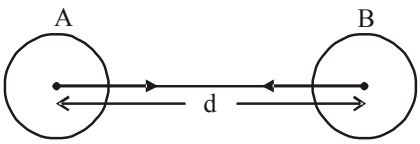
Chapter 2

Gravitation

- **Universal Law of Gravitation :** Every object in the universe attracts every other object with a force which is proportional to the product of their masses and inversely proportional to the square of the distance between them. The force is along the line joining the centres of two objects.



Let two objects A and B of masses M and m lie at a distance d from each other as shown in figure given above. Let the force of attraction between two objects be F. According to the universal law of gravitation, the force between two objects is directly proportional to the product of their masses. That is,

$$F \propto M \times m \qquad \ldots(1)$$

And the force between two objects is inversely proportional to the square of the distance between them, that is,

$$F \propto \frac{1}{d^2} \qquad \ldots(2)$$

Combining equations (1) and (2), we get

$$F \propto \frac{M \times m}{d^2} \qquad \ldots(3)$$

or, $$F = G\frac{M \times m}{d^2} \qquad \ldots(4)$$

where G is the constant of proportionality and is called the universal gravitation constant. The S.I. unit of G can be obtained by substituting the units of force, distance and mass in Eq. (4) as $N\,m^2\,kg^{-2}$.

The accepted value of G is $6.673 \times 10^{-11}\ N\,m^2\,kg^{-2}$.

- When an objects fall down forwards the earth under the gravitational force alone, we say the object are in free-fall. The velocity of a freely falling body changes and is said to be accelerated. This acceleration is called acceleration due to gravity, denoted by 'g'. Unit is m/s^2.

As $F = ma \qquad (\because\ a = g) \qquad \ldots(i)$

$F = mg \qquad \ldots(ii)$

and $F = G = \frac{Mm}{d^2}$ (iii) Universal law of Gravitation

$\therefore \quad mg = G = \frac{Mm}{d^2}$ from (ii) and (iii)

$\therefore \quad g = \frac{GM}{d^2}$

M = Mass of the earth.

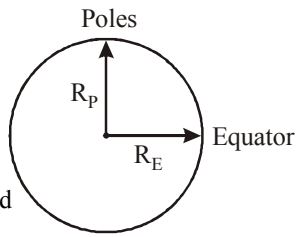
d = distance between the object and the earth.

G = Gravitational constant.

If the object is placed on the earth then $d = R$.

(R = radius of the earth)

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



- Earth is not a sphere.

It is flattened at poles.

Hence R_p – Radius at pole and

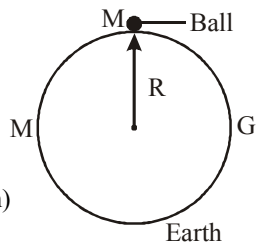
R_ε – Radius at equator.

$R_q > R_p$

$g \propto \frac{1}{R}$

$\therefore$ The value of 'g' is more at Poles = ($9.9\ m/s^2$) and less at equator = ($9.8\ m/s^2$)

- Calcualte value of g.



$$g = G\frac{M}{R^2}$$

$G = 6.67 \times 10^{-11}\ Nm^2/kg^2$

$M = 6 \times 10^{24}$ kg. (Mass of the Earth)

$R = 6.4 \times 10^6$ m

On substituting the given values.

$$g = \frac{6.7 \times 10^{-11}\,Nm^2kg^2 \times 6 \times 10^{24}\,kg}{(6.4 \times 10^6\,m)^2}$$

$g = 9.8\ m/s^2$.

- The quantity of matter in a body is called mass. The SI unit of mass is kilogram (kg). Mass is usually denoted by 'm'.

Characteristics of mass

(i) Mass is a scalar quantity.

(ii) The mass of a body remains the same at all places. This means, the mass of a body on the earth, on the moon, or anywhere in the outer space remains the same.

(iii) The mass of a body can be measured with the help of a two-pan balance.

- The weight of a body on the earth is equal to the force with which the body is attracted towards the earth. Thus, the weight of a body on the earth is equal to the force of gravity exerted by the earth on that body. We know that

Force of gravity acting on a body

= Mass of the body × Acceleration due to gravity

The force of gravity acting on a body by definition is equal to the weight of that body. So

Weight of the body = Mass of the body × Acceleration due to gravity

$W = m \times g = mg$

The weight of an object can change from one place to the other, from one planet to the other.

- **Weight of an Object on the Moon:** Let the mass of an object be m. Let its weight on the moon be W_m. Let the mass of the moon be M_m and its radius be R_m.

By applying the universal law of gravitation, the weight of the object on the moon will be

$$W_m = G\frac{M_m \times m}{R_m^2} \quad \ldots(1)$$

Let the weight of the same object on the earth be W_e. The mass of the earth is M and its radius is R.

