1 : Units and Measurement

I. Multiple Choice Questions

1. One of the combinations from the fundamental physical constants is hc / G. The unit of this expression is

   a) kg^2 b) m^3 c) s^{-1} d) m

2. If the error in the measurement of radius is 2% then the error in the determination of volume of the sphere will be

   a) 8 % b) 2% c) 4% d) 6%

3. If the length and time period of an oscillating pendulum have errors of 1% and 3% respectively, then the error in measurement of acceleration due to gravity is

   a) 4% b) 5% c) 6% d) 7%

4. The length of a body is measured as 3.51 m, if the accuracy is 0.01 m then the percentage error in the measurement is

   a) 351% b) 1% c) 0.28% d) 0.035%

5. Which of the following has the highest number of significant figures?

   a) 0.007 m^2 b) 2.64×10^{24} kg c) 0.0006032 m^2 d) 6..3200 J

6. If $\pi = 3.14$ then the value of π^2 is

   a) 9.8596 b) 9.860 c) 9.86 d) 9.9

7. Which of the following pairs of physical quantities have same dimension?

   a) force and power b) torque and energy
   c) torque and power d) force and torque

8. The dimensional formula of Planck's constant h is

   a) $[ML^2T^{-1}]$ b) $[ML^2T^{-3}]$ c) $[MLT^{-1}]$ d) $[ML^3T^{-3}]$

9. The velocity of a particle v at an instant t is given by $v = at + bt^2$. The dimensions of b is

   a) [L] b) $[LT^{-1}]$ c) $[LT^{-2}]$ d) $[LT^{-3}]$

10. The dimensional formula for gravitational constant G is

    a) $[ML^3T^{-2}]$ b) $[M^{-1}L^3T^{-2}]$ c) $[M^{-1}L^{-3}T^{-2}]$ d) $[ML^{-3}T^2]$

11. The density of a material in CGS system of units is 4 g cm^{-3}. In a system of units in which unit of length is 10 cm and unit of mass is 100 g, then the value of density of material will be

    a) 0.04 b) 0.4 c) 40 d) 400

12. If the force is proportional to square of velocity, then dimension of proportionality constant is

    a) $[MLT^0]$ b) $[MLT^{-1}]$ c) $[ML^{-2}T]$ d) $[ML^{-1}T^0]$

13. The dimension $\left(\mu_0 \epsilon_0\right)^{-1/2}$ is

    a) length b) time c) velocity d) force

14. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are taken as three fundamental constants. Which of the following combinations of these has the dimension of length?

a) $\frac{\sqrt{hG}}{c^{3/2}}$ b) $\frac{\sqrt{hG}}{c^{5/2}}$ c) $\frac{\sqrt{hc}}{G}$ d) $\sqrt{\frac{GC}{h^{3/2}}}$

15. A length–scale (l) depends on the permittivity (ε) of a dielectric material, Boltzmann constant (k_B), the absolute temperature (T), the number per unit volume (n) of certain charged particles, and charge (q) carried by each of the particles. Which of the following expression for l is dimensionally correct?

a) $l = \sqrt{\frac{nq^2}{\varepsilon k_B T}}$ b) $l = \sqrt{\frac{\varepsilon k_B T}{nq^2}}$ c) $l = \sqrt{\frac{q^2}{\varepsilon n^{\frac{2}{3}} k_B T}}$ d) $l = \sqrt{\frac{q^2}{\varepsilon n k_B T}}$

Answers :

1) a 2) d 3) d 4) c 5) d 6) c 7) b 8) a 9) d 10) b 11) c
12) d 13) c 14) a 15) b

Solutions :

1. A) Dimension of $\left[\frac{hc}{G}\right] = \frac{[ML^2T^{-1}][LT^{-1}]}{[M^{-1}L^3T^{-2}]} = [M^2]$. Unit is kg^2
2. d) $V = \frac{4}{3}\pi r^3$, $\frac{\Delta V}{V} x 100 = 3x\frac{\Delta r}{r} x 100 = 3x2\% = 6\%$
3. d) $g = \frac{\Delta\pi^2 l}{T^2}$, $\frac{\Delta g}{g} x100 = \frac{\Delta l}{l} x100 + 2x\frac{\Delta T}{T} x100 = 1\% + 2 \ x \ 3\% = 7\%$
4. c) Percentage error = $\frac{\Delta l}{l} x100\% = \frac{0.01}{3.51} x100\% = \frac{1}{3.51} = 0.284\%$
5. d) Significant figure of (0.007 m^2, 2.64 x 10^{24}kg, 0.0006032m^2 and 6.3200J) is (1,3,4 and 5)
6. c) π^2 = 3.14 x 3.14 = 9.8596. The result is to be corrected to 3 significant digits. Hence value π^2 = 9.86
7. b) Dimensions of torque and energy is $[ML^2T^{-2}]$
8. a) Dimensions of Planck's contant is $[ML^2T^{-1}]$
9. d) $v = at + bt^2$, $[LT^{-1}] = [a][T] + [b][T^2] = [LT^{-2}][T] + [LT^{-3}][T^2]$
Hence dimensions of b is $[LT^{-3}]$
10. b) Dimensional formula of gravitational constant is $[M^{-1}L^3T^{-2}]$
11. c) $n_1u_1 = n_2u_2$, $4\frac{g}{cm^3} = n_2\frac{100g}{(10cm)^3}$, $4 = \frac{n_2}{10}$, $n_2 = 40$
12. d) $F \propto v^2$, $F = Kv^2$, $[MLT^{-2}] = [K][LT^{-1}]^2 = [ML^{-1}T^0][L^2T^{-2}]$
Hence dimensions of k is $[ML^{-1}T^0]$

$[M^{-1}L^{3}T^{-2}]^{y}[M^{0}LT^{-1}]^{z}$ $([M^{0}L^{1}T^{0}] = [M^{x-y}L^{2x+3y+z}T$

Equating : $x - y = 0$ .... (1)

$2x + 3y + z = 1$ .... (2)

$-x - 2y - z = 0$ .... (3)

From (1) $x = y$ .... (4)

From(2) $2x + 3x + z = 1$, $5x + z = 1$ .... (5)

From (3) $-x - 2x - z = 0$, $-3x - z = 0$...... (6)

(5) + (6) $\Rightarrow 5x + z - 3x - z = 1$, $2x = 1$, $x = \frac{1}{2}$

$\therefore y = \frac{1}{2}$, $2x + 3y + z = 1$, $2x\frac{1}{2} + 3x\frac{1}{2} + z = 1$

$1 + \frac{3}{2} + z = 1$, $z = \frac{-3}{2}$

$\therefore l \propto h^{1/2}\ G^{1/2}\ c^{1/2}$, $l \propto \frac{\sqrt{hG}}{c^{3/2}}$

5. b) $F = \frac{1}{4\pi\varepsilon}\frac{q^2}{r^2}$, $\frac{\varepsilon}{q^2} = \frac{1}{4\pi\ Fr^2}$ Dimensions of $\frac{\varepsilon}{q^2} = \frac{1}{[MLT^{-2}L^{2}]} = \frac{1}{[ML^{3}T^{-2}]}$

$n = \frac{k}{V}$, $\frac{1}{n} = \frac{V}{k}$ Dimensions of $\frac{1}{n}$ is $[L^3]$

$\frac{1}{2}k_BT$ = kinetic energy E. Dimensions of k_BT is $[ML^2T^{-2}]$

$\therefore$ Dimensions of $\frac{\varepsilon k_B T}{nq^2}$ is $\frac{[L^3][ML^2T^{-2}]}{[ML^3T^{-2}]} = [L^2]$

Hence $l = \sqrt{\frac{\varepsilon k_B T}{nq^2}}$ is dimensionally correct

Creative Questions

1. SI system is considered superior to other systems because
   (a) of its permanence and reproduceability (b) it do not vary with time
   (c) it is coherent system of units (d) all the above
2. Red light has a wavelength of 7000 Å. In μm it is
   (a) 0.7 μm (b) 7 μm (c) 70 μm (d) 0.07 μm

3. A speck of dust weighs 1.6×10^{-10} kg. How many such particles would weigh 1.6 kg?
(a) 10^{-10} (b) 10^{10} (c) 10 (d) 10^{-1}

4. The force acting on a particle is found to be proportional to velocity. The constant of proportionality is measured in terms of
(a) kg s^{-1} (b) kg s (c) kg m s^{-1} (d) kg m s^{-2}

5. The mass of an electron is 9.11×10^{-31} kg. How many electrons would weigh 1 kg?
(a) 10.97×10^{30} (b) 1.097×10^{30} (c) 1097×10^{30} (d) 0.1097×10^{30}

6. Which of the following are equivalent?
(a) 6400 km and 6.4×10^{8} cm (b) 2×10^{4} cm and 2×10^{6} mm
(c) 800 m and 80×10^{2} m (d) 100 μm and 1 mm

7. How many significant figures are there in 30.00?
(a) 1 (b) 2 (c) 3 (d) 4 (AIIMS 1999)

8. If $\pi = 3.14$ the value of π^2 correct to significant figures is
(a) 9.86 (b) 9.85 (c) 9.8596 (d) 9.859

9. The number of significant figures of 23.023, 0.0003 and 2.1×10^{-3} are respectively
(a) 4, 4 and 2 (b) 5, 1 and 2 (c) 5, 1 and 5 (d) 5, 5 and 2 (AIEEE 2010)

10. The number of significant digits in 0.0006032 is
(a) 8 (b) 7 (c) 4 (d) 2

11. The length of a body is measured as 3.51 m. If the accuracy is 0.01 m, then the percentage error in the measurement is
(a) 351% (b) 1% (c) 0.28 % (d) 0.035%

12. If the error in the measurement of radius of sphere is 2% then the error in the determination of volume of the sphere will be
(a) 2% (b) 4% (c) 6% (d) 8% (AIPMT 2008)

13. The density of the material of a cube is measured by measuring its mass and length of its side. If the maximum errors in the measurement of mass and the length are 3% and 3% respectively, the maximum error in the measurement of density is
(a) 7% (b) 9% (c) 12% (d) 13% (AIPMT 1996)

14. Percentage errors in the measurement of mass and speed are 2% and 3% respectively. The error in the estimate of kinetic energy obtained by measuring mass and speed will be
(a) 12% (b) 10% (c) 8% (d) 2% (AIPMT 1995)

15. If $f = x^2$ then the relative error in f is
(a) $\frac{\Delta x}{x}$ (b) $(\Delta x)^2$ (c) $\frac{2\Delta x}{x}$ (d) $\frac{(\Delta x)^2}{x}$ (IIT 1991)

16. If error in measurement of radius of sphere is 1% what will be the error in measurement of volume?
(a) 1% (b) 1/3 % (c) 3% (d) 10% (AFMC 2005)

17. If g is the acceleration due to gravity, the quantity ½ gt^2 has the dimensions of
(a) distance (b) velocity (c) acceleration (d) force

18. The velocity of a body is expressed as $v = \frac{x}{t} + yt$. The dimensional formula for x is
(a) ML^oT^o (b) M^oLT^o (c) M^oL^oT (d) MLT^o

19. The dimensional formula for Planck's constant is
(a) MLT (b) ML^3T^2 (c) ML^oT^4 (d) ML^2T^{-1}

20. .... have the same dimensional formula
(a) Force and momentum (b) Stress and strain
(c) Density and linear density (d) Work and potential energy

21. The dimensional formula for gravitational constant is
(a) $M^1L^3T^{-2}$ (b) $M^{-1}L^3T^{-2}$ (c) $M^{-1}L^{-3}T^{-2}$ (d) $M^1L^{-3}T^{-2}$

22. Pressure gradient has the same dimensions as that of (AFMC 2004)
(a) velocity gradient (b) potential gradient (c) energy gradient (d) none of these

23. Which of the following sets have different dimensions? (IIT 2005)
(a) Pressure, Young's modulus, stress
(b) E.M.F., potential difference, electric potential
(c) Heat, work done, energy (d) Dipole moment, electric flux, electric field

24. The physical quantities not having the same dimensions are (AIEEE 2003)
(a) torque and work (b) speed and $1/\mu_o\varepsilon_o$
(c) momentum and Planck's constant (d) stress and Young's modulus

25. If the dimensions of a physical quantity are given by $M^aL^bT^c$, then the physical quantity will be (AIPMT 2009)
(a) velocity , if a = 1, b = 0 and c = -1 (b) acceleration , if a = 1, b = 1 and c = -2
(c) force , if a = 0, b = -1 and c = -2 (d) pressure , if a = 1, b = -1 and c = -2

26. Which of the following pair does not have similar dimensions? (AIIMS 2001)
(a) stress and pressure (b) angle and strain
(c) tension and surface tension (d) Planck's constant and angular momentum

27. The dimension of Planck's constant equals to that of (AIPMT 2001)
(a) energy (b) momentum (c) angular momentum (d) power

28. Which one of the following groups have quantities that do not have the same dimensions? (AIPMT 2000)
(a) velocity, speed (b) pressure, stress (c) force, impulse (d) work, energy

29. The dimensions of impulse are same as that of (AIPMT 1996)
(a) linear momentum (b) angular momentum (c) pressure (d) force

30. The dimensional formula for impulse is (AIPMT 1991)
(a) MLT^{-2} (b) MLT^{-1} (c) ML^2T^{-1} (d) M^2LT^{-2}

31. Identify the pair whose dimensions are equal (AIEEE 2002)
(a) torque and work (b) stress and energy
(c) force and stress (d) force and work

32. Out of the following pair, which one does not have identical dimensions is
(a) Moment of inertia and moment of a force (b) Work and torque (AIEEE 2005)
(c) Angular momentum and Planck's constant (d) Impulse and momentum

33. Dimensions of $\frac{1}{\mu_o \varepsilon_o}$ where symbols have their usual meanings are: (AIEEE 2003)
(a) $[L^{-1}T]$ (b) $[L^2T^2]$ (c) $[L^2T^{-2}]$ (d) $[LT^{-1}]$

34. The ratio of the dimensions of Planck's constant and that of the moment of inertia is the dimension of (AIPMT 2005)
(a) time (b) frequency (c) angular momentum (d) velocity

35. A student measured the diameter of a small steel ball using a screw gauge of least count 0.01 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of – 0.004 cm, the correct diameter of the ball is:- (NEET 2018)
(a) 0.521 cm b) 0.525 cm c) 0.053 cm d) 0.529 cm

Answers :

1 (d)	2 (a)	3 (b)	4 (a)	5 (b)	6 (a)	7 (d)	8 (a)	9 (b)	10 (c)	11 (c)
12 (c)	13 (d)	14 (c)	15 (c)	16 (c)	17 (a)	18 (b)	19 (d)	20 (d)	21 (b)	22 d)
23 (d)	24 (b)	25 (d)	26 (c)	27 (c)	28 (c)	29 (a)	30 (b)	31 (a)	32 (a)	33 (c)
34 (b)	35 (d)									

Solutions :

2. (a) $7000\ Å = 7000 \times 10^{-10}m = 0.7 \times 10^{-6}m = 0.7\ \mu m$

3. (b) $n = \frac{1.6 kg}{1.6 \times 10^{-10} kg} = 10^{10}$

4. (a) $F \propto v$, $F = Kv$, $K = \frac{F}{v} = \frac{kg\,ms^{-2}}{ms^{-1}} = kg\ s^{-1}$

5. (b) $\frac{1kg}{9.11 \times 10^{-31}kg} = \frac{10 \times 10^{30}}{9.11} = 1.097 \times 10^{30}$

6. (a) $6400\ km = 6400 \times 10^3 m = 6400 \times 10^3 \times 10^2 cm = 6.4 \times 10^8 cm$

11. (c) $\frac{0.01 \times 100\%}{3.51} = \frac{100\%}{351} = 0.28\%$

12. (c) $V = \frac{4}{3}\pi r^3$, $\frac{\Delta V}{V} \times 100 = 3\frac{\Delta r}{r} \times 100 = 3 \times 2\% = 6\%$

13. (d) $\rho = \frac{m}{V} = \frac{m}{l^3}$, $\frac{\Delta \rho}{\rho} \times 100 = \frac{\Delta m}{m} \times 100 + 3\frac{\Delta l}{l} \times 100 = 4\% + 3 \times 3\% = 13\%$

Creative Questions

1. What determines the nature of the path followed by the particle?
   a) speed b) velocity c) acceleration d) both velocity and acceleration
2. The displacement of a particle can have
   a) positive value b) zero value c) negative value d) all the above
3. If the displacement of a particle is zero, then what can we say about its distance covered?
   a) It must be zero b) it cannot be zero
   c) it is negative d) it may or may not be zero
4. The condition for the distance and displacement of a moving object to be equal is when the body moves along a
   a) circle b) parabola c) straight line d) hyperbola
5. The speed of a particle is
   a) always positive b) can be negative
   c) can be both positive or negative d) always negative
6. The magnitude of velocity and speed of an object are equal when the body moves along a
   a) straight line b) parabola c) circle d) hyperbola
7. The numerical ratio of velocity to speed is
   a) less than 0 b) less than 1
   c) either greater than or equal to 1 d) either less than or equal to 1
8. Which of the following changes, when a particle is moving with uniform velocity?
   a) speed b) velocity c) acceleration d) position vector
9. If the time-displacement graph of a particle is parallel to the time axis, the velocity of particle is
   a) zero b) infinity c) variable d) equal to its acceleration numerically
10. Two bodies are moving in opposite direction with speed v. What is the magnitude of their relative velocity?
    a) 0 b) v c) v / 2 d) 2v
11. A train of 150 m length is going towards north direction at a speed of 10 ms^{-1}. A parrot flies at a speed of 5 ms^{-1} towards south direction parallel to the railway track. The time taken by the parrot to cross the train is equal to (AIPMT 1992)
    a) 12 s b) 8 s c) 15 s d) 10s
12. The displacement of particle is given by $x = a_0 + \frac{a_1 t}{2} - \frac{a_2 t^2}{3}$. What is its acceleration? (AFMC 2006)
    a) $2a_2/3$ b) $-2a_2/3$ c) a_2 d) zero
13. The displacement of a body is given to be ...

a) increasing with time b) decreasing with time c) constant but not zero d) zero

14. A moving body is covering distances in proportion to the square of time along a straight line. The acceleration of the body is

a) increasing b) decreasing c) zero d) constant

15. The displacement of a particle along a straight line at time t is given by $x = a_0 + a_1 t + a_2 t^2$ where a_0, a_1 and a_2 are constants. The acceleration of the particle is (AFMC 1999)

a) a_0 b) a_1 c) a_2 d) $2a_2$

16. The acceleration of a moving body can be found from:

a) area under velocity-time graph b) area under distance-time graph

c) slope of the velocity-time graph d) slope of the distance-time graph

17. The slope of the velocity-time graph for retarded motion is

a) positive b) negative c) zero d) cannot be predicted

18. The distances travelled by a body falling freely from rest in the first, second and third second are in the ratio (AIPMT 1991)

a) 1: 2: 3 b) 1: 3: 5 c) 1: 4: 9 d) none of the above

19. A body is released from the top of a tower of height *h* metre. It takes *t* second to reach the ground. Where is the ball at time t / 2 second?

a) At h / 2 metre from the ground b) At h / 4 metre from the ground

c) At 3 h / 4 metre from the ground

d) Depends upon the mass and volume of the ball

20. A particle moves along X-axis in such a way that its coordinate *x* varies with time *t* according to the expression $x = 2 - 5t + 6t^2$. The initial velocity of the particle is (IIT 1987)

a) $-5\ ms^{-1}$ b) $-3\ ms^{-1}$ c) $6\ ms^{-1}$ d) $3\ ms^{-1}$

21. A body moving with a constant speed on a horizontal surface does not have

a) velocity b) momentum c) kinetic energy d) acceleration (CET 1999)

22. If a particle is moving with a constant speed along a straight line, we do not require a force to (KERALA 1990)

a) decrease its momentum b) change the direction

c) increase its speed d) keep it moving with uniform velocity

23. A graph is drawn with force along Y-axis and time along X-axis. The area under the graph represents (KERALA 1990)

a) momentum b) couple c) moment of the force d) impulse of the force.

24. A bird weighs 2 kg and is inside a cage of 1 kg. If it starts flying, then the weight of the bird and cage assembly is (AFMC 1997)

a) 4 kg b) 3 kg c) 2.5 kg d) 1.5 kg

25. If an iron ball and wooden ball of the same radius are released from a height h in vacuum, the time taken by both of these to reach the ground is

a) roughly equal b) exactly equal c) unequal d) zero (AFMC 1998)

26. A particle at rest starts moving in a horizontal straight line with uniform acceleration. The ratio of the distance covered during the fourth and the third second is

a) $\frac{4}{3}$ b) $\frac{26}{9}$ c) $\frac{7}{5}$ d) 2

27. A body moves along the east with velocity 20 km h^{-1} and then due north with velocity of 15 km h^{-1}. The resultant velocity is (AFMC 1995)

a) 5 km h^{-1} b) 15 km h^{-1} c) 20 km h^{-1} d) 25 km h^{-1}

28. When a ball is thrown up vertically with velocity v_0, it reaches a maximum height of h. If one wishes to triple the maximum height, then the ball should be thrown with velocity (AIIMS 200_)

a) $\sqrt{3}\ v_0$ b) $3\ v_0$ c) $9\ v_0$ d) $3\ v_0/2$

29. Three different objects of masses m_1, m_2 and m_3 are allowed to fall from rest and from the same point O along three different frictionless paths. The speeds of the three objects, on reaching the ground, will be in the ratio of (AIPMT 199_)

a) $m_1 : m_2 : m_3$ b) $m_1 : 2m_2 : 3m_3$

c) $1/m_1 : 1/m_2 : 1/m_3$ d) 1 : 1 : 1

30. A body is projected upwards with a velocity u. The velocity of the body on reaching the point, from where it was projected upwards is (AIIMS 199_)

a) v = 0 b) v = 2 u c) v = 0.5u d) v = u

31. Which of the following is a vector quantity?

a) Distance b) Temperature c) Mass d) Momentum

32. Which of the following is a scalar quantity? (AIPMT 199_)

a) Electric current b) Electric field c) Acceleration d) Linear momentum

33. Which of the following quantities is a scalar? (AIPMT 198_)

a) Electric field b) Velocity c) Angular momentum d) Electrostatic potential

34. Identify the concept that represents a vector quantity? (CET 199_)

a) work b) kinetic energy c) power d) angular momentum

35. Identify the vector quantity among the following : (AIPMT 199_)

a) heat b) angular momentum c) distance d) energy

36. Which one is a vector quantity? (AFMC 200_)

a) Flux density b) Magnetic field intensity c) Temperature d) Time

37. Which of the following is a scalar? (Kerala 199_)

a) Displacement b) Kinetic energy c) Couple d) Momentum

38. Which of the following is a vector? (AFMC 199_)

a) Electric current b) Gravitational potential c) Current density d) angle

39. Which of the following is not a vector quantity? (AFMC 199_)

a) Speed b) Velocity c) Displacement d) Torque

40. When three forces acting at a point are in equilibrium

a) each force is equal to the vector sum of the other two forces
b) each force is greater than the sum of the other two forces
c) each force is greater than the difference of the other two forces
d) equal to product of the other two forces.

41. Minimum number of unequal vectors which can give zero resultant are :
a) two (b) three (c) four (d) more than four (AFMC 2005)

42. Which of the following cannot be resultant of forces of 5 N and 10 N?
a) 8 N (b) 7 N (c) 5 N (d) 2 N (AFMC 1996)

43. If a ladder is not in equilibrium against a smooth vertical wall, then it can be made in equilibrium by (AIPMT 1998)
a) increasing the angle of inclination b) decreasing the angle of inclination
c) increasing the length of the ladder d) decreasing the length of the ladder

44. Essential characteristic of equilibrium is (IIT 1989)
a) momentum equal to zero b) acceleration equal to zero
c) kinetic energy equal to zero d) velocity equal to zero

45. Two equal vectors have a resultant equal to either. The angle between them is
a) 60^0 b) 90^0 c) 100^0 d) 120^0 (AIIMS 2001)

46. If two forces of equal magnitudes act simultaneously on a body in the east and the north directions, then the body will (AIIMS 2009)
a) displace in the north direction b) displace in the east direction
c) displace in the north-east direction d) remain at rest

47. If $\bar{A}\cdot\bar{B} = |\bar{A}\times\bar{B}|$, then angle between $\bar{A}$ and $\bar{B}$ is
a) 0^0 b) $\pi/2$ c) π d) $\pi/4$

48. Two forces of magnitude 8 N and 15 N respectively act at a point. If the resultant force is 17 N, the angle between the forces has to be
a) 60^0 b) 45^0 c) 90^0 d) 30^0 (JIPMER 1982)

49. The magnitudes of vectors $\bar{A}$, $\bar{B}$ and $\bar{C}$ are 12, 5 and 13 units respectively and $\bar{A}+\bar{B}=\bar{C}$. The angle between vectors $\bar{A}$ and $\bar{B}$ is (AIPMT 1982)
a) 0 b) π c) $\pi/2$ d) $\pi/4$

50. What is the maximum number of components into which a force can be resolved?
a) 2 b) 3 c) 4 d) any number

51. What is the maximum number of rectangular components into which a vector can be resolved in a plane?
a) 2 b) 3 c) 4 d) any number

52. Two vectors $\bar{A}$ and $\bar{B}$ are such that $|\bar{A}+\bar{B}| = |\bar{A}-\bar{B}|$ the angle between the vectors $\bar{A}$ and $\bar{B}$ is (IIT 1984)
a) 0^0 b) 60^0 c) 90^0 d) 180^0

53. What is dot product of two vectors of magnitude 3 and 5, if angle betw[een] them is 60^0? (AFMC 19[...])
a) 9.5 b) 8.4 c) 7.5 d) 5.2

54. The vectors $\vec{P} = a\hat{i} + a\hat{j} + 3\hat{k}$ and $\vec{Q} = a\hat{i} - 2\hat{j} - \hat{k}$ are perpendicular to e[ach] other. The positive value of a is : (AIIMS 20[...])
a) 23 b) 9 c) 8 d) 3

55. A stone is dropped from the window of a train moving along a horiz[ontal] straight track. The path of the stone as observed by an observer on groun[d]
a) straight line b) parabola c) circular c) hyperbola

56. Which of the following does not confirm to a projectile? (CET 19[...])
a) A bullet fired from a gun b) A stone thrown horizontally from the top of a towe[r]
c) Throwing a cricket ball from one player to another d) Taking off of an airc[raft]

57. A hunter aims his gun directly at a monkey sitting on a distant tree. A[t the] moment the bullet leaves the gun, the monkey drops itself downwards vertica[lly]. The bullet will
a) hit the monkey b) not hit the monkey
c) pass above the monkey's head d) none of the above

58. A body A is dropped vertically from the top of a tower. If another identical body [B is] thrown horizontally from the same point at the same instant, then (AIIMS 1[...])
a) A will reach the ground earlier than B b) B will reach the ground earlier than [A]
c) both A and B will reach the ground simultaneously d) either (a) or (b)

59. A bomb is dropped from an aeroplane moving horizontally at constant spee[d]. [If] air resistance is taken into consideration, then the bomb: (AFMC 19[...])
a) falls on earth exactly below the aeroplane
b) falls on the earth behind the aeroplane
c) falls on the earth ahead of the aeroplane d) flies with the aeroplane

60. An aeroplane is flying horizontally at a velocity u. It drops a packet from a hei[ght] h. The time taken by the packet to reach the ground will be : (Kerala 19[...])
a) $\sqrt{2hg}$ b) $\sqrt{\frac{2h}{g}}$ c) $\sqrt{\frac{h}{2g}}$ d) $\sqrt{\frac{u}{h}}$

61. An aeroplane is moving with a horizontal velocity u at a height h. The velo[city] of packet dropped from it on the earth's surface will be : (AFMC 19[...])
a) $\sqrt{u^2 - 2gh}$ b) 2gh c) $\sqrt{2gh}$ d) $\sqrt{u^2 + 2gh}$

62. Which of the following is constant in a projectile motion? (AIIMS 19[...])
a) horizontal component of the velocity b) vertical component of the veloc[ity]
c) velocity of projection d) all of these

63. The direction of motion of a projectile at the highest point on its traje[ctory] becomes
a) horizontal b) vertical c) tangential d) none of these (AFMC 19[...])

64. 65. 66. 67. 68. 69 70 71 72 73 74 75

64. A particle of mass m is projected with velocity v making an angle of 45° with the horizontal. When the particle lands on the level ground, the magnitude of the change in momentum will be

a) $m v \sqrt{2}$ (b) $\sqrt{2}$ m v (c) 2 m v (d) zero (AIPMT 2008)

65. Two projectiles are fired with the same velocity. If one is projected at an angle of 30° and the other at 60° to the horizontal, then the ratio of their horizontal ranges is

a) 1 : 1 (b) 4 : 1 (c) 1 : 2 (d) 2 : 1 (AIIMS 2009)

66. At the uppermost point of a projectile the angle between its velocity and acceleration is

a) 0° b) 45° c) 90° d) 180° (AIIMS 2002)

67. At the top of the trajectory of a particle, the acceleration is

a) maximum (b) minimum (c) zero (d) g (Manipal 1995)

68. A gun fires two bullets with same velocity at 60° and 30° with horizontal. The bullets strike at the same horizontal distance. The ratio of maximum height for the two bullets is

a) 2 : 1 (b) 3 : 1 (c) 4 : 1 (d) 1 : 1

69. An object is thrown along a direction inclined at an angle 45° with the horizontal. The horizontal range of the object is equal to

a) vertical height b) twice the vertical height

c) thrice the vertical height d) four times the vertical height

70. Two bullets are fired at angle θ and (90 - θ) to the horizontal with same speed. The ratio of their time of flight is

a) 1 : 1 b) tan θ : 1 c) 1 : tan θ d) $\tan^2\theta : 1$

71. A water fountain on the ground sprinkles water all around it. If the speed of water coming out of the fountain is v, the total area around the fountain that gets wet is

a) $\pi v^2 / g$ b) $\pi v^4 / g^2$ c) $\pi v^4 / 2g^2$ d) $\pi v^2 / g^2$ (AIEEE 2011)

72. If R and H represent the horizontal range and maximum height achieved by a projectile, then which of the following relations holds? (AIIMS 2009)

a) $\frac{H}{R} = 4\cot\theta$ b) $\frac{R}{H} = 4\cot\theta$ c) $\frac{H}{R} = 4\tan\theta$ d) $\frac{R}{H} = 4\tan\theta$

73. Two vectors $\vec{A}$ and $\vec{B}$ are at right angle to each other, if

a) $\vec{A} + \vec{B} = 0$ b) $\vec{A} - \vec{B} = 0$ c) $\vec{A} \times \vec{B} = 0$ d) $\vec{A} \cdot \vec{B} = 0$ (IIT 1985)

74. Angle between velocity vector and acceleration vector in uniform circular motion is

a) 0° b) 90° c) 180° d) 270° (AIIMS 2004)

75. The direction of the angular velocity vector is along

a) the tangent to the circular path b) the inward radius

c) the outward radius d) the axis of rotation

76. Two particles having mass M and m are moving in circular paths having radius R and r. If their time periods are same, then the ratio of angular velocity will be (AIPMT 2001)

a) r / R b) R / r c) 1 d) $\sqrt{R/r}$

77. The ratio of the distance covered to the displacement covered by a body along a semi-circle of radius r is

a) 2π b) $\pi/2$ c) π d) none of the above

78. For a particle revolving in a circular path, the acceleration of the particle is

a) along the tangent b) along the radius
c) along the circumference of the circle d) zero

79. If a particle travels in a circle, covering equal angles in equal times, its velocity vector

a) changes in magnitude only b) remains constant
c) changes in direction only d) changes both in magnitude and direction

80. A particle moves along a circular path under the action of a force. The work done by the force is

a) positive and non-zero b) zero c) negative and non-zero d) none of the above

81. A body is moving along a circle with constant speed. If its speed and radius of the circular path are doubled, the centripetal force will

a) become zero b) get doubled c) remain the same d) get halved

82. The physical quantity which remains stationary in an uniform circular motion is

a) speed b) kinetic energy c) kinetic energy and speed d) instantaneous velocity

83. A particle revolves around a circular path. The centripetal acceleration of the particle is inversely proportional to : (AFMC 1997)

a) mass of the particle b) radius of the path
c) velocity of the particle d) both mass and velocity

84. A particle moves in a circular path of radius r. In half the period of revolution, its displacement and distance covered are (IIT 1983)

a) 2r, $2\pi r$ b) $r/\sqrt{2}$, πr c) 2 r, πr d) r, πr

85. A particle of mass M is moving in a horizontal circle of radius R with uniform speed v. When it moves from one point to a diametrically opposite point, its

a) kinetic energy changes by $1/2\ Mv^2$ b) momentum does not change
c) momentum changes by 2 Mv d) kinetic energy changes by Mv^2 (AIPMT 1992)

86. Force responsible for the circular motion of the body is : (AFMC 2003)

a) centripetal force b) centrifugal force c) gravitational force d) none of these

87. Two particles of equal mass revolve in circular paths of radii r_1 and r_2 respectively with the same angular velocity. The ratio of their centripetal forces will be

a) r_1 / r_2 (b) r_2 / r_1 (c) $(r_2 / r_1)^{1/2}$ (d) $(r_2 / r_1)^2$ (AFMC 2001)

88. If the radii of circular paths of two particles of same masses are in the ratio of 1 : 2 then to have a constant centripetal force, their velocities should be in a ratio of

a) $1 : \sqrt{2}$ (b) $\sqrt{2} : 1$ (c) 4 : 1 (d) 1 : 4 (AIIMS 1996)

89. When milk is churned, cream separates out because of the (AIPMT 1991)

(a) centripetal force (b) gravitational force (c) frictional force (d) centrifugal force

90. A stone tied to a string is rotated with a uniform speed in a vertical plane. If mass of the stone is m, length of the string is r and linear speed of the stone is v then tension in the string, when the stone is at its lowest point is (g = acceleration due to gravity) (AIIMS 2001)

a) mg (b) $\frac{mv^2}{r}$ (c) $\frac{mv^2}{r} - mg$ (d) $\frac{mv^2}{r} + mg$

Answers :

1 (d)	2 (d)	3 (d)	4 (c)	5 (a)	6 (a)	7 (d)	8 (d)	9 (a)	10 (d)	11 (d)	12 (b)
13 (a)	14 (d)	15 (d)	16 (c)	17 (b)	18 (c)	19 (c)	20 (a)	21 (d)	22 (d)	23 (d)	24 (b)
25 (b)	26 (c)	27 (d)	28 (a)	29 (d)	30 (d)	31 (d)	32 (a)	33 (d)	34 (b)	35 (b)	36 (b)
37 (b)	38 (c)	39 (a)	40 (a)	41 (b)	42 (d)	43 (a)	44 (b)	45 (d)	46 (c)	47 (d)	48 (c)
49 (c)	50 (d)	51 (a)	52 (c)	53 (c)	54 (d)	55 (b)	56 (d)	57 (a)	58 (c)	59 (c)	60 (b)
61 (c)	62 (a)	63 (a)	64 (b)	65 (a)	66 (c)	67 (d)	68(b)	69 (d)	70(b)	71(b)	72 (b)
73 (d)	74 (b)	75 (d)	76 (c)	77 (b)	78 (b)	79 (c)	80 (b)	81 (b)	82 (c)	83 (b)	84 (c)
85 (c)	86 (a)	87 (a)	88 (a)	89 (d)	90 (d)						

Solutions :

11. (d) $t = \frac{x}{v} = \frac{150}{10-(-5)} = \frac{150}{15} = 10$ s

12. (b) $x = a_0 + \frac{a_1 t}{2} - \frac{a_2 t^2}{3}$, $\frac{dx}{dt} = \frac{a_1}{2} - \frac{2a_2 t}{3}$, $\frac{d^2x}{dt^2} = \frac{-2a_2}{3}$

13. (a) $x \propto t^3$, $\frac{dx}{dt} \propto 3t^2$, $\frac{d^2x}{dt^2} \propto 6t$, $\frac{d^2x}{dt^2} \propto t$

14. (d) $x \propto t^2$, $\frac{dx}{dt} \propto 2t$, $\frac{d^2x}{dt^2} \propto 2$, $\frac{d^2x}{dt^2}$ = constant

15.(d) $x = a_0 + a_1 t + a_2 t^2$, $\frac{dx}{dt} = a_1 + 2a_2 t$, $\frac{d^2x}{dt^2} = 2a_2$

18. (c) $s = \frac{1}{2}gt^2$, $s_1 = \frac{g}{2}$, $s_2 = 2g$, $s_3 = \frac{9g}{2}$, $s_1 : s_2 : s_3$: 1 : 4 : 9

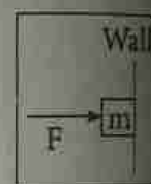
19.(c) $h = \frac{1}{2}gt^2$, $h_1 = \frac{1}{2}g\left(\frac{t}{2}\right)^2 = \frac{h}{4}$, $h - \frac{h}{4} = \frac{3h}{4}$

Unit 3 : Laws of Motion

I. Multiple Choice Questions

1. When a car takes a sudden left turn in the curved road, passengers are pushed towards the right due to
   a) inertia of direction   b) inertia of motion
   c) inertia of rest   d) absence of inertia

2. An object of mass m held against a vertical wall by applying horizontal force F as shown in the figure. The minimum value of the force F is



   a) Less than mg
   b) Equal to mg
   c) Greater than mg
   d) Cannot determine

3. A vehicle is moving along the positive x direction. If sudden brake is applied,
   a) frictional force acting on the vehicle is along negative x direction
   b) frictional force acting on the vehicle is along positive x direction
   c) no frictional force acts on the vehicle
   d) frictional force acts in downward direction

4. A book is at rest on the table which exerts a normal force on the book. If this force is considered as reaction force, what is the action force according to Newton's third law?
   a) Gravitational force exerted by Earth on the book
   b) Gravitational force exerted by the book on Earth
   c) Normal force exerted by the book on the table   d) None of the above

5. Two masses m_1 and m_2 are experiencing the same force where $m_1 < m_2$. The ratio of their acceleration a_1 / a_2 is
   a) 1   b) less than 1   c) greater than 1   d) all the three cases

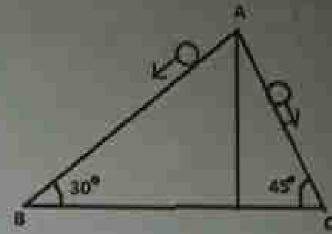
6. Choose appropriate free body diagram for the particle experiencing net acceleration along negative Y direction. (Each arrow mark represents the force acting on the system).

a) greater acceleration along the path AB

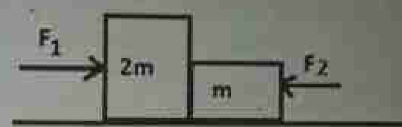
b) greater acceleration along the path AC

c) same acceleration in both the paths

d) no acceleration in both the paths



8. Two blocks of masses m and 2m are placed on a smooth horizontal surface as shown. In the first case only a force F_1 is applied from the left. Later only a force F_2 is applied from the right. If the force acting at the interface of the two blocks in the two cases is same, then $F_1 : F_2$ is



a) 1 : 1 b) 1 : 2 c) 2 : 1 d) 1 : 3

9. Force acting on the particle moving with constant speed is

a) always zero b) need not be zero c) always non-zero d) cannot be concluded

10. An object of mass m begins to move on the plane inclined at an angle θ. The coefficient of static friction of inclined surface is μ_s. The maximum static friction experienced by the mass is

a) mg b) $\mu_s mg$ c) $\mu_s mg \sin\theta$ d) $\mu_s mg \cos\theta$

11. When the object is moving at constant velocity on the rough surface

a) net force on the object is zero b) no force acts on the object

c) only external force acts on the object d) only kinetic friction acts on the object

12. When an object is at rest on the inclined rough surface

a) static and kinetic frictions acting on the object is zero

b) static friction is zero but kinetic friction is not zero

c) static friction is not zero and kinetic friction is zero

d) static and kinetic frictions are not zero

13. The centrifugal force appears to exist

a) only in inertial frames b) only in rotating frames

c) in any accelerated frame d) both in inertial and non-inertial frames

14. Choose the correct statement from the following:

a) Centrifugal and centripetal forces are action reaction pairs

b) Centripetal force is a natural force

c) Centrifugal force arises from gravitational force

d) Centripetal force acts towards the center and centrifugal force appears to act away from the center in a circular motion

15. If a person moving from pole to equator, the centrifugal force acting on him

a) increases b) decreases c) remains the same d) increases and then decrease

Answers :

1) a 2) c 3) a 4) c 5) c 6) c 7) b 8) c 9) b 10) d 11) a

12) c 13) b 14) d 15) a

Solutions :

5. (c) $F = m_1 a_1 = m_2 a_2$, $\frac{a_1}{a_2} = \frac{m_2}{m_1}$. Since $m_1 < m_2$, $\frac{a_1}{a_2}$ is greater than 1

7. (b) Acceleration along AC is $g \sin 45^o = \frac{9.8}{\sqrt{2}} = \frac{9.8}{1.414} = 6.93\ ms^{-2}$

Acceleration along AB is $g \sin 30^o = \frac{9.8}{2} = 4.9\ ms^{-2}$

8. (c) Let f = force acting at the interface of the two blocks a = acceleration.

