Gravitation

OBJECTIVE TYPE QUESTIONS

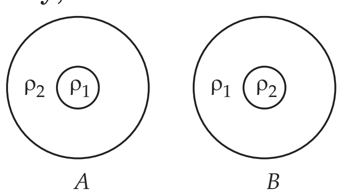
Multiple Choice Questions (MCQs)

1. When an object is thrown upward, the force of gravity is
(a) opposite to the direction of motion
(b) in the same direction as the direction of motion
(c) becomes zero at the highest point
(d) increases as it rises up.

2. The weight of a body of mass 5 kg is
(a) 69.0 N (b) 79.0 N (c) 49.0 N (d) 39.0N

3. The value of G was first determined experimentally by
(a) Newton (b) Henry Cavendish
(c) Kepler (d) Galileo

4. Two planets A and B of same mass and same radius are shown in the figure. ρ_1 and ρ_2 are densities of the materials in the planets and $\rho_1 > \rho_2$. If the accelerations due to gravity on the surfaces of the planets A and B are g_A and g_B respectively, then



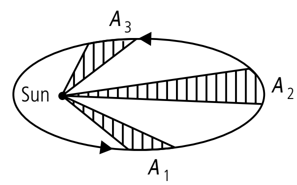
(a) $g_A = g_B$
(b) $g_A < g_B$
(c) $g_A > g_B$
(d) Given information is not sufficient

5. Which of the following statements is/are correct?
I. Mass of an object is the measure of its inertia.
II. Heavier the object smaller is the inertia.
III. The mass of an object is variable.
(a) Only I (b) I and III
(c) II and III (d) I and II

6. If a planet existed whose mass was twice that of Earth and whose radius 3 times greater, how much will a 1 kg mass weigh on the planet?
(a) 25 N (b) 2.17 N (c) 1.1 N (d) 5 N

7. If g_0, g_h and g_d be the acceleration due to gravity at earth's surface, at height h and at a depth d respectively, then
(a) $g_0 > g_h$ and $g_0 > g_d$ (b) $g_0 < g_h$ and $g_0 < g_d$
(c) $g_0 > g_h$ and $g_0 < g_d$ (d) $g_0 < g_h$ and $g_0 > g_d$.

8. A planet moving around sun sweeps out area A_1 in two days, A_2 in three days and A_3 in six days. Then the relation between A_1, A_2 and A_3 is



(a) $3A_1 = 2A_2 = A_3$ (b) $2A_1 = 3A_2 = 6A_3$
(c) $3A_1 = 2A_2 = 6A_3$ (d) $6A_1 = 3A_2 = 2A_3$.

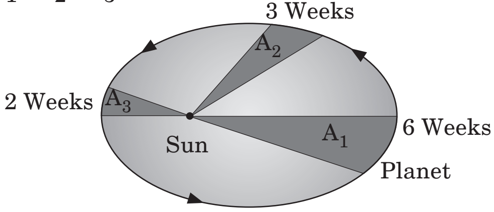
9. The mass of a body is increased 4 fold and mass of other body is increased 16 fold. How should the distance between them be changed to keep the same gravitational force between them?
(a) 4 times (b) $\frac{1}{4}$ times
(c) 8 times (d) $\frac{1}{8}$ times

10. A stone is allowed to fall from the top of a tower 100 m high and at the same time another stone is projected vertically upwards from the ground with a velocity of 25 m/s. Calculate when the two stones will meet.
(a) 4 s (b) 3.6 s (c) 2 s (d) 8 s

11. The mass of a body is measured to be 12 kg on the earth. If it is taken to the moon, its mass will be
(a) 12 kg (b) 6 kg (c) 2 kg (d) 72 kg.

12. A balloon of mass m is rising with an acceleration a. A fraction of its mass is detached from the balloon. Its acceleration will
(a) decrease (b) increase
(c) remain the same (d) none of these

13. In figure, the line that joins a planet to the sun sweeps out areas A_1, A_2, A_3 in times intervals 6 weeks, 3 weeks and 2 weeks respectively. How are A_1, A_2, A_3 related?



(a) $A_1 = 3A_2 = 2A_3$
(b) $A_1 = 2A_2 = 3A_3$
(c) $2A_1 = A_2 = A_3$
(d) $A_1 = 3A_2 = A_3$

14. If g_e is acceleration due to gravity on earth and g_m is acceleration due to gravity on moon, then

(a) $g_e = g_m$ (b) $g_e < g_m$
(c) $g_e = \frac{1}{6} g_m$ (d) $g_e = \frac{1}{6} g_m$

15. The unit of $\frac{G}{g}$ is

(a) kg m^{-1} (b) kg m^{-2}
(c) m^2 kg^{-1} (d) m kg^{-1}

16. Match the List-I and II and choose correct option below.

List-I	List-II
(P) $r^3 = T^2 \times$ constant	1. $u = 0$
(Q) $v = gt$	2. Weight
(R) $m \times g$	3. Equation of motion
(S) $v^2 = u^2 + 2gh$	4. Kepler's law

(a) P - 4, Q - 1, R - 2, S - 3
(b) P - 4, Q - 2, R - 3, S - 1
(c) P - 2, Q - 4, R - 1, S - 3
(d) P - 1, Q - 4, R - 2, S - 3

17. If the mass of the body on the surface of the earth is 50 kg, its mass at the centre of the earth is

(a) zero (b) more than 50 kg
(c) less than 50 kg (d) equal to 50 kg

18. Two identical copper spheres of radius R are in contact with each other. If the gravitational attraction between them is F, find the relation between F and R.