Celestial body	Mass (kg)	Radius (m)
Earth	5.98×10^{24}	6.37×10^{6}
Moon	7.36×10^{22}	1.74×10^{6}

From eq. (1) we have,

$$W_e = G\frac{M \times m}{R^2} \quad \ldots(2)$$

Substituting the values from table in eqs. (1) and (2), we get

$$W_m = G\frac{7.36 \times 10^{22}\ \text{kg} \times \text{m}}{(1.74 \times 10^{6}\ \text{m})}$$

$W_m = 2.431 \times 10^{10}\,G \times m$ ...(3a)

and $W_e = 1.474 \times 10^{11}\,G \times m$ ...(3b)

Dividing eq. (3a) by eq. (3b), we get

$$\frac{W_m}{W_e} = \frac{2.431 \times 10^{10}}{1.474 \times 10^{11}}$$

or $$\frac{W_m}{W_e} = 0.165 \approx \frac{1}{6} \quad \ldots(4)$$

$$\frac{\text{Weight of the object on the moon}}{\text{Weight of the object on the earth}} = \frac{1}{6}$$

Weight of the object on the moon = $\frac{1}{6}\times$ its weight on the earth.

- The force applied on a surface in a direction perpendicular (or normal) to the surface is called thrust. The S.I. unit of thrust is newton (N).
- **Pressure :** Force per unit area of the surface acting in a direction perpendicular (or normal) to it is called pressure (P). If F is the force acting perpendicularly on a surface having an area A, then

$$\text{Pressure} = \frac{\text{Force acting normally on the surface}}{\text{Area of the surface}}$$

$$P = \frac{F}{A}$$

The S.I. unit of pressure is Newton per metre square (Nm^{-2}). Another name for the S.I. unit of pressure is pascal (Pa). $1\ Pa = 1\ Nm^{-2}$

- **Pressure in fluids :** A substance which can flow is called a **fluid**. All liquids and gases are thus fluids.
- **Buoyancy :** The tendency of a fluid to exert an upward force on a body immersed partly or wholly in it is called **buoyancy**. The resultant upward force experienced by a body when immersed in a fluid is called **buoyant** force or **upward thrust**.
- **Archimede's principle :** When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.
- **Applications of Archimede's principle :** Archimede's principle is applied for

(1) determination of density and relative density of substances

(2) design of ships and submarines

Exercise 1

DIRECTIONS : This section contains multiple choice questions. Each question has 4 choices (1), (2), (3) and (4) out of which only one is correct.

1. The force of gravitation between two bodies does not depend on:
   (1) their separation
   (2) the product of their masses
   (3) the sum of their masses
   (4) the gravitational constant
2. The acceleration due to gravity
   (1) has the same values everywhere in space
   (2) has the same value everywhere on the earth
   (3) varies with the latitude on the earth
   (4) is greater on the moon due to its smaller diameter
3. Newton's law of gravitation is applicable to
   (1) bodies of the solar system only
   (2) bodies on the earth
   (3) planets only
   (4) all bodies of the universe
4. The force that causes acceleration and keeps the body moving along the circular path is acting
   (1) towards the center
   (2) away from the center
   (3) along the tangent to the circular path
   (4) in the direction of circular motion
5. All bodies whether large or small fall with the
   (1) same force (2) same acceleration
   (3) same velocity (4) same momentum

6. Weightlessness experienced while orbiting the earth in a spaceship is the result of
   (1) zero gravity (2) inertia
   (3) acceleration (4) centre of gravity
7. When an object falls freely to the earth, the force of the gravity is
   (1) opposite to the direction of motion
   (2) in the same direction as that of motion
   (3) zero
   (4) constant
8. The motion of the moon around the earth is due to
   (1) the centrifugal force
   (2) the centripetal force
   (3) Neither (1) nor (2)
   (4) Both (1) and (2)
9. The weight of a body at the centre of the earth is
   (1) zero
   (2) infinite
   (3) same as at other places
   (4) slightly greater than that at poles
10. The weight of an object
   (1) is the gravity of the matter it contains
   (2) refers to its inertia
   (3) is the same as its mass but expressed in different units
   (4) is the force with which it is attracted to the earth
11. In vacuum all freely falling objects
   (1) have the same speed
   (2) have the same velocity
   (3) have the same acceleration
   (4) have the same force
12. The centripetal force is provided to the planet by the
   (1) force of repulsion between the planet and the Sun
   (2) force of attraction of the Sun
   (3) heat energy of the Sun
   (4) All of these
13. At which of the following locations, the value of g is the largest?
   (1) On top of the Mount Everest
   (2) On top of Qutub Minar
   (3) At a place on the equator
   (4) A camp site in Antarctica
14. A ball is thrown vertically upwards. The acceleration due to gravity.
   (1) is in the direction opposite to the direction of its motion
   (2) is in the same direction as the direction of its motion
   (3) increases as it comes down
   (4) becomes zero at the highest point
15. Pressure exerted by a sharp needle on a surface is :
   (1) more than the pressure exerted by a blunt needle
   (2) less than the pressure exerted by a blunt needle
   (3) equal to the pressure exerted by a blunt needle
   (4) None of these
16. Which of the following is the force of attraction exists between objects ?
   (1) The inter molecular force of attraction
   (2) The force of buoyancy
   (3) The friction between planet and Sun
   (4) The force of attraction between objects is called the gravitational force.
17. Buoyant force on an object due to a fluid always acts:
   (1) in the downward direction
   (2) side ways
   (3) in the upper direction
   (4) None of these
18. A wooden cube floating in water supports a mass m = 0.2kg on its stop. When the mass is removed the cube rises by 2cm. The side of the cube is – (density of water $10^3 kg/m^3$)
   (1) 6 cm (2) 12 cm
   (3) 8 cm (4) 10 cm
19. A ball of relative density 0.8 fall into water from a height of 2m. The depth to which the ball will sink is –
   (1) 8 m (2) 2 m
   (3) 6 m (4) 4 m
20. Universal law of gravitation states that every object in the universe
   (1) Attracts every other object with a force
   (2) The force of attraction is proportional to the product of their masses
   (3) The force is inversely proportional to the square of the distance between them
   (4) All of these
21. Iron nail sinks in water because :
   (1) weight of nail is less than the buoyant force acting on it due to water
   (2) weight of nail is equal to the buoyant force acting on it due to water
   (3) weight of nail is greater than the buoyant force acting on it due to water
   (4) weight of nail increases in the water
22. When an object is made to float in two different liquids of density d_1 and d_2 , the lengths of the object seen above the liquid surface are l_1 and l_2 respectively. Which of the following is the correct alternative?
   (1) $d_2 > d_1$, if $l_1 > l_2$
   (2) $d_1 > d_2$, if $l_2 > l_1$
   (3) $d_1 < d_2$, if $l_2 > l_1$
   (4) $d_2 < d_1$, if $l_2 > l_1$
23. An object just foats in water. If common salt is added into the water
   (1) the volume of the object immersed in the liquid decreases
   (2) the object sinks
   (3) the object first sinks and then floats up
   (4) cannot be determined
24. Kepler's laws governing the motion of planets are:
   (1) The orbit of a planet is an eclipse with the Sun at one of the foci
   (2) The line joining the planet and the Sun sweep equal areas in equal intervals of time
   (3) The cube of the mean distance of a planet (r) from the Sun is proportional to the square of its orbital period (T)
   (4) All of these
25. A substance floats in water, but sinks in coconut oil. The density of the substance
   (1) is less than the density of water
   (2) is greater than the density of oil
   (3) Both (1) and (2)
   (4) Cannot be decided from the given information
26. A nurse applies a force of 3.8 N to the syringe's piston of radius 0.9 cm. Find the increase in pressure of the fluid in the syringe?
   (1) 14.927 kPa (2) 469.13 Pa
   (3) 46.9 mPa (4) 422 Pa

