HSPTA MALAPPURAM

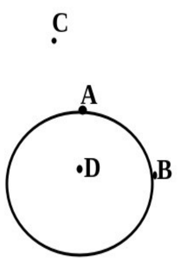
PHYSOL-*The Solution for Learning Physics*

Question Bank

CHAPTER 8- GRAVITATION

Each question scores One

1	The acceleration due to gravity-----------with increase of altitude. Ans: Decreases.
2	The acceleration due to gravity ----------with increase of depth. Ans: Decreases.
3	At the centre of earth , the acceleration due to gravity ,g= ------- Ans : Zero.
4	Three objects with a mass of 40 kg each are placed in a straight line 50 cm apart. What is the net gravitational force at the centre object due to the other two? Ans: Zero.
5	Acceleration due to gravity is independent of .... (Mass of earth / mass of body) Ans: Mass of body.
6	Write the relation between acceleration due to gravity and gravitational constant. Ans: $g=\frac{GM}{R^2}$
7	Define acceleration due to gravity Ans:The acceleration produced in a body due to force of gravity is called acceleration due to gravity and its value is 9.8 m/ s^2.
8	The value of acceleration due to gravity is maximum at the ------------------ i) Poles ii) equator iii) Centre of the earth (iv) None of these Ans: Poles
9	a) A ball bounces more on the surface of the moon than on the earth. Explain why. Ans: 1) small acceleration due to gravity at the surface of moon. 2) Zero air friction b) Acceleration due to gravity is independent of .... (mass of earth / mass of body) Ans: Mass of the body
10	Escape speed of an object from the earth.......Ans: 11.2 km/s
11	A rat and a horse are to be projected from earth into space. State whether the velocity is the same or different in projecting each animal. Justify. Ans: Yes. Escape velocity is independent of the mass of the body projected.
12	What will be the period of a simple pendulum, if this experiment is performed inside a satellite? Ans: we have, T = $2\pi\sqrt{\frac{l}{g}}$ In a satellite which is revolving around earth, g = 0. Therefore T = Infinity. That means, the simple pendulum will not oscillate at all.
13	Value of universal Gravitational constant is....... Ans. 6.67×10^{-11} Nm^2/kg^2

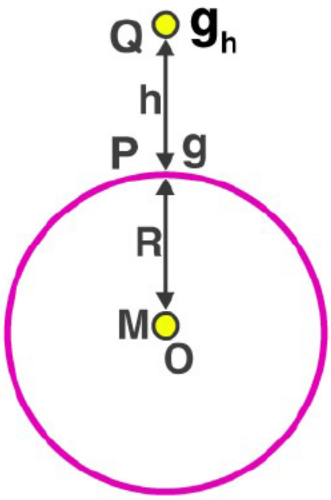
14	The gravitational force between two masses in air is F. If they are inside water of density 1000Kg/m^3at the same initial distance. The new gravitational force will be Ans: F
15	Dimensional formula of acceleration due to gravity is....... Ans. LT^{-2}
16	Variation of g with height is given by the equation...... Ans. g'= $\frac{gR^2}{(R+h)^2}$
17	Mass of earth is..... Ans. $6X10^{24}$ kg
18	Radius of earth is...... Ans. 6400km
19 a)	Volume of earth is.... Ans. $10^{21}m^3$
20	Density of earth is...... Ans. $6X10^3$ kg/m^3
21	Density of earth is given by the eqn.... Ans. $\frac{3g}{4\pi RG}$
22	Weight of a body of mass m, at tye centre of the earth is.... Ans:Zero
23	An object is placed at four different points A, B, C & D near the Surface of earth. which of the point, the object feel Maximum weight  Ans: A
24	Choose the correct alternative i.g increases / decreases with increase in the altitude Ans. g decreases ii.g independent of the mass of the earth / mass of the body. Ans. Mass of the body iii.g is maximum/ minimum at the poles. Ans. Maximum iv.g increases / decreases with increase in the depth Ans. g decreases

Each question scores Two

1 A ball bounces more on the surface of the moon than on the earth. Explain why.
Ans: Ball bounces more on the surface of the moon because acceleration due to gravity at the moon is 1/6 th that of the earth.

