Mass per unit volume is defined as density.

$$\rho = \lim_{\Delta v \to 0} \frac{dm}{dV} = \frac{dm}{dV} = \frac{m}{V}$$

Relative Density

It is defined as the ratio of the density of the given fluid to the density of pure water at 4°C. It is given by

$$= \frac{Density\ of\ given\ liquid}{Density\ of\ pure\ water\ at\ 4°C}$$

The density of water is maximum at 4°C and is equal to 1.0×10^3 kgm^{-3}.

Relative density is measured by hydrometer.

Pressure

If a uniform force is exerted normal to an area (A), then *average pressure (P_{av}) is defined as the normal force (F) per unit area.*

$$i.e.,\ P_{av} = \frac{F}{A}$$

In limiting sense, *pressure* The pressure exerted by liquid (density = Á) at depth 'h' below the surface of liquid, $p = h$ Á g.

SI unit: pascal (Pa), 1 Pa = 1 N/m^2

Practical units: atmospheric pressure (atm), bar and torr

1 atm = 1.01325×10^5Pa = 1.01325 bar = 760 torr = 760 mm of Hg column pressure.

Pascal's Law of Transmission of Fluid Pressure

Pascal's law is stated in following ways:

- The pressure in a fluid at rest is same at all the points if gravity is ignored.
- A liquid exerts equal pressures in all directions.
- If the pressure in an enclosed fluid is changed at a particular point, the change is transmitted to every point of the fluid and to the walls of the container without being diminished in magnitude.

Applications of Pascal's law: Hydraulic machines, lifts, presses and brakes, are based on the Pascal's law.

Atmospheric Pressure

Force exerted by air column on unit cross-section area of sea level is called atmospheric pressure (P_0)

$$P_0 = \frac{F}{A} = 101.3 kN/m^2$$

Barometer is used to measure atmospheric pressure which was **discovered by Torricelli.**
Atmospheric pressure varies from place to place and at a particular place from time to time.
Sudden fall in barometer reading is the indication of **storm**.

- **Slow fall** in barometre reading is the indication of **rain**.
- **Slow rise** in barometre reading is the indication of **clear weather**.
- Atmospheric pressure decreases with height or altitude. This is why- fountain pen leaks in aeroplane at height, cooking on the mountain is difficult, etc.

Buoyancy and Archimedes Principle

If a body is partially or wholly immersed in a fluid, it experiences an upward force due to the fluid surrounding it. This phenomenon of force exerted by fluid on the body is called **buoyancy** and force is called **buoyant force** or **upthrust**.
Archimedes' Principle: *It states that the buoyant force on a body that is partially or totally immersed in a fluid is equal to the weight of the fluid displaced by it.*

Bernoulli's Principle

When incompressible, non-viscous, irrotational liquid i.e., ideal liquid flow from one position to other in streamline path then in its path at every point, the sum of pressure energy, kinetic energy and potential energy per unit volume remains constant. Blowing of roofs by storms, sprayer action of carburetor, etc. are based on Bernoulli's principle.

Viscosity

The property of a fluid due to which it opposes the relative motion between its different layers is called viscosity (or fluid friction or internal friction) and the force between the layers opposing the relative motion is called **viscous force**.

Terminal Velocity

It is maximum constant velocity acquired by the body while falling freely in a viscous medium.

Surface Tension

The liquid surface behaves like a stretched elastic membrane which has a natural tendency to contract and tends to have a minimum possible surface area. This property of liquid is called surface tension.

$$\textit{Surface tension } T = \frac{\textit{Force } F}{\textit{Length } L}$$

Examples of surface tension

(i) Raindrops are spherical in shape.

(ii) The hair of a shaving brush cling together when taken out of water.

(iii) Oil spread on cold water but remains as a drop on hot water etc.

Surface tension of a liquid decreases with temperature and becomes zero at critical temperature.

Capillarity

A glass tube with fine bore and open at both ends is known as capillary tube. *The property by virtue of which a liquid rise or fall in a capillary tube is known as* ***capillarity***. Rise or fall of liquid in tubes of narrow bore (capillary tube) is called capillary action. Rise of kerosene in lanterns, rise of ink in fountain pen etc. are due to capillary action.

Exercise

DIRECTIONS : This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which only one is correct.