27. A rectangular tank of 6 m long, 2 m broad and 2 m deep is full of water, the thrust acting on the bottom of the tank is:
(1) 23.52×10^4 N (2) 23.52 N
(3) 11.76×10^4 N (4) 3.92×10^4 N

28. According to Kepler, force acting on an orbiting planet is given by
(1) F = m g (2) F O < v^2 / r
(3) F = m g h (4) None of these

29. A solid cylinder of density 800 kg m^{-3} floats in water. The percentage volume of solid cylinder outside the water is :
(1) 10 (2) 80
(3) 50 (4) 20

30. Two stretched membranes of area 2 cm^2 and 3 cm^2 are placed in a liquid at the same depth. The ratio of the pressure on them is:
(1) 1 : 1 (2) 2 : 3
(3) 3 : 2 (4) $2^2 : 3^2$

31. A body weight 40 g in air. If its volume is 10 cc, in water it will weigh:
(1) 30 g (2) 40 g
(3) 50 g (4) data insufficient

32. Pick up the correct relationship
(1) Gravitational constant G = Fd^2 / M × m
(2) G = g M / R^2
(3) G = g
(4) All of these

33. The gravitational force between two objects is F. If masses of both objects are halved without changing distance between them, then the gravitational force would become
(1) F/4 (2) F/2
(3) F (4) 2 F

34. A boy is whirling a stone tied with a string in an horizontal circular path the string breaks, the stone
(1) will continue to move in the circular path
(2) will move along a straight line towards the centre of the circular path
(3) will move along a straight line tangential to the circular path
(4) will move along a straight line perpendicular to the circular path away from the boy

35. An object is put one by one in three liquids having different densities. The object floats with $\frac{1}{9}, \frac{2}{11}$ and $\frac{3}{7}$ parts of their volumes outside the liquid surface in liquids of densities d_1, d_2 and d_3 respectively. Which of the following statement is correct?
(1) $d_1 > d_2 > d_3$ (2) $d_1 > d_2 < d_3$
(3) $d_1 < d_2 > d_3$ (4) $d_1 < d_2 < d_3$

36. S.I. Unit of G is
(1) m s^{-2} (2) N m^2 kg^{-2}
(3) No unit (4) None of these

37. Two particles are placed at some distance. If the mass of each of the two particles is doubled, keeping the distance between them unchanged, the value of gravitational force between them will be
(1) $\frac{1}{4}$ times (2) 4 times
(3) $\frac{1}{2}$ times (4) unchanged

38. The weight of an object at the centre of the earth of radius R is
(1) zero
(2) infinite
(3) R times the weight at the surface of the earth
(4) $1/R^2$ times the weight at surface of the earth

39. A girl stands on a box having 60 cm length, 40 cm breadth and 20 cm width in three ways. In which of the following cases, pressure exerted by the brick will be
(1) maximum when length and breadth form the base
(2) maximum when breadth and width form the base
(3) maximum when width and length form the base
(4) the same in all the above three cases