2 Derive an expression for variation of 'g' with height 'h' from the surface of earth.
Ans:

Let g--> acceleration due to gravity on the surface of earth.
g_h--> acceleration due to gravity at a height 'h'.
h--> height from the surface of earth.
R--> Radius of earth.
M--> Mass of earth.



We have $g=\frac{GM}{R^2}$ and $g_h=\frac{GM}{(R+h)^2}$

Therefore $g_h=\frac{GM}{R^2(1+\frac{h}{R})^2}=g(1+\frac{h}{R})^{-2}$

For $\frac{h}{R}$ << 1 , using binomial expression,

$$g_h=g[1-\frac{2h}{R}]$$

Thus the acceleration due to gravity decreases with height from the surface of earth.

3 How do you explain weightlessness in an artificial satellite?
Ans: Astronauts merely feel weightless because there is no external contact force pushing or pulling upon their body. They are in a state of free fall.

4 Can a person on the moon experience weight? Why?
Ans: Yes. Because there is a gravitational force of moon acting on the person. It is approximately 1/6 th of that due to earth. So the person experiences weight.

5 If you imagine the motion of a body from the centre of the earth to the surface of the moon, what change will you observe in the weight of the body during that motion? (Neglect the effect of all other objects).
Ans: At the centre of earth g=0, therefore the body feel weightlessness. As it moves to wards the surface 'g' increases and hence the weight. At the surface of earth 'g' is maximum and hence weight is maximum. As it goes from the surface of earth towards moon again 'g' decreases with height and hence weight decreases to a minimum.

6 Why does earth impart same acceleration on all bodies?

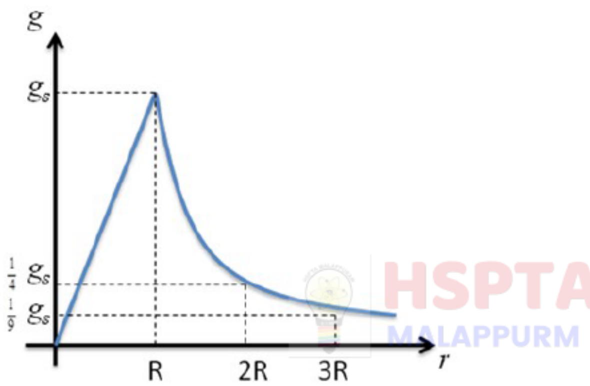
Ans: Acceleration due to gravity $g=\frac{GM_E}{R_E^2}$

Where G--> gravitational constant.
M_E --> mass of earth
R_E --> Radius of earth.

Here Acceleration due to gravity is independent of shape, size and mass of the body. Thus earth impart same acceleration on all bodies.

7 At what height 'h' the value of 'g' will be half of that on the surface of the earth? (Radius of earth is =6400km)

Ans: At a height 'h'

	$g_h = g\left[\frac{R}{R+h}\right]^2$ When $g_h = \frac{g}{2}$ $\frac{g}{2} = g\left[\frac{R}{R+h}\right]^2$ $\frac{1}{2} = \left[\frac{R}{R+h}\right]^2$ $\frac{1}{\sqrt{2}} = \frac{R}{R+h}$ $R+h = \sqrt{2}\,R$ $h = (\sqrt{2}-1)R$ Therefore $h = (1.44-1)\,x\,6400 = 2650\,km.$
8	Draw a graph showing the variation of ‘g’ with depth and height from the surface of the earth. Assume that the density of earth is constant. Ans: 
9	Imagine a point mass ‘m’ maintained at the centre of a shell of uniform density having mass ‘M’. If the radius of the shell is R, what will be the gravitational force exerted by the shell on the point mass? Explain Ans: Zero. As it is considered as the entire mass of the shell is concentrated at the centre of the shell.
10	a)The kinetic energy of a satellite revolving around earth is 200MJ. What is its potential energy? Ans: Potential energy of the satellite = - 400 M J b)How much energy is required for it to escape from the gravitational pull of earth? Ans:Minimum 200MJ energy (= T.E) is required to escape from the gravitational pull of earth.
11	Why G is called universal Gravitational constant? Ans:The gravitational force between two masses is independent of the medium in which masses are placed.
12	Mass and weight of an object on the surface of the Earth is 10kg and 98 N. What are the corresponding values when the object is placed on the surface of moon (given that acceleration due to gravity on the surface of moon is g/6) Ans:Mass on the surface of moon= 10kg weight = mg' = mg/6= 98/6