1. The force of gravitation between two bodies does not depend on:
   (a) their separation
   (b) the product of their masses
   (c) the sum of their masses
   (d) the gravitational constant
2. The acceleration due to gravity
   (a) has the same values everywhere in space
   (b) has the same value everywhere on the earth
   (c) varies with the latitude on the earth
   (d) is greater on the moon due to its smaller diameter
3. Newton's law of gravitation is applicable to
   (a) bodies of the solar system only
   (b) bodies on the earth
   (c) planets only
   (d) all bodies of the universe
4. The force that causes acceleration and keeps the body moving along the circular path is acting
   (a) towards the center
   (b) away from the center
   (c) along the tangent to the circular path
   (d) in the direction of circular motion
5. All bodies whether large or small fall with the
   (a) same force
   (b) same acceleration
   (c) same velocity
   (d) same momentum
6. Weightlessness experienced while orbiting the earth in a spaceship is the result of
   (a) zero gravity
   (b) inertia
   (c) acceleration
   (d) centre of gravity
7. When an object falls freely to the earth, the force of the gravity is
   (a) opposite to the direction of motion
   (b) in the same direction as that of motion
   (c) zero

(d) constant

8. The motion of the moon around the earth is due to
   (a) the centrifugal force
   (b) the centripetal force
   (c) Neither (a) nor (b)
   (d) Both (a) and (b)
9. The weight of a body at the centre of the earth is
   (a) zero
   (b) infinite
   (c) same as at other places
   (d) slightly greater than that at poles
10. The weight of an object
   (a) is the gravity of the matter it contains
   (b) refers to its inertia
   (c) is the same as its mass but expressed in different units
   (d) is the force with which it is attracted to the earth
11. In vacuum all freely falling objects
   (a) have the same speed
   (b) have the same velocity
   (c) have the same acceleration
   (d) have the same force
12. The centripetal force is provided to the planet by the
   (a) force of repulsion between the planet and the Sun
   (b) force of attraction of the Sun
   (c) heat energy of the Sun
   (d) All of these
13. At which of the following locations, the value of g is the largest?
   (a) On top of the Mount Everest
   (b) On top of Qutub Minar
   (c) At a place on the equator
   (d) A camp site in Antarctica
14. A ball is thrown vertically upwards. The acceleration due to gravity.
   (a) is in the direction opposite to the direction of its motion
   (b) is in the same direction as the direction of its motion
   (c) increases as it comes down
   (d) becomes zero at the highest point
15. Pressure exerted by a sharp needle on a surface is :

(a) more than the pressure exerted by a blunt needle
(b) less than the pressure exerted by a blunt needle
(c) equal to the pressure exerted by a blunt needle
(d) None of these

16. Which of the following is the force of attraction exists between objects ?
(a) The inter molecular force of attraction
(b) The force of buoyancy
(c) The friction between planet and Sun
(d) The force of attraction between objects is called the gravitational force.

17. Buoyant force on an object due to a fluid always acts:
(a) in the downward direction
(b) side ways
(c) in the upper direction
(d) 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 $10^3 kg/m^3$)
(a) 6 cm
(b) 12 cm
(c) 8 cm
(d) 10 cm

19. Universal law of gravitation states that every object in the universe
(a) Attracts every other object with a force
(b) The force of attraction is proportional to the product of their masses
(c) The force is inversely proportional to the square of the distance between them
(d) All of these

20. Iron nail sinks in water because :
(a) weight of nail is less than the buoyant force acting on it due to water
(b) weight of nail is equal to the buoyant force acting on it due to water
(c) weight of nail is greater than the buoyant force acting on it due to water
(d) weight of nail increases in the water

21. 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 1_1 and 1_2 respectively. Which of the following is the correct alternative?