40. Value of G is
(1) 9.8 m s^{-2}
(2) 6.673×10^{-11} N m^2 kg^{-2}
(3) 6.673 N
(4) 9.8 N

41. An apple falls from a tree because of gravitational attraction between the earth and apple. If F_1 is the magnitude of force exerted by the earth on the apple and F_2 is the magnitude of force exerted by apple on earth, then
(1) F_1 is very much greater than F_2
(2) F_2 is very much greater than F_1
(3) F_1 is only a little greater than F_2
(4) F_1 and F_2 are equal

42. If upthrust U is equal to $\frac{1}{4}$ th the weight of the object in air, then the weight felt in the liquid is
(1) $\frac{1}{4}$ W (2) $\frac{3}{4}$ W
(3) $\frac{1}{2}$ W (4) 2W

43. Variation of g with distance r from the centre of earth with ($r > R_e$) is best given as
(1) $g \propto \frac{1}{r}$ (2) $g \propto \frac{1}{r^2}$
(3) $g \propto r$ (4) $g \propto r^2$

44. Gravitational force between the earth and an object on the surface of earth is best given by the formula
(1) F = m g (2) F = g M / r^2
(3) F = G × M × m / d^2 (4) All of these

45. Four planets A, B, C and D made up of same material have radius of $\frac{r}{2}$, r, $2r$ and $4r$ respectively. The order of the planets in increasing order of the acceleration due to gravity (on their surface) is
(1) A, B, C, D (2) B, C, D, A
(3) A, C, B, D (4) D, C, B, A

46. A mass weighing W can float if the upthrust U is related as
(1) $U > W$ (2) $U = W$
(3) $U < W$ (4) $U \geq W$

47. In a tank having 'h' height of liquid, two points at a depth $\frac{3h}{4}$ from free surface have pressures P_A and P_B. When the point A is more closer to the wall than B. Then
(1) $P_A > P_B$ (2) $P_A < P_B$
(3) $P_A = P_B$ (4) Depends on density

48. Universal law of gravitation explains the phenomenon
(1) The force that binds us to the earth
(2) The motion of the moon around the earth or planets around the Sun
(3) The tides due to the moon and the Sun
(4) All of the these

49. The least value of apparent weight of a body in a fluid is
(1) > 0
(2) = 0
(3) < 0
(4) depends on the density of solid and fluid

50. A heavy cylinder of length 1 is slowly taken out of a dense liquid. The weight felt as it is taken out of the liquid.
(1) will remain the same
(2) increases as it comes out
(3) decreases as it comes out
(4) increases till it attains the weight in air

51. An empty closed drum and a filled drum of same dimension will bring
(1) same upthrust (2) same volume
(3) both (1) and (2) (4) neither (1) nor (2)

52. Acceleration due to gravity for objects on or near the surface of the earth is represented as
(1) $g = G M / R^2$ (2) $g = G M m / d^2$
(3) Both (1) and (2) (4) Neither (1) nor (2)

53. Upthrust varies as a body comes out of the liquid as
A : It depends on immersed volume alone
B : Volume = Cross-section area × Length
Then
(1) Only A is correct
(2) Only B is correct
(3) Both A and B are correct
(4) Neither A nor B is correct

54. An earth-like planet has a radius equal to double the earth's radius. The acceleration due to gravity on its surface will be
(1) g (2) $\frac{g}{2}$
(3) $2g$ (4) g^2

55. If the weight of an object in air and a dense liquid and W_a and W_l respectively, then upthrust
(1) $W_a - W_l$ (2) $U = W_l + W_a$
(3) $U = W_l - W_a$ (4) $U = 2W_l$

56. The value of g becomes
(1) greater at the poles than at the equator
(2) greater at the equator than at the North Pole
(3) greater at the equator than at the South Pole
(4) zero at the equator

57. To find the density of a liquid, a student used the following steps. The sequence of steps followed is given. Identify the wrong step.
A : Collected displaced volume of water to know the volume V of immersed body.
B : Found the weight (W) of the body in air
C : Found the weight W_l of the body in water when immersed completely.
D : Found $\frac{V}{W}$ to get the result
(1) A (2) B
(3) C (4) D

58. Three equal masses are placed at the corners of an equilateral triangle. Each mass in this arrangement will have
(1) two gravitational forces of attraction
(2) the net gravitational force on each is not on the line joining them
(3) both (1) and (2)
(4) only (1)

59. Four students A, B, C and D find the acceleration due to gravity at the top of Ooty, Nainital, Mount Everest and Shimla. The acceleration due to gravity is the least
(1) at Ooty since it is the highest
(2) at Mount Everest as it is the highest
(3) at Nainital as only latitude has the effect and not height of the peak.
(4) at Shimla as it is the coldest

60. Value of g is taken as
(1) Positive for acceleration during free fall
(2) Negative when the objects are thrown upwards
(3) Positive in both cases
(4) Only (1) and (2)

61. An object is thrown upwards and rises to the height of 10 m, which of the following is not correct.
(1) Initial velocity = 14 ms^{-1}
(2) Final velocity = 0 ms^{-1}
(3) Time taken to reach the highest point = 1.43 s
(4) Acceleration of the object = + 9.8 ms^{-2}