$F_1 - f = 2ma$, $F_1 \propto 2ma$, $F_2 - f = ma$, $F_2 \propto ma$, $\frac{F_1}{F_2} = \frac{2ma}{ma} = 2$, $F_1 : F_2 = 2 : 1$

9. (b) In uniform circular motion, particle moves with constant speed, but centripetal force acts on it.

Creative Questions

1. Which of the following is non - conservative force? (AIIMS 1996)

(a) Interatomic force (b) Gravitational force (c) Electrostatic force (d) Viscous force

2. A spring balance P is suspended from a rigid support. Another identical spring balance Q is fastened to the hook of the balance P and a body of weight 2 kgf is attached to the spring balance Q. Then, (AIIEEE 2003)

(a) both P and Q will read 2 kgf. (b) both P and Q will read 1 kgf.

(c) P will read 2 kgf, while Q will read zero.

(d) P will read zero, while Q will read 2 kgf.

3. Three blocks with masses m, 2m and 3m are connected by strings, as shown in the figure. After an upward force F is applied on block m, the masses move upward at constant speed v. What is the net force on the block of mass 2m? (g is the acceleration due to gravity).

(a) zero (b) 2 mg

(c) 3 mg (d) 6 mg (NEET 2013)

4. Physical independence of force is a consequence of Newton's (AIPMT 1991)
(a) third law of motion (b) second law of motion (c) first law of motion (d) all of these

5. Newton's first law of motion gives the concept of
(a) energy (b) work (c) momentum (d) inertia

6. Inertia of a body has direct dependence on
(a) velocity (b) mass (c) area (d) volume

7. Inertia is the property by virtue of which the body is unable to change by itself (IIT 1982)
(a) the state of rest only (b) the state of uniform linear motion only
(c) the direction of motion only (d) the steady state of rest and uniform linear motion

8. While dusting a carpet, we give a sudden jerk or beat it with a stick, because
(a) inertia of rest keeps the dust in its position and the dirt gets removed as the carpet moves away. (AFMC 1981)
(b) jerk compensates for the force of adhesion between the dust and carpet and the dust is removed.
(c) Inertia of motion removes the dust.
(d) no inertia is involved in the process, it is simply due to practical experience.

9. An athlete runs some distance before taking a long jump, because (IIT 1982)
(a) he gains energy to take him through long distance.
(b) it helps to apply large force.
(c) by running, he gives himself larger inertia of motion.
(d) by running, action and reaction forces increase.

10. When a train stops, the passengers move forward. It is due to
(a) inertia of passenger (b) inertia of train
(c) gravitational pull by earth (d) none of these

11. When a bus suddenly takes a turn, the passengers are thrown outwards, due to (AFMC 1999)
(a) speed of bus (b) inertia of motion
(c) acceleration of motion (d) none of the above

12. The units of impulse are the same as that of
(a) energy (b) momentum (c) power (d) velocity

13. Which of the following quantities has its unit as newton - second? (CET 1998)
(a) torque (b) momentum (c) energy (d) Planck's constant

14. A particle of mass m is moving with a uniform velocity v_1. It is given an impulse such that its velocity becomes v_2. The impulse is equal to (AIPMT 1990)
(a) $m(v_2 - v_1)$ (b) $\frac{1}{2}m(v_2^2 - v_1^2)$ (c) $m(v_1 + v_2)$ (d) $m(v_1 - v_2)$

15. A graph is drawn with force along Y-axis and time along X-axis. The area under the graph represents
(a) momentum (b) couple (c) moment of the force (d) impulse of the force
16. A body of mass 3.513 kg is moving along the X-axis with a speed of 5.00 ms^{-1}. The magnitude of its momentum is recorded as (AIEEE **2008**)
(a) 17.56 kg m s^{-1} (b) 17.565 kg m s^{-1} (c) 17.6 kg m s^{-1} (d) 17.57 kg m s^{-1}
17. A ball of mass 150 g moving with an acceleration 20 m/s^2 is hit by a force, which acts on it for 0.1 s. The impulse of the force is (AIPMT **1996**)
(a) 0.5 N s (b) 0.1 N s (c) 0.3 N s (d) 1.2 N s
18. A player takes 0.1 s in catching a ball of mass 150 g moving with 20 m/s. The force imparted by the ball on the hands of the player is (AIPMT **2001**)
(a) 0.3 N (b) 3 N (c) 30 N (d) 300 N
19. A body, under the action of a force $\vec{F} = 6\hat{i} - 8\hat{j} + 10\hat{k}$ acquires an acceleration of $1ms^{-2}$. The mass of the body is (AIMPT **2009**)
a) $2\sqrt{10}$ kg (b) 10 kg (c) 20 kg (d) $10\sqrt{2}$ kg
20. A mass m moving with velocity u strikes a wall normally and returns with the same speed. What is the magnitude of the change in momentum of the body when it returns?
(a) 4 mu (b) mu (c) 2 mu (d) zero
21. A body moving with a constant speed on a horizontal surface does not have
(a) velocity (b) momentum (c) kinetic energy (d) acceleration (CET **1999**)
22. Two bodies of masses m and 4m are moving with equal kinetic energies. The ratio of their linear momenta is: (AIPMT **1997**)
(a) 1 : 4 (b) 4 : 1 (c) 1 : 2 (d) 1 : $\sqrt{2}$
23. A car having a mass of 1000 kg is moving at a speed of 30 m/s. Brakes are applied to bring the car to rest. If the frictional force between the tyres and the road surface is 5000 N the car will come to rest in
(a) 5 s (b) 10 s (c) 12 s (d) 6 s
24. What force will change the velocity of a body of mass 1 kg from 20 m s^{-1} to 30 m s^{-1} in 2s?
(a) 25 N (b) 10 N (c) 5 N (d) 2 N (AIPMT **1999**)
25. The working of a rocket is based on Newton's which law of motion?
(a) first law (b) second law (c) third law of motion (d) first and second law
26. A shell, in its flight, explodes into four unequal parts. Which of the following is conserved?

(a) momentum (b) kinetic energy
(c) potential energy (d) both kinetic and potential energy (AIPMT 1997)

27 Rocket engines lift a rocket from the earth surface, because hot gases with high velocity
(a) push against the air (b) push against the earth (AIIMS 1998)
(c) react against the rocket and push it up (d) heat up the air which lifts the rocket

28. A body at rest breaks into two pieces of equal masses. The parts will move
(a) in same direction (b) along different directions
(c) in opposite directions with equal speeds
(d) in opposite directions with unequal speeds

29. A shell is fired from a cannon. It explodes in mid air. Its total (AIPMT 1994)
(a) momentum increases (b) momentum decreases
(c) KE increases (d) KE decreases

30. A man is at rest in the middle of a pond. He can get himself to the shore by making use of Newton's (AIPMT 1981)
(a) first law (b) second law (c) third law (d) all the laws

31. When we kick a stone, we get hurt. Due to which property of the stone it happens?
(a) Inertia (b) Velocity (c) Reaction (d) Momentum

32. When a horse pulls a wagon, the force that causes the horse to move forward is the force (AIIMS 2010)
(a) that ground exerts on the horse. (b) that horse exerts on the ground.
(c) that wagon exerts on the horse. (d) that horse exerts on the wagon.

33. A particle of mass 0.3 kg is subjected to a force $F = -kx$ with $k = 15\ Nm^{-1}$. What will be its initial acceleration, if it is released from a point 20 cm away from the origin? (AIEEE 2005)
(a) $3\ m\ s^{-2}$ (b) $15\ m\ s^{-2}$ (c) $5\ m\ s^{-2}$ (d) $10\ m\ s^{-2}$

34. The working of a rocket is based on the principle of (CET 1999)
(a) elasticity (b) Kepler's laws (c) Newton's laws (d) conservation of momentum

35. A gun fires a bullet of mass 50 g with a velocity of $30\ ms^{-1}$. Because of this, the gun is pushed back with a velocity of $1\ m\ s^{-1}$. The mass of the gun is (AIIMS 2001)
(a) 5.5 kg (b) 3.5 kg (c) 1.5 kg (d) 0.5 kg

36. A bullet of mass 200 g is fired with a velocity $30\ ms^{-1}$ from a gun of mass 100 kg. The recoil velocity of the gun is (AIPMT 1996)
(a) $10\ m\ s^{-1}$ (b) $5\ m\ s^{-1}$ (c) $0.06\ m\ s^{-1}$ (d) $0.03\ m\ s^{-1}$

37 A man in a lift weighs more, when the lift (AIPMT 1979)
(a) begins to go up (b) is going up steadily

(c) is slowing down (d) is descending freely.

38. A person is standing in an elevator. In which situation he finds his weight less?

(a) When the elevator moves upward with constant acceleration

(b) When the elevator moves downward with constant acceletation

(c) When the elevator moves upward with uniform velocity

(d) When the elevator moves downward with uniform velocity (AIIMS 2005)

39. A man weighs 80 kg. He stands on a weighing scale in a lift which is moving upwards with a uniform acceleration of 5 m/s^2. What would be the reading on the scale? ($g = 10\ m/s^2$)

(a) 800 N (b) 1200 N (c) zero (d) 400 N (AIPMT 2003)

40. The mass of a lift is 2000 kg. The tension in the supporting cable is 28000 N. Its acceleration is (AIPMT 2009)

(a) 30 m s^{-2} downwards (b) 4 m s^{-2} upwards

(c) 4 m s^{-2} downwards (d) 14 m s^{-2} upwards

41. A lift of mass 1000 kg is moving upwards with an acceleration of $1 m/s^2$. The tension developed in the string which is connected to lift is ($g = 9.8\ m/s^2$) (AIPMT 2001)

(a) 9800 N (b) 10800 N (c) 11000 N (d) 10000 N

42. A lift is moving down with acceleration a. A man in the lift drops a ball inside the lift. The acceleration of the ball as observed by the man in the lift and a man standing stationary on the ground are respectively (AIEEE 2002)

(a) g , g (b) g – a , g - a (c) g – a , g (d) a , g

43. A person of mass 60 kg is inside a lift of mass 940 kg and presses the button on control panel. The lift starts moving upwards with an acceleration 1.0 m/s^2. If $g = 10 m/s^2$, the tension in the supporting cable is (AIPMT 2011)

(a) 9680 N (b) 11000 N (c) 1200 N (d) 8600 N

44. Which one is the self-adjusting force? (AFMC 2009)

(a) Kinetic friction (b) Static friction (c) Nuclear force (d) None of these

45. If the normal force is doubled, then coefficient of friction is (AIIMS 1994)

(a) halved (b) tripled (c) doubled (d) not changed

46. While walking on ice, one should take small steps to avoid slipping. This is because, smaller steps ensure

(a) larger friction (b) smaller friction (c) larger normal force (d) smaller normal force

47. Which of the following surface in contact has maximum coefficient of friction?

(a) Wood on wood (b) Steel on steel

(c) Rubber tyre on dry concrete (d) Rubber tyre on wet concrete

48. An object is moving on a plane surface with uniform velocity $10\ ms^{-1}$ in presence of a force 10 N. The frictional force between the object and the surface is
(a) 1 N (b) – 10 N (c) 10 N (d) 100 N

49. Why the tyres are circular in shape?
(a) They require less material (b) Rolling friction is smaller than sliding friction
(c) It is easy to inflate the circular tyres (d) None of the above.

50. How does the proper inflation of tyres save fuel?
(a) Normal reaction decreases (b) Sliding contact with the road increases
(c) Normal reaction increases (d) Sliding contact with the road decreases

51. When two surfaces are coated with a lubricant, then they (AIIMS 2001)
(a) roll upon each other (b) slide upon each other
(c) stick to each other (d) none of the above

52. A cyclist of mass m is taking a circular turn of radius R on a frictional level road with a velocity v. Inorder that the cyclist does not skid
(a) $\frac{mv^2}{2} > \mu mg$ (b) $\frac{mv^2}{r} > \mu mg$ (c) $\frac{mv^2}{r} < \mu mg$ (d) $\frac{v}{r} = \mu g$

53. A car of mass 1000 kg negotiates a banked curve of radius 90 m on a frictionless road. If the banking angle is 45^0, the speed of the car is (AIPMT 2012)
(a) $20\ ms^{-1}$ (b) $30\ ms^{-1}$ (c) $5\ ms^{-1}$ (d) $10\ ms^{-1}$

54. A block B is pushed momentarily along a horizontal surface with an initial velocity v. If μ is the coefficient of sliding friction between B and the surface, block B will come to rest after a time (AIPMT 2007)
(a) $\frac{v}{g\mu}$ (b) $\frac{g\mu}{v}$ (c) $\frac{g}{v}$ (d) $\frac{g^2}{v}$

55. A block of mass m is placed on a smooth wedge of inclination θ. The whole system is accelerated horizontally, so that the block does not slip on the wedge. The force exerted by the wedge on the block (g is acceleration due to gravity) will be
(a) mg cos θ (b) mg sin θ (c) mg (d) mg tan θ (AIPMT 2004)

56. What will be the maximum speed of a car on a road turn of radius 100 m, if the coefficient of friction between the tyres and the road is 0.4? (Take $g = 10\ m/s^2$) (AIPMT 1995)
(a) $20\ ms^{-1}$ (b) $2\ ms^{-1}$ (c) $200\ ms^{-1}$ (d) $0.2\ ms^{-1}$

57. A body of mass m is placed on a rough surface with coefficient of friction μ inclined at θ. If the mass is in equilibrium, then (AIIMS 1996)
(a) $\theta = \tan^{-1}\mu$ (b) $\theta = \tan^{-1}\frac{1}{\mu}$ (c) $\theta = \tan^{-1}\frac{m}{\mu}$ (d) $\theta = \tan^{-1}\frac{\mu}{m}$

58. A cubical block rests on an inclined plane of coefficient of friction $\mu = 1/\sqrt{3}$. What should be the angle of inclination that the block just slides down the inclined plane?
   (a) 30^0 (b) 60^0 (c) 45^0 (d) 90^0 (J & K CET 2011)
59. A horizontal force of 980 N is required to slide a body of mass 500 kg over a flat surface. The coefficient of friction is
   (a) 0.1 (b) 0.02 (c) 0.2 (d) 0.4
60. A force F_1 of 500 N is required to push a car of mass 1000 kg slowly at constant speed on a level road. If a force F_2 of 1000 N is applied, the acceleration of the car will be (Manipal 2010)
   (a) zero (b) 1.5 ms^{-2} (c) 1ms^{-2} (d) 0.5 ms^{-2}
61. Which one of the following statements is incorrect? (NEET 2018)
   (a) Rolling friction is smaller than sliding friction
   (b) Limiting value of static friction is directly proportional to normal reactions
   (c) Frictional force opposes the relative motion
   (d) Coefficient of sliding friction has dimensions of length

Answers :

1 (d)	2 (a)	3 (a)	4 (c)	5 (d)	6 (b)	7 (d)	8 (a)	9 (c)	10 (a)	11 (b)	12 (b)
13 (b)	14 (a)	15 (d)	16 (d)	17 (c)	18 (c)	19 (d)	20 (c)	21 (d)	22 (c)	23 (d)	24 (c)
25 (c)	26 (a)	27 (c)	28 (c)	29 (c)	30 (c)	31 (c)	32 (a)	33 (d)	34 (d)	35 (c)	36 (c)
37 (a)	38 (b)	39 (b)	40 (b)	41 (b)	42 (c)	43 (b)	44 (b)	45 (d)	46 (a)	47 (c)	48 (b)
49 (b)	50 (d)	51 (b)	52 (c)	53 (b)	54 (a)	55 (d)	56 (a)	57 (a)	58 (a)	59 (c)	60 (d)
61 (d)											

Solutions:

3. (a) All the blocks are moving with constant velocity. So acceleration is zero. Hence, the net force on all the blocks will be zero.

16. (d) Momentum p = mv = 3.513 x 5.00 = 17.565 $kgms^{-1}$

   Since velocity is measured upto second decimal place only p = 17.57 kg ms^{-1}

17. (c) Impulse $I = F_{av}t = mat = 0.15 \times 20 \times 0.1 = 0.3$ Ns

18. (c) $F = \frac{m(v_1 - v_2)}{t} = \frac{0.15(20-0)}{0.1} = 1.5 \times 20 = 30$ N

19. (d) $\vec{F} = 6\hat{i} - 8\hat{j} + 10\hat{k}$, $|\vec{F}| = \sqrt{36+64+100} = 10\sqrt{2}$ N, $a = 1\,ms^{-1}$ $F = ma$, $m = \frac{F}{a}$

   $m = \frac{F}{a}a = \frac{10\sqrt{2}}{1} = 10\sqrt{2}$ kg

20. (c) Change in momentum = mu − (−mu) = 2mu

Book problems(1 mark):

1. An object of mass 2.5 kg experience a force of 5 N. The acceleration experienced by it is
   a) 0.5 ms^{-2} b) 0.05 ms^{-2} c) 2.5 ms^{-2} d) 5 ms^{-2}
2. The position vector of a particle is given by $\vec{r} = 3t\hat{i} + 5t^2\hat{j} + 7\hat{k}$. The acceleration produced in it is
   a) $3\hat{i}$ b) $5\hat{j}$ c) $7\hat{k}$ d) $10\hat{j}$
3. An object of mass 10 kg moving with a speed of 15 ms^{-1} hits a wall and comes to rest in 0.03 s. The average force on the object is
   a) 5000 N b) 50 N c) 15 N d) 500 N
4. An object of mass 10 kg moving with a speed of 15 ms^{-1} hits a wall and comes to rest in 10 s. The average force on the object is
   a) 5000 N b) 50 N c) 15 N d) 500 N.
5. An object of mass 2 kg rests on a floor. If the coefficient of static friction between the object and the floor is 0.8 the force that must be applied on the object to move it is
   a) 15.68 N b) 0.8 N c) 19.6 N d) 1.568 N
6. A stone of mass 0.25 kg tied to a string execute uniform circular motion with a speed of 2 ms^{-1} in a circular path of radius 3 m. The tensional force acting on the stone is
   a) 0.25 N b) 4 N c) 0.333 N d) 2 N
7. A spider of mass 50 g is hanging on a string of a cob web. The tensions in the string is
   a) 49 N b 9.8 N c) 0.49 N d) 4.9 N
8. A foot ball player kicks a 0.8 kg ball and imparts it a velocity 12 ms^{-1}. The contact between the foot and the ball is only for one sixtieth of a second. The average kicking force is
   a) 12 N b) 576 N c) 57.6 N d) 5760 N
9. A stone of mass 2 kg is attached to string of length 1 meter. Thestring can withstand maximum tension 200 N. The maximum speed the stone can have during the whirling motion is
   a) 2 ms^{-1} b) 200 ms^{-1} c) 1 ms^{-1} d) 10 ms^{-1}
10. A car takes a turn with velocity 50 ms^{-1} on the circular road of radius of curvature 10 m. The centrifugal force experienced by a person of mass 60 kg inside the car is
    a) 15,000 N b) 15 N c) 150 N d) 1500 N
11. A body of mass 100 kg is moving with an acceleration of 50 cm s^{-2}. The force experienced by it is
    a) 50 N b) 0.5 N c) 5 N d) 9.8 N
12. A gun weighing 25 kg fires a bullet weighing 30 g with the speed of 200 ms^{-1}. The speed of recoil of the gun is
    a) 240 ms^{-1} b) 30 ms^{-1} c) -0.24 ms^{-1} d) -240 ms^{-1}
13. A wooden box lying on an inclined plane starts sliding when the angle of inclination is 45°. The coefficient of friction is
    a) 1 b) $\sqrt{3}$ c) 1.414 d) 1.75

14. Two masses m_1 = 5 kg and m_2 = 4 kg tied to a string are hanging over a light frictionless pulley. If g = 10 ms^{-2}, the acceleration of each mass when left free to move is

a) 1.1cms^{-2} b) 1 ms^{-2} c) 1.1 ms^{-2} d) 0.1 ms^{-2}

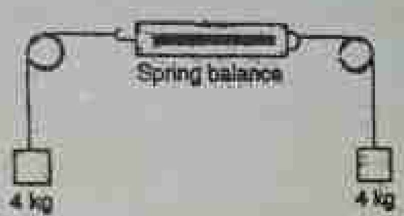
15. The coefficient of friction between a block and plane is $1/\sqrt{3}$. If the inclination of the plane gradually increases, the angle at which the body will begin to slide is

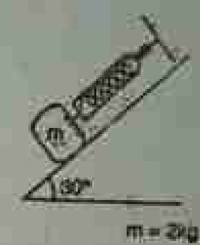
a) 60° b) 30° c) 45° d) 15°

Answers : 1(b) 2(d) 3(a) 4(c) 5(a) 6(c) 7(c) 8(b) 9(d) 10(a)
11(a) 12(c) 13(a) 14(c) 15(b)

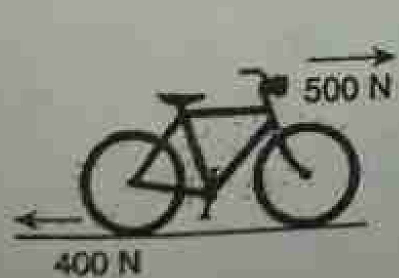
Book problems (2 marks) :

1. What is the reading shown in spring balance?





2. A football player kicks a 0.8 kg ball and imparts it a velocity 12 ms^{-1}. The contact between the foot and ball is only for one – sixtieth of a second. Find the average kicking force.
3. If two objects of masses 2.5 kg and 100 kg experience the same force 5 N what is the acceleration experienced by each of them?
4. Calculate the acceleration of the bicycle of mass 25 kg as shown in figure



5. Apply Newton's second law to a mango hanging from a tree. Mass of the mango is 400 g.
6. A body of mass 100 kg is moving with an acceleration of 50 cms^{-2}. Calculate the force experienced by it.
7. A spider of mass 50 g is hanging on a string of a cob web. What is the tension in the string?
8. The position vector of a particle is given by $\vec{r} = 3t\hat{i} + 5t^2\hat{j} + 7\hat{k}$. Find the direction ... net force?

Unit 4 : Work, Energy and Power

I. Multiple Choice Questions:

1. A uniform force of $(2\hat{i}+\hat{j})$ N acts on a particle of mass 1 kg. The particle displaces from position $(3\hat{j}+\hat{k})$ m to $(5\hat{i}+3\hat{j})$ m. The work done by the force on the particle is

   a) 9 J b) 6 J c) 10 J d) 12 J

2. A ball of mass 1 kg and another of mass 2 kg are dropped from a tall building whose height is 80 m. After, a fall of 40 m each towards Earth, their respective kinetic energies will be in the ratio of

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

3. A body of mass 1 kg is thrown upwards with a velocity 20 m s^{-1}. It momentarily comes to rest after attaining a height of 18 m. How much energy is lost due to air friction? (Take g = 10 m s^{-2})

   a) 20 J b) 30 J c) 40J d) 10J

4. An engine pumps water continuously through a hose. Water leaves the hose with a velocity v and m is the mass per unit length of the water of the jet. What is the rate at which kinetic energy is imparted to water?

   a) $\frac{1}{2}mv^3$ b) mv^3 c) $\frac{3}{2}mv^2$ d) $\frac{5}{2}mv^2$

5. A body of mass 4 m is lying in xy-plane at rest. It suddenly explodes into three pieces. Two pieces each of mass m move perpendicular to each other with equal speed v. The total kinetic energy generated due to explosion is

   a) mv^2 b) $\frac{3}{2}mv^2$ c) $2mv^2$ d) $4mv^2$

6. The potential energy of a system increases, if work is done

   a) by the system against a conservative force

   b) by the system against a non-conservative force

   c) upon the system by a conservative force

   d) upon the system by a non-conservative force

7. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop?

   a) $\sqrt{2gR}$ b) $\sqrt{3gR}$ c) $\sqrt{5gR}$ d) $\sqrt{gR}$

8. The work done by the conservation force for a closed path is

   a) always negative b) zero c) always positive d) not defined

9. If the linear momentum of the object is increased by 0.1%, then the kinetic energy is increased by

a) 0.1% b) 0.2% c) 0.4% d) 0.01%

10. If the potential energy of the particle is $\alpha - \frac{\beta x^2}{2}$, then force experienced by the particles is

a) $F = \frac{\beta}{2}x^2$ b) $F = \beta x$ c) $F = -\beta x$ d) $F = -\frac{\beta}{2}x^2$

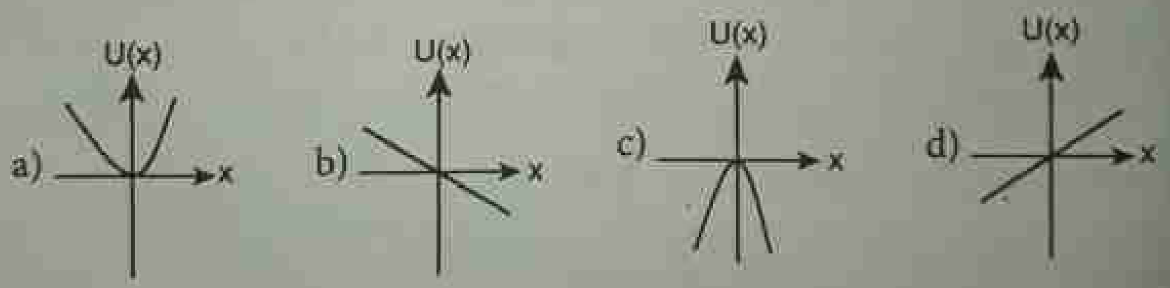
11. A wind-powered generator converts wind energy into electric energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electrical energy. For wind speed v, the electrical power output will be proportional to

a) v b) v^2 c) v^3 d) v^4

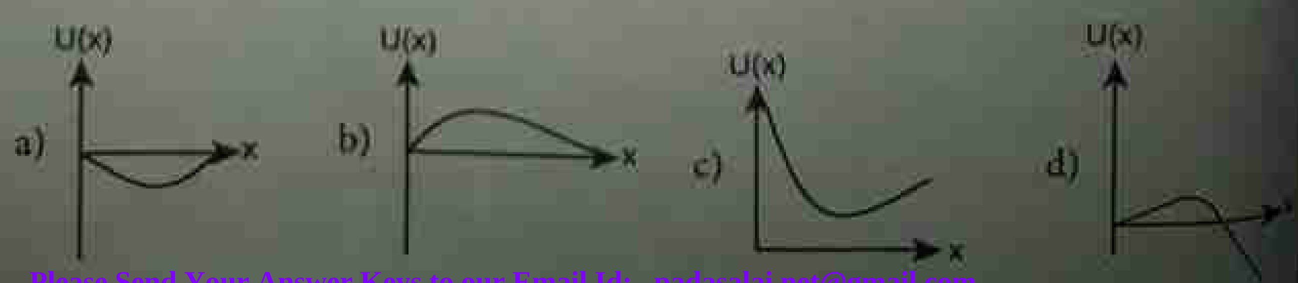
12. Two equal masses m_1 and m_2 are moving along the same straight line with velocities 5 ms^{-1} and -9 ms^{-1} respectively. If the collision is elastic, then calculate the velocities after the collision of m_1 and m_2 respectively

a) -4 ms^{-1} and 10 ms^{-1} b) 10 ms^{-1} and 0 ms^{-1} c) -9 ms^{-1} and 5 ms^{-1} d) 5 ms^{-1} and 1 ms^{-1}

13. A particle is placed at the origin and a force $F = kx$ is acting on it (where k is a positive constant). If U (0) = 0, the graph of U (x) versus x will be (where U is the potential energy function)



14. A particle which is constrained to move along x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here, k and a are positive constants. For $x \geq 0$, the functional form of the potential energy U(x) of the particle is



15. A spring of force constant k is cut into two pieces such that one piece is double the length of the other. Then, the long piece will have a force constant of

a) $\frac{2}{3}k$ b) $\frac{3}{2}k$ c) 3k d) 6k

Answers:

1) c 2) d 3) a 4) a 5) b 6) a 7) c 8) b 9) b 10) c 11) c
12) c 13) c 14) d 15) b

Solution:

1. c) $\vec{s} = \vec{r_2} - \vec{r_1} = (5\hat{i} + 3\hat{j}) - (3\hat{j} + \hat{k}) = (5\hat{i} - \hat{k})$ m

$W = \vec{F} \cdot \vec{s} = (2\hat{i} + \hat{j}).(5\hat{i} - \hat{k}) = 10J$

2. d) At a given height, velocity of both the balls are equal.

$$\frac{K_1}{K_2} = \frac{\frac{1}{2}m_1 v_1^2}{\frac{1}{2}m_2 v_2^2} = \frac{m_1}{m_2} = \frac{1}{2}, K_1 : K_2 = 1 : 2$$

3. a) $m = 1kg$, $v = 20\ ms^{-1}$, $h = 18\ m$, $g = 10\ ms^{-2}$

Initial K.E = $\frac{1}{2}mv^2 = \frac{1}{2} \times 1 \times 20^2 = 200J$

P.E. at the maximum height = mgh = 1 x 10 x 18 = 180 J

∴ Energy lost due to air friction = 200 – 180 = 20 J

4. a) Given m = mass per unit length of water

In one second water flows through v metre

Mass of water leaving in one second M = mv

K.E.imparted to water in one second

$$= \frac{1}{2}Mv^2 = \frac{1}{2}mv^3$$

5. b) Momentum before explosion is zero.

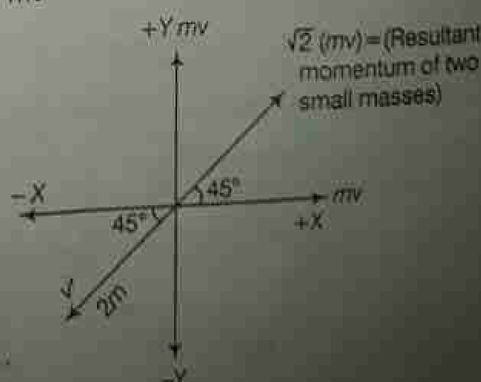
After explosion momentum along + x direction is mv

along + y direction is mv

Resultant = $\sqrt{m^2v^2 + m^2v^2} = \sqrt{2}\,mv$

Let v' be the velocity of mass 2m

$2mv' = \sqrt{2}\,mv$. Hence $v' = v/\sqrt{2}$



Creative Questions

1. The work performed on an object does not depend upon
   (a) force applied (b) angle at which force is inclined to the displacement
   (c) initial velocity of the object (d) displacement.
2. A main pushes a wall and fails to displace it. He does
   (a) no work at all (b) negative work
   (c) maximum positive work (d) positive work but not maximum work
3. When work done by the force of gravity is negative
   (a) PE increase (b) KE decreases (b) PE remains constant (d) PE decreases
4. Work done by a simple pendulum in one complete oscillation is: (AFMC 2002)
   (a) zero (b) $\sqrt{mg}$ (c) mg cosθ (d) mg sinθ
5. A boy carrying a box on his head is walking on a level road from one place to another on a straight road is doing no work. This statement is (AIIMS 1999)
   (a) correct (b) incorrect (c) partly correct d) insufficient data
6. A body of mass 100 g is rotating in a circular path of radius r with constant velocity The work done in one complete revolution is:
   (a) (r / 100)J (b) (100 / r)J (c) 100rJ (d) zero (AFMC 1998)
7. A labourer of mass 60 kg climbs up a 20 m long staircase to the top of a building 10 m high. What is the work done by him ? (Take g = 10 ms^{-2})
   (a) 3 kJ (b) 6 kJ (c) 12 kJ (d) 24 kJ
8. A force $(3\hat{i}+4\hat{j})$ N acts on a body and displaces it by $(3\hat{i}+4\hat{j})$m. The work done by the force is
   (a) 10J (b) 12 J (c) 16 J (d) 25 J
9. A force $\vec{F}=(5\hat{i}+3\hat{j}+2\hat{k})$N is applied over a particle which displaces it from its origin to the point $\vec{r}=(2\hat{i}-\hat{j})$m. The work done on the particle is (AIEEE 2004)
   (a) -7 J (b) +7 J (c) +10 J (d) +13 J
10. A body, constrained to move in the Y-direction, is subjected to a force $\vec{F}=(-2\hat{i}+15\hat{j}+6\hat{k})$N What is the work done by this force in moving the body through a distance of 10 m along the Y-axis?
   (a) 20 J (b) 150 J (c) 160 J (d) 190 J
11. Work done by a force $\vec{F}=(\hat{i}+2\hat{j}+3\hat{k})$N acting on a particle in displacing it from the point $\vec{r_1}=\hat{i}+\hat{j}+\hat{k}$ to the point $\vec{r_2}=\hat{i}-\hat{j}+2\hat{k}$ is

(a) -3J (b) -1 J (c) zero (d) 2J

12. 300 J of work is done in sliding a 2 kg block up an inclined plane of height 10 m. Taking $g = 10\ m/s^2$, work done against friction is (AIPMT 2006)

(a) 200 J (b) 100 J (c) zero (d) 1000 J

13. A spring of force constant 800 Nm^{-1} has an extension of 5 cm. The work done in extending it from 5 cm to 15 cm is (AIEEE 2002)

(a) 16 J (b) 8 J (c) 32 J (d) 24 J

14. A bullet of mass 10 g leaves a rifle at an initial velocity of 1000 m/s and strikes the earth at the same level with a velocity of 500 m/s. The work done to overcome the resistance of air will be (AIPMT1989)

(a) 375 J (b) 3750 J (c) 5000 J (d) 500 J

15. Consider a drop of rain water having mass 1g falling from a height of 1 km. It hits the ground with a speed of 50 m/s. The work done by the gravitational force is ($g = 10\ ms^{-2}$). (NEET 2017)

(a) 1.25 J (b) 100 J (c) 10 J (d) -10 J

16. Potential energy cannot be expressed in

(a) J (b) Nm (c) Ns (d) Ws

17. A long spring is stretched by 2 cm. Its potential energy is U. If the spring is stretched by 10 cm, its potential energy would be

(a) $\frac{U}{25}$ (b) $\frac{U}{5}$ (c) 5U (d) 25 U

18. The potential energy of a system increases, if work is done (AIPMT 2011)

(a) by the system against a conservations force

(b) by the system against a non-conservative force

(c) upon the system by a conservative force

(d) upon the system by a non-conservative force

19. Kinetic energy with any reference must be (AIIMS 1994)

(a) zero (b) positive (c) negative (d) both positive and negative

20. If the new velocity of a body is twice of its previous velocity, then kinetic energy will become (AFMC 1996)

(a) 2 times (b) 0.5 times (c) 4 times (d) 6 times

21. A light and a heavier body have equal kinetic energy. Which one has greater momentum? (AIPMT 1985)

(a) The heavier body (b) The light body

(c) Both have equal momentum (d) Data given is incomplete

22. The mass of the body is halved and its speed is doubled. What happens to the kinetic energy of the body?

(a) gets doubled (b) becomes four times (c) becomes eight times (d) remains unchanged

23. A ball of mass 2 kg and another of mass 4 kg are dropped together from a 60 ft tall building. After, a fall of 30 ft each towards earth, their respective kinetic energies will be in the ratio of (AIPMT 2004)

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

24. A body of mass 1 kg is thrown upwards with a velocity 20 ms^{-1}. It momentarily comes to rest after attaining a height of 18 m. How much energy is lost due to air friction? (AIPMT 2009)

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

25. Two bodies with kinetic energies in the ratio 4 : 1 are moving with equal linear momentum. The ratio of their masses is (AIPMT 1999)

(a) 1 : 2 (b) 1 : 1 (c) 4 : 1 (d) 1 : 4

26. Two masses 1g and 9 g are moving with equal kinetic energies. The ratio of the magnitudes of their respective linear momenta is (AIPMT 1993)

(a) 1 : 9 (b) 9 : 1 (c) 1 : 3 (d) 3 : 1

27. The momentum of a body is p and its kinetic energy is E. Which of the following is the relation between p and E if the mass of the body be M?