(a) $d_2 > d_1$, if $1_1 > 1_2$
(b) $d_1 > d_2$, if $1_2 > 1_1$
(c) $d_1 < d_2$, if $1_2 > 1_1$
(d) $d_2 < d_1$, if $1_2 > 1_1$

22. An object just foats in water. If common salt is added into the water
(a) the volume of the object immersed in the liquid decreases
(b) the object sinks
(c) the object first sinks and then floats up
(d) cannot be determined

23. Kepler's laws governing the motion of planets are:
(a) The orbit of a planet is an eclipse with the Sun at one of the foci
(b) The line joining the planet and the Sun sweep equal areas in equal intervals of time
(c) The cube of the mean distance of a planet (r) from the Sun is proportional to the square of its orbital period (T)
(d) All of these

24. A substance floats in water, but sinks in coconut oil. The density of the substance
(a) is less than the density of water
(b) is greater than the density of oil
(c) Both (a) and (b)
(d) Cannot be decided from the given information

25. 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?
(a) 14.927 kPa
(b) 469.13 Pa
(c) 46.9 mPa
(d) 422 Pa

26. 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:
(a) 23.52×10^4 N
(b) 23.52 N
(c) 11.76×10^4 N
(d) 3.92×10^4 N

27. According to Kepler, force acting on an orbiting planet is given by
    (a) $F = mg$
    (b) $F O < v^2 / r$
    (c) $F = mgh$
    (d) None of these
28. 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:
    (a) 1 : 1
    (b) 2 : 3
    (c) 3 : 2
    (d) $2^2 : 3^2$
29. Pick up the correct relationship
    (a) Gravitational constant $G = Fd^2 / M \times m$
    (b) $G = gM / R^2$
    (c) $G = g$
    (d) All of these
30. 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
    (a) F/4
    (b) F/2
    (c) F
    (d) 2 F
31. A boy is whirling a stone tied with a string in an horizontal circular path the string breaks, the stone
    (a) will continue to move in the circular path
    (b) will move along a straight line towards the centre of the circular path
    (c) will move along a straight line tangential to the circular path
    (d) will move along a straight line perpendicular to the circular path away from the boy
32. 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?
    (a) $d_1 > d_2 > d_3$
    (b) $d_1 > d_2 < d_3$
    (c) $d_1 < d_2 > d_3$
    (d) $d_1 < d_2 < d_3$
33. S.I. Unit of G is

(a) $m\ s^{-2}$
(b) $N\ m^2\ kg^{-2}$
(c) No unit
(d) None of these

34. 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
(a) $\frac{1}{4}$ times
(b) 4 times
(c) $\frac{1}{2}$ times
(d) unchanged

35. The weight of an object at the centre of the earth of radius R is
(a) zero
(b) infinite
(c) R times the weight at the surface of the earth
(d) $1/R^2$ times the weight at surface of the earth

36. 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
(a) maximum when length and breadth form the base
(b) maximum when breadth and width form the base
(c) maximum when width and length form the base
(d) the same in all the above three cases

37. Value of G is
(a) $9.8\ m\ s^{-2}$
(b) $6.673 \times 10^{-11}\ N\ m^2\ kg^{-2}$
(c) 6.673 N
(d) 9.8 N

38. 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
(a) F_1 is very much greater than F_2
(b) F_2 is very much greater than F_1

(c) F_1 is only a little greater than F_2
(d) F_1 and F_2 are equal

39. 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
(a) $\frac{1}{4}$ W
(b) $\frac{3}{4}$ W
(c) $\frac{1}{2}$ W
(d) 2W

40. Gravitational force between the earth and an object on the surface of earth is best given by the formula
(a) F = m g
(b) $F = g M / r^2$
(c) $F = G \times M \times m / d^2$
(d) All of these

41. 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
(a) A, B, C, D
(b) B, C, D, A
(c) A, C, B, D
(d) D, C, B, A

42. Universal law of gravitation explains the phenomenon
(a) The force that binds us to the earth
(b) The motion of the moon around the earth or planets around the Sun
(c) The tides due to the moon and the Sun
(d) All of the these

43. The least value of apparent weight of a body in a fluid is
(a) > 0
(b) = 0
(c) < 0
(d) depends on the density of solid and fluid

44. 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.

