CHAPTER 8

GRAVITATION

SOLUTIONS

TEXTUAL QUESTIONS AND ANSWERS
EXERCISES

Q1. In which manner the force of gravitation will change when

i) The distance between them is made double?
ii) The distance between them is reduced to half?

Ans: Gravitational force of attraction between two masses.

$$F = G\frac{Mm}{d^2}$$

i) When the distance between them is made double, the new force becomes

$$F_1 = G\frac{Mm}{(2d)^2}$$

$$= \frac{1}{4}G\frac{Mm}{(d)^2}$$

$$= \frac{1}{4}F$$

Hence, the force of attraction decreases by $\frac{1}{4}$ times the original force of attraction.

ii) When the distance between them is reduced to half , the new force becomes,

$$F_2 = \frac{GM_m}{\left(\frac{1}{2}d\right)^2}$$

$$= 4G\frac{M_m}{d^2} = 4F$$

Hence, the force of attraction increases 4 times the original force of attraction.

Q2. We know that the gravitational force acting on all objects is proportional to their masses. Why then a heavier object does not fall faster than a lighter object?

Ans: Because at the same place the acceleration due to gravity is the same for all bodies irrespective of their masses.

Q3. If each body in the universe attracts every other body, why don't two books kept on a table come towards each other and collide?

Ans: The force of attraction between the mass of the earth and a book is too large as compared to that of the books. Hence, two books kept on a table don't come towards each other and collide.

Q4. Distinguish between 'G' and 'g'.

Ans:

DIFFERENCES	
g	**G**
i) It is a vector quantity. ii) g is not a universal constant. iii) It is the acceleration acquired by a body due to earth's gravitational pull on it.	i) It is a scalar quantity. ii) G is a universal constant. iii) It is numerically equal to the force of attraction between two masses of 1 kg each separated by a distance of 1m.

Q5. Starting from Newton's law of gravitation, show that the value of 'g' decreases as one goes above the earth's surface.

Ans: From Newton's law of gravitation,

$$\mathbf{F = G\frac{Mm}{R^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Where M=mass of the earth
m= mass of the object
R=radius of the earth
G= universal gravitation constant.

And **F=mg ………………. (ii),** [Newton's II law of motion,]

From (i) & (ii), we get

$$\mathbf{mg = G\frac{Mm}{R^2}}$$

Therefore, $\mathbf{g = \frac{GM}{R^2}}$ ……………. **(iii)**

Now, the body is raised through a vertical height "h" above the surface of the earth. Then, the acceleration due to gravity is given by

$$\mathbf{mg' = \frac{GMm}{(R+h)^2}}$$

$$g' = \frac{GM}{(R+h)^2} \text{ .... (iv)}$$

Dividing (iv) by (iii), we get,

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

$$g' = g\left[\frac{R^2}{(R+h)^2}\right] \text{............................ (v)}$$

Hence, the value of 'g' decreases as one goes above the earth's surface.

Q6. We know that the earth and the moon are attracted to each other by gravitational force. Does the earth attract the moon with a force which is greater or smaller or the same as the force with which the moon attracts the earth? Give reason for your answer.

Ans: According to the universal law of gravitation, the earth attracts the moon. According to Newton's third law of motion, the moon also attracts the earth with an equal force or the same force in magnitude but opposite in direction.

Q7. From the universal law of gravitation, we have learnt that the moon attracts the earth, why does the earth not move towards the moon?

Ans: The earth has greater mass. So, the acceleration towards the moon is smaller. Hence, it does not move towards the moon.

Q8. What will happen to the force between two bodies, if

i) The mass of one of them is doubled?

ii) The distance between the bodies is doubled?

iii) The masses of both are doubled?

Ans: Let the masses of the two bodies A and B be M and m respectively and the distance between them be d.

The gravitational force of attraction between A and B is given by

$F = G\frac{M \times m}{d^2}$, where 'G' is the universal gravitational constant.

i) Suppose the mass of the body A is doubled
The new mass, M' = 2M
Therefore, the new force of attraction,

$$F' = G\frac{M'm}{d^2}$$

$$= G\frac{2Mxm}{d^2}$$

$$= 2G\ \frac{Mxm}{d^2}$$

= 2F

Hence, the force of attraction increases by 2 times the original force of attraction.

ii) Let the new distance between A and B be d',
d' = 2d
Therefore, the new force of attraction,

$$F' = G\ \frac{M \times m}{d'^2}$$

$$= G\ \frac{M \times m}{(2d)^2} \qquad = G\ \frac{M \times m}{4d^2} \qquad = \frac{1}{4}G\ \frac{M \times m}{d^2}$$

$$= \frac{1}{4} \times F$$

Hence, the force of attraction decreases by $\frac{1}{4}$ times the original force of attraction.

iii) Let the new masses of the body A and B be M' and m' respectively,
M' = 2 M and m' = 2m
Therefore, the new force of attraction,

$$F' = G\ \frac{M' \times m'}{d^2}$$

$$= G\ \frac{2M \times 2m}{d^2} \qquad = G\ \frac{4M \times m}{d^2} \qquad = 4G\ \frac{M \times m}{d^2}$$

= 4 F

Hence, the force of attraction increases by 4 times the original force of attraction.