62. The weight of an object is the
(1) Mass of the object
(2) Force with which it is attracted towards the earth
(3) Product of its mass and acceleration due to gravity
(4) Only (2) and (3)

63. Weight on object weighing 10 kg on earth will become
(1) $1/6^{th}$ on the moon (2) $W_m = G M m / R_m^2$
(3) 98 N on moon (4) All of these

64. The force acting on an object perpendicular to the surface is called
(1) buoyancy (2) thrust
(3) surface Tension (4) None of these

65. Pressure is
(1) Thrust per unit area (2) Measured in N m^{-2}
(3) Measured in Pascal (4) All of these

66. Buoyant force is
(1) the upward force exerted by a liquid on an object
(2) known as up thrust
(3) force exerted by an object on the liquid
(4) Only (1) and (2)

67. Magnitude of the buoyant force depends on
(1) mass of the object (2) mass of the fluid
(3) density of the fluid (4) weight of the object

68. Select the correct statement :
(1) Objects of density less than that of a liquid will float on the liquid.
(2) Objects of density more than that of a liquid will sink in the liquid.
(3) Both (1) and (2)
(4) None of these

69. Archimedes principle states that :
(1) When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.
(2) When a body is floating on a liquid, it experiences a down ward force that is equal to the weight of the fluid under it
(3) When a body is immersed in a fluid, it experiences an upward force that is equal to the difference in their weights
(4) All are true

70. Relative density of a substance
(1) is described as the ratio of the density of a substance to that of air
(2) is described as the ratio of the density of a substance to that of water
(3) does not have any unit
(4) Both (2) and (3)

Exercise 2

Matching Based MCQ

DIRECTIONS (Qs. 1 to 6) : Match Column-I with Column-II and select the correct answer using the codes given below the columns.

1.

	Column -I		Column -II
(A)	Acceleration due to gravity	(p)	kg
(B)	Mass	(q)	ms^{-2}
(C)	Weight	(r)	$Nm^2 kg^{-2}$
(D)	Gravitational constant	(s)	Nm^{-2}
(E)	Pressure	(t)	Newton

(1) (A) – (q); (B) – (p); (C) – (t); (D) – (s); (E) – (r)
(2) (A) – (q); (B) – (p); (C) – (r); (D) – (t); (E) – (s)
(3) (A) – (q); (B) – (p); (C) – (t); (D) – (r); (E) – (s)
(4) (A) – (p); (B) – (q); (C) – (t); (D) – (r); (E) – (s)

2.

	Column -I		Column -II
(A)	Body sink	(p)	$\rho = d$
(B)	Fully submerged	(q)	$\rho > d$
(C)	Partly submerged	(r)	$\rho < d$
(D)	Body float	(s)	$\rho \leq d$

(1) (A) – (q); (B) – (p); (C) – (r); (D) – (s)
(2) (A) – (p); (B) – (q); (C) – (r); (D) – (s)
(3) (A) – (q); (B) – (r); (C) – (p); (D) – (s)
(4) (A) – (q); (B) – (p); (C) – (s); (D) – (r)

3.

	Column -I		Column -II
(A)	Sucking of a cold drink using a straw	(p)	Archimede's principle
(B)	Fish weighs less in water than in air	(q)	Laws of floatation
(C)	Relative density of solids	(r)	Upthrust
(D)	Hydrometer	(s)	Atmospheric pressure

(1) (A) – (r); (B) – (s); (C) – (p); (D) – (q)
(2) (A) – (s); (B) – (r); (C) – (p); (D) – (q)
(3) (A) – (s); (B) – (p); (C) – (r); (D) – (q)
(4) (A) – (s); (B) – (r); (C) – (q); (D) – (p)

4.

	Column -I		Column -II
(A)	Wobbling	(p)	Water
(B)	Relative density	(q)	Same as on the earth in any planet
(C)	Value of G	(r)	9.8 newton
(D)	Weight of 1 kg	(s)	Presence of numerous invisible celestial objects.

(1) (A) – (p); (B) – (q); (C) – (r); (D) – (s)
(2) (A) – (s); (B) – (r); (C) – (q); (D) – (p)
(3) (A) – (p); (B) – (s); (C) – (r); (D) – (q)
(4) (A) – (s); (B) – (p); (C) – (q); (D) – (r)

5.

	Column -I		Column -II
(A)	Archimede's	(p)	Weight
(B)	Pressure in a liquid	(q)	Volume of immersed body
(C)	Apparent weight	(r)	Density of liquid
(D)	Feeling lighter	(s)	Volume of liquid

(1) (A) – (q); (B) – (p); (C) – (r); (D) – (s)
(2) (A) – (r); (B) – (s); (C) – (p); (D) – (q)
(3) (A) – (p); (B) – (s); (C) – (r); (D) – (q)
(4) (A) – (s); (B) – (p); (C) – (q); (D) – (r)

6.