(a) will remain the same
(b) increases as it comes out
(c) decreases as it comes out
(d) increases till it attains the weight in air

45. An empty closed drum and a filled drum of same dimension will bring
(a) same upthrust
(b) same volume
(c) both (a) and (b)
(d) neither (a) nor (b)

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

47. 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
(a) Only A is correct
(b) Only B is correct
(c) Both A and B are correct
(d) Neither A nor B is correct

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

49. The value of g becomes
(a) greater at the poles than at the equator
(b) greater at the equator than at the North Pole
(c) greater at the equator than at the South Pole
(d) zero at the equator

50. 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
(a) at Ooty since it is the highest
(b) at Mount Everest as it is the highest
(c) at Nainital as only latitude has the effect and not height of the peak.
(d) at Shimla as it is the coldest

51. Value of g is taken as
    (a) Positive for acceleration during free fall
    (b) Negative when the objects are thrown upwards
    (c) Positive in both cases
    (d) Only (a) and (b)
52. An object is thrown upwards and rises to the height of 10 m, which of the following is not correct.
    (a) Initial velocity = 14 ms^{-1}
    (b) Final velocity = 0 ms^{-1}
    (c) Time taken to reach the highest point = 1.43 s
    (d) Acceleration of the object = + 9.8 ms^{-2}
53. The weight of an object is the
    (a) Mass of the object
    (b) Force with which it is attracted towards the earth
    (c) Product of its mass and acceleration due to gravity
    (d) Only (b) and (c)
54. Weight on object weighing 10 kg on earth will become
    (a) $1/6^{th}$ on the moon
    (b) $W_m = G M m / R_m^2$
    (c) 98 N on moon
    (d) All of these
55. The force acting on an object perpendicular to the surface is called
    (a) buoyancy
    (b) thrust
    (c) surface Tension
    (d) None of these
56. Pressure is
    (a) Thrust per unit area
    (b) Measured in N m^{-2}
    (c) Measured in Pascal
    (d) All of these
57. Buoyant force is
    (a) the upward force exerted by a liquid on an object
    (b) known as up thrust
    (c) force exerted by an object on the liquid
    (d) Only (a) and (b)
58. Magnitude of the buoyant force depends on

(a) mass of the object
(b) mass of the fluid
(c) density of the fluid
(d) weight of the object

59. Select the correct statement :
(a) Objects of density less than that of a liquid will float on the liquid.
(b) Objects of density more than that of a liquid will sink in the liquid.
(c) Both (a) and (b)
(d) None of these

60. Archimedes principle states that :
(a) 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.
(b) 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
(c) When a body is immersed in a fluid, it experiences an upward force that is equal to the difference in their weights
(d) All are true

61. Relative density of a substance
(a) is described as the ratio of the density of a substance to that of air
(b) is described as the ratio of the density of a substance to that of water
(c) does not have any unit
(d) Both (b) and (c)

Hints & SOLUTIONS

1. **(c)**
2. **(c)**
3. **(d)**
4. **(a)** The force that causes acceleration and keeps the body moving along the circular path is acting towards the center.
5. **(b)**
6. **(a)**
7. **(b)**
8. **(b)** The motion of the moon around the earth is due to the centripetal force.
9. **(a)**
10. **(d)**
11. **(c)**
12. **(b)** The centripetal force is provided to the satellite by the force of attraction of the Sun.
13. **(d)**
14. **(a)**
15. **(a)**
16. **(d)** The force of attraction between objects is called the gravitational force.
17. **(c)**
18. **(d)**
19. **(d)** 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.
20. **(c)**
21. **(c)**
22. **(a)**
23. **(d)** Kepler's laws governing the motion of planets are:
    (a) The orbit of a planet is an eclipse with the Sun at one of the foci
    (b) The line joining the planet and the Sun sweep equal areas in equal intervals of time
    (c) The cube of the mean distance of a planet (r) from the Sun is proportional to the square of its orbital period (T).

24. **(c)**
25. **(a)**
26. **(a)**
27. **(a)** According to Kepler, force acting on an orbiting planet is given by $F O < v^2 / r$.
28. **(a)**
29. **(a)** Gravitational constant $G = Fd^2 / M \times m$
30. **(a)**
31. **(c)**
32. **(d)**
33. **(b)** S.I. Unit of G is $N\ m^2\ kg^{-2}$
34. **(b)**
35. **(a)**
36. **(b)**
37. **(b)** Value of $G = 6.673 \times 10^{-11}\ N\ m^2\ kg^{-2}$
38. **(d)**
39. **(b)**
40. **(c)** Gravitational force between the earth and an object on the surface of earth is best given by the formula

    $F = G \times M \times m / d^2$.
41. **(a)**
42. **(d)** 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.
43. **(b)**
44. **(d)**
45. **(c)**
46. **(a)** Acceleration due to gravity for objects on or near the surface of the earth is represented as $g = G M / R^2$
47. **(c)**
48. **(c)**
49. **(a)** The value of g becomes greater at the poles than at the equator, because is not a perfect sphere.
50. **(b)**
51. **(d)** Value of g is taken as positive for acceleration during free fall and negative, if the objects are thrown upwards.