(a) $p=\sqrt{2ME}$ (b) $p=\frac{\sqrt{2E}}{M}$ c) $E=\sqrt{\frac{p^2}{M}}$ d) None of these

28. The momentum of a body is p and its kinetic energy is E. When its momentum becomes 2p its kinetic energy will be

(a) E / 2 (b) 3E (c) 2E (d) 4E

29. Two bodies of masses 4 kg and 5 kg are moving with equal momentum. Then the ratio of their respective kinetic energies is (KCEE 2011)

(a) 4 : 5 (b) 2 :1 (c) 1 : 3 (d) 5 : 4

30. When the K.E of a body becomes four times of its initial value, its momentum will

(a) become twice its initial value (b) become three times its initial value

(c) become four times its initial value (d) remains constant (AIIMS 1998)

31. The unit of power in SI (watt) is equivalent to

(a) kg m s^{-2} (b) kg $m^2 s^{-2}$ (c) kg $m^2 s^{-3}$ (d) none of the above

32. If a force F is applied on a body and the body moves with velocity v, the power will be

(a) F... (b) F / v (c) Fv^2 (d) F/v^2

33. A particle moves with a velocity $(5\hat{i} - 3\hat{j} + 6\hat{k})ms^{-1}$ under the influence of a consta[nt] force $\vec{F} = (10\hat{i} + 10\hat{j} + 20\hat{k})N$. The instantaneous power applied to the particle is

(a) 200 J/s (b) 40 J/s (c) 140 J/s (d) 170 J/s

34. An engine exerts a force $\vec{F} = (20\hat{i} - 3\hat{j} + 5\hat{k})$ N and moves with velocity $\vec{v} = (6\hat{i} + 20\hat{j} - 3\hat{k})$ m/s. The power of the engine is

(a) 45 W (b) 75 W (c) 20 W (d) 10 W

35. An engine pumps water through a hose pipe. Water passes through the pipe an[d] leaves it with a velocity of 2 ms^{-1}. The mass per unit length of water in the pipe i[s] 100 kgm^{-1}. What is the power of the engine? (AIPMT 201[0])

(a) 400 W (b) 200 W (c) 100 W (d) 800 W

36. An engine pumps water continuously through a hose. Water leaves the hose with [a] velocity v and m is the mass per unit length of the water jet. What is the rate a[t] which kinetic energy is imparted to water? (AIPMT 2009)

(a) ½ mv^3 (b) mv^3 (c) ½ mv^2 (d) ½ m^2v^2

37. For an elastic collision

(a) the K.E first increases and then decreases (b) final K.E never remains consta[nt]

(c) final K.E is less than the initial K.E (d) initial K.E is equal to the final K.E

38. A bullet hits and gets embedded in a solid block resting on a horizontal frictionless table. Which of the following is conserved?

(a) momentum and kinetic energy (b) kinetic energy alone

(c) momentum alone (d) potential energy alone

39. Two identical balls A and B having velocities of 0.5 m/s and -0.3 m/s respective[ly] collide elastically in one dimension. The velocities of B and A after the collisi[on] respectively will be (NEET 201[6])

(a) -0.3 m/s and 0.5 m/s (b) 0.3 m/s and 0.5 m/s

(c) -0.5 m/s and 0.3 m/s (d) 0.5 m/s and -0.3 m/s

40. Two equal masses m_1 and m_2 moving along the same straight line with velociti[es] +3 m/s and -5 m/s respectively collide elastically. Their velocities after the collisi[on] will be respectively (AIPMT 199[8])

(a) + 4 m/s for both (b) -3 m/s and +5 m/s

(c) – 4 m/s and +4 m/s (d) -5 m/s and +3 m/s

41. In elastic collision, 100% energy transfer takes place, when (AIIMS 200[1])

(a) $m_1 = m_2$ (b) $m_1 > m_2$ (c) $m_1 < m_2$ (d) $m_1 = 2m_2$

42. In inelastic collision between two spherical rigid bodies, the (AIIMS 200[5])

(a) total kinetic energy is conserved (b) total mechanical energy is not conser[ved]

(c) linear momentum is not conserved (d) linear momentum is conserved

43. A particle of mass *m* moving with velocity v collides with a stationary particle of mass 2 m. After collision, the speed of the stationary particle will be

(a) 2v / 3 (b) 2v (c) v / 3 (d) 3 v (AIIMS 1999)

44. A bullet of mass m moving with a speed v strikes a wooden block of mass M and gets embedded into the block. The final speed is (Manipal 1993)

(a) $\sqrt{\frac{M}{M+m}}\,v$ (b) $\sqrt{\frac{m}{M+m}}\,v$ (c) $\frac{m}{M+m}v$ (d) $\frac{v}{2}$

45. A body of mass m moving with velocity 3 km / h collides with a body of mass 2m at rest. Now, the coalesced mass starts to move with a velocity

(a) 1 km / h (b) 2 km / h (c) 3 km / h (d) 4 km / h (AIPMT 1996)

46. The coefficient of restitution for a perfectly elastic collision is

(a) 1 (b) zero (c) infinite (d) -1 (AIPMT 1988)

47. Which of the following is not a conservative force?

(a) gravitational force (b) spring force (c) elastic force (d) viscous force

48. A moving block having mass m, collides with another stationary block having mass 4m. The lighter block comes to rest after collision. When the initial velocity of the lighter block is v, then the value of coefficient of resistitution (e) will be

(a) 0.5 (b) 0.25 (c) 0.8 (d) 0.4 (NEET 2018)

Answers:

1 (c)	2 (a)	3 (a)	4 (a)	5 (a)	6(d)	7(b)	8 (d)	9 (b)	10 (b)	11 (b)	12 (b)
13 (b)	14 (b)	15 (c)	16 (c)	17 (d)	18 (a)	19 (b)	20 (c)	21(a)	22 (a)	23 (c)	24 (a)
25 (d)	26 (c)	27 (a)	28 (d)	29 (d)	30 (a)	31 (c)	32 (a)	33 (c)	34 (c)	35 (d)	36 (a)
37 (d)	38 (c)	39 (d)	40 (d)	41 (a)	42 (d)	43 (a)	44 (c)	45 (a)	46 (a)	47 (d)	48 (b)

Solutions:

3. (a) When work is done against force of gravity, it is negative.
   As height increases, PE also increases.
4. (a) In one complete oscillation, displacement is zero. Hence work done is zero
5. (a) Work done against gravity $= Fs\cos 90^0 = 0$
6. (d) Work done is zero since displacement is zero.
7. (b) $W = mgh = 60 \times 10 \times 10 = 6000\ J = 6\ kJ$
8. (d) $W = \vec{F}.\vec{s} = (3\hat{i}+4\hat{j}).(3\hat{i}+4\hat{j}) = 9+16 = 25\ J$
9. (b) $W = \vec{F}.\vec{s} = (5\hat{i}+3\hat{j}+2\hat{k}).(2\hat{i}-\hat{j}) = 10-3 = +7\ J$
10. (b) $W = \vec{F}.\vec{s} = (-2\hat{i}+15\hat{j}+6\hat{k}).(10\hat{j}) = 150\ J$

Unit 5 : Motion of System of Particles and Rigid Body

I. Multiple Choice Questions:

1. The center of mass of a system of particles does not depend upon,
   a) position of particles b) relative distance between particles
   c) masses of particles d) force acting on particle
2. A couple produces,
   a) pure rotation b) pure translation
   c) rotation and translation d) no motion
3. A particle is moving with a constant velocity along a line parallel to positive X-axis. The magnitude of its angular momentum with respect to the origin is,
   a) zero b) increasing with x c) decreasing with x d) remaining constant
4. A rope is wound around a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder if the rope is pulled with a force 30 N?
   a) 0.25 rad s^{-2} b) 25 rad s^{-2} c) 5 m s^{-2} d 25 m s^{-2}
5. A closed cylindrical container is partially filled with water. As the container rotates in a horizontal plane about a perpendicular bisector, its moment of inertia
   a) increases b) decreases
   c) remains constant d) depends on direction of rotation
6. A rigid body rotates with an angular momentum L. If its kinetic energy is halved, the angular momentum becomes,
   a) L b) L / 2 c) 2 L d) $L/\sqrt{2}$
7. A particle undergoes uniform circular motion. The angular momentum of the particle remain conserved about,
   a) the center point of the circle b) the point on the circumference of the circle
   c) any point inside the circle d) any point outside the circle
8. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along
   a) a line perpendicular to the plane of rotation
   b) the line making an angle of 45° to the plane of rotation
   c) the radius d) tangent to the path
9. Two discs of same moment of inertia rotating about their regular axis passing through center and perpendicular to the plane of disc with angular velocities ω_1 and ω_2. They are brought into contact face to face coinciding the axis of rotation. The expression for loss of energy during this process is,

a) $\frac{1}{4} I (\omega_1 - \omega_2)^2$ b) $I (\omega_1 - \omega_2)^2$ c) $\frac{1}{8} I (\omega_1 - \omega_2)^2$ d) $\frac{1}{2} I (\omega_1 - \omega_2)^2$

10. A disc of moment of inertia I_a is rotating in a horizontal plane about is symmetry axis with a constant angular speed ω. Another disc initially at rest of moment of inertia I_b is dropped coaxially on to the rotating disc. Then, both the discs rotate with same constant angular speed. The loss of kinetic energy due to friction in the process is

a) $\frac{1}{2} \frac{I_b^2}{(I_a + I_b)} \omega^2$ b) $\frac{I_b^2}{(I_a + I_b)} \omega^2$ c) $\frac{(I_b - I_a)^2}{(I_a + I_b)} \omega^2$ d) $\frac{1}{2} \frac{I_a I_b}{(I_a + I_b)} \omega^2$

11. The ratio of the acceleration for a solid sphere (mass m and radius R) rolling down an incline of angle θ without slipping and slipping down the incline without rolling is

a) 5 : 7 b) 2 : 3 c) 2 : 5 d) 7 : 5

12. From a disc of radius R a mass M, a circular hole of diameter R , whose rim passes through the center is cut. What is the moment of inertia of the remaining part of the disc about the perpendicular axis passing through it

a) $\frac{15\ MR^2}{32}$ b) $\frac{13\ MR^2}{32}$ c) $\frac{11\ MR^2}{32}$ d) $\frac{9\ MR^2}{32}$

13. The speed of a solid sphere after rolling down from rest without sliding on an inclined plane of vertical height h is

a) $\sqrt{\frac{4}{3} gh}$ b) $\sqrt{\frac{10}{7} gh}$ c) $\sqrt{2gh}$ d) $\sqrt{\frac{1}{2} gh}$

14. The speed of the center of a wheel rolling on a horizontal surface is v_0. A point on the rim in level with the center will be moving at a speed

a) zero b) v_0 c) $\sqrt{2}\ v_0$ d) $2v_0$

15. A round object of mass M and radius R rolls down without slipping along an inclined plane. The frictional force

a) dissipates kinetic energy as heat b) decreases the rotational motion

c) decreases the rotational and translational motion

d) converts translational energy into rotational energy

Answers:

1) d 2) a 3) d 4) b 5) a 6) d 7) a 8) a 9) a 10) d 11) a 12) b
13) b 14) d 15) d

∴ M.I of the remaining part of the disc

$$= \frac{MR^2}{2} - \frac{3}{32}MR^2 = \frac{MR^2}{2}\left(1 - \frac{3}{16}\right) = \frac{13}{32}MR^2$$

13. (b) When a solid sphere rolls down on an inclined plane its total K.E. $= \frac{7}{10}mv^2$

Hence $mgh = \frac{7}{10}mv^2$, $v^2 = \frac{10gh}{7}$, $v = \sqrt{\frac{10}{7}gh}$

On reaching the bottom it has only P.E.

14. (d) When a wheel rolls, given velocity of the centre of mass = v_0. So at the top of the rim, the velocity = velocity of centre of mass + linear velocity = $v_0 + v_0 = 2v_0$

At the bottom velocity = $v_0 - v_0 = 0$

Creative Questions

1. Unit of centre of mass in SI system is
   (a) m (b) kg m² (c) kg m (d) kg
2. A body falling vertically downwards under gravity breaks into two parts of unequal masses. The centre of mass of the two parts taken together shifts horizontally towards
   (a) heavier piece (b) does not shift horizontally
   (c) lighter piece (d) depends on the vertical velocity at the time of breaking
3. Two balls are thrown simultaneously in air. The acceleration of the centre of mass of the balls, while in air
   (a) depends on the direction of the motion of the balls (b) is equal to g
   (c) depends on the masses of the two balls
   (d) depends on the speeds of the two balls
4. A ball kept in a closed box moves in the box, making collisions with the walls. The box is kept on a smooth surface. The velocity of the centre of mass
   (a) of the box remains constant
   (b) of the box plus the ball system remains constant
   (c) of the ball remains constant (d) of the ball relative to the box remains constant
5. The centre of mass of a system shall be
   (a) at the centre of the system (b) outside the system
   (c) inside the system (d) inside or outside the system

6. The centre of mass of a system of particles does not depend on (AIPMT 1997)
   (a) masses of the particles
   (b) forces on the particles
   (c) position of the particles
   (d) relative distances between the particles
7. Consider a system of two identical particles. One of the particles is at rest and the other has an acceleration a. The centre of mass has an acceleration
   (a) zero (b) a/2 (c) a (d) 2a
8. There identical metal balls, each of radius r are placed touching each other on a horizontal surface, such that an equilateral triangle is formed, when centres of three balls are joined. The centre of mass of the system is located at (AIPMT 1999)
   (a) horizontal surface
   (b) centre of one of the balls
   (c) line joining centres of any two balls
   (d) point of intersection of the medians
9. A solid sphere of radius R is placed on a smooth horizontal surface. A horizontal force F is applied at height h from the lowest point. For the maximum acceleration of the centre of mass
   (a) h = R (b) h = 2R (c) h = 0
   (d) the acceleration will be same whatever h may be (AIPMT 2002)
10. A rod is of length 3 m and its mass acting per unit length is directly proportional to distance x from its one end. The centre of gravity of the rod from that end will be at
   (a) 1.5 m (b) 2 m (c) 2.5 m (d) 3 m (AIPMT 2002)
11. At any instant, a rolling body may be considered to be in pure rotation about an axis through the point of contact. This axis is translating forward with speed (AIPMT 1990)
   (a) equal to centre of mass
   (b) zero
   (c) twice of centre of mass
   (d) none of the above
12. A shell at rest explodes. The centre of mass of the fragments
   (a) moves along a parabolic path (b) moves along an elliptical path
   (c) moves along a straight line (d) remains at rest
13. Two balls of equal mass are projected from a tower simultaneously with equal speeds. One at angle θ above the horizontal and the other at the same angle θ below the horizontal. The path of the centre of mass of the two balls is
   a) a vertical straight line
   (b) a horizontal straight line
   (c) a straight line at angle α ($< \theta$) with horizontal (d) a parabola
14. Two persons of masses 55 kg and 64 kg respectively, are at the opposite ends of a boat. The length of the boat is 3 m and weighs 100 kg. The 55 kg man walks unto the 65 kg man and sits with him. If the boat is in still water the centre of mass of the system shifts by (AIPMT 2012)
   (a) 3 m (b) 2.3 m (c) zero (d) 0.75 m

15. Two particles which are initially at rest, move towards each other under the action of their internal attraction. If their speeds are v and 2 v at any instant, then the speed of centre of mass of the system will be (AIPMT 2010)

(a) 2 v (b) 0 (c) 1.5 v (d) v

16. In a carbon monoxide molecule, the carbon and the oxygen atoms are separated by a distance 1.12×10^{-10}m. The distance of the center of mass from the carbon atom is (AIPMT 1997)

(a) 0.64×10^{-10}m (b) 0.56×10^{-10}m (c) 0.51×10^{-10}m (d) 0.48×10^{-10}m

17. The angular speed of minute arm in a watch is:

(a) $\frac{\pi}{21600}$ rads^{-1} (b) $\frac{\pi}{12}$ rads^{-1} (c) $\frac{\pi}{3600}$ rads^{-1} (d) $\frac{\pi}{1800}$ rads^{-1}

18. In which of the following cases, the angular velocity is useful? (AFMC 1997)

(a) When velocity of a body is in a straight line (b) When a body is rotating

(c) When a body moves with a constant linear acceleration (d) none of these

19. A particle moves in a circle of radius 5 cm with constant speed and time period $0.2\,\pi$ s. The acceleration of the particle is (AIPMT 2011)

(a) 25 m/s^2 (b) 36 m/s^2 (c) 5 m/s^2 (d) 15 m/s^2

20. A wheel has angular acceleration of 3 rad/s^2 and an initial angular speed of 2 rad/s. In a time of 2 s, it has rotated through an angle of (AIPMT 2007)

(a) 6 rad (b) 10 rad (c) 12 rad (d) 4 rad

21. If a flywheel makes 120 rev/min, then its angular speed will be (AIPMT 1996)

(a) $8\,\pi$ rad/s (b) $6\,\pi$ rad/s (c) $4\,\pi$ rad/s (d) $2\,\pi$ rad/s

22. The angular speed of an engine wheel making 90 rev/ min is (AIPMT 1995)

a) 1.5π rad/s (b) 3π rad/s (c) 4.5π rad/s (d) 6π rad/s

23. Two racing cars of masses m and 4 m are moving in circles of radii r and 2r respectively. If their speeds are such that each makes a complete circle in the same time, then the ratio of the angular speeds of the first to the second car is

(a) 8 : 1 (b) 4 : 1 (c) 2 : 1 (d) 1 : 1 (AIPMT 1995)

24. The moment of inertia of a body comes into play (AIPMT 1999)

(a) in linear motion (b) in rotational motion

(c) in projectile motion (d) in periodic motion

25. The moment of inertia of a body does not depend on

(a) the angular velocity of the body (b) the mass of the body

(c) the axis of rotation of the body (d) the distribution of the mass in the body

35. Spokes are used in a cycle wheel
(a) to increase the strength of the wheel
(b) to increase the moment of inertia of the wheel
(c) to give better shape to the wheel (d) None of these

36. The rate of change of angular momentum is equal to
(a) Force (b) Angular acceleration (c) Torque (d) Moment of Inertia

37. Angular momentum is the vector product of
(a) linear momentum and radius vector (b) moment of inertia and angular veloc
(c) linear momentum and angular velocity (d) linear velocity and radius vector

38. If r denotes the distance between the sun and the earth, then the angula momentum of the earth around the sun is proportional to (Kerala CEE 2011)
(a) r^3 (b) r (c) $\sqrt{r}$ (d) r^2

39. If $\vec{F}$ is the force acting on a particle having position $\vec{r}$ vector and $\vec{\tau}$ be the torque o this force about the origin, then (AIPMT 2009)
(a) $\vec{r}.\vec{\tau} \neq 0$ and $\vec{F}.\vec{\tau} = 0$ (b) $\vec{r}.\vec{\tau} > 0$ and $\vec{F}.\vec{\tau} < 0$
(c) $\vec{r}.\vec{\tau} = 0$ and $\vec{F}.\vec{\tau} = 0$ (d) $\vec{r}.\vec{\tau} = 0$ and $\vec{F}.\vec{\tau} \neq 0$

40. A mass M is moving with a constant velocity parallel to X-axis. Its angula momentum with respect to origin (IIT 1985)
(a) goes on increasing (b) goes on decreasing (c) remains constant (d) is zero

41. Relation between torque and angular momentum is similar to the relation between
(a) acceleration and velocity (b) mass and moment of inertia
(c) force and momentum (d) energy and displacement

42. A particle undergoes uniform circular motion. About which point on the plane of the circle, will the angular momentum of the particle remain conserved? (IIT 2003)
(a) centre of the circle (c) inside the circle
(c) outside the circle (d) on the circumference of the circle

43. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along (AIPMT 2012)
(a) a line perpendicular to the plane of rotation (b) the tangent to the orbit
(c) the line making an angle of 45^0 to the plane of rotation (d) the radius

44. If there is change of angular momentum from 1 Js to 4 Js in 4 s, then the torque is (AIIMS 1997)
(a) $\frac{3}{4}$ J (b) 1 J (c) $\frac{5}{4}$ J (d) $\frac{4}{3}$ J

45. Angular momentum of the body is conserved

(a) always (b) never

(c) in the absence of external torque (d) in the presence of external torque

46. The torque of a force $\vec{F} = -6\hat{i}$ acting at a point $r = 4\hat{j}$ about the origin will be

(a) $-24\hat{k}$ (b) $24\hat{k}$ (c) $24\hat{j}$ (d) $24\hat{i}$

47. When a body is projected at an angle with the horizontal in the uniform gravitational field of the earth, the angular momentum of the body about the point of projection, as it proceeds along its path

(a) remains constant (b) increases (c) decreases

(d) initially decreases and after its highest point increases

48. A man is sitting on a rotating stool with his arms outstretched. Suddenly he folds his arm. The angular velocity

(a) decreases (b) increases (c) becomes zero (d) remains constant

49. An athlete diving off a high springboard can perform a variety of exercises in the air before entering the water below. Which one of the following parameters will remain constant during the fall. The athlete's

(a) linear momentum (b) moment of inertia

(c) kinetic energy (d) angular momentum.

50. A disc is rotating with angular velocity ω. A child sits on it. What is conserved?

(AIPMT 2001)

(a) Linear momentum (b) Angular momentum

(c) Kinetic energy (d) Moment of inertia

51. A man is standing at the centre of a rotating turn table with his arms stretched. If he draws his arms inwards and thereby reduces his moment of inertia by a factor k, the angular speed of the turn-table (Manipal 1993)

(a) remains constant (b) increases by a factor k

(c) decreases by a factor of k (d) decreases by a factor of k^2

52. The motion of planets in the solar system is an example of the conservation of:

(AIIMS 2003)

(a) mass (b) linear momentum (c) angular momentum (d) energy

53. A circular disc is rotating with angular velocity ω. If a man standing at the edge of the disc walks towards its centre, then the angular velocity of the disc: (AFMC 2002)

(a) is not changed (b) is halved (c) decreases (d) increases

54. The moment of the force, $\vec{F} = 4\hat{i} + 5\hat{j} - 6\hat{k}$ at (2, 0, -3), about the point (2, -2, -2), is given by:- (NEET 2018)

a) $-8\hat{i} - 4\hat{j} - 7\hat{k}$ b) $-4\hat{i} - \hat{j} - 8\hat{k}$ c) $-7\hat{i} - 8\hat{j} - 4\hat{k}$ d) $-7\hat{i} - 4\hat{j} - 8\hat{k}$

55. A solid sphere is in rolling motion. In rolling motion a body possesses translational kinetic energy (K_t) as well as rotational kinetic energy (K_r) simultaneously. The ratio $K_t : (K_t + K_r)$ for the sphere is (NEET 2018)

a) 7 : 10 b) 5 : 7 c) 10 : 7 d) 2 : 5

56. A solid sphere is rotating freely about its symmetry axis in free space. The radius of the sphere is increased keeping its mass same. Which of the following physical quantities would remain constant for the sphere? (NEET 2018)

a) Angular velocity b) Moment of inertia
c) Rotational kinetic energy d) Angular momentum

Answers:

1 (a) 2 (b) 3 (b) 4 (b) 5 (d) 6 (b) 7 (b) 8 (d) 9 (d) 10 (a) 11 (a) 12 (a)
13 (d) 14 (c) 15 (b) 16 (a) 17 (d) 18 (b) 19 (c) 20 (b) 21 (c) 22 (d) 23 (d) 24 (b)
25 (a) 26 (b) 27 (a) 28 (d) 29 (a) 30 (b) 31 (c) 32 (a) 33 (c) 34 (a) 35 (b) 36 (c)
37 (b) 38 (d) 39 (c) 40 (d) 41 (c) 42 (a) 43 (a) 44 (a) 45 (c) 46 (b) 47 (b) 48 (b)
49 (d) 50 (b) 51 (b) 52 (c) 53 (d) 54 (d) 55(b) 56 (d)

Solutions:

7. (b) $m(\vec{0}) + m(a) = (m + m)a'$, $2ma' = ma$, $a' = a/2$

9. (d) Linear acceleration of centre of mass $a = F/M$
This is same wherever the force is applied.

10. (a) The mass is uniformly distributed. So centre of gravity will be at 1.5 m from its end.

14. (c) Net external force on the system is zero. Hence centre of mass remains unchanged.

15. (b) No external force acts on the system. Hence speed of centre of mass in zero

16. (a) $X_{cm} = \frac{12\times0+16\times1.12\times10^{-10}}{12+16} = 0.64\times10^{-10}m$

17. (d) $\omega = \frac{2\pi}{T} = \frac{2\pi}{60\times60} = \frac{\pi}{1800} rads^{-1}$

19. (c) $a = r\omega^2 = \frac{4\pi^2 r}{T^2} = \frac{4\pi^2\times5\times10^{-2}}{0.04\pi^2} = 5ms^{-2}$

20. (b) $\theta = \omega_0 t + \frac{1}{2}\alpha t^2 = 2\times2+\frac{1}{2}\times3\times2^2 = 4+6 = 10 rad$

21. (c) $\omega = 2\pi n = 2\pi\times\frac{4\times\ldots}{\ldots}$

$$t = \left(\sqrt{\frac{2gh}{1+\frac{K^2}{R^2}}}\right)\left(\frac{\frac{K^2}{R^2}}{g\sin\theta}\right) = \sqrt{\frac{2h\left(1+\frac{K^2}{R^2}\right)}{g\sin^2\theta}}$$

For a given inclined plane, the object with the least value of radius of gyration K will reach the bottom first.

Book problems (1 mark) :

1. Two point masses 3 kg and 5 kg are at 4 m and 8 m from the origin on X- axis. The position of center of mass of the two point masses from the origin is
a) 2.5 m b) 6.5 m c) 5.2 m d) 5.6 m
2. Two point masses 3 kg and 5 kg are at 4m and 8 m from the origin on X- axis. The position of center of mass of the two point masses from 3 kg mass is
a) 2.5 m b) 6.5 m c) 5.2 m d) 5.6 m
3. If a force of 2.5N is applied perpendicular to the handle of a spanner of length 15 cm, the torque exerted by the force about the centre of the nut is
a) 37.5 Nm b) 2.5 Nm c) 0.15 Nm d) 0.375 Nm
4. A force of $\vec{F} = (4\hat{i} - 3\hat{j} + 5\hat{k})$ N is applied at a point whose position vector is $\vec{r} = (7\hat{i} + 4\hat{j} - 2\hat{k})$ m. The torque of force about the origin is
a) $(14\hat{i} + 43\hat{j} - 37\hat{k})$ Nm b) $(14\hat{i} - 43\hat{j} - 37\hat{k})$ Nm
c) $(-14\hat{i} - 43\hat{j} - 37\hat{k})$ Nm d) $(-14\hat{i} + 43\hat{j} - 37\hat{k})$ Nm
5. A cyclist while negotiating a circular path with speed 20 ms^{-1} is found to bend by 30° with the vertical. The radius of the circular path is (g = 10 ms^{-2})
a) 40 m b) 120 m c) 69.28 m d) 6.928 m
6. The moment of inertia of a disc of mass 3 kg and radius 5.0cm about an axis passing through the center and perpendicular to the plane of the disc is
a) 0.375 kgm^2 b) 1.125 kgm^2 c) 0.1875 kgm^2 d) 0.75 kgm^2
7. The moment of inertia of a circular disc of mass 3 kg and radius 50cm about an axis touching the edge and perpendicular to the plane of the disc is
a) 0.375 kgm^2 b) 1.125 kgm^2 c) 0.8175 kgm^2 d) 0.75 kgm^2
8. The moment of inertia of a disc of mass 3 kg radius 50cm about an axis passing through the center and lying on the plane of the disc is
a) 0.375 kgm^2 b) 1.125 kgm^2 c) 0.1875 kgm^2 d) 0.75 kgm^2
9. A solid sphere of mass 20 kg and radius 0.25 m rotates with an angular velocity 5 rad s^{-1} about an axis passing through the center. Its angular momentum is
a) 2.5 kgm^2s^{-1} b) 0.25 kgm^2s^{-1} c) 0.5 kgm^2s^{-1} d) 0.125 kgm^2s^{-1}

Answers : 1(b) 2(a) 3(d) 4(b) 5(c) 6(c) 7(b) 8(c) 9(a)

Book problems (2 marks) :

1. Two point masses 3 kg and 5 kg are at 4 m and 8 m from the origin on X-axis. Locate the position of center of mass of the two point masses (i) from the origin and (ii) from 3 kg mass.

Unit 6: Gravitation

I. Multiple Choice Questions

1. The linear momentum and position vector of the planet is perpendicular to each other at
   a) perihelion and aphelion b) at all points
   c) only at perihelion d) no point

2. If the masses of the Earth and Sun suddenly double, the gravitational force between them will
   a) remain the same b) increase 2 times
   c) increase 4 times d) decrease 2 times

3. A planet moving along an elliptical orbit is closest to the Sun at distance r_1 and farthest away at a distance of r_2. If v_1 and v_2 are linear speeds at these points respectively. Then the ratio v_1/v_2 is
   a) $\frac{r_2}{r_1}$ b) $(r_2/r_1)^2$ c) $\frac{r_1}{r_2}$ d) $(r_1/r_2)^2$

4. The time period of a satellite orbiting Earth in a circular orbit is independent of
   a) Radius of the orbit b) The mass of the satellite
   c) Both the mass and radius of the orbit
   d) Neither the mass nor the radius of its orbit

5. If the distance between the Earth and Sun were to be doubled from its present value, the number of days in a year would be
   a) 64.5 b) 1032 c) 182.5 d) 730

6. According to Kepler's second law, the radial vector to a planet from the Sun sweeps out equal areas in equal intervals of time. This law is a consequence of
   a) conservation of linear momentum b) conservation of angular momentum
   c) conservation of energy d) conservation of kinetic energy

7. The gravitational potential energy of the Moon with respect to Earth is
   a) always positive b) always negative
   c) can be positive or negative d) always zero

8. The kinetic energies of a planet in an elliptical orbit about the Sun, at positions A, B and C are K_A, K_B and K_C respectively. AC is the major axis and SB is perpendicular to AC at the position of the sun S as shown in the figure. Then

   a) $K_A > K_B > K_C$ b) $K_B < K_A < K_C$
   c) $K_A < K_B < K_C$ d) $K_B > K_A > K_C$

9. The work done by the Sun's gravitational force on the Earth is
   a) always zero
   b) always positive
   c) can be positive or negative
   d) always negative
10. If the mass and radius of the Earth are both doubled, then the acceleration due to gravity g'
    a) remains same b) g / 2 c) 2 g d) 4 g
11. The magnitude of the Sun's gravitational field as experienced by Earth is
    a) same over the year
    b) decreases in the month of January and increases in the month of July
    c) decreases in the month of July and increases in the month of January
    d) increases during day time and decreases during night time
12. If a person moves from Chennai to Trichy, his weight
    a) increases b) decreases
    c) remains same d) increases and then decreases
13. An object of mass 10 kg is hanging on a spring scale which is attached to the roof of a lift. If the lift is in free fall, the reading in the spring scale is
    a) 98 N b) zero c) 49 N d) 9.8 N
14. If the acceleration due to gravity becomes 4 times its original value, then escape speed
    a) remains same
    b) 2 times of original value
    c) becomes halved
    d) 4 times of original value
15. The kinetic energy of the satellite orbiting around the Earth is
    a) equal to potential energy
    b) less than potential energy
    c) greater than kinetic energy
    d) zero

Answers : 1) a 2) c 3) a 4) b 5) b 6) b 7) b 8) a 9) c
10) b 11) c 12) a 13) b 14) b 15) b

Solution :

1\. a) This is because the orbit of the planet is elliptical

2\. c) $F = \frac{GM_1M_2}{r^2}$, $F' = \frac{G(2M_1)(2M_2)}{r^2} = 4$ F, increases 4 times

3\. a) Angular momentum at the closest point = angular momentum at the farthest point. $mr_1v_1 = mr_2v_2$, $r_1v_1 = r_2v_2$, $\frac{v_1}{v_2} = \frac{r_2}{r_1}$

5. b) $\frac{T_2^2}{T_1^2}=\frac{d_2^3}{d_1^3}$, $T_2^2=T_1^2\left(\frac{2d_1}{d_1}\right)^3$, $T_2=T_1\sqrt{8}$ = 365 × 2.828 = 1032 days.

8. a) L = mv r = Iω = constant

KE = K = $\frac{L^2}{2I}$. From figure $I_A < I_B < I_C$. Hence $K_A > K_B > K_C$

10.b) $g=\frac{GM_E}{R_E^2}$, $g'=\frac{G(2M_E)}{(2R_E)^2}=\frac{g}{2}$

11. c) The gravitational field decreases as distance increases. The distance between the sun and earth increases in the month of July and decreases in the month of January. Hence the magnitude of the sun's gravitational field as experienced by earth decreases in the month of July and increases in the month of January.

12. a) g = GM / R^2. So $g \propto 1/R^2$. The value of R decreases from Chennai to Trichy. So the value of g increases from Chennai to Trichy. Thus if a person moves from Chennai to Trichy his weight increases.

14. b) $v_e=\sqrt{2gR_E}$, $v_e'=\sqrt{2(4g)R_E}=2v_e$ two times of original value.