	= 16.33 N
13	Find the value of g at a height equal to Radius of earth? Ans. g' = $\frac{gR^2}{(R+h)^2}$ g'= $\frac{gR^2}{(R+R)^2}$ g'= $\frac{gR^2}{4R^2}$ g'= $\frac{g}{4}$
14	The tidal effect of moon's pull is greater than tidal effect of the sun although sun's pull is greater than moon's pull? Ans. The distance between moon and earth is very much less than distance between sun and earth. So the force due to moon is greater than that of sun.
15	Among the known types of forces in nature, gravitational force is weakest, then why it plays a dominant role for motion of bodies on the terrestrial, astronomical and cosmological scale. Ans. Gravitational force will be dominating when the masses are large. Here the bodies are lighter but mass of earth is large. Similar to that if planets are considered gravitational force have dominant role
16	Which is greater, the attraction of earth for 1 kg of iron or attraction of 1 kg irons for earth? Explain. Ans. Both forces are same. One is the action and the other one is the reaction. As per newton's third law action and reaction are equal and opposite. So they are same
17	No two bodies on earth move towards each other due to force of gravitational attraction between them. Why? Ans. Here the masses are lighter, so the gravitational force between them will be very small
18	When an apple falls towards the earth, the earth move up to meet apple. Is this true? If yes why earth's motion is not noticeable? Ans. No. F=ma. Here mass of earth is very large, so acceleration produced on earth will be infinitesimally small, so there is no noticable movement.
19	An aircraft is going from earth to moon how does its weight change as it goes from earth to moon? Will be there any change in mass? Ans. No. Mass is a constant. It will not change from place to place
20	Why one can jump higher on the surface of moon. than on earth? Ans. g on the surface of moon is 1/6 to the g of earth. So weight will be reduced. So we can jump more height on the surface of moon than on the earth
21	Explain why tennis ball bounces higher on hills than in plains? Ans. g at the top of hills should be small comparing to that at the surface. So weight will be less and it bounces more at the top of hills
22	Find the value of g of a planet having mass 4 times that of earth and radius double that of earth? $g=GM/R^2$ $g'= G4M/(2R)^2$ $g'= 4GM/4R^2$

g'= GM/R^2

g'=g

23 Find the value of g at a depth equal to 1/4 of radius of earth?

Ans. g'= $g(1-\frac{d}{R})$

g'= $g(1-\frac{R/4}{R})$

g'=g(1-1/4)

g'=3g/4

Each question scores Three

1 Acceleration due to gravity decreases with depth.

(a). Prove the above statement by deriving the proper equation.

(b). Using the equation, show that acceleration due to gravity is maximum at the surface and zero at the centre of the earth.

2 Ans: (a) Let g--> acceleration due to gravity on the surface of earth.

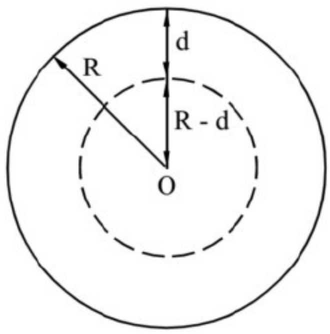
g_d--> acceleration due to gravity at a depth 'd'.

d--> depth from the surface of earth.

R--> Radius of earth.

M--> Mass of earth.

ρ-->density of earth.



We have $g=\frac{GM}{R^2}$

But mass $M=\frac{4}{3}\pi R^3 \rho$

Therefore $g=\frac{4}{3}\pi R \rho G$

Similarly $g_d=\frac{4}{3}\pi(R-d)\rho G$

Therefore $g_d=g[1-\frac{d}{R}]$

Thus the acceleration due to gravity decreases with depth from the surface of earth.

(b) At the surface of earth d=0, therefore acceleration due to gravity is maximum. At the centre of earth d=R, therefore acceleration due to gravity is equal to zero.