52. **(d)** 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.

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

54. **(d)** 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. $W_m = G M m / R_m^2$

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

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

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

58. **(c)** Magnitude of the buoyant force depends on the density of the fluid.

59. **(c)** 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.

60. **(a)** 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.

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

Chapter 3

Work, Energy and Power

WORK

- In physics work is defined if force applied on object displaces the object in direction of force. We define the work as : Product of the force and displacement in the direction of applied force or product of displacement and force in the direction of displacement.

  W = Force × displacement (force in direction of displacement)

- The SI unit of force is a newton and the unit of length is a metre (m). So the SI unit of work is newton-meter which is written as Nm. This unit (Nm) is also called joule (J), i.e.

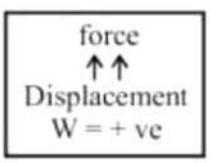
  1 joule = 1 newton . 1 metre

  Abbreviated, this is 1 J = 1 Nm

  When a force of 1 newton moves a body through a distance of 1 metre in its own direction the work done is 1 Joule.

- If displacement is in the direction of the force

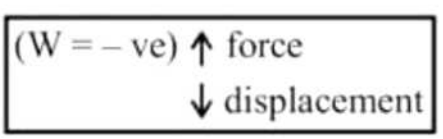
  $W = F \times S$



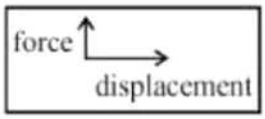
  When a horse pulls a cart, the applied force and the displacement are in the same direction. So, work done by the horse is positive.

- If displacement is in the direction opposite to the force.

  $W = -F \times S$



- If displacement is perpendicular to the force work done is zero.



Examples :

(i) A coolie with a luggage on his head, moving on a horizontal platform, does no work, since the direction of force is vertically up and displacement horizontal (even though he might feel physically tired).

(ii) If a boy tries to push a heavy boulder, by applying a force, but unable to displace it, then work done by the boy is zero.

- The energy may be defined as the capacity of a body to do work. The SI unit of energy is joule (*J*). Quite often, a bigger unit called kilo Joule (*kJ*) is used. Energy is a scalar quantity.

  1 kilo Joule = 1000 Joules

  or 1 kJ = 1000 J

ENERGY

- Energy is the capacity of doing work
- It is a scalar quantity,
- The SI unit is joule (i) same as of work.

  Forms of energy : The various forms include potential energy, kinetic energy, heat energy, chemical energy, and light energy.
- Energy possessed by a body by virtue of its state of motion is called Kinetic energy. Kinetic energy is always positive and is a scalar. The fact, that moving bodies carry energy with them is proved by some of the several happenings in day to day life.

  Kinetic Energy, $K = \frac{1}{2}mv^2$, when m is the mass and v is the velocity of body.

Examples :

(i) A stone thrown with some velocity, breaks the window pane.

(ii) A moving vehicle, when accidently happens to collide with another vehicle at rest or motion, leads to destruction.

- Potential energy is energy due to position. If a body is in a position such that if it were released it would begin to move, it has potential energy. There are two common forms of potential energy, gravitational and elastic.

(i) Gravitational Potential Energy (GP_E) : When an object is raised through a height work is said to be done on it against gravity. The energy possessed by such an object is called the gravitational potential energy.

(ii) Elastic Potential energy : This is a kind of potential energy which is due to a change in the shape of a body. The change in shape of a body can be brought about by stretching, compressing, bending and twisting the body. Some work has to be done to change the shape of a body. This work gets stored in the deformed body in the form of elastic potential energy.

- **Law of Conservation of Energy :** According to this law, energy can only be converted from one form to another: it can neither be created or destroyed. The total energy before and after the transformation remains the same. The law of conservation of energy is valid in all situations and for all kinds of transformations.