(a) $F \propto R^4$ (b) $F \propto R^{3/2}$
(c) $F \propto R^{-2}$ (d) $F \propto R^{-4}$

19. Relation between mass of body and its weight is

(a) $w = mg$ (b) $w = \frac{m}{g}$
(c) $g = m - w$ (d) $w = m + g$

20. Choose the correct statement.

(a) Weight is a vector quantity.
(b) The weight of a body in interplanetary space is maximum.
(c) Weight increases when the bodies go up.
(d) 1 N = 1 kg m s^{-1}

21. Average distance of the earth from the sun is L_1. If one year of the earth = D days, one year of another planet whose average distance from the sun is L_2 will be

(a) $D\left(\frac{L_2}{L_1}\right)^{1/2}$ days (b) $D\left(\frac{L_2}{L_1}\right)^{3/2}$ days
(c) $D\left(\frac{L_2}{L_1}\right)^{2/3}$ days (d) $D\left(\frac{L_2}{L_1}\right)$days.

22. A particle is dropped from a tower 180 m high. How long does it take to reach the ground? Take $g = 10$ m/s^2.

(a) 2 s (b) 6 s (c) 5 s (d) 8 s

23. The value of acceleration due to gravity is high if

(a) mass and radius both are small
(b) mass is small and radius is large
(c) mass is large and radius is small
(d) mass and radius both are large.

24. A person in a spaceship moving in space, experience weightlessness as the value of

(a) mass is zero
(b) acceleration due to gravity is zero
(c) gravitational force is zero
(d) none of these

25. Which of the following is correct for mass?

(a) It is a vector quantity.
(b) It is not a fundamental property of material body.
(c) It is the force with which the earth attracts a body.
(d) It is the quantity of matter contained in a body.

26. What happens to the acceleration due to gravity with the increase in altitude from the surface of the earth?

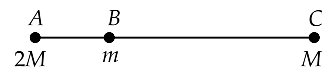
(a) Increases (b) Decreases
(c) First decreases and then increases
(d) Remains same

27. An astronaut in the orbit in a spacecraft feels weightlessness
(a) due to the absence of gravity inside
(b) due to the fact that spacecraft has no energy
(c) because acceleration in the orbit is equal to acceleration of gravity outside
(d) there is no gravity outside

28. An apple falls towards the earth because the earth attracts it. The apple also attracts the earth by the same force. Why do we not see the earth rising towards the apple?
(a) Acceleration of the earth is very large when compared to that of apple.
(b) Acceleration of the earth is equal to that of apple.
(c) Acceleration of the earth is neither high nor too low.
(d) Acceleration of the earth is very small when compared to that of apple.

29. According to Kepler's law the relationship between T (time period of revolution of a planet) and r (the semi-major axis of ellipse) is
(a) $T^2 \propto r$ (b) $T^2 \propto r^2$
(c) $T^2 \propto r^{-3}$ (d) $T \propto r^{3/2}$

30. Particles of masses $2M$, m and M are respectively at points A, B and C with $AB = 1/2(BC)$. m is much-much smaller than M and at time $t = 0$, they are all at rest. At subsequent times before any collision takes place



(a) m will remain at rest.
(b) m will move towards M.
(c) m will move towards $2M$.
(d) m will have oscillatory motion.

Case Based MCQs

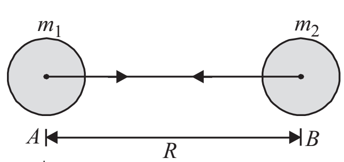
Case I : Read the passage given below and answer the following questions from 31 to 35.
According to universal law of gravitation, the force between two particles or bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between these particles or bodies.
Consider two bodies A and B having masses m_1 and m_2 respectively. Let the distance between these bodies be R. The force of gravitation between these bodies is given by

$F \propto m_1 m_2$ and $F \propto \frac{1}{R^2}$

$$F = G\frac{m_1 m_2}{R^2}$$

Where G is constant and is known as "universal gravitational constant".

31. Newton's law of gravitation is vald



(a) in laboratory
(b) only on the earth
(c) only in our solar system
(d) everywhere

32. Gravitational force is a
(a) repulsive force (b) attractive force
(c) neither (a) nor (b) (d) both (a) and (b)

33. Two particles of mass m_1 and m_2, approach each other due to their mutual gravitational attraction only. Then
(a) accelerations of both the particles are equal.
(b) acceleration of the particle of mass m_1 is proportional to m_1.
(c) acceleration of the particle of mass m_1 is proportional to m_2.
(d) acceleration of the particle of mass m_1 is inversely proportional to m_1.

34. Gravitational force between two bodies is 1 N. If the distance between them is made half, what will be the force?
(a) 2 N (b) 4 N (c) 6 N (d) 7 N

35. How does the force of gravitation between two objects change when the distance between them is reduced to half?
(a) Force of gravitation becomes 4 times
(b) Force of gravitation becomes 9 times
(c) Force of gravitation becomes 6 times
(d) Force of gravitation becomes 12 times

Case II : Read the passage given below and answer the following questions from 36 to 38.
There is no atmosphere on the moon. This is because gas molecules need a certain amount of force of attraction to be retained on a heavenly

body. The force of attraction of the moon is less than the required force, hence no atmosphere can exist.