3 Find the height at which g become 1/3 of g at the surface?(Radius of earth is =6400km)

Ans.

g' = $\frac{gR^2}{(R+h)^2}$

$\frac{g}{3} = \frac{gR^2}{(R+h)^2}$

$(R+h)^2=3R^2$

R+h= $\sqrt{3}R$

h=($\sqrt{3}$ -1)R

h=(1.73-1)x6400Km

h=0.73x6400Km

h=4672Km

4 Find the height at which value of g at that point is equal to value of g at a depth 600Km from the surface?

Ans. At a height

g'= $g(1-\frac{2h}{R})$

At a depth g'= $g(1-\frac{d}{R})$

Both are equal.

$$g(1-\frac{2h}{R}) = g(1-\frac{d}{R})$$

$$(1-\frac{2h}{R}) = (1-\frac{d}{R})$$

2h=d

h=d/2

h=600/2=300Km

5 Find the percentage change in g at a height 3200 Km from the surface of earth? (Radius of earth is =6400km)

Ans:

g' = $\frac{gR^2}{(R+h)^2}$

g'= $\frac{gR^2}{(R+\frac{R}{2})^2}$

g'= $\frac{gR^2}{\frac{(9R^2)}{4}}$

g'=4g/9

Percentage change

=(g-g')*100/g

=5*100/9

=55%

Each question scores Four

1 The value of acceleration due to gravity (g) is same for all objects at a given place.

(a) Derive an equation for the acceleration due to gravity in terms of radius (R) and mass (M) of the earth.

(b)Arrive at mathematical expressions for variation of g below and above the surface of the earth.

Ans: (a)If the mass m is situated on the surface of earth, then

$$F=mg=\frac{GmM_E}{R_E^2}$$

Therefore

Acceleration due to gravity $g=\frac{GM_E}{R_E^2}$

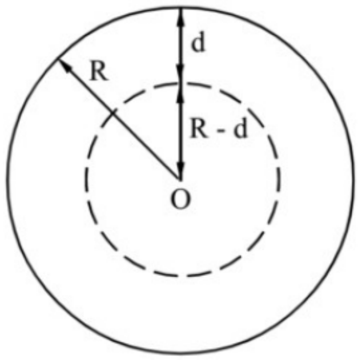
Where G--> gravitational constant.

M_E --> mass of earth

R_E --> Radius of earth.

(b)**Variation of acceleration due to gravity with depth from the surface of earth:**

Let g--> acceleration due to gravity on the surface of earth.
g_d--> acceleration due to gravity at a depth 'd'.
d--> depth from the surface of earth.
R--> Radius of earth.
M--> Mass of earth.
ρ-->density of earth.



We have $g=\frac{GM}{R^2}$

But mass $M=\frac{4}{3}\pi R^3\rho$

Therefore $g=\frac{4}{3}\pi R\rho G$

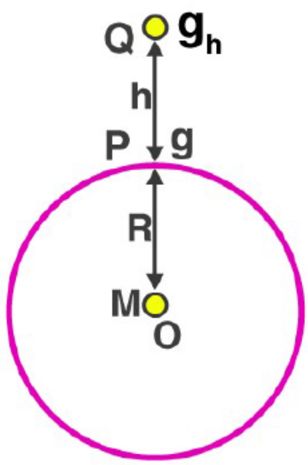
Similarly $g_d=\frac{4}{3}\pi(R-d)\rho G$

Therefore $g_d=g[1-\frac{d}{R}]$

Thus the acceleration due to gravity decreases with depth from the surface of earth.

Variation of acceleration due to gravity with altitude (height) from the surface of earth:

Let g--> acceleration due to gravity on the surface of earth.
g_h--> acceleration due to gravity at a height 'h'.
h--> height from the surface of earth.
R--> Radius of earth.
M--> Mass of earth.



We have $g=\frac{GM}{R^2}$ and $g_h=\frac{GM}{(R+h)^2}$

Therefore $g_h=\frac{GM}{R^2(1+\frac{h}{R})^2}=g(1+\frac{h}{R})^{-2}$

For $\frac{h}{R}$ << 1 , using binomial expression,

$g_h=g[1-\frac{2h}{R}]$

Thus the acceleration due to gravity decreases with height from the surface of earth.

2 Earth satellites are objects which revolve around the earth. Consider a satellite at a height 'h' from the surface of the earth (**Non Focus Area Topic**)
a) Give an equation for its orbital velocity. b) Obtain an equation for the period of the above satellite.