Some Equipments used to Transform Energy is given below

S. No.	Equipment	Energy Transformed
1.	Dynamo	Mechanical energy into electrical energy
2.	Candle	Chemical energy into light and heat energy
3.	Microphone	Sound energy into electrical energy
4.	Loud Speaker	Electrical energy into sound energy
5.	Solar Cell	Solar energy into electrical energy
6.	Electric Bulb	Electrical energy into light and heat energy
7.	Battery	Chemical energy into electrical energy
8.	Electric motor	Electrical energy into mechanical energy

- Let an object of mass, m be made to fall freely from a height, *h*. At the start, the potential energy is *mgh* and kinetic energy is zero because its velocity is zero. The total energy of the object is thus mgh. As it falls, its potential energy will change into kinetic energy. If v is the velocity of the object at a given instant, the kinetic energy would be $\frac{1}{2}mv^2$. As the fall of the object continues, the potential energy would decrease while the kinetic energy would increase. When the object is about to reach the ground, h = 0 and v will be the highest. Therefore, the kinetic energy would be the largest and potential energy the least. However, the sum of the potential energy and kinetic energy of the object would be the same at all points. That is, potential energy + kinetic energy = constant

  or $mgh + \frac{1}{2}mv^2$ = constant

  The sum of kinetic energy and potential energy of an object is its total mechanical energy.

POWER

- The time rate of doing work is defined as power (*P*). If equal works are done in different times,

power will be different. More quickly work is done, power will be more.

$$\text{Power} = \frac{\text{work}}{\text{time}}$$

- The unit of power is the joule per second and this is called the watt (*W*). When large amounts of power are involved, a more convenient unit is the kilowatt (kW) where 1 kW = 1000 W.

  1 Megawatt = 10^6 watt

  Power was also measured earlier in a unit called horse power. Even these days, the unit of horse power is in common use.

  1 horse power = 746 watt

  The unit kilowatt-hour means one kilowatt of power supplied for one hour. It is, therefore, the unit of energy.

  1 KWh = (1000 J/s) × 60 × 60s = 3.6×10^6 J

Exercise

DIRECTIONS : This section contains multiple choice questions. Each question has 4 choices (a), (b), (c) and (d) out of which only one is correct.

1. Which is not a unit of energy?
   (a) Watt second
   (b) Kilo watt hour
   (c) Watt
   (d) Joule
2. 1 kilowatt hour is equal to
   (a) 1 joule
   (b) 100 joule
   (c) 36 joule
   (d) 3.6×10^3 kilo joule
3. A stone of mass 1 kg is raised through 1m height
   (a) The loss of gravitational potential energy by the stone is 1 joule
   (b) The gain of gravitational potential energy by the stone is 1 joule
   (c) The loss of gravitational potential energy is 9.8 joule
   (d) The gain of gravitational potential energy is 9.8 joule
4. Scientific concept of work suggest that a work is said to be done if
   (a) a force acts on an object
   (b) the object must be displaced
   (c) energy must be consumed
   (d) Both (a) and (b)
5. The kinetic energy of a body will become eight times if –
   (a) its mass is made four times
   (b) its velocity is made four times
   (c) both the mass and velocity are doubled
   (d) both the mass and velocity are made four times
6. For a body falling freely under gravity from a height

(a) only the potential energy goes on increasing
(b) only the kinetic energy goes on increasing
(c) both kinetic energy as well as potential energy go on increasing
(d) the kinetic energy goes on increasing while potential energy goes on decreasing

7. Work done is defined as
(a) product of force and displacement
(b) distance through which the object is moved
(c) mass of the object getting displaced
(d) product of force and mass

8. The kinetic energy acquired by a body of mass 'm' after travelling a fixed distance from rest under the action of a constant force is
(a) directly proportional to mass m
(b) inversely proportional to mass m
(c) inversely proportional to mass $m^{1/2}$
(d) independent of mass m

9. If a force F is applied on a body and it moves with velocity v, the power will be –
(a) Fv
(b) F/v
(c) Fv^2
(d) F/v^2

10. The kinetic energy of a body becomes twice its initial value. The new momentum of the body will be
(a) 2 times
(b) $\sqrt{2}$ times
(c) 4 times
(d) unchanged