15. b) PE = U = $\frac{-GM_sM_E}{(R_E+h)}$, KE = $\frac{1}{2}\frac{GM_sM_E}{(R_E+h)}$. Thus KE < PE

Creative Questions:

1. The force of gravitation is (AIIMS 2002)
   (a) repulsive (b) electrostatic (c) conservative (d) non-conservative
2. Which of the following is an evidence to show that there must be a force acting on earth and directed towards the sun? (AIIMS 1980)
   (a) Deviation of the falling bodies towards east
   (b) Revolution of the earth round the sun
   (c) Phenomenon of day and night (d) Apparent motion of sun round the earth
3. Two spheres of same size, one of mass 2 kg and another of mass 4 kg are dropped simultaneously from the top of Qutabminar. When they are 1 m above the ground, the two spheres have the same (AIIMS 2006)
   (a) momentum (b) kinetic energy (c) potential energy (d) acceleration

4. Two spheres of masses m and M are situated in air and the gravitational force between them is F. The space around the masses is now filled with a liquid of specific gravity 3. The gravitational force will now be (AIPMT 2003)

(a) F (b) 3 F (c) F / 3 (d) F / 9

5. A man waves his arms, while walking. This is (AIIMS 2000)

(a) to keep constant velocity (b) to ease the tension

(c) to increase the velocity (d) to balance the effect of earth's gravity

6. If the distance between two masses is doubled, the gravitational force between them

(a) is reduced to half (b) is reduced to a quarter

(c) is doubled (d) becomes four times

7. A satellite of the earth is revolving in a circular orbit with a uniform speed v. If the gravitational force suddenly disappears, the satellite will (AIIMS 1982)

(a) continue to move with velocity v along the original orbit

(b) move with a velocity v tangentially to the original orbit

(c) fall down with increasing velocity

(d) ultimately come to rest, some where on the original orbit

8. If the radius of earth shrinks by one percent and its mass remaining the same then acceleration due to gravity on the earth's surface will (AIIMS 1994)

(a) decrease (b) increase (c) remains constant (d) either (a) or (c)

9. Let g_1 and g_2 denote acceleration due to gravity on the surface of the earth and on a planet, whose mass and radius are twice that of the earth. Then

(a) $g_1 = g_2$ (b) $g_1 = 2g_2$ (c) $g_2 = 2g_1$ (d) $g_1 = 2g_2^2$

10. What will be the formula for mass of the earth in terms of g, R and G? (AIPMT 1997)

(a) $\frac{g^2R}{G}$ (b) $\frac{G^2R}{g}$ (c) $\frac{GR}{g}$ (d) $\frac{gR^2}{G}$

11. Two planets of radii r_1 and r_2 are made from the same material. The ratio of the acceleration due to gravity g_1 / g_2 at the surfaces of the planets is (AIIMS 1985)

(a) $\frac{r_1}{r_2}$ (b) $\frac{r_2}{r_1}$ (c) $\left(\frac{r_1}{r_2}\right)^2$ (d) $\left(\frac{r_2}{r_1}\right)^2$

12. If a planet consists of a satellite, whose mass and radius are both half that of earth, then acceleration due to gravity (g) at its surface should be: (AFMC 2000)

(a) 29.4 ms^{-2} (b) 19.6 ms^{-2} (c) 9.8 ms^{-2} (d) 4.9 ms^{-2}

13. If mass of a body is M on the earths surface, then the mass of the same body on the moon's surface is (AIIMS 1997)

(a) M / 6 (b) zero (c) M (d) none of these

14. The acceleration due to gravity at a height 1 km above the earth is the same as at a depth d below the surface of earth, then (NEET 2017)

(a) d = 1 km (b) $d = \frac{3}{2}$ km (c) d = 2 km (d) $d = \frac{1}{2}$ km

15. Two astronauts are floating in gravitational free space after having lost contact with their space ship. The two will (NEET 2017)

(a) move towards each other (b) move away from each other

(c) will become stationary (d) keep floating at the same distance between them

16. The weight of a body at earth's surface is W. At a depth half way to the centre of the earth, it will be (AIPMT 1989)

(a) W (b) W / 2 (c) W / 4 (d) W / 8

17. Force due to gravity is least at a latitude of

(a) 0^0 (b) 45^0 (c) 60^0 (d) 90^0

18. The height at which the weight of a body becomes $1/16^{th}$ its weight on the surface of the earth (radius R) is (AIPMT 2012)

(a) 5 R (b) 15 R (c) 3 R (d) 4 R

19. If the value of g at the height h above the surface of the earth is the same as at a depth x below it, then (both x and h being much smaller than the radius of the earth)

(a) $x = h$ (b) $x = 2h$ (c) $x = h / 2$ (d) $x = h^2$

20. At what depth below the surface of the earth, is the value of g same as that of a height of 5 km? (AIIMS 2000)

(a) 10 km (b) 7.5 km (c) 5 km (d) 2.5 km

21. The weight of a body at the centre of the earth is (AFMC 1988)

(a) zero (b) infinite (c) same as on the surface of earth (d) none of the above

22. A body weighed 250 N on the surface assuming the earth to be a sphere of uniform mass density, how much would it weigh half way down to the centre of earth? (AIIMS 1995)

(a) 240 N (b) 210 N (c) 195 N (d) 125 N

23. Average density of the earth (AIEEE 2005)

(a) does not depend on g (b) is a complex function of g

(c) is directly proportional to g (d) is inversely proportional to g

24. The acceleration due to gravity g and mean density of the earth ρ are related by which of the following relations? (G is the gravitational constant and R is radius of the earth) (AIPMT 1997)

(a) $\rho = \frac{4\pi g R^2}{3G}$ (b) $\rho = \frac{4\pi g R^3}{3G}$ (c) $\rho = \frac{3g}{4\pi GR}$ (d) $\rho = \frac{3g}{4\pi GR^3}$

25. If the Earth stops rotating, the value of g at the equator will (AIPMT 1986)

(a) increase (b) decrease (c) remain same (d) become zero

26. Where is the intensity of the gravitational field of the earth maximum?
(a) centre of the earth (b) equator (c) poles (d) same every where

27. The angular speed of earth (in rad s^{-1}), so that an object on equator may appear weightless is :
(a) 1.25×10^{-3} (b) 1.50×10^{-3} (c) 1.56 (d) 0.125 (AFMC 1998)

28. If the spinning speed of the earth is increased, then weight of the body at the equator:
(a) does not change (b) doubles (c) decreases (d) increases (AFMC 2002)

29. Acceleration due to gravity is least
(a) at the equator (b) at the poles
(c) at a point in between equator and any pole (d) none of the above

30. If we move from equator to pole, the value of acceleration due to gravity:
(a) first increases then decreases (b) remains same
(c) increases (d) decreases (AFMC 2009)

31. If g is the acceleration due to gravity on the earth's surface, the gain in the potential energy of an object of mass m raised from the surface of the earth to a height equal to the radius R of the earth is : (AIEEE 2004)
(a) $\frac{1}{4}$ mgR (b) $\frac{1}{2}$ mgR (c) 2 mgR (d) mgR

32. A body of mass m is placed on earth's surface, which is taken from earth's surface to a height of h = 3 R. Then, change in gravitational potential energy is
(a) $\frac{mgR}{4}$ (b) $\frac{mgR}{2}$ (c) $\frac{2mgR}{3}$ (d) $\frac{3mgR}{4}$ (AIPMT 2002)

33. The escape velocity for a body projected vertically upwards from the surface of earth is 11 kms^{-1}. If the body is projected at an angle of 45^0 with the vertical, the escape velocity will be (AIEEE 2003)
(a) $11/\sqrt{2}$ kms^{-1} (b) 11 kms^{-1} (c) $11\sqrt{2}$ kms^{-1} (d) 22 kms^{-1}

34. The escape velocity of a body depends upon mass as : (AIEEE 2002)
(a) m^0 (b) m (c) m^2 (d) m^3

35. The escape velocity of a sphere of mass m is given by (G = universal gravitational constant, M = mass of the earth and R = radius of the earth) (AIPMT 1999)
(a) $\sqrt{\frac{GM}{R}}$ (b) $\sqrt{\frac{2GM}{R}}$ (c) $\sqrt{\frac{2Gm}{R^3}}$ (d) $\frac{GM}{R^2}$

36. The escape speed on Earth is 11.2 kms^{-1}. Its value for a planet having double the radius and eight times the mass of the Earth is
(a) 11.2 kms^{-1} (b) 5.6 kms^{-1} (c) 22.4 kms^{-1} (d) 44.8 kms^{-1}

37. The escape velocity of a body on the surface of the earth is 11.2 km/s. If the earth's mass increases to twice its present value and the radius of the earth becomes half, the escape velocity would become (AIPMT 1997)

(a) 44.8 km/s (b) 22.4 km/s (c) 11.2 km/s d) 5.6 km/s

38. The velocity with which a projectile, must be fired so that it escapes earth's gravitation, does not depend on : (AIIMS 2003)

(a) mass of the earth (b) mass of the projectile
(c) radius of the projectile's orbit (d) gravitational constant

39. An artificial satellite is revolving around the earth in a circular orbit. If its speed is half of the escape velocity, then its height above the surface of earth of radius R is: (AFMC 1998)

(a) R / 4 (b) R / 2 (c) 2R (d) R

40. A planet in a distant solar system is 10 times more massive than the earth and its radius is 10 times smaller. Given that the escape velocity from the earth is 11 km s^{-1}, the escape velocity from the surface of the planet is (AIEEE 2008)

(a) 0.11 km s^{-1} (b) 1.1 km s^{-1} (c) 11 kms^{-1} (d) 110 km s^{-1}

41. Escape velocity from the earth is 11.2 km/s. Another planet of same mass has radius 1/4 times that of the earth. What is the escape velocity from another planet? (AIPMT 2001)

(a) 11.2 km/s b) 44.8 km/s (c) 22.4 km/s d) 5.6 km/s

42. If r represents the radius of orbit of satellite of mass m moving around a planet of mass M. The velocity of the satellite is given by

(a) $v^2 = \frac{GM}{r}$ (b) $v = \frac{GM}{r}$ (c) $v^2 = \frac{GMm}{r}$ (d) $v = \frac{Gm}{r}$

43. Orbital velocity of a satellite revolving round the earth is independent of the

(a) mass of the earth (b) mass of the satellite
(c) radius of the earth (d) radius of the orbit

44. If suddenly the gravitational force of attraction between earth and a satellite revolving around it becomes zero, then the satellite will: (AIEEE 2002)

(a) continue to move in its orbit with same velocity
(b) become stationary in its orbit
(c) move tangentially to the original orbit with the same velocity.
(d) move towards the earth

45. A ball is dropped from a satellite revolving around the earth at a height of 120 km. The ball will (AIPMT 1996)

(a) continue to move with the same speed along a straight line tangentially to the satellite at that time
(b) continue to move with the same speed along the original orbit of satellite
(c) fall down to the earth gradually (d) go far away in space

46. A satellite of mass m revolves around the earth of radius R at a height h from its surface. If g is the acceleration due to gravity on the surface of the earth, the orbital speed of the satellite is : (AIEEE 2004)

(a) g h (b) $\frac{gR}{R-h}$ (c) $\frac{gR^2}{R+h}$ (d) $\left(\frac{gR^2}{R+h}\right)^{1/2}$

47. If v_e and v_o represent the escape velocity and orbital velocity of a satellite corresponding to a circular orbit of radius R(radius of earth), then (AIPMT 1982)

(a) $v_e = v_o$ (b) $v_e = \sqrt{2}\ v_o$ (c) $v_e = v_0 / \sqrt{2}$ (d) v_e and v_0 are not related

48. There is no atmosphere on the moon, because (AIIMS 1994)

(a) it is closer to the earth and also it has the inactive inert gases in it.
(b) it is too far from the sun and has very low pressure in its outer surface
(c) escape velocity of gas molecules is greater than their root mean square velocity
(d) escape velocity of gas molecules is less than their root mean square velocity

49. A bomb explodes on the moon. How long will it take for the sound to reach the earth? (AFMC 2005)

(a) 10 s (b) 1,000 s (c) 1 day (d) will never reach

50. The ratio of velocity of a satellite rotating around earth in a circular orbit close to the surface of the earth to escape velocity from earth is

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

51. A seconds pendulum is mounted in a rocket. Its period of oscillation decreases when the rocket (AIPMT 1991)

(a) comes down with uniform acceleration
(b) moves up with uniform acceleration
(c) moves round the earth in a geo-stationary orbit
(d) moves up with a uniform velocity

52. The time period of an earth satellite in circular orbit is independent of :

(a) the mass of the satellite (b) both the mass and radius of the orbit
(c) neither the mass of the satellite nor the radius of its orbit (AIEEE 2004)
(d) radius of its orbit

53. The distances of two planets from the sun are 10^{13}m and 10^{12}m respectively. The ratio of the time periods of these planets is (AIPMT 1994)

(a) 100 b) $10\sqrt{10}$ c) $\sqrt{10}$ d) $1/\sqrt{10}$

54. The kinetic energy needed to project a body of mass m from the earth's surface (radius R) to infinity is: (AIEEE 2002)

a) mg R / 2 b) 2mg R c) mg R d) mg R / 4

55. A satellite A of mass m is at a distance r from the surface of the earth. Another satellite B of mass 2m is at distance of 2 r from the earth's surface. Their time periods are in the ratio of (AIPMT 1993)

a) 1 : 2 b) 1 : 16 c) 1 : 32 d) $1 : 2\sqrt{2}$

56. The time period of a satellite in a circular orbit of radius R is T. The period of another satellite in a circular orbit of radius 4 R is (AIPMT 1982)

(a) 4T (b) T / 4 (c) 8T (d) T / 8

57. The time period of a satellite of earth is 5 hours. If the separation between the earth and the satellite is increased to 4 times the previous value, the new time period will become (AIEEE 2003)

(a) 10 hour (b) 80 hour (c) 40 hour (d) 20 hour

58. The atmosphere is held to the earth by (AIPMT 1992)

(a) winds (b) gravity (c) clouds (d) the rotation of the earth

59. For a satellite moving in an orbit around the earth, the ratio of kinetic energy to potential energy is (AIPMT 2005)

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

60. A missile is launched with a velocity less than the escape velocity. The sum of its kinetic and potential energies (IIT 1986)

(a) is positive (b) is negative (c) is zero

(d) may be positive or negative depending upon its initial velocity

61. The amount of work required to send a body of mass m from earth's surface to a height R / 2 where R is radius of earth is

(a) $\frac{mgR}{2}$ (b) $\frac{mgR}{3}$ (c) $\frac{mgR}{4}$ (d) $\frac{5mgR}{3}$

62. A satellite of mass m is moving in a circular orbit at a distance R above the surface of a planet of mass M and radius R. The amount of work done to shift the satellite to a higher orbit at a distance 2 R above the surface of the planet is : (AFMC 2009)

(a) $\frac{MmgR}{M+m}$ (b) $\frac{MmgR}{6(M+m)}$ (c) $\frac{mgR}{6}$ (d) mgR

63. The distance of a geo-stationary satellite from the centre of earth is nearest to (R = radius = 6400 km) (AFMC 2001)

(a) 18 R (b) 10R (c) 5.7R (d) 5R

64. Persons sitting in artificial satellite of the earth have (radius R = 6,400 km)

(a) zero mass (b) zero weight (c) certain definite weight (d) infinite weight

65. The weightlessness in a satellite is due to (AFMC 2009)

(a) zero gravitational acceleration (b) zero velocity

(c) zero mass (d) none of these

66. The time period of a simple pendulum in a satellite is
(a) same as on earth (b) unity (c) infinite (d) zero

67. Which of the following objects do not belong to the solar system? (AIIMS 1995)
(a) comets (b) nebulae (c) asteroids (d) planets

68. All the known planets move in (AIIMS 1994)
(a) straight path (b) circular path (c) elliptical path (d) hyperbolic path

69. The radius vector, drawn from the sun to a planet sweeps out equal areas in equal intervals of time. This is the statement of (AIIMS 1995)
(a) Kepler's first law (b) Kepler's second law
(c) Kepler's third law (d) Newton's third law

70. According to Kepler's law, the radius vector sweeps out equal areas in equal intervals of time. The law is a consequence of the conservation of
(a) angular momentum (b) linear momentum (c) energy (d) all the above

71. A planet moving along an elliptical orbit is closest to the sun at a distance r_1 and farthest away at a distance of r_2. If v_1 and v_2 are the linear velocities at these points respectively, then the ratio v_1 / v_2 is (AIPMT 2011)

(a) $\frac{r_2}{r_1}$ (b) $\left(\frac{r_2}{r_1}\right)^2$ (c) $\frac{r_1}{r_2}$ (d) $\left(\frac{r_1}{r_2}\right)^2$

72. The period of revolution of the planet A round the sun is 8 times that of B. The distance of A from the sun is how many times greater than that of B from the sun?
(a) 5 (b) 4 (c) 3 (d) 2 (AIPMT 1997)

73. The force keeping the planets in elliptical orbit is
(a) electrostatic force (b) nuclear force (c) gravitational force (d) magnetic force

74. If the Earth is at one fourth of its present distance from the sun, the duration of the year will be
(a) one fourth of the present year (b) half the present year
(c) one - eighth the present year (d) one - sixth the present year

75. A satellite in a circular orbit of radius R has a period of 4 hour. Another satellite with orbital radius 3 R around the same planet will have a period
(a) 4 hour (b) $8\sqrt{2}$ hour (c) 16 hour (d) $12\sqrt{3}$ hour (AFMC 2008)

76. The acceleration due to gravity at a height $(1/20)^{th}$ the radius of the earth above the earth's surface is 9 ms^{-2}. It's value at an equal distance below the surface of the earth is (g = 10 ms^{-2})
(a) 0 (b) 9 ms^{-2} (c) 9.8 ms^{-2} (d) 9.5 ms^{-2}

Answers :

1(c)	2 (b)	3 (d)	4 (a)	5 (d)	6 (b)	7 (b)	8 (b)	9 (b)	10 (d)	11(a)
12(b)	13(c)	14(c)	15(a)	16(b)	17(a)	18(c)	19(b)	20(a)	21(a)	22(d)
23(c)	24(c)	25(a)	26(c)	27(a)	28(c)	29(a)	30(c)	31(b)	32(d)	33(b)
34(a)	35(b)	36(c)	37(b)	38(b)	39(d)	40(d)	41(c)	42(a)	43(b)	44(c)
45(b)	46(d)	47(b)	48(d)	49(d)	50(c)	51(b)	52(a)	53(b)	54(c)	55(d)
56(c)	57(c)	58(b)	59(b)	60(b)	61(b)	62(c)	63(c)	64(b)	65(a)	66(c)
67(b)	68(c)	69(b)	70(a)	71(a)	72(b)	73(c)	74(c)	75(d)	76(d)	

Solutions :

6.(b) $F = \frac{Gm_1m_2}{r^2}$, $F' = \frac{Gm_1m_2}{(2r)^2} = \frac{F}{4}$

8.(b) $g = \frac{GM}{R^2}$, $g \propto \frac{1}{R^2}$. When R decreases, g increases

9.(b) $g_1 = \frac{GM}{R^2}$, $g_2 = \frac{G(2M)}{(2R)^2} = \frac{g_1}{2}$, $g_1 = 2g_2$

11.(a) $\rho = \frac{3g_1}{4\pi G r_1} = \frac{3g_2}{4\pi G r_2}$, $\frac{g_1}{g_2} = \frac{r_1}{r_2}$

12.(b) $g_1 = \frac{GM}{R^2} = 9.8\ ms^{-2}$, $g_2 = \frac{G(M/2)}{(R/2)^2} = 2g_1 = 2 \times 9.8 = 19.6\ ms^{-2}$

14. (c) $g_d = g_h$, $g\left(1 - \frac{d}{R}\right) = g\left(1 - \frac{2h}{R}\right)$, $\frac{d}{R} = \frac{2h}{R}$, $d = 2h = 2$ km

16. (b) $mg_d = mg\left(1 - \frac{d}{R}\right) = W\left(1 - \frac{R}{2} \times \frac{1}{R}\right) = W\left(1 - \frac{1}{2}\right) = \frac{W}{2}$

18. (c) $\frac{GMm}{(R+h)^2} = \frac{1}{16}\frac{GMm}{R^2}$, $(R+h)^2 = (4R)^2$, $R + h = 4R$, $h = 3R$

19. (b) $g_h = g_d$, $g\left(1 - \frac{2h}{R}\right) = g\left(1 - \frac{x}{R}\right)$, $\frac{x}{R} = \frac{2h}{R}$, $x = 2h$

20. (a) $g_d = g_h$, $g\left(1 - \frac{2 \times 5}{R}\right) = g\left(1 - \frac{d}{R}\right)$, $\frac{d}{R} = \frac{10}{R}$, $d = 10$ km

22. (d) $W_d = W\left(1 - \frac{d}{R}\right) = 250\left(1 - \frac{R}{2} \times \frac{1}{R}\right) = 250\left(1 - \frac{1}{2}\right) = \frac{250}{2} = 125$ N

23. (c) $g = \frac{4}{3}G\pi R\rho$, $\rho \propto g$

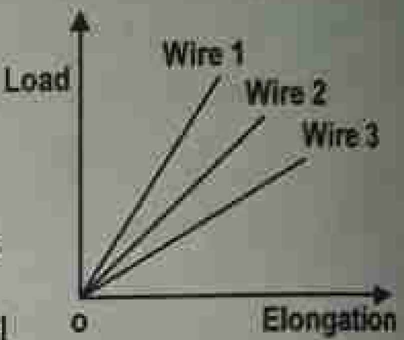
Unit 7 : Properties of Matter

I. Multiple Choice Questions :

1. Consider two wires X and Y. The radius of wire X is 3 times the radius of Y. If they are stretched by the same load then the stress on Y is
(a) equal to that on X (b) thrice that on X
(c) nine times that on X (d) Half that on X

2. If a wire is stretched to double of its original length, then the strain in the wire is
(a) 1 (b) 2 (c) 3 (d) 4

3. The load - elongation graph of three wires of the same material are shown in figure. Which of the following wire is the thickest?
(a) wire 1 (b) wire 2 (c) wire 3
(d) all of them have same thickness



4. For a given material, the rigidity modulus is $(1/3)^{rd}$ of Young's modulus. Its Poisson's ratio is
(a) 0 (b) 0.25 (c) 0.3 (d) 0.5

5. A small sphere of radius 2 cm falls from rest in a viscous liquid. Heat is produced due to viscous force. The rate of production of heat when the sphere attains its terminal velocity is proportional to
(a) 2^2 (b) 2^3 (c) 2^4 (d) 2^5

6. Two wires are made of the same material and have the same volume. The area of cross sections of the first and the second wires are A and 2A respectively. If the length of the first wire is increased by Δl on applying a force F, how much force is needed to stretch the second wire by the same amount?
(a) 2 (b) 4 (c) 8 (d) 16

7. With an increase in temperature, the viscosity of liquid and gas, respectively will
(a) increase and increase (b) increase and decrease
(c) decrease and increase (d) decrease and decrease

8. The Young's modulus for a perfect rigid body is
(a) 0 (b) 1 (c) 0.5 (d) infinity

9. Which of the following is not a scalar?
(a) viscosity (b) surface tension (c) pressure (d) stress

10. If the temperature of the wire is increased, then the Young's modulus will
(a) remain the same (b) decrease
(c) increase rapidly (d) increase by a very small amount

11. Copper of fixed volume V is drawn into a wire of length l. When this wire is subjected to a constant force F,the extension produced in the wire is Δl. If Y represents the Young's modulus, then which of the following graphs is a straight line?
(a) Δl verses V (b) Δl verses Y (c) Δl versese F (d) Δl verses $\frac{1}{l}$

12. A certain number of spherical drops of a liquid of radius r coalesce to form a single drop of radius R and volume V. If T is the surface tension of the liquid, then
(a) energy $= 4VT\left(\frac{1}{r}-\frac{1}{R}\right)$ is released (b) energy $= 3VT\left(\frac{1}{r}+\frac{1}{R}\right)$ is absorbed

(c) energy = $3VT\left(\frac{1}{r}-\frac{1}{R}\right)$ is released

(d) energy is neither released nor absorbed.

13. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied?
(a) length = 200 cm, diameter = 0.5 mm (b) length = 200 cm, diameter = 1 mm
(c) length =200 cm, diameter= 2 mm (d) length = 200 cm, diameter = 3 m

14. The wettability of a surface by a liquid depends primarily on
(a) viscosity (b) surface tension
(c) density (d) angle of contact between the surface and the liquid

15. In a horizontal pipe of non- uniform cross section, water flows with a velocity of 1 ms^{-1} at a point where the diameter of the pipe is 20 cm. The velocityof water is 1.5 ms^{-1} at a point where the diameter of the pipe is
(a) 8 cm (b)16 cm (c) 24 cm (d) 32 cm

Answers : 1) c 2) a 3) a 4) d 5) d 6) b 7) c 8) d 9) d 10) b 11) c 12) c 13) a 14)d 15) b

Solutions:

2. (a) strain = $\frac{\Delta l}{l}=\frac{l}{l}=1$

3. a) Larger the slope, lesser is the strain. Slope of wire 1 is larger. Hence wire 1 is thickest because thicke st wire will have least strain.

4. d) $\mu=\frac{y}{2n_R}-1=\frac{y}{2\times\frac{y}{3}}-1=\frac{3}{2}-1=0.5$

5. (d) $\frac{dQ}{dt}=F_t v_t=6\pi\eta r\, v_t(v_t)=6\pi\eta r\, v_t^2=6\pi\eta r\left(\frac{2r^2(\rho-\sigma)}{9\eta}g\right)^2,\ \frac{dQ}{dt}\propto r^5$

6. (b) $Y=\frac{Fl}{A\Delta l}$. But $V=Al$, $l=\frac{V}{A}$, $F=\frac{YA\Delta l}{l}=\frac{YA^2\Delta l}{V}$

$\frac{F}{F'}=\left(\frac{A_1}{A_2}\right)^2=\left(\frac{A}{2A}\right)^2=\frac{1}{4}$, $F'=4F$

11. (c) Within elastic limit, stress $\propto$ strain, $\frac{F}{A}\propto\frac{\Delta l}{l}$, $F\propto\Delta l$

Δl versus F is a straight line.

12. (c) Energy released = surface tension x increase in area
$= T\times 4\pi R^3\left(\frac{1}{r}-\frac{1}{R}\right)=3T\left(\frac{4}{3}\pi R^3\right)\left(\frac{1}{r}-\frac{1}{R}\right)=3VT\left(\frac{1}{r}-\frac{1}{R}\right)$

13. a) $Y=\frac{Fl}{A\Delta l}$, $\Delta l=\frac{Fl}{Y\pi\frac{D^2}{4}}=\frac{4Fl}{\pi YD^2}=\frac{kl}{D^2}$

a) $\Delta l = \frac{k \times 2}{(0.5 \times 10^{-3})^2} = 8k \times 10^6$ b) $\Delta l = \frac{k \times 2}{(10^{-3})^2} = 4k \times 10^6$

c) $\Delta l = \frac{k \times 2}{(2 \times 10^{-3})^2} = 0.5k \times 10^6$ d) $\Delta l = \frac{k \times 2}{(3 \times 10^{-3})^2} = 0.2k \times 10^6$

15. b) $a_1 v_1 = a_2 v_2$, $\frac{\pi D_1^2 v_1}{4} = \frac{\pi D_2^2 v_2}{4}$, $20^2 \times 1 = D_2^2 \times 1.5$, $D_2 = 16$ cm

Creative Questions:

1. Bodies get deformed, when suitable forces are applied. On the withdrawal of the forces, certain bodies regain their original shape or size. This property is called
   (a) elasticity (b) rigidity (c) plasticity (d) inertia
2. According to Hooke's law of elasticity, if stress is increased, the ratio of stress to strain (AIIMS 2001)
   (a) increases (b) decreases (c) becomes zero (d) remains constant
3. The longitudinal extension of any elastic material is very small. In order to have an appreciable change, the material must be in the form of
   (a) long thick wire (b) short thick wire (b) long thin wire (d) short thin wire
4. The Young's modulus of the material of a wire is equal to the (Kerala CEE 2009)
   (a) stress required to increase its length four times (b) strain produced in it
   (c) stress required to produce unit strain (d) half the strain produced in it
5. Unit of longitudinal strain is
   (a) cm (b) cm^{-2} (c) no unit d) pascal
6. If the length of the wire and mass suspended are doubled in a Young's modulus experiment, then Young's modulus of the wire
   (a) remains unchanged (b) becomes double
   (c) becomes 4 times (d) becomes 16 times
7. Two wires of the same radii and material have their lengths in the ratio 1 : 2. If these are stretched by the same force, the strains produced in the two wires will be in the ratio
   (a) 1 : 4 (b) 1 : 2 (c) 2 : 1 (d) 1 : 1
8. If the Young's modulus of a wire becomes numerically equal to the applied stress, then the length of the wire
   (a) does not change (b) increases by 100%
   (c) increases by 50% (d) increases by 125%
9. Copper of fixed volume V is drawn into wire of length l. When this wire is subjected to a constant force F, the extension produced in the wire is Δl. Which of the following graphs is a straight line? (NEET 2014)
   (a) Δl versus $1/l$ (b) Δl versus l^2 (c) Δl versus $1/l^2$ (d) Δl versus l
10. For a perfect rigid body, Young's modulus is
   (a) zero (b) infinity (c) 1 (d) -1

11. Which of the following is more elastic? (CET 1998)
(a) glass (b) steel (c) sponge (d) rubber

12. A wire is stretched by a certain amount under a load. If the load and radius both are increased to four times, the new stretch caused in the wire is how many times the original stretch?
(a) 4 times (b) 2 times (c) 1/4 times (d) 1/2 times

13. Which of the following affects the elasticity of a substance?
(a) hammering and annealing (b) change in temperature
(c) impurity in the substance (d) all of these

14. Steel is preferred for making springs over copper for the reason that (AIIMS 1999)
(a) steel is cheaper (b) steel has greater density
(c) Young's modulus of steel is more than that of copper
(d) Young's modulus of copper is more than that of steel

15. A copper wire and steel wire of same diameter and length are connected end to end and force is applied, which stretches their combined length by 1 cm. The wire will have
(a) same stress and strain (b) different stress and strain
(c) different stress and same strain (d) same stress and different strain

16. An iron bar of length L, cross-section A and Young's modulus Y is pulled by a force F from ends so as to produce an elongation l. Which of the following is correct?
(a) $l \propto 1/L$ (b) $l \propto A$ (c) $l \propto 1/A$ (d) $l \propto Y$

17. Young's modulus of the material of a wire of length L and radius r is Y Nm^{-2}. If the length is reduced to L / 2 and radius to r/2 the Young's modulus will be
(a) Y (b) 2Y (c) Y/4 (d) Y/2

18. A wire is stretched by ΔL by a load. If the load and radius are both increased to four times, the new stretch caused in the wire is (AIPMT 2001)
(a) ΔL (b) $\frac{\Delta L}{4}$ (c) $4\,\Delta L$ (d) $\frac{\Delta L}{2}$

19. The Young's modulus of steel is twice that of brass. Two wires of same length and of same area of cross - section, one of steel and another of brass are suspended from the same roof. If we want the lower ends of the wires to be at the same level, then the weights added to the steel and brass wires must be in the ratio of (NEET 2015)
(a) 4 : 1 (b) 1 : 1 (c) 1 : 2 (d) 2 : 1

20. Two wires are made of the same material and have the same volume. However, wire 1 has cross-sectional area A and wire 2 has cross - sectional area 3A. If the length of wire 1 increases by Δx on applying force F, how much force is needed to stretch wire 2 by the same amount? (AIEEE 2009)
(a) F (b) 4 F (c) 6 F (d) 9 F

21. For a wire of length l maximum change in length under stress condition is 2 mm. What is the change in length under same conditions, when length of wire is halved? (AFMC 2005)
(a) 1 mm (b) 2 mm (c) 4 mm (d) 8 mm

22. A wire of length L and radius r fixed at one end and a force F applied to the other end produces an extension l. The extension produced in another wire of the same material of length 2 L and radius 2 r by a force 2 F is (AIPMT 1992)
(a) l (b) $2l$ (c) $l/2$ (d) $4l$

23. If S is stress and q is Young's modulus of material of a wire, the energy stored in the wire per unit volume in terms of S and q is (AIEEE 2003)
(a) $\frac{2q}{S^2}$ (b) $\frac{S^2}{2q}$ (c) $\frac{S}{2q}$ (d) $\frac{2q}{S}$

24. For steel $q = 2 \times 10^{11}$ N/m^2, the force required to double the length of a steel wire of area 1 cm^2 is
(a) 2×10^7 N (b) 2×10^5 N (c) 2×10^8 N (d) 2×10^5 N

25. A steel wire of cross-sectional area 3×10^{-6} m^2 can withstand a maximum strain of 10^{-3}. Young's modulus of steel is 2×10^{11} N/m^2. The maximum mass this wire can hold is
(a) 40 kg (b) 60 kg (c) 80 kg (d) 100 kg

26. The Young's modulus of brass and steel are respectively 1.0×10^{11} Nm^{-2} and 2.0×10^{11} Nm^{-2}. A brass wire and a steel wire of the same length are extended by 1 mm each under the same force. If radii of brass and steel wires are R_B and R_s respectively, then (AFMC 2010)
(a) $R_s = \sqrt{2} R_B$ (b) $R_S = R_B/\sqrt{2}$ (c) $R_s = 4 R_B$ (d) $R_s = R_B/2$

27. An iron rod of length 2 m and cross-sectional area of 50 mm^2 is stretched by 0.5 mm, when a mass of 250 kg is hung from its lower end. Young's modulus of iron rod is: (AFMC 1999)
(a) 19.6×10^{20} N m^{-2} (b) 19.6×10^{18} N m^{-2}
(c) 19.6×10^{15} N m^{-2} (d) 19.6×10^{10} N m^{-2}

28. The Young's modulus of a wire is q. If the energy per unit volume is E then the strain will be
(a) $\sqrt{\frac{2E}{q}}$ (b) $E\sqrt{2q}$ (c) Eq d) $\frac{E}{q}$

29. Strain energy per unit volume in a stretched string is
(a) $\frac{1}{2}$ stress x strain (b) stress x strain (c) (stress x strain)^2 (d) $\frac{\text{stress}}{\text{strain}}$

30. If in a wire of Young's modulus q, longitudinal strain x is produced, then the value of potential energy stored in its unit volume will be (AIIMS 2001)
(a) qx^2 (b) $2qx^2$ (c) $0.5q^2x$ (d) $0.5qx^2$

31. The breaking stress of a wire depends upon (AIIMS 2002)
(a) length of the wire (b) radius of the wire
(c) material of the wire (d) shape of the cross-section

32. A wire of length 1m is suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower end. The weight stretches the wire by 1 mm. The elastic energy stored in the wire is
(a) 0.1J (b) 1J (c) 0.5J (d) 0.01J (AIEEE 2003)

33. A heavy mass is attached to a thin wire and is whirled in a vertical circle. The wire is most likely to break,
(a) when the mass is at the lowest point (b) when the mass is at the highest point
(c) when the wire is horizontal (d) none of the above.

34. A stretched rubber has (AIIMS 1999)
(a) increased kinetic energy (b) increased potential energy
(c) decreased kinetic energy (d) decreased potential energy

35. The bulk modulus for an incompressible liquid is
(a) zero (b) unity (c) infinity (d) between 0 and 1

36. For a constant hydraulic stress on an object, the fractional change in the object's volume ($\Delta V/V$) and its bulk modulus are related as: (AIIMS 2005)
(a) $\frac{\Delta V}{V} \propto K$ (b) $\frac{\Delta V}{V} \propto \frac{1}{K}$ (c) $\frac{\Delta V}{V} \propto K^2$ (d) $\frac{\Delta V}{V} \propto \frac{1}{K^2}$

37. A sphere of radius 3 cm is subjected to a pressure of 100 Pa. Its volume decreases by 0.3 cc. What will be its bulk modulus? (CET 2013)
(a) $4\pi \times 10^5$ Pa (b) $4\pi \times 3 \times 10^3$ Pa (c) $4\pi \times 10^6$ Pa (d) $4\pi \times 10^8$ Pa

38. The pressure of a medium is changed from 1.01×10^5 Pa to 1.165×10^5 Pa and change in volume is 10% keeping temperature constant. The bulk modulus of the medium is (IIT 2005)
(a) 1.55×10^3 Pa (b) 1.5×10^{-6} Pa (c) 1.55×10^5 Pa (d) 1.55×10^6 Pa

39. The bulk modulus of a fluid is inversely proportional to
(a) change in pressure (b) volume of fluid
(c) change in volume (d) none of the above

40. Shearing stress produces a change in
(a) shape (b) area (c) volume (d) length

41. Shear strain is represented by
(a) angle of twist (b) angle of shear (c) deforming force (d) deforming torque

42. For a given material the Young's modulus is 2.4 times that of the rigidity modulus, then Poisson's ratio is (Manipal 2010)
(a) 0.2 (b) 0.4 (c) 1.2 (d) 2.4

43. In practice, Poisson's ratio σ lies between
(a) $-\infty$ to $+\infty$ (b) 0 and $+\infty$ (c) 0 and 0.5 (d) 0.5 and 1.0

44. Sudden fall of atmospheric pressure by a large amount indicates (AIPMT 1974)
(a) storm (b) rain (c) fair weather (d) cold wave

45. Water reservoirs are made thicker at the bottom than at the top, because (AFMC 2005)
    (a) water is denser at the bottom
    (b) potential energy of water is greater at the bottom
    (c) pressure is greater at the bottom
    (d) kinetic energy of water is greater at the bottom
46. The most characteristic property of a liquid is (AIIMS 1982)
    (a) elasticity (b) fluidity (c) formlessness (d) volume conservation
47. Hydraulic press is based on (AFMC 2004)
    (a) Archimedes' principle (b) Bernoulli's equation
    (c) Pascal's law (d) Reynold's law
48. A body is floating in a liquid. The upthrust on the body is
    (a) zero (b) equal to the weight of liquid displaced
    (c) less than the weight of liquid displaced (d) none of the above
49. Increase in pressure at one point of the enclosed liquid in equilibrium or rest is transmitted equally to all other points of liquid. This illustrates: (AFMC 2003)
    (a) buoyant force (b) Pascal's law (c) gravitational law (d) electrostatic law
50. A body measures 5 N in air and 2N when put in water. The buoyant force is
    (a) 7 N (b) 9 N (c) 3 N (d) zero (AFMC 2003)
51. The approximate depth of an ocean is 2700 m.The compressibility of water is 45.4×10^{-11} Pa^{-1} and density of water is 10^3 kg/m^3. What fractional compression of water will be obtained at the bottom of the ocean? (NEET 2015)
    (a) 0.8×10^{-2} (b) 1×10^{-2} (c) 1.2×10^{-2} (d) 1.4×10^{-2}
52. The reading of spring balance when a block is suspended from it in air is 6 N. This reading is changed to 4 N when the block is immersed in water. The specific gravity of the block is
    (a) 3 (b) 2 (c) 6 (d) 1.5
53. A block of gold weighing 100 g in air is immersed in water with a string tied to a spring balance. The probable weight indicated by the spring balance would be
    (a) less than 100 g (b) more than 100 g (c) 100 g (d) zero
54. Two hail stones as whose radii are in the ratio of 1 : 2 fall from a height of 50 km. Their terminal velocities are in the ratio of
    (a) 1 : 9 (b) 9 : 1 (c) 4 : 1 (d) 1 : 4
55. The rain drops falling from the sky neither hit us hard nor make holes on the ground because they move with
    (a) constant acceleration (b) variable acceleration
    (c) variable speed (d) constant velocity
56. An object entering Earth's atmosphere at a high velocity catches fire due to
    (a) viscosity of air (b) the high heat content of atmosphere
    (c) pressure of certain gases (d) high force of g

57. Two rain drops of same radius r falling with terminal velocity v merge and form a bigger drop of radius R. The terminal velocity of the bigger drop is (AIIMS **2010**)

(a) $\frac{vR}{r}$ (b) $\frac{vR^2}{r^2}$ (c) v (d) 2v

58. In the case of a sphere falling through a viscous medium, it attains terminal velocity when (J&K CET **2011**)

(a) viscous force plus buoyant force become equal to force of gravity

(b) viscous force is zero (c) buoyant force becomes equal to the force of gravity

(d) viscous force plus force of gravity becomes equal to buoyant force

59. Viscosity is the internal property of the liquids and the gases and is more closely related to

(a) elasticity (b) inertia (c) tension (d) friction

60. When water flows slowly over a surface, different layers have different velocities. This is due to (Kerala **1990**)

(a) surface tension (b) impurities contained in the water

(c) difference of pressure between different layers (d) viscosity

61. As the temperature of water increases, its viscosity

(a) remains unchanged (b) decreases (c) increases

(d) increases or decreases depending on the external pressure

62. Rain drop falling through the atmosphere attains terminal velocity, because of

(a) the upward thrust due to air (b) viscosity of air.