36. The value of g on moon is .... times that of earth

(a) $\frac{1}{3}$ (b) $\frac{1}{4}$ (c) $\frac{1}{5}$ (d) $\frac{1}{6}$

37. Mass of the moon is .... that of earth

(a) more than (b) less than

(c) equal to (d) can't say

38. If the weight of an object is 60 kg f on earth then, its weight on moon is ....

(a) 10 kg f (b) 20 kg f

(c) 30 kg f (d) 40 kg f

Case III : Read the passage given below and answer the following questions from 39 to 41.

All freely falling bodies fall with a uniform acceleration due to gravity. As a result, all the equations of motion for the uniformly accelerated bodies moving in a straight line are applicable to the freely falling bodies.

39. The value of g is taken as positive when a body is

(a) dropped from a certain height

(b) moving in horizontal direction

(c) both (a) and (b)

(d) none of these

40. Velocity of an object at maximum height in case it has been thrown vertically upward is

(a) maximum (b) minimum

(c) zero (d) 9.8 m s^{-1}

41. During free fall, the acceleration of the object is

(a) zero (b) non-uniform

(c) constant (d) none of these

Assertion & Reasoning Based MCQs

For question numbers 42-50, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Both assertion and reason are true, and reason is correct explanation of the assertion.

(b) Both assertion and reason are true, but reason is not the correct explanation of the assertion.

(c) Assertion is true, but reason is false.

(d) Assertion is false, but reason is true.

42. Assertion : It is the gravitational force exerted by the sun and the moon on the sea water that causes to the formation of tides in the sea.

Reason : Gravitational force of attraction is a strong force.

43. Assertion : The value of acceleration due to gravity changes with the height, depth and shape of the earth.

Reason : Acceleration due to gravity is zero at the centre of the earth.

44. Assertion : When distance between two bodies is doubled and also mass of each body is doubled, then the gravitational force between them remains the same.

Reason : According to Newton's law of gravitation, force is directly proportional to the product mass of bodies and inversely proportional to square of the distance between them.

45. Assertion : Any two objects in the universe attract each other by a force called gravitational force.

Reason : The force of gravitation exerted by the earth is called gravity.

46. Assertion : Universal gravitational constant G is a scalar quantity.

Reason : The value of G is same through out the universe.

47. Assertion : When a body is thrown up, the acceleration due to gravity at the topmost point is zero.

Reason : The acceleration due to gravity is always directed towards the centre of the earth for a freely falling body.

48. Assertion : If we drop a stone and a sheet of paper from a balcony of first floor, then stone will reach the ground first.

Reason : The resistance due to air depends on velocity only.

49. Assertion : Kepler's second law of planetary motion is also known as Kepler's law of areas.

Reason : The line joining the planet and the sun sweeps equal areas in equal intervals of time.

50. Assertion : A sheet of paper falls slower, than one that is crumpled in to a ball?

Reason : Sheet of paper has lesser weight than that is crumpled into a ball.

SUBJECTIVE TYPE QUESTIONS

Very Short Answer Type Questions (VSA)

1. At what place on the earth's surface is the weight of a body maximum?

2. State the Kepler's third law.

3. Why is G called the universal gravitational constant?

4. What is the ratio of the force of attraction between two bodies kept in air and the same distance apart in water?

5. What is the centripetal force?

6. The weight of a body is 50 N. What is its mass? (g = 9.8 m s^{-2})

7. Define universal gravitational constant.

8. Which is more fundamental-mass or weight of a body?

9. Newton's law of gravitation is also called inverse square law. Why is it so called?

10. Suppose gravity of Sun suddenly becomes zero, then in which direction will the Earth begin to move if no other celestial body affects it?

Short Answer Type Questions (SA-I)

11. Can a body have mass but no weight?

12. Give the difference between g and G.

13. How does the gravitational force between two bodies changes if the distance between them is tripled?

14. Find the ratio between the values of acceleration due to gravity at a height 1 km above and at a depth of 1 km below the earth's surface.
(radius of earth is R)

15. Out of aphelion and perihelion, where is the speed of the earth more and why?

16. When does an object show weightlessness?

17. What is the acceleration of free fall?

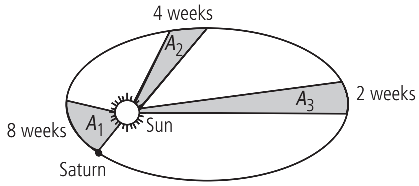
18. What is the source of centripetal force that a planet requires to revolve around the sun? On what factors does that force depend?

19. There are two kinds of balances *i.e.*, a beam balance and a spring balance. If both the balances give the same measure of a given body on the surface of the earth, will they give the same measure on the surface of the moon? Explain.

20. Two objects of masses m and $2m$ having the same size are dropped simultaneously from heights h_1 and h_2 respectively. Find out the ratio of time they would take in reaching the ground.

Short Answer Type Questions (SA-II)

21. (a) The line that joins the Saturn to the Sun sweeps areas A_1, A_2 and A_3 in time intervals of 6 weeks, 3 weeks and 2 weeks respectively as shown in the figure. What is the correct relation between A_1, A_2 and A_3?



(b) The time period of a planet of a star is 8 hours. What will be time period if the separation between the planet and the star is increased to 9 times the previous value?

22. In which direction do the following forces act when an object is in motion?
(a) Frictional force
(b) Gravitational force
(c) Centripetal force

23. Two identical copper spheres of radius R are in contact with each other. If the gravitational attraction between them is F, find the relation between F and R.

