Displacement$$

So, $W = m\ \times g\ \times h$

- This work done is stored in the body as potential energy.

$$\boxed{Potential\ energy = m\ \times g\ \times h}$$

$m = mass\ of\ the\ body$
$g = acceleration\ due\ to\ gravity$
$h = height\ of\ the\ body\ above\ the\ surface\ of\ the\ earth/any\ refernce\ point$

6. Formula of Power: -

- Power is rate of doing work.

$$\boxed{P = \frac{Work\ done}{Time\ taken}}$$

$P = power$

$W = work\ done$

$t = time\ taken$

- When work is done, an equal amount of energy is consumed. So, power is defined as the rate at which energy is consumed.

$$\boxed{\boldsymbol{W.D = \frac{Energy\ consumed}{Time\ taken}}}$$

$P = power$

$E = Energy\ consumed$

$t = time\ taken$

- The S.I unit of power is Watt (W)
- One watt is the power of an appliance which consumes energy at the rate of one joule per second.

$$\boxed{\boldsymbol{1\ watt = \frac{1\ joule}{1\ second}}}$$

Or,

$$\boxed{\boldsymbol{1\ W = \frac{1\ J}{1\ s}}}$$

$$\boxed{1\ Watt = 1\ joule\ per\ second}$$

7. Watt is a small unit of power. Bigger units of power are Kilowatt (kW), Megawatt (MW) and horse power.

$$1\ kilowatt = 1000\ watts$$
$$1\ kW = 1000\ W$$

$$1\ Megawatt = 1000{,}000\ watts$$
$$1\ MW = 1000{,}000\ W$$
$$1\ MW = 10^6\ W$$

$$1\ horse\ power = 746\ watts$$

8. The commercial unit of energy is $kilowatt\ hour\ (kWh)$.

9. Relation between $\boldsymbol{kilowatt - hour\ and\ Joule}$: -

1 $kilowatt - hour$ is the amount of energy consumed at the rate of 1 $kilowatt$ for 1 $hour$.

1 $\boldsymbol{kilowatt - hour}$ = 1 $\boldsymbol{kilowatt}$ for 1 hour

1 $\boldsymbol{kilowatt - hour}$ = 1000 $\boldsymbol{watt}$ for 1 hour - - - - 1

But, $1\ watt = \frac{1\ joule}{1\ second}$

So, equation (1) becomes:

$$1\ kilowatt - hour = 1000\frac{joules}{seconds}\quad for\ 1\ hour$$

And, 1 hour $= 60\ \times 60\ seconds$

So, $$\boldsymbol{1\ kilowatt - hour = 1000\frac{joules}{seconds} \times 60\ \times 60\ seconds}$$

Or, $$\boldsymbol{1\ kilowatt - hour = 36{,}00{,}000\ joules}$$

$$\boldsymbol{1\ kilowatt - hour = 3.6\ \times\ 10^6\ J}$$

Chapter – 5: Sound

1. **Wavelength:**

- The minimum distance in which a sound wave repeats itself is called its wavelength.
- The wavelength is denoted by Greek letter, lambda, λ.
- The S.I unit for measuring wavelength is metre (m).

2. **Time-period:**

- The time required for one complete wave or cycle is called time-period of the wave.
- The time taken for one vibration is called time-period.
- The S.I unit of time-period is seconds (s).
- If two waves are produced in 1 second, then the time required to produce one wave is $\frac{1}{2}$ second or 0.5 second.

3. **Frequency:**

- The number of complete waves or cycles produced in one second is called frequency of the waves.
- The S.I unit of frequency is hertz (Hz).

$$\boxed{\mathbf{1\ Hz = 1\ vibration\ per\ second}}$$

- Frequency of a wave id the reciprocal of its time-period.

$$\boxed{\mathbf{Frequency = \frac{1}{Time\ period}}}$$

$$\boxed{\mathbf{f = \frac{1}{t}}}$$

$$f = frequency\ of\ the\ wave$$

$$T = time - period\ of\ the\ wave$$

4. **Relationship between velocity, frequency and wavelength of a wave: -**

$$Velocity = \frac{Distance\ travelled}{Time\ taken}$$

- If a wave travels a distance lambda, λ (which is its wavelength) in time T, then;

$$\boldsymbol{v = f \times \lambda}$$

$v = velocity\ of\ the\ wave$

$f = frequency$

$\lambda = wavelength$

5. Speed of sound in various materials (or Media): -

S/No.	Material (or Medium)	Speed of sound (or Velocity of sound)
1.	$Dry\ Air$ $(at\ 0^o\ C)$	$332\ m/s$
2.	$Dry\ Air$ $(at\ 20^o\ C)$	$344\ m/s$
3.	$Hydrogen$ $(at\ 0^o\ C)$	$1284\ m/s$
4.	$Water\ (Distilled)$ $(at\ 20^o\ C)$	$1498\ m/s$
5.	$Sea - Water$ $(at\ 0^o\ C)$	$1531\ m/s$
6.	$Blood$ $(at\ 37^o\ C)$	$1570\ m/s$
7.	$Copper$ $(at\ 20^o\ C)$	$3750\ m/s$
8.	$Aluminium$ $(at\ 20^o\ C)$	$5100\ m/s$
9.	$Iron\ (or\ Steel)$ $(at\ 20^o\ C)$	$5130\ m/s$
10.	$Glass$ $(at\ 20^o\ C)$	$5170\ m/s$