(c) force of gravity (d) surface tension of water

63. Spherical balls of radius a are falling in a viscous fluid of viscosity η with a velocity v. The retarding viscous force acting on the spherical ball is: (AIEEE **2004**)

(a) directly proportional to a but inversely proportional to *v*

(b) directly proportional to both radius *a* and velocity *v*

(c) inversely proportional to both radius a and velocity *v*

(d) inversely proportional to a but directly proportional to velocity *v*

64. A sphere of mass M and radius a is falling in a viscous fluid. The terminal velocity attained by the falling object will be proportional to (AIIMS **2004**)

(a) a^2 (b) a (c) 1 / a (d) $1/a^2$

65. An air bubble rises from the bottom of a lake of large depth. The rising speed of air bubble will

(a) go on increasing till it reaches surface

(b) go on decreasing till it reaches surface

(c) increase in the beginning, then will become constant

(d) be constant all through out

66. As a bubble moves upwards, besides the buoyancy force, the forces acting are (IIT 2008)
    (a) The force of gravity alone
    (b) The force due to gravity and the force due to the pressure of the liquid
    (c) The force due to gravity and the force due to the viscosity of the liquid
    (d) The force due to gravity, the force due to the pressure of the liquid and the force due to the viscosity of the liquid
67. The ratio of the terminal velocities of two drops of radii a and a / 2 is
    (a) 2 (b) 1 (c) 1 / 2 (d) 4
68. If the terminal speed of a sphere of gold (density = 19.5 kg m^{-3}) is 0.2 m s^{-1} in a viscous liquid (density = 1.5 kg m^{-3}, then the terminal speed of a sphere of silver (density = 10.5 kg m^{-3}) of the same size in the same liquid is (AIIMS 2008)
    (a) 0.1 m s^{-1} (b) 0.133 m s^{-1} (c) 0.2 m s^{-1} (d) 0.4 m s^{-1}
69. The rate of flow (V) of viscous liquid and coefficient of viscosity (η) are related as
    (a) $\eta \propto 1/V^4$ (b) $\eta \propto 1/V$ (c) $\eta \propto V^4$ (d) $\eta \propto V$
70. If the radius of a tube is doubled, the rate of flow increases by
    (a) 8 times (b) 16 times (c) 4 times (d) 2 times
71. Rate of a flow of a liquid in a capillary tube of length *l* and radius r is V. Then, the rate of flow of the same liquid in another capillary tube of length 2 *l* and radius 2 r is
    (a) 2 V (b) 4 V (c) 8 V (d) 16V
72. Under a constant pressure head, the rate of flow of orderly volume flow of liquid through a capillary tube is V. If the length of the capillary tube is doubled and the diameter of the bore is halved, the rate of flow would become (AIIMS 1980)
    (a) V / 4 (b) 16 V (c) V/8 (d) V / 32
73. Two water pipes of diameters 2 cm and 4 cm are connected with the main supply line. The velocity of flow of water in the pipe of 2 cm diameter is that through 4 cm diameter pipe. (IIT 1980)
    (a) four times (b) one - fourth (c) twice (d) one - half
74. A rain drop of radius 0.3 mm has a terminal velocity of 1ms^{-1} in air. The viscosity of air is 1.8 x 10^{-5} Nsm^{-2}. Then, the viscous force on the drop will be : (AFMC 2002)
    (a) 101.73 x 10^{-9} N (b) 10.173 x 10^{-9} N (c) 16.695 x 10^{-9} N (d) 16.95 x 10^{-9} N
75. A liquid flows through two capillary tubes connected in series. Their lengths are L and 2 L and radius *r* and 2*r* respectively. Then the pressure difference across the first and second tubes are in the ratio : (AIPMT 1991)
    (a) 8 (b) 2 (c) 4 (d) 1 / 8
76. In a streamline flow (Manipal 2009)
    (a) the speed of a particle always remains same
    (b) the velocity of a particle always remains same
    (c) the kinetic energies of all particles arriving at a given point are the same
    (d) the momentum of all the particles arriving at a given point are the same

89. Which of the following is the unit of surface tension?

(a) Newton / metre (b) Joule / $(metre)^2$ (c) kg / $(second)^2$ (d) all the above

90. Three liquids of densities ρ_1, ρ_2 and ρ_3 (with $\rho_1 > \rho_2 > \rho_3$) having the same value of surface tension T rises to the same height in three identical capillaries. The angles of contact θ_1, θ_2 and θ_3 obey (NEET 2016)

(a) $\frac{\pi}{2} < \theta_1 < \theta_2 < \theta_3 < \pi$ (b) $\pi > \theta_1 > \theta_2 > \theta_3 > \frac{\pi}{2}$

(c) $\frac{\pi}{2} > \theta_1 > \theta_2 > \theta_3 \geq 0$ (d) $0 \leq \theta_1 < \theta_2 < \theta_3 < \frac{\pi}{2}$

91. A liquid does not wet the sides of a solid, if the angle of contact is

(a) zero (b) obtuse (c) acute (d) 90^0

92. The height of liquid in a capillary tube (AIPMT 1980)

(a) decreases with a decreas in the diameter of the tube

(b) increases with an increases in density of the liquid

(c) decreases with an increase in surface tension

(d) is independent of the orientation of the tube

93. Water rises to a height h in a capillary tube. If the length of capillary tube above the surface of water is made less than h then (NEET 2015)

(a) water rises upto a point a little below the top and stays there

(b) water does not rise at all

(c) water rises upto the tip of capillary tube and then stays overflowing like a fountain

(d) water rises upto the top of capillary tube and stays there without overflowing

94. Water rises to a height of 16.3 cm in a capillary tube of height 18 cm above the water level. If the tube is cut at a height of 12 cm (AIPMT 1987)

(a) water will come as a fountain from the capillary tube

(b) water will stay at a height of 12 cm in the capillary tube

(c) the height of the water in the capillary will be 10.3 cm

(d) water will flow down the sides of the capillary tube

95. A capillary tube is dipped vertically in a liquid. The level of liquid in the capillary will be the same as that outside the capillary, if the angle of contact is

(a) zero (b) 90^0 (c) acute (d) obtuse (AIPMT 1993)

96. When two capillary tubes of different diameters are dipped vertically, the rise of the liquid is

(a) same in both the tubes (b) more in the tube of larger diameter

(c) less in the tube of smaller diameter (d) more in the tube of smaller diameter

97. Water rises to a height of 30 mm in a capillary tube. If the radius of the capillary tube is made $3/4^{th}$ of its previous value, the height to which the water will rise in the tube is

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

98. Excess of pressure inside a bubble is (AIPMT 1992)
(a) directly proportional to its radius (b) inversely proportional to its radius
(c) directly proportional to square of its radius (d) independent of its radius

99. The surface tension of soap solution is 25×10^{-3} Nm^{-1}. The excess pressure inside a soap bubble of diameter 1 cm is (AIIMS 1987)
(a) 10 Pa (b) 20 Pa (c) 5 Pa (d) None of these

100. At critical temperature, the surface tension of a liquid (AIIMS 1980)
(a) is zero (b) is infinity
(c) is same as that of any other temperature (d) None of these

101. On mixing salt in water. the surface tension of water will
(a) increase (b) decrease (c) remain unchanged (d) none of these

102. If two soap bubbles of different radii are connected by a tube, (AIEEE 2004)
(a) air flows from the bigger bubble to the smaller bubble till the sizes become equal
(b) air flows from bigger bubble to the smaller bubble till the sizes are interchanged
(c) air flows from the smaller bubble to the bigger (d) there is no flow of air

103. If work W is done in blowing a bubble of radius R from soap solution, then the work done in blowing a bubble of radius 2R from the same solution is
(a) W / 2 (b) 2 W (c) 4 W (d) 6 W

104. The excess of pressure inside two soap bubbles of diameters in the ratio 2 : 1 is
(a) 1 : 4 (b) 2 : 1 (c) 1 : 2 (d) 4 : 1

105. Two capillary tubes of radii r_1 and r_2 are dipped in water. If the corresponding rise of water are h_1 and h_2 the ratio of h_1 / h_2 is
(a) r_1 / r_2 (b) $r_1 - r_2$ (c) r_2 / r_1 (d) $r_2 - r_1$

106. The surface tension of a soap solution is 2×10^{-2} N / m. To blow a bubble of radius 1 cm, the work done is
(a) $4\pi \times 10^{-6}$ J (b) $8\pi \times 10^{-6}$ J (c) $12\pi \times 10^{-6}$ J (d) $16\pi \times 10^{-6}$ J

107. A spherical drop of water has 1 mm radius. If the surface tension of water is 70×10^{-3} Nm^{-1} then difference of pressure between inside and outside the spherical drop is (AIIMS 2001)
(a) 35 N m^{-2} (b) 70 N m^{-2} (c) 140 Nm^{-2} (d) zero

108. Water rises in a capillary tube to a height of 4 cm. If the area of cross-section of another pipe is one fourth of the first pipe the water will rise in the second pipe to a height of
(a) 2 cm (b) 4 cm (c) 8 cm (d) 16 cm

109. The radius of a soap bubble is r and the surface tension of soap solution is T. Keeping the temperature constant, the extra energy needed to double the radius of the soap bubble by blowing is (AIIMS 1994)
(a) $32\pi r^2 T$ (b) $24\pi r^2 T$ (c) $16\pi r^2 T$ (d) $8\pi r^2 T$

110. Work done in changing the area of a soap film from $6 \times 10\ cm^2$ to $10 \times 11\ cm^2$ is 3×10^{-4}J. What is the surface tension (in $N\ m^{-1}$)? (AIIMS 2000)
(a) 2×10^{-2} (b) 4×10^{-2} (c) 6×10^{-2} (d) 8×10^{-2}

111. A rectangular film of liquid is extended from (4 cm x 2 cm) to (5 cm x 4 cm). If the work done is 3×10^{-4} J the value of the surface tension of the liquid is(NEET 2016)
(a) 0.2 Nm^{-1} (b) 8.0 Nm^{-1} (c) 0.250 Nm^{-1} (d) 0.125 Nm^{-1}

112. A big drop of radius R is formed by 100 small droplets of water. The radius of small drop is: (AFMC 1998)
(a) R / 10 (b) R / 100 (c) R / 500 (d) R / 1,000

113. In the case of streamline flow, the loss of energy is
(a) minimum (b) maximum (c) zero (d) none of the above

114. Water flows through a horizontal pipe of varying cross-section at the rate of 0.2 $m^3\ s^{-1}$. The velocity of water at a point where the area of cross-section of the pipe is 0.01 m^2 is
(a) 2 ms^{-1} (b) 20 ms^{-1} (c) 200 ms^{-1} (d) 0.2 ms^{-1}

115. An incompressible fluid flows steadily through a cylindrical pipe which has radius 2 R at point A and R at a point B further along the flow direction. If the velocity at A is v, then velocity at B is (AIIMS 2001)
(a) v / 2 (b) v (c) 2 v (d) 4 v

116. Water is flowing through two horizontal pipes of different diameters which are connected together. The diameters of the two pipes are 3 cm and 6 cm respectively. If the speed of water in the narrower tube is 4 m / s then the speed of water in the wider tube is
(a) 16 m / s (b) 1 m / s (c) 4 m / s (d) 2 m / s

117. Bernoulli's theorem is based on : (AFMC 2000)
(a) conservation of mass, energy and momentum
(b) conservation of momentum
(c) conservation of mass (d) conservation of energy

118. A gale blows over a house. The force due to gale to the roof is (IIT 1988)
(a) in the downward direction (b) in the upward direction
(c) in the horizontal direction (d) zero

119. Which of the following is not based on the applications of Bernoulli's theorem?
(a) an atomizer (b) scent sprayer (c) hydraulic lift (d) lift of an aeroplane

Answers:

1(a)	2(d)	3(c)	4(c)	5(c)	6(a)	7(d)	8(b)	9(b)	10(b)	11(b)	12(c)
13(d)	14(c)	15(d)	16(c)	17(a)	18(b)	19(d)	20(d)	21(a)	22(a)	23(b)	24(a)
25(b)	26(b)	27(d)	28(a)	29(a)	30(d)	31(c)	32(a)	33(a)	34(b)	35(c)	36(b)
37(b)	38(c)	39(c)	40(a)	41(b)	42(a)	43(c)	44(a)	45(c)	46(d)	47(c)	48(b)
49(b)	50(c)	51(c)	52(a)	53(a)	54(d)	55(d)	56(a)	57(b)	58(c)	59(d)	60(d)

61(b) 62(b) 63(b) 64(a) 65(c) 66(c) 67(d) 68(a) 69(b) 70(b) 71(c) 72(d)
73(a) 74(a) 75(a) 76(c) 77(a) 78(a) 79(a) 80(d) 81(a) 82(b) 83(b) 84(a)
85(a) 86(d) 87(c) 88(c) 89(d) 90(d) 91(b) 92(d) 93(d) 94(b) 95(b) 96(d)
97(c) 98(b) 99(b) 100(a) 101(a) 102(c) 103(c) 104(c) 105(c) 106(d) 107(c)
108(c) 109(b) 110(c) 111(d) 112(a) 113(c) 114(b) 115(d) 116(b) 117(d) 118(b)
119(c)

Solutions :

7. (d) $q = \frac{Fl}{\pi r^2 dl_1} = \frac{F(2l)}{\pi r^2 dl_2}$, $dl_2 = 2dl_1$, $\frac{dl_1}{l_1} : \frac{dl_2}{l_2} = \frac{dl_1}{l} : \frac{2dl_1}{2l} = 1 : 1$

8. (b) $q = \frac{\text{stress}}{\text{strain}}$. If q = stress, strain $= \frac{\Delta l}{l} = 1$, $\Delta l = l$ length increases by 100%

9. (b) $q = \frac{Fl}{A\Delta l}$, Volume $V = Al$, $A = \frac{V}{l}$

$q = \frac{Fl^2}{V\Delta l}$, $\Delta l = \frac{Fl^2}{qV}$, $\Delta l \propto l^2$. Δl versus l^2 is a straight line

10. $q = \frac{Fl}{A\Delta l}$. For a rigid body $\Delta l = 0$. Hence q is infinity.

11. $Y = \frac{Fl}{A\Delta l}$. For a given load Δl for steel is less than for rubber.

Hence Y for steel is large, more elastic.

12. (c) q is same for a given material.

15. (d) Same stress, different strains due to different increase in lengths.

16. (c) $q = \frac{FL}{Al}$, $A\,l$ = constant, $l \propto \frac{1}{A}$

18. (b) $Y = \frac{Mgl}{\pi r^2 \Delta l} = \frac{(4M)gL}{\pi(4r)^2 \Delta L_2}$, $4\Delta L_2 = \Delta L$, $\Delta L_2 = \frac{\Delta L}{4}$

19. (d) For steel $q_1 = \frac{M_1 gl}{A\Delta l}$. For brass $q_2 = \frac{M_2 gl}{A\Delta l}$

Given $q_1 = 2q_2$, $\frac{q_1}{q_2} = \frac{M_1}{M_2} = 2$, $M_1 = 2M_2$, $M_1 : M_2 = 2 : 1$

20. (d) $q = \frac{Fl}{A\Delta x} = \frac{F_2 l_2}{(3A)\Delta x}$, $Fl = \frac{F_2 l_2}{3}$

Given $Al = (3A)\,l_2$, $l = 3\,l_2$, $F(3\,l_2) = \frac{F_2 l_2}{3}$, $F_2 = 9F$

21. (a) $q = \frac{Fl}{A\Delta l} = \frac{Fl/2}{A\Delta l_2}$, $2\Delta l_2 = \Delta l$, $\Delta l_2 = \frac{\Delta l}{2} = \frac{2}{2} = 1$ mm

c) **Bunsen burner:** In this , the gas comes out of the nozzle with high velocity, hence the pressure in the stem decreases. So outside air reaches into the burner through an air vent and the mixture of air and gas give a blue flame.

d) Bernoulli's concept is mainly used in the design of carburetor of automobiles, filter pumps, atomizers and sprayers.

For example, the carburetor has a very fine channel called nozzle through which the air is allowed to flow in larger speed. In this case, the pressure is lowered at the narrow neck and in turn, the required fuel or petrol is sucked into the chamber so as to provide the correct mixture of air and fuel necessary for ignition process.

47. How will you explain the working of an atomizer or sprayer?

A bottle is filled with thermocol balls. One end of a flexible tube is kept inside the bottle immersed inside the balls. The free end is rotated and we find the balls sprayed all around. This explains the working of an atomizer or sprayer.

Book problems (1 mark):

1. A capillary tube d mm is dipped in water such that the water rises to height of 30 mm. If the radius of the capillary is made 2/3 of its previous value, the height upto which water will rise in the new capillary is
a) 4.5 mm b) 45 mm c) 45 cm d) 0.45 mm
2. A wire 10 m long has a cross-sectional area 1.25×10^{-4} m^2 is subjected to a load of 5 kg. If Young's modulus of the material is 4×10^{10} Nm^{-2}, the elongation produced in the wire is (Take g = 10 ms^{-2})
a) 10^{-4} m b) 10^{4} m c) 10^{-2} m d) 10^{2} m
3. A metallic cube of side 100 cm is subjected to a uniform force acting normal to the whole surface of the cube. The pressure is 10^6 pascal. If the volume changes by 1.5×10^{-5} m^3, the bulk modulus of the material is
a) 0.667×10^{10} Nm^{-2} b) 0.667 Nm^{-2} c) 6.67×10^{-10} Nm^{-2} d) 6.67×10^{10} Nm^{-2}
4. A metal cube of side 0.20 m is subjected to a shearing force of 4000 N. The top surface is displaced through 0.50 cm with respect to the bottom, the shear modulus of elasticity of the metal is
a) 4×10^{-6} Nm^{-2} b) 0.4×10^{-6} Nm^{-2} c) 4×10^{6} Nm^{-2} d) 10^{6} Nm^{-2}
5. If 2.4×10^{-4} J of work is done to increase the area of a film of soap bubble from 50 cm^2 to 100 cm^2, the value of surface tension of soap solution is
a) 2.4×10^{-2} Nm^{-1} b) 2.4 Nm^{-1} c) 0.24 Nm^{-1} d) 2.4×10^{2} Nm^{-1}
6. If excess pressure is balanced by a column of oil (with specific gravity 0.8) 4 mm high, where R = 2.0 cm, the surface tension of the soap bubble is
a) 15.68 Nm^{-1} b) 1.568 Nm^{-1} c) 15.68×10^{-2} Nm^{-1} d) 1568 Nm^{-1}

Answers: 1 (b) 2 (a) 3 (d) 4 (c) 5 (a) 6 (c)

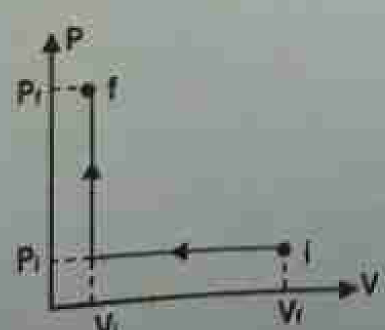
Book problems (2 mark):

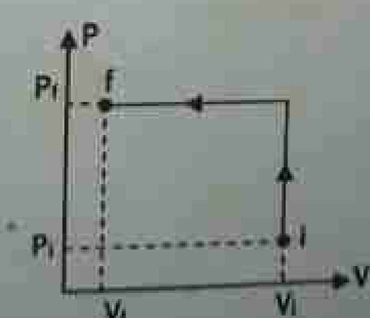
1. A capillary of diameter d mm is dipped in water such that the water rises to a height of 30 mm. If the radius of the capillary is made 2/3 of its previous value, then compute the height upto which water will rise in the new capillary?

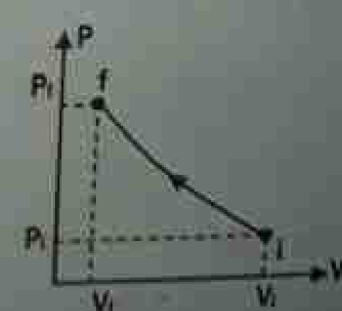
Unit 8: Heat and Thermodynamics

I. Multiple Choice Questions :

1. In hot summer after a bath, the body's
   a) internal energy decreases b) internal energy increases
   c) heat decreases d) no change in internal energy and heat
2. The graph between volume and temperature in Charle's law is
   a) an ellipse b) a circle c) a straight line d) a parabola
3. When a cycle tyre suddenly bursts, the air inside the tyre expands. This process is
   a) isothermal b) adiabatic c) isobaric d) isochoric
4. An ideal gas passes from one equilibrium state (P_1, V_1, T_1, N) to another equilibrium state ($2P_1$, $3V_1$, T_2, N). Then
   a) $T_1 = T_2$ b) $T_1 = T_2/6$ c) $T_1 = 6T_2$ d) $T_1 = 3T_2$
5. When a uniform rod is heated, which of the following quanity of the rod will increase
   a) mass b) weight c) center of mass d) moment of inertia
6. When food is cooked in a vessel by keeping the lid closed, after some time the steam pushes the lid outward. By considering the steam as a thermodynamic system, then in the cooking process
   a) $Q > 0, W > 0$ b) $Q < 0, W > 0$ c) $Q > 0, W < 0$ d) $Q < 0, W < 0$
7. When you exercise in the morning, by considering your body as thermodynamic system, which of the following is true?
   a) $\Delta U > 0, W > 0$ b) $\Delta U < 0, W > 0$ c) $\Delta U < 0, W < 0$ d) $\Delta U = 0, W > 0$
8. A hot cup of coffee is kept on the table. After some time it attains a thermal equilibrium with the surroundings. By considering the air molecules in the room as a thermodynamic system, which of the following is true?
   a) $\Delta U > 0, Q = 0$ b) $\Delta U > 0, W < 0$ c) $\Delta U > 0, Q > 0$ d) $\Delta U = 0, Q > 0$
9. An ideal gas is taken from (P_i, V_i) to (P_f, V_f) in three different ways. Identify the process in which the work done on the gas the most

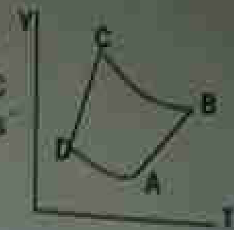


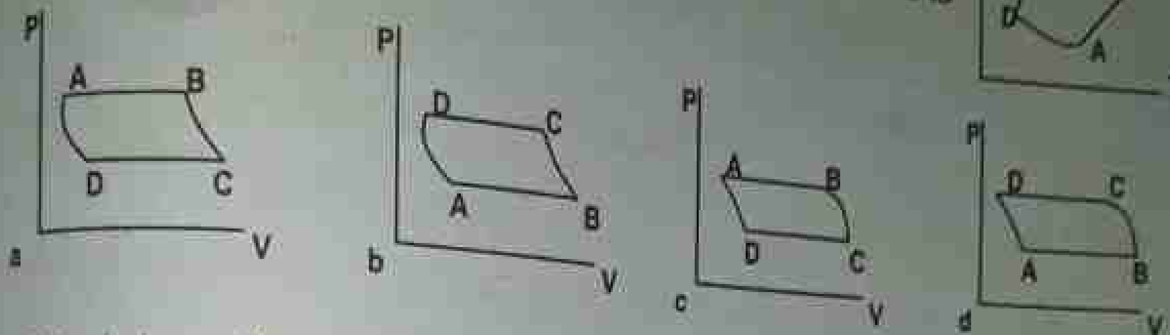




   a) Process A b) process B c) Process C
   d) Equal work is done in process A,B & C

10. The V-T diagram of an ideal gas which goes through a reversible cycle A→B→C→D is shown below. (processes D→A and B→C are adiabatic) The corresponding PV diagram for the process is (all figures are schematic)





11. A distant star emits radiation with maximum intensity at 350 nm. The temperature of the star is

a) 8280 K b) 5000 K c) 7260 K d) 9044 K

12. Identify the state variables given here ?

a) Q , T, W b) P, T, U c) Q , W d) P, T, Q

13. In an isochoric process, we have

a) W = 0 b) Q = 0 c) $\Delta U = 0$ d) $\Delta T = 0$

14. The efficiency of a heat engine working between the freezing point and boiling point of water is

a) 6.25 % b) 20 % c) 26.8% d) 12.5 %

15. An ideal refrigerator has a freezer at temperature -12^0C. The coefficient of performance of the engine is 5. The temperature of the air (to which the heat ejected) is

a) 50^0C b) 45.2^0C c) 40.2^0C d) 37.5^0C

Answers: 1) a 2) C 3) b 4) b 5) d 6) a 7) b 8) c 9) b 10) b 11) a 12) b 13) a 14) c 15) c

Solutions :

4. (b) $P_1V_1 = RT_1$, $P_2V_2 = RT_2$, $\frac{RT_2}{RT_1} = \frac{(2P_1)(3V_1)}{P_1V_1}$, $T_1 = \frac{T_2}{6}$

5. (d) Because length of the rod increases.

11. (a) $T = \frac{2.898 \times 10^{-3}}{350 \times 10^{-9}} = 8280$ K

14. (c) $\eta = 1 - \frac{T_L}{T_H} = 1 - \frac{273}{373} = 1 - 0.732 = 0.268$ (or) 26.8 %

15. (c) $\beta = \frac{T_L}{T_H - T_L}$, $5 = \frac{261}{T_H - 261}$, $T_H = 313.2 - 273 = 40.2^0C$

Creative Quuestions:

1. The temperature scale, which is independent of the properties of any substance is the
(a) Celsius scale (b) Reaumer scale (c) Fahrenheit scale (d) Kelvin scale
2. On which of the following scales of temperature, the temperature is never negative?
(a) Celsius (b) Fahrenheit (c) Reaumur (d) Kelvin
3. On the absolute scale if temperature is given by Kelvin, steam point has a value of
(a) 373 K (b) 273 K (b) -273 K (d) 0 K (AFMC 1995)
4. The correct value of 0^0C on Kelvin scale is (IIT 1988)
(a) 273.15 K (b) 272.85 K (c) 273 K (d) 273.2 K
5. Oxygen boils at -183^0C. This is approximately (AIPMT 1992)
(a) $-297\ ^0F$ (b) $-329\ ^0F$ (c) $-261\ ^0F$ d) $-215\ ^0F$
6. At what temperature, do the Celsius and Fahrenheit scales give the same reading?
(a) $40\ ^0F$ (b) $-40\ ^0C$ (c) $0\ ^0C$ (d) $40\ ^0R$ (AIPMT 1979)
7. The value of absolute zero on Celsius scale is (AIPMT 1979)
(a) $0\ ^0C$ (b) $-32\ ^0C$ (c) $-40\ ^0C$ (d) $-273.15\ ^0C$
8. The reading of Centigrade thermometer coincides with that of Fahrenheit thermometer in a liquid. The temperature of the liquid is (AFMC 2009)
(a) $-40\ ^0C$ (b) $0\ ^0C$ (c) $100\ ^0C$ (d) $313\ ^0C$
9. The bulb of one thermometer is spherical, while that of other is cylindrical. If both of them have equal amounts of mercury, which one will respond quickly to the temperature?
(a) spherical (b) cylindrical (c) elliptical (d) both spherical and elliptical
10. The change in temperature of a body is 50^0C. The change in temperature on the Kelvin scale is (AIPMT 1992)
(a) 70 K (b) 30 K (c) 50 K (d) 323 K
11. A constant volume air thermometer works on (IIT 1980)
(a) Archemedes' principle (b) Boyle's law (c) Pascal's law (d) Charles' law
12. Gas thermometers are more sensitive than liquid thermometers, because
(a) gases do not change their state easily
(b) gases are easily available and cheap
(c) gases have very low density
(d) expansion of gases is regular over a wide range of temperature
13. A device used to measure very high temperature is
(a) Pyrometer (b) Thermometer (c) Bolometer (d) Calorimeter
14. The temperature of the sun ($5,000^0C$) is measured with (AIPMT 1989)
(a) Platinum resistance thermometer (b) gas thermometer
(c) pyrometer (d) vapour pressure thermometer

15. In cold countries, water pipes sometimes burst, because

(a) pipe contracts (b) when water freezes, it takes heat from pipes

(c) when water freezes, pressure increases (d) water expands on freezing

16. Two spheres of same size are made of the same material but one is hollow and the other is solid. They are heated to the same temperature. Then, (AIPMT 1983)

(a) both the spheres will expand equally

(b) hollow sphere will expand more than the solid one

(c) solid sphere will expand more than the hollow one (d) none of the above

17. A thin circular disc with a concentric hole in it is heated. The diameter of the cavity will (IIT 1988)

(a) increase (b) decrease (c) remain unaffected (d) none of the above

18. A solid ball of metal has a concentric spherical cavity within it. If the ball is heated, the volume of the cavity will (IIT 1986)

(a) increase (b) decrease (c) remain unaffected. (d) none of these

19. The running of fan makes us comfortable during summer, because it

(a) decreases the temperature of air

(b) increases the thermal conductivity of air

(c) increases the rate of evaporation of perspiration

(d) cuts off the thermal radiation reaching us

20. The diameters of steel rods A and B having the same length are 2 cm and 4 cm respectively. They are heated through 100^0 C. The ratio of increase in length of rod A to that of the rod B is

(a) 1 (b) 1 / 2 (c) 2 (d) 4

21. The radius of a ring is R and its coefficient of linear expansion is α. If the temperature of ring increases by θ then its circumference will increase by

(a) $\pi R \alpha \theta$ (b) $2\pi R \alpha \theta$ (c) $\pi R \alpha \frac{\theta}{2}$ (d) $\pi R \alpha \frac{\theta}{4}$

22. The coefficients of linear expansions of brass and steel are α_1 and α_2 respectively. When we take a brass rod of length l_1 and a steel rod of length l_2 at 0^0C, then the difference in their lengths $(l_1 - l_2)$ will remain the same at all temperatures, if (AIPMT 1999) (AFMC 2003)

(a) $\alpha_1 l_1 = \alpha_2 l_2$ (b) $\alpha_1 l_2 = \alpha_2 l_1$ (c) $\alpha_1^2 l_2 = \alpha_2^2 l_1$ (d) $\alpha_1 l_2^2 = \alpha_2 l_1^2$

23. When a metallic sphere is heated, the largest increase is in its (AFMC 2005)

(a) volume (b) area (c) diameter (d) same in all

24. A beaker is completely filled with water at 4^0C. It will overflow if

(a) heated above 4^0C (b) cooled below 4^0C

(c) both heated and cooled above and below 4^0C respectively

(d) none of the above

25. Water falls from a height 500 m. What is the rise in temperature of water at bottom if the whole energy remains in the water? (specific heat of water = 4,200J kg^{-1}K^{-1})

(a) 1.16 °C (b) 0.490 °C (c) 0.24 °C (d) 0.19 °C (AFMC 1997)

26. Heat given to a body, which raises its temperature by 1 °C is (AIEEE 2002)
(a) water equivalent (b) temperature gradient
(c) thermal capacity (d) specific heat

27. Calorimeters are made of which of the following? (AIIMS 1996)
(a) Glass (b) Metal (c) Wood (d) Either glass or wood

28. When a solid is converted into a gas, directly by heating, then this process is known as (AIIMS 1999)
(a) boiling (b) sublimation (c) vaporization (d) condensation

29. The sprinkling of water reduces slightly the temperature of a closed room, because
(a) temperature of water is less than that of the room. (AFMC 2008)
(b) specific heat of water is high
(c) water has large latent heat of vaporization (d) water is a bad conductor of heat

30. Compared to burn due to air at 100°C, a burn due to steam at 100°C is (IIT 1988)
(a) more dangerous (b) less dangerous
(c) equally dangerous (d) none of the above

31. The dimensional formula for latent heat is
(a) $M^0 L^2 T^{-2}$ (b) $M L^2 T^{-2}$ (c) $M L T^{-2}$ (d) $M L^2 T^{-2}$

32. Transmission of heat by molecular vibrations is (AIPMT 1992)
(a) conduction (b) convection (c) radiation (d) scattering

33. The two ends of a rod of length L and uniform cross-sectional area A is kept at temperatures T_1 and T_2 ($T_1 > T_2$). The rate of heat transfer $\frac{dQ}{dt}$ through the rod in a steady state is given by (AIPMT 2009)
(a) $\frac{dQ}{dt} = \frac{KL(T_1 - T_2)}{A}$ (b) $\frac{dQ}{dt} = \frac{K(T_1 - T_2)}{LA}$
(c) $\frac{dQ}{dt} = KLA(T_1 - T_2)$ (d) $\frac{dQ}{dt} = \frac{KA(T_1 - T_2)}{L}$

34. Coefficient of thermal conductivity depends on (AFMC 1996)
(a) nature of material (b) heat produced
(c) difference in temperature (d) atmospheric pressure.

35. The unit of thermal conductivity in SI is
(a) $J\ s^{-1}\ m^{-1}\ K^{-1}$ (b) $W\ s^{-1}\ m^{-1}\ K^{-1}$ (c) $kcal\ s^{-1}\ m^{-1}\ K^{-1}$ (d) $cal\ s^{-1}\ m^{-1}\ K^{-1}$ (AIPMT 1974)

36. Thermal conductivity of a metal plate depends upon
(a) temperature difference between the two sides
(b) thickness of the metal plate
(c) area of the plate (d) all the above

37. Woollen clothes keep the body warm, because wool (AIIMS 1998)
(a) is a bad conductor (b) increases the temperature of body

(c) decrease the temperature (d) all of these

38. Mud houses are cooler in summer and warmer in winter because

(a) Mud is superconductor of heat (b) Mud is good conductor of heat

(c) Mud is bad conductor of heat (d) None of the above

39. Snow is more heat insulating than ice, because

(a) Air is filled in porous of snow (b) Ice is more bad conductor than snow

(c) Air is filled in porous of ice (d) Density of ice is more

40. Two thin blankets keep more warmth than one blanket of thickness equal to these two. The reason is

(a) Their surface area increases

(b) A layer of air is formed between these two blankets which is bad conductor

(c) These have more wool (d) They absorb more heat from outside

41. Ice formed over lakes

(a) has very high thermal conductivity and helps in further ice formation

(b) has very low conductivity and retards further formation of ice

(c) permits quick convection and retards further formation of ice

(d) is very good radiator

42. Cloudy nights are usually warmer than clear ones, because clouds

(a) do not radiate heat (b) do not absorb heat

(c) have low thermal conductivity (d) have high thermal conductivity

43. An ideal material for making cooking vessels must be having (IIT 1986)

(a) small conductivity and large heat capacity

(b) large heat capacity and large conductivity

(c) small heat capacity and large conductivity

(d) small heat capacity and small conductivity

44. On a cold morning, a metal surface will feel colder to touch than a wooden surface, because (AIIMS 1996)

(a) metal has high specific heat (b) metal has high thermal conductivity

(c) metal has low specific heat (d) metal has low thermal conductivity

45. A piece of glass is heated to a high temperature and then allowed to cool. If it cracks, a probable reason for this is the following property of glass: (AIPMT 1988)

(a) Low thermal conductivity (b) High thermal conductivity

(c) High specific heat (d) High melting point

46. The two ends of a metal rod are maintained at temperatures 100°C and 110°C. The rate of heat flow in the rod is found to be 4 J / s. If the ends are maintained at temperatures 200°C and 210°C the rate of heat flow will be (NEET 2015)

(a) 44 J /s (b) 16.8 J /s (c) 8 J /s (d) 4 J /s

47. Consider two rods of same length and different specific heat (C_1, C_2), thermal conductivities (K_1, K_2) and area of cross-sections (A_1, A_2) and both having

temperatures (T_1, T_2) at their ends. If their rate of loss of heat due to conduction is equal, then (AIPMT 2002)

(a) $K_1A_1 = K_2A_2$ (b) $K_1A_1 / C_1 = K_2A_2 / C_2$ (c) $K_2A_1 = K_1A_2$ (d) $K_2A_1 / C_2 = K_1A_2 / C_1$

48. A cylindrical rod having temperatures T_1 and T_2 at its ends. The rate of flow of heat is Q_1 cals^{-1}. If all the dimensions (length and radius) are doubled keeping temperature constant, then the rate of flow of heat Q_2 will be (AIPMT2001)

(a) $Q_2 = 2Q_1$ (b) $Q_2 = Q_1/2$ (c) $Q_2 = Q_1/4$ (d) $Q_2 = 4Q_1$

49. Heat is flowing through the cylindrical rods of the same material. The diameters of the rods are in the ratio 1 : 2 and their lengths are in the ratio 2 : 1. If the temperature difference between their ends is the same, then the ratio of the amount of heat conducted through them per unit time will be (AIPMT1995)

(a) 1 : 1 (b) 2 : 1 (c) 1 : 4 (d) 1 : 8

50. A drop of water is sprinkled on a red hot iron plate. The drop forms a small sphere, but does not vaporize immediately. This happens because

(a) boiling point of water gets raised (b) red hot iron is poor conductor of heat

(c) the temperature decreases at the point where water drop touches iron plate

(d) a layer of water vapour is formed between the drop and the plate, which prevents conduction of heat

51. Which one of the following processes depends on gravity? (AIPMT 2000)

(a) Conduction (b) Convection (c) Radiation (d) None of these

52. The presence of gravitational field is required for the heat transfer by

(a) stirring liquids (b) conduction (c) natural convection (d) radiation

53. While measuring the thermal conductivity of a liquid, we keep the upper part hot and lower cool, so that (AIPMT 1985)

(a) convection may be stopped (b) radiation may be stopped

(c) heat conduction is easier downwards

(d) it is easier and more convenient to do so

54. For proper ventilation of building, windows must be open near the bottom and top of the walls so as to let pass

(a) more air (b) cool air into the room and hot air to leave the room

(c) cool air near the roof and hot air near the bottom (d) hot air near the bottom

55. The layers of atmosphere are heated through

(a) Convection (b) Conduction (c) Radiation (d) None of these

56. Air is a bad conductor of heat, still vacuum is preferred between the walls of the thermos flask because

(a) it is difficult to fill the air between the walls of the thermos flask

(b) due to more pressure of air, the flask can crack

(c) by convection, heat can flow through air (d) none of the above

57. The freezer in a refrigerator is located at the top section, so that (AFMC 2008)

(a) the entire chamber of the refrigerator is cooled quickly due to convection
(b) the motor is not heated (c) the heat gained from the environment is high
(d) the heat gained from the environment is low

58. In which of the following process, convection does not take place primarily?
(a) sea and land breeze (b) boiling of water
(c) warming of glass of the bulb due to filament (d) heating of air around a furnace (IIT 2005)

59. In which process the rate of transfer of heat is maximum? (AFMC 2010)
(a) Conduction (b) Radiation (c) Convection (d) Equal in all the three

60. Which of the following statement is true about the radiation emitted by human body? (AIPMT 2003)
(a) The radiation emitted lies in the ultraviolet region and hence is not visible
(b) The radiation is emitted during the summer and absorbed during the winter
(c) The radiation is emitted only during the day
(d) The radiation emitted is in the infra-red region