	Column -I		Column -II
(A)	Jumping from a boat	(p)	No overflow
(B)	Throwing hands in front	(q)	Move from equator to poles
(C)	Increase in g	(r)	Move a boat without rowing
(D)	Ice floating on water at brim	(s)	Boat displaces in the opposite direction

(1) (A) – (r); (B) – (s); (C) – (p); (D) – (q)
(2) (A) – (s); (B) – (p); (C) – (r); (D) – (q)
(3) (A) – (s); (B) – (r); (C) – (q); (D) – (p)
(4) (A) – (p); (B) – (q); (C) – (r); (D) – (s)

Statement Based MCQ

7. Consider the following statements :
   (a) Copernicus discovered that the earth moves around the sun.
   (b) An astronaut cannot use a straw to sip a drink on the surface of the moon.
   (c) The S.I. unit of weight is kilogram.
   Which of these statement(s) is/are correct ?
   (1) (a) and (b) (2) (a) and (c)
   (3) (b) and (c) (4) All are correct
8. Consider the following statements :
   (a) Weightlessness experienced while orbiting the earth in a spaceship is the result of zero gravity.
   (b) All freely falling bodies are weightless.
   Which of these statement(s) is/are correct ?
   (1) (a) only (2) (b) only
   (3) Both (a) and (b) (4) Neither (a) nor (b)
9. Consider the following statements :
   (a) The acceleration due to gravity of moon is equal to that of the earth.
   (b) The value of G is independent of the nature, size and mass of the interacting bodies.
   Which of these statement(s) is/are correct ?
   (1) (a) only (2) (b) only
   (3) Both (a) and (b) (4) Neither (a) nor (b)
10. Consider the following statements :
   (a) A dam for storing water is made thinner at the bottom then at the top.
   (b) The ratio of buoyant forces experienced by a solid body when immersed in two liquids whose relative densities are 1 and 0.5 respectively is 2 : 1.
   (c) The buoyancy of an object depends both on the material and shape of the object.
   Which of these statement(s) is/are correct ?
   (1) (a) and (b) (2) (a) and (c)
   (3) Only (b) (4) Only (c)
11. Consider the following statements :
   (a) SI unit of thrust is newton (N).
   (b) A man sitting in a boat which is floating on a pond. If the man drinks some water from the pond, the level of the water in the pond decreases.
   Which of these statement(s) is/are correct ?
   (1) (a) only (2) (b) only
   (3) Both (a) and (b) (4) Neither (a) nor (b)
12. Consider the following statements :
   (a) The objects appear to be more heavy when submerged in water than they are in air.
   (b) A needle place carefully on the surface of water may float, whereas a ball of the same material will always sink.
   Which of these statement(s) is/are correct ?
   (1) (a) only (2) (b) only
   (3) Both (a) and (b) (4) Neither (a) nor (b)
13. Consider the following statements :
   (a) When the masses and the separation between them are tripled the force of attraction remains the same.
   (b) Upthrust on a body depends on the acceleration due to gravity, density of the liquid and the volume of the body immersed in the liquid.
   (1) Both '(a)' and '(b)' are true statements
   (2) '(a)' is true but '(b)' is false
   (3) '(a)' is false but '(b)' is true
   (4) Both '(a)' and '(b)' are false
14. Consider the following statements :
   (a) When upthrust is greater than the weight, the body floats inside the liquid.
   (b) Gravitational force between two charges can be attractive or repulsive.
   (c) Two equal masses separated by a distance experience F newton of force. On placing an equal mass at the mid-point the force becomes half.
   (1) '(a)', '(b)' and '(c)' all are true statements.
   (2) '(a)' is true, '(b)' is false and '(c)' is true statements.
   (3) '(a)', '(b)' and '(c)' all are false statements.
   (4) '(a)' is false, '(b)' is true and '(c)' is true statements.
15. Consider the following statements :
   (a) Acceleration due gravity at poles is greater than that at equator.
   (b) Weight of body at centre of the earth is zero.
   Which of these statement(s) is/are correct ?
   (1) (a) only (2) (b) only
   (3) Both (a) and (b) (4) Neither (a) nor (b)
16. Consider the following statements :
   (a) For a spherically symmetric earth, the acceleration due to gravity should be about the same at the equator and at the poles.
   (b) If earth suddenly stops rotating about its axis, then the value of g will be same at all the places.
   Which of these statement(s) is/are correct ?
   (1) (a) only (2) (b) only
   (3) Both (a) and (b) (4) Neither (a) nor (b)

Passage Based MCQ

DIRECTIONS (Qs. 17 to 22) : Read the passage(s) given below and answer the questions that follow.

PASSAGE - 1

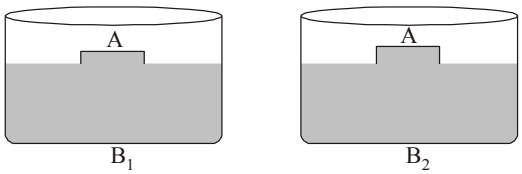
The quantity of matter contained in an object is called mass. It remains constant whether the object is on earth, moon or even in the outer space. Weight on the other hand is the force of attraction of earth with which an object is attracted towards the earth. Now, suppose a man weighs 600 N on earth, his weights on moon would be 100 N.

17. The mass of man on earth, if g is 10 m/s^2 is
   (1) 60 kg (2) 10 kg
   (3) 6000 kg (4) 1000 kg
18. The mass of man on moon is
   (1) 60 kg (2) 10 kg
   (3) 6000 kg (4) 1000 kg
19. Acceleration due to gravity on moon is
   (1) 10 m/s^2 (2) 9.8 m/s^2
   (3) 1.66 m/s^2 (4) 1 m/s^2

PASSAGE - 2

The upward force exerted by the water fluid on the body is known as upthrust or buoyancy. The magnitude of the buoyant force depends on the density of the fluid.