Ans:a) $v_0=\sqrt{\frac{GM}{R+h}}$

<u>b)Time period of satellite</u>

It is the time taken by the satellite to revolve once round the earth. If r is the radius of the orbit and v is the orbital velocity, time period, $T=\frac{2\pi r}{v_o}$ -------(1) But $v_o=\sqrt{\frac{GM}{r}}$ -------- (2)

Substituting eq (2) in eq (1) we get $T = \frac{2\pi r}{\sqrt{\frac{GM}{r}}} = 2\pi\sqrt{\frac{r^3}{GM}}$ -------- (3).

But r = R + h. Therefore $T = 2\pi\sqrt{\frac{(R+h)^3}{GM}}$ -------- (4).

c) The direction of revolution of geostationary satellite is from …………

i) east to west ii) west to east iii) north to south iv) south to north

Ans: west to east

3 Nowadays we are familiar with satellites. (**Non Focus Area Topic**)

a)Why does satellite need no fuel to go around a planet in its fixed orbit?

Ans: While a satellite is revolving around earth, the necessary centripetal force is provided by the gravitational force of attraction. No other force is required for the satellite to keep in orbital motion. That is why a satellite needs no fuel to go around a planet in its fixed orbit.

b) Obtain an equation for the orbital velocity of a satellite revolving around earth. Hence explain why the orbital velocity of a satellite is independent of mass of the satellite but depends on the mass of the planet.

Ans: Consider a satellite of mass m moving round in a closed orbit of radius r with orbital velocity v_o. Let M be the mass of earth and R its radius.

When the satellite is in stable orbit, the centripetal force is provided by the gravitational force.

That is $\frac{m v_0^2}{r} = \frac{GMm}{r^2}$ or $v_0 = \sqrt{\frac{GM}{r}}$ -------- (1)

If h is the height of the satellite above earth, r = R + h

$v_0 = \sqrt{\frac{GM}{R+h}}$ -------- (2) But $g = \frac{GM}{R^2}$ or $GM = gR^2$ -------- (3).

Substituting eq(3) in eq(2) we get $v_0 = \sqrt{\frac{gR^2}{R+h}}$ -------- (4)

According to the above equation the orbital velocity of a satellite is independent of mass of the satellite but depends on the mass of the planet.

c) The moon does not have an atmosphere around it. Give reason.

Ans: If gases molecules were present in moon, the rms velocity of the gas molecules would be greater than escape velocity on the surface of moon and hence all gases molecules were escaped out.

Each question scores Five

1 a) The minimum velocity with which a body is to be projected so that it never returns to earth is called the escape velocity. Arrive at an expression for escape velocity of earth.

Ans:

Let M be the mass of earth and R is its radius. Let v_e be the velocity of a body of mass m with which it is to be projected so that it escapes from the gravitational field of earth.

Kinetic energy near the surface of earth K.E= ½ m v_e^2

Potential energy of the body on the surface of earth , $P.E = \frac{-GMm}{R}$

Total energy of the body near the surface of earth,

$T.E = K.E + P.E = \frac{1}{2} m v_e^2 + \frac{-GMm}{R}$ -------- (1)

At infinity, K.E = P.E = 0. Therefore the total energy of the body at infinity = 0 -----(2)

According to the law of conservation of energy, the total energy near the surface of earth is equal to the total energy at infinity. That is $\frac{1}{2} m v_e^2 + \frac{-GMm}{R} = 0$

Or $\frac{1}{2} m v_e^2 = \frac{GMm}{R}$ or $v_e = \sqrt{\frac{2GM}{R}}$ -------- (3)

Put G M = g R^2 in eq (3) we get, $v_e = \sqrt{\frac{2gR^2}{R}} = \sqrt{2gR}$ ------ (4)

b) Explain whether escape velocity depends on mass of the body or not.

We have the escape velocity $v_e = \sqrt{\frac{2GM}{R}}$

According to this equation the orbital velocity is independent of the mass of the body.

c) Show how escape velocity and orbital velocity are related.

Ans: We have the orbital velocity for minimum orbit, $v_{01} = \sqrt{gR}$

Therefore, escape velocity $v_e = \sqrt{2gR} = \sqrt{2}\, v_{01}$

escape velocity $= \sqrt{2}$ orbital velocity for minimum orbit.

d) A satellite is revolving very close to earth. What is the percentage increase in velocity needed to make it escape from the gravitational field of the earth?

Ans: 41.4% Note: $\frac{\sqrt{2}v - v}{v} \times 100 = (1.414 - 1) \times 100 = 41.4\%$