24. Suppose gravitational pull varies inversely as n^{th} power of the distance. Show that the time period of a planet in circular orbit of radius R around the sun will be proportional to $R^{(n+1)/2}$.

25. The force of attraction between the two bodies depend upon their masses and distance between them? A student thought that two bricks tied together would fall faster than a single one under the action of gravity. Do you agree with his hypothesis or not? Comment.

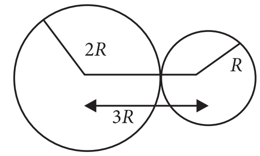
26. The earth is acted upon by gravitation of Sun, even though it does not fall into the Sun. Why?

27. On the earth, a stone is thrown from a height in a direction parallel to the earth's surface while another stone is simultaneously dropped from the same height. Which stone would reach the ground first and why?

28. The weight of any person on the moon is about 1/6 times that on the earth. He can lift a mass of 15 kg on the earth. What will be the maximum mass, which can be lifted by the same force applied by the person on the moon?

29. Calculate the average density of earth in terms of g, G and R.

30. Two uniform solid spheres of radii R and $2R$ are at rest with their surfaces just touching. Find the force of gravitational attraction between them if density of spheres be ρ?



Direction : Read the passage given below and answer the following questions:

Earth attracts every object towards its centre. Therefore, every object, when free, falls towards the earth due to gravitational force of earth on it. This is the phenomenon of free fall. The acceleration produced in a body in free fall due to gravitational force of earth on the body is called acceleration due to gravity (g). On the surface of earth, g = 9.8 m/s^2. This value does not depend on mass of the body or nature of the body.

31. Convert the value of g in km/h^2

32. Is the value of g on moon the same as on earth?

33. How does gravity differ from gravitation?

Long Answer Type Question (LA)

34. Derive expression for force of attraction between two bodies and then define gravitational constant.

35. A ball thrown up is caught back by the thrower after 6 s. Calculate (a) the velocity with which the ball was thrown up, (b) the maximum height attained by the ball and (c) the distance of the ball starting from the highest point after 2 s. Take, g = 10 m s^{-2}.

36. An object weighs 294 N on the earth.
(a) What are the differences between the mass of an object and its weight?
(b) What would be its mass on the moon?
(c) What is the acceleration due to gravity on the moon?

ANSWERS

OBJECTIVE TYPE QUESTIONS

1. (a) : When an object is thrown upwards, the force of gravity acts in the direction opposite to that of motion.

2. (c) : $W = mg = 5 \times 9.8 = 49$ N

3. (b) : The value of universal gravitational constant G was first determined experimentally by English scientist Henry Cavendish in 1798.

4. (a) : We know, $g = \frac{GM}{R^2}$

As both the planets have same mass and same radii so, $g_A = g_B$.

5. (a) : Heavier the object, greater is the inertia. The mass of an object is constant.

6. (b) : Here, $M_p = 2\,M_e$ and $R_p = 3R_e$

$m = 1$ kg, $W_p = ?$

As $g_e = \dfrac{GM_e}{R_e^2}$ and $g_p = \dfrac{GM_p}{R_p^2}$

$$\frac{g_p}{g_e} = \frac{M_p}{R_p^2} \times \frac{R_e^2}{M_e} = \frac{M_p}{M_e} \times \left(\frac{R_e}{R_p}\right)^2$$

$$g_p = g_e \times \frac{M_p}{M_e} \times \left(\frac{R_e}{R_p}\right)^2$$

or $g_p = 9.8 \times 2 \times \left(\dfrac{1}{3}\right)^2 = 2.17$ m/s^2

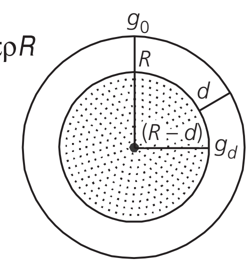
$W_p = mg_p = 1 \times 2.17 = 2.17$ N

7. (a) : At a height h,

$$g_h = \frac{GM}{(R+h)^2} = \frac{g_0 R^2}{(R+h)^2} \qquad \left(\because\ g_0 = \frac{GM}{R^2}\right)$$

$\therefore\ g_0 > g_h$

As, $g_0 = \dfrac{GM}{R^2} = \dfrac{G}{R^2} \times \dfrac{4}{3}\pi R^3 \rho = \dfrac{4}{3} G\pi\rho R$



At a depth d, $g_d = \dfrac{4}{3} G\pi\rho(R-d)$

$\therefore\ \dfrac{g_0}{g_d} = \dfrac{R}{R-d}$

$\therefore\ g_0 > g_d$

8. (a) : When the planet revolves around the sun, its areal velocity remains constant.

$\therefore\ \dfrac{A_1}{t_1} = \dfrac{A_2}{t_2} = \dfrac{A_3}{t_3}$; $\dfrac{A_1}{2} = \dfrac{A_2}{3} = \dfrac{A_3}{6}$

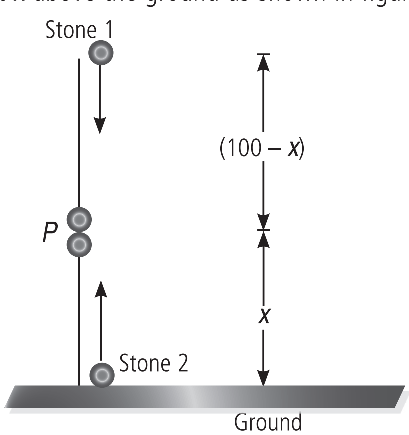
or $3A_1 = 2A_2 = A_3$

9. (c) : $F = \dfrac{Gm_1 m_2}{d^2} = \dfrac{G(4m_1)(16m_2)}{d'^2}$

$\therefore\ d'^2 = 64d^2$ or $d' = 8d$

10. (a) : Here, $h = 100$ m.