11. Unit of work done is
(a) Joule
(b) Newton meter
(c) Calorie
(d) Both (a) and (b)

12. Kinetic energy of a body moving with speed 10 m/s is 30J. If its speed becomes 30 m/s, its kinetic energy will be

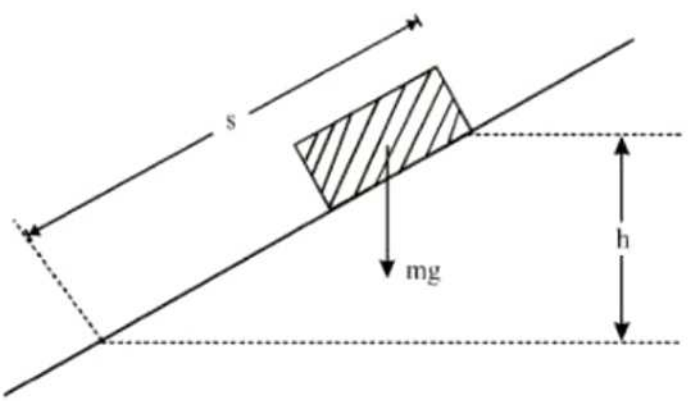
(a) 10 J
(b) 90 J
(c) 180 J
(d) 270 J

13. When you compress a coil spring you do work on it. The elastic potential energy
(a) increases
(b) decreases
(c) disappears
(d) remains the same

14. No work is done when
(a) a nail is plugged into a wooden board
(b) a box is pushed along a horizontal floor
(c) there is no component of force parallel to the direction of motion
(d) there is no component of force normal to the direction of force

15. Work done by a force can be
(a) only positive
(b) only negative
(c) both positive and negative
(d) None of these

16. The work done against gravity in moving the block a distance s up the slope is



(a) mh
(b) mgs
(c) ms
(d) mgh

17. Potential energy of your body is minimum when

(a) you are standing
(b) you are sitting on a chair
(c) you are sitting on the ground
(d) you lie down on the ground

18. A body of mass 2 kg is dropped from a height of 1 m. Its kinetic energy as it touches the ground is
(a) 19.6 N
(b) 19.6 J
(c) 19.6 kg
(d) 19.6 m

19. Negative value of work done indicates that
(a) force and displacement are in the same direction
(b) more than one force is acting on the object
(c) displacement and force are in opposite directions
(d) Both (b) and (c)

20. Work done is zero/when
(a) force and displacement of the body are in the same direction
(b) force and displacement of the body are in the opposite direction
(c) force acting on the body is perpendicular to the direction of the displacement of the body
(d) None of these

21. The energy of 4900 J was expanded in lifting a 50 kg mass. The mass was raised to a height of –
(a) 10 m
(b) 98 m
(c) 960 m
(d) 245000 m

22. When a stone is thrown upward to a certain height, it possesses
(a) potential energy
(b) kinetic energy
(c) wind energy
(d) sound energy

23. Capacity of doing work is termed as
(a) pressure
(b) energy
(c) force
(d) displacement

24. A fast wind can turn the blades of a windmill because it possesses –
    (a) potential energy
    (b) kinetic energy
    (c) chemical energy
    (d) heat energy
25. If a stone of mass m falls a vertical distance d, the decrease in gravitational potential energy is –
    (a) mg/d
    (b) $md^2/2$
    (c) mgd
    (d) md/g
26. A block of weight W is pulled a distance ℓ along a horizontal table. The work done by the weight is –
    (a) $W\ell$
    (b) 0
    (c) $Wg\ell$
    (d) $W\ell/g$
27. Unit of energy is
    (a) same as the unit of work
    (b) joule
    (c) Both (a) and (b)
    (d) Neither (a) nor (b)
28. The proper care and maintenance of machines require
    (a) to make them good rooking
    (b) for preserving them for future
    (c) for their efficient and longer use
    (d) None of these
29. Solar cookers are used
    (a) to cook our food
    (b) in artificial satellites
    (c) converting into electrical energy
    (d) in drying clothes and other materials
30. What is the sign of the work done by gravity on a man standing on a platform?
    (a) Zero
    (b) Positive
    (c) Negative
    (d) Depends on the particular situation
31. A body at rest can have –

(a) speed
(b) energy
(c) momentum
(d) velocity

32. What is the sign of the work performed on an object in uniform circular motion?
(a) Zero
(b) Positive
(c) Negative
(d) Depends on the particular situation