Wooden block – A



B_1 – Beaker with tap water

B_2 – Beaker with salty water

The buoyant force exerted in B_2 is more as compared to B_1. The object may float, sink or remain half submerged and half above water, the density of the fluid and object decides this.

– If the density of object is **less** than the fluid → it will **float** on the liquid.

– If the density of object is **more** than the fluid then it will **sink** in the liquid.

– If the density of object is same as the density of fluid, then it will half float and half sink.

20. The cork floats while the nail sinks in the water, this is due to
    (1) density of cork is more than nail
    (2) density of nail is more than cork
    (3) density of cork is less than the density of water
    (4) density of iron is less than the density of water
21. Buoyant force exerted by different fluids on a given body is
    (1) Same (2) Different
    (3) Zero (4) Negligible
22. Liquid A is denser than liquid *B*, a body of wood is dipped in both the liquids ? The buoyant force experience by the body in
    (1) liquid A is more (2) liquid B is more
    (3) liquid A is less (4) None of the above

Assertion Reason Based MCQ

DIRECTIONS (Qs. 23 to 28) : Following questions consist of two statements, one labelled as the **'Assertion'** and the other as **'Reason'**. You are to examine these two statements carefully and select the answer to these items using the code given below.

Code :

(1) Both A and R are individually true and R is the correct explanation of A:
(2) Both A and R are individually true but R is not the correct explanation of A.
(3) A is true but R is false
(4) A is false but R is true.

23. **Assertion :** The value of acceleration due to gravity does not depend upon mass of the body.
    Reason : Acceleration due to gravity is a constant quantity.
24. **Assertion :** When distance between two bodies is doubled and also mass of each body is also doubled, gravitational force between them remains the same.
    Reason : According to Newton's law of gravitation, force is directly proportional to mass of bodies and inversely proportional to distance between them.
25. **Assertion :** A person sitting in an artificial satellite revolving around the earth feels weightless.
    Reason : There is no gravitational force on the satellite.
26. **Assertion :** Whether the object is falling towards or moving away from earth, the direction of acceleration is always towards earth.
    Reason : The value of '*g*' is 9.8 m/s^2.
27. **Assertion :** The value of '*g*' is greater at the equator than at the poles.
    Reason : Radius is more at the equator than at the poles.
28. **Assertion :** Weight of a falling body of mass *m* is *mg*.
    Reason : Acceleration due to gravity reduces as one goes from the pole to the equator.

Correct Definition Based MCQ

29. Universal law of gravitation is
    (1) $F = \frac{GM \times m}{d}$ (2) $d^2G = \frac{M \times m}{F}$
    (3) $d^2 = G\frac{M \times m}{F}$ (4) $F = \frac{G \times M}{d^2 m}$
30. Weight of the body is
    (1) $m \times g$ (2) m/g
    (3) $m + g$ (4) $m - g$
31. Buoyancy is
    (1) tendency of fluid to exert an downward force on a body partly or totally immersed in it.
    (2) tendency of fluid to exert an upward force on a body partly or totally immersed in it.
    (3) tendency of fluid to exert an upward force on a body partly immersed in it.
    (4) tendency of fluid to exert an upward force on a body totally immersed in it.
32. Relative density of a substance is
    (1) $\frac{\text{Density of substance}}{\text{Density of water}}$
    (2) $\frac{\text{Density of substance}}{\text{Density of ethanol}}$
    (3) $\frac{\text{Density of water}}{\text{Density of substance}}$
    (4) $\frac{\text{Density of substance}}{\text{Density of ethanol and water mixture}}$

Feature Based MCQ

33. On the basis of following features identify the correct option.
(I) It is a scalar quantity.
(II) This quantity remains the same at all places.
(1) Mass (2) Weight
(3) Both (1) and (2) (4) Neither (1) nor (2)

34. On the basis of following features identify the correct option.
(I) It is measured in units of Nm^{-2}.
(II) Magnitude of this quantity is more for gases in comparison to liquids.
(1) Thrust (2) Pressure
(3) Both (1) and (2) (4) Neither (1) nor (2)

35. On the basis of following features identify the correct option.
(I) It is used for determination of relative density of substances.
(II) It is used for design of ships and submarines.
(1) Principle of floatation
(2) Archimede's principle
(3) Both (1) and (2)
(4) Neither (1) nor (2)

Hints & SOLUTIONS

Exercise 1

1. **(3)** **2.** **(3)** **3.** **(4)**

4. **(1)** The force that causes acceleration and keeps the body moving along the circular path is acting towards the center.

5. **(2)** **6.** **(1)** **7.** **(2)**

8. **(2)** The motion of the moon around the earth is due to the centripetal force.

9. **(1)** **10.** **(4)** **11.** **(3)**

12. **(2)** The centripetal force is provided to the satellite by the force of attraction of the Sun.

13. **(4)** **14.** **(4)** **15.** **(1)**

16. **(4)** The force of attraction between objects is called the gravitational force.