Let the two stones meet after t seconds at a point P which is at a height x above the ground as shown in figure.



For stone 1,

$u = 0$, $h = (100 - x)$ m, $a = g = 9.8$ m/s^2

From $s = ut + \dfrac{1}{2}at^2$,

$(100 - x) = 0 + \dfrac{1}{2} \times 9.8\ t^2 = 4.9\ t^2$ ...(i)

For stone 2,

$u = 25$ m/s, $h = x$, $a = -g = -9.8$ m/s^2

From $s = ut + \dfrac{1}{2}at^2$, $x = 25t + \dfrac{1}{2}(-9.8)t^2$

$= 25t - 4.9\ t^2$ ...(ii)

Adding eqn. (i) and (ii), $100 - x + x = 25t$, $t = \dfrac{100}{25} = 4$ s

11. (a) : Mass of the body is constant and does not change from place to place.

12. (b)

13. (b) : According to Kepler's 2nd law, areal velocity of planet is constant.

$\dfrac{A_1}{6} = \dfrac{A_2}{3} = \dfrac{A_3}{2}$ or $A_1 = 2A_2 = 3A_3$

14. (d) : On moon, $g_m = \dfrac{1}{6} g_e$

15. (c) : $g = \dfrac{GM}{R^2}$ or $\dfrac{G}{g} = \dfrac{R^2}{M} = \dfrac{\text{m}^2}{\text{kg}} = \text{m}^2\ \text{kg}^{-1}$

16. (a) : P – 4, Q – 1, R – 2, S – 3

17. (d) : Mass of a body does not depend on its location. It is constant everywhere.

18. (a) : Let M be the mass of each copper sphere and ρ be the uniform density of copper.

$\therefore\ M = \left(\dfrac{4}{3}\pi R^3\right)\rho$

The force of gravitational attraction between the two spheres is

$$F = \frac{GMM}{(R+R)^2} = \frac{G}{4R^2}\left(\frac{4}{3}\pi R^3 \rho\right)^2 = \left(\frac{4}{9}G\pi^2\rho^2\right)R^4$$

If ρ is constant, then $F \propto R^4$.

19. (a) : Weight of body = Mass × acceleration due to gravity

$\therefore\ W = mg$

20. (a) : Weight is a vector quantity.

21. (b) : According to Kepler's third law,

$T^2 \propto r^3$ or $T \propto r^{3/2}$

$\therefore\ \dfrac{D'}{D} = \left(\dfrac{L_2}{L_1}\right)^{3/2}$ or $D' = D\left(\dfrac{L_2}{L_1}\right)^{3/2}$ days

22. (b) : Here, $u = 0$, $h = 180$ m, $t = ?$, $v = ?$, $g = 10$ m/s^2

From $v^2 - u^2 = 2gh$, $v^2 - 0 = 2 \times 10 \times 180$

$v = \sqrt{2 \times 10 \times 180} = 60$ m/s

From $v = u + gt$, $60 = 0 + 10\,t$

or $t = \dfrac{60}{10} = 6$ s

23. (c) : Acceleration due to gravity,

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

24. (b) : $W = mg$

In space, $g = 0$

$\therefore \quad W = 0$

25. (d)

26. (b) : Acceleration due to gravity decreases with the increase in altitude.

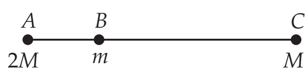
27. (c)

28. (d) : The mass of the earth is extremely large as compared to that of apple. So, acceleration of the earth is very small when compared to that of apple.

29. (d) : According to Kepler's third law

$T^2 \propto r^3$ or $T \propto r^{3/2}$

30. (c) :



Force on mass m at B due to mass $2M$ at A is

$$F_1 = \frac{Gm \times 2M}{(AB)^2} \text{ along } BA$$

Force on mass m at B due to mass M at C is

$$F_2 = \frac{GmM}{(BC)^2} \text{ along } BC$$

$\therefore$ Resultant force on mass m at B due to masses at A and C is

$F_R = F_1 - F_2$

($\because$ F_1 and F_2 are acting in opposite directions)

$$= \frac{2GmM}{(AB)^2} - \frac{GmM}{(BC)^2}$$

$\because \quad AB = \dfrac{1}{2}BC$

$$\therefore \quad F_R = \frac{2GmM}{\left(\frac{1}{2}BC\right)^2} - \frac{GmM}{(BC)^2} \text{ along } BA$$

$$= \frac{8GmM}{(BC)^2} - \frac{GmM}{(BC)^2} \text{ along } BA$$

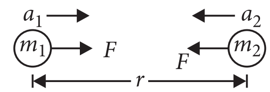
$$= \frac{7GmM}{(BC)^2} \text{ along } BA$$

Therefore, m will move towards $2M$.

31. (d) : Newton's law of gravitation is a universal law.

32. (b) : Gravitational force is an attractive force.

33. (c) : Given situation is shown in the figure.



