Class Notes

Class : IX	Topics: (Gravitation) Motion of objects under the influence of Gravitational Force of the Earth; Mass; Weight; Difference between Mass and Weight; Weight of an object on the surface of Moon
Subject: Physics	
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Motion of objects under the influence of Gravitational Force of the Earth:

We learnt the equations of motion in the first chapter, Motion. The criteria of the validity of these equations is that the *acceleration must be constant*.

In case of free fall we notice that the all bodies executing this type of motion moves with constant acceleration. So the same equations of motion will be applicable in case of free fall. In case of free fall, the motion is vertical by nature. There will be some changes in the general symbol in case of vertical motion. It can be understood from the following table very well.

Linear Motion	Vertical Motion (Free fall)
Initial velocity 'u'	No Change. It is 'u' only
Final velocity 'v'	No Change. It is 'v' only
Time 't'	No Change. It is 't' only
Acceleration 'a'	Symbol changes to 'g' (gravitational acceleration)
Displacement 's'	Symbol changes to 'h' (height)

General Equation of Motion	Equations of Motion for freely falling bodies
$v = u + at$	$v = u + gt$
$s = ut + \frac{1}{2}at^2$	$h = ut + \frac{1}{2}gt^2$
$v^2 = u^2 + 2as$	$v^2 = u^2 + 2gh$

For solving, the numerical problems, the following points should be remembered:

i). If the body is falling freely then initial velocity u = 0

ii). If the body is falling vertically downwards then its velocity increases so 'g' is positive i.e. g = + 9.8 m/s^2

iii). If the body is moving vertically upwards then velocity decreases so 'g' is negative i.e. g = - 9.8 m/s^2

iv). When a body is thrown vertically upwards, its final velocity v = 0

v). If a body is thrown vertically upwards then time to reach the highest point is equal to time to fall from the same height.

Mass:

Mass of a body is defined as the quantity of matter contained in the body. It is denoted by 'm'. S.I. unit of mass is kilogram (kg) and C.G.S. unit is gram.

Following are some important points:

i). Mass of a body can never be zero.
ii). Mass of a body is constant i.e. it remains the same at all places.
iii). Mass is a measure of inertia of the body, so mass is also known as inertia mass.
iv). Mass of a body is a scalar quantity i.e. it has no direction and can be added algebraically.
v). Mass of a body can be measured with the help of a beam balance.

Weight:

Weight of the body is defined as the force with which a body is attracted by the earth towards the centre of the earth. Weight of a body is denoted by W.

We know that,

$$F = ma$$

The acceleration produced by the gravitational force is the acceleration due to gravity g.

Thus the force on the body is given by $F = mg$

Therefore, the weight of the body is also $W = mg$

Weight is a vector quantity. Hence it has magnitude and direction.

S.I. unit of weight is same as that of the force i.e. Newton (N)

Some important points about weight of a body are as follows:

i) Weight of a body can be zero for example at the centre of the earth $g = 0$
$W = m \times 0 = 0$
ii) Since the value of 'g' changes from place to place, therefore the weight of the body is not constant i.e. it changes place to place.
iii) Weight of a body is a vector quantity i.e. it has magnitude and direction both.
iv) Weight of a body can be measured with the help of spring balance.
v) At a given place, 'g' is constant therefore, Weight $W \propto m$. Thus, weight is a measure of the mass of the body.

Difference between Mass and Weight:

Mass	Weight
1. Mass is the quantity of matter contained in the body	1. Weight is the gravitational force of earth acting on the body
2. It is the measure of inertia.	2. It is the measure of gravity.
3. Mass is a constant quantity.	3. Weight is not a constant.
4. Mass is a scalar quantity	4. Weight is a vector quantity.
5. Mass is measured by beam balance.	5. Weight is measured by spring balance.
6. Mass can never be zero.	6. Weight may be zero.
7. Its S.I. unit is kilogram (kg).	7. Its S.I. unit is Newton (N)

Weight of an object on the surface of Moon:

Consider a body of mass m on the surface of the earth. Let M_e be the mass of the earth and R_e be its radius.
Since, weight of a body is the force with which the earth attracts the body

$\therefore$ weight of the body on the earth's surface $W_e = \frac{GM_e m}{R_e^2}$ → i

and weight of the body on the moon is the force with which the moon attracts the body

$\therefore$ weight of the object on the moon $W_m = \frac{GM_m m}{R_m^2}$ → ii

where M_m be the mass of the moon and R_m be the radius of the moon.
Dividing equation (ii) by equation (i), we get

$$\frac{W_m}{W_e} = \frac{GM_m m}{R_m^2} \times \frac{R_e^2}{GM_e m}$$

or

$$\frac{W_m}{W_e} = \left(\frac{M_m}{M_e}\right) \times \left(\frac{R_e^2}{R_m^2}\right) \quad \text{→ iii}$$

Here,

M_e(mass of earth) $= 6\times10^{24}$ kg

M_m(mass of the moon) $= 7.4\times10^{22}$ kg

R_e(radius of earth) $= 6400$ km $= 6.4\times10^6$ m

R_m(radius of moon) $= 1740$ km $= 1.74\times10^6$ m

Put these values in equation (iii), we get

$$\frac{W_m}{W_e} = \frac{7.4\times10^{22}\times(6.4\times10^6)^2}{6\times10^{24}\times(1.74\times10^6)^2} = 0.1667 = \frac{1}{6}$$

or

$$W_m = \frac{1}{6}W_e \quad \text{→ iv}$$

Thus, weight of a body on the surface of moon $= \frac{1}{6}\times$ weight of the body on the surface of the earth.