17. **(3)** **18.** **(4)** **19.** **(1)**

20. **(4)** Universal law of gravitation states that every object in the universe attracts every other object with a force, which is proportional to the product of their masses and inversely proportional to the square of the distance between them.

21. **(3)** **22.** **(3)** **23.** **(1)**

24. **(4)** Kepler's laws governing the motion of planets are:
(1) The orbit of a planet is an eclipse with the Sun at one of the foci
(2) The line joining the planet and the Sun sweep equal areas in equal intervals of time
(3) The cube of the mean distance of a planet (r) from the Sun is proportional to the square of its orbital period (T).

25. **(3)** **26.** **(1)** **27.** **(1)**

28. **(1)** According to Kepler, force acting on an orbiting planet is given by $F O < v^2 / r$.

29. **(4)** **30.** **(1)** **31.** **(1)**

32. **(1)** Gravitational constant $G = Fd^2 / M \times m$

33. **(1)** **34.** **(3)** **35.** **(4)**

36. **(2)** S.I. Unit of G is $N\ m^2\ kg^{-2}$

37. **(2)** **38.** **(1)** **39.** **(2)**

40. **(2)** Value of $G = 6.673 \times 10^{-11}\ N\ m^2\ kg^{-2}$

41. **(4)** **42.** **(2)** **43.** **(2)**

44. **(3)** Gravitational force between the earth and an object on the surface of earth is best given by the formula

$F = G \times M \times m / d^2$.

45. **(1)** **46.** **(2)** **47.** **(3)**

48. **(4)** Universal law of gravitation explains several unconnected phenomenon like the force that binds us to the earth, the motion of the moon around the earth or the planets around the Sun and also the formation of tides due to the moon and the Sun.

49. **(2)** **50.** **(4)** **51.** **(3)**

52. **(1)** Acceleration due to gravity for objects on or near the surface of the earth is represented as $g = G M / R^2$

53. **(3)** **54.** **(3)** **55.** **(1)**

56. **(1)** The value of g becomes greater at the poles than at the equator, because is not a perfect sphere.

57. **(3)** **58.** **(3)** **59.** **(2)**

60. **(4)** Value of g is taken as positive for acceleration during free fall and negative, if the objects are thrown upwards.

61. **(4)** An object is thrown upwards it is moving against the gravitation. So, the acceleration of the object is taken as negative. Using the equations of motion, calculate the values of u, v, and t.

62. **(4)** The weight of an object is the force with which it is attracted towards the earth. $W = mg$

63. **(4)** Weight on object weighing 10 kg on earth will become $1/6^{th}$ on the moon, i.e. 98 N. It is calculated by using the formula. $W_m = G M m / R_m^2$

64. **(2)** The force acting on an object perpendicular to the surface is called thrust.

65. **(4)** Pressure is the thrust per unit area. Its S.I. Unit is Pascal or $N\ m^{-2}$

66. **(4)** The upward force exerted by a liquid on an object is known as up thrust or buoyant force.

67. **(3)** Magnitude of the buoyant force depends on the density of the fluid.

68. **(3)** Objects of density less than that of a liquid will float on the liquid and the objects of density more than that of a liquid will sink in the liquid.

69. **(1)** Archimedes principle states that: when a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

70. **(4)** Relative density of a substance is described as the ratio of the density of a substance to that of water.

Exercise 2

1. **(3)** **2.** **(1)** **3.** **(2)**

4. **(4)** **5.** **(2)** **6.** **(3)**

7. **(1)** The weight of an object is the force on the object due to gravity. The unit of measurement for weight is that of force, which in the International System of Units (SI) is the newton.

8. **(3)**

9. **(2)** The acceleration due to gravity at moon is 1.62 m/s^2. This is approximately 1/6 that of the acceleration due to gravity on Earth, 9.81 m/s^2.

10. **(3)** **11.** **(3)**

12. **(2)** **Buoyancy** is an upward force exerted by a liquid, gas or other fluid, that opposes the weight of an immersed object.

13. **(1)** **14.** **(3)** **15.** **(3)**

16. **(2)** There is difference in acceleration due to gravity at equator and poles.The gravity is more on the poles due 2 factors:-

(1) the effect due to the angular rotation of earth is minimum or zero at poles.

(2) the earth is flatish towards the poles so g is more at poles.

17. **(1)** $W = m \times g$

$6000 = m \times 10$

$m = 60$ kg

18. **(1)** Mass remains same everywhere. So mass on moon = 60 kg

19. **(3)** $W = m \times g$

$100 = 60 \times g$

$g = 100/60 = 1.66\ m/s^2$

20. **(3)** **21.** **(2)** **22.** **(1)**

23 **(3)** The total (the apparent gravity) is about 0.5 percent greater at the poles than at the equator.

24. **(1)**

25 **(3)** There is only one main force acting on a satellite when it is in orbit, and that is the gravitational force exerted on the satellite by the Earth. This force is constantly pulling the satellite towards the centre of the Earth.

26. **(2)**

27 **(4)** The value of g is greater at poles in comparison to equator.

28. **(2)** **29.** **(3)** **30.** **(1)**

31. **(2)** **32.** **(1)** **33.** **(1)**

34. **(2)** **35.** **(2)**