Gravitational force,

$$F = \frac{Gm_1m_2}{r^2}$$

Acceleration of particle of mass m_1,

$$a_1 = \frac{F}{m_1} = \frac{Gm_2}{r^2}$$

$\therefore \quad a_1 \propto m_2$

34. (b) : Gravitational force is inversely proportional to the square of the distance between them.

$F \propto \dfrac{1}{r^2}$; Now, $\dfrac{F_1}{F_2} = \left(\dfrac{r_2}{r_1}\right)^2$

Here, $r_2 = \dfrac{r_1}{2}$, $F_2 = F_1\left(\dfrac{r_1}{r_2}\right)^2 = 1\left(\dfrac{4}{1}\right) = 4$ N

35. (a) : Force of gravitation,

$$F \propto \frac{1}{R^2}$$

If R is reduced to $\dfrac{R}{2}$

$F \propto \dfrac{1}{\left(\frac{R}{2}\right)^2}$ *i.e.*, $F \propto \dfrac{4}{R^2}$

The force of gravitation becomes 4 times.

36. (d)

37. (b)

38. (a) : Weight on moon $= \dfrac{\text{Weight on earth}}{6}$

$= \dfrac{60 \text{ kgf}}{6} = 10$ kgf

39. (c) **40. (c)** **41. (c)**

42. (c) : Gravitational force of attraction is the reason behind the formation of tides. It is a weak force.

43. (b) : The value of g changes with height, depth and is zero at the centre of the earth.

44. (a) : $F = G\dfrac{m_1 m_2}{r^2}$.

45. (b)

46. (b) : The value of G is independent of direction and is a constant through out the universe.

47. (d) : Acceleration due to gravity at the topmost point in case of a stone thrown upward is not zero.

48. (c) **49. (a)** **50. (c)**

SUBJECTIVE TYPE QUESTIONS

1. At the poles, weight of the body is maximum.

2. The square of the time period of revolution of a planet is proportional to the cube of the semi-major axis of the ellipse traced out by the planet.

3. The constant G is universal because it is independent of the nature and size of bodies, the space where they are kept and at the time at which the force is considered.

4. 1 : 1, because the gravitational force does not depend on the nature of the medium.

5. The force required for a body to move in a circular path is called centripetal force.

6. Here, $W = 50$ N

$g = 9.8 \text{ m s}^{-2}$

we have, mass $= \dfrac{W}{g} = \dfrac{50 \text{ N}}{9.8 \text{ m s}^{-2}}$

Mass = 5.10 kg

7. The universal gravitational constant is the force of attraction between two point masses of 1 kg each kept at a distance of 1 m.

8. Mass is more fundamental than weight because the mass of a body remains constant while its weight changes from place to place due to change in the value of g.

9. According to Newton's law of gravitation, the magnitude of the gravitational force between two objects is inversely proportional to the square of the distance between them, *i.e.*, $F \propto 1/r^2$. That is why this law is also called inverse square law.

10. The Earth will move in the direction of the tangent to the Sun orbit.

11. Yes, mass of a body is constant wherever it is taken. But weight of body, $W = mg$. The weight will be zero where $g = 0$ *e.g.* at the centre of Earth.

12.

	g		G
1.	It is defined as acceleration due to gravity.	1.	It is defined as universal gravitational constant
2.	Value of $g = 9.8$ m/s^2	2.	Value of $G = 6.67 \times 10^{-11}$ N m^2/kg^2
3.	SI unit = m/s^2	3.	SI unit = Nm^2/kg^2
4.	It changes from place to place. At poles value of g is more than that of at equator.	4.	It remains constant.

13. Gravitational force between two bodies is given by

$$F = \frac{Gm_1m_2}{r^2} \quad \text{...(i)}$$

When distance between bodies is tripled *i.e.* $r' = 3r$, then

$$F' = \frac{Gm_1m_2}{(r')^2} = \frac{Gm_1m_2}{(3r)^2} = \frac{1}{9}\frac{Gm_1m_2}{r^2} \quad \text{...(ii)}$$

Dividing equation (ii) by equation (i), we get

$$\frac{F'}{F} = \frac{1}{9} \text{ or } F' = \frac{1}{9}F$$

Thus, the gravitational force between the bodies become $\frac{1}{9}$ times its original value.

14. Acceleration due to gravity at a height h above the earth's surface is

$$g_h = g\left(1 - \frac{2h}{R}\right) \text{ for } h << R \quad \text{...(i)}$$

where g is the acceleration due to gravity on the earth's surface and R is the radius of the earth.

Acceleration due to gravity at a depth d below the earth's surface is

$$g_d = g\left(1 - \frac{d}{R}\right) \quad \text{...(ii)}$$

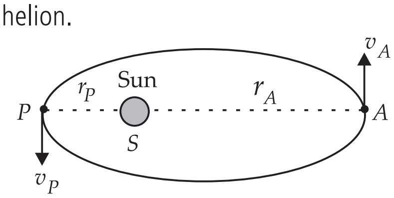
Divide (i) by (ii)

$$\therefore \quad \frac{g_h}{g_d} = \frac{\left(1 - \frac{2h}{R}\right)}{\left(1 - \frac{d}{R}\right)} = \frac{R - 2h}{(R - d)}$$

Here, $h = 1$ km, $d = 1$ km

$$\therefore \quad \frac{g_h}{g_d} = \frac{R - 2}{R - 1}$$

15. In the figure, point A represents aphelion and point P perihelion.



According to Kepler's second law, areal velocity is constant but linear velocity is not constant. So,

$r_P \times v_P = r_A \times v_A$

$$\Rightarrow \quad \frac{r_A}{r_P} = \frac{v_P}{v_A} \quad \because r_A > r_P \quad \text{so,} \quad v_P > v_A.$$

Hence, speed of the earth at the perihelion is more than that at the aphelion.