61. A block of ice in a room at normal temperature
(a) does not radiate (b) radiates less but absorbs more
(c) radiates more than it absorbs (d) radiates as much as it absorbs

62. According to Newton's law of cooling, the rate of cooling of a body is proportional to $(\Delta\theta)^n$ where $\Delta\theta$ is the difference of temperature between the body and the surrounding , then n is equal to (AIIMS 2010)
(a) 2 (b) 3 (c) 4 (d) 1

63. A beaker full of hot water is kept in a room. If it cools from 80^0C to 75^0C in t_1 minute, from 75^0C to 70^0C in t_2 minute and from 70^0C to 65^0C in t_3 minute then
(a) $t_1 = t_2 = t_3$ (b) $t_1 < t_2 = t_3$ (c) $t_1 < t_2 < t_3$ (d) $t_1 > t_2 > t_3$

64. Which of the following surface will radiate heat to a large extent?
(a) white polished (b) white rough (c) black polished (d) black rough (AIIMS 1998)

65. Heat travels through vacuum by
(a) conduction (b) convection
(c) radiation (d) both by conduction and convextion (Kerala 1990)

66. Heat energy from the sun reaches the earth by
(a) scattering (b) conduction (c) radiation (d) convection

67. The thermal radiation from a hot body travels in vacuum with a velocity of (Kerala 2010)
(a) $330\ m\ s^{-1}$ (b) $2 \times 10^8\ m\ s^{-1}$ (c) $1200\ m\ s^{-1}$ (d) $3 \times 10^8\ m\ s^{-1}$ (AFMC 2005)

68. A hot body and a cold body are kept in vacuum separated from each other. Which of the following causes decrease in temperature of the hot body?
(a) Radiation (b) Convection (c) Conduction
(d) Temperature remains unchanged (IIT 2002)

69. An ideal black body at room temperature is thrown into a furnace. It is observed that

(a) initially, it is the darkest body and at later times the brightest
(b) it is the darkest body at all times (c) it cannot be distinguished at all times
(d) initially, it is the darkest body and at later times it cannot be distinguished

70. A hot body will radiate heat most rapidly, if its surface is (IIT 1992)
(a) white and polished (b) white and rough
(c) black and polished (d) black and rough

71. Which of the following is best close to an ideal black body? (AIPMT 2002)
(a) Cavity maintained at constant temperature (b) Platinum black
(c) A lump of charcoal heated to high temperature (d) Kerosene lamp

72. A black body when hot, emits heat radiation of (CET 1999)
(a) infrared wavelengths (b) ultraviolet wavelengths
(c) all wavelengths (d) a particular wavelength

73. A polished metal plate with a rough black spot on it is heated to about 1400 K and quickly taken to a dark room. Which one of following statements will be true?
(a) The spot will appear brighter than the plate
(b) The spot will appear darker than the plate
(c) The spot and plate will appear equally bright
(d) The spot and plate will not be visible in the dark room

74. A thermos flask is polished well (AFMC 1996)
(a) to make it attractive (b) for shining
(c) to absorb all radiations from outside (d) to reflect all radiations from outside

75. There is a black spot on a body. If the body is heated and carried to a dark room then it glows more. This can be explained on the basis of
(a) Newton's law of cooling (b) Wein's law (c) Kirchhoff's law (d) Stefan's law

76. Distribution of energy in the spectrum of a black body can be correctly represented by
(a) Wein's law (b) Stefan's law (c) Planck's law (d) Kichhoff's law

77. Which of the following law states that "good absorbers of heat are good emitters"?
(a) Stefan's law (b) Kirchhoff's law (c) Planck's law (d) Wein's law

78. The absorptive power of perfectly black body is: (AFMC 2003)
(a) 0 (b) 1 (c) less than 1 (d) infinity

79. The ratio of the emissive power to the absorptive power of all substances for a particular wavelength is the same at given temperature. The ratio is knows as
(a) the emissive power of a perfectly black body
(b) the emissive power of any type of body
(c) the Stefan's constant (d) the Wein's constant

80. If e_λ and a_λ be the emissive power and absorptive power of a body, then according to Kirchhoff's law, which is true (E_λ = emissive power of perfectly black body)

(a) $e_\lambda = a_\lambda = E_\lambda$ (b) $e_\lambda E_\lambda = a_\lambda$ (c) $e_\lambda = a_\lambda E_\lambda$ (d) $e_\lambda a_\lambda E_\lambda$ = constant

81. At 273°C the emissive power of a perfect black body is R. What is its value at 0°C?

(a) $\frac{R}{4}$ (b) $\frac{R}{16}$ (c) $\frac{R}{2}$ (d) None of these (Manipal **2010**)

82. Radiation emitted by a surface is directly proportional to (AFMC **1995**)

(a) third power of its temperature (b) fourth power of its temperature
(c) second power of its temperature (d) equal to its temperature

83. A spherical black body with a radius of 12 cm radiates 450 watt power at 500 K. If the radius were halved and the temperature doubled, the power radiated in watt would be (NEET **2017**)

(a) 450 (b) 1000 (c) 1800 (d) 225

84. Wien's displacement law expresses relation between (AIPMT **2002**)

(a) wavelength corresponding to maximum energy and absolute temperature
(b) radiated energy and wavelength (c) emissive power and temperature
(d) colour of light and temperature

85. The wavelength of the radiation emitted by a body depends upon

(a) the nature of its surface (b) the area of its surface
(c) the temperature of its surface (d) all the above factors

86. The wavelength corresponding to maximum intensity of radiation emitted by a source at temperature 2000 K is λ then what is the wavelength corresponding to maximum intensity of radiation at temperature 300 K? (AIPMT **2001**)

(a) $\frac{2}{3}\lambda$ (b) $\frac{16}{81}\lambda$ (c) $\frac{81}{16}\lambda$ (d) $\frac{4}{3}\lambda$

87. A black body at 1227°C emits radiations with maximum intensity at a wavelength of 5000 A°. If the temperature of the body is increased by 1000°C the maximum intensity will be observed at (AIPMT **2006**)

(a) 4000 A° (b) 5000 A° (c) 6000 A° (d) 3000 A°

88. If λ_m denotes the wavelength at which the radiative emission from a black body at a temperature T K is maximum, then (AIPMT **2004**)

(a) $\lambda_m \propto T^4$ (b) λ_m is independent of T (c) $\lambda_m \propto T$ (d) $\lambda_m \propto T^{-1}$

89. When the temperature of a black body is increased, the wavelength of radiation corresponding to the maximum intensity of radiation (AIPMT **1993**)

(a) increases (b) decreases (c) remains the same
(d) depends upon the material of the body

90. If the temperature of the sun is doubled, the rate of energy received on earth will be increased by a factor of (AIPMT **1993**)

(a) 2 (b) 4 (c) 8 (d) 16

91. The surface temperature of the stars is determined using (KCET **2009**)

(a) Planck's law (b) Wien's displacement law
(c) Rayleigh-Jeans law (d) Kirchhoff's law

(a) momentum (b) charge (c) mass (d) energy

102. An ideal gas A and a real gas B have their volumes increased from V to 2V under isothermal conditions. The increase in internal energy (AIPMT 1993)

(a) will be same in both A and B (b) will be zero in both the gases

(c) of B will be more than that of A (d) of A will be more than that B

103. The internal energy of a perfect gas is

(a) partly kinetic and partly potential (b) wholly potential

(c) wholly kinetic (d) depends on the ratio of two specific heats

104. If Q , U and W denote respectively the heat added, change in internal energy and the work done in a closed cycle process, then (AIPMT 2008)

(a) W = 0 (b) Q = W = 0 (c) U = 0 (d) Q = 0

105. 110J of heat is added to a gaseous system, whose internal energy is 40J then the amount of external work done is (AIPMT 1993)

(a) 150 J (b) 70 J (c) 110 J (d) 40 J

106. The internal energy change in a system that has absorbed 2 kcal of heat and done 500 J of work is (AIPMT 2009)

(a) 8900 J (b) 6400 J (c) 5400 J (d) 7900 J

107. Which of the following process is reversible? (AIPMT 2005)

(a) Transfer of heat by radiation (b) Electrical heating of a nichrome wire

(c) Transfer of heat by conduction (d) Isothermal compression

108. In an isothermal change of an ideal gas $\Delta U = 0$. The change in heat energy ΔQ is equal to (AIPMT 1998)

(a) 0.5 ΔW (b) ΔW (c) 1.5 ΔW (d) 2 ΔW

109. A sample of gas expands from volume V_1 to V_2. The amount of work done by the gas is greatest, when the expansion is (AIPMT 1997)

(a) isothermal (b) isobaric (c) adiabatic (d) equal in all cases

110. In which process, the PV indicator diagram is a straight line parallel to volume axis? (AFMC 2009)

(a) Isothermal (b) Isobaric (c) Irreversible (d) Adiabatic

111. Internal energy of a gas decreases, when (AIPMT 1992)

(a) it absorbs heat (b) the change is cyclic

(c) the change is adiabatic expansion (d) none of the above.

112. The pressure, temperateure relation for an adiabatic expansion is (AIPMT 1996)

(a) $P^{\gamma} T^{\gamma-1}$ = constant (b) $P^{\gamma-1} T^{\gamma}$ = constant

(c) $P^{\gamma} T^{1-\gamma}$ = constant (d) $P^{1-\gamma} T^{\gamma}$ = constant

113. A gas expands under constant pressure P from volume V_1 to V_2. The work done by the gas is (AIPMT 1990)

(a) $P(V_2 - V_1)$ (b) $P(V_1 - V_2)$ (c) $P(V_1^{\gamma} - V_2^{\gamma})$ (d) $P\left(\frac{1}{V_1} - \frac{1}{V_2}\right)$

114. Which of the following parameters does not characterize the thermodynamic state of matter? (AIEEE 2003)
(a) Temperature (b) Pressure (c) Work (d) Volume

115. Heat capacity of a substance is infinite. It means (AIIMS 1997)
(a) heat is given out (b) heat is taken in
(c) no change in temperature, whether heat is taken in or given out
(d) all of these

116. In a cyclic process, the internal energy of the gas
(a) increases (b) decreases (c) remains constant (d) becomes zero

117. The process of production of heat by friction is
(a) an adiabatic change (b) an isothermal change
(c) a reversible change (d) an irreversible change

118. Indicator diagram is a graph between
(a) P and T (b) V and T (c) P and V (d) None of the above

119. The efficiency of a Carnot engine depends on the temperature of (AIPMT 1999)
(a) working substance (b) source only (c) sink only (d) source and sink

120. If the temperature of the source is increased, the efficiency of a Carnot engine (AIIMS 1992)
(a) increases (b) decreases
(c) remains constant (d) first increases and then remains constant

121. Even Carnot engine cannot give 100% efficiency, because we cannot : (AIEEE 2002)
(a) prevent radiation (b) find ideal sources
(c) reach absolute zero temperature (d) eliminate friction

122. A refrigerator with its power on, is kept in a closed room. The temperature of the room will
(a) rise (b) fall (c) remains the same (d) depend on the area of the room

123. The efficiency of a Carnot engine operating between temperatures of 100^0C and -23^0C will be (AIPMT 1997)
(a) $\frac{100-23}{273}$ (b) $\frac{100+23}{373}$ (c) $\frac{100+23}{100}$ (d) $\frac{100-23}{100}$

124. The temperatures of source and sink of a heat engine are 127^0C and 27^0C respectively. An inventor claims its efficiency to be 26% then (AIPMT 2001)
(a) it is impossible (b) it is possible with high probability
(c) it is possible with low probability (d) data is insufficient

Answers :

1(d)	2(d)	3(a)	4(a)	5(a)	6(b)	7(d)	8(a)	9(b)	10(c)	11(d)	12(d)
13(a)	14(c)	15(c)	16(a)	17(a)	18(a)	19(c)	20(a)	21(b)	22(a)	23(a)	24(c)
25(a)	26(c)	27(b)	28(b)	29(c)	30(a)	31(a)	32(a)	33(d)	34(a)	35(a)	36(d

37(a) 38(c) 39(a) 40(b) 41(b) 42(c) 43(c) 44(b) 45(a) 46(d) 47(a) 48(a)
49(d) 50(d) 51(b) 52(c) 53(a) 54(b) 55(a) 56(c) 57(a) 58(c) 59(b) 60(d)
61(b) 62(d) 63(c) 64(d) 65(c) 66(c) 67(d) 68(a) 69(a) 70(d) 71(a) 72(c)
73(a) 74(d) 75(c) 76(c) 77(b) 78(b) 79(a) 80(c) 81(b) 82(b) 83(c) 84(a)
85(c) 86(a) 87(d) 88(d) 89(b) 90(d) 91(b) 92(a) 93(c) 94(b) 95(d) 96(a)
97(b) 98(b) 99(a) 100(d) 101(d) 102(b) 103(c) 104(c) 105(b) 106(d) 107(d) 108(b)
109(b) 110(b) 111(c) 112(d) 113(a) 114(c) 115(c) 116(c) 117(d) 118(c) 119(d) 120(a)
121(c) 122(a) 123(b) 124(a)

Solutions :

5. (a) $\frac{C}{5}=\frac{F-32}{9}$, $\frac{-183}{5}=\frac{F-32}{9}$, $5F-160=-1647$, $5F=-1487$, $F=-297^{0}F$

6. (b) $\frac{x}{5}=\frac{x-32}{9}$, $9x = 5x-160$, $4x=-160$, $x=-40^{0}C$

20. (a) Increase in length for two rods of same material is independent of their diameters.

21. (b) Original value of circumference $l = 2\pi R$. Hence $\Delta l = l\alpha\theta = 2\pi r\alpha\theta$

22. (a) $\Delta l_1 = \Delta l_2$, $\alpha_1 l_1 t = \alpha_2 l_2 t$, $\alpha_1 l_1 = \alpha_2 l_2$

23. (a) $\Delta V = \frac{4}{3}\pi(\Delta r)^3$, $\Delta A = 4\pi(\Delta r)^2$, Increase in diameter = $(2\Delta r)$

Hence largest increase is in volume.

25. (a) $ms(\theta_2-\theta_1) = mgh$, $\theta_2-\theta_1 = \frac{9.8\times500}{4200} = 1.16^{0}C$

30. (a) Steam has large latent heat (540 k cal g^{-1})

31. (a) Unit is J kg^{-1}, dimensions = $\frac{ML^2T^{-2}}{M} = M^0L^2T^{-2}$

46. (d) Temperature difference = $110^0C - 100^0C = 10^0$ and $210^0C - 200^0C = 10^0C$

Rate of flow $\propto$ temperature difference between the two ends.

$\therefore$Rate of flow in first case = rate of flow in second case = 4 Js^{-1}

47. (a) $\frac{K_1A_1(T_1-T_2)}{l} = \frac{K_2A_2(T_1-T_2)}{l}$, $K_1A_1 = K_2A_2$

48. (a) $Q_1 = \frac{K\pi r^2(\theta_1-\theta_2)}{l}$, $Q_2 = \frac{K\pi(2r)^2(\theta_1-\theta_2)}{2l_2}$, $\frac{Q_2}{Q_1} = 2$, $Q_2 = 2Q_1$

49. (d) $\frac{r_1}{r_2} = \frac{1}{2}$, $r_2 = 2r_1$, $\frac{l_1}{l_2} = 2$, $l_1 = 2l_2$

$Q_1 = \frac{K\pi r_1^2(\theta_1-\theta_2)}{2l_2}$, $Q_2 = \frac{k\pi(2r_1)^2(\theta_1-\theta_2)}{l_2}$, $\frac{Q_1}{Q_2} = \frac{1}{8}$, $Q_1 : Q_2 = 1:8$

Unit 9 : Kinetic Theory of Gases

I. Multiple Choice Questions :

1. A particle of mass m is moving with speed u in a direction which makes 60° with respect to x axis. It undergoes elastic collision with the wall. What is the change in momentum in x and y direction?

(a) $\Delta p_x = mu$, $\Delta p_y = 0$ (b) $\Delta p_x = -2mu$, $\Delta p_y = 0$
(c) $\Delta p_x = 0$, $\Delta p_y = mu$ (d) $\Delta p_x = mu$, $\Delta p_y = 0$

2. A sample of ideal gas is at equilibrium.Which of the following quantity is zero?
(a) rms speed (b) average speed
(c) average velocity (d) most probable speed

3. An ideal gas is maintained at constant pressure. If the temperature of an ideal gas increases from 100 K to 1000 K then the rms speed of the gas molecules
(a) increases by 5 times (b) increases by 10 times
(c) remains same (d) increases by 7 times

4. Two identically sized rooms A and B are connected by an open door. If the room A is air conditioned such that its temperature is 4° lesser than room B, which room has more air in it?
(a) Room A (b) Room B
(c) Both room has same air (d) Cannot be determined

5. The average translational kinetic energy of gas molecules depends
(a) on number of moles and T (b) only on T (c) on P and T (d) on P only

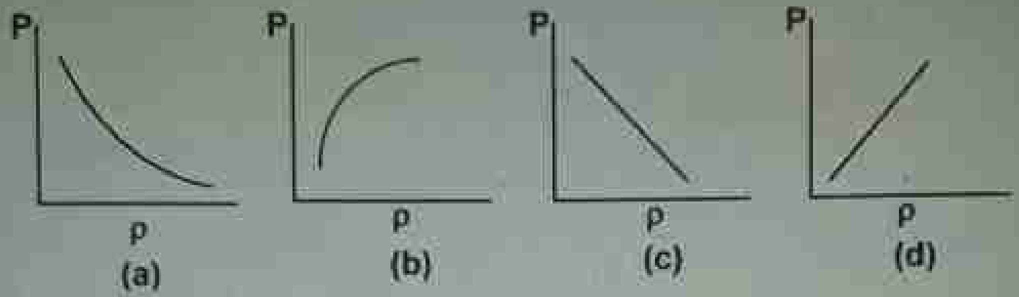
6. If the internal energy of an ideal gas U and volume V are doubled then the pressure
(a) doubles (b) remains same (c) halves (d) quadruples

7. The ratio $\gamma = \frac{C_p}{C_v}$ for a gas mixture consisting of 8 g helium and 16 g of oxygen is
(a) 23/15 (b) 15/23 (c) 27/11 (d) 17/27

8. A container has one mole of monotomic ideal gas. Each molecule has f degrees of freedom. What is the ratio of $\gamma = \frac{C_p}{C_v}$?
(a) f (b) $\frac{f}{2}$ (c) $\frac{f}{f+2}$ (d) $\frac{f+2}{f}$

9. If the temperature and pressure of a gas is doubled the mean free path of the gas molecules
(a) remains same (b) doubled (c) tripled (d) quadrapoled

10. Which of the following shows the correct relationship between the pressure and density of an ideal gas at constant temperature?



11. A sample of gas consist of μ_1 moles of monoatomic molecules μ_2 moles of diatomic molecules and μ_3 moles of linear triatomic molecules. The gas is kept at high temperature. What is the total number of degrees of freedom?

(a) $[3\mu_1 + 7(\mu_2 + \mu_3)]N_A$ (b) $[3\mu_1 + 7\mu_2 + 6\mu_3]N_A$

(c) $[7\mu_1 + 3(\mu_2 + \mu_3)]N_A$ (d) $[3\mu_1 + 6(\mu_2 + \mu_3)]N_A$

12. If s_p and s_v denote the specific heats of nitrogen gas per unit mass at constant pressure and constant volume respectively, then

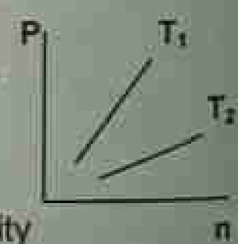
(a) $s_p - s_v = 28R$ (b) $s_p - s_v = R/28$ (c) $s_p - s_v = R/14$ (d) $s_p - s_v = R$

13. Which of the following gases will have least r ms speed at a given temperature ?

(a) Hydrogen (b) Nitrogen (c) Oxygen (d) Carbon dioxide

14. For a given gas molecule at a fixed temperature, the area under the Maxwell- Boltzmann distribution curve is equal to

(a) $\frac{PV}{kT}$ (b) $\frac{kT}{PV}$ (c) $\frac{P}{NkT}$ (d) PV



15. The following graph represents the pressure verus number density for ideal gas at two different temperatures T_1 and T_2. The graph implies

(a) $T_1 = T_2$ (b) $T_1 > T_2$ (c) $T_1 < T_2$ (d) cannot be determined

Answers : 1) a 2) c 3) b 4) a 5) a 6) b 7) c 8) d 9) a 10) d 11) a 12) b 13) d 14) a 15) b

Solutions :

1. (a) x componet of velocity is reversed. y component remins unchanged

3. (b) $\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{10,000}{100}} = 10$, $v_2 = 10v_1$ increases by 10 times

4. (a) because the RMS velocity of air molecules in room A is less than that in B

5. (a) Average translational $\overline{KE} = u = \frac{3}{2}\mu RT$, u depends on number of moles μ and temperature T

6. (b) $P = \frac{2U}{3V} = \frac{2(2U)}{3(2V)}$ remains same

7. (c) $\gamma = \frac{C_p}{C_v} = \frac{5\mu_1 + 7\mu_2}{3\mu_1 + 5\mu_2} = \frac{5\times 2 + 7\times\frac{1}{2}}{3\times 2 + 5\times\frac{1}{2}} = \frac{27}{17}$

8. (d) $f = 3$, $\gamma = \frac{c_p}{c_v} = \frac{5}{3} = \frac{3+2}{3} = \frac{f+2}{f}$

9. a) $\lambda = \frac{kT}{\sqrt{2}\pi d^2 P} = \frac{k(2T)}{\sqrt{2}\pi d^2 (2P)}$, remains same

10. (d) $P = \frac{1}{3}\rho\overline{v^2}$, $P \propto \rho$ at constant temperature.

11. (a) $f = 3\mu_1 N_A + 7\mu_2 N_A + 7\mu_3 N_A = [3\mu_1 + 7(\mu_2 + \mu_3)]N_A$

12. (b) $s_p - s_v = \frac{C_p}{M} - \frac{C_v}{M} = \frac{C_p - C_v}{M} = \frac{R}{28}$

13. (d) $v_{rms} \propto \frac{1}{\sqrt{m}}$. Among the four, CO_2 has highest molecular mass.

Hence v_{rms} for CO_2 is least.

14. (a) $PV = NkT$, $N = \frac{PV}{kT}$ = area under the Maxwell's molecular speed distribution graph

15. b) $P = \frac{1}{3}nm\overline{v^2}$. But $\overline{v^2} \propto T$. $P \propto nT$. Hence $T_1 > T_2$

Creative Questions.

1. Which one of the following is not an assumption in the kinetic theory of gases? (Manipal 2010)
   (a) The volume occupied by the molecules of the gas is negligible.
   (b) The force of attraction between the molecules is negligible
   (c) The collision between molecules are elastic (d) All molecules have same speed
2. The temperature of a gas is due to
   (a) P.E. of the molecules (b) K.E. of the molecules
   (c) Intermolecular force of attraction (d) None of the above
3. The temperature of a gas is held constant, while its volume is decreased. The pressure exerted by the gas on the walls of the container increases, because its molecules (AIIMS 1996)
   (a) are in contact with the walls for a shorter time
   (b) strike the walls with higher velocities (d) strike the walls more frequently
   (c) strike the walls with large force (IIT 2010)
4. A real gas behaves like an ideal gas, if its
   a) pressure and temperature are both high

b) pressure and temperature are both low
c) pressure is high and temperature is low
d) pressure is low and temperature is high

5. The relation PV = R T can describe behaviour of real gas as ideal gas at (AIPMT 1990)
a) high temperature and high density
b) high temperature and low density
c) low temperature and low density d) low temperature and high density

6. At constant volume if temperature is increased, then (AIPMT 1989)
a) collision on walls will decrease b) number of collisions per unit time will increase
c) collisions will be in straight lines d) collisions will not change

7. The average velocity of the molecules in a gas in equilibrium is (AIIMS 2009)
a) proportional to $\sqrt{T}$ b) proportional to T c) proportional to T^2 d) equal to zero

8. According to kinetic theory of gases, at absolute zero temperature (AIPMT 1990)
a) water freezes b) liquid helium freezes
c) molecular motion stops d) liquid hydrogen freezes

9. The pressure exerted by the molecules of a gas is due to
a) molecules losing their K.E. b) sticking to the walls
c) change of momentum d) molecules gaining K.E.

10. A pressure cooker reduces cooking time for food, because (AIEEE 2003)
a) heat is more evenly distributed in the cooking space.
b) cooking involves chemical changes helped by a rise in temperature.
c) boiling point of water involved in cooking is increased.
d) the higher pressure inside the cooker crushes the food.

11. Avogadro number is the number of molecules in (AIPMT1983)
a) one litre of a gas at N.T.P b) one mole of a gas
c) one gram of a gas d) one kilogram of gas

12. SI unit of universal gas constant is
a) cal / $^{\circ}$C b) J mol^{-1} c) J mol^{-1} K^{-1} d) J / kg^{-1}

13. The pressure of a given mass of gas at constant temperature is P and its volume is V. The PV versus V graph is (KCET 1989)
a) a hyperbola b) straight line parallel to the V-axis
c) straight line parallel to PV-axis d) straight line having slope one

14. At a given temperature, the ratio of the RMS velocity of hydrogen to the RMS velocity of oxygen is
a) 4 b) 1 / 4 c) 16 d) 8

15. The quantity PV / kT represents
a) mass of the gas b) kinetic energy of the gas
c) number of moles of the gas d) number of molecules in the gas

16. Relation between pressure P and energy E of a gas is (AIMPT 1991)

a) $P = \frac{2}{3}E$ b) $P = \frac{1}{3}E$ c) $P = \frac{3}{2}E$ d) $P = 3E$

17. The ideal gas is one, which obeys (KCET 1990)

a) Boyle's law b) Charles' law

c) Boyle's law and Charles' law d) Avogadro's law

18. A given surface is hit elastically and normally by n balls per second, all the balls having the same mass m and moving with the same velocity u. The force exerted on the surface is

a) 2 mnu b) mnu^2 c) $mnu^2 / 2$ d) $2\ mnu^2$ (KCET 1989)

19. The type of motion associated with the molecules of a gas is

a) streamline motion b) vortex motion

c) Brownian motion d) osmotic motion

20. If at the same temperature and pressure, the densities of two diatomic gases are d_1 and d_2 respectively, the ratio of mean kinetic energy per molecule of gases will be

a) 1 : 1 b) $d_1 : d_2$ c) $\sqrt{d_1} : \sqrt{d_2}$ d) $\sqrt{d_2} : \sqrt{d_1}$

21. The r.m.s. velocity of a particle is v at pressure P. If the pressure increases by two times, keeping temperature constant, then r.m.s. velocity will become (AFMC 1996)

a) 0.5 v b) v c) 2 v d) 4 v

22. The velocities of three molecules are 3 v, 4 v and 5 v respectively. Their rms speed will be

a) $\sqrt{\frac{50}{3}}v$ b) $\sqrt{\frac{5}{2}}v$ c) $\frac{7}{2}v$ d) $\frac{5}{2}v$

23. Four molecules of a gas have speed 1, 2, 3 and 4 kms^{-1}. The value of the RMS speed of the gas molecules is

a) $\frac{1}{2}\sqrt{15}\ km\ s^{-1}$ b) $\frac{1}{2}\sqrt{10}\ km\ s^{-1}$ c) $2.5\ km\ s^{-1}$ d) $\sqrt{\frac{15}{2}}\ km\ s^{-1}$

24. When volume of an ideal gas is increased two times and temperature is decreased half of its initial temperature, then pressure becomes

a) 2 times b) 4 times c) 1 / 4 times d) 1 / 2 times

25. The density of a gas at normal pressure and 27^0C temperature is 24 units. keeping the pressure constant, the density at 127^0C will be

a) 6 units b) 12 units c) 18 units d) 24 units

26. Two containers A and B are partly filled with water and closed. The volume of A is twice that of B and it contains half the amount of water in B. If both are at the same temperature, the water vapour in the containers will have pressure in the ratio of (AIPMT 1988)

a) 1 : 2 b) 1 : 1 c) 2 : 1 d) 4 : 1

27. The temperature of a gas is raised from 27°C to 927°C. The r.m.s. speed
a) $\sqrt{\frac{927}{27}}$ times the earlier value b) remains the same (AIPMT 1994)
c) gets halved d) gets doubled

28. The gases carbon - monoxide (CO) and nitrogen at the same temperature have kinetic energies E_1 and E_2 respectively. Then (AIMPT 2000)
a) $E_1 = E_2$ b) $E_1 > E_2$ c) $E_1 < E_2$ d) E_1 and E_2 cannot be compared

29. The equation of state, corresponding to 8 g of O_2 is (AIMPT 1994)
a) PV = 8RT b) PV = $\frac{RT}{4}$ c) PV = RT d) PV = $\frac{RT}{2}$

30. The root mean square velocity of a gas molecule of mass m at a given temperature is proportional to (AIMPT 1990)
a) m^0 b) m c) $\sqrt{m}$ d) $m^{-1/2}$

31. The equation of state for 5 g of oxygen at a pressure P and temperature T, when occupying a volume V, will be (AIMPT 2004)
a) PV = $\frac{5RT}{32}$ b) PV = $\frac{5RT}{16}$ c) PV = $\frac{5RT}{2}$ d) PV = 5RT

32. At what temperature rms speed of air molecules is double of that of NTP?
a) 819°C b) 719 °C c) 909°C d) None of these (CET 2009)

33. In kinetic theory of gases, a molecule of mass m of an ideal gas collides with a wall of vessel with velocity v. The change in the linear momentum of the molecule is
a) 2 mv b) mv c) - mv d) zero (AIIMS 1997)

34. An ideal gas is heated from 27°C to 627°C at constant pressure. If initial volume of the gas was 4 m^3, then the final volume will be (AIIMS 1995)
a) 2 m^3 b) 4 m^3 c) 6 m^3 d) 12 m^3

35. For Boyle's law to hold good, the gas should be (AIIMS 1994)
a) perfect and of constant mass and temperature
b) real and of constant mass and temperature
c) perfect and at constant temperature but variable mass
d) real and at constant temperature but variable mass

36. In a vessel, the gas is at a pressure P. If the mass of all the molecules is halved and their speed is doubled, then the resultant pressure will be (AIMMS 1994)
a) 4 P b) 2P c) P d) P / 2

37. Pressure of an ideal gas is increased by keeping temperature constant. What is the effect on kinetic energy of molecules? (AFMC 2006)
a) Increases b) Decreases c) No change d) Can't be determined

38. A bulb contains one mole of hydrogen mixed with one mole of oxygen at temperature T. The ratio of r.m.s. values of velocity of hydrogen molecules to that of oxygen molecules is
a) 1 : 16 b) 1 : 4 c) 4 : 1 d) 16 : 1 (AIIMS 1994)

39. Oxygen molecule is 16 times heavier than hydrogen molecule. If they are at the same temperature T, the ratio of kinetic energies of oxygen to that of hydrogen is

a) 1 b) 16 c) 4 d) 256

40. The temperature of an ideal gas is increased from 120 K to 480 K. If at 120 K the root mean square speed of gas molecules is v then at 480 K it will be

a) 4v b) 2v c) v / 2 d) v / 4

41. What will be the temperature when the rms velocity is double of that at 300 K? (WB JEE 2010)

a) 300 K b) 600 K c) 900 K d) 1200 K

42. Two gases are at absolute temperatures 300 K and 350 K respectively. Ratio of average kinetic energy of their molecules is

a) 7 : 6 b) 6 : 7 c) 36 : 49 d) 49 : 36

43. At 27^0C temperature, the kinetic energy of an ideal gas is E_1. If the temperature is increased to 327^0C, then the kinetic energy will be : (AFMC 2000)

a) $E_1 / \sqrt{2}$ b) $\sqrt{2}\ E_1$ c) $2\ E_1$ d) $E_1 / 2$

44. For an ant moving on a horizontal surface, its number of degrees of freedom is

a) 1 b) 2 c) 3 d) 6 (AIPMT 1993)

45. The translational kinetic energy of one mole of a gas is equal to

a) $\frac{3}{2}$ RT b) $\frac{2}{3}$ kT c) $\frac{1}{2}$ RT d) $\frac{3}{2}$ kT

46. A polyatomic gas with n degrees of freedom has a mean energy per molecule is

a) $\frac{nkT}{N}$ b) $\frac{nkT}{2N}$ c) $\frac{nkT}{2}$ d) $\frac{3kT}{2}$ (AIPMT 1989)

47. If γ is the ratio of specific heats of a perfect gas, then the number of degrees of freedom of a molecule of the gas is (AIPMT 2000)

a) $\frac{25(\gamma-1)}{2}$ b) $\frac{9(\gamma-1)}{2}$ c) $\frac{3\gamma-1}{2\gamma-1}$ d) $\frac{2}{\gamma-1}$

48. The molar specific heats of an ideal gas at constant pressure and constant volume are denoted by C_P and C_V respectively. If $\gamma = C_P / C_V$ and R is the universal gas constant, then C_V is equal to (NEET 2013)

a) $\frac{1+\gamma}{1-\gamma}$ b) $\frac{R}{\gamma-1}$ c) $\frac{\gamma-1}{R}$ d) γR

49. A gas mixture consists of 2 moles of O_2 and 4 moles of Ar at temperature T. Neglecting all vibrational modes, the total internal energy of the system is (NEET 2017)

a) 15 RT b) 9 RT c) 11RT d) 4 RT

50. The ratio $C_p / C_v = \gamma$ for a gas. Its molecular weight is M. Its specific heat capacity at constant pressure is

a) $\frac{R}{\gamma-1}$ b) $\frac{\gamma R}{\gamma-1}$ c) $\frac{\gamma R}{M(\gamma-1)}$ d) $\frac{\gamma RM}{\gamma-1}$

51. The ratio of specific heats $C_p / C_v = \gamma$ in terms of degree of freedom n is given by

a) $\left(1+\frac{1}{n}\right)$ b) $\left(1+\frac{n}{3}\right)$ c) $\left(1+\frac{2}{n}\right)$ d) $\left(1+\frac{n}{2}\right)$ (NEET 2015)

52. For hydrogen gas $C_P - C_V = a$ and for oxygen gas $C_P - C_V = b$. The relation between a and b is (AIPMT 1991)

a) a = 16 b b) 16 a = b c) a = 4b d) a = b

53. If for a gas $R / C_V = 0.67$ this gas is made up of molecules, which are

a) diatomic b) mixture of diatomic and polyatomic (AIPMT 1992)

c) monoatomic d) polyatomic

54. The specific heat at constant pressure is greater than that of the same gas at constant volume because

a) at constant volume work is done in expanding the gas

b) at constant pressure work is done in expanding the gas

c) the molecular attraction increases more at constant pressure

d) the molecular vibration increases more at constant pressure

55. The mean free path of molecules of a gas, (radius r) is inversely proportional to

a) r^3 b) r^2 c) r d) r^{-2} (NEET 2014)

56. Mean free path of gas molecules at constant temperature is inversely proportional to

a) pressure (P) b) volume (V) c) mass (m) d) number density (n)

Answers :

1 (d)	2(b)	3 (d)	4(d)	5(b)	6(b)	7(d)	8(c)	9(c)	10(c)	11(b)	12(c)
13(b)	14(a)	15(d)	16(a)	17(c)	18(a)	19(c)	20(a)	21(b)	22(a)	23(d)	24(c)
25(c)	26(b)	27(d)	28(a)	29(b)	30(d)	31(a)	32(a)	33(a)	34(d)	35(a)	36(b)
37(c)	38(c)	39(a)	40(b)	41(d)	42(b)	43(c)	44(b)	45(a)	46(c)	47(d)	48(b)
49(c)	50(b)	51(c)	52(d)	53(c)	54(b)	55(d)	56(d)				

Solutions :

4. (d) If pressure is low and at high temperature, molecules will be far apart. Hence force of attraction or repulsion between the molecules will be less. A real gas will behave like an ideal gas.

7. (b) In equilibrium, molecules move at random. Hence average velocity is zero.

10. (c) Boiling point of water increases with the increase in pressure.