Q9. What do you mean by the weight of a body? State its unit.

Ans: The force with which the earth attracts the body is called the weight of the body. Its unit is Newton (N).

Q10. Suggest two methods of comparing masses of two bodies A&B i.e. m_A and m_B

Ans: i) by using a common balance.

ii) By comparing their weights.

Q11. When you put an object on a spring balance, do you get the mass of the object or its weight?

Ans: We get the weight of the object.

Q12. A force of 20N acts on a body whose weight is 9.8N on the earth. What is the mass of the body and how much is its acceleration?

Ans: Here,

W = mg

9.8 = m × 9.8 [since g = 9.8 m/s^2].

Therefore, m = 1 kg.

When a force 20 N acts on a body of mass 1 kg,

acceleration, a $= \frac{F}{m} = \frac{20N}{1kg}$ = 20 m/s^2.

Q13. A stone is released from top of a roof whose height is 19.6m. Calculate its final velocity just before reaching ground.

Ans: Here,

u = 0, stone is at rest

h=19.6m; g=9.8m/s^2

v=?

Using the relation, we have

$$v^2=u^2+2gh$$

$$v^2=0+2\times9.8\times19.6$$

$$v^2= (19.6)^2$$

Therefore, $v = \sqrt{(19.6)^2} = 19.6 m/s$.

Hence, the final velocity of the stone just before reaching the ground is 19.6m/s.

Q14. A ball which is thrown upwards vertically returns to the earth after 8s. Find

i) The initial velocity with which it is thrown up.

ii) The maximum height it reaches.

iii) Its position after 5 s.

Ans: Time to reach the maximum height,

$t = \frac{8}{2} = 4s$; $g = 9.8 m/s^2$

v=0 (at the maximum height)

i) Using the relation,

v=u-gt, for a ball thrown upwards

u = 9.8×4

Therefore u =39.2m/s

Thus, the velocity with which it was thrown up = 39.2m/s.

ii) Using the relation, we have

$$v^2 = u^2 - 2gh$$

$$\Rightarrow 0^2 = (39.2m/s)^2 - 2x9.8m/s^2\ x\ h$$

$$\Rightarrow -(39.2)^2 = -2\ x\ 9.8\ x\ h$$

$$\therefore h = \frac{-(39.2)^2}{-2\ x\ 9.8}$$

$$= \frac{39.2\ x\ 39.2}{19.6}$$

$$= 2\ x\ 39.2$$

$$= 78.4\ m$$

So, the maximum height it reaches is 78.4m.

iii) In 4s, the ball reaches the maximum height and in (5-4)s =1s, it falls from the top.

Distance covered in 1s from maximum height,

$h = \frac{1}{2}ut + gt^2 = \frac{1}{2} \times 9.8 \times 1^2$ [u =0]

= 4.9 m

The position of the ball after 5s = (78.4-4.9)m

= 73.5m

Q15. A stone is dropped from a height of 49m and simultaneously another ball is thrown upwards from the ground with a speed of 40m/s. When and where do the two stones meet?

Ans: Let x m be the position at a distance from the top where the two stones meet after time t.

Using the relation, we have

$$h = ut + \frac{1}{2}gt^2 \text{[for downward motion]}$$

$$x = 0 + \frac{1}{2} \times 9.8 \times t^2$$

$$x = 4.9t^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(i)$$

If the stone is thrown upward,

u = 40m/s, h = (49-x);g = -9.8m/s^2

From the relation, we have

$$h = ut + \frac{1}{2}gt^2$$

$$(49-x) = 40t - \frac{1}{2} \times 9.8 \times t^2$$

$$49 - 4.9t^2 = 40t - 4.9t^2 \quad [x = 4.9t^2]$$

40t = 49

t = 49/40s = 1.225s.

$$x = 4.9x\left(\frac{49}{40}\right)^2 = 7.35\text{m}$$

Hence, the two stones will meet at a height = (49-7.35) m.

= 41.6m, above the ground.

Q16. A particle is taken to a height R above the earth's surface where R is the radius of the earth. The acceleration due to gravity of the earth at that point is

A) 2.45m/s^2 B) 3.45m/s^2

C) 4.9m/s^2 D) 9.8m/s^2

Ans: (A) 2.45m/s^2

Q17. **Two bodies A and B of masses 1kg and 2kg respectively are dropped near the earth's surface. Let the acceleration of A and B be a_1 and b_1 respectively, then**

A) $\boldsymbol{a_1 > b_1}$ **B)** $\boldsymbol{a_1 < b_1}$ **C)** $\boldsymbol{a_1 \neq b_1}$

D) $\boldsymbol{a_1 = b_1}$

Ans: D) $a_1 = b_1$

Q18. **When a body is thrown up, the force of gravity is**

A) In the upward direction B) in the downward direction

C) Zero D) in the horizontal direction.

Ans: B) in the downward direction.

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