16. Weightlessness is a state when weight of an object is zero. It occurs when a body is in a state of free fall under the effect of gravity alone.

17. When a body is released from a height, it begins to fall freely due to earth's gravitational force acting on it. Due to this force, the body experiences an acceleration towards centre of earth. This acceleration is the acceleration of free fall and is called the acceleration due to gravity.

18. Gravitational force. This force depends on the product of the masses of the planet and sun and the distance between them.

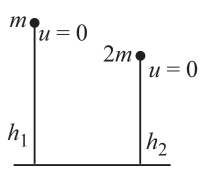
19. Beam balance measure the mass of a body. Since mass of a body remains constant so the beam balance will give the same measure on the surface of the earth and on the surface of the moon.

On the other hand, spring balance measures the weight of a body. Weight of the body $W = mg$. It means, weight of a body depends upon the value of g. Since value of g on the moon $= \frac{1}{6}$ times the value of g on the earth, so the spring balance shows $\frac{1}{6}$ times the weight of the body on the earth at the surface of the moon.

20. Using the formula, $s = ut + \frac{1}{2}at^2$, we can write

$$h_1 = 0 + \frac{1}{2}gt_1^2 \quad \text{or} \quad t_1 = \sqrt{\frac{2h_1}{g}}$$

$$h_2 = 0 + \frac{1}{2}gt_2^2 \quad \text{or} \quad t_2 = \sqrt{\frac{2h_2}{g}}$$



$$\Rightarrow \quad \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}}$$

21. (a) According to Kepler's second law, the areal velocity of the planet around the sun is constant.

Therefore, $\frac{\Delta A}{\Delta t} = \text{constant} \Rightarrow \frac{A_1}{8} = \frac{A_2}{4} = \frac{A_3}{2}$

$A_1 > A_2 > A_3$ and $A_1 = 2A_2$, $A_1 = 4A_3$.

(b) Here, time period of a planet of star, T is 8 h.

By Kepler's third law,

$T'^2 \propto r^3$ …(i)

If separation is increased to 9 times, then time period, $T'_2 \propto (9r)^3$ …(ii)

Dividing eqn. (ii) by eqn. (i),

$$\frac{T'^2}{T^2} = \frac{(9r)^3}{r^3} = 729 \quad \text{or} \quad \frac{T'}{T} = 27$$

$\therefore \quad T' = 27 \times T = 27 \times 8 = 216$ h $= 9$ days

22. (a) Backward direction of relative motion

(b) Downward direction

(c) Towards the centre of the circle

23. Let M be the mass of each copper sphere and ρ be the uniform density of copper.

$$\therefore \quad M = \left(\frac{4}{3}\pi R^3\right)\rho$$

The force of gravitational attraction between the two spheres is

$$F = \frac{GM\ M}{(R+R)^2} = \frac{G}{4R^2}\left(\frac{4}{3}\pi R^3\ \rho\right)^2 = \left(\frac{4}{9}G\pi^2\ \rho^2\right)R^4$$

24. As gravitational pull of sun on the planet provides necessary centripetal force to the planet, therefore

$$\frac{GM\ m}{R^n} = mR\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 mR}{T^2} \qquad \textit{or} \qquad T^2 = \frac{4\pi^2 mR^{n+1}}{GM\ m}$$

$$T = \frac{2\pi}{\sqrt{GM}}R^{(n+1)/2}$$

Hence $T \propto R^{(n+1)/2}$

25. As is known from Newton's law of gravitation, force of attraction (F) between two bodies is directly proportional to the product of their masses, and inversely proportional to the square of the distance between their centres.

i.e., $\quad F \propto m_1\ m_2$, and $F \propto \frac{1}{d^2}$

The hypothesis of the student is wrong. This is because acceleration due to gravity, with which brick/bricks fall does not depend upon mass of the bricks. So the two bricks tied together would not fall faster than a single one.

26. The earth does not fall into the sun due to gravitational pull of sun on earth. This is because earth is not stationary. It is revolving around the sun in a particular orbit. The centripetal force required by the earth for revolution around the sun is provided by gravitational pull of sun on the earth. In other words, gravitational pull of sun on earth is spent up in providing necessary centripetal force required by the earth for revolution around the sun. Hence the earth does not fall into the sun.

27. Both the stones will reach the ground simultaneously. This is because motion along the horizontal and motion along the vertical are independent of each other.

In the vertical direction, for both the stones, $s = h$, $u = 0$ and $a = g$. From $s = ut + \frac{1}{2}at^2, h = 0 + \frac{1}{2}gt^2, t = \sqrt{\frac{2h}{g}}$

$\therefore$ times taken by both stones to reach the ground will be same.

28. Here, $W_m = \frac{1}{6}W_e$

$$\therefore \quad g_m = \frac{1}{6}g_e$$

Force applied by the person on earth to lift a mass m

$F = m\,g_e = 15\ g_e$

If he can lift a mass m' on moon by applying same force, then $F = m' \, g_m$

$\therefore \quad F = m' \, g_m = 15 \, g_e$

$m' = 15\dfrac{g_e}{g_m} = 15 \times 6 = 90$ kg.