14. (a) Molecular weight of hydrogen $M_1 = 2$ g. Molecular weight of oxygen $M_2 = 32$ g

$$\frac{C_1}{C_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{32}{2}} = 4$$

20. (a) Mean kinetic energy per molecule of both gases $= \frac{5}{2}$ k T

22. (a) $C_{rms} = \sqrt{\frac{c_1^{\,2} + c_2^{\,2} + c_3^{\,2}}{3}} = \sqrt{\frac{9v^2 + 16v^2 + 25v^2}{3}} = \sqrt{\frac{50}{3}}\,v$

Unit 10 : Oscillations

I. Multiple Choice Questions :

1. In a simple harmonic oscillation, the acceleration against diaplacement for one complete oscillation will be

(a) an ellipse (b) a circle (c) a parabola (d) a straight line

2. A particle executing SHM crosses points A and B with the same velocity. Having taken 3 s in passing from A to B, it returns to B after another 3 s. The time period is

(a) 15 s (b) 6 s (c) 12 s (d) 9 s

3. The length of a second's pendulum, on the surface of the Earth is 0.9 m. The length of the same pendulum on surface of planet X such that the acceleration of the planet X is n times greater than the Earth is

(a) 0.9 n (b) $\frac{0.9}{n}$ (c) $0.9\ n^2$ (d) $\frac{0.9}{n^2}$

4. A simple pendulum is suspended from the roof of a school bus which moves in a horizontal direction with an acceleration a, then the time period is

(a) $T \propto \frac{1}{g^2+a^2}$ (b) $T \propto \frac{1}{\sqrt{g^2+a^2}}$ (c) $T \propto \sqrt{g^2+a^2}$ (d) $T \propto (g^2+a^2)$

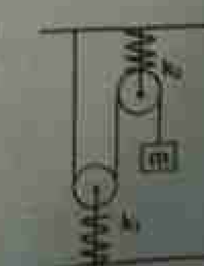
5. Two bodies A and B whose masses are in the ratio 1 : 2 are suspended from two separate massless springs of force constants k_A and k_B respectively. If the two bodies oscillate vertically such that their maximum velocities are in the ratio 1 : 2 the ratio of the amplitude of A to that of B is

(a) $\sqrt{\frac{k_B}{2k_A}}$ (b) $\sqrt{\frac{k_B}{8k_A}}$ (c) $\sqrt{\frac{2k_B}{k_A}}$ (d) $\sqrt{\frac{8k_B}{k_A}}$

6. A spring is connected to a mass m suspended from it and its time period for vertical oscillation is T. The spring is now cut into two equal halves and the same mass is suspended from one of the halves. The period of vertical oscillation is

(a) $T' \sqrt{2}T$ (b) $T' = \frac{T}{\sqrt{2}}$ (c) $T'' = \sqrt{2}T$ (d) $T' = \sqrt{\frac{T}{2}}$

7. The time period for small vertical oscillations of block of mass m when the masses of the pulleys are negligible and spring constant k_1 and k_2 is



(a) $T = 4\pi\sqrt{m\left(\frac{1}{k_1}+\frac{1}{k_2}\right)}$ (b) $T = 2\pi\sqrt{m\left(\frac{1}{k_1}+\frac{1}{k_2}\right)}$

(c) $T = 4\pi\sqrt{m(k_1+k_2)}$ (d) $T = 2\pi\sqrt{m(k_1+k_2)}$

8. A simple pendulum has a time period T_1. When its point of suspension is moved vertically upwards according as $y = k t^2$ where y is vertical distance covered and $k = 1 ms^{-2}$, its time period becomes T_2. Then, $\frac{T_1^2}{T_2^2}$ is ($g = 10 ms^{-2}$)

(a) $\frac{5}{6}$ (b) $\frac{11}{10}$ (c) $\frac{6}{5}$ (d) $\frac{5}{4}$

9. An ideal spring of spring constant k is suspended from the ceiling of a room and a block of mass M is fastend to its lower end. If the block is released when the spring is un-stretched, then the maximum extension in the spring is

(a) $4\frac{Mg}{k}$ (b) $\frac{Mg}{k}$ (c) $2\frac{Mg}{k}$ (d) $\frac{Mg}{2k}$

10. A pendulum is hung in a very high building oscillates to and fro motion freely like a simple harmonic oscillator. If the acceleration of the bob is $16 ms^{-2}$ at a distance of 4 m from the mean position, then the time period is

a) 2 s (b) 1 s (c) 2π s (d) π s

11. A hollow sphere is filled with water. It is hung by a long thread. As the water flows out of a hole at the bottom, the period of oscillation will

(a) first increase and then decrease (b) first decrease and then increase
(c) increase continuously d) decrease continuously

12. The damping force on an oscillator is directly proportional to the velocity. The units of the constant of proportionality are

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

13. When a damped harmonic oscillator completes 100 oscillations, its amplitude is reduced to 1/3 of its initial value. What will be its amplitude when it completes 200 oscillations?

(a) $\frac{1}{5}$ (b) $\frac{2}{3}$ (c) $\frac{1}{6}$ (d) $\frac{1}{9}$

14. Which of the following differential equations represents a damped harmonic oscillator?

(a) $\frac{d^2y}{dt^2} + y = 0$ (b) $\frac{d^2y}{dt^2} + \gamma\frac{dy}{dt} + y = 0$ (c) $\frac{d^2y}{dt^2} + k^2y = 0$ (d) $\frac{dy}{dt} + y = 0$

15. If the inertial mass and gravitational mass of the simple pendulum of length l are not equal, then the time period of the simple pendulum is

(a) $T = 2\pi\sqrt{\frac{m_i l}{m_g g}}$ (b) $T = 2\pi\sqrt{\frac{m_g l}{m_i g}}$ (c) $T = 2\pi\frac{m_g}{m_i}\sqrt{\frac{l}{g}}$ (d) $T = 2\pi\frac{m_i}{m_g}\sqrt{\frac{l}{g}}$

Answers : 1) d 2) c 3) a 4) b 5) b 6) b 7) a 8) c 9) c 10) d
11) a 12) c 13) d 14) b 15) a

13. (d) If A_o is the initial amplitude, the amplitude after time t is $A = A_o e^{-\lambda t}$. When the amplitude reduces to 1/3 of its initial value after 100 vibration then , after 200 (2 x100) oscillation the amplitude will reduce by $1/3^2 = 1/9$ of its initial value.

Creative Questions.

1. In simple harmonic motion , the particle is
   (a) always accelerated (b) always retarded
   (c) alternately accelerated and retarded d) neither accelerated nor retarded
2. The motion which is not simple harmonic is (Kerala 2011)
   (a) vertical oscillations of a spring (b) motion of simple pendulum
   (c) motion of a planet around the sun (d) oscillation of liquid column in a U- tube
3. Which one of the following is a simple harmonic motion? (AIPMT 1994)
   (a) Ball bouncing between two rigid vertical walls
   (b) Earth spinning about its axis
   (c) Particle moving in a circle with uniform speed
   (d) Wave moving through a string fixed at both ends
4. A particle is moving in a circle with uniform speed Its motion is (AIPMT 1978)
   (a) periodic and simple harmonic (b) periodic but not simple harmonic
   (c) not periodic (d) none of the above
5. A particle moving along the X-axis executes SHM when the force on it is given by (Both A and k are positive time constants) (AIPMT 1994)
   (a) Akx (b) Ae^{-kx} (c) $A\cos kx$ (d) $-Akx$
6. Which one of the following equations of motion represents simple harmonic motion? (where k , k_0 , k_1 and a are all positive)
   (a) Acceleration $= -k_0x + k_1x^2$ (b) Acceleration $= -k(x + a)$
   (c) Acceleration $= k(x + a)$ (d) Acceleration $= kx$ (AIPMT 2009)
7. Which of the following is the necessary condition for SHM?
   (a) constant period (b) displacement and acceleration are proportional
   (c) constant acceleration (d) displacement and torque are proportional
8. The displacement of a particle in SHM in one time period is
   (a) x (b) $2x$ (c) $4x$ (d) zero
9. $x(t) = A\cos(\omega t + \phi)$ is the equation of SHM. In this equation ϕ is called
   (a) phase (b) frequency (c) amplitude (d) displacement (J&K CET 2011)
10. In SHM, phase difference between displacement and velocity is ϕ_1 and that between displacement and acceleration is ϕ_2 then
    (a) $\phi_2 = 2\phi_1$ (b) $\phi_2 = \phi_1$ (c) $\phi_1 = 2\phi_2$ (d) none of these
11. Which of the following relationships between the acceleration a and displacement y of a particle represents simple harmonic motion? (CET 1998)
    (a) $a = 0.5y$ (b) $a = 400y^2$ (c) $a = -20y$ (d) $a = -3y^2$

12. The displacement of a particle executing SHM is given by $x = 0.01 \sin(100\pi t + 0.05)$. Its time period is
(a) 0.01 s (b) 0.02 s (c) 0.1 s (d) 0.2 s

13. A body of mass 2 g is executing SHM about a mean position with an amplitude 10 cm. If the maximum velocity is 100 cms^{-1} its velocity is 50 cms^{-1} at a distance of
(a) $5\sqrt{2}$ cm (b) $50\sqrt{3}$ cm (c) $5\sqrt{3}$ cm (d) $10\sqrt{3}$ cm

14. The damping force on an oscillator is directly proportional to its velocity. The unit of the constant of proportionality is (AIPMT 2012)
(a) kg ms^{-1} (b) kg ms^{-2} (c) kg s^{-1} (d) kg s

15. Two simple harmonic motions of angular frequency 100 rad s^{-1} and 1000 rad s^{-1} have the same displacement amplitude. The ratio of their maximum acceleration is (AIPMT 2008)
(a) 1 : 10 (b) 1 : 10^2 (c) 1 : 10^3 (d) 1 : 10^4

16. A particle executing simple harmonic motion of amplitude 5 cm has maximum speed of 31.4 cms^{-1}. The frequency of its oscillation is (AIPMT 2005)
(a) 3 Hz (b) 2 Hz (c) 4 Hz (d) 1 Hz

17. A particle executes S.H.M. starting from its mean position. Its amplitude is a and its time period is T. What is the displacement when its speed is half of its maximum speed? (AIPMT 1996)
(a) $\frac{a\sqrt{2}}{3}$ (b) $\frac{a\sqrt{3}}{2}$ (c) $\frac{2a}{\sqrt{3}}$ (d) $\frac{2a}{\sqrt{2}}$

18. If a simple harmonic oscillator has got a displacement of 0.02 m and acceleration equal to 2 ms^{-2} at any time, the angular frequency of the oscillator is equal to (AIPMT 1992)
(a) 10 rad s^{-1} (b) 0.1 rad s^{-1} (c) 100 rad s^{-1} (d) 1 rad s^{-1}

19. The phase difference between the instantaneous velocity and acceleration of a particle executing simple harmonic motion is (AIIMS 2007)
(a) 0.5π (b) π (c) 0.707π (d) zero

20. A particle executes a simple harmonic motion of time period T. Find the time taken by the particle to go directly from its mean position to half the amplitude (AIPMT 2007)
(a) $\frac{T}{2}$ (b) $\frac{T}{4}$ (c) $\frac{T}{8}$ (d) $\frac{T}{12}$

21. The time period of a body executing S.H.M is 4 s. After how much interval from time $t = 0$, its displacement will be half of its amplitude? (AIIMS 1995)
(a) $\frac{1}{2}$ s (b) $\frac{1}{3}$ s (c) $\frac{1}{4}$ s (d) $\frac{1}{16}$ s

22. A particle is executing a simple harmonic motion. Its maximum acceleration is α and maximum velocity is β. Then, its time period of vibration will be (AFMC 1998)
(a) $\frac{2\pi\beta}{[illegible]}$ (b) $\frac{\beta^2}{[illegible]2}$ (c) $\frac{\alpha}{\beta}$ (d) $\frac{\beta^2}{\alpha}$

33. The equation of a particle executing SHM is $2\frac{d^2x}{dt^2} + 32x = 0$. Its time period is

(a) zero (b) $\pi/2$ (c) π (d) 2π

34. In S.H.M. the acceleration of the particle is zero, when velocity is

(a) zero (b) half of its maximum value (b) maximum (d) none of these

35. A force of 6.4 N stretches a vertical spring by 0.1 m. The mass that must be suspended from the spring so that it oscillates with a period of $\pi/4$ s is

(a) $\pi/4$ kg (b) 1 kg (c) 1/4 kg (d) 10 kg

36. The period of oscillation of a mass M suspended from a spring of negligible mass is T. If along with it another mass M is also suspended, the period of oscillation will now be

(a) T (b) $T/\sqrt{2}$ (c) 2 T (d) $\sqrt{2}$ T (AIPMT 2010)

37. A rectangular block of mass m and area of cross-section A floats in a liquid of density ρ. If it is given a small vertical displacement from equilibrium, it undergoes oscillation with a time period T. Then. (AIPMT 2006)

(a) $T \propto \sqrt{\rho}$ (b) $T \propto \frac{1}{\sqrt{A}}$ (c) $T \propto \frac{1}{\rho}$ (d) $T \propto \frac{1}{\sqrt{m}}$

38. Two springs of spring constants k_1 and k_2 are joined in series. The effective spring constant of the combination is given by (AIPMT 2004)

(a) $\sqrt{k_1 k_2}$ (b) $\frac{k_1 + k_2}{2}$ (c) $k_1 + k_2$ (d) $\frac{k_1 k_2}{k_1 + k_2}$

39. A mass m is vertically suspended from a spring of negligible mass. The system oscillates with a frequency n. What will be the frequency of the system, if a mass 4 m is suspended from the same spring? (AIPMT 1998)

(a) n/4 (b) 4 n (c) n/2 (d) 2n

40. A particle of mass m is hanging vertically by an ideal spring of force constant k. If the mass is made to oscillate vertically, its total energy is (AIPMT 1978)

(a) maximum at extreme position (b) maximum at mean position
(c) minimum at mean position (d) same at all positions

41. A mass m is suspended from two coupled springs connected in series. The spring constants are k_1 and k_2. The time period of the suspended mass is (AIPMT 1990)

(a) $T = 2\pi\sqrt{\frac{m}{k_1 - k_2}}$ (b) $T = 2\pi\sqrt{\frac{mk_1k_2}{k_1 + k_2}}$

(c) $T = 2\pi\sqrt{\frac{m}{k_1 + k_2}}$ (d) $T = 2\pi\sqrt{\frac{m(k_1 + k_2)}{k_1k_2}}$

42. If the period of oscillation of mass m suspended from a spring is 2 s then the period of mass 4 m will be (AIIMS 1998)

(a) 1 s (b) 4 s (c) 8 s (d) 16 s

43. If a spring of mass 30 kg has spring constant of 15 N m^{-1}, then its time period is

(a) 2π s (b) $2\sqrt{2\pi}$ s (c) $2\sqrt{\pi}$ s (d) $2\sqrt{2}$ s (AIIMS 1996)

44. The length of seconds pendulum at a place where g = 9.8 ms^{-2} is

(a) 0.25 m (b) 1 m (c) 0.99 m (d) 0.50 m

45. A simple pendulum of frequency n falls freely under gravity from certain height from the ground level. Its frequency of oscillation will (Kerala CEE 2011)

(a) remain unchanged (b) be greater than n

(c) be less than n (d) become zero

46. If the metal bob of a simple pendulum is replaced by a wooden bob, its time period will

(a) increase (b) decrease (AIIMS 1998)

(c) remain the same (d) first increases and then decreases

47. An oscillating pendulum after some time becomes slow in motion and finally stops due to : (AFMC 2003)

(a) air friction (b) earth's gravity (c) mass of pendulum (d) none of these

48. The period of oscillation of a simple pendulum of constant length at earth's surface is T. Its period inside a mine is (AIPMT 1973)

(a) greater than T (b) less than T (c) equal to T (d) cannot be compared

49. What effect occurs on the frequency of a pendulum, if it is taken from the earth's surface to deep into a mine? (AFMC 2005)

(a) Increses (b) Decreases (c) First increases, then decreases (d) No effect

50. A simple pendulum is made of a hollow sphere containing mercury and then suspended by means of a wire. If a little mercury is drained off, the period of pendulum will : (AFMC 2006)

(a) remain unchanged (b) increase (c) decrease (d) become erratic

51. A child, swinging on a swing in sitting position, stands up. Then, the time period of the swing will : (AIEEE 2002)

(a) increase (b) decrease (c) remain the same

(d) increase, if the child is high and decrease, if the child is short.

52. A hole is bored along the diameter of earth and a stone is dropped into the frictionless tunnel. If the radius of earth is R, then the time period of the stone executing SHM is

(a) $2\pi\sqrt{\frac{2R}{g}}$ (b) $2\pi\sqrt{\frac{R}{2g}}$ (c) $2\pi\sqrt{\frac{R}{g}}$ (d) none of these (AFMC 1998)

53. A hollow sphere is filled with water. It is hung by a long thread. As the water flows out of a hole at the bottom, the period of oscillation will (AIPMT 1997)

(a) first increase and then decrease (b) first decrease and then increase

(c) increase continuously (d) decrease continuously

54. Time period of a simple pendulum will be double, if we (AFMC 1995)

(a) increase the length 4 times (b) increase the length 2 times

(c) decrease the length 4 times (d) decrease the length 2 times

55. For a simple pendulum, the graph between l and T will be (AIPMT 1992)

(a) a straight line (b) a curved one (c) a hyperbola (d) a parabola

56. A simple pendulum is suspended from the roof of a trolley which moves in a horizontal direction with an acceleration α. The time period is given by $T' = 2\pi\sqrt{\frac{l}{g'}}$ where g' is (AIPMT 1991)

(a) $g' = g$ (b) $g' = g - \alpha$ (c) $g' = g + \alpha$ (d) $g' = \sqrt{g^2 + \alpha^2}$

57. The time period of a simple pendulum is 2 s. If its length is increased by 4 times, then its period becomes (AIPMT 1999)

(a) 16 s (b) 12 s (c) 8 s (d) 4 s

58. For a simple pendulum, the graph between l and T^2 will be a

(a) staight line (b) circle (c) hyperbola (d) parabola

59. A particle executes SHM along a straight line with an amplitude a. Its PE is maximum when the displacement is (AIPMT 1982)

(a) $\pm$ a (b) zero (c) $\pm a/2$ (d) $a/\sqrt{2}$

60. A linear harmonic oscillator has a total energy of 160 J. Its

(a) maximum potential energy is 100 J (b) maximum kinetic energy is 160 J

(c) minimum potential energy is 100 J (d) maximum kinetic energy is 100 J

61. A particle executes SHM with an amplitude 4 cm. At what displacement from the mean position its energy is half kinetic and half potential?

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

62. A particle executing SHM has a kinetic energy $K_o \cos^2 \omega t$. The maximum values of the potential energy and the total energy are respectively (AIPMT 2007)

(a) 0 and $2K_o$ (b) $K_o/2$ and K_o (c) K_o and $2K_o$ (d) K_o and K_o

63. The potential energy of a simple harmonic oscillator when it is half way to its end point is (AIPMT 2003)

(a) $\frac{1}{4}E$ (b) $\frac{1}{2}E$ (c) $\frac{2}{3}E$ (d) $\frac{1}{8}E$

64. The displacement of a particle between maximum potential energy position and maximum kinetic energy position in simple harmonic motion is (AIPMT 2002)

(a) $\pm a/2$ (b) $\pm a$ c) $\pm 2a$ d) ± 1

65. A linear harmonic oscillator of force constant 2×10^6 N/m and amplitude 0.01m has a total mechanical energy of 100 J. Its (AIPMT 1996)

(a) maximum potential energy is 100 J (b) maximum potential energy is 50 J

(c) maximum potential energy is zero (d) minimum potential energy is 200J

66. In a simple harmonic motion, when the displacement is one - half the amplitude, what fraction of the total energy is kinetic? (AIPMT 1996)

(a) zero (b) $\frac{1}{4}$ (c) $\frac{1}{2}$ (d) $\frac{3}{4}$

67. A body executes SHM with an amplitude a. At what displacement from the mean position, the potential energy of the body is one - fourth of its total energy ?

(a) $\frac{a}{4}$ (b) $\frac{a}{2}$ (c) $\frac{3a}{4}$ (d) some other fraction of a (AIPMT 1993)

68. A particle performing SHM passes through mean position has (AIPMT 1992)

(a) maximum potential energy (b) maximum kinetic energy
(c) minimum kinetic energy (d) maximum acceleration

69. The angular velocity and the amplitude of a simple pendulum is ω and α respectively. At a displacement x from the mean position, if its kinetic energy is T and potential energy is U then the ratio of T to U is (AIPMT 1991)

(a) $\frac{\alpha^2 - x^2\omega^2}{x^2\omega^2}$ (b) $\frac{x^2\omega^2}{\alpha^2 - x^2\omega^2}$ (c) $\frac{\alpha^2 - x^2}{x^2}$ (d) $\frac{x^2}{\alpha^2 - x^2}$

70. The total energy of a particle executing SHM is proportional to (AIPMT 1974)

(a) displacement from equilibrium position (b) frequency of oscillation
(c) velocity in equilibrium position (d) square of amplitude of motion

71. If x is the displacement of a particle executing simple harmonic motion, its total energy is (AIEEE 2004)

(a) $\propto x$ (b) $\propto x^2$ (c) independent of x (d) $\propto x^{1/2}$

72. In a simple harmonic oscillator, at the mean position : (AIEEE 2002)

(a) kinetic energy is minimum, potential energy is maximum
(b) both kinetic and potential energies are maximum
(c) kinetic energy is maximum, potential energy is minimum
(d) both kinetic and potential energies are minimum

73. In SHM restoring force is F = - kx where k is force constant, x is displacement and a is amplitude of motion, then total energy depends upon (AIPMT 2001)

(a) k, a, m (b) k , x , m (c) k , a (d) k , x

74. Resonance is a special case of (AFMC 1996)

(a) forced vibrations (b) natural vibrations
(c) damped vibrations (d) undamped vibrations

Answers :

1(c)	2(c)	3(d)	4(b)	5(d)	6(b)	7(b)	8(d)	(9)a	10(a)	11(c)	12(b)
13(c)	14(c)	15(b)	16(d)	17(b)	18(a)	19(a)	20(d)	21(b)	22(a)	23(a)	24(a)
25(b)	26(c)	27(b)	28(b)	29(c)	30(c)	31(c)	32(c)	33(b)	34(c)	35(b)	36(d)

37(b)	38(d)	39(c)	40(d)	41(d)	42(b)	43(b)	44(c)	45(d)	46(c)	47(a)	48(a)
49(b)	50(b)	51(b)	52(c)	53(a)	54(a)	55(d)	56(d)	57(d)	58(a)	59(a)	60(b)
61(a)	62(d)	63(a)	64(b)	65(a)	66(d)	67(b)	68(b)	69(c)	70(c)	71(c)	72(c)
73(c)	74(a)										

Solutions :

6. (b) Acceleration $\propto$ (- displacement)

10. (a) Phase difference between displacement and velocity $\phi_1 = \pi/2$

Phase difference between displacement and acceleration $\phi_2 = \pi$. Hence $\phi_2 = 2\phi_1$

11. (c) Acceleration $a = -\omega^2 y$

12. (b) Comparing $x = 0.01 \sin(100\pi t + 0.05)$ with $x = a\sin(\omega t + \phi_0)$ we get

$$\omega = \frac{2\pi}{T} = 100\pi, \quad T = \frac{2}{100} = 0.02 \text{ s}$$

13. (c) $v_0 = \omega a$, $100 = \omega \times 10$, $\omega = 10 \text{ rad s}^{-1}$

$v^2 = \omega^2(a^2 - y^2)$, $50^2 = 10^2(100 - y^2)$, $100 - y^2 = 25$, $y^2 = 75$, $y = 5\sqrt{3}$ cm

14. (c) $F \propto v$, $F = kv$, $k = \frac{F}{v} = \frac{\text{kgms}^{-2}}{\text{ms}^{-1}} = \text{kg s}^{-1}$

15. (b) $\frac{a_1}{a_2} = \frac{\omega_1^2 a}{\omega_2^2 a} = \frac{100^2}{1000^2} = \frac{1}{10^2}$, $a_1 : a_2 = 1 : 10^2$

16. (d) $a\omega = a(2\pi n) = 31.4 \times 10^{-2} \text{ ms}^{-1}$, $n = \frac{31.4 \times 10^{-2}}{2 \times 3.14 \times 5 \times 10^{-2}} = 1\text{Hz}$

17. (b) $v = \omega\sqrt{a^2 - x^2}$, $\frac{a\omega}{2} = \omega\sqrt{a^2 - x^2}$

$a^2 - x^2 = \frac{a^2}{4}$, $x^2 = \frac{3a^2}{4}$, $x = \frac{\sqrt{3}}{2}a$

18. (a) $\omega = \sqrt{\frac{a}{x}}$; $\omega^2 = \frac{a}{x} = \frac{2}{0.02} = 100$, $\omega = 10 \text{ rad s}^{-1}$

20. (d) $x = a\sin\frac{2\pi t}{T}$, $\frac{a}{2} = a\sin\frac{2\pi t}{T}$, $\frac{1}{2} = \sin\frac{2\pi t}{T}$, $\frac{2\pi t}{T} = \frac{\pi}{6}$, $t = \frac{T}{12}$

21. (b) $t = \frac{T}{12} = \frac{4}{12} = \frac{1}{3}$ s

22. (a) $a\omega^2 = \alpha$, $a\omega = \beta$, $\frac{\alpha}{\beta} = \omega$, $\frac{2\pi}{T} = \frac{\alpha}{\beta}$, $T = \frac{2\pi\beta}{\alpha}$

Unit 11 : Waves

I. Multiple Choice Questions :

1. A student tunes his guitar by striking a 120 hertz with a tuning fork, and simultaneously plays the 4th string on his guitar. By keen observation, he hears the amplitude of the combined sound oscillating thrice per second. Which of the following frequencies is the most likely the frequency of the 4th string on his guitar?

   (a) 130 (b) 117 (c) 110 (d) 120

2. A transverse wave moves from a medium A to a medium B.In medium A , the velocity of the transverse wave is 500 ms^{-1} and the wavelength is 5 m. The frequency and the wavelength of the wave in medium B when its velocity is 600 ms^{-1} respectively are

   (a) 120 Hz and 5 m (b) 100 Hz and 5 m (c) 120 Hz and 6 m (d) 100 Hz and 6 m

3. For a particular tube, among six harmonic frequencies below 1000 Hz, only four harmonic frequencies are given: 300 Hz, 600 Hz, 750 Hz and 900 Hz. What are the two other frequencies missing from this list?

   (a) 100 Hz , 150 Hz (b) 150 Hz , 450 Hz (c) 450 Hz , 700 Hz (d) 700 Hz , 800 Hz

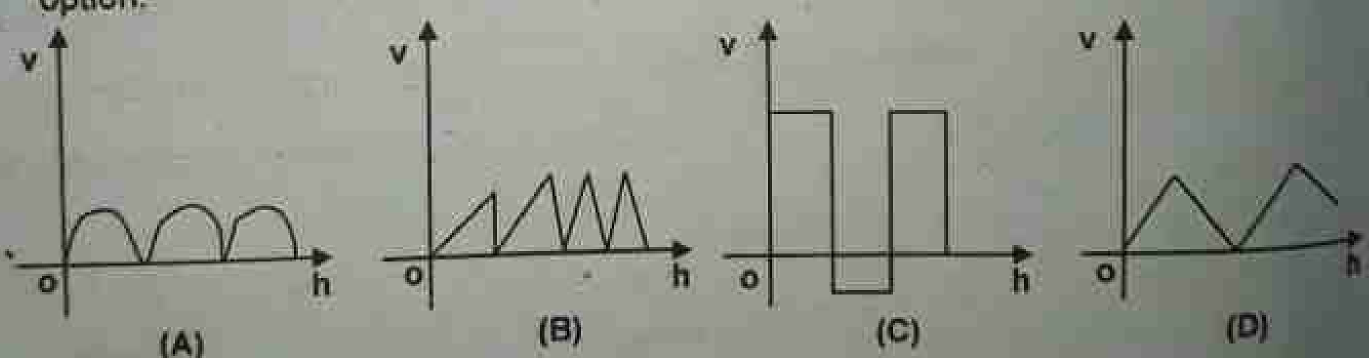
4. Which of the following options is correct?

A	B
(1) Quality	(A) Intensity
(2) Pitch	(B) Waveform
(3) Loudness	(C) Frequency

Options (1), (2) and (3) respectively are

(a) (B), (C) and (A) (b) (C), (A) and (B)
(c) (A), (B) and (C) (d) (B), (A) and (C)

5. Campare the velocities of the waveforms given below and choose the correct option.



where v_A , v_B, v_C and v_D are velocities given in (A) , (B) , (C) and (D) respectively.

a) $v_A > v_B > v_D > v_C$ b) $v_A < v_B < v_D < v_C$
c) $v_A = v_B = v_D = v_C$ d) $v_A > v_B = v_D > v_C$

6. A sound wave whose frequency is 5000 Hz travels in air and then hits the water surface. The ratio of its wavelength in water and air is

   (a) 4.30 (b) 0.23 (c) 5.30 (d)1.23

7. A person standing between two parallel hills fires a gun and hears the first echo after t_1 sec and the second echo after t_2 secs. The distance between the two hills is

(a) $\frac{v(t_1 - t_2)}{2}$ (b) $\frac{v(t_1 t_2)}{2(t_1 + t_2)}$ (c) $v(t_1 + t_2)$ (d) $\frac{v(t_1 + t_2)}{2}$

8. An air column in a pipe which is closed at on end, will be in resonance with the vibrating body of frequency 83 Hz. Then the length of the air column is

(a) 1.5 m (b) 0.5 m (c) 1.0 m (d) 2.0 m

9. The displacement y of a wave travelling in the x direction is given by

$y = (2 \times 10^{-3}) \sin(300t - 2x + \frac{\pi}{4})$ where x and y are measured in meter and t in second. The speed of the wave is

(a) 150 ms^{-1} (b) 300 ms^{-1} (c) 450 ms^{-1} (d) 600 ms^{-1}

10. Consider two uniform wires vibrating simultaneously in their fundamental notes. The tensions, densites, lengths and diameters of the two wires are in the ratio 8 : 1, 1 : 2, x : y and 4 : 1 repectively. If the note of the higher pitch has a frequency of 360 Hz and the number of beats produced per second is 10, then the value of x : y is

a) 36 : 35 (b) 35 : 36 (c) 1 : 1 (d) 1 : 2

11. Which of the following represents a wave ?

(a) $(x - vt)^3$ (b) $x(x + vt)$ (c) $\frac{1}{x + vt}$ d) $\sin(x + vt)$

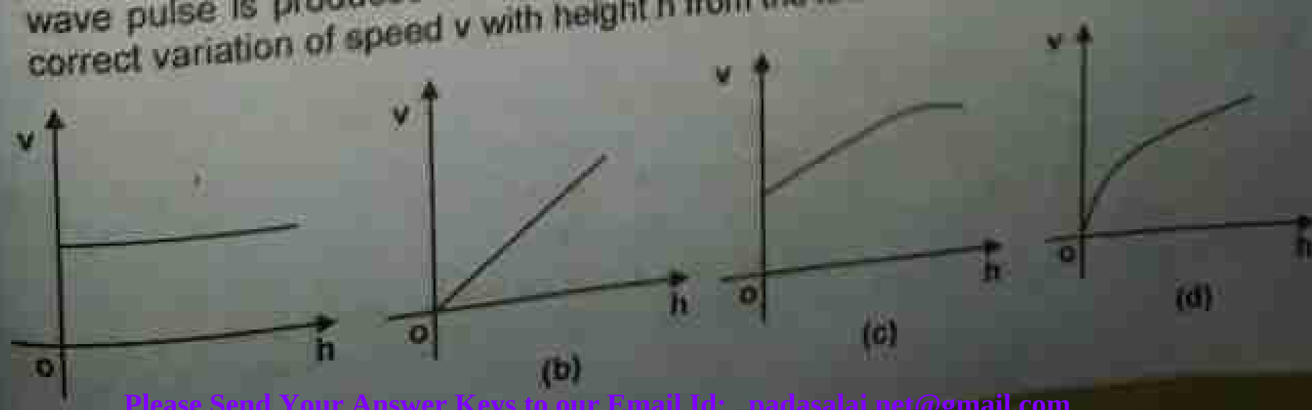
12. A man sitting on a swing which is moving to an angle of 60° from the vertical is blowing a whistle which has a frequency of 2.0 k Hz. The whistle is 2.0 m from the fixed support point of the swing. A sound detector which detects the whistle sound is kept in front of the swing. The maximum frequency the sound detector detected is

(a) 2.027 kHz (b) 1.974 kHz (c) 9.74 kHz (d) 1.011 kHz

13. Let $y = \frac{1}{1+x^2}$ at t = 0 s be the amplitude of the wave propagating in the positive x - direction. At t = 2s, the amplitude of the wave propagating becomes $y = \frac{1}{1+(x-2)^2}$. Assume that the shape of the wave does not change during propagation. The velocity of the waves is

(a) 0.5 m s^{-1} (b) 1.0 m s^{-1} (c) 1.5 m s^{-1} (d) 2.0 m s^{-1}

14. A uniform rope having mass m hangs vertically from a rigid support. A transverse wave pulse is produced at the lower end. Which of the following plots shows the correct variation of speed v with height h from the lower end?



(a) (b) (c) (d)

15. An organ pipe A closed at one end is allowed to vibrate in its first harmonic and another pipe B open at both ends is allowed to vibrate in its third harmonic. Both A and B are in resonance with a given tuning fork. The ratio of the length of A and B is

a) $\frac{8}{3}$ (b) $\frac{3}{8}$ (c) $\frac{1}{6}$ (d) $\frac{1}{3}$

Answers : 1) b 2) d 3) b 4) a 5) c 6) a 7) d 8) c 9) a 10) a 11) d 12) a 13) b 14) d 15) c

Solutions :

2. (d) Frequency $f = \frac{v_1}{\lambda_1} = \frac{500}{5} = 100\ H_z$, $\lambda_2 = \frac{v_2}{f} = \frac{600}{100} = 6\ m$

3. (b) The Frequencies are in the ratio

1 : 2 : 3 : 4 : 5 : 6 = 150 Hz : 300 Hz : 450 Hz : 600 Hz : 750 Hz : 900 Hz

The missing frequencies are 150 Hz , 450 Hz

4. (b) Quality (waveform) Pitch (frequency), Loudness (intensity)

6. (a) $F = \frac{v_1}{\lambda_1} = \frac{v_2}{\lambda_2}, \frac{\lambda_2}{\lambda_1} = \frac{v_2}{v_1} = \frac{1493\ ms^{-1}}{346.3\ ms^{-1}} = 4.3$

7. (d) $2d = vt_1 + vt_2$, $d = \frac{v(t_1 + t_2)}{2}$

8. (c) $f = \frac{v}{4L}$, $L = \frac{v}{4f} = \frac{331}{4 \times 83} = \frac{331}{332} = 1.0\ m$

9. (a) Comparing the given equation with $y = A \sin(\omega t - kx + \phi)$ we get

$\omega = 300, k = 2\ v = \frac{\omega}{k} = \frac{300}{2} = 150\ ms^{-1}$

10. (a) $f_1 l_1 = f_2 l_2$ $(360 - 10) l_1 = 360\, l_2$, $350 l_1 = 360 l_2$, $l_1 : l_2 = 36 : 35$

11. (d) $y = \sin(x + vt)$, $\frac{dy}{dx} = \cos(x + vt)$, $\frac{d^2y}{dx^2} = -\sin(x + vt) = -y$

$\frac{dy}{dt} = v\cos(x + vt)$, $\frac{d^2y}{dt^2} = -v^2 \sin(x + vt) = -v^2 y$

It satisfies the condition $\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2}$ Hence $y = \sin(x + vt)$ represents a wave

15. (c) $\frac{v}{4L_1} = \frac{3v}{2L_2}$, $6L_1 = L_2$, $\frac{L_1}{L_2} = \frac{1}{6}$

Creative Questions :

1. When a wave passes from one medium to another, there is change of
   (a) frequency and velocity (b) frequency and wavelength
   (c) wavelength and velocity (d) frequency, wavelength and velocity
2. For a wave propagating in a medium, identify the property that is independent of the others : (AIIMS 2006)
   (a) velocity (b) wavelength
   (c) frequency (d) all these depend on each other
3. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1,500 ms^{-1} and in air it is 300 ms^{-1}. The frequency of sound rcorded by an observer, who is standing in air is ? (IIT 2004)
   (a) 120 Hz (b) 200 Hz (c) 600 Hz (d) 3,000 Hz
4. With the propagation of a longitudinal wave through a material medium, the quantities transmitted in the propagation direction are (AIPMT 1992)
   (a) energy , momentum and mass (b) energy
   (c) energy and mass (d) energy and linear momentum
5. In a longitudinal wave there is a state of maximum compression at a point at an instant. The frequency of wave is 50 Hz. After what time will the same point be in the state of maximum rarefaction?
   (a) 0.01 s (b) 0.002 s (c) 25 s (d) 50 s
6. Which one of the following statements is true? (AIPMT 2006)
   (a) Both light and sound waves in air are transverse
   (b) The sound waves in air are longitudinal while the light waves are transverse
   (c) Both light and sound waves in air are longitudinal
   (d) Both light and sound waves can travel in vacuum
7. The waves in which the particles of the medium vibrate in a direction perpendicular to the direction of wave motion is known as (AIIMS 1996)
   (a) transverse waves (b) longitudinal waves
   (c) propagated waves (d) none of these
8. The distance between two consecutive crests in a wave train produced in a string is 5 cm. If 2 complete waves pass through any point per second, the velocity of wave is (AIMPT1990)
   (a) 10 $cm\ s^{-1}$ (b) 2.5 $cm\ s^{-1}$ (c) 5 $cm\ s^{-1}$ (d) 15 $cm\ s^{-1}$
9. The frequency of a sound wave is n and its velocity is v. If the frequency is increased to 4n, the velocity of the wave will be
   (a) v (b) 2 v (c) 4 v (d) v / 4
10. Sound waves travel at 350 m / s through a warm air and at 3500 m / s through brass. The wavelength of a 700 Hz acoustic wave as it enters brass from warm air (AIMPT 2011)
    (a) increases by a factor 20 (b) increases by a factor 10
    (c) decreases by a factor 20 (d) decreases by a factor 10

11. A wave enters into water from air. In air, frequency, wavelength, intensity and velocity are n_1, λ_1, I_1 and v_1 respectively. In water the corresponding quantities are n_2, λ_2, I_2 and v_2 respectively, then (AIPMT 2001)
(a) $I_1 = I_2$ (b) $n_1 = n_2$ (c) $v_1 = v_2$ (d) $\lambda_1 = \lambda_2$

12. In a sinusoidal wave, the time required for a particular point to move from maximum displacement to zero displacement is 0.17 s. The frequency of the wave is (AIPMT 1998)
(a) 1.47 Hz (b) 0.36 Hz (c) 0.73 Hz (d) 2.94 Hz

13. An hospital uses an ultrasonic scanner to locate tumours in a tissue. The operating frequency of the scanner is 4.2 MHz. The speed of sound in a tissue is 1.7 km/s. The wavelength of sound in tissue is close to (AIPMT 1995)
(a) 4×10^{-4} m (b) 8×10^{-4} m (c) 4×10^{-3} m (d) 8×10^{-3} m

14. The speed of a wave in a medium is 760 ms^{-1}. If 3600 waves are passing through a point in the medium in 2 min, then their wavelength is (AIPMT1995)
(a) 13.8 m (b) 25.3 m (c) 41.5 m (d) 57.2 m

15. If vibrations of a string are to be increased by a factor 2, tension in the string must be made (AIIMS 1999)
(a) half (b) twice (c) four times (d) eight times

16. A wave of frequency 100 Hz is sent along a string towards a fixed end. When this wave travels back after reflection, a node is formed at a distance of 10 cm from the fixed end of the string. The speed of the incident and reflected waves are (AIPMT 1994)
(a) 5 ms^{-1} (b) 10 ms^{-1} (c) 20 ms^{-1} (d) 40 ms^{-1}

17. A 5.5 m length of string has a mass of 0.035 kg. If the tension in the string is 77 N the speed of a wave on the string is (AIPMT 1989)
(a) 110 ms^{-1} (b) 165 ms^{-1} (c) 77 ms^{-1} (d) 102 ms^{-1}

18. The speed of sound in air is 350 ms^{-1}. The frequency of the tuning fork that produces sound waves of wavelength 0.7 m in air is
(a) 400 Hz (b) 420 Hz (c) 450 Hz (d) 500 Hz

19. Elastic waves in a solid are (CET 1988)
(a) transverse (b) longitudinal
(c) either transverse or longitudinal (d) neither transverse nor longitudinal

20. To increase the frequency from 100 Hz to 400 Hz the tension in the string has to be changed by
(a) 4 times (b)16 times (c) 2 times (d) none of these

21. Angle between wave velocity and particle velocity of a longitudinal wave is (AFMC 2010)
(a) 90^0 (b) 60^0 (c) 0^0 (d) 120^0

22. Newton's formula for the velocity of sound in gases is (AIIMS 1998)
(a) $v = \sqrt{\frac{P}{\rho}}$ (b) $v = \sqrt{\frac{\rho}{P}}$ (c) $v = \sqrt{\frac{\rho}{2P}}$ (d) $v = \sqrt{\frac{2P}{\rho}}$

34. A transverse wave is represented by the equation $y = y_0 \sin \frac{2\pi}{\lambda}(vt - x)$. For what value of λ is the particle velocity equal to two times the wave velocity?
(a) $\lambda = 2\pi y_0$ (b) $\lambda = \pi y_0/3$ (c) $\lambda = \pi y_0/2$ (d) $\lambda = \pi y_0$ (AIPMT 1998)

35. The equation of a sound wave is given as $y = 0.005 \sin(62.4x + 316t)$. The wavelength of this wave is (AIPMT 1996)
(a) 0.4 unit (b) 0.3 unit (c) 0.2 unit (d) 0.1 unit

36. From a wave equation $y = 0.5 \sin \frac{2\pi}{3.2}(64t - x)$ the frequency of the wave is
(a) 5 Hz (b) 15 Hz (c) 20 Hz (d) 25 Hz (AIPMT 1995)

37. A wave on a string is travelling and the displacement of particles on it is given by $y = A \sin(2t - 0.1x)$. Then the wavelength of the wave is (AIIMS 2009)
(a) 20 m (b) 10π m (c) 20π m (d) 40π m

38. A transverse wave passes through a string with the equation $y = 10 \sin\pi(0.02x - 2t)$ where x is in metre and t in second. The maximum velocity of the particles in wave motion is
(a) 63 ms^{-1} (b) 78 ms^{-1} (c) 100 ms^{-1} (d) 121 ms^{-1} (AIIMS 2000)

39. The equation of a simple harmonic wave is given by $y = 5 \sin \frac{\pi}{2}(100t - x)$ where x and y are in metre and time t is in seconds. The period of the wave is
(a) 0.01 s (b) 0.04 s (c) 1 s (d) 5 s (AFMC 2008)

40. Sound of frequency 256 Hz passes through a medium. The maximum displacement is 0.1 m. The maximum velocity is equal to
(a) 60π ms^{-1} (b) 51.2π ms^{-1} (c) 256 ms^{-1} (d) 512 ms^{-1}

41. Velocity of sound waves in air is 330 ms^{-1}. For a particular sound wave in air, path difference of 40 cm is equivalent to phase difference of 1.6π. The frequency of this wave is (AIPMT 1990)
(a) 165 Hz (b) 150 Hz (c) 660 Hz (d) 330 Hz

42. The frequency of a sinusoidal wave is $y = 0.40 \cos(2000t + 0.80)$ is (AIPMT 1992)
(a) 1000π Hz (b) 2000 Hz (c) 20 Hz (d) $1000/\pi$ Hz

43. A plane wave is represented as $y = 3\cos(\frac{x}{4} - 10t - \frac{\pi}{2})$ where x and y are in meter and t in second. The maximum velocity of the particles of the medium due to this is
(a) 30 ms^{-1} (b) $3\pi/2$ ms^{-1} (c) 3/4 ms^{-1} (d) 40 ms^{-1} (AIIMS 2001)

44. In a transverse progressive wave of amplitude a, the maximum particle velocity is four times its wave velocity. The wavelength of the wave is (AFMC 2000)
(a) $2\pi a$ (b) πa (c) $\pi a/2$ (d) $\pi a/4$

45. Two sound waves having a phase difference of 60^0 have path difference of

(a) 2λ (b) $\lambda/2$ (c) $\lambda/6$ (d) $\lambda/3$ (AIPMT 1996)

46. The loudness and pitch of a sound note depends on (AFMC 2008)

(a) intensity and frequency (b) frequency and number of harmonics

(c) intensity and velocity (d) frequency and velocity

47. Sound waves from a point source are propagating in all directions. What will be the ratio of amplitude at a distance 9 m and 25 m from the source?

(a) 25 : 9 (b) 9 : 25 (c) 81 : 625 (d) 625 : 81

48. The intensity level of two sounds are 100 dB and 50 dB. Their ratio of intensities are

(a) 10^1 (b) 10^5 (c) 10^3 (d) 10^{10}

49. If the amplitude of sound is doubled and the frequency reduced to one - fourth, the intensity of sound at the same point will (AIPMT 1992)

(a) increase by a factor of 2 (b) decrease by a factor of 2

(c) decrease by a factor of 4 (d) remains unchanged

50. The distance between two points differing in phase by 60^0 on a wave having wave velocity 360 ms^{-1} and frequency 500 Hz is

(a) 0.36 m (b) 0.18 m (c) 0.48 m (d) 0.12 m

51. Two waves are said to be coherent, if they have (AIPMT 1995)

(a) same phase but different amplitude

(b) same frequency but different amplitude

(c) same frequency, phase and amplitude

(d) different frequency, phase and amplitude

52. A wave has SHM whose period is 4 s while another wave which also possesses SHM has its period 3 s. If both are combined, then the resultant wave will have the period equal to

(a) 4 s (b) 5 s (c) 12 s (d) 3 s

53. Number of beats produced by two waves $y_1 = a \sin 2000 \pi t$ and $y_2 = a \sin (2008 \pi t)$ is (AIPMT 1993)

(a) 0 (b) 1 (c) 4 (d) 8

54. Two sound waves of wavelengths 5 m and 5.5 m respectively, each propagate in a gas with velocity 330 m/s. The number of beats per second is (AIPMT 2006)

(a) 12 (b) zero (c) 1 (d) 6

55. For production of beats, the two sources must have (AIPMT 1992)

(a) different frequencies and same amplitude

(b) different frequencies and same phase

(c) different frequencies, same amplitude and same phase

(d) different frequencies

56. Two waves of wavelengths 50 cm and 51 cm produce 12 beats s^{-1}. The velocity of wave is (AIPMT 1999)
(a) 306 ms^{-1} (b) 331 ms^{-1} (c) 340 ms^{-1} (d) 360 ms^{-1}

57. Beats are result of
(a) diffraction (b) destructive interference (c) constructive interference
(d) superposition of two waves of nearly equal frequencies (CET 2011)

58. In a stationary wave all the particles
(a) on either side of a node vibrate in same phase
(b) in the region between two nodes vibrate in same phase
(c) In the region between two antinodes vibrate in same phase
(d) of the medium vibrate in same phase (Manipal 2011)

59. When a stationary wave is formed, its frequency is
(a) same as that of the individual waves (b) twice that of the individual waves
(c) half that of the individual waves (d) $\sqrt{2}$ times that of the individual waves

60. Energy is not carried by which of the following wave? (AIIMS 1999)
(a) stationary (b) progressive (c) transverse (d) electromagnetic

61. In the case of a travelling wave, the reflection at a rigid boundary will take place with a phase change of (J & KCET 2011)
(a) $\pi/2$ rad (b) $\pi/4$ rad (c) π rad (d) $\pi/6$ rad

62. Two waves of same frequency and intensity superimpose on each other in opposite phases. After superposition, the intensity will (AIPMT 1996)
(a) increase (b) decrease (c) remains constant (d) become zero

63. Standing waves are produced in 10 m long stretched string. If the string vibrates in 5 segments and wave velocity is 20 ms^{-1}, the frequency is (AIPMT 1997)
(a) 2 Hz (b) 4 Hz (c) 5 Hz (d) 10 Hz

64. Two waves are approaching each other with a velocity of 20 ms^{-1} and frequency n. The distance between two consecutive nodes is
(a) 20/n (b) 10/n (d) 5/n (d) n/10 (AIPMT 1995)

65. A wave of frequency 100 Hz is sent along a string towards a fixed end. When this wave travels back after reflection, a node is formed at a distance of 10 cm from the fixed end of the string. The speed of incident and reflected waves are
(a) 5 m / s (b) 10 m /s (c) 20 m / s (d) 40 m / s (AIPMT 1994)

66. A standing wave having 3 nodes and 2 antinodes are formed between two atoms having a distance of 1.21 Å between them. The wavelength of the standing wave is (AIPMT 1998)
(a) 1.21 Å (b) 1.42 Å (c) 6.05 Å (d) 3.63 Å

67. In order to increase the fundamental frequency of a stretched string from 100 Hz to 400 Hz the tension must be increased by
(a) 2 times (b) 4 times (c) 8 times (d) 16 times

68. A pulse of a wavetrain travels along a stretched string and reaches the fixed end of the string. It will be reflected back with (AIPMT 1997)
(a) a phase change of 180^0 with velocity reversed
(b) the same phase as the incident pulse with no reversal of velocity
(c) a phase change of 180^0 with no reversal of velocity
(d) the same phase as the incident pulse but with velocity reversed

69. What type of vibrations are produced in a sitar wire? (AIPMT 1992)
(a) progressive transverse (b) progressive longitudinal
(c) stationary transverse (d) stationary longitudinal

70. A stretched string resonates with tuning fork of frequency 512 Hz when length of the string is 0.5 m . The length of the string required to vibrate resonantly with a tuning fork of frequency 256 Hz would be (AIPMT 1993)
(a) 0.25 m (b) 0.5 m (c) 1 m (d) 2 m

71. If you set up the seventh harmonic on a string fixed at both ends , how many nodes and antinodes are set up in it?
(a) 8 , 7 (b) 7 , 7 (c) 8 , 9 (d) 9 , 8

72. Four wires of identical lengths, diameters and materials are stretched on a sonometer box. The ratio of their tensions is 1 : 4 : 9 : 16. The ratio of their fundamental frequencies is (AIPMT 1989)
(a) 16 : 9 : 4 : 1 (b) 4 : 3 : 2 : 1 (c) 1 : 2 : 3 : 4 (d) 1 : 4 : 9 : 16

73. A string in a musical instrument is 50 cm long and its fundamental frequency is 800 Hz. If a frequency of 1,000 Hz is to be produced, then required length of string is
(a) 62.5 cm (b) 50 cm (c) 40 cm (d) 37.5 cm (AIIMS 2002)

74. The frequency of the first harmonic emitted by a string is 100 Hz. The frequency of the third overtone is
(a) 200 Hz (b) 300 Hz (c) 400 Hz (d) 500 Hz

75. A pipe open at both ends will produce (AIPMT 1992)
(a) all the harmonics (b) all the odd harmonics
(c) all the even harmonics (d) none of the harmonics

76. An organ pipe, open at both ends, produces
(a) longitudinal stationary waves (b) longitudinal travelling waves
(c) transverse stationary waves (d) transverse travelling waves

77. An open organ pipe of length L vibrates in its fundamental mode. The pressure variation is maximum
(a) at the two ends (b) at the middle of the pipe
(c) at distances L / 4 inside the ends (d) at distances L / 8 inside the ends (AIIMS 1998)

78. An organ pipe vibrates in fundamental mode with the medium as air, nitrogen and oxygen. With the medium change
(a) the wavelength changes (b) both wavelength and frequency changes
(c) both wavelength and frequency remain unaltered (d) the frequency changes

79. A closed organ pipe vibrating in the third overtone has (AIMPT 1991)
(a) three nodes and three antinodes (b) three nodes and four antinodes
(c) four nodes and three antinodes (d) four nodes and four antinodes

80. The fundamental frequencies of an open and a closed pipe each of same length L with v as the speed of sound in air respectively are (Manipal 2011)
(a) $\frac{v}{2L}$ and $\frac{v}{L}$ (b) $\frac{v}{L}$ and $\frac{v}{2L}$ (c) $\frac{v}{2L}$ and $\frac{v}{4L}$ (d) $\frac{v}{4L}$ and $\frac{v}{2L}$

81. The second overtone of an open pipe has the same frequency as the first overtone of a closed pipe of 2 m long. The length of the open pipe is
(a) 2 m (b) 4 m (c) 0.5 m (d) 0.75 m

82. If we study the vibrations of a pipe open at both ends, which of the following statements is not true? (NEET 2013)
(a) open end will be antinode
(b) pressure change will be maximum at both ends
(c) odd harmonics of the fundamental frequency will be generated
(d) all harmonics of the fundamental frequency will be generated

83. The fundamental frequency of a closed organ pipe of length 20 cm is equal to the second overtone of an organ pipe open at both the ends. The length of organ pipe open at both the ends is (NEET 2015)
(a) 80 cm (b) 100 cm (c) 120 cm (d) 140 cm

84. A cylindrical resonance tube open at both ends, has a fundamental frequency f in air. If half of the length is dipped vertically in water, the fundamental frequency of the air column will be (AIPMT 1997)
(a) 2 f (b) 3 f / 2 (c) f (d) f / 2

85. The fundamental frequency of a closed pipe is 220 Hz. If one fourth of the pipe is filled with water, the frequency of the first overtone of the pipe is now
(a) 220 Hz (b) 440 Hz (c) 880 Hz (d) 1760 Hz (AFMC 2011)

86. A closed organ pipe is excited to support the third overtone. The pipe has
(a) 3 nodes and 3 antinodes (b) 2 nodes and 4 antinodes (AIPMT 1991)
(c) 4 nodes and 3 antinodes (d) 3 nodes and 4 antinodes

87. If v_1 is the resonance frequency of a pipe open at both ends and v_2 the resonance frequency of a pipe open at one end only and both are vibrating in the fundamental mode, and the pipes are of same length, then (AIPMT 1986)
(a) $v_1 = 2v_2$ (b) $v_1 = v_2$ (c) $2v_1 = v_2$ (d) $3v_1 = 4v_2$

88. An air column, closed at one end and open at the other end resonates with a tuning fork when the smallest length of the column is 50 cm. The next larger length of the column resonating with the same tuning fork is (NEET 2016)
(a) 150 cm (b) 200 cm (c) 66.7 cm (d) 100 cm

89. If the fundamental frequency of a closed pipe is 50 Hz, then frequency of second overtone is (AFMC 2004)
(a) 50 Hz (b) 100 Hz (c) 150 Hz (d) 250 Hz

90. The speed of sound in air is 350 ms^{-1}. The fundamental frequency of an open pipe 50 cm long will be (AIPMT 1991)
(a) 175 Hz (b) 350 Hz (c) 700 Hz (d) 50 Hz

91. If the speed of sound in air is v the fundamental frequency of air column in a pipe of length L closed at one end is (IIT 1996)
(a) $\frac{v}{2L}$ (b) $\frac{v}{L}$ (c) $\frac{3v}{L}$ (d) $\frac{v}{4L}$

92. A closed organ pipe and an open organ pipe have their first overtone identical in frequency. Their lengths are in the ratio (AIPMT 1992)
(a) 1 : 2 (b) 2 : 3 (c) 3 : 4 (d) 4 : 5

93. In a closed organ pipe, the fundamental frequency is ν. What will be the ratio of the frequencies of the next three overtones ?
(a) 2 : 3 : 4 (b) 3 : 4 : 5 (c) 3 : 7 : 11 (d) 3 : 5 : 7

94. Air is blown at the mouth of a tube of length equal to 25 cm and diameter equal to 2 cm open at both ends. Velocity of sound is 330 ms^{-1}. The sound emitted by the tube will have all frequencies in the group (AIPMT 1989)
(a) 660, 1320, 1980 Hz (b) 660, 990, 3300 Hz
(c) 330, 660, 1320 Hz (d) 330, 990, 1650 Hz

95. Doppler's effect in sound is due to : (AFMC 2003)
(a) motion of source (b) motion of observer
(c) relative motion of source and observer (d) none of the above

96. The pitch of a sound wave is related to its
(a) frequency (b) amplitude (c) velocity (d) beats

97. A train is moving with a constant speed along a circular track. The engine of the train emits a sound of frequency f. The frequency heard by the guard at rear end of the train is (UPCPMT 2011)
(a) less than f (b) equal to f (c) is greater than f
(d) may be greater than, less than or equal to f depending on the factors like speed of train, length of train and radius of circular track

1. A source of sound of frequency 150 Hz is moving in a direction towards an observer with a velocity 110 ms^{-1}. If the velocity of sound is 330 ms^{-1}, the frequency of sound heard by the person is
(a) 225 Hz (b) 200 Hz (c) 150 Hz (d) 100 Hz

2. When both source and listener move in the same direction with a speed equal to half the speed of sound, the change in frequency of the sound is
(a) zero (b) 25% (c) 50% (d) 100%

3. A vehicle, with a horn of frequency n is moving with a velocity of 30 ms^{-1}. An observer moves in a direction perpendicular to the direction of motion of the vehicle. He perceives the sound to have a frequency $(n + n_1)$. Then (if the sound velocity in air is 300 ms^{-1}) (AIPMT 1998)

(a) $n_1 = 10\,n$ (b) $n_1 = 0$ (c) $n_1 = 0.1\,n$ (d) $n_1 = -0.1\,n$

4. A star which is emitting radiation at a wavelength of 5000 Å is approaching the earth with a velocity of 1.50×10^6 m/s. The change in wavelength of the radiation as received on the earth is (AIPMT 1996)

(a) 0.25 Å (b) 2.5 Å (c) 25 Å (d) 250 Å

Answers :

1(c)	2(c)	3(c)	4(b)	5(a)	6(b)	7(a)	8(a)	9(a)	10(b)	11(b)	12(a)
13(a)	14(b)	15(c)	16(c)	17(a)	18(d)	19(c)	20(b)	21(c)	22(a)	23(b)	24(b)
25(c)	26(a)	27(b)	28(a)	29(c)	30(a)	31(c)	32(b)	33(d)	34(d)	35(d)	36(c)
37(c)	38(a)	39(b)	40(b)	41(c)	42(d)	43(a)	44(c)	45(c)	46(a)	47(d)	48(b)
49(c)	50(d)	51(c)	52(c)	53(c)	54(d)	55(d)	56(a)	57(d)	58(b)	59(a)	60(a)
61((c)	62(d)	63(c)	64(b)	65(c)	66(a)	67(d)	68(a)	69(c)	70(c)	71(a)	72(c)
73(c)	74(c)	75(a)	76(a)	77(b)	78(a)	79(d)	80(c)	81(b)	82(b)	83(c)	84(c)
85(c)	86(d)	87(a)	88(a)	89(d)	90(b)	91(d)	92(c)	93(d)	94(a)	95(c)	96(a)
97(b)	98(a)	99(a)	100(b)	101(c)							

Solutions :

5. (a) Period $T = \frac{1}{n} = \frac{1}{50} = 0.02$ s. Time between maximum compression and next maximum rarefaction = half period = 0.01s

8. (a) $v = n\lambda = 2 \times 5 = 10\ cms^{-1}$

10. (b) $\frac{v_2}{v_1} = \frac{n\lambda_2}{n\lambda_1}$, $\frac{3500}{350} = \frac{700\,\lambda_2}{700\,\lambda_1}$, $\lambda_2 = 10\ \lambda_1$. Increases by a factor 10

11. (b) When a wave enters, from one medium to another, its wavelength, intensity and velocity get changed, its frequency remains unchanged. Hence $n_1 = n_2$

12. (a) $\frac{T}{4} = 0.17$, $T = 0.68$, $n = \frac{1}{T} = \frac{1}{0.68} = \frac{100}{68} = 1.47$ Hz

13. (a) $\lambda = \frac{V}{n} = \frac{1.7\times10^3}{4.2\times10^6} = 4\times10^{-4}$m

14. (b) Frequency $n = \frac{\text{total number of waves}}{\text{time taken}} = \frac{3600}{120} = 30$ Hz

$\lambda = \frac{v}{n} = \frac{760}{30} = 25.3$ m

Doppler effect in sound is asymmetrical. It implies that the apparent change in the frequency is different when the source of sound moves towards or away from a stationary observer (OR) as that occurs when the observer moves with the same velocity towards or away from a stationary source. So Doppler effect in sound is asymmetrical.

Doppler effect in light is symmetrical. It implies that Doppler shift is same when the source of light moves towards or away from a stationary observer (OR) the observer moves with the same velocity towards or away from the stationary source.

15. **Mention the applications of Doppler effect.**

i) While observing, the spectra from distant stars or galaxies if the spectral lines of the star are found to shift towards red end of the spectrum, then the star is receding away from the Earth. Similarly if the spectral lines of the star are found to shift towards the blue end of the spectrum, then the star is approaching the Earth. By measuring the Doppler shift $\Delta\lambda = \frac{v}{c}\lambda$ the velocities and distances of various galaxies can be predicted.

ii) Doppler shift confirms the hypothesis that the universe is expanding.

iii) Doppler effect is made use of in knowing the speeds of the vehicles by the traffic police.

iv) Doppler effect is used in RADAR to detect enemy planes.

v) Doppler effect is used in SONAR for the detection of submarines under the sea water.

<u>Book problems (1 mark) :</u>

1. The average range of frequencies at which human beings can hear sound waves varies from 20 Hz to 20 kHz. If the speed of sound is 340 ms^{-1}, the wavelength range is

a) 20 m to 0.2 m b) 17 m to 0.017 m c) 17 cm to 1.7 cm d) 17 m to 1.7 cm

2. The Youngs modulus of steel is 2×10^{11} N m^{-2} and its density is 7800 kgm^{-3}. The speed of sound in steel rod is

a) 5×10^4 ms^{-1} b) 5 ms^{-1} c) 0.5 ms^{-1} d) 5×10^3 ms^{-1}

3. An increase in pressure of 100 k P_a cause a certain volume of water to decrease by o.005 % of its original volume. The bulk modulus of water is

a) 1×10^9 Pa b) 200 MPa c) 2×10^9 Pa d) 2×10^8 Pa

4. The bulk modulus of water is 2×10^9 Pa. The speed of sound in water is

a) 1.414 ms^{-1} b) 1414 ms^{-1} c) 14.14 ms^{-1} d) 2×10^3 ms^{-1}

5. A man stands at a distance from a cliff and claps his hands. He receives an echo from the cliff after 4 second. If the speed of sound is 343 ms^{-1}, the distance between the man and the cliff is

a) 0.686 km b) 68.6 m c) 68.6 m d) 68.6 km

6. If the wavelength of a sine wave is 1 m, the corresponding wave number is

a) π rad m^{-1} b) 1.57 rad m^{-1} c) 6.28 rad m^{-1} d) 62.8 rad m^{-1}

7. If the wavelength of a sine wave is 6 m, the corresponding wave number is

a) 2π rad m^{-1} b) 1.05 rad m^{-1} c) 10.5 rad m^{-1} d) 6.28 rad m^{-1}

8. A mobile phone tower transmits a wave signal of frequency 900 MHz. The wavelength of the transmitted wave is

a) 0.33 m b) 33 m c) 0.33 cm d) 33 km

9. Two sound waves of wavelengths 5 m and 6 m propagate through a gas with velocity 330 ms^{-1}. The number of beats produced per second is

a) 11 b) 5 c) 10 d) 33

10. A baby cries on seeing a dog and the cry is detected at a distance of 3 m with an intensity of 10^{-2} Wm^{-2}. The intensity of the baby's cry at a distance of 6 m is

a) 0.25×10^{-2} Wm^{-2} b) zero c) 0.25×10^{-2} Wm^{-2} d) 25 Wm^{-2}

11. The third harmonics of a closed organ pipe is equal to the funddamental frequency of an open organ pipe. If the length of the closed organ pipe is 30 cm, the length of the open organ pipe is

(a) 20 m (b) 0.2 m (c) 2 cm (d) 20 cm

12. In a resonance air column apparatus if the first and second length of resonance are 0.2 m and 0.7 m the end correction is

(a) 0.05 m (b) 0.05 cm (c) 5 m (d) 0.27 m

13. In a resonance air column apparatus the frequency of the tuning fork used is 256 H_z. If the first and second length of resonance are 20 cm and 85 cm, the velocity of sound in air is

(a) 332 cms^{-1} (b) 333 ms^{-1} (c) 300 ms^{-1} (d) zero

14. Two organ pipes have same length, one is closed and the other is open. If the fundamental frequency of closed pipe is 250 Hz, the fundamental frequency of the open pipe is

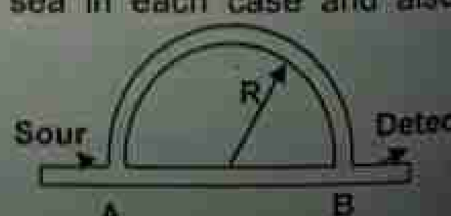
(a) 500 H_z (b) 250 H_z (c) 125 H_z (d) 750 H_z

Answers: 1(b) 2(d) 3(c) 4(b) 5(a) 6(c) 7(b) 8(a) 9(a) 10(a) 11(d) 12 (a) 13(b) 14(a)

Book problems (2 mark) :

1. The speed of a wave in a certain medium is 900 m/s. If 3000 waves passes over a certain point of the medium in 2 minute, then compute its wavelength?

2. A ship in a sea sends SONAR waves straight down into the sea water from the bottom of the ship. The signal reflects from the deep bottom bed rock and returns to the ship after 3.5 s. After the ship moves to 100 km it sends another signal which returns back after 2 s. Calculate the depth of the sea in each case and also compute the difference in height between two cases.



3. A sound wave is transmitted into a tube as shown in figure. The sound wave splits into two waves at the point A which recombine at point B. Let R be the radius of the semi-circle which is varied

23. The Laplace correction was necessary to Newton's calculation of velocity of sound, because propagation of sound in a medium is (EAMC 1996)
(a) isothermal process (b) adiabatic process
(c) isobaric process (d) isochoric process
24. The velocity of sound in any gas depends upon (AIPMT 1992)
(a) wavelength of sound (b) density and elasticity of gas
(c) intensity of sound waves (d) amplitude and frequency of sound
25. Choose the correct statement :
(a) Sound can travel through vacuum
(b) Sound waves produced in air are transverse in nature
(c) Sound travels faster in metals than in air
(d) The speed of sound is independent of temperature
26. The velocity of sound in a gas at pressure P and density ρ is (AIIMS 2009)
(a) $v = \sqrt{\frac{\gamma P}{\rho}}$ (b) $v = \sqrt{\frac{P}{\gamma \rho}}$ (c) $v = \gamma\sqrt{\frac{P}{\rho}}$ (d) $v = \sqrt{\frac{2P}{\rho}}$
27. Which of the following does not affect the velocity of sound (AIPMT 1992)
(a) temperature of the gas (b) pressure of the gas
(c) mass of the gas (d) specific heat capacities of the gas
28. What is the effect of velocity of sound waves when humidity increases? (AIPMT1996)
(a) increases (b) decreases (c) remains same (d) becomes zero
29. The velocity of sound in a gas is proportional to its (AIPMT 1985)
(a) square of bulk modulus (b) bulk modulus
(c) square root of bulk modulus (d) density
30. SONAR emits (AIPMT 1985)
(a) radio waves (b) ultrasonic waves (c) light waves (d) magnetic waves
31. The temperature at which the speed of sound in air becomes double of its value at 27°C is (IIT1987)
(a) 54°C (b) 327°C (c) 927°C (d) -123°C
32. The velocities of sound at the same temperature in two monoatomic gases of densities ρ_1 and ρ_2 are v_1 and v_2 respectively. If $\rho_1 / \rho_2 = 4$ then the value of v_1/v_2 is (AIIMS 2002)
(a) 1 / 4 (b) 1 / 2 (c) 2 (d) 4
33. A transverse wave is represented by the equation $y = A \sin(\omega t - kx)$. For what value of the wavelength λ is the wave velocity equal to the maximum particle velocity? (AIPMT 2010)
(a) A (b) $\pi A/2$ (c) πA (d) $2\pi A$

23. The displacement x (in metre) of a particle in simple harmonic motion is related to time t (in second) as $x = 0.01 \cos(\pi t + \pi/4)$. The frequency of the motion will be

a) 0.5 Hz (b) 1.0 Hz (c) $\pi/2$ Hz (d) π Hz

24. A point performs simple harmonic oscillations of period T and the equation of the motion is given by $x = a \sin(\omega t + \pi/6)$. After the elapse of what fraction of the time period , the velocity of the point will be equal to half of its maximum velocity?

(a) T / 12 (b) T / 8 (c) T / 6 (d) T / 3 (AIPMT 2008)

25. If the displacement of a particle executing SHM is given by

$y = 0.05 \sin(100t + \pi/2)$ cm The maximum velocity of the particle is

(a) 0.5 cms^{-1} (b) 0.05 ms^{-1} (c) 100 ms^{-1} (d) 50 ms^{-1}

26. If the magnitude of displacement of a particle executig SHM is equal to its acceleration , then its time period is

(a) 1 s (b) π s (c) 2π s (d) 4π s

27. Which one of the following statements is true for the speed v and the acceleration α of a particle executing simple harmonic motion? (AIPMT 2004)

(a) when v is maximum , α is maximum (b) when v is maximum , α is zero

(c) value of α is zero , whatever may be the value of v

(d) when v is zero , α is zero

28. When a particle executes SHM there is always a constant ratio between its displacement and

(a) velocity (b) acceleration (c) mass (d) time period

29. In simple harmonic motion , the ratio of acceleration of the particle to its displacement at any time is a measure of

(a) spring constant (b) angular frequency

(c) $(\text{angular frequency})^2$ (d) restoring force

30. The average acceleration of a particle performing SHM over one complete oscillation is

(a) $\frac{\omega^2 A}{2}$ (b) $\frac{\omega^2 A}{\sqrt{2}}$ (c) zero (d) $A\omega^2$ (CET 2010)

31. A particle is executing simple harmonic motion with a period of T second and amplitude a metre. The shortest time it takes to reach a point $a/\sqrt{2}$ m from its mean position is

(a) T (b) T / 4 (c) T / 8 (d) T / 16

32. The phase (at a time t) of a particle in simple harmonic motion tells

(a) only the position of the particle at time t

(b) only the direction of motion of the particle at time t

(c) both the position and direction of motion of the particle at time t

(d) neither the position of the particle nor its direction of motion at time t

92. A black body is at temperature of 500 K. It emits energy at rate which is proportional to (AIPMT 1997)
(a) $(500)^4$ (b) $(500)^3$ (c) $(500)^2$ (d) 500

93. A black body at 227°C radiates heat at the rate of 7 cal cm^{-2} s^{-1}. At a temperature of 727°C the rate of heat radiated in the same unit will be (AIPMT 2009)
(a) 60 (b) 50 (c) 112 (d) 80

94. A black body is at 727°C. It emits energy at a rate which is proportional to
(a) $(727)^2$ (b) $(1000)^4$ (c) $(1000)^2$ (d) $(727)^4$ (AIPMT 2007)

95. If the radius of a star is R and it acts as a black body, what would be the temperature of the star, in which the rate of energy production is Q? (σ stands for Stefan's constant) (AIPMT 2012)

(a) $\frac{Q}{4\pi R^2\sigma}$ (b) $\left(\frac{Q}{4\pi R^2\sigma}\right)^{-1/2}$ (c) $\left(\frac{4\pi R^2 Q}{\sigma}\right)^{1/4}$ (d) $\left(\frac{Q}{4\pi R^2\sigma}\right)^{1/4}$

96. The total radiant energy per second, per unit area, normal to the direction of incidence, received at a distance R from the centre of a star of radius r whose outer surface radiates as a black body at a temperature T K is given by (σ is Stephen's constant) (AIPMT2010)

(a) $\frac{\sigma r^2T^4}{R^2}$ (b) $\frac{\sigma R^2T^4}{4\pi r^2}$ (c) $\frac{\sigma r^2T^4}{R^4}$ (d) $\frac{4\pi\sigma r^2T^4}{R^2}$

97. During an isothermal expansion, a confined ideal gas does -150J of work against its surroundings. This implies that (AIPMT 2011)
(a) 300 J of heat has been added to the gas
(b) 150 J of heat has been added to the gas
(c) no heat is transferred because the process is isothermal
(d) 150 J of heat has been removed from the gas

98. In thermodynamic processes which of the following statement is not true?
(a) In an adiabatic process the system is insulated from the surroundings
(b) In an isochoric process pressure remains constant
(c) In an adiabatic process pV^{γ} = constant
(d) In an isothermal process the temperature remains constant

99. If ΔU and ΔW represent the increase in internal energy and work done by the system respectively in a thermodynamical process, which of the following is true? (AIPMT 2010)
(a) ΔU = - ΔW in an adiabatic process (b) ΔU = ΔW in an isothermal process
(c) ΔU = ΔW in an adiabatic process (d) ΔU = - ΔW in an isothermal process

100. The property of the system that does not change during an adiabatic change is
(a) temperature (b) volume (c) pressure (d) heat

101. First law of thermodynamics is a consequence of the conservation of

77. In the case of a sphere falling through a viscous medium, it attains terminal velocity when
(a) viscous force plus buoyant force becomes equal to force of gravity
(b) viscous force is zero
(c) viscous force plus force of gravity becomes equal to buoyant force
(d) buoyant force becomes equal to force of gravity. (J&K CET 2011)

78. If the temperature of a liquid is raised, then its surface tension is
(a) decreased (b) increased (c) does not change (d) equal to viscosity

79. A square frame of side l is dipped in a soap solution. When the frame is taken out, a soap film is formed. The force on the frame due to surface tension T of the soap solution is
(a) $8\,Tl$ (b) $4\,Tl$ (c) $10\,Tl$ (d) $12\,Tl$

80. Surface tension is due to
(a) elastic force (b) gravitational force (c) adhesive force (d) cohesive force

81. What causes the free surface of a liquid to have minimum area?
(a) Surface tension (b) Pressure difference on the two sides of the free surface
(c) Viscosity (d) None of the above

82. The spherical shape of a rain drop is due to (AIPMT 1992)
(a) density of water. (b) surface tension (c) atmospheric pressure (d) gravity

83. Hairs of shaving brush cling together when it is removed from water is due to
(a) force of attraction between hair (b) surface tension
(c) viscosity of water (d) characteristic property of hair

84. Soap helps in cleaning clothes, because
(a) it reduces surface tension (b) it increases surface tension
(c) it absorbs the dirt (d) of some other reasons

85. The spiders and insects move and run on the surface of water without sinking because
(a) elastic membrane is formed on water due to property of surface tension
(b) spiders and insects are lighter (c) spiders and insects swim on water
(d) spiders and insects experience upthrust

86. Water does not wet an oily glass because
(a) cohesive force of oil > adhesive force between oil and glass (c) oil repels water
(b) cohesive force of oil > cohesive force of water
(d) cohesive force of water > adhesive force between water and oil molecules

87. The meniscus of the liquid, which rises in a capillary tube is
(a) convex (b) plane (c) concave (d) connot be predicted

88. Angle of contact can vary between
(a) 0^0 to 90^0 (b) 90^0 to 180^0 (c) 0^0 to 180^0 (d) 0^0 to 360^0

26. Rotational analogue of mass in linear motion is
(a) Weight (b) Moment of inertia (c) Torque (d) Angular momentum

27. The moment of inertia of a disc having mass M and radius R, about an axis passing through its centre and perpendicular to its plane is
(a) $\frac{1}{2}MR^2$ (b) MR^2 (c) $\frac{1}{4}MR^2$ (d) $\frac{5}{4}MR^2$

28. A ring of radius r and mass m rotates about an axis passing through its centre and perpendicular to its plane with angular velocity ω. Its kinetic energy is
(a) $mr\omega^2$ (b) $\frac{1}{2}mr\omega^2$ (c) $I\omega^2$ (d) $\frac{1}{2}I\omega^2$

29. The moment of inertia of a rigid body, depends upon (AFMC 2002)
(a) distribution of mass from the axis of rotation (b) angular velocity of the body
(c) angular acceleration of the body (d) mass of the body

30. A particle of mass 1 kg is kept at (1 m, 1 m, 1m). The moment of inertia of this particle about Z-axis would be
(a) 1 kg m^2 (b) 2 kg m^2 (c) 3 kg m^2 (d) None of these

31. A wire of mass m and length l is bent in the form of a circular ring. The moment of inertia of the ring about its axis is (AIIMS 2010)
(a) ml^2 (b) $\frac{ml^2}{2\pi^2}$ (c) $\frac{ml^2}{4\pi^2}$ (d) $\frac{ml^2}{8\pi^2}$

32. A circular disc is to be made using iron and aluminium. To keep its moment of inertia maximum about a geometrical axis, it should be so prepared that (AIPMT 2002)
(a) aluminium is at the interior and iron surrounds it
(b) iron is at the interior and aluminium surrounds it
(c) aluminium and iron layers are in alternate order
(d) sheet of iron is used at both external surfaces and aluminium sheet as inner material

33. A flywheel rotating about a fixed axis has kinetic energy of 360 J when its angular speed is 30 rad/s. The moment of inertia of the wheel about the axis of rotation is
(a) 0.6 kg m^2 (b) 0.15 kg m^2 c) 0.8 kg m^2 (d) 0.75 kg m^2 (AIPMT 1990)

34. Generally the mass of a fly wheel is concentrated on its rim. Why?
(a) To increase the moment of inertia (b) To decrease the moment of inertia
(c) To obtain stable equilibrium (d) To obtain a strong wheel