33. A constant force of 10 N causes a box to move at a constant speed of 2 m/s. How much work is done in 10 seconds?
(a) 200 J
(b) 50 J
(c) 10 J
(d) 2 J

34. An object of 2 kg is moving with a velocity of 5 m/s. If its velocity is doubled, the kinetic energy will become
(a) 100 J
(b) 25 J
(c) 200 J
(d) 2.5 J

35. A mass is kept stationary by an external force. All of the following are true except –
(a) the point of application of the force does not move
(b) no work is done on the mass
(c) there is no net force on the mass
(d) the external force may perform work on the mass

36. A bird flying in the sky has –
(a) K.E. only
(b) P.E. only
(c) neither K.E. nor P.E.
(d) both K.E. and P.E.

37. The sum of the change in kinetic and potential energy is always
(a) zero
(b) positive
(c) negative
(d) None of the above

38. A man of a mass 80 kg runs up a staircase in 12 seconds. Another man B of mass 60 kg runs

up the same staircase in 11 seconds. The ratio of powers of A and B is –

(a) 11 : 12
(b) 11 : 9
(c) 12 : 11
(d) 9 : 11

39. A lorry and a car moving with the same K.E. are brought to rest by applying the same retarding force, then –
(a) lorry will come to rest in a shorter distance
(b) car will come to rest in a shorter distance
(c) both come to rest in a same distance
(d) None of the above

40. A weight-lifter lifts 200 kg from the ground to a height of 2 metre in 9 second. The average power generated by the man is
(a) 15680 W
(b) 3920 W
(c) 1960 W
(d) 980 W

41. Gravitational potential energy of an object will
(a) increase by increasing the path along which the object is moved
(b) decrease by increasing the path along which the object is moved
(c) not effected by changing the path, provided the overall height is same
(d) None of these

42. Total mechanical energy of an object is
(a) Potential energy + Kinetic energy = Constant
(b) $mgh + \frac{1}{2} mv^2 = \text{constant}$
(c) Both (a) and (b)
(d) None of these

43. Rate of doing work is termed as
(a) force
(b) mechanical energy
(c) power
(d) momentum

44. 1 kilowatt = -----
(a) 1000 W
(b) 1000 J s^{-1}
(c) 1000 N m s^{-1}
(d) All of these

45. Commercial unit of power is kilowatt-hour (kW h)
    (a) 1 kW h = 3.6×10^6 J
    (b) 1 kW h is the energy consumed in one hour at the rate of 1000 Js^{-1}
    (c) 1 kW h = 1 unit of electrical energy
    (d) All these statements are correct
46. An electrical appliance of 500 W is used for 5 hours per day. Energy consumed in 30 days will be
    (a) 2.5 kW h
    (b) 25 kW h
    (c) 75 kW h
    (d) None of these
47. Sun is said to be the ultimate source of energy. Solar energy gets transformed into
    (a) chemical energy during photosynthesis
    (b) heat energy in drying food grains
    (c) electrical energy in solar cells
    (d) All of these
48. The potential energy of a freely falling object decreases progressively.
    (a) The law of conservation of energy is violated
    (b) Potential energy gets converted into kinetic energy progressively
    (c) Sum of Potential Energy and Kinetic Energy at any point during the free fall remains constant
    (d) Both (b) and (c)
49. When a freely falling object hits the ground, its kinetic energy is
    (a) Converted into heat energy
    (b) Used to form a crater in the ground
    (c) Collides and then rebounds
    (d) Any of the three are possible
50. If velocity of a body is twice of previous velocity, then kinetic energy will become –
    (a) 2 times
    (b) 1/2 times
    (c) 4 times
    (d) 1 times
51. If the K.E. of a body is increased by 300%, its momentum will increase by –

(a) 100%
(b) 150%
(c) $\sqrt{300}\%$
(d) 175%

52. A ball of mass 2 kg and another of mass 4 kg are dropped together from a 60 feet tall building. After a fall of 30 feet each towards earth, their respective kinetic energies will be in the ratio of –

(a) $\sqrt{2}:1$
(b) 1 : 4
(c) 1 : 2
(d) $1:\sqrt{2}$

53. A man of weight 60 kg wt. takes a body of mass 15 kg at a height 10m on a building in 3 minutes. The efficiency of mass is –

(a) 10%
(b) 20%
(c) 30%
(d) 40%