29. Suppose earth is a perfect sphere of radius R.

$\therefore \quad$ Volume of earth $= \dfrac{4}{3}\pi R^3$

If ρ is average density of earth, then mass of earth,

M = volume × density

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

From Newton's law of gravitation,

$$g = \frac{GM}{R^2} = \frac{G}{R^2}\left(\frac{4}{3}\pi R^3 \rho\right)$$

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

$$\rho = \frac{3g}{4\pi RG}$$

30. Here, distance between the centre of two spheres is $3R$. Also, density of spheres is ρ.

Thus, mass of the sphere of radius R,

$$M_R = \left(\frac{4}{3}\pi R^3\right) \times \rho = \frac{4\pi R^3 \rho}{3}$$

and, mass of the sphere of radius $2R$,

$$M_{2R} = \left[\frac{4}{3}\pi (2R)^3\right]\rho = \frac{32\pi R^3 \rho}{3}$$

Hence, force of gravitational attraction between the spheres can be calculated as $F = \dfrac{GM_R M_{2R}}{(3R)^2}$

On solving this, we get $F = \dfrac{128\pi^2 R^4 \rho^2 G}{81}$

31. $g = \dfrac{9.8 \text{ m}}{(\text{sec})^2} = \dfrac{9.8 \times 10^{-3}\text{ km}}{\left(\dfrac{1}{60 \times 60}\text{ h}\right)^2}$

$= 9.8 \times 10^{-3} \times 3600 \times 3600 \text{ km/h}^2 = 1.27 \times 10^5 \text{ km/h}^2$

32. No, the value of g on moon is only $\dfrac{1}{6}$th of its value on earth.

33. The force of attraction between any two objects by virtue of their masses is called gravitational force, whereas the force of gravitation exerted by a huge heavenly body on a smaller object near its surface is called its gravity or the force of gravity.

34. From Newton's law of gravitation, every body in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Let us consider two bodies A and B of masses m_1 and m_2 which are separated by a distance r. Then the force of gravitation (F) acting on the two bodies is given by

$$F \propto m_1 \times m_2 \qquad \ldots\text{(i)}$$

$$\text{and} \quad F \propto \frac{1}{r^2} \qquad \ldots\text{(ii)}$$

Combining (i) and (ii), we get

$$F \propto \frac{m_1 \times m_2}{r^2} \quad \text{or} \quad F = G \times \frac{m_1 m_2}{r^2}$$

where G is a constant known as universal gravitational constant.

Here, if the masses m_1 and m_2 of the two bodies are of 1 kg and the distance (r) between them is 1 m, then putting $m_1 = m_2 =$ 1 kg and $r = 1$ m in the above formula, we get $G = F$

Thus, the gravitational constant G is numerically equal to the force of gravitation which exists between two bodies of unit masses kept at a unit distance from each other.

35. (a) Let u = velocity with which the ball was thrown up.

$v = 0$, at the highest point.

$t = \dfrac{6}{2} = 3$ s (time to reach highest point)

Using, $v = u + gt$,

we get, $0 = u - 10 \times 3$ or $u = 30 \text{ m s}^{-1}$

Thus, the ball was thrown with a velocity of 30 m s^{-1}.

(b) To find the maximum height attained by the ball

$v^2 - u^2 = -2gh$ or, $0 - 30^2 = -20\,h$

or $\quad h = \dfrac{900}{20} = 45$ m

Thus, the maximum height attained by the ball = 45 m

(c) To find the distance travelled by the ball in 2 s from the highest point.

Here, $u = 0$ and $t = 2$ s

Using, $s = ut + \dfrac{1}{2}gt^2$, we get

$$= 0 + \frac{1}{2} \times 10 \times (2)^2 = 20 \text{ m}$$

$\therefore \quad s = 20$ m

Thus, the ball will be 20 m below the highest point after 2 s.

36. (a)

	Mass	Weight
1.	Mass of a body is the measure of its inertia.	Weight of the body is the force with which it is attracted towards the earth (*W = mg*).
2.	Its S.I. unit is kg.	Its S.I. unit is newton.
3.	It remains constant everywhere.	Its value changes from the place to place.
4.	It can be measured by common balance.	It is measured by spring balance.

(b) Weight of the object on the earth

$W_e = 294$ N

Mass of the object on the earth $m_e = ?$

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

We know, $W_e = m_e \times g_e$

By putting the values of the given physical quantities in the above formula, we get

$294 \text{ N} = m_e \times 9.8 \text{ m/s}^2$

$$m_e = \frac{294 \text{ N}}{9.8 \text{ m/s}^2} = 30 \text{ kg}$$

Thus, the mass of the object on the earth is 30 kg. We know the mass of a body remains constant everywhere in the universe. So, the mass of the object will be 30 kg on the surface of moon.

(b) Now, to find the acceleration due to gravity on the moon, we have to find the weight of the body on the moon.

We know, the weight of an object on the moon

$$= \left(\frac{1}{6}\right) \times \text{its weight on the earth}$$

$$W_m = \frac{1}{6} \times 294 \text{ N}$$

$W_m = 49$ N

Using the formula,

$W_m = m_m \times g_m$

$49 \text{ N} = 30 \text{ kg} \times g_m$

$$g_m = \frac{49 \text{ N}}{30 \text{ kg}} = 1.633 \text{ m/s}^2$$

Thus, the acceleration due to gravity on the moon is 1.63 m/s^2.

☺☺☺