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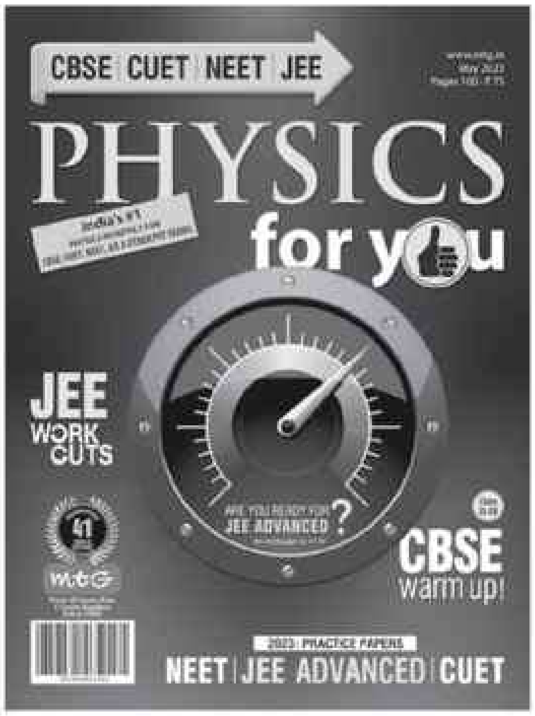

PHYSICS for you

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PRACTICE PAPER

NEET 2023

SECTION - A

1. If $\vec{A}=3\hat{i}-2\hat{j}+\hat{k}, \vec{B}=\hat{i}-3\hat{j}+5\hat{k}$ and $\vec{C}=2\hat{i}+\hat{j}-4\hat{k}$ form a right angled triangle. Then out of the following which one is satisfied?
(a) $\vec{A}=\vec{B}+\vec{C}$ and $A^2=B^2+C^2$
(b) $\vec{A}=\vec{B}+\vec{C}$ and $B^2=A^2+C^2$
(c) $\vec{B}=\vec{A}+\vec{C}$ and $B^2=A^2+C^2$
(d) $\vec{B}=\vec{A}+\vec{C}$ and $A^2=B^2+C^2$

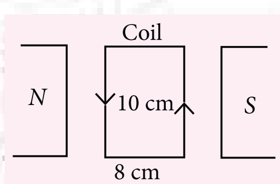
2. A train is moving north with speed 20 m s^{-1}. If it turns west with same speed, then the change in velocity will be
(a) $20\sqrt{2}$ m s^{-1} SW (b) $20\sqrt{2}$ m s^{-1} NW
(c) 40 m s^{-1} NE (d) 20 m s^{-1} SE

3. Under the action of a given coulombic force the acceleration of an electron is 2.5×10^{22} m s^{-2}. Then the magnitude of the acceleration of a proton under the action of same force is nearly
(a) 1.6×10^{-19} m s^{-2} (b) 9.1×10^{31} m s^{-2}
(c) 1.4×10^{19} m s^{-2} (d) 1.6×10^{27} m s^{-2}

4. In a potentiometer experiment the balancing with a cell is at length 250 cm. On shunting the cell with a resistance of 2 Ω, the balancing length becomes 125 cm. The internal resistance of the cell is
(a) 2 Ω (b) 4 Ω (c) 0.5 Ω (d) 1 Ω

5. The dimensions of the quantity $\vec{E}\times\vec{B}$, where $\vec{E}$ represents the electric field and $\vec{B}$ the magnetic field, which may be given as
(a) $[MT^{-3}]$ (b) $[M^2LT^{-5}A^{-2}]$
(c) $[M^2LT^{-3}A^{-1}]$ (d) $[MLT^{-2}A^{-2}]$

6. A coil of 50 turns carrying a current of 2 A in a magnetic field of 0.5 T. The torque acting on the coil is



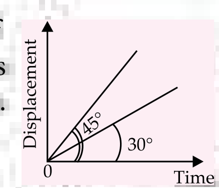
(a) 0.4 N m clockwise
(b) 0.2 N m anti-clockwise
(c) 0.4 N m anti-clockwise
(d) 0.2 N m clockwise

7. A susceptibility of a certain magnetic material is 400. What is the class of the magnetic material ?
(a) Ferromagnetic (b) Diamagnetic
(c) Ferroelectric (d) Paramagnetic

8. The capacitance of a parallel plate capacitor with air as medium is 3 μF. With the introduction of a dielectric medium between the plates, the capacitance becomes 15 μF. The permittivity of the medium is
(a) 5 C^2 N^{-1} m^{-2}
(b) 15 C^2 N^{-1} m^{-2}
(c) 0.44×10^{-10} C^2 N^{-1} m^{-2}
(d) 8.854×10^{-11} C^2 N^{-1} m^{-2}

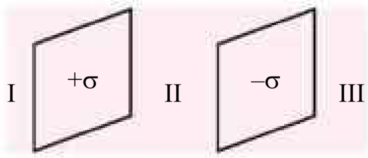
9. We are able to obtain fairly large currents in a conductor because
(a) the electron drift speed is usually very large
(b) the number density of free electrons is very high and this can compensate for the low values of the electron drift speed and the very small magnitude of the electron charge
(c) the number density of free electrons as well as the electron drift speeds are very large and these compensate for the very small magnitude of the electron charge
(d) the very small magnitude of the electron charge has to be divided by the still smaller product of the number density and drift speed to get the electric current.

10. The displacement-time graphs of two moving particles make angles of 30° and 45° with the *X*-axis. The ratio of their velocities is



(a) $\sqrt{3}:2$ (b) 1 : 1
(c) 1 : 2 (d) $1:\sqrt{3}$

11. Two large thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and magnitude 27×10^{-22} C m^{-2}. The electric field $\vec{E}$ in region II in between the plates is

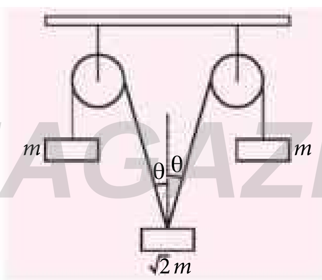


(a) 4.25×10^{-8} N C^{-1} (b) 6.28×10^{-10} N C^{-1}
(c) 3.05×10^{-10} N C^{-1} (d) 5.03×10^{-10} N C^{-1}

12. Two point masses A and B having masses in the ratio 4 : 3 are separated by a distance of 1 m. When another point mass C of mass M is placed in between A and B, the force between A and C is 1/3 of the force between B and C. Then the distance of C from A is

(a) $\frac{2}{3}$ m (b) $\frac{1}{3}$ m (c) $\frac{1}{4}$ m (d) $\frac{2}{7}$ m

13. The pulleys and the strings shown in figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ should be



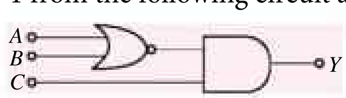
(a) 0° (b) 30° (c) 45° (d) 60°

14. A ray is incident at an angle of incidence i on one surface of a prism of small angle A and emerges normally from opposite surface. If the refractive index of the material of prism is μ, the angle of incidence i is nearly equal to

(a) $-\frac{A}{\mu}$ (b) $\frac{A}{2\mu}$ (c) μA (d) $-\frac{\mu A}{2}$

15. Which one of the following statements is correct in the case of
(a) shearing stress, there is change in volume.
(b) hydraulic stress, there is no change in shape.
(c) shearing stress, there is no change in shape.
(d) hydraulic stress, there is no change in volume.

16. The inputs A, B and C to be given in order to get an output $Y = 1$ from the following circuit are



(a) 0, 1, 0 (b) 1, 0, 0 (c) 0, 0, 1 (d) 1, 1, 0

17. An aeroplane is flying with a uniform speed of 150 km hr^{-1} along the circumference of a circle. The change in its velocity in half the revolution (in km hr^{-1}) is
(a) 150 (b) 50 (c) 200 (d) 300

18. Two parallel wires 1 m apart carry currents of 1 A and 3 A respectively in opposite directions. The force per unit length acting between these two wires is
(a) 6×10^{-7} N m^{-1} attractive
(b) 6×10^{-5} N m^{-1} attractive
(c) 6×10^{-7} N m^{-1} repulsive
(d) 6×10^{-5} N m^{-1} repulsive

19. A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 m/s. A bob is suspended from the roof of the car by a light wire of length 1.0 m. The angle made by the wire with the vertical is

(a) $\frac{\pi}{3}$ (b) $\frac{\pi}{6}$ (c) $\frac{\pi}{4}$ (d) 0°

20. A square card of side length 1 mm is being seen through a magnifying lens of focal length 10 cm. The card is placed at a distance of 9 cm from the lens. The apparent area of the card through the lens is
(a) 1 cm^2 (b) 0.81 cm^2
(c) 0.27 cm^2 (d) 0.60 cm^2

21. A single slit of width a is illuminated by violet light of wavelength 400 nm and the width of the diffraction pattern is measured as y. When half of the slit width is covered and illuminated by yellow light of wavelength 600 nm, the width of the diffraction pattern is
(a) zero and the pattern vanishes
(b) $y/3$
(c) $3y$
(d) none of these

22. Which of the following is not true?
(a) For a point charge, electrostatic potential varies as $1/r$.
(b) For a dipole, the potential depends on the magnitude of position vector and dipole moment vector.
(c) The potential of an electric dipole varies as $1/r$ at large distance.
(d) For a point charge, the electrostatic field varies as $1/r^2$.

23. Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different

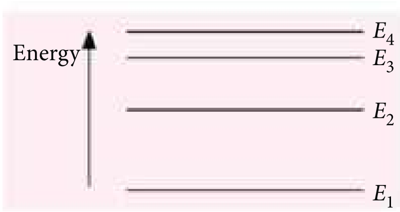
ways. The work done by the gas is W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic. Then
(a) $W_2 > W_1 > W_3$ (b) $W_2 > W_3 > W_1$
(c) $W_1 > W_2 > W_3$ (d) $W_1 > W_3 > W_2$

24. A particle of mass $6m$ at rest decays into two particles of masses $2m$ and $4m$ having non-zero velocities. What will be the ratio of the de Broglie wavelengths of two particles?
(a) 2 (b) 1/2 (c) 1 (d) 1/4

25. A cord is wound over the rim of a flywheel of mass 20 kg and radius 25 cm. A mass 2.5 kg attached to the cord is allowed to fall under gravity. The angular acceleration of the flywheel is
(a) 25 rad/s^2 (b) 20 rad/s^2
(c) 10 rad/s^2 (d) 5 rad/s^2

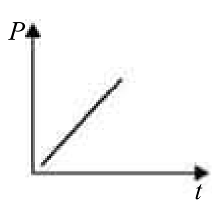
26. The temperature of an ideal gas is increased from 27 °C to 127 °C, then percentage increase in v_{rms} is
(a) 37% (b) 11% (c) 33% (d) 15.5%

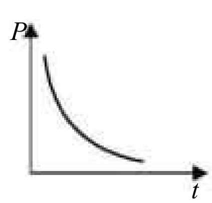
27. Figure represents in simplified form some of the lower energy levels of the hydrogen atom. If the transition of an electron from E_4 to E_2 were associated with the emission of blue light, which one of the following transitions could be associated with the emission of red light?

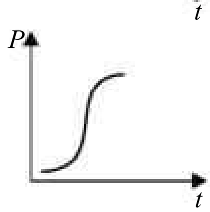


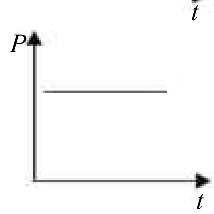
(a) E_4 to E_1 (b) E_3 to E_1
(c) E_3 to E_2 (d) E_1 to E_3

28. A soap bubble formed at the end of the tube is blown very slowly. The graph between excess of pressure inside the bubble with time is

(a) 

(b) 

(c) 

(d) 

29. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion?
(a) 0.18 m/s^2 (b) 0.2 m/s^2
(c) 0.1 m/s^2 (d) 0.15 m/s^2

30. A block whose mass is 1 kg is fastened to a spring. The spring has a spring constant of 100 N m^{-1}. The block is pulled to a distance x = 10 cm from its equilibrium position at x = 0 on a frictionless surface from rest at t = 0. The kinetic energy and potential energy of the block when it is 5 cm away from the mean position is
(a) 0.375 J, 0.125 J (b) 0.125 J, 0.375 J
(c) 0.125 J, 0.125 J (d) 0.375 J, 0.375 J

31. A high energy α-particle with a $_7N^{14}$ nucleus to produce a $_8O^{17}$ nucleus. What could be the other products of this collision?
(a) a γ-photon alone
(b) a γ-photon and a β-particle
(c) a γ-photon and a neutron
(d) a γ-photon and a proton.

32. Assertion (A) : A convex lens of glass (μ = 1.5) behave as a diverging lens when immersed in carbon disulphide of higher refractive index (μ = 1.65).

Reason (R) : A diverging lens is thinner in the middle and thicker at the edges.

In the light of above statements, choolse the correct answer from the following options below.

(a) A is true but R is false.

(b) Both A and R are true and R is the correct explanation of A.

(c) Both A and R are true but R is not the correct explanation of A.

(d) A is false but R is true.

33. Rays from the sun are focused by a lens of diameter 5 cm on to a block of ice. and 10 g of ice is melted in 20 min. Therefore the heat from the sun reaching the earth per min per square centimetre is

(Latent heat of ice, $L = 80$ cal g^{-1})

(a) 2.04 cal (b) 0.51 cal

(c) 4.08 cal (d) 3.02 cal

34. Figure (*a*) and figure (*b*) both are showing the variation of resistivity (ρ) with temperature (*T*) for some materials. Identify the type of these materials.

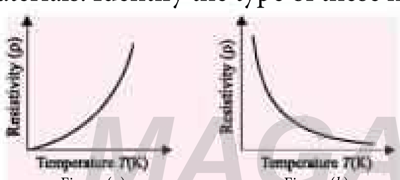


Figure (*a*) Figure (*b*)

(a) Conductor and semiconductor

(b) Conductor and Insulator

(c) Insulator and semiconductor

(d) Both are conductors

35. Wire having tension 225 N produces six beats per second when it is tuned with a fork. When tension changes to 256 N, it is tuned with the same fork, the number of beats remain unchanged. The frequency of the fork will be

(a) 186 Hz (b) 225 Hz

(c) 256 Hz (d) 280 Hz

SECTION - B

Attempt any 10 questions out of 15.

36. In Young's double slit experiment, the wavelength of light was changed from 7000 Å to 3500 Å. While doubling the separation between the slits, which of the following is not true for this experiment?

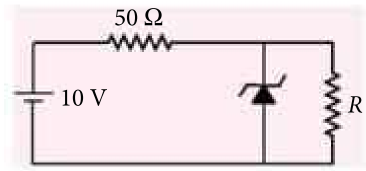
(a) The width of fringes does not changes.

(b) The colour of bright fringes changes.

(c) The separation between dark fringes changes.

(d) The colour of bright fringes does not change

37. The 6 V Zenerdiode is shown in figure has negligible resistance and a knee current of 5 mA. The minimum value of *R* (in Ω), so that the voltage across it does not fall below 6 V is



(a) 40 (b) 60 (c) 72 (d) 80

38. A system consisting of two masses connected by a massless rod lies along the *x*-axis. A 0.4 kg mass is at a distance $x = 2$ m while a 0.6 kg mass is at a distance $x = 7$ m. The *x*-coordinate of the centre of mass is

(a) 5 m (b) 3.5 m (c) 4.5 m (d) 4 m

39. On a photosensitive material, when frequency of incident radiation is increased by 30%, kinetic energy of emitted photoelectrons increases from 0.4 eV to 0.9 eV. The work function of the surface is

(a) 1 eV (b) 1.267 eV

(c) 1.4 eV (d) 1.8 eV

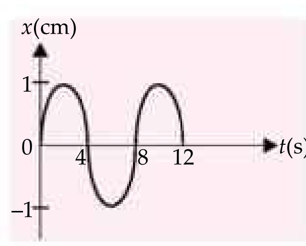
40. 70 calories of heat are required to raise the temperature of 2 moles of an ideal gas at constant pressure from 30°C to 35°C. The amount of heat required to raise the temperature of the same sample of the gas through the same range at constant volume is

(Gas constant = 2 cal mol^{-1} K^{-1})

(a) 30 cal (b) 50 cal

(c) 70 cal (d) 90 cal

41. The *x*-*t* graph of a particle undergoing simple harmonic motion is as shown in the figure.

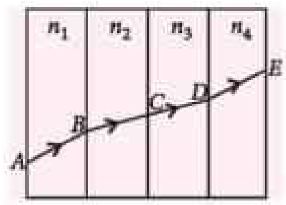


The acceleration of the particle at $t = \frac{4}{3}$ s is

(a) $\frac{\sqrt{3}}{32}\pi^2$ cm s^{-2} (b) $-\frac{\pi^2}{32}$ cm s^{-2}

(c) $\frac{\pi^2}{32}$ cm s^{-2} (d) $-\frac{\sqrt{3}}{32}\pi^2$ cm s^{-2}

42. A whistle whose air column is open at both ends has a fundamental frequency of 5100 Hz. If the speed of sound in air is 340 m s^{-1}, the length of the whistle, in cm, is

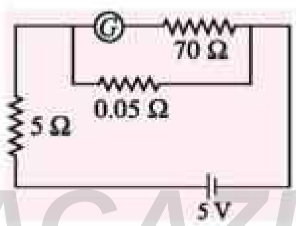


(a) 5/3 (b) 10/3 (c) 5 (d) 20/3

43. Radon has 3.8 days as its half-life. How much radon will be left out of 15 mg mass after 38 days?
(a) 1.05 mg (b) 0.015 mg
(c) 0.231 mg (d) 0.50 mg

44. The ratio of radii of earth to another planet is 2/3 and the ratio of their mean densities is 4/5. If an astronaut can jump to a maximum height of 1.5 m on the earth, with the same effort, the maximum height he can jump on the planet is
(a) 1 m (b) 0.8 m (c) 0.5 m (d) 1.25 m

45. In the given circuit, a galvanometer with a resistance of 70 Ω is converted to an ammeter by a shunt resistance of 0.05 Ω, total current measured by this device is



(a) 0.88 A (b) 0.77 A
(c) 0.55 A (d) 0.99 A

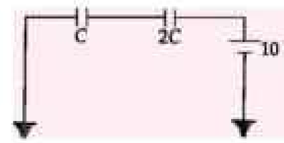
46. A ray of light passes through four transparent media with refractive indices n_1, n_2, n_3 and n_4 as shown. The surface of all media are parallel. If the emergent ray *DE* is parallel to incident ray *AB*, then
(a) $n_1 = n_4$ (b) $n_2 = n_4$
(c) $n_3 = n_4$ (d) $n_1 = \frac{n_2 + n_3 + n_4}{3}$

47. At what velocity does water emerge from an orifice in a tank in which gauge pressure is 3×10^5 N m^{-2} before the flow starts? (Take the density of water = 1000 kg m^{-3}.)
(a) 24.5 m s^{-1} (b) 14.5 m s^{-1}
(c) 34.5 m s^{-1} (d) 44.5 m s^{-1}

48. Statement I : A plot of stopping potential (V_s) vs frequency (υ) for different metals, has greater slope for metals with greater work functions.
Statement II : As work function increases, it requires greater energy to extricate the electrons from the surface of their metals.
In the light of above statements, choose the appropriate answer from the options given :
(a) Both statement I and statements II are true.
(b) Statement I is true but statement II is false.
(c) Both statement I and statement II are false.
(d) Statement I is false but statement II is true.

49. The mass of a box measured by a grocer's balance is 2.3 kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. What is the total mass of the box and the difference in the masses of the pieces to correct significant figures?
(a) 2.34 kg, 0 g (b) 2.3 kg, 0.02 g
(c) 2.34 kg, 0.02 g (d) 2.3 kg, 0 g

50. In the circuit shown in figure, $C = 6$ μF. The charge stored in the capacitor of capacity C is



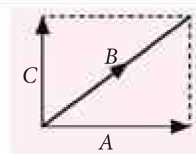
(a) zero (b) 90 μC (c) 40 μC (d) 60 μC

SOLUTIONS

1. (c) : $|\vec{A}| = \sqrt{9+4+1} = \sqrt{14}$

$|\vec{B}| = \sqrt{1+9+25} = \sqrt{35}$

$|\vec{C}| = \sqrt{4+1+16} = \sqrt{21}$



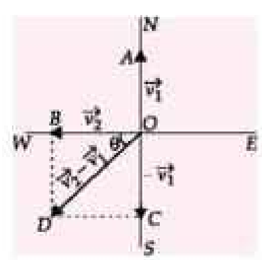
∴ Resultant of A and C is, $B^2 = A^2 + C^2$

$\vec{A} \cdot \vec{C} = 0$ (∴, $\vec{A}$ and $\vec{C}$ are perpendicular to each other).

Also, $\vec{B} = \vec{A} + \vec{C}$

2. (a) : Here, $\vec{v}_1 = 20$ m s^{-1} due north $= \overrightarrow{OA}$

$\vec{v}_2 = 20$ m s^{-1} due west $= \overrightarrow{OB}$



Change in velocity

$\Delta\vec{v} = \vec{v}_2 - \vec{v}_1 = \vec{v}_2 + (-\vec{v}_1)$

$= \overrightarrow{OB} + \overrightarrow{OC} = \overrightarrow{OD}$

$|\Delta\vec{v}| = \sqrt{v_2^2 + v_1^2}$

$= \sqrt{(20)^2 + (20)^2} = 20\sqrt{2}$ m s^{-1}

$\tan\theta = \frac{v_2}{v_1} = \frac{20}{20} = 1 = \tan 45°$, θ = 45° SW

3. (c) : The acceleration due to given coulombic force F is

$a = \frac{F}{m}$ or $a \propto \frac{1}{m}$

∴ $\frac{a_p}{a_e} = \frac{m_e}{m_p}$, where m_e and m_p are masses of electron and proton respectively.

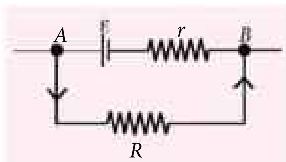
$$a_p = \frac{a_e m_e}{m_p} = \frac{(2.5\times10^{22}\text{ m s}^{-2})(9.1\times10^{-31}\text{ kg})}{(1.67\times10^{-27}\text{ kg})}$$

$= 13.6 \times 10^{18}$ m s$^{-2} \approx 1.4 \times 10^{19}$ m s^{-2}

4. (a) : If potential gradient = K

$\varepsilon = 250$ K

$V_{AB} = \varepsilon - ir = iR = 125K$



As, $i = \frac{125K}{R} = \frac{125K}{2}$

Now, $\varepsilon - ir = 125K$

$250K - \frac{125}{2}K(r) = 125K \quad \therefore \quad r = 2\ \Omega.$

5. (b) : Electric field, $E = \frac{F}{q} = \frac{[\text{MLT}^{-2}]}{[\text{AT}]} = [\text{MLT}^{-3}\text{A}^{-1}]$

Magnetic field, $B = \frac{F}{qv} = \frac{[\text{MLT}^{-2}]}{[\text{AT}][\text{LT}^{-1}]} = [\text{MT}^{-2}\text{A}^{-1}]$

$\therefore$ The dimensions of quantity $\vec{E}\times\vec{B}$

$= [\text{MLT}^{-3}\text{A}^{-1}][\text{MT}^{-2}\text{A}^{-1}] = [\text{M}^2\text{LT}^{-5}\text{A}^{-2}]$

6. (a) : $\vec{\tau} = \vec{m}\times\vec{B}$ or $\tau = mB\sin\theta$

or $\tau = mB$ [$\because \theta = 90°$] or $\tau = NIAB$

$= 50 \times 2 \times 10 \times 8 \times 10^{-4} \times 0.5$

$= 0.4$ N m (clockwise direction)

7. (a) : As, susceptibility is large and positive, the given material is ferromagnetic.

8. (c) : Capacitance of a parallel plate capacitor with air is, $C = \frac{\varepsilon_0 A}{d}$

Capacitance of a same parallel plate capacitor with the introduction of a dielectric medium is, $C' = \frac{K\varepsilon_0 A}{d}$

Where, K is the dielectric constant of a medium.

or $\frac{C'}{C} = K$ or $K = \frac{15}{3} = 5$ or $K = \frac{\varepsilon}{\varepsilon_0}$

or $\varepsilon = K\varepsilon_0 = 5\times8.854\times10^{-12} = 0.44\times10^{-10}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$

9. (b) : $I = neAv_d$

v_d is of order of few m s^{-1}, $e = 1.6 \times 10^{-19}$ C,

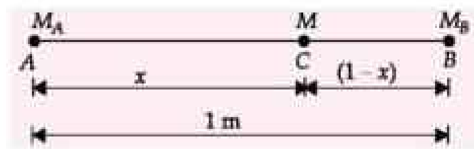
A is of the order of mm^2, so a large I is due to a large value of n in conductors.

10. (d) : Slope of displacement-time graph gives velocity.

$\therefore \frac{v_1}{v_2} = \frac{\tan\theta_1}{\tan\theta_2} = \frac{\tan 30°}{\tan 45°} = \frac{1}{\sqrt{3}}$

11. (c) : The value of $\vec{E}$ in the region II, in between the plates $= \frac{\sigma}{\varepsilon_0} = \frac{27\times10^{-22}}{8.85\times10^{-12}} = 3.05\times10^{-10}\ \text{N C}^{-1}$

12. (a) : Let the point mass C be placed at a distance of x m from the point mass A as shown in the figure.



Here, $\frac{M_A}{M_B} = \frac{4}{3}$

The force between A and C is $F_{AC} = \frac{M_A GM}{x^2}$ ...(i)

The force between B and C is $F_{BC} = \frac{M_B GM}{(1-x)^2}$ ...(ii)

According to given problem $F_{AC} = \frac{1}{3}F_{BC}$

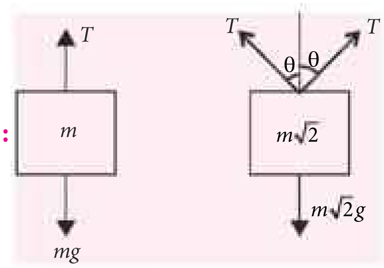
$\therefore \frac{GM_A M}{x^2} = \frac{1}{3}\left(\frac{GM_B M}{(1-x)^2}\right)$ (Using (i) and (ii))

or $\frac{M_A}{x^2} = \frac{M_B}{3(1-x)^2}$ or $\frac{M_A}{M_B} = \frac{x^2}{3(1-x)^2}$

or $\frac{4}{3} = \frac{x^2}{3(1-x)^2} \Rightarrow +2 = \frac{x}{1-x}$ or $-2 = \frac{x}{1-x}$

$\Rightarrow x = \frac{2}{3}$ m or 2 m; only $x = \frac{4}{3}$ m is possible for the given case.

13. (c) :



$T = mg$ and $2T\cos\theta = m\sqrt{2}g$

$2mg\cos\theta = m\sqrt{2}g$; $\cos\theta = \frac{1}{\sqrt{2}}$ or $\theta = 45°$

MONTHLY TEST DRIVE CLASS XI ANSWER KEY

1. (d)	2. (a)	3. (d)	4. (a)	5. (c)
6. (b)	7. (c)	8. (b)	9. (a)	10. (a)
11. (d)	12. (c)	13. (a)	14. (a)	15. (a)
16. (b)	17. (c)	18. (c)	19. (c, d)	20. (a,d)
21. (a, c, d)	22. (b,c)	23. (a, c, d)	24. (5)	25. (16)
26. (66)	27. (d)	28. (c)	29. (a)	30. (d)

14. (c) : As, refracted ray emerges normally from opposite surface, $r_2 = 0$

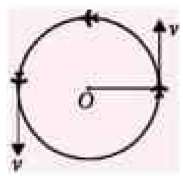
As, $A = r_1 + r_2 \quad \therefore \quad r_1 = A$

Now, $\mu = \frac{\sin i_1}{\sin r_1} \approx \frac{i_1}{r_1} = \frac{i}{A}$ or $i = \mu A$

15. (b) : In case of shearing stress there is a change in shape without any change in volume. In case of hydraulic stress there is a change in volume without any change in shape.

16. (c)

17. (d) : The situation is shown in adjacent figure.



Taking upwards direction to be positive, then the change in the velocity of the aeroplane in half the revolution is

$\Delta v = v - (-v) = 2v = 2(150 \text{ km hr}^{-1}) = 300 \text{ km hr}^{-1}$

18. (c) : The force per unit length acting between two parallel wires carrying currents I_1 and I_2 and placed at a distance d apart is, $f = \frac{\mu_0 I_1 I_2}{2\pi d}$

Here, $I_1 = 1$ A, $I_2 = 3$ A, $d = 1$ m

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\therefore \quad f = \frac{(4\pi \times 10^{-7} \text{ T m A}^{-1})(1 \text{ A})(3 \text{ A})}{2\pi(1 \text{ m})}$

$= \quad 6 \times 10^{-7} \text{ N m}^{-1}$

As, the currents are in opposite directions, so f is repulsive.

19. (c) : Let, θ be the angle made by the wire with the vertical.

$\therefore \quad \tan\theta = \frac{v^2}{rg}$

Here, $v = 10$ m/s, $r = 10$ m, $g = 10$ m/s^2

$\therefore \quad \tan\theta = \frac{(10 \text{ m/s})^2}{10\text{ m}(10 \text{ m/s}^2)} = 1, \theta = \tan^{-1}(1) = \frac{\pi}{4}$

20. (a) : Area of a square card = 1 mm × 1 mm = 1 mm^2

Focal length of magnifying lens (converging lens), $f = +10$ cm

Object distance, $u = -9$ cm

According to thin lens formula, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{+10 \text{ cm}} + \frac{1}{-9 \text{ cm}} = \frac{1}{10 \text{ cm}} - \frac{1}{9 \text{ cm}}$

or $\quad v = -90$ cm

Magnification, $m = \frac{v}{u} = \frac{-90 \text{ cm}}{-9 \text{ cm}} = 10$

$\therefore$ Apparent area of the card through the lens

$= \quad 10 \times 10 \times 1 \text{ mm}^2 = 100 \text{ mm}^2 = 1 \text{ cm}^2$

21. (c) : In single slit experiment width of central maximum, $y = \frac{2\lambda D}{a}$

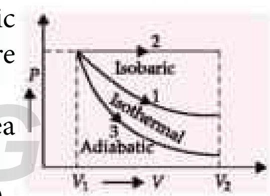
$\therefore \quad \frac{y'}{y} = \frac{\lambda'}{a'} \times \frac{a}{\lambda} = \frac{600}{a/2} \times \frac{a}{400} \quad \therefore \quad y' = 3y$

22. (c) : Electrostatic potential for a point charge varies as, $V \propto \frac{1}{r}$.

Potential of dipole depends on magnitude of position vector and dipole moment.

$V = \frac{\vec{P}.\hat{r}}{4\pi\varepsilon_0 r^2}$ electric field due to point charge varies as, $E \propto \frac{1}{r^2}$.

23. (a) : The isothermal, isobaric and adiabatic processes are shown in the P.V. graphs.



As, work done by the gas = area under the $P - V$ graph.

Here, $(\text{Area})_2 > (\text{Area})_1 > (\text{Area})_3$

$\therefore \quad W_2 > W_1 > W_3$

24. (c) : de-Brogile wavelength, $\lambda \propto \frac{1}{p} \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{p_2}{p_1}$

$\therefore \quad p_1 = p_2 \quad \Rightarrow \quad \lambda_1 = \lambda_2$

TRIO

The same THREE LETTERS will complete these three words.

Can you find the three-letter sequence?

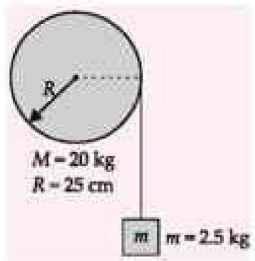
E L E C T R O _ _ _ I N E S C E N C E

_ _ _ EN

P E N D U _ _ _

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names will be published in next issue.

25. (c) : Moment of inertia of flywheel about its axis,



$$I = \frac{MR^2}{2}$$
$$= \frac{(20\ \text{kg})(25 \times 10^{-2}\ \text{m})^2}{2}$$
$$= \quad 25 \times 25 \times 10^{-3}\ \text{kg m}^2$$

Torque acting on the flywheel,

$$\tau = FR = mgR = (2.5\ \text{kg})\ (10\ \text{m/s}^2)\ (25 \times 10^{-2}\ \text{m})$$
$$= 25 \times 25 \times 10^{-2}\ \text{N m}$$

Angular acceleration of the flywheel,

$$\alpha = \frac{\tau}{I} = \frac{25 \times 25 \times 10^{-2}}{25 \times 25 \times 10^{-3}} = 10\ \text{rad/s}^2$$

26. (d) : $v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$

$$\%\ \text{increase in}\ v_{\text{rms}} = \frac{\sqrt{\frac{3RT_2}{M}} - \sqrt{\frac{3RT_1}{M}}}{\sqrt{\frac{3RT_1}{M}}} \times 100$$
$$= \frac{\sqrt{T_2} - \sqrt{T_1}}{\sqrt{T_1}} \times 100 = \frac{\sqrt{400} - \sqrt{300}}{\sqrt{300}} \times 100$$
$$= \frac{20 - 17.32}{17.32} \times 100 = 15.5\%$$

27. (c) : $\upsilon_{\text{Blue}} > \upsilon_{\text{Red}}$. If E_4 to E_2 gives blue light, then the ΔE for red light must be smaller than $(E_4 - E_2)$. From the available choice, we can say E_3 to E_2 would be correct.

28. (b) : As excess pressure inside the soap bubble of radius r, is

$$P = \frac{4S}{r} \quad \text{or} \quad P \propto \frac{1}{r}$$

Therefore, as r increases with time, P decreases.

So, the variation of P with time t will be a parabolic curve as shown is option (b)

29. (c) : Here, $m = 10\ \text{g} = 10^{-2}\ \text{kg}$,
$R = 6.4\ \text{cm} = 6.4 \times 10^{-2}\ \text{m}$, $K_f = 8 \times 10^{-4}\ \text{J}$
$K_i = 0$, $a_t = ?$
Using work energy theorem,
Work done by all the forces = Change in KE

$$W_{\text{tangential force}} + W_{\text{centripetal force}} = K_f - K_i$$
$$\Rightarrow \quad F_t \times s + 0 = K_f - 0 \quad \Rightarrow \quad ma_t \times (2 \times 2\pi R) = K_f$$
$$\Rightarrow a_t = \frac{K_f}{4\pi Rm} = \frac{8 \times 10^{-4}}{4 \times \frac{22}{7} \times 6.4 \times 10^{-2} \times 10^{-2}}$$
$$= \quad 0.099 \approx 0.1\ \text{m s}^{-2}$$

30. (a) : Here, $m = 1\ \text{kg}$, $k = 100\ \text{N m}^{-1}$
$A = 10\ \text{cm} = 0.1\ \text{m}$
The block executes SHM, its angular velocity is given by

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{100\ \text{N m}^{-1}}{1\ \text{kg}}} = 10\ \text{rad s}^{-1}$$

Velocity of the block at $x = 5\ \text{cm} = 0.05\ \text{m}$ is

$$v = \omega\sqrt{A^2 - x^2} = 10\sqrt{(0.1)^2 - (0.05)^2} = 10\sqrt{7.5 \times 10^{-3}}\ \text{m s}^{-1}$$

Kinetic energy of the block,

$$K = \frac{1}{2}mv^2 = \frac{1}{2} \times 1 \times 0.75 = 0.375\ \text{J}$$

Potential energy of the block,

$$U = \frac{1}{2}kx^2 = \frac{1}{2} \times 100 \times (0.05)^2 = 0.125\ \text{J}$$

31. (d) : By conserving Z and A on both sides

$${}_2\alpha^4 + {}_7\text{N}^{14} \rightarrow {}_8\text{O}^{17} + {}_1p^1 + \gamma$$

32. (c) : $\mu = \frac{\mu_g}{\mu_c} = \frac{1.5}{1.65} < 1$

from $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

As, f becomes negative.
Therefore, the lens behaves as a diverging lens.

33. (a) : If s calorie of heat is received from the sun per cm^2 per minute, the heat collected by the lens of radius 2.5 cm in 20 minutes is

$$Q_1 = s \times A \times t = s \times \pi \times (2.5)^2 \times (20) = (392.75)s\ \text{cal}$$

Heat required to melt 10 g of ice is

$$Q_2 = mL = 10 \times 80 = 800\ \text{cal}$$

According to given problem $Q_1 = Q_2$

$$\therefore \quad 392.75s = 800 \ \text{or} \ s = 2.04\ \text{cal cm}^{-2}\ \text{min}^{-1}$$

34. (a) : In conductors due to increase in temperature the resistivity increases and in semiconductors it decreases exponentially.

35. (a) : By law of tension, $n \propto \sqrt{T}$

$$\therefore \quad \frac{n_1}{n_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{225\ \text{N}}{256\ \text{N}}} = \frac{15}{16}$$

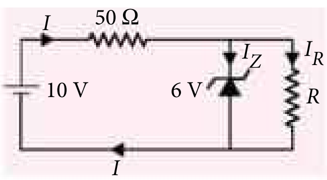
Let the frequency of tuning fork be n.
In both cases, number of beats per second is six and $n_1 < n_2$
$\therefore \quad n_1 = n - 6$ and $n_2 = n + 6$

$\therefore \quad \frac{n-6}{n+6}=\frac{15}{16} \Rightarrow 16n-96=15n+90 \Rightarrow n=186$ Hz

36. (c) : As $\beta=\frac{\lambda D}{d}$,

Therefore, when λ is halved and d is doubled, β becomes $1/2^{th}$.
The separation between successive dark fringes reduces. It does not remain unchanged.

37. (d) :



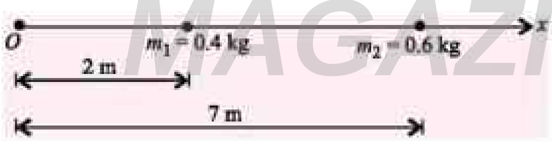
The voltage across 50 Ω = 10 V – 6 V = 4 V
The current through 50 Ω is,

$$I=\frac{4\text{ V}}{50\ \Omega}=0.08\text{ A}=80\text{ mA}$$

The current through R is,
$I_R = I - I_Z = 80\text{ mA} - 5\text{ mA} = 75\text{ mA}$
The minimum value of R is,

$$R_{min}=\frac{6\text{ V}}{75\times10^{-3}\text{ A}}=0.08\times10^{3}\ \Omega=80\ \Omega$$

38. (a) :



The x-coordinate of the centre of mass is

$$X_{CM}=\frac{m_1x_1+m_2x_2}{m_1+m_2}=\frac{0.4\times2+7\times0.6}{0.4+0.6}=5\text{ m}$$

39. (b) : The kinetic energy of the electron is
K.E. = $h\upsilon - \phi_0$; $\quad h\upsilon$ = K.E. + ϕ_0
$h\upsilon = 0.4 + \phi_0$ ...(i)
Given, frequency of incident radiation is increased by 30%

$$\therefore \quad h\upsilon+\frac{30}{100}h\upsilon=1.3\,h\upsilon$$

$1.3\,h\upsilon = 0.9 + \phi_0$ (Using (i)) ...(ii)

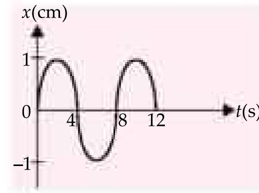
or $\quad 0.38=0.3\phi_0 \Rightarrow \phi_0=\frac{0.38}{0.3}=1.267$ eV

40. (b) : The amount of heat required at constant pressure is

$$\Delta Q=nC_P\Delta T \quad \therefore \ C_P=\frac{\Delta Q}{n\Delta T}=\frac{70}{2(35-30)}=7\text{ cal}$$

As $\quad C_P - C_V = R$
$\therefore \quad C_V = C_P - R = 7 - 2 = 5$ cal mol^{-1} K^{-1}
The amount of heat required at constant volume is
$\Delta Q = nC_V\Delta T = 2 \times 5 \times (35 - 30) = 50$ cal

41. (d) : From graph, A = 1 cm, T = 8 s



$$x=A\sin\omega t=A\sin\frac{2\pi}{T}t$$

At $\quad t=\frac{4}{3}$ s,

$$x=1\sin\frac{2\pi}{8}\times\frac{4}{3}=\sin\frac{\pi}{3}=\frac{\sqrt{3}}{2}\text{ cm}$$

In SHM, acceleration = $-\omega^2x$

$$=-\frac{4\pi^2}{T^2}\times\frac{\sqrt{3}}{2}\text{ cm s}^{-2} \quad \left(\because\ \omega=\frac{2\pi}{T}\right)$$

$$=-\frac{4\pi^2}{(8)^2}\times\frac{\sqrt{3}}{2}=-\frac{\sqrt{3}\pi^2}{32}\text{ cm s}^{-2}$$

42. (b) : Let L be the length of the whistle.

Fundamental frequency, $\upsilon=\frac{v}{2L}$ or $L=\frac{v}{2\upsilon}$

Substituting the given values , we get

$$L=\frac{340}{2\times5100}=\frac{1}{30}\text{ m}=\frac{10}{3}\text{ cm}$$

43. (b) : Here, $n=\frac{t}{T_{1/2}}=\frac{38}{3.8}=10$

$$\text{As, } N=N_0\left(\frac{1}{2}\right)^n \Rightarrow m=m_0\left(\frac{1}{2}\right)^n=15\times\left(\frac{1}{2}\right)^{10}$$

$$=\frac{15}{1024}=0.015\text{ mg}$$

44. (b) : Here, $\frac{R_e}{R_p}=\frac{2}{3},\ \frac{\rho_e}{\rho_p}=\frac{4}{5},\ h_e=1.5\text{ m},\ h_p=?$

PE of person at maximum height to which he can jump on earth = PE at the maximum height to which he can jump on planet.

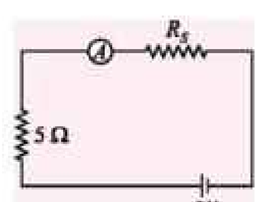
$$\therefore \quad mg_eh_e=mg_ph_p \text{ or } m\frac{GM_e}{R_e^2}h_e=m\frac{GM_p}{R_p^2}h_p$$

$$\text{or} \quad mG\frac{\frac{4}{3}\pi R_e^3\rho_eh_e}{R_e^2}=mG\frac{\frac{4}{3}\pi R_p^3\rho_ph_p}{R_p^2}$$

or $\quad R_e\rho_eh_e=R_p\rho_ph_p$

$$\text{or} \quad h_p=\frac{R_e}{R_p}\times\frac{\rho_e}{\rho_p}\times h_e=\frac{2}{3}\times\frac{4}{5}\times1.5=0.8\text{ m}$$

45. (d) : The equivalent circuit of the given circuit is shown in the figure below.



$$\text{Here, } R_S=\frac{R_Gr_s}{R_G+r_S}=\frac{70\times0.05}{70+0.05}$$

$\therefore \quad R_S = 0.0499\ \Omega = 0.05\ \Omega$

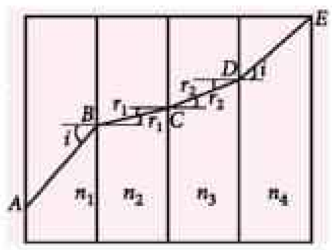
The total resistance in the circuit is

$R = R_S + 5\ \Omega = 0.05 + 5 = 5.05\ \Omega$

The current measured by the device

$$I = \frac{V}{R} = \frac{5}{5.05} = 0.99\ \text{A}$$

46. (a) : Apply Snell's law



$${}^1n_2 = \frac{\sin i}{\sin r_1},\quad {}^2n_3 = \frac{\sin r_1}{\sin r_2}$$

$${}^3n_4 = \frac{\sin r_2}{\sin i}$$

$${}^1n_2 \times {}^2n_3 \times {}^3n_4 = 1$$

or $\dfrac{n_2}{n_1}\times\dfrac{n_3}{n_2}\times\dfrac{n_4}{n_3} = 1$ or $n_4 = n_1$.

47. (a) : Here, $P = 3 \times 10^5$ N m^{-2}, $\rho = 1000$ kg m^{-3}, $g = 9.8$ m s^{-2}

As, $P = h\rho g$

$$\therefore \quad h = \frac{P}{\rho g} = \frac{3\times10^5}{1000\times9.8}\ \text{m}$$

Velocity of efflux, $v = \sqrt{2gh} = \sqrt{\dfrac{2\times9.8\times3\times10^5}{1000\times9.8}}$

$= \sqrt{600} = 24.495\ \text{ms}^{-1} \approx 24.5\ \text{ms}^{-1}$

48. (d) : Statement-I is false, Statement-II is true.

$$eV_s = h\upsilon - W;\ V_s = \left(\frac{h}{e}\right)\upsilon - \left(\frac{W}{e}\right)$$

For V_s *vs* υ graph, slope = h/e = constant.

49. (b) : Total mass = 2.3 kg + 0.02015 kg + 0.02017 kg = 2.34032 kg = 2.3 kg

Difference of mass of the gold pieces = 20.17 g − 20.15 g = 0.02 g

50. (c) : In the given figure, the two capacitors are in series. Therefore, their equivalent capacitance is

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{C} + \frac{1}{2C} = \frac{3}{2C} \quad \text{or} \quad C_s = \frac{2C}{3}$$

As, the capacitors are connected in series, therefore, charge on each capacitor is same. Hence,

$$q = C_s \times V = \frac{2C}{3}V = \frac{2\times6}{3}\times10 = 40\ \mu\text{C}$$

PRACTICE PAPER 2023

CUET (UG)

Exam on 21^{st} to 31^{st} May 2023

Section II of CUET (UG) is Domain specific. In this section of Physics, 35 questions to be attempted out of 45.

SECTION-A

(All questions are compulsory.)

1. The temperature coefficient of resistance of an alloy used for making resistors is

(a) small and positive (b) small and negative
(c) large and positive (d) large and negative

2. **Statement 1 :** The electric flux emanating out and entering a closed surface are 8×10^3 and 2×10^3 V m respectively. The charge enclosed by the surface is 0.053 μC.

Statement 2 : Gauss's theorem in electrostatics may be applied to verify.

(a) If both statement 1 and statement 2 are true and statement 1 is the correct explanation of statement 2
(b) If both statement 1 and statement 2 are true but statement 2 is not the correct explanation of statement 1
(c) If statement 1 is true but statement 2 is false
(d) If both statement 1 and statement 2 are false.

3. When a soap bubble is charged

(a) the radius remains the same
(b) its radius may increase or decrease
(c) its radius increases
(d) its radius decreases.

4. The angles of dip at the poles and the equator respectively are

(a) 30°, 60° (b) 0°, 90° (c) 45°, 90° (d) 90°, 0°

5. **Assertion :** At resonance, *LCR* series circuit have a maximum current.

Reason : At resonance, in *LCR* series circuit, the current and e.m.f are in phase with each other.

(a) If both assertion and reason are true and reason is the correct explanation of assertion
(b) If both assertion and reason are true but reason is not the correct explanation of assertion
(c) If assertion is true but reason is false
(d) If both assertion and reason are false.

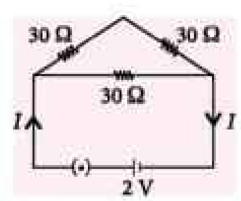
6. In a double slit experiment, instead of taking slits of equal widths, one slit is made twice as wide as the other. Then, in the interference pattern

(a) the intensities of both maxima and the minima increase
(b) the intensity of the maxima increases and the minima has zero intensity
(c) the intensity of the maxima decreases and that of the minima increases
(d) the intensity of the maxima decreases and the minima has zero intensity.

7. Two point charges *A* = +3 nC and *B* = +1 nC are placed 5 cm apart in air. The work done to move charge *B* towards *A* by 1 cm is

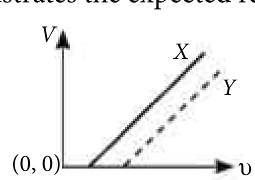
(a) 2.0×10^{-7} J (b) 1.35×10^{-7} J
(c) 2.7×10^{-7} J (d) 12.1×10^{-7} J

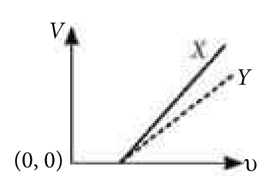
8. Find the current flowing through the given circuit.

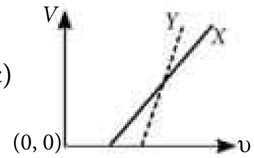


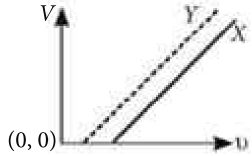
(a) 10 A
(b) 0.1 A
(c) 40 A
(d) 80 A

9. In a photoelectric experiment, electrons are ejected from metals *X* and *Y* by light of frequency υ. The potential difference *V* are required to stop the electrons is measured for various frequencies. If *Y* has a greater work function than *X*, which graph illustrates the expected results?

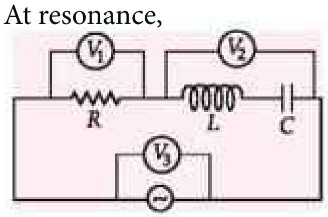
(a) 

(b) 

(c) 

(d) 

10. In the figure shown, three ac voltmeters are connected. At resonance,



(a) $V_2 = 0$ (b) $V_1 = 0$
(c) $V_3 = 0$ (d) $V_1 = V_2 \neq 0$

11. Match the correct pairs.

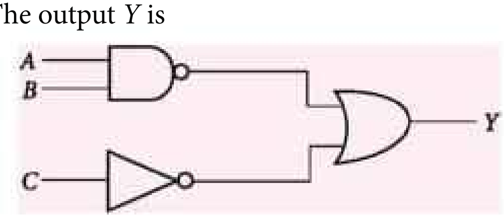
	Emission series		Make transitions from higher levels to following levels
A	Lyman series	P	$n = 1$
B	Paschen series	Q	$n = 2$
C	Balmer series	R	$n = 3$
D	Brackett series	S	$n = 4$
		T	$n = 5$

(a) A–P; B–R; C–Q; D–S
(b) A–P; B–Q; C–R; D–T
(c) A–Q; B–R; C–S; D–T
(d) A–T; B–S; C–R; D–Q

12. Two parallel long wires A and B carry currents i_1 and $i_2 (< i_1)$. When i_1 and i_2 are in the same direction, the magnetic field at a point mid way between the wires is 10 μT. If i_2 is reverse the field becomes 30 μT. The ratio i_1/i_2 is
(a) 1 (b) 2 (c) 3 (d) 4

13. Li nucleus has three protons and four neutrons. Mass of Li nucleus is 7.016005 amu. Mass of proton is 1.007277 amu and mass of neutron is 1.008665 amu. Mass defect of lithium nucleus in amu is
(a) 0.04048 amu (b) 0.04050 amu
(c) 0.04052 amu (d) 0.04055 amu

14. The inputs to the digital circuit are shown below. The output Y is



(a) $A + B + \overline{C}$ (b) $(A + B)\overline{C}$
(c) $\overline{A} + \overline{B} + \overline{C}$ (d) $\overline{A} + \overline{B} + C$

15. Match the Column I with Column II.

	Column I		Column II
(A)	Ohm's law is applicable to	(p)	metals
(B)	Ohm's law is not applicable to	(q)	greater resistivity
(C)	alloys have	(r)	diodes, electrolytes, semiconductors.

(a) A – r, B – q, C – p (b) A – p, B – r, C – q
(c) A – r, B – p, C – q (d) A – q, B – r, C – p

SECTION-B

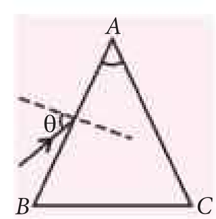
(Attempt any 20 questions.)

16. In order to establish an instantaneous displacement current of 1 mA in the space between the plates of 2 μF parallel plate capacitor, the rate of change of potential difference is
(a) 100 V s^{-1} (b) 200 V s^{-1}
(c) 300 V s^{-1} (d) 500 V s^{-1}

17. The radius of hydrogen atom in the ground state is 5.3×10^{-11} m. After collision with an electron, it is found to have radius of 21.2×10^{-11} m. What is the principal quantum number n of the final state of the atom?
(a) $n = 4$ (b) $n = 2$ (c) $n = 16$ (d) $n = 3$

18. An infinitely long cylinder is kept parallel to a uniform magnetic field B directed along positive z-axis. The direction of induced current on the surface of cylinder as seen from the z-axis will be
(a) clockwise of the +ve z-axis
(b) anticlockwise of the +ve z-axis
(c) zero
(d) along the magnetic field.

19. Monochromatic light is incident on a glass prism of angle A. If refractive index of the material of the prism is μ, a ray incident at an angle θ, on the face AB would get transmitted through the face AC of the prism provided



(a) $\theta > \cos^{-1}\left[\mu \sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

(b) $\theta < \cos^{-1}\left[\mu \sin\left(A + \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

(c) $\theta > \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

(d) $\theta < \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

20. The total energy of a hydrogen atom in its ground state is –13.6 eV. If the potential energy in the first excited state is taken as zero then the total energy in the ground state will be

(a) –3.4 eV (b) 3.4 eV
(c) –6.8 eV (d) 6.8 eV

21. Statement 1 : The photoelectrons produced by a monochromatic light beam incident on a metal surface, have a spread in their kinetic energies.

Statement 2 : The work function of the metal varies as a function of depth from the surface.

(a) If both statement 1 and statement 2 are true and statement 1 is the correct explanation of statement 2
(b) If both statement 1 and statement 2 are true but statement 2 is not the correct explanation of statement 1
(c) If statement 1 is true but statement 2 is false
(d) If both statement 1 and statement 2 are false.

22. In a *p-n* junction diode, change in temperature due to heating

(a) affects only reverse resistance
(b) affects only forward resistance
(c) does not affect resistance of *p-n* junction
(d) affects the overall *V - I* characteristics of *p-n* junction

23. A coil has an inductance of 0.7 henry and is joined in series with a resistance of 220 Ω. When an alternating emf of 220 V at 50 cycles per second, is applied to it, then wattless component of current in the circuit is

(a) 7 A (b) 5 A (c) 0.7 A (d) 0.5 A

24. In an *n-p-n* transistor circuit, the collector current is 10 mA. If 90% of the electrons emitted reach the collector

(a) the emitter current will be nearly 9 mA and the base current will be nearly 1 mA.
(b) the emitter current will be nearly 11 mA and the base current will be nearly 9 mA.
(c) the emitter current will be nearly 11 mA and the base current will be nearly 1 mA.
(d) the emitter and base currents will be 10 mA and 1 mA respectively.

25. A paramagnetic substance of susceptibility 3×10^{-4} is placed in a magnetising field of 4×10^{-4} A m^{-1}. Then the intensity of magnetisation in the units of A m^{-1} is

(a) 1.33×10^{8} (b) 0.75×10^{-8}
(c) 12×10^{-8} (d) 14×10^{-8}

26. A transmitting antenna at the top of a tower has a height of 20 m. For obtaining 40 km as the maximum distance between the transmitter and receiver for satisfactory communication in LOS mode, the height of receiving antenna should be (radius of the earth $R = 64 \times 10^5$ m)

(a) 30 m (b) 35 m
(c) 40 m (d) 45 m

27. Match column I with column II.

Column I		Column II	
(A)	Electrical conductivity of conductor depends on	(p)	Dimension (length, area of cross section etc.)
(B)	Conductance of a conductor depends on	(q)	temperature
(C)	For a given potential differences applied across a conductor of given length, current in it will depend on	(r)	nature of conductor

(a) A → (p, q); B → (p, q, r); C → (p, q, r)
(b) A → (p); B → (r); C → (p, q)
(c) A → (q); B → (q, r); C → (p, r)
(d) A → (r); B → (p, r); C → (q, r)

28. Assertion : In meter bridge experiment, a high resistance is always connected in series with a galvanometer.

Reason : As resistance increases current through the circuit increases.

(a) If both assertion and reason are true and reason is the correct explanation of assertion
(b) If both assertion and reason are true but reason is not the correct explanation of assertion
(c) If assertion is true but reason is false
(d) If both assertion and reason are false.

29. The gap between the frequency of the side bands in an amplitude modulated wave is
(a) twice that of the carrier signal
(b) twice that of the message signal
(c) the same as that of the message signal
(d) the sum or difference of the frequencies of carrier and message signal

30. Match the following.

	Column I		Column II
(A)	A convex lens in a denser medium will behave like a	(p)	converging lens
(B)	A concave lens in a rarer medium will behave like a	(q)	diverging lens
(C)	A plano-convex lens silvered on its curved surface and placed in air will behave like a	(r)	concave mirror

(a) A → (p); B → (p); C → (q)
(b) A → (q); B → (q); C → (r)
(c) A → (r); B → (r); C → (p)
(d) A → (q); B → (p); C → (q)

31. A solenoid of length 30 cm with 10 turns per centimetre and area of cross-section 40 cm^2 completely surrounds another co-axial solenoid of same length, area of cross-section 20 cm^2 with 40 turns per centimetre. The mutual inductance of the system is
(a) 10 H (b) 8 H (c) 3 mH (d) 30 mH

32. The ratio of resolving powers of an optical microscope for two wavelengths λ_1 = 4000 Å and λ_2 = 6000 Å is
(a) 9 : 4 (b) 3 : 2 (c) 16 : 81 (d) 8 : 27

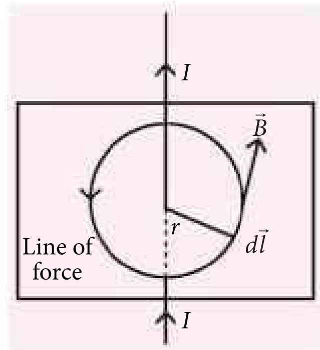
33. A point source of electromagnetic radiation has an average power output of 1500 W. The maximum value of electric field at a distance of 3 m from this source in V m^{-1} is
(a) 500 (b) 100 (b) $\frac{500}{3}$ (d) $\frac{250}{3}$

34. The half life of radon is 3.8 days. After how many days will only $(1/20)^{th}$ of radon sample be left over?
(a) 5 (b) 10 (c) 15 (d) 17

35. The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately
(a) 540 nm (b) 400 nm
(c) 310 nm (d) 220 nm.

CASE BASED MCQs

Case I : Read the passage given below and answer the following questions from 36 to 40.

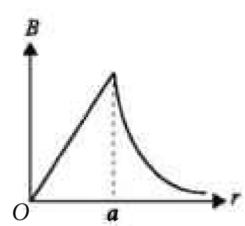


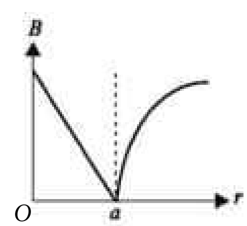
Ampere's law gives a method to calculate the magnetic field due to given current distribution. According to it, the circulation $\oint \vec{B} \cdot d\vec{l}$ of the resultant magnetic field along a closed plane curve is equal to μ_0 times the total current crossing the area bounded by the closed curve provided the electric field inside the loop remains constant. Ampere's law is more useful under certain symmetrical conditions. Consider one such case of a long Straight wire with circular cross-section (radius R) carrying current I uniformly distributed across this cross-section.

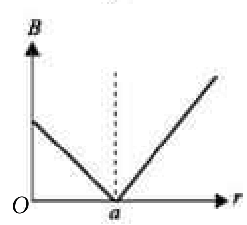
36. The magnetic field at a radial distance r from the centre of the wire in the region $r > R$, is
(a) $\frac{\mu_0 I}{2\pi r}$ (b) $\frac{\mu_0 I}{2\pi R}$ (c) $\frac{\mu_0 I R^2}{2\pi r}$ (d) $\frac{\mu_0 I r^2}{2\pi R}$

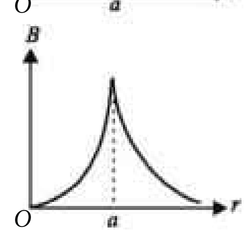
37. The magnetic field at a distance r in the region $r < R$ is
(a) $\frac{\mu_0 I}{2r}$ (b) $\frac{\mu_0 I r^2}{2\pi R^2}$ (c) $\frac{\mu_0 I}{2\pi r}$ (d) $\frac{\mu_0 I r}{2\pi R^2}$

38. A long straight wire of a circular cross section (radius a) carries a steady current I and the current I is uniformly distributed across this cross-section. Which of the following plots represents the variation of magnitude of magnetic field B with distance r from the centre of the wire?

(a)


(b)


(c)


(d)


39. A long straight wire of radius R carries a steady current I. The current is uniformly distributed across its cross-section. The ratio of magnetic field at $R/2$ and $2R$ is

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

40. A direct current I flows along the length of an infinitely long straight thin walled pipe, then the magnetic field is

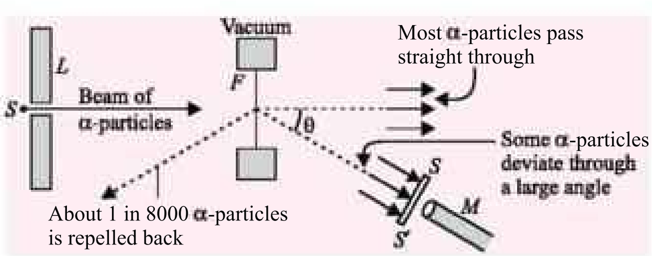
(a) uniform throughout the pipe but not zero
(b) zero only along the axis of the pipe
(c) zero at any point inside the pipe
(d) maximum at the centre and minimum at the edges.

Case II : Read the passage given below and answer the following questions from 41 to 45.

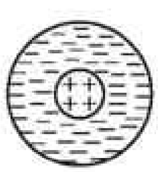
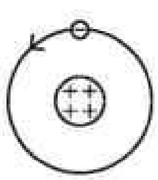
In 1911, Rutherford, along with his assistants, H. Geiger and E. Marsden, performed the alpha particle scattering experiment. H. Geiger and E. Marsden took radioactive source ($^{214}_{83}$Bi) for α-particles. A collimated beam of α-particles of energy 5.5 MeV was allowed to fall on 2.1×10^{-7} m thick gold foil. The α-particles were observed through a rotatable detector consisting of a Zinc sulphide screen and microscope. It was found that α-particles got scattered. These scattered α-particles produced scintillations on the zinc sulphide screen. Observations of this experiment are as follows

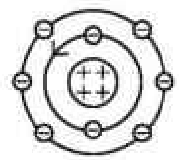
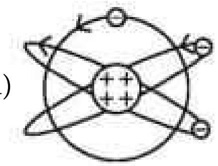
(I) Most of the α-particles passed through the foil without deflection.
(II) Only about 0.14% of the incident α-particles scattered by more than 1°.
(III) Only about one α-particle in every 8000 α-particles deflected by more than 90°.

These observations led to many arguments and conclusions which laid down the structure of the nuclear model of an atom.



41. Rutherford's atomic model can be visualised as

(a)  (b) 

(c)  (d) 

42. Gold foil used in Geiger-Marsden experiment is about 10^{-8} m thick. This ensures

(a) gold foil's gravitational pull is small or possible
(b) gold foil is deflected when α-particle stream is not incident centrally over it
(c) gold foil provides no resistance to passage of α-particles
(d) most α-particle will not suffer more than 1° scattering during passage through gold foil

43. In Geiger-Marsden scattering experiment, the trajectory traced by an α-particle depends on

(a) number of collision
(b) number of scattered α- particles
(c) impact parameter
(d) none of these

44. In the Geiger-Marsden scattering experiment, in case of head-on collision, the impact parameter should be

(a) maximum (b) minimum
(c) infinite (d) zero

45. The fact only a small fraction of the number of incident particles rebound back in Rutherford scattering indicates that

(a) number of α-particles undergoing head-on-collision is small
(b) mass of the atom is concentrated in a small volume
(c) mass of the atom is concentrated in a large volume
(d) both (a) and (b).

TRIO

ANSWERS APRIL 2023

The three letter word is **E C T**.

R **E C T** I F I E R
U N I D I R **E C T** I O N A L
R E F L **E C T** I O N

Winners : *Sapnodip Pramanik (W.B) Tapadyuti Chaudhary (W.B) Evereen Tafannoom (W.B)*

SOLUTIONS

1. **(a) :** The temperature coefficient of resistance of an alloy used for making resistors is small and positive.

2. **(a) :** According to Gauss's theorem in electrostatics,
$\phi = q/\in_0$
$q = \in_0\phi = 8.85 \times 10^{-12}\,[8 \times 10^3 - 2 \times 10^3]$
$= 53.10 \times 10^{-9}\ \text{C} = 0.053\ \mu\text{C}.$

3. **(c) :** When a soap bubble is charged, the charge gets uniformly distributed over its surface which results in repulsion between nearby charges. This causes, the bubble to expand.

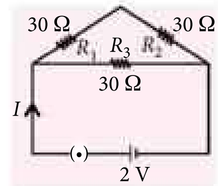
4. **(d) :** Since angle of dip at a place is defined as the angle δ, which is the direction of total intensity of earth's magnetic field B makes with a horizontal line in magnetic meridian,
At poles $B = B_V$ and $B_V = B\sin\delta$
$\therefore\ \sin\delta = 1 \Rightarrow \delta = 90°$
At equator $B = B_H$ and $B_H = B\cos\delta$
$\therefore\ \cos\delta = 1 \Rightarrow \delta = 0°.$

5. **(b) :** At resonance $X_L = X_C$ or $\omega L = \dfrac{1}{\omega C}$. Because of this impedance of LCR series circuit become equal to resistance of circuit $\left(Z = \sqrt{R^2 + (X_L - X_C)^2}\right)$.
Therefore from $I = \dfrac{E}{Z} = \dfrac{E}{R}$, at resonance, current in LCR series circuit is maximum. Correspondingly phase angle is also equal to zero. Therefore emf and current are in phase in LCR series circuit.

6. **(a) :** $I_{\max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$
$I_{\min} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$
Now, initially $I_1 = I_2 = I_0 \Rightarrow I_{\max} = 4I_0$
$I_{\min} = 0$
After, the width of one slit is made twice of the other slit. (Amplitude $\propto$ slit width (s))
$A_2 \propto s,\ I'_2 \propto A_2^2,\ I'_2 = I_0$
$A_1 \propto 2s \Rightarrow I_1 \propto 4s^2 \propto 4A_2^2 = 4I_0$
$I'_{\max} = \left(\sqrt{I'_1} + \sqrt{I'_2}\right)^2 = \left(\sqrt{4I_0} + \sqrt{I_0}\right)^2 = 9I_0$
$I'_{\min} = \left(\sqrt{I'_1} - \sqrt{I'_2}\right)^2 = \left(\sqrt{4I_0} - \sqrt{I_0}\right)^2 = I_0$
$I'_{\max} > I_{\max}$ and $I'_{\min} > I_{\min}$

7. **(b) :** Required work done = Change in potential energy of the system
$$W = U_f - U_i = k\frac{q_1q_2}{r_f} - k\frac{q_1q_2}{r_i} = k\,q_1q_2\left[\frac{1}{r_f} - \frac{1}{r_i}\right]$$
$$\therefore\ W = (9 \times 10^9)(3 \times 10^{-9} \times 1 \times 10^{-9}) \times \left[\frac{1}{4\times10^{-2}} - \frac{1}{5\times10^{-2}}\right]$$
$$= 27 \times 10^{-7} \times (0.05) = 1.35 \times 10^{-7}\ \text{J}$$

8. **(b) :** $R_s = R_1 + R_2 = 30 + 30 = 60\ \Omega$



$$\frac{1}{R_{eq}} = \frac{1}{R_s} + \frac{1}{R_3}$$
$$= \frac{1}{60} + \frac{1}{30} = \frac{1+2}{60} = \frac{3}{60}\ \Omega$$

In pursuit of a magic number, physicists discover new uranium isotope

While studying the atoms of heavy elements, physicists in Japan discovered a previously unknown isotope of uranium, with atomic number 92 and mass number 241, *i.e.*, uranium-241.

The finding refines our understanding of nuclear physics. What shapes the large nuclei of heavy elements take and how often (or rarely) defines the boundaries of models that physicists use to design nuclear power plants and models of exploding stars.

"The discovery of a new neutron-rich uranium isotope is the first since 1979," Toshitaka Niwase, a postdoctoral fellow with the KEK Wako Nuclear Science Centre (WNSC), Japan, and a member of the study, wrote in an email to *The Hindu*.

The arrangement of protons and neutrons in an atomic nucleus follows some rules. We know what these rules are based on the nuclei's properties and structure.

"In general, an atom's mass is slightly lower than the sum of the masses of protons, neutrons, and electrons," Michiharu Wada, head of the WNSC and another member of the group, explained via email.

So, systematically measuring the mass of "uranium and its neighbourhood elements yield essential nuclear information to understand the synthesis of such heavy elements in explosive astronomical events".

The researchers accelerated uranium-238 nuclei into plutonium-198 nuclei at the KEK Isotope Separation System. The resulting nuclear fragments contained different isotopes. This is how the researchers identified uranium-241 and measured the mass of its nucleus.

Theoretical calculations suggest it could have a half-life of 40 minutes, according to Dr. Niwase.

The team used time-of-flight mass spectrometry to estimate the mass of each nucleus depending on the time it took to reach a detector. "Precise mass value is a good fingerprint of atomic nuclides," Dr. Wada said.

There is particular interest in 'magic number' nuclei: containing a number of protons or neutrons such that the resulting nucleus is highly stable. The heaviest known 'magic' nucleus is lead (82 protons). Physicists have been trying to find the next such element.

"We'd like to extend the systematic mass measurements towards many neutron-rich isotopes, at least to neutron number 152, where a new 'magic number' is expected," Dr. Wada said.

Their work is a "first step" in this direction, he added.

Their paper was published by *Physical Review* Letters on March 31.

Courtesy : The Hindu

$\Rightarrow$ $R_{eq} = 20\ \Omega$

$\therefore$ Current, $I = \frac{V}{R_{eq}} = \frac{2}{20}\text{A} = 0.1\text{ A}$

9. (a) : $eV_s = h\upsilon - W$

$V_s = \left(\frac{h}{e}\right)\upsilon - \left(\frac{W}{e}\right)$

V_s vs υ graph is a straight line with constant slope = $\frac{h}{e}$

$\Rightarrow$ X and Y will be parallel.

When $V_s = 0$, $\upsilon_0 = \left(\frac{W}{h}\right)$.

As $W_Y > W_X \Rightarrow \upsilon_{0Y} > \upsilon_{0X}$.

It means the υ intercept of Y graph will be larger than the υ-intercept of X graph.

10. (a) : At resonance, V_L and V_C are equal in magnitude but have phase difference of 180° relative to each other.

$\therefore$ $V_{LC} = V_L - V_C = 0$

Hence, voltmeter V_2 read 0 volt.

11. (a)

12. (b): $\frac{\mu_0}{4\pi}\frac{2i_1}{r} - \frac{\mu_0}{4\pi}\frac{2i_2}{r} = 10\ \mu\text{T}$

$\frac{\mu_0}{4\pi}\frac{2i_1}{r} + \frac{\mu_0}{4\pi}\frac{2i_2}{r} = 30\ \mu\text{T}$

On solving $i_1 = 20$ A and $i_2 = 10$ A. $\therefore$ $i_1/i_2 = 2$

13. (a) : Here, $m_p = 1.007277$ amu

$m_n = 1.008665$ amu, $m_{Li} = 7.016005$ amu

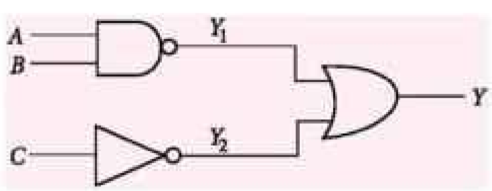
Sum of the masses of three protons and four neutrons

$= 3m_p + 4m_n = 3 \times 1.007277 + 4 \times 1.008665$

$= 3.021831 + 4.03466 = 7.056491$ amu

$\therefore$ Mass defect = 7.056491 – 7.016005 = 0.040486 amu

14. (c) :



Output of NAND gate, $Y_1 = \overline{A \cdot B}$

Output of NOT gate, $Y_2 = \overline{C}$

Output of OR gate, $Y = Y_1 + Y_2 = \overline{A \cdot B} + \overline{C}$

$= \overline{A} + \overline{B} + \overline{C}$ $\quad (\because\ \overline{A \cdot B} = \overline{A} + \overline{B})$

15. (b)

16. (d): $I_D = 1$ mA $= 10^{-3}$ A; $C = 2\ \mu$F $= 2 \times 10^{-6}$ F

$I_D = I_C = \frac{d}{dt}(CV) = C\frac{dV}{dt}$

Therefore, $\frac{dV}{dt} = \frac{I_D}{C} = \frac{10^{-3}}{2\times10^{-6}} = 500\ \text{V s}^{-1}$

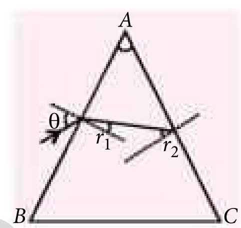
Therefore, applying a varying potential difference of 500 V s^{-1} would produce a displacement current of desired value.

17. (b): $r_n \propto n^2$ or $n \propto \sqrt{r_n}$. If r_i is the initial orbital radius and r_f is the final orbital radius, then the principal quantum number of the final state is

$n = \sqrt{\frac{r_f}{r_i}} = \left(\frac{21.2\times10^{-11}}{5.3\times10^{-11}}\right)^{1/2} = 2$

18. (c) : Since the magnetic field is uniform, hence there is no change in the magnetic flux linked with cylindrical wire and hence no current will be induced on the surface of cylindrical wire.

19. (c) : According to Snell's law,



$\sin\theta = \mu\sin r_1$

$\Rightarrow$ $\sin r_1 = \frac{\sin\theta}{\mu}$

or $r_1 = \sin^{-1}\left(\frac{\sin\theta}{\mu}\right)$

Now, $A = r_1 + r_2$

$\therefore$ $r_2 = A - r_1 = A - \sin^{-1}\left(\frac{\sin\theta}{\mu}\right)$ ...(i)

For the ray to get transmitted through the face AC, r_2 must be less than critical angle,

i.e., $r_2 < \sin^{-1}\left(\frac{1}{\mu}\right)$

or $A - \sin^{-1}\left(\frac{\sin\theta}{\mu}\right) < \sin^{-1}\left(\frac{1}{\mu}\right)$ (using (i))

$\Rightarrow$ $\sin^{-1}\left(\frac{\sin\theta}{\mu}\right) > A - \sin^{-1}\left(\frac{1}{\mu}\right)$

$\Rightarrow$ $\frac{\sin\theta}{\mu} > \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)$

$\Rightarrow$ $\theta > \sin^{-1}\left[\mu\sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$

20. (c) : The total energy in the first excited state is $-\frac{13.6}{4}$ eV = −3.4 eV.

This consists of the kinetic energy of 3.4 eV and the potential energy of –6.8 eV. In order to take the PE here as zero, we add 6.8 eV to all energy levels. The total energy in the ground state then becomes (–13.6 + 6.8) eV = –6.8 eV.

21. (c) : Assertion is correct, but the work function only depends on the photoelectric metal.

22. (d): Due to heating, number of electron-hole pairs will increase, so overall resistance of diode will change. Due to which forward biasing and reversed biasing both are changed.

23. (d): Here, $X_L = \omega L = 2\pi\upsilon L = 2\pi \times 50 \times 0.7 = 220\ \Omega$

$R = 220\ \Omega$

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{220^2 + 220^2} = 220\sqrt{2}\ \Omega$$

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{Z} = \frac{220\text{ V}}{220\sqrt{2}\ \Omega} = \frac{1}{\sqrt{2}}\text{ A}$$

$$\sin\phi = \frac{X_L}{Z} = \frac{220}{220\sqrt{2}} = \frac{1}{\sqrt{2}}$$

$$\text{Wattless current} = I_{\text{rms}} \sin\phi = \frac{1}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = \frac{1}{2}\text{ A} = 0.5\text{ A}$$

24. (c) : For a transistor, $I_E = I_B + I_C$ ... (i)

Given that, $I_C = \frac{90}{100} I_E = \frac{9}{10} I_E$

Since $I_C = 10$ mA

$\therefore\ I_E = 10 \times \frac{10}{9}\text{ mA} = 11.1\text{ mA} \approx 11\text{ mA}$

and $I_B = I_E - I_C = (11.1 - 10)$ mA (Using (i))

$= 1.1$ mA ≈ 1 mA

25. (c) : $I = \chi H = (4 \times 10^{-4}) \times (3 \times 10^{-4})$

$= 12 \times 10^{-8}\ \text{A m}^{-1}$

26. (d): The maximum distance between the transmitter and receiver for satisfactory communication in LOS mode is

$$d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

where h_T and h_R are the heights of transmitting and receiving antennas respectively.

Here, $d_M = 40\text{ km} = 40 \times 10^3$ m,

$h_T = 20$ m, $R = 64 \times 10^5$ m

$$\therefore\ 40\times10^3\text{ m} = \sqrt{2(64\times10^5\text{ m})(20\text{ m})} + \sqrt{2(64\times10^5\text{ m})h_R}$$

$$40\times10^3\text{ m} = 16\times10^3\text{m} + \sqrt{(128\times10^5\text{ m})h_R}$$

or $$\sqrt{(128\times10^5\text{ m})h_R} = 40\times10^3\text{ m} - 16\times10^3\text{ m}$$

$$= 24 \times 10^3\text{ m}$$

Squaring both sides, we get

$(128 \times 10^5\text{ m})h_R = (24 \times 10^3\text{ m})^2$

$$h_R = \frac{(24\times10^3\text{ m})^2}{(128\times10^5\text{ m})} = 45\text{ m}$$

27. (a) : A → (p, q); B → (p, q, r); C → (p, q, r)

Electrical conductivity of a conductor depends on temperature of the martial. It decreases with the increase in temperature. It also depends upon the nature of martial.

Conductance (the reciprocal of resistance also depends upon dimension of material apart from temperature and nature of material.

$J = \sigma E$, so current density depends upon electric field. For a given conductor, σ is fixed.

Contributed by : Sanodip Pramanik (W.B.)

SOLUTIONS TO APRIL 2023 WORD GRID

E	L	E	C	T	R	I	C	U	R	R	E	N	T
L	E	N	F	R	E	E	F	A	L	L	D	E	F
E	N	A	R	P	Q	R	S	T	A	B	C	D	E
V	G	A	I	N	E	R	T	I	A	X	Y	Z	U
E	P	C	C	F	S	I	N	S	I	T	A	N	C
L	H	O	T	R	I	C	U	O	G	U	R	M	A
O	A	S	I	O	N	O	F	T	T	L	O	T	R
C	A	T	O	S	I	P	E	O	W	R	T	L	O
I	L	R	N	E	U	N	I	N	U	N	M	O	M
T	F	E	A	D	I	S	P	E	R	S	I	O	N
Y	P	E	L	S	W	T	U	S	R	A	O	P	I
T	E	A	T	R	A	N	S	F	O	R	M	E	R
R	R	L	R	T	V	F	T	T	S	A	N	U	N
A	M	M	A	R	E	A	R	A	C	M	E	T	E
C	A	A	N	A	L	N	E	R	I	E	X	E	R
C	N	G	S	C	E	G	A	R	L	T	X	N	R
U	E	N	I	C	N	E	M	C	L	E	L	S	T
R	N	E	S	U	G	O	L	Y	A	R	A	I	U
A	T	T	T	R	T	S	I	Y	T	M	E	O	C
C	O	I	O	I	H	T	N	A	O	M	E	N	E
Y	E	S	R	S	D	A	E	A	N	M	E	T	E
Y	S	M	A	M	S	T	D	B	F	E	L	N	R

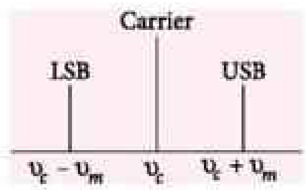
Across
1. Freefall
2. Inertia
3. Transformer
4. Current
5. Dispersion

Down
1. Friction
2. Isotones
3. Wavelength
4. Transistor
5. Streamline

Current will depend upon resistance, which depends upon dimension, temperature and nature of material.

28. (c) : The resistance of the galvanometer is fixed. In meter bridge experiments, to protect the galvanometer from a high current, high resistance is connected to the galvanometer in order to protect it from damage.

29. (b): The frequency spectrum of an amplitude modulated wave is shown in the figure.



The gap between the frequency of the side bands (*i.e.* upper side band and lower side band) is called bandwidth and it is given by bandwidth = $\upsilon_{USB} - \upsilon_{LSB}$

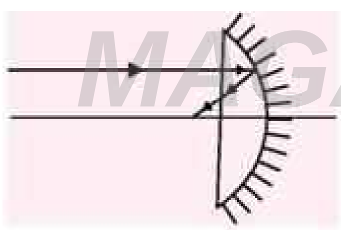
$$= (\upsilon_c + \upsilon_m) - (\upsilon_c - \upsilon_m) = \upsilon_c + \upsilon_m - \upsilon_c + \upsilon_m = 2\upsilon_m$$

i.e., Bandwidth = twice of the frequency of the message signal.

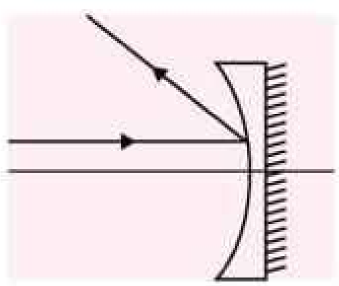
30. (b) : A → (q); B → (q); C → (r)

A convex lens in a denser medium will behave like a concave lens or diverging lens.

A concave lens in a rarer medium will behave like a concave lens or diverging lens.



Behaves like concave mirror.



Behaves like convex mirror.

31. (c) : Mutual inductance of the system,

$M = \mu_0 n_1 n_2 A_2 l$

where A_2 is the area of inner solenoid

$n_1 = 10\ \text{cm}^{-1} = 1000\ \text{m}^{-1}$

$n_2 = 40\ \text{cm}^{-1} = 4000\ \text{m}^{-1}$

$l = 30\ \text{cm} = 30 \times 10^{-2}\ \text{m}$

$A_2 = 20\ \text{cm}^2 = 20 \times 10^{-4}\ \text{m}^2$

$\therefore\ M = 4\pi \times 10^{-7} \times 1000 \times 4000 \times 20 \times 10^{-4} \times 30 \times 10^{-2}$

$= 301.44 \times 10^{-5}\ \text{H} = 3\ \text{mH}$

32. (b): The resolving power of an optical microscope,

$$\text{RP} = \frac{2\mu \sin\theta}{\lambda};\ \therefore \frac{\text{RP}_1}{\text{RP}_2} = \frac{6000}{4000} = \frac{3}{2}$$

33. (b): Average intensity of electromagnetic waves is

$$I = \frac{P}{4\pi r^2} = \frac{1}{2}\varepsilon_0 E_0^2 c \quad \text{or} \quad E_0 = \left[\frac{P}{2\pi r^2 \varepsilon_0 c}\right]^{1/2}$$

Substituting the given values, we get

$$E_0 = \left[\frac{1500}{2\pi(3)^2 \times \left[\left(1/4\pi \times 9 \times 10^9\right)\right] \times 3 \times 10^8}\right]^{1/2}$$

$= 100\ \text{V m}^{-1}$

34. (d): $\lambda = \frac{0.693}{T_{1/2}}$, Here, $T_{1/2} = 3.8$ days

$$\therefore\ \lambda = \frac{0.693}{3.8} = 0.182 \text{ per day}$$

If initially at $t = 0$, the number of atoms present be N_0, then the number of atoms N left after a time t is given by

$$N = N_0 e^{-\lambda t} \quad \text{or} \quad \frac{N}{N_0} = e^{-\lambda t} \quad \text{or} \quad \frac{1}{20} = e^{-\lambda t} \quad \therefore\ e^{\lambda t} = 20$$

Taking log on both sides we get,

$\lambda t = \log_e 20 = 2.3026 \log_{10} 20$

$$t = \frac{2.3026 \log_{10} 20}{\lambda} = \frac{2.3026 \log_{10} 20}{0.182} \approx 17 \text{ days.}$$

35. (c) : Let λ_m = Longest wavelength of light

$$\therefore\ \frac{hc}{\lambda_m} = \phi(\text{work function})$$

$$\therefore\ \lambda_m = \frac{hc}{\phi} = \frac{(6.63 \times 10^{-34}) \times (3 \times 10^8)}{4.0 \times 1.6 \times 10^{-19}} \text{ or } \lambda_m = 310 \text{ nm.}$$

36. (a) : Magnetic field due to a long current carrying wire at r

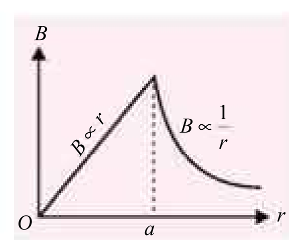
$$B = \frac{\mu_0 I}{2\pi r}$$

37. (d) : Let I' be the current in region $r < R$

$$\text{Then, } I' = \frac{I}{\pi R^2}\pi(r^2) \quad \text{or} \quad I' = \frac{Ir^2}{R^2}$$

$$\text{So, magnetic field, } B = \frac{\mu_0 I'}{2\pi r} = \frac{\mu_0 I r^2}{2\pi R^2 r} = \frac{\mu_0 I r}{2\pi R^2}$$

38. (a) : Magnetic field due to a long straight wire of radius a carrying current I at a point distant r from the centre of the wire is given as follows



$$B = \frac{\mu_0 Ir}{2\pi a^2} \quad \text{for } r < a \,;\, B = \frac{\mu_0 I}{2\pi a} \quad \text{for } r = a$$

$$B = \frac{\mu_0 I}{2\pi r} \quad \text{for } r > a$$

The variation of magnetic field B with distance r from the centre of wire is shown in the figure.

39. (d): Let the magnetic fields due to a long straight wire of radius R carrying a steady current I at a distance r from the centre of the wire are

$$B_1 = \frac{\mu_0 Ir}{2\pi R^2} \quad (\text{For } r < R) \quad \text{and} \quad B_2 = \frac{\mu_0 I}{2\pi R} \quad (\text{For } r > R)$$

So, the magnetic field at $r = \frac{R}{2}$ is $B_1 = \frac{\mu_0 I}{2\pi R^2}\left(\frac{R}{2}\right) = \frac{\mu_0 I}{4\pi R}$

and at $r = 2R$ is $B_2 = \frac{\mu_0 I}{2\pi(2R)} = \frac{\mu_0 I}{4\pi R}$

$\therefore$ Their corresponding ratio is

$$\frac{B_1}{B_2} = \frac{(\mu_0 I/4\pi R)}{(\mu_0 I/4\pi R)} = 1$$

40. (c)

41. (d): Rutherford's atom had a positively charged centre and electrons were revolving outside it. It is also called the planetary model of the atom as in option (d).

42. (d): As the gold foil is very thin, it can be assumed that α-particles will suffer not more than one scattering during their passage through it. Therefore, computation of the trajectory of an α-particle scattered by a single nucleus is enough.

43. (c): Trajectory of α-particles depends on impact parameter which is the perpendicular distance of the initial velocity vector of the α particles from the centre of the nucleus. For small impact parameter α particle close to the nucleus suffers larger scattering.

44. (b): At minimum impact parameter, α particles rebound back ($\theta \approx \pi$) and suffers large scattering.

45. (d): In case of head-on-collision, the impact parameter is minimum and the α-particle rebounds back. So, the fact that only a small fraction of the number of incident particles rebound back indicates that the number of α-particles undergoing head-on collision is small. This in turn implies that the mass of the atom is concentrated in a small volume. Hence, option (a) and (b) are correct.

UNSCRAMBLE ME

Unscramble the words given in column I and match them with their explanations in column II.

Column I	Column II
1. ERROMEBTA	(a) A light wave whose parts are all in phase with each other.
2. EITCOEPLIR	(b) Property of a material that allows to regain its original shape.
3. EDNO	(c) Instrument used to measure atmospheric pressure.
4. TITYCISAEL	(d) Negative electrode of an electron tube.
5. ONCATIECFITIR	(e) Property of substance whereby it is fully repelled by a magnet.
6. CETHOAD	(f) Interaction between moving objects that lasts for certain time.
7. OCSITP	(g) Object thrown into space at some angle under the action of gravity.
8. LLIONSIOC	(h) Point of no disturbance of a standing wave.
9. HEROCTEN	(i) Branch of physics which deals with behavior and properties of light.
10. AIDGNSMITAME	(j) Electric process which converts alternating current into direct current.

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

JEE 2023 PRACTICE PAPER ADVANCED

Exam on 4th June

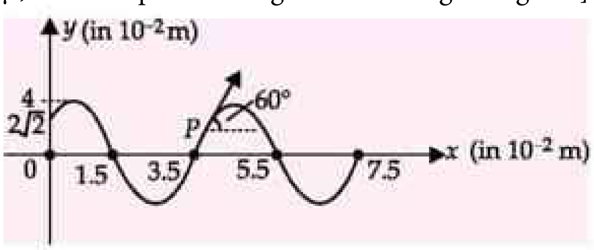
PAPER - I

SECTION 1

This section contains EIGHT (08) questions.
The answer to each question is a NUMERICAL VALUE.
For each question, enter the correct numerical value of the answer using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. If the numerical value has more than two decimal places, truncate/round-off the value to TWO decimal places.
Answer to each question will be evaluated according to the following marking scheme:

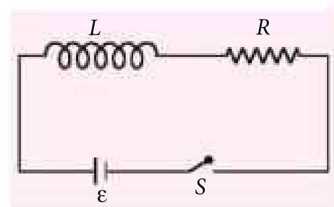
Full Marks : +3 *ONLY if the correct numerical value is entered;*
Zero Marks : 0 *In all other cases.*

1. The figure shows a snap photograph of a vibrating string at $t = 0$. The particle P is observed moving up with velocity $20\sqrt{3}$ cm s^{-1}. The tangent at P makes an angle 60° with x-axis. The total energy carried by the wave per cycle of the string, is $n\pi^2 \times 10^{-5}$ J. The value of n is _____. [Assuming that μ, the mass per unit length of the string = 50 g m^{-1}]

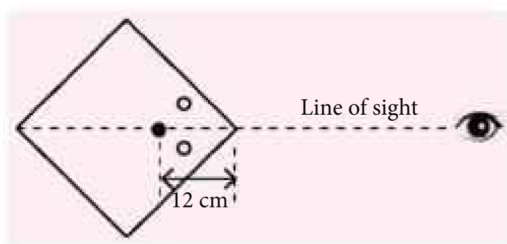


2. A diatomic ideal gas is heated at constant volume until the pressure is doubled and again heated at constant pressure until volume is doubled. The average molar heat capacity for whole process is $\frac{nR}{6}$. The value of n is _______.

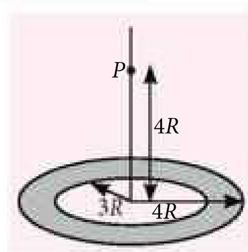
3. As shown in the figure, a battery of emf ε is connected to an inductor L and resistance R in series. The switch is closed at $t = 0$. The total charge that flows from the battery, between $t = 0$ and $t = t_c$ (t_c is the time constant of the circuit) is $\frac{\varepsilon L}{eR^n}$ where the value of n is ________.



4. A large square container with thin transparent vertical walls and filled with water (refractive index $\frac{4}{3}$) is kept on a horizontal table. A student holds a thin straight wire vertically inside the water 12 cm from one of its corners, as shown schematically in the figure. Looking at the wire from this corner, another student sees two images of the wire, located symmetrically on each side of the line of sight as shown. The separation between these images is ____________ cm.



5. A thin uniform annular disc (see the figure) of mass M has an outer radius $4R$ and an inner radius $3R$. The work required to take a unit mass from point P on its axis to infinity is $\frac{2GM}{xR}(4\sqrt{2}-5)$. The value of x is ________.



6. A circular disc X of radius R is made from an iron plate of thickness t, and another disc Y of radius $4R$

is made from an iron plate of thickness $t/4$. Then the relation between the moment of inertia I_X and I_Y is given by $I_Y = nI_X$. The value of n is _______.

7. Two soap bubbles combine to form a single bubble. In this process, the change in volume and surface area are respectively V and A. If P is the atmospheric pressure, and T is the surface tension of the soap solution, the relation which is true is given by $nPV + 4TA$. The value of n is _______.

8. The bob of a simple pendulum executes simple harmonic motion in water with a period t, while the period of oscillation of the bob is t_0 in air. Neglecting frictional force of water and given that the density of the bob is $(4/3) \times 1000$ kg m^{-3}, true relationship between t and t_0 is $t = xt_0$ where the value of x is ________.

SECTION 2

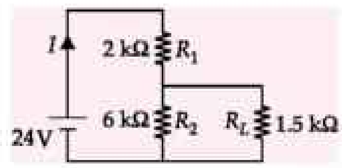
This section contains SIX (06) question stems.
There are FOUR (04) options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct answer(s).
For each question, choose the option(s) corresponding to (all) the correct answer(s).
Answer to each question will be evaluated according to the following marking scheme.

Full Marks :	*+4*	*ONLY if (all) the correct option(s) is(are) chosen;*
Partial Marks :	*+3*	*If all the four options are correct but ONLY two options are chosen, both of which are correct;*
Partial Marks :	*+2*	*If three or more options are correct but ONLY two options are chosen, both of which are correct option;*
Partial Marks :	*+1*	*If two or more options are correct but ONLY one option is chosen and it is a correct option;*
Zero Marks :	*0*	*If none of the options is chosen (i.e. the question is unanswered);*
Negative Marks :	*–2*	*In all other cases.*

9. Two wires A and B have equal lengths and are made of the same material, but the diameter of A is twice that of wire B. Then, for a given load
   (a) the extension of A will be four that of B
   (b) the extensions of A and B will be equal
   (c) the strain in B is four times that in A
   (d) the strain in A and B will be equal.

10. Two fixed charges $-2Q$ and $+Q$ are located at points $(-3a, 0)$ and $(+3a, 0)$
    (a) points where the electric potential due to the two charges is zero, lie on a circle of radius $4a$ and centre $(5a, 0)$
    (b) potential is zero at $x = 0$ and $x = 9a$
    (c) If a particle of charge $+q$ is released from the centre of the circle obtained in part (a) it will eventually cross the circle
    (d) Electric field at origin is along x-axis.

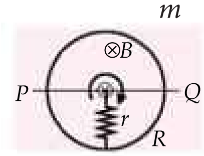
11. For the circuit shown in the figure,



    (a) the current I through the battery is 7.5 mA
    (b) the potential difference across R_L is 18 V
    (c) ratio of powers dissipated in R_1 and R_2 is 3
    (d) if R_1 and R_2 are interchanged, magnitude of the power dissipated in R_L will decreases by a factor of 9.

12. A particle of charge q and mass m moves rectilinearly under the action of an electric field $E = \alpha - \beta x$. Here, α and β are positive constants and x is the distance from the point where the particle was initially at rest. Then,
    (a) the motion of the particle is oscillatory
    (b) the amplitude of the particle is (α/β)
    (c) the mean position of the particle is at $x = (\alpha/\beta)$
    (d) the maximum acceleration of the particle is $\frac{q\alpha}{m}$.

13. In figure, R is a fixed conducting ring of negligible resistance and radius a. PQ is a uniform rod of resistance r. It is hinged at the centre of the ring and rotated about this point in clockwise direction with a uniform angular velocity ω. There is uniform magnetic field of strength B pointing inward and r is a stationary resistance. Then



    (a) current through r is zero
    (b) current through r is $\frac{2B\omega a^2}{5r}$
    (c) direction of current in external resistance r is from centre to circumference.
    (d) direction of current in external resistance r is from circumference to centre.

14. When a point light source of power W emitting monochromatic light of wavelength λ is kept at a distance a from a photo-sensitive surface of work function ϕ and area S, we will have

(a) Number of photons striking the surface per unit time as $W\lambda S/4\pi hca^2$

(b) The maximum energy of the emitted photoelectrons as $(1/\lambda)(hc - \lambda\phi)$

(c) The stopping potential needed to stop the most energetic emitted photoelectrons as $(e/\lambda)(hc - \lambda\phi)$

(d) Photo-emission only if λ lies in the range $0 \le \lambda \le (hc/\phi)$.

SECTION 3

This section contains FOUR (04) Matching List Sets.
Each set has ONE Multiple Choice Question.
Each set has TWO lists: List-I and List-II.
List-I has Four entries (I), (II), (III) and (IV) and List-II has Five entries (P), (Q), (R), (S) and (T).
FOUR options are given in each Multiple Choice Question based on List-I and List-II and ONLY ONE of these four options satisfies the condition asked in the Multiple Choice Question.
Answer to each question will be evaluated according to the following marking scheme:

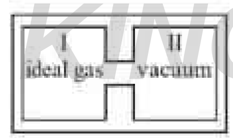
Full Marks :	+3	ONLY if the option corresponding to the correct combination is chosen;
Zero Marks :	0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks :	–1	In all other cases.

15. Match the following.

	Column I		Column II
I.	Radius of orbit depends on principal quantum number as	P.	increase
II.	Due to orbital motion of electron, magnetic field arises at the center of nucleus is proportional to principal quantum number as	Q.	decrease
III.	If electron is going from lower energy level to higher energy level, then velocity of electron will	R.	proportional to $\frac{1}{n^2}$
IV.	If electron is going from lower energy level to higher energy level, then total energy of electron will	S.	proportional to n^2
		T.	proportional to $\frac{1}{n^5}$

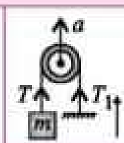
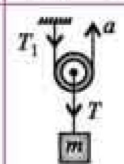
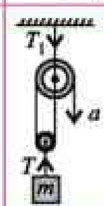
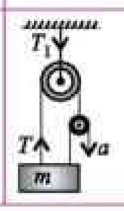
(a) I → (Q), II → (P), III → (S), IV → (T)
(b) I → (S), II → (T), III → (Q), IV → (P)
(c) I → (Q), II → (P), III → (S), IV → (R)
(d) I → (T), II → (Q), III → (P), IV → (R)

16. Column I contains a list of processes involving expansion of an ideal gas. Match this with column II describing the thermodynamic change during this process.

	Column I		Column II
I.	An insulated container has two chambers separated by a valve. Chamber I contains an ideal gas and the chamber II has vacuum. The valve is opened. 	P.	The temperature of the gas decreases
II.	An ideal monatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^2}$, where V is the volume of the gas	Q.	The temperature of the gas increases.
III.	An ideal monatomic gas expands to twice its original volume such that its pressure $P \propto \frac{1}{V^{4/3}}$, where V is its volume	R.	The gas loses heat
IV.	An ideal monatomic gas expands such that its pressure P and volume V follows the behaviour shown in the graph 	S.	The gas gains heat
		T.	The temperature of the gas remains constant

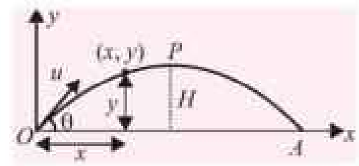
(a) I → (Q), II → (P), III → (S), IV → (T)
(b) I → (P, S), II → (T), III → (Q, S), IV → (P)
(c) I → (Q), II → (P), III → (S), IV → (R)
(d) I → (T), II → (P, R), III → (P, S), IV → (Q, S)

17. The string and pulley are ideal. Given : mass of the block is m, T is the tension in the string shown, a_{pulley} is the acceleration of the movable pulley in each case, $a = \frac{g}{3}$ where g is the acceleration due to gravity. T_1 is the force on the fixed support.

Column I		Column II	
I.		P.	$a_{block} \leq a$
II.		Q.	$a_{pulley} \leq a$
III.		R.	$T > mg$
IV.		S.	$T_1 > \frac{3}{2} mg$

(a) I → (P, Q, R), II → (Q, R, S), III → (P, Q), IV → (R, S)
(b) I → (Q, R, S), II → (P, Q, R), III → (P, Q, R, S), IV → (P, Q)
(c) I → (Q), II → (P), III → (S), IV → (R)
(d) I → (P, Q), II → (Q, R), III → (P), IV → (P, Q, R, S)

18. The trajectory of a projectile in a vertical plane is $y = \sqrt{3}x - 2x^2$. $[g = 10 \text{ m s}^{-2}]$



Column I		Column II	
I.	Maximum height, H	P.	$\frac{\sqrt{3}}{2}$
II.	Range OA	Q.	60°
III.	Time of flight	R.	$\sqrt{\frac{3}{10}}$
IV.	Angle of projection	S.	$\frac{3}{8}$

(a) I → (S), II → (P), III → (R), IV → (Q)
(b) I → (S), II → (T), III → (Q), IV → (P)
(c) I → (Q), II → (P), III → (S), IV → (R)
(d) I → (T), II → (Q), III → (P), IV → (R)

PAPER - II

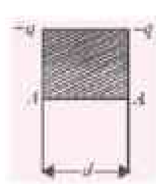
SECTION 1

This section contains EIGHT (08) questions.
The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 TO 9, BOTH INCLUSIVE.
For each question, enter the correct integer corresponding to the answer using the mouse and the on screen virtual numeric keypad in the place designated to enter the answer.
Answer to each question will be evaluated according to the following marking scheme:

Full Marks :	*+3*	*If ONLY the correct integer is entered;*
Zero Marks :	*0*	*If the question is unanswered;*
Negative Marks :	*–1*	*In all other cases.*

1. A man of 80 kg is standing on the rim of a circular platform of mass 200 kg. The platform rotates about its axis at 12 rpm. The man moves from rim to centre of the platform. The system rotates at the rate of 11x rpm, then the value of x is _____. (The moment of inertia of man at the centre may be negelcted)

2. A parallel plate capacitor has separation d = 8.85 × 10^{-4}m. The plate area is 0.04 m^2. A slab of dielectric constant K = 9 is placed inside the capacitor as shown.The capacitor is then charged to a

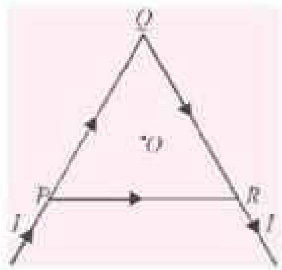


potential difference of 110 V. The work done by an agent is 4.84×10^{-n} J, then the value of n is ______.

3. A block of mass m moving with speed v compresses a spring through a distance x before its speed is halved. Spring constant is given by $\frac{3mv^2}{qx^2}$, then the value of q is ______.

4. The relative density of a material is found by weighing the body first in air and then in water. If the weight in air is and weight in water is then, find the maximum permissible percentage error in relative density.

5. An equilateral triangle of side length l is formed from a piece of wire of uniform resistance. The current I is fed as shown in the figure. The magnitude of the magnetic field at its centre O is ________.



6. A pendulum clock looses 12 second a day at 25 °C and gains 3 second a day at 15 °C. The coefficient of linear expansion of the wire of pendulum, is 3.47×10^{-x} nm, than the value of x is _______.

7. The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is 8235×10^{-x} nm, than the value of x is _______.

8. A man in a balloon rising vertically with an acceleration of 4.9 m/s^2 releases a ball 2 sec after the balloon is let go from the ground. The greatest height above the ground reached by the ball is $7.35x$, than the value of x is _____. (g = 9.8 m/s^2)

SECTION 2

This section contains SIX (06) questions.

Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is (are) correct answer(s).

For each question, choose the option(s) corresponding to (all) the correct answer(s).

Answer to each question will be evaluated according to the following marking scheme:

Full Marks :	*+4*	*ONLY if (all) the correct option(s) is(are) chosen;*
Partial Marks :	*+3*	*If all the four options are correct but ONLY three options are chosen;*
Partial Marks :	*+2*	*If three or more options are correct but ONLY two options are chosen, both of which are correct;*
Partial Marks :	*+1*	*If two or more options are correct but ONLY one option is chosen and it is a correct option;*
Zero Marks :	*0*	*If unanswered;*
Negative Marks :	*–2*	*In all other cases.*

9. An infinite number of charges each equal to q are placed along the x-axis at $x = 1$, $x = 2$, $x = 4$ and so on. A charge $q/2$ is placed at $x = 0$. Then

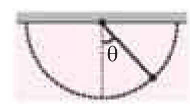
(a) the potential at $x = 0$ is $\frac{q}{4\pi\varepsilon_0}$

(b) the potential at $x = 0$ is $\frac{q}{2\pi\varepsilon_0}$

(c) the potential energy is $\frac{q^2}{4\pi\varepsilon_0}$

(d) the potential energy is $\frac{q^2}{8\pi\varepsilon_0}$.

10. A simple pendulum is vibrating with an angular amplitude of 90° as shown in figure, then



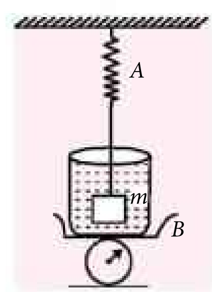
(a) $\theta = 0$, acceleration directed downward

(b) $\theta = 0$, acceleration directed upward

(c) $\theta = 90°$, acceleration directed downward

(d) $\theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$, acceleration directed horizontal

11. The spring balance A reads 2 kg with a block m suspended from it. A balance B reads 5 kg when a beaker with liquid is put on the pan of the balance. The two balances are now so arranged that the hanging mass is inside the liquid in the beaker as shown in the figure. In this situation:



(a) the balance A will read more than 2 kg

(b) the balance B will read more than 5 kg

(c) the balance A will read less than 2 kg and B will read more than 5 kg

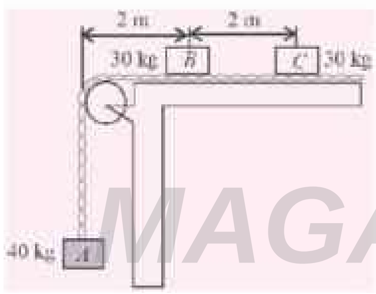
(d) the balance A and B will read 2 kg and 5 kg respectively.

12. Two short bar magnets of magnetic moments M each are arranged at the opposite corners of a square of side d such that their centres coincide with the corners and their axes are parallel. If the like poles are in the same direction, the magnetic induction at any of the other corners of the square is

(a) $\frac{\mu_0}{4\pi}\frac{M}{d^3}$ (b) $\frac{\mu_0}{4\pi}\frac{2M}{d^3}$

(c) $\frac{\mu_0}{4\pi}\frac{M}{2d^3}$ (d) $\frac{\mu_0}{4\pi}\frac{M^3}{2d^3}$

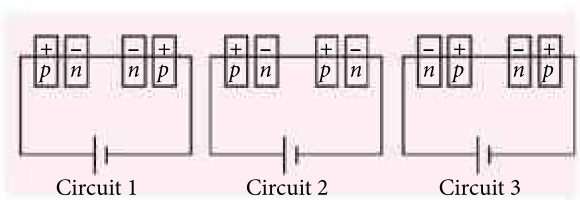
13. Two 30 kg blocks rest on a massless belt which passes over a fixed pulley and is attached to a 40 kg block. If coefficient of friction between the belt and the table as well as between the belt and the blocks B and C is μ and the system is released from rest from the position shown, the speed with which the block B falls off the belt is



(a) $2\sqrt{2}$ m/s if $\mu = 0.2$ (b) $\sqrt{2}$ m/s if $\mu = 0.2$

(c) 2 m/s if $\mu = 0.5$ (d) 2.5 m/s if $\mu = 0.5$

14. Two identical p-n junctions may be connected in series with a battery in three ways, as shown in figure. The potential drops across the two p-n junctions are equal in



(a) circuit 1 and circuit 2
(b) circuit 2 and circuit 3
(c) circuit 3 and circuit 1
(d) circuit 1 only.

SECTION 3

This section contains FOUR (04) questions.
Each question has FOUR options (a), (b), (c) and (d). ONLY ONE of these four options is the correct answer.
For each question, choose the option corresponding to the correct answer.
Answer to each question will be evaluated according to the following marking scheme:

Full Marks :	***+3***	***If ONLY the correct option is chosen;***
Zero Marks :	***0***	***If none of the options is chosen (i.e. the question is unanswered);***
Negative Marks :	***–1***	***In all other cases.***

15. The rms value of the electric field of the light coming from the sun is 720 N C^{-1}. The total average energy density of the electromagnetic wave is

(a) 3.3×10^{-3} J m^{-3} (b) 4.58×10^{-6} J m^{-3}

(c) 6.37×10^{-9} J m^{-3} (d) 81.35×10^{-12} J m^{-3}.

16. Standing waves are produced by the superposition of two waves $y_1 = 0.05 \sin(3\pi t - 2x)$ and $y_2 = 0.05 \sin(3\pi t + 2x)$ where x and y are in metres and t is in second. What is the amplitude of the particle at $x = 0.5$ m? Given cos 57.3° = 0.54.

(a) 2.7 cm (b) 5.4 cm

(c) 8.1 cm (d) 10.8 cm

17. The two slits are 1 mm apart from each other and illuminated with a light of wavelength 5×10^{-7} m. If the distance of the screen is 1 m from the slits, then the distance between third dark fringe and fifth bright fringe is

(a) 1.5 mm (b) 0.75 mm

(c) 1.25 mm (d) 0.625 mm

18. A gaseous mixture consists of 16 g of helium and 16 g of oxygen. The ratio C_P/C_V of the mixture is

(a) 1.4 (b) 1.54 (c) 1.59 (d) 1.62

SOLUTIONS

PAPER - I

1. **(16) :** $A = 4 \times 10^{-3}$m, $\lambda = 5.5 - 1.5 = 4$ cm

Slope of tangent at point P,

$$\frac{\partial y}{\partial x} = \tan 60° = \sqrt{3}$$

For the particle P,

$$\frac{\partial y}{\partial t} = -\left(\frac{\partial y}{\partial x}\right)$$

$$\Rightarrow +20\sqrt{3} = -v(\sqrt{3}) \Rightarrow v = -20 \text{ cm s}^{-1}$$

$$f = \frac{v}{\lambda} = \frac{20 \text{ cm s}^{-1}}{4 \text{ cm}} = 5 \text{ Hz}$$

Energy carried in one wavelength

$$E=\frac{1}{2}\mu A^2\omega^2\lambda=\frac{1}{2}\times\frac{50}{1000}\times(4\times10^{-2})^2\times(10\pi)^2\times\frac{4}{100}$$

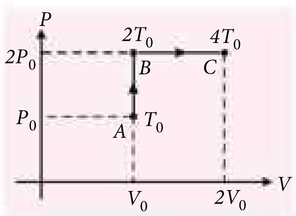
$= 16\pi^2 \times 10^{-5}$ J

2. (19) : Let initial pressure, volume, temperature be P_0, V_0, T_0 indicated by state A in P-V diagram shown in figure. The gas is then isochorically taken to state $B(2P_0, V_0, 2T_0)$ and then taken from state B to state $C(2P_0, 2V_0, 4T_0)$ isobarically.

Total heat absorbed by 1 mole of gas

$\Delta Q = C_V(2T_0 - T_0) + C_P(4T_0 - 2T_0)$

$$=\frac{5}{2}RT_0+\frac{7}{2}R\times2T_0=\frac{19}{2}RT_0$$



Total change in temperature from state A to C is

$\Delta T = 3T_0$

$\therefore$ Molar heat capacity

$$=\frac{\Delta Q}{\Delta T}=\frac{\frac{19}{2}RT_0}{3T_0}=\frac{19}{6}R$$

3. (2) : In case of charging, $i = i_0(1 - e^{-t/\tau})$

where, $\tau = L/R = t_c$

$$\text{So, charge } q=\int_0^{t_c} i\,dt=\int_0^{t_c} i_0(1-e^{t/t_c})dt$$

$$=\frac{\varepsilon}{R}\int_0^{t_c}(1-e^{-t/t_c})dt=\frac{\varepsilon}{R}\left[t+t_ce^{-t/t_c}\right]_0^{t_c}$$

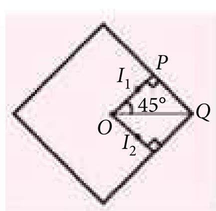
$$=\frac{\varepsilon}{R}\left[(t_c+t_ce^{-t_c/t_c})-(0+t_ce^{-0})\right]$$

$$=\frac{\varepsilon}{R}[(t_c+t_ce^{-1})-t_c]=\frac{\varepsilon}{R}t_ce^{-1}=\frac{\varepsilon}{Re}\times\frac{L}{R};\ q=\frac{\varepsilon L}{eR^2}$$

4. (3) : Let the two images of object O formed be I_1 and I_2.

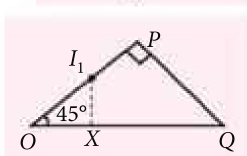
In ΔPOQ, $\angle POQ = 45°$

$$\therefore\ PO = OQ\cos45° = \frac{12}{\sqrt{2}}\text{ cm}$$



$$\text{Now, } {}^1\mu_2=\frac{\text{apparent depth}}{\text{original depth}}$$

$$\therefore\ \frac{1}{4/3}=\frac{PI_1}{PO}$$



$$\Rightarrow\ PI_1=\frac{3}{4}\times\frac{12}{\sqrt{2}}=\frac{9}{\sqrt{2}}\text{ cm}$$

$$\therefore\ OI_1=OP-PI_1=\frac{12}{\sqrt{2}}-\frac{9}{\sqrt{2}}=\frac{3}{\sqrt{2}}\text{ cm}$$

$$\therefore\ I_1X=OI_1\sin45°=\frac{3}{\sqrt{2}}\times\frac{1}{\sqrt{2}}=\frac{3}{2}\text{ cm}$$

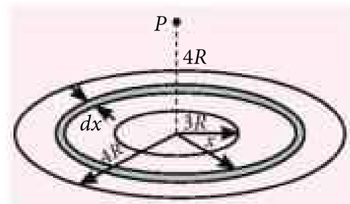
Hence, the distance between two images,

$$I_1I_2=2I_1X=\frac{2\times3}{2}=3\text{ cm}$$

5. (7) : Mass per unit area of the disc,

$$\sigma=\frac{\text{Mass}}{\text{Area}}=\frac{M}{\pi\left((4R)^2-(3R)^2\right)}=\frac{M}{7\pi R^2}$$

Consider a ring of radius x and thickness dx as shown in the figure.



Mass of the ring,

$dM = \sigma 2\pi x dx$

$$=\frac{2\pi Mxdx}{7\pi R^2}$$

Potential at point P due to annular disc is

$$V_P=\int_{3R}^{4R}-\frac{GdM}{\sqrt{(4R)^2+(x)^2}}=-\frac{GM2\pi}{7\pi R^2}\int_{3R}^{4R}\frac{xdx}{\sqrt{16R^2+x^2}}$$

Solving, we get

$$V_P=-\frac{GM2\pi}{7\pi R^2}\left[\sqrt{16R^2+x^2}\right]_{3R}^{4R}=-\frac{2GM}{7R}\left(4\sqrt{2}-5\right)$$

Workdone in moving a unit mass from P to $\infty = V_\infty - V_P$

$$=0-\left(\frac{-2GM}{7R}\left(4\sqrt{2}-5\right)\right)=\frac{2GM}{7R}(4\sqrt{2}-5)$$

6. (64)

EXAM ALERT 2023

Exam	Date
NEET	7th May
MHT CET PCM	9th to 13th May
MHT CET PCB	15th to 20th May
KCET BM	20th May
KCET PC	21st May
CUET	21st to 31st May
KCET Language Test	22nd May
BITSAT Session I	22nd to 26th May
JEE Advanced	4th June
BITSAT Session II	18th to 22nd June

7. (3) : Let radii of two soap bubbles are a and b respectively and radius of single larger bubble is c.

$$P_c = P + \frac{4T}{c},\ P_a = P + \frac{4T}{a},\ P_b = P + \frac{4T}{b}$$

$$\text{and } V_a = \frac{4}{3}\pi a^3, V_b = \frac{4}{3}\pi b^3 \quad \text{...(i)}$$

$$\text{and } V_c = \frac{4}{3}\pi c^3$$

[Now as mass is conserved, $\therefore\ n_a + n_b = n_c$]

$$i.e., \frac{P_a V_a}{RT_a} + \frac{P_b V_b}{RT_b} = \frac{P_c V_c}{RT_c} \quad (PV = \eta RT)$$

As temperature is constant,

$\therefore\ T_a + T_b = T_c$, So, $P_a V_a + P_b V_b = P_c V_c$ ...(ii)

From equation (i) equation (ii) becomes

$$\left(P + \frac{4T}{a}\right)\left(\frac{4}{3}\pi a^3\right) + \left(P + \frac{4T}{b}\right)\left(\frac{4}{3}\pi b^3\right) = \left(P + \frac{4T}{c}\right)\left(\frac{4}{3}\pi c^3\right)$$

i.e., $4T(a^2 + b^2 - c^2) = P(c^3 - a^3 - b^3)$

Now, $V = \frac{4}{3}\pi(a^3 + b^3 - c^3)$ and $A = 4\pi(a^2 + b^2 - c^2)$

$$\therefore \frac{TA}{\pi} = -\frac{3}{4\pi}VP \quad \text{or} \quad 4TA + 3PV = 0$$

8. (2) : The time period of simple pendulum in air

$$T = t_0 = 2\pi\sqrt{\left(\frac{l}{g}\right)}$$

Where, l is the length of simple pendulum.
In water, effective weight of bob
W' = weight of bob in air – upthrust
$\Rightarrow\ \rho V g_{eff} = \rho V g - \rho' V g = (\rho - \rho')Vg$
where ρ = density of bob, ρ' = density of water

$$\therefore g_{eff} = \left(\frac{\rho - \rho'}{\rho}\right)g = \left(1 - \frac{\rho'}{\rho}\right)g$$

$$\therefore t = 2\pi\sqrt{\frac{l}{\left(1 - \frac{\rho'}{\rho}\right)g}} \quad \text{Thus, } \frac{t}{t_0} = \sqrt{\frac{1}{\left(1 - \frac{\rho'}{\rho}\right)}}$$

$$= \sqrt{\frac{1}{1 - \frac{1000}{(4/3 \times 1000)}}} = \sqrt{\left(\frac{4}{4-3}\right)} = 2 \Rightarrow t = 2t_0$$

9. (a,c): Area of cross section, $A = \frac{\pi d^2}{4}$

where d is the diameter of the wire.

$$\text{Therefore, } l = \frac{4FL}{\pi d^2 Y}$$

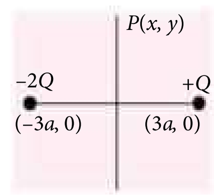
Since F, L and Y are the same for wires A and B

$$\therefore l \propto \frac{1}{d^2}$$

i.e., the extension is inversely proportional to the square of the diameter. Hence, choice (a) is correct. The strain is $\frac{l}{L} = \frac{4F}{\pi d^2 Y}$. Thus, strain $\propto \frac{1}{d^2}$

Hence, choice (c) is correct.

10. (a,c,d) : For $V_P = 0$



$$k\frac{2Q}{\sqrt{(x+3a)^2 + y^2}} = \frac{kQ}{\sqrt{(3a-x)^2 + y^2}}$$

$\Rightarrow\ 4(3a - x)^2 + 4y^2 = (x + 3a)^2 + y^2$
$\Rightarrow\ x^2 + y^2 - 10ax + 9a^2 = 0$
$\Rightarrow\ (x - 5a)^2 + y^2 = 16a^2$
$\therefore$ locus is a circle of radius $4a$ and centre $(5a, 0)$.
Let potential 0 for $x = x$ on x-axis.

$$\therefore \frac{-2Q}{(x+3a)} \times \frac{1}{(4\pi\varepsilon_0)} + \frac{Q}{(x-3a)}\frac{1}{4\pi\varepsilon_0} = 0$$

or $2x - 6a = x + 3a \Rightarrow x = 9a$ only
Centre is on x-axis at $(5a, 0)$, at this position net force on $+q$ is

$$F = \frac{-2Qq}{4\pi\varepsilon_0(8a)^2} + \frac{Qq}{4\pi\varepsilon_0(4a^2)} = +\text{ve}$$

$\therefore$ Particle will move in positive x-axis and eventually cross the circle.
Electric field at origin is along negative x-axis.

11. (a,d) : Total resistance of the circuit

$$R = 2 + \frac{6 \times 1.5}{6 + 1.5} = 3.2\ \text{k}\Omega$$

$$\text{Now } I = \frac{24}{3.2 \times 10^3} = 7.5 \times 10^{-3}\ \text{A}$$

$$\text{Current in } R_L,\ i_1 = \frac{7.5 \times 10^{-3} \times 6}{(6 + 1.5)} = 6 \times 10^{-3}\ \text{A}$$

Power, $P_1 = i_1^2 \times R_L = (6 \times 10^{-3})^2 \times 1.5 \times 10^3 = 54 \times 10^{-3}$ J

After R_1 and R_2 interchanged, total resistance

$$R = 6 + \frac{2 \times 1.5}{2 + 1.5} = 6.86\ k\Omega$$

$$\text{Total current, } I = \frac{24}{6.86 \times 10^3} = 3.5 \times 10^{-3}\ \text{A}$$

Now current in R_L, $=\dfrac{3.5\times10^{-3}\times2}{(2+1.5)}=2\times10^{-3}$ A

Power, $P_1' = (2\times10^{-3})^2\times1.5\times10^3 = 6\times10^{-3}$ J

Clearly $P_1 : P_1' = 9$.

12. (a,b,c,d) : $a=\dfrac{F}{m}=\dfrac{qE}{m}=\dfrac{q}{m}(\alpha-\beta x)$ ...(i)

$a=0$ at $x=\dfrac{\alpha}{\beta}$

i.e., force on the particle is zero at $x=\dfrac{\alpha}{\beta}$

So, mean position of the particle is at $x=\dfrac{\alpha}{\beta}$

Equation (i) can be written as $v\dfrac{dv}{dx}=\dfrac{q}{m}(\alpha-\beta x)$

$\therefore \int_0^v v\,dv=\dfrac{q}{m}\int_0^x(\alpha-\beta x)dx \Rightarrow \dfrac{v^2}{2}\dfrac{qx}{m}\left(\alpha-\dfrac{\beta}{2}x\right)$

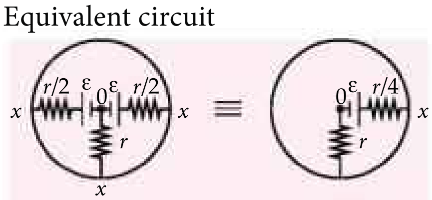
$\therefore v=\sqrt{\dfrac{2qx}{m}\left(\alpha-\dfrac{\beta}{2}x\right)}$, $v=0$ at $x=0$ and $x=\dfrac{\alpha}{\beta}$.

So, the particle oscillates between $x=0$ and $x=\dfrac{2\alpha}{\beta}$

with mean position at $x=\dfrac{\alpha}{\beta}$

Maximum acceleration of the particle is at extreme positions (at $x=0$ or $x=2\alpha/\beta$) and $a_{max}=q\,\alpha/m$ [from equation (i)]

13. (b,d) : Equivalent circuit



(i) (ii)

Induced emf, $\varepsilon=\dfrac{B\omega r^2}{2}=\left(\dfrac{B\omega a^2}{2}\right)$ ($\because$ radius $= a$)

By nodal equation $4\left(\dfrac{x-\varepsilon}{r}\right)+\left(\dfrac{x-0}{r}\right)=0$

$5x = 4\varepsilon$

$\Rightarrow x=\dfrac{4\varepsilon}{5}=\dfrac{2B\omega a^2}{5r}$ and $I=\dfrac{x}{\varepsilon}=\dfrac{2B\omega a^2}{5r}$

Also direction of current in '*r*' will be toward negative terminal, *i.e.*, from rim to origin. Alternately, by equivalence of cell (Figure (ii)), $I=\dfrac{\varepsilon}{r+\dfrac{r}{4}}=\dfrac{4\varepsilon}{5r}$

14. (a,b,d) : The energy of each photon is hc/λ, so that the number of photons released per unit time is $W/(hc/\lambda)$. These photons are spread out in all directions over an area $4\pi a^2$, so that the 'share' of an area S is a fraction $S/4\pi a^2$ of the total number of photons emitted.

$\therefore W\left(\dfrac{S}{4\pi a^2}\right)=\dfrac{nhc}{\lambda t}$ or $\dfrac{n}{t}=\dfrac{WS\lambda}{4\pi hca^2}$

The maximum energy of emitted photoelectrons is

$E_{max} = hc - \phi = \dfrac{hc}{\lambda}-\phi=\dfrac{1}{\lambda}(hc-\lambda\phi)$

The stopping potential is given by, $eV_S = E_{max}$

Hence, $V_s=\dfrac{E_{max}}{e}=\dfrac{1}{e\lambda}(hc-\lambda\phi)$

For photoemission to be possible, we have $hc \ge \phi$.

Hence, $\dfrac{hc}{\lambda}\ge\phi$ or $\lambda\le\dfrac{hc}{\phi}$

Thus, the permitted range of values of λ is $0\le\lambda\le\dfrac{hc}{\phi}$

Hence, the correct choices are (a), (b) and (d).

15. (b) : (I) $\to$ (S); (II) $\to$ (T); *(III) $\to$ (Q); (IV) $\to$ (P).

$r_n=\dfrac{0.529n^2}{Z}$ Å

So, (I) $\to$ (S)

Magnetic field, $B = \dfrac{12.5Z^3}{n^5}T$

So, (II) $\rightarrow$ (T)

$V_n = \dfrac{2.2\times10^6 Z}{n} \Rightarrow V_n \propto \dfrac{1}{n} \quad \therefore n\uparrow V_n\downarrow$

So, (III) $\rightarrow$ (Q)

Total energy, $E_n = \dfrac{-13.6Z^2}{n^2}\text{eV}$; $\therefore n\uparrow E_n\uparrow$

So, (IV) $\rightarrow$ (P)

16. (d) : (I)$\rightarrow$(T); (II)$\rightarrow$(P,R); (III)$\rightarrow$(P, S); (IV)$\rightarrow$(Q,S)

(I) An ideal gas expands in vacuum, no work is done (W = 0). Also the container is insulated therefore no heat is lost or gained (Q = 0). According to first law of thermodynamics

$\Delta U = Q + W \quad \therefore \quad \Delta U = 0$

$\Rightarrow$ There is no change in the temperature of the gas

(II) Given PV^2 = constant

$\Rightarrow$ $V \times T$ = constant

As the gas expands its volume increases and temperature decreases.

$\therefore$ (P) is the correct option.

To find whether heat is released or absorbed, let us find a relationship between Q and change in temperature ΔT.

We know that $Q = nC\Delta T$

where C = molar specific heat

Also for a polytropic process we have

$C = C_v + \dfrac{R}{1-n}$ and PV^n = constant

Here PV^2 = constant. Therefore n = 2

$\therefore \quad C = C_v + \dfrac{R}{1-2} = C_v - R$

For monatomic gas, $C_v = \dfrac{3}{2}R$

$\therefore \quad C = \dfrac{3}{2}R - R = \dfrac{R}{2}; Q = n\times\dfrac{R}{2}\times\Delta T.$

In this case the temperature decrease *i.e.*, ΔT is negative. Therefore Q is negative. This in turn means that heat is lost by the gas during the process. Thus, (R) is the correct option.

Proceeding in the same way we get,

(III) $V^{1/3} \times T$ = constant

$\Rightarrow$ As the gas expands and volume increases, the temperature decreases.

Therefore (P) is the correct option.

In this process, $x = \dfrac{4}{3}$.

$\therefore \quad C = C_v + \dfrac{R}{1-\frac{4}{3}} = \dfrac{3}{2}R + \dfrac{3R}{-1} = \dfrac{3}{2}R - 3R = \dfrac{-3R}{2}$

$\therefore \quad Q = n\left(\dfrac{-3R}{2}\right)\Delta T$

As ΔT is negative, Q is positive. This in turn means that heat is gained by the gas during the process, thus (S) is the correct option.

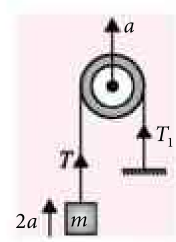
(IV) $\quad \Delta T = \dfrac{\Delta(PV)}{nR}$

Here $\Delta(PV)$ is positive $\therefore$ ΔT is positive

$\therefore$ Temperature increases. So, (Q) is the correct option.

Work done is also positive, so Q is also positive

17. (b) : (I) $\rightarrow$ (Q,R,S); (II) $\rightarrow$ (P,Q,R); (III) $\rightarrow$ (P,Q,R,S); (IV) $\rightarrow$ (P, Q)



(a) $\rightarrow$ (Q, R, S) : $a_{block} = 2a$

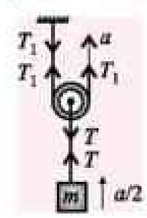
$\therefore \quad a_{block} > a$

$T - mg = m(2a)$

$T = mg + 2ma = \dfrac{5mg}{3}$

$a_{pulley} = a \Rightarrow a_{pulley} \le a$

$T_1 = T$



(b) $\rightarrow$ (P, Q, R) : $T - mg = \dfrac{ma}{2}$

$\Rightarrow \quad T = \dfrac{7\,mg}{6}$

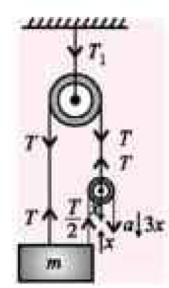
$T_1 = \dfrac{T}{2} = \dfrac{7mg}{12} < \dfrac{3}{2}mg$

(c) $\rightarrow$ (P, Q, R, S) : $a_{pulley} = \dfrac{a}{2} = a_{block}$

$T - mg = \dfrac{ma}{2} \Rightarrow T = \dfrac{7}{6}mg$

$T_1 = \dfrac{3T}{2} = \dfrac{7}{4}mg > \dfrac{3}{2}mg$

$2T_2 = T, 3T_2 = T_1$



(d) $\rightarrow$ (P, Q) : $a_{pulley} = x = \dfrac{a}{3}$

$a_{block} = x\uparrow$

$T + \dfrac{T}{2} - mg = \dfrac{ma}{3}$; $T = \dfrac{20\,mg}{27}$; $T_1 = 2T = \dfrac{40\,mg}{27}$

18. (a) : (I) → (S); (II) → (P); (III) → (R); (IV) → (Q)

(I) → (S) : $y=\sqrt{3}\,x-2x^2$

Maximum heights $\frac{dy}{dx}=0$ (At P)

$$\Rightarrow \sqrt{3}-4x=0 \text{ or } x=\frac{\sqrt{3}}{4}$$

$$\Rightarrow H=\sqrt{3}\left(\frac{\sqrt{3}}{4}\right)-2\left(\frac{\sqrt{3}}{4}\right)^2=\frac{3}{4}-\frac{3}{8}=\frac{3}{8}$$

(II) → (P) : At A, $y = 0$ and $x = R$

$$0=\sqrt{3}R-2R^2 \Rightarrow R=\frac{\sqrt{3}}{2}$$

(III) → (R) : $v_x = u_x$ (constant)

$$v_y=\frac{dy}{dt}=\sqrt{3}v_x-4xv_x=(\sqrt{3}-4x)v_x$$

At $t = 0$, $x = 0$, $y = 0$; $v_y=\sqrt{3}u_x$

$$u=\sqrt{{v_x}^2+{y_y}^2}=\sqrt{1+(\sqrt{3})^2}\,u_x=2u_x$$

At $t = T$, $r = R$, $y = 0$; $v_y=(\sqrt{3}-4R)u_x$

$$v_y=u_y-gT \Rightarrow (\sqrt{3}-4R)u_x=\sqrt{3}u_x-gT$$

$$\Rightarrow T=\frac{4Ru_x}{g}=\frac{4}{g}(u_xT)u_x$$

$$\therefore {u_x}^2=\frac{g}{4} \text{ or } u_x=\sqrt{\frac{g}{4}}=\sqrt{\frac{5}{2}}$$

$$T=\frac{R}{u_x}=\frac{\sqrt{3}}{2}\cdot\sqrt{\frac{2}{5}}=\sqrt{\frac{3}{10}}$$

(IV) → (Q) : Angle of projection

$$\tan\theta=\frac{u_y}{u_x}=\frac{\sqrt{3}u_x}{u_x}=\sqrt{3} \quad \therefore \theta=60°.$$

PAPER - II

1. (2) : If r is the radius of the platform and M is its mass,

Moment of inertia of platform about the axis $=\frac{Mr^2}{2}$

Moment of inertia of the system with the man at the rim

$$=\frac{Mr^2}{2}+mr^2,\ =\frac{200r^2}{2}+80r^2 = 180\,r^2$$

Moment of inertia with the man at the centre is $\frac{Mr^2}{2}=100\,r^2$

By conservation of angular momentum,

$180\,r^2\,\omega_1 = 100\,r^2\,\omega_2$

$$\omega_2=\frac{180}{100}\omega_1=\frac{180\times 12}{100}=21.6\text{ rpm} \simeq 22\text{ rpm}$$

2. (5) : The capacitance $(C)=\frac{(A/2)\varepsilon_0}{d}+\frac{(A/2)K\varepsilon_0}{d}$

$$=\frac{A\varepsilon_0}{2d}(1+K)=\frac{0.04\times 8.85\times 10^{-12}}{2\times 8.85\times 10^{-4}}[1+9] = 2\times 10^{-9}\text{ F}$$

$\therefore$ The energy stored $(U_i)=\frac{1}{2}CV^2$

$$=\frac{1}{2}\times 2\times 10^{-9}\times (110)^2 = 1.21\times 10^{-5}\text{ J}$$

After the slab is removed:

The capacitance, $C_0=\frac{A\varepsilon_0}{d}$

$$=\frac{0.04\times 8.85\times 10^{-12}}{8.85\times 10^{-4}} = 4\times 10^{-10}\text{ F}$$

The charge on the plate, $Q = CV = 2.2.\times 10^{-7}$ C

$\therefore$ The energy stored, $U_f=\frac{Q^2}{2C_0} = 6.05\times 10^{-5}$ J

$\therefore$ Work done by the agent, $W = U_f - U_i$

$= (6.05 - 1.21)\times 10^{-5}\text{ J} = 4.84\times 10^{-5}$ J

3. (4) : Initial kinetic energy $=\frac{1}{2}mv^2$

Final energy $=\frac{1}{2}m\left(\frac{v}{2}\right)^2+\frac{1}{2}kx^2$

By principle of conservation of energy,

$$\frac{1}{2}mv^2=\frac{1}{2}m\frac{v^2}{4}+\frac{1}{2}kx^2 \ \therefore \quad k=\frac{3mv^2}{4x^2}$$

4. (5) : Relative density $=\frac{W_a}{W_a-W_w}$, $\rho=\frac{W_a}{w}$

where ρ is relative density, W_a weight in air and w is loss in weight.

$$\frac{\Delta\rho}{\rho}=\frac{\Delta W_a}{W_a}-\frac{\Delta w}{w}$$

For maximum error, $\frac{\Delta\rho}{\rho}=\frac{\Delta W_a}{W_a}+\frac{\Delta w}{w}$

For maximum percentage error

$$\frac{\Delta\rho}{\rho}\times 100=\frac{\Delta W_a}{W_a}\times 100+\frac{\Delta w}{w}\times 100$$

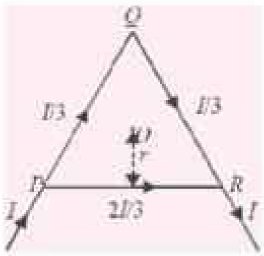
Given $\Delta W_a = 0.1$ gmf and $W_a = 10.0$ gmf

$w = 10.0 - 5.0 = 5.0$ gmf

$\Delta w = \Delta W_a + \Delta w_w = 0.1 + 0.1 = 0.2$ gmf

$$\frac{\Delta\rho}{\rho}\times 100 = \left(\frac{0.1}{10.0}\right)\times 100 + \left(\frac{0.2}{5.0}\right)\times 100 = 1 + 4 = 5\%$$

5. (0) : Refer figure, the magnetic field induction at O due to current through PR is



$$B_1 = \frac{\mu_0}{4\pi}\frac{2I/3}{r}[\sin 30° + \sin 30°] = \frac{\mu_0}{4\pi}\frac{2I}{3r}$$

It is directed outside the paper.

The magnetic field induction at O due to current through PQR is

$$B_2 = 2\times\frac{\mu_0}{4\pi}\frac{(I/3)}{r}[\sin 30° + \sin 30°] = \frac{\mu_0}{4\pi}\frac{2I}{3r}$$

It is directed inside the paper.

$\therefore$ Resultant magnetic field induction at O is $B_1 - B_2 = 0$

6. (5) : $dT = \frac{1}{2}\alpha\,\Delta\theta T$

Time lost or gained per day, $dT = \left(\frac{1}{2}\alpha\,\Delta\theta\right)86400$

$$12 = \frac{1}{2}\alpha\,(25-\theta)\,86400 \quad \text{...(i)}$$

$$3 = \frac{1}{2}\alpha\,(\theta-15)\,86400 \quad \text{...(ii)}$$

Solving eqns. (i) and (ii), we get

$$\frac{12}{3} = \frac{25-\theta}{\theta-15} \text{ or } 4(\theta - 15) = 25 - \theta \Rightarrow \theta = 17°\text{C}$$

Putting $\theta = 17$ °C in eqn. (i), we get

$$12 = \frac{1}{2}\alpha(25-17)\,86400$$

$$\text{or}\quad \alpha = \frac{24}{8\times 86400} = \frac{1}{28800}\text{K}^{-1} = 3.47\times 10^{-5}\,\text{K}^{-1}$$

7. (1) : The series in UV region is Lyman series. Longest wavelength corresponds to minimum energy which occurs in transition from $n = 2$ to $n = 1$.

$$\therefore\ 122 = \frac{1/R}{\frac{1}{1^2} - \frac{1}{2^2}} \quad \text{...(i)}$$

The smallest wavelength in the infrared region corresponds to maximum energy of Paschen series.

$$\lambda = \frac{1/R}{\frac{1}{3^2} - \frac{1}{\infty}} \quad \text{...(ii)}$$

From (i) and (ii), $\lambda = 823.5$ nm

8. (2) : For balloon, $u = 0$, $a = 4\times 9$ m/s^2, $t = 2$ sec,

$\therefore\ v = u + at = 0 + (4\times 9)\times 2$

$v = 9\times 8$ m/s ...(i)

For ball, initial velocity $= 9\times 8$ m/s

final velocity = 0, at top.

$\therefore\ v^2 = u^2 + 2gH$

$0 = (9.8)^2 - 2\times 9\times 8\,H$

$$\text{or}\quad H = \frac{(9.8)^2}{2\times 9.8} = 4.9 \text{ m} \quad \text{...(ii)}$$

Height in 1st two seconds when balloon rises,

$$S = ut\frac{1}{2} + at^2$$

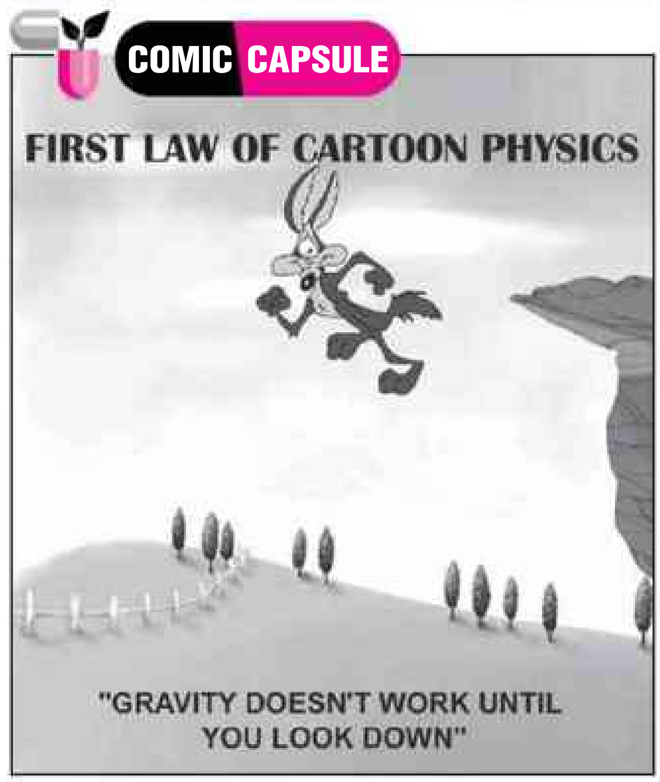
$$H_1 = 0 + \frac{1}{2}\times(4\times 9)\,(2)^2$$

$H_1 = 9.8$ m ...(iii)

Total height $= H + H_1 = 4.9 + 9.8 = 14.7$ m

9. (b, c) : (b) The potential at the point $x = 0$ due to given set of changes is

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{r_1} + \frac{q}{r_2} + \frac{q}{r_3} + \frac{q}{r_4} + ...\right]$$



$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{1}+\frac{q}{2}+\frac{q}{4}+\frac{q}{8}+...\right] = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{1}+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+...\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{1}+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+...\right] = \frac{q}{4\pi\varepsilon_0}\cdot\frac{1}{1-(1/2)}$$

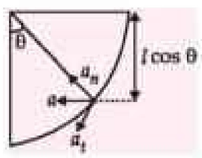
(using the formula of sum of infinite G.P.)

$$= \frac{q}{2\pi\varepsilon_0}.$$

(c) If a charge $q/2$ is placed, potential energy,

$$\text{P.E.} = \frac{q}{2\pi\varepsilon_0}\cdot\frac{q}{2} = \frac{q^2}{4\pi\varepsilon_0}.$$

10. (b,c,d) : At $\theta = 90°$, $v = 0$,



$\therefore \quad a_n = \frac{v^2}{r} = 0$ and $a_t = g\sin 90° = g$

At any angular position θ, $h = l\cos\theta$

$\therefore \quad v^2 = 2gl\cos\theta$

$a_n = \frac{v^2}{r} = \frac{2gl\cos\theta}{l} = 2g\cos\theta$ and $a_t = g\sin\theta$

Thus $\tan\theta = \frac{a_x}{a_t}$ or $\frac{\sin\theta}{\cos\theta} = \frac{2g\cos\theta}{g\sin\theta}$

or $\quad 2\cos^2\theta = \sin^2\theta = 1-\cos^2\theta$

$\therefore \quad \cos\theta = \frac{1}{\sqrt{3}}$

11. (b, c) : When the hanging mass is inside the liquid, the liquid will apply an upthrust on the mass. Hence the balance A will read less than 2 kg. Infact m loses a weight when dipped in a liquid.

An upthrust acts on block m.

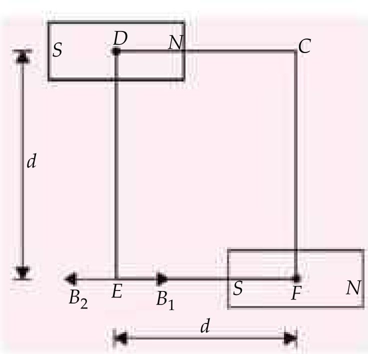
By reaction, an equal force will be exerted on the liquid contained in beaker in the downward direction.

Hence B will read more than 5 kg.

Hence (b) and (c) both are correct.

Infact (b) is contained in (c). So it is adequate to say that (c) holds good.

12. (a) :



Magnetic induction at point E due to magnet at F (axial point) is $B_1 = \frac{\mu_0}{4\pi}\frac{2M}{d^3}$

It acts along EF.

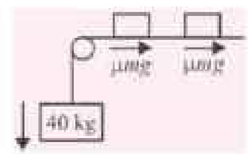
Magnetic induction at point E due to magnet at D (equatorial point) is $B_2 = \frac{\mu_0}{4\pi}\frac{M}{d^3}$

It acts along FE.

Resultant magnetic induction at point E is

$$B = B_1 - B_2 = \frac{\mu_0 M}{4\pi d^3}$$

13. (a, c) : Maximum possible acceleration of block will be $= \mu g$



(i) When $\mu = 0.2$, maximum acceleration possible so that block does not slip is 2 ms^{-2}

Now acceleration of system assuming block don't slip is

$$a = \frac{40g - 2\mu mg}{100} = 3.8 \text{ ms}^{-2}$$

$\because \quad \mu = 0.2$

as 3.8 > 2. Hence the assumption is wrong and blocks will slip on the belt.

$\therefore \quad$ maximum force applicable on block B is μmg

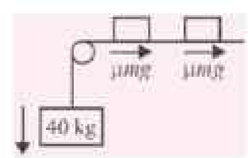
$\therefore \quad$ Acceleration of block = 2 ms^{-2}.

Hence velocity of B when it strikes pulley is

$v_2 = 0 \times 2 + 2 \times 2 \times 2$ or, $v_2 = 8$ m/s^{-1}.

$\therefore \quad v = 2\sqrt{2}$ ms^{-1}.

(ii) When $\mu = 0.5$ maximum acceleration possible so that block does not slip is 5 ms^{-2}.



$$a = \frac{40g - 2\mu mg}{100} = 1 \text{ ms}^{-2}$$

$\because \quad \mu = 0.5$

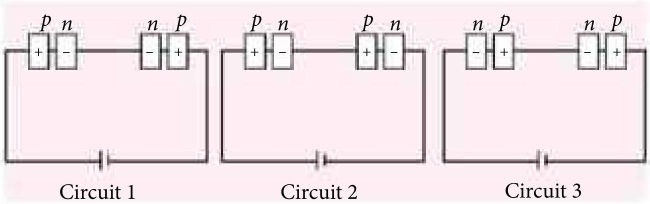
as 1 < 5 hence, blocks do not slip and acceleration of block B is 1 ms^{-2}.

$\therefore \quad$ Hence velocity of B when it strikes pulley is

$v_2 = 0_2 + 2 \times 1 \times 2$ or, $v_2 = 4$

$\therefore \quad v = 2$ ms^{-1}.

14. (b) : The potential drops across the two p-n junctions, connected in series, are equal in circuit 2 and circuit 3. These two circuits are either forward biased or reverse biased in terms of the p-n junctions.



In circuit 1, the two p-n junctions are such that one is forward biased and the other is reverse biased.

15. (b) : Total average energy density of electromagnetic wave is $<u> = \frac{1}{2}\varepsilon_0 E_{rms}^2 + \frac{1}{2\mu_0}B_{rms}^2$

$$= \frac{1}{2}\varepsilon_0 E_{rms}^2 + \frac{1}{2\mu_0}\left(\frac{E_{rms}^2}{c^2}\right) \left(\because B_{rms} = \frac{E_{rms}}{c}\right)$$

$$= \frac{1}{2}\varepsilon_0 E_{rms}^2 + \frac{1}{2\mu_0}E_{rms}^2\varepsilon_0\mu_0 \qquad \left(\because \quad c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}\right)$$

$$= \frac{1}{2}\varepsilon_0 E_{rms}^2 + \frac{1}{2}\varepsilon_0 E_{rms}^2 = \varepsilon_0 E_{rms}^2$$

$= (8.85 \times 10^{-12}) \times (720)^2 = 4.58 \times 10^{-6}$ J m^{-3}

16. (b) : Here, $y_1 = 0.05 \sin(3\pi t - 2x)$

$y_2 = 0.05 \sin(3\pi t + 2x)$

According to superposition principle, the resultant displacement is $y = y_1 + y_2 = 0.05 [\sin(3\pi t - 2x) + \sin(3\pi t + 2x)]$

or $y = 0.05 \times 2 \sin 3\pi t \cos 2x$

or $y = (0.1\cos 2x) \sin 3\pi t = A \sin 3\pi t$

where $A = 0.1\cos 2x$ = amplitude of the resultant standing wave.

At $x = 0.5$ m,

$A = 0.1\cos 2x = 0.1\cos(2 \times 0.5) = 0.1\cos 1$(radian)

$= 0.1 \cos \frac{180°}{\pi} = 0.1\cos 57.3°$

or $A = 0.1 \times 0.54$ m $= 0.054$ m $= 5.4$ cm

17. (c) : Given : $\lambda = 5 \times 10^{-7}$ m, $D = 1$ m, $d = 1$ mm.

Distance of n^{th} bright fringe from the centre $= \frac{nD\lambda}{d}$

where $n = 1, 2, 3, ...$

So the distance of 5^{th} bright fringe $= \frac{5D\lambda}{d}$

Distance of n^{th} dark fringe from the centre $= \left(n - \frac{1}{2}\right)\frac{D\lambda}{d}$

where $n = 1, 2, 3, 4, ...$

3^{rd} dark fringe $= \left(3 - \frac{1}{2}\right)\frac{D\lambda}{d} = \frac{5}{2}\frac{D\lambda}{d}$

Distance between them $= \left(5 - \frac{5}{2}\right)\frac{D\lambda}{d} = \frac{5}{2}\frac{D\lambda}{d}$

$$= \frac{5 \times 1 \times 5 \times 10^{-7}}{2 \times 1 \times 10^{-3}} = 12.5 \times 10^{-4} \text{ m} = 1.25 \text{ mm}$$

18. (d) : For 16 g of helium, $n_1 = \frac{16}{4} = 4$

For 16 g of oxygen, $n_2 = \frac{16}{32} = \frac{1}{2}$

For mixture of gases,

$$C_V = \frac{n_1 C_{V_1} + n_2 C_{V_2}}{n_1 + n_2} \quad \text{where} \quad C_V = \frac{f}{2}R$$

$$C_P = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 + n_2} \quad \text{where} \quad C_P = \left(\frac{f}{2} + 1\right)R$$

For helium, $f_1 = 3$, $n_1 = 4$. For oxygen, $f_2 = 5$, $n_2 = \frac{1}{2}$

$$\therefore \frac{C_P}{C_V} = \frac{\left(4 \times \frac{5}{2}R\right) + \left(\frac{1}{2} \times \frac{7}{2}R\right)}{\left(4 \times \frac{3}{2}R\right) + \left(\frac{1}{2} \times \frac{5}{2}R\right)} = \frac{47}{29} = 1.62$$

SOLUTIONS TO APRIL 2023 QUIZ CLUB

1. Decibel.
2. The lower reading of barometer indicates low pressure - rainfall.
3. Ernest Rutherford
4. Bulb 2 and Bulb 3.
5. Gamma Rays, UV Rays
6. Series, Parallel
7. Temperature
8. Length of second pendulum is 1 m.
9. Irregular or diffused reflection
10. Conservation of momentum, Newton's third law of motion.
11. John H. Glen
12. Saturn
13. 18 years 11 days 8 hours
14. Leibnitz mountain
15. 6.25×10^{18} electrons
16. There will be no capillary action and water will not rise.
17. 1/100 second
18. Frequency, Colour
19. Nuclear fission
20. Handle Q as weight is at greater distance as compared to Handle P.

Winner : *Tabbasoom (Kerala)*

UCD
Unique Career in Demand

Explore the available Unique Career Options!

Graduation in Neurotechnology

Neurotechnology is an assembly of methods or instruments that enable a direct connection which interfaces with the nervous system to monitor or modulate neural activity. Neurotechnology offers large-scale multi-biometric AFIS SDK, PC-based, embedded, smart card fingerprint, face, eye iris, voice and palmprint identification, etc. In 2016, Elon Musk, launched Neuralink, a company dedicated to the development of an implantable brain-machine interface. The idea is, through painless surgery, to implant very thin wires, about five microns in diameter into the cerebral cortex to obtain and send information.

Job Prospectus

Neurotechnology plays the major role in the market of biometrics and AI technologies. Neurotechnologists measure the statistical analysis of people's unique physical and behavioral characteristics. This technology is mainly used for identifying individuals who are under surveillance. Neurotechnologist deals with deep brain stimulation, transcranial magnetic stimulation, transcranial direct current stimulation, electrophysiology, implants and Pharmaceuticals, etc. If you are looking to make career in this sector, then there are number of industries that are looking to hire neurotechnologists in both government as well as private sector.

Eligibility

Candidates must have cleared the 10+2 level from any recognised board. Physics, Chemistry and Biology must be the compulsory subjects in 10+2. Candidates must have a minimum aggregate marks of 50% in the 10+2 level.

Top Colleges

- **Jawaharlal Institute of Postgraduate Medical Education & Research, Puducherry, (JIPMER)**
- Medical College, Thiruvananthapuram
- Medical College, Alappuzha
- Medical College, Kottayam
- Medical College, Kozhikode
- John Enoch College of Pharmacy, Karamana, Thiruvananthapuram

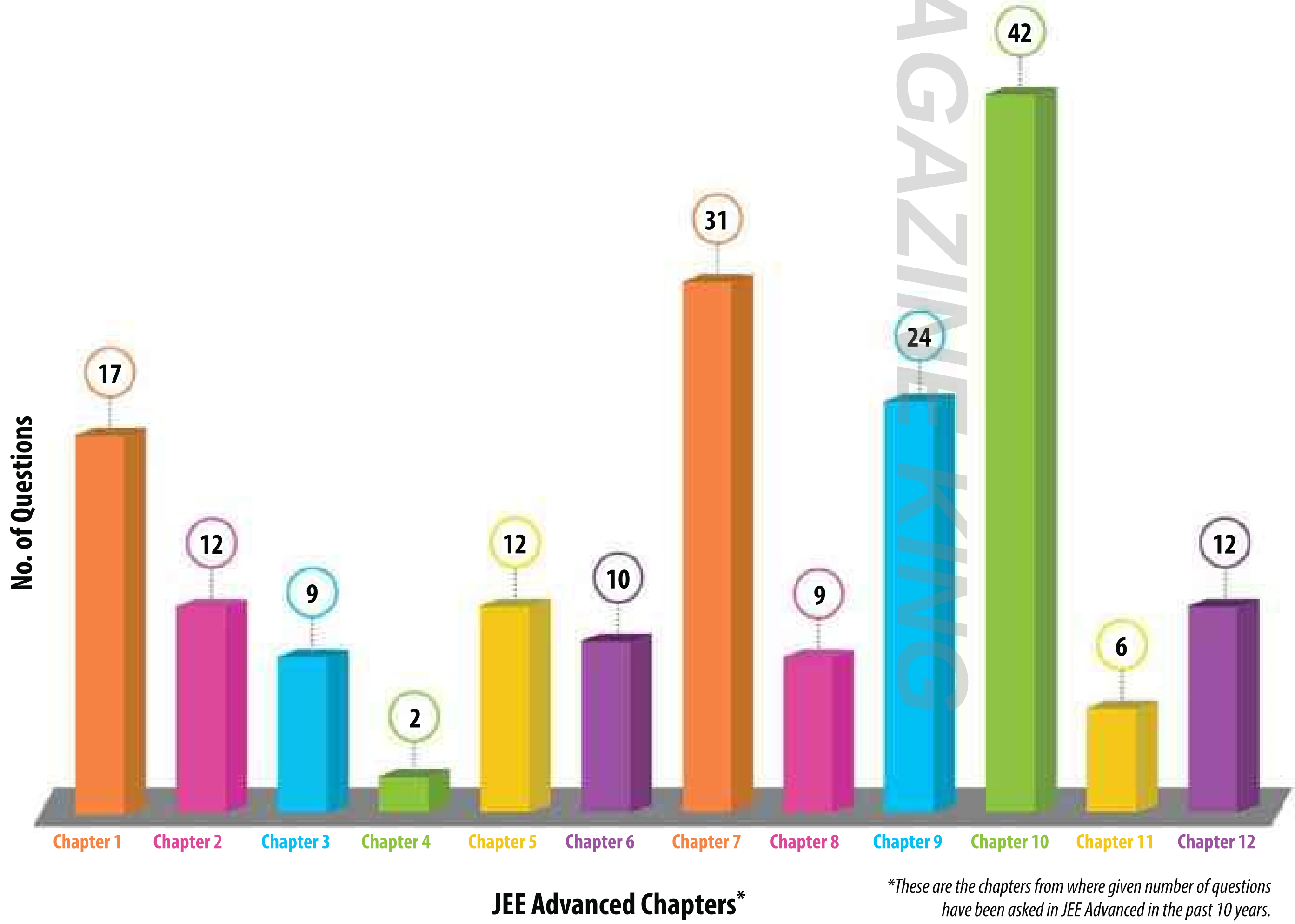
Jawaharlal Institute of Postgraduate Medical Education & Research (JIPMER), Puducherry

The B.Sc. Neurotechnology is a three years course and was started in 2011 with an intake of five students per year through an open entrance exam. It is the first institute in India to start Neurotechnology as a comprehensive three year B.Sc. course.

Are You Ready for JEE Advanced?

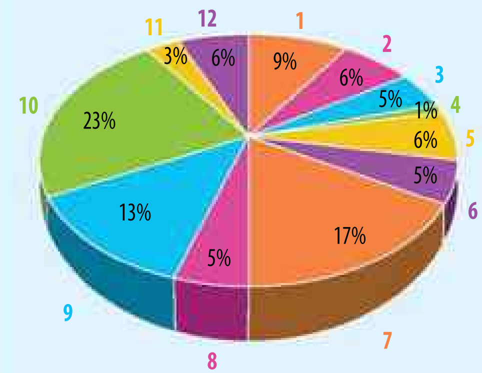
CLASS-11

Past 10 Years (2013-2022) Chapterwise Trend Analysis of JEE Advanced Questions



*These are the chapters from where given number of questions have been asked in JEE Advanced in the past 10 years.

Weightage Percentage



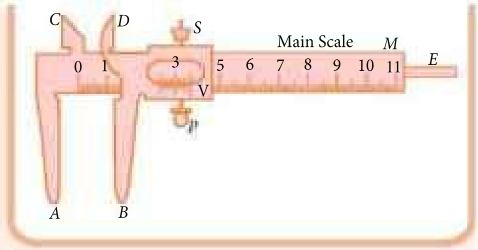
CHAPTERS

- Chapter 1 : Units, Measurements and Errors
- Chapter 2 : Practical Physics
- Chapter 3 : Kinematics
- Chapter 4 : Laws of Motion
- Chapter 5 : Work, Energy and Power
- Chapter 6 : Centre of Mass, Momentum and Impulse
- Chapter 7 : Rotational Motion
- Chapter 8 : Gravitation
- Chapter 9 : Properties of Matter
- Chapter 10 : Heat and Thermodynamics
- Chapter 11 : Simple Harmonic Motion
- Chapter 12 : Waves

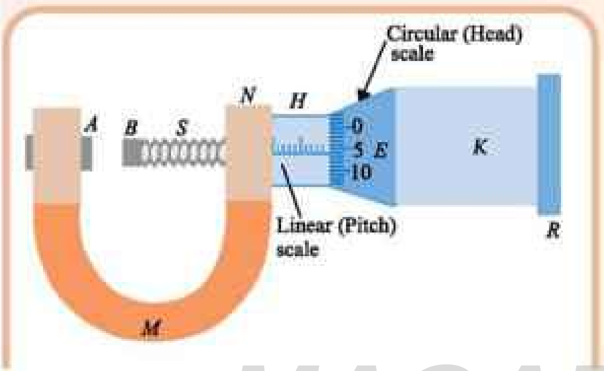
Practical Physics

Least Count

The smallest value of a physical quantity which can be measured accurately with an instrument is called the least count (L.C) of the measuring instrument.



Least count of Vernier Callipers – Suppose the size of one main scale division (M.S.D) is M units and that of one vernier scale division (V.S.D) is V units. Also let the length of 'a' main scale divisions is equal to the length of 'b' vernier scale divisions.



The quantity $(M - V)$ is called vernier constant (V.C) or least count (L.C) of the vernier callipers.

$$\text{L.C} = \left(\frac{b-a}{b}\right)M$$

Least Count of Screw Gauge :

$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of divisions on the circular scale}}$$

$$\text{Here, Pitch} = \frac{\text{Distance moved by the screw on the linear scale}}{\text{Number of full rotations given}}$$

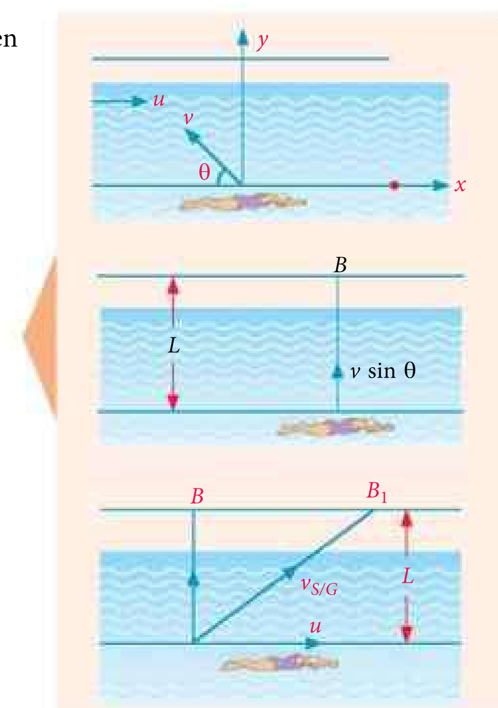
Kinematics

Crossing the River

Let a person wanted to cross the river. Different relative velocities are given here.

$$\vec{v}_{S/R} = -v\cos\theta\,\hat{i} + v\sin\theta\,\hat{j}\ ;\ \vec{v}_{R/G} = u\,\hat{i}$$

$$\vec{v}_{S/G} = \vec{v}_{S/R} + \vec{v}_{R/G} = (u - v\cos\theta)\,\hat{i} + v\sin\theta\,\hat{j}$$



- Crossing the river along shortest path

  For shortest path, drift = 0

  ⇒ velocity of swimmer w.r.t. ground along x direction must be zero.

  ∴ $v\cos\theta = u$

  Crossing time, $t = \dfrac{L}{v\sin\theta} = \dfrac{L}{\sqrt{v^2 - u^2}}$

- Minimum drift in crossing the river if $v < u$

  $x = (u - v\cos\theta)\dfrac{L}{v\sin\theta}$ ...(i), $x = \left(\dfrac{u}{v}\operatorname{cosec}\theta - \cot\theta\right)L$

  For x to be minimum, $\dfrac{dx}{d\theta} = 0$

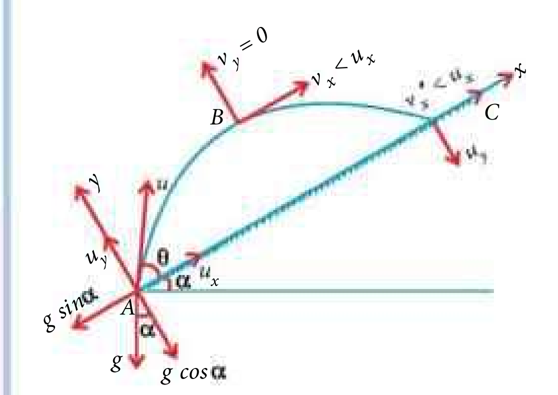
  $\Rightarrow \left(\dfrac{u}{v}(-\operatorname{cosec}\theta\cot\theta) + \operatorname{cosec}^2\theta\right)L = 0\ ;\ \cos\theta = \dfrac{v}{u}$

  Putting the value of θ in equation (i) we get minimum drift.

Projectile Motion on an Inclined Plane

Particle is projected up the inclined plane : We assume x-axis along the incline and y-axis perpendicular to the inclined plane as shown.

x-direction	y-direction
$a_x = -g\sin\alpha$	$a_y = -g\cos\alpha$
$u_x = u\cos\theta$	$u_y = u\sin\theta$



Time of flight

$$s_y = u_y t + \frac{1}{2}a_y t^2;\ \ 0 = (u\sin\theta)t - \frac{1}{2}(g\cos\alpha)t^2$$

$$t = 0 \ \text{ or } \ t = \frac{2u\sin\theta}{g\cos\alpha} \ \Rightarrow \ T = \frac{2u\sin\theta}{g\cos\alpha}$$

Maximum height from the inclined plane

At maximum distance perpendicular to the inclined plane, the y-component of velocity becomes zero.

$$v_y^2 = u_y^2 + 2a_y s_y$$

$$0 = (u\sin\theta)^2 - 2(g\cos\alpha)H$$

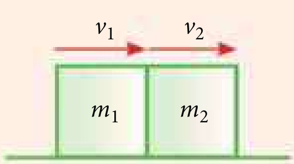
$$H = \frac{u^2\sin^2\theta}{2g\cos\alpha}$$

Time of flight and maximum height formula in this case is similar to that in case of projectile motion on a horizontal surface H and T depends only on u_y and a_y.

Laws of Motion

Constraint Motion

When two or more objects are connected to each other such that the motion of one affects the path and motion of other, this is called constrained motion.



In the figure, the constraint in the motion of the block is due to direct contact.

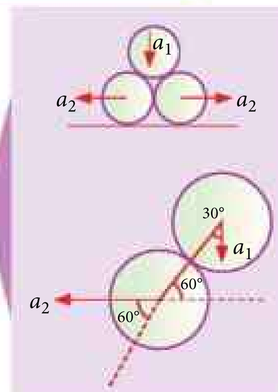
Normal Constraint

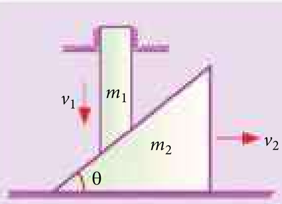
Three identical cylinders are released.

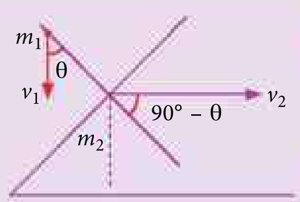
For contact component of acceleration along the normal must be equal

$$a_1\cos30° = a_2\cos60°$$

$$\sqrt{3}a_1 = a_2$$







To find the relation between velocity of rod and that of wedge at any instant.

Component of velocity along perpendicular to the contact plane must be equal. $v_1\cos\theta = v_2\cos(90° - \theta)$

$\tan\theta = v_1/v_2$

BRAIN MAP

Units and Measurements

Fundamental Units

The units selected for measurement of the base quantities are known as the base units or fundamental units.

Derived Units

The physical quantities derived from the fundamental quantities are derived quantities and their units are known as derived units.

Supplementary Units

Units of plane angle and solid angle are known as supplementary units. It is of two types.

(i) **Radian (rad) :** It is defined as the plane angle subtended at the centre of a circle by an arc equal in length to the radius of circle.

$$\theta \text{ (in radians)} = \frac{\text{Arc}}{\text{Radius}} = \frac{l}{r}$$

(ii) **Steradian (sr) :** It is defined as the solid angle subtended at the centre of a sphere by a surface of the sphere which is equal in area to that of a square, having each side equal to the radius of the sphere.

$$\Omega \text{(in steradian)} = \frac{\text{Surface Area}}{(\text{Radius})^2}$$

UNITS

Unit of a physical quantity is defined as the standard of measurement of that quantity.

UNITS and MEASUREMENTS

MEASUREMENTS

All quantities arising in physics are measured. Measurement is basically a comparison process in which the chosen standard has the same nature as the quantity to be measured.

Applications of Dimensional Analysis

- **Main uses of dimensional analysis :**
  To convert a physical quantity from one system of units to another. To check the correctness of a given physical relation.
  To derive a relationship between different physical quantities.
- **Homogeneity principle :** According to this principle a physical equation will be dimensionally correct if the dimension of all the terms occurring on both sides of the equation are the same.
- **Conversion of one system of units to another :** It is based on the fact that the magnitude of a physical quantity remains the same, whatever may be the system of measurements.

Dimensional Formulae and Dimensional Equation

- **Dimensional formula :** The expression which shows how and which of the fundamental quantities represent the dimensions of a physical quantity is called the dimensional formula, of the physical quantity.
- **Dimensional equation :** The equation obtained by equating a physical quantity with its dimensional formula is called the dimensional equation of the given physical quantity.

Dimension of Physical Quantity

The dimensions of a physical quantity are the powers (or exponents) to which the fundamental quantities are raised to represent that quantity completely.

Measurement of Length

- **Length :** It is the measure of the distance between two points in space.
- Direct methods for the measurement of length : a metre scale is used for measuring lengths from 10^{-3} m to 10^{2} m; a vernier callipers is used for measuring lengths upto 10^{-4} m and a screw gauge and spherometer are used to measure lengths upto 10^{-5} m.
- Indirect methods for large distances : echo (reflection) method; triangulation method; parallax method.
- Indirect method for small distances : **avogadro's hypothesis** and **tunnelling microscopy**.

Measurement of Mass

- **Inertial mass :** It is a measure of the reluctance i.e., inertial on the part of the object to change its motion when a force is applied on it.
- **Gravitational mass :** It is a measure of the pull on the object exerted by the earth.

Measurement of Time

According to Einstein, "Time is simply what a clock reads". Any phenomenon that repeats itself after equal intervals of time can be used as a time standard.

Errors in Measurement

The error in a measurement is equal to the difference between the true value and the measured value of the quantity.

Error = True value – Measured value

Significant Figures

The number of digits in a measurement about which one reasonably sure plus the first uncertain digit are called significant digits or significant figures.

Types of Error

Systematic errors are those errors that tend to be in one direction, either positive or negative. Systematic errors can be minimised by improving experimental techniques, selecting better instruments and removing personal bias as far as possible.

Random errors are the errors, which occur irregularly. They are random with respect to sign and size. **Least count error :** The smallest value that can be measured by the measuring instrument is called its least count and error associated with resolution of the instrument is known as least count error.

Absolute Error, Relative Error and Percentage Error

- **Absolute error :** The magnitude of the difference between the true value of the quantity measured and the individual measured value is called absolute error.
- **Mean absolute error :** It is the arithmetic mean of the magnitudes of absolute errors in all the measurements of the quantity. It is represented by Δa_{mean}.

$$\Delta a_{mean} = \frac{|\Delta a_1| + |\Delta a_2| + \ldots + |\Delta a_n|}{n}, \quad \Delta a_{mean} = \frac{1}{n}\sum_{i=1}^{n}|\Delta a_i|$$

- Mean value of measurement $a_{mean} = \dfrac{a_1 + a_2 + \ldots + a_n}{n}$,

$$a_{mean} = \frac{1}{n}\sum_{i=1}^{n} a_i$$

The final value of measurement may be written as

$a = a_{mean} \pm \Delta a_{mean}$

- **Relative error or fractional error** =

$$\frac{\text{mean absolute error}}{\text{mean value}} = \frac{\Delta a_{mean}}{a_{mean}}$$

- **Percentage error :** When the relative error is expressed in percentage is known as percentage error.
- Percentage error, $\delta a = \dfrac{\Delta a_{mean}}{a_{mean}} \times 100\%$

Rounding Off

- **Rule-1 :** If the digit to be dropped is less than 5, then the preceding digit is left unchanged,
- **Rule-2 :** If the digit to be dropped is more than 5, then the preceding digit is raised by one.
- **Rule-3:** If the digit to be dropped is 5 followed by non digit zero, then the preceding digit is raised by one.
- **Rule-4 :** If the digit to be dropped is 5 or 5 followed by zero, then preceding digit is left unchanged, if it is even.
- **Rule-5 :** If the digit to be dropped is 5 or 5 followed by zero, then the preceding digit is raised by one, if it is odd.

Rules to Find the Significant Figures

- **Rule-1 :** All non-zero digits are significant.
- **Rule-2 :** All zeros occurring between two non-zero digits are significant.
- **Rule-3 :** If the number is less than 1, the zero(s) on the right of decimal point, but to the left of the first non-zero digit are not significant.
- **Rule-4 :** In a number without a decimal point, the terminal or trailing zero(s) are not significant.
- **Rule-5 :** In a number with a decimal point, the trailing zero(s) are significant.

Note : The power (or exponent) of 10 is irrelevant to the determination of significant figures.

Work, Energy and Power, Centre of Mass

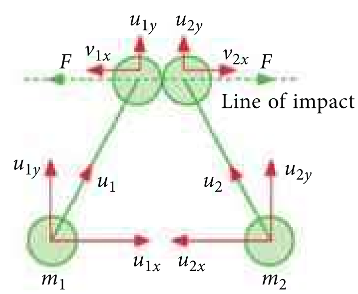
Oblique Collision

- Linear momentum of individual particles change along common normal but the total linear momentum remain conserved.

  $m_1u_{1x} - m_2u_{2x} = m_2v_{2x} - m_1v_{1x}$

  x-axis is the line of impact.

  Velocity along y-axis remains unchanged.

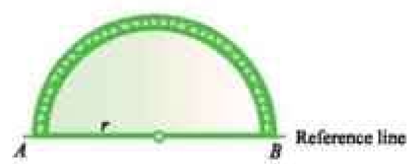


- Applying conservation of mechanical energy the speed of slip of the chain

$$mgh = \frac{1}{2}mv^2$$

$$mg\left(\frac{2r}{\pi} + \frac{\pi r}{2}\right) = \frac{1}{2}mv^2$$

$$\Rightarrow v = \sqrt{2\left(\frac{2r}{\pi} + \frac{\pi r}{2}\right)g}$$



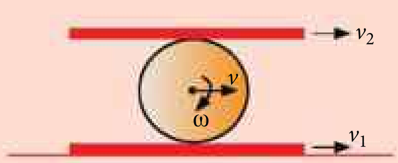
Rotational Motion

Rolling

For rolling, relative velocity at all points of contact must be zero.

$\therefore \quad v - \omega R = v_1$

and $\quad v + \omega R = v_2$

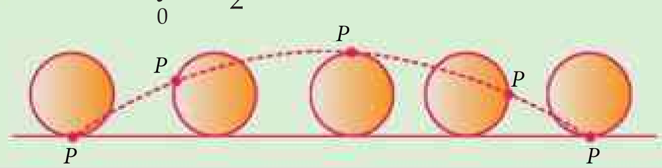


Distance moved by the point P in one full rotation

Path of the point P is a cycloid. $v_P = 2\omega R \sin\frac{\theta}{2}$, where $\theta = \omega t$.

Distance moved in time dt, $dS = v_P dt = 2R\omega \sin\frac{\omega t}{2} dt$

$$S = 2R\omega \int_0^{\frac{2\pi}{\omega}} \sin\frac{\omega t}{2} dt = 8R$$



Gravitation

Motion along elliptical orbits

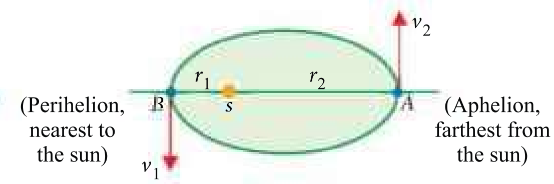
(Perihelion) $r_1 = a - ae = a(1-e)$ ...(i)

(Aphelion) $r_2 = a + ae = a(1+e)$ ...(ii)

$$v_1 = \sqrt{\frac{GM(1+e)}{a(1-e)}} \quad \text{and} \quad v_2 = \sqrt{\frac{GM(1+e)}{a(1+e)}}$$

Total energy of the satellite in elliptical orbit,

$$E = \frac{1}{2}mv_1^2 - \frac{GMm}{r_1} = \frac{1}{2}m\frac{GM(1+e)}{a(1-e)} - \frac{GMm}{a(1-e)} = \frac{-GMm}{2a}$$



Properties of Matter

Since cross-sectional area is same.

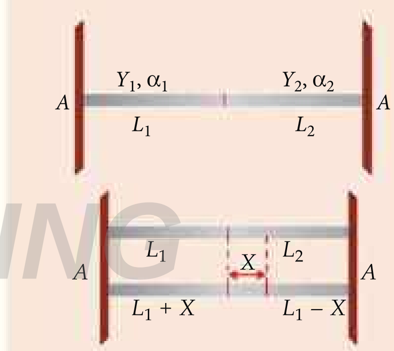
$\therefore$ At equilibrium, (Thermal stress)$_1$ = (Thermal stress)$_2$

$$\left(\frac{\Delta L_1 - X}{L_1}\right)Y_1 = \left(\frac{\Delta L_2 + X}{L_2}\right)Y_2\,;\ \text{where } \Delta L_1 = L_1\alpha_1\Delta T \text{ and } \Delta L_2 = L_2\alpha_2\Delta T$$

$$\frac{(L_1\alpha_1\Delta T - X)}{L_1}Y_1 = \left(\frac{L_2\alpha_2\Delta T + X}{L_2}\right)Y_2 \text{ or } X\left(\frac{Y_1}{L_1} + \frac{Y_2}{L_2}\right) = (Y_1\alpha_1 - Y_2\alpha_2)\,\Delta T$$

$$\therefore\ X = \left(\frac{Y_1\alpha_1 - Y_2\alpha_2}{\frac{Y_1}{L_1} + \frac{Y_2}{L_2}}\right)\Delta T$$

For no shift in junction, $X = 0$ $\therefore$ $\left(\frac{Y_1\alpha_1 - Y_2\alpha_2}{\frac{Y_1}{L_1} + \frac{Y_2}{L_2}}\right)\Delta T = 0$ or $Y_1\alpha_1 = Y_2\alpha_2$



Time of emptying a tank

Say at time t, the level of the liquid in the container is h and velocity of efflux, $v = \sqrt{2gh}$. Rate of flow = $A_2v = A_2\sqrt{2gh}$

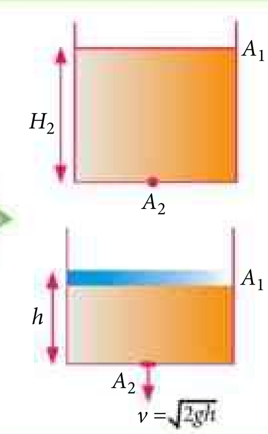
h decreases with increase in time, so

$$-A_1\frac{dh}{dt} = A_2\sqrt{2gh} \Rightarrow -\frac{A_1}{A_2\sqrt{2g}}\int_{H_2}^{H_1}\frac{dh}{\sqrt{h}} = \int_0^t dt \Rightarrow t = \frac{\sqrt{2}A_1}{\sqrt{g}A_2}(\sqrt{H_2} - \sqrt{H_1})$$

where t is the time to fall from height H_2 to H_1.

For time to empty the tank final level $H_1 = 0$ and say initial level $H_2 = H$.

$$t = \frac{\sqrt{2}A_1\sqrt{H}}{\sqrt{g}A_2} = \frac{A_1}{A_2}\sqrt{\frac{2H}{g}}$$



Heat and Thermodynamics

Carnot engine

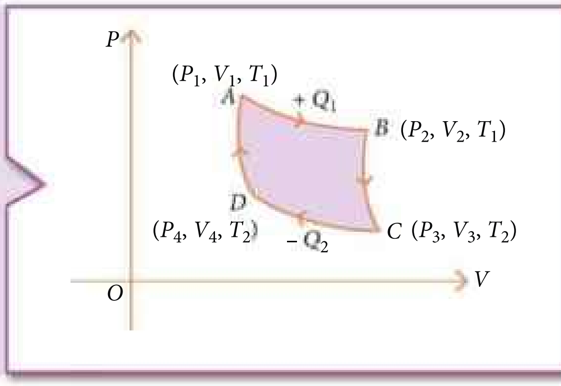
It is an ideal heat engine. It is a theoretical engine which is free from all defects of practical engine. It has maximum efficiency.

Total work done in the cycle

$W = W_1 + W_2 + W_3 + W_4$

$$= nRT_1 \ln\left(\frac{V_2}{V_1}\right) + \frac{nR(T_1 - T_2)}{\gamma - 1} - nRT_2 \ln\left(\frac{V_3}{V_4}\right) - \frac{nR(T_1 - T_2)}{\gamma - 1}$$

$$= nR\left[T_1 \ln\left(\frac{V_2}{V_1}\right) - T_2 \ln\left(\frac{V_3}{V_4}\right)\right]$$



Oscillations (SHM) and Waves

Oscillations of a liquid column in a V-tube

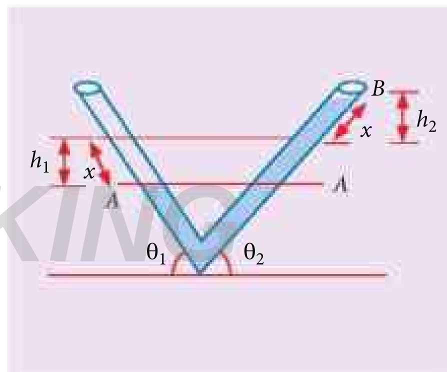
Liquid is pressed by distance x in left limb, it rises by x in the right limb. Difference in level of liquid in both the limbs is $h_1 + h_2$.

Restoring force, $F = -(h_1 + h_2)A\rho_0 g$

$$\therefore \quad F = -(x\sin\theta_1 + x\sin\theta_2)A\rho_0 g \Rightarrow a = -\frac{(\sin\theta_1 + \sin\theta_2)A\rho_0 g x}{m}$$

where m is the mass of the liquid column in the limbs.

$$\Rightarrow \quad \omega = \sqrt{\frac{\rho_0 A g(\sin\theta_1 + \sin\theta_2)}{m}} \quad \Rightarrow T = 2\pi\sqrt{\frac{m}{\rho_0 A g(\sin\theta_1 + \sin\theta_2)}}$$



Special cases of Doppler's effect in sound

A source is moving towards a wall

Consider a source of sound moving towards a stationary cliff/wall with speed vs emitting a sound of frequency, f. There is a stationary observer (O).

Beat frequency heard by the observer,

$$f_b = f'' - f' = \left(\frac{v}{v - v_s} - \frac{v}{v + v_s}\right)f$$

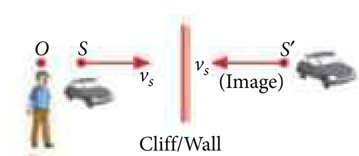
Sound source and observer are moving in a direction making an angle with the line joining them

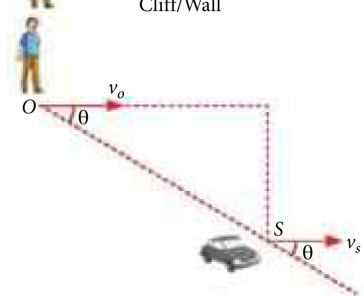
$$f' = \left(\frac{v + v_o \cos\theta}{v + v_s \cos\theta}\right)f$$

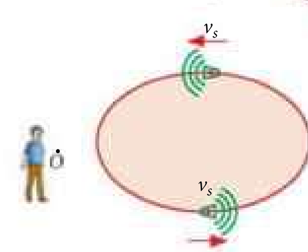
When source is rotating

When source moves towards the observer, then the frequency heard will be maximum.

$$f_{max} = \left(\frac{v}{v - v_s}\right)f$$







GK CORNER

Enhance Your General Knowledge with Current Updates!

INDIAN ECONOMY

- **Finance Bill 2023 passed in Lok Sabha :** The Lok Sabha passed the Finance Bill 2023, which implements tax proposals for the upcoming fiscal year, without any discussion. The passage of the bill occurred amid opposition uproar over the "Adani controversy".
- **Adani's $108 billion crisis shakes investors' faith in India :** Adani Group shares hitting banks that have given loans to the companies. Government-controlled State Bank of India has tumbled 11% since the Hindenburg Report came out. Foreign institutional investors pulled a net $2 billion out of India's stock market from the country January 27 through January 31, the biggest three-day selloff since March.
- **World Bank 2022-23 GDP Forecast for India :** The World Bank has increased India's GDP forecast for the current fiscal year from its October estimate of 6.5% to 6.9%. World Bank's Latest Forecast The World Bank has raised its forecast for India's economic growth to 6.9% because of the economy's resilience while facing external challenges as well .
- **GST revenue collection increases 13% to ₹ 1.60 lakh crore in March 2023 :** The Goods and Services Tax (GST) revenue collection for March 2023 has increased by 13% to ₹ 1.60 lakh crore, according to data released by the Ministry of Finance. This marks the third consecutive month of increase in GST collections and is a positive sign for India's economy, which has been grappling with the impact of the COVID-19 pandemic.
- **India, Malaysia can now trade in Indian rupee :** The Ministry of External Affairs declared that trade between India and Malaysia can now be conducted using the Indian Rupee (INR) as a mode of settlement, in addition to other currencies. This announcement follows the launch of the Foreign Trade Policy (FTP) 2023 by the Ministry of Commerce the day before, which reaffirmed the government's determination to establish the rupee as a global currency. This move is expected to boost bilateral trade between the two countries and reduce transaction costs for businesses.
- **India's retail inflation drops to 6.44% :** India's retail inflation for February slows down to 6.44% as against 6.52% in January 2023, according to data published by the Ministry of Statistics and Programme Implementation on March 13.
- **Global Recession 2023 :** The report predicts that India's economy will reach $10 trillion by 2035 and rank third globally by 2032.Since the US is one of the great superpowers, a mild or deeper recession will eventually have worldwide repercussions. The crisis ultimately grew and spread into a global economic shock, manifesting itself in a number of European bank failures, drops in several stock indices, and significant falls in the value of the Indian market.

- **India's forex reserves fall $2.40 billion to three months low of $560 billion :** According to data from the Reserve Bank of India, the country's foreign exchange reserves declined by $2.397 billion to $560 billion as of March 10, 2023. This marks a three-month low for India's foreign exchange reserves after they had increased for the first time in five weeks to $562.40 billion as of March 3.

- **India's per capita income doubles since 2014-15 NSO :** India's per capita income in nominal terms doubled to ₹ 1,72,000 since 2014-15 but uneven income distribution remains a challenge. As per the National Statistical Office (NSO), the annual per capita (net national income) at current prices is estimated at ₹ 1,72,000 in 2022-23, up from ₹ 86,647 in 2014-15, suggesting an increase of about 99%.

Test Yourself!

1. Which of the following statements about Indian budget is incorrect?
(a) Non-tax receipts of the government mainly consists of interest and dividends on investment in addition to fees and other receipts for services rendered by the government.
(b) Interest payments on debt is part of the revenue expenditure.
(c) All grants to the state governments and union territories except for use of creation of capital assets.
(d) None of the above.

2. Which of the following statements is incorrect about Indian economy?
(a) The capital expenditure of Union government has increased approximately four times since Fiscal year 2016.
(b) The NPAs of banks have been falling for last 2 years.
(c) There has been constant increase in forex reserves.
(d) None of the above.

3. As per the World Bank's April update, what is India's GDP forecast for fiscal year 2022-23?
(a) 7.5 % (b) 8.0 %
(c) 8.5 % (d) 9.0 %

4. As per the recent update from the IMF (July 2022), what is India's growth forecast for 2022-23?
(a) 6.8 % (b) 7.0 %
(c) 7.4 % (d) 8.0 %

5. Finance Ministry has made unauthorised publication of which data as compoundable offence?
(a) GDP Data
(b) Export-import data
(c) Inflation Data
(d) Foreign Exchange Reserves Data

6. The union cabinet approved an addition funding of ₹ 820 crore for which book, to expand it services?
(a) India Post Payments Bank
(b) Unity Small Finance Bank
(c) NSDL Payment Band
(d) AU Small Finance Bank

7. As per the recent OECD report, what is the GDP forecast for India for FY23?
(a) 6.1% (b) 6.6%
(c) 7.2% (d) 7.5%

8. As of January 2023, what is the interest rate for the General Provident Fund?
(a) 6.1% (b) 7.1%
(c) 8.1% (d) 8.5%

9. What is the percentage by which the government hiked the interest rates of small savings schemes for the April-June quarter?
(a) 57 (b) 70
(c) 56 (d) 80

10. What is India's share in the global arms imports?
(a) 10% (b) 15%
(c) 20% (d) 25%

Answer Key

1.	(c)	**2.**	(c)	**3.**	(b)	**4.**	(c)	**5.**	(b)
6.	(a)	**7.**	(b)	**8.**	(b)	**9.**	(a)	**10.**	(b)

JEE WORK OUTS

COMPREHENSION : PASSAGE TYPE

Passage 1 : A ball of radius R carries a positive charge whose volume charge density depends only on the distance r from the ball's centre as : $\rho = \rho_0\left(1 - \frac{r}{R}\right)$ where ρ_0 is a constant.

1. The magnitude of electric field as a function of the distance r inside the ball is given by

(a) $E = \frac{\rho_0}{\varepsilon_0}\left(\frac{r}{3} - \frac{r^2}{4R}\right)$ (b) $E = \frac{\rho_0}{\varepsilon_0}\left(\frac{r}{4} - \frac{r^2}{3R}\right)$

(c) $E = \frac{\rho_0}{\varepsilon_0}\left(\frac{r}{3} + \frac{r^2}{4R}\right)$ (d) $E = \frac{\rho_0}{\varepsilon_0}\left(\frac{r}{4} + \frac{r^2}{3R}\right)$

2. The magnitude of the electric field as a function of the distance r outside the ball is given by

(a) $E = \frac{\rho_0 R^3}{8\varepsilon_0 r^2}$ (b) $E = \frac{\rho_0 R^3}{12\varepsilon_0 r^2}$

(c) $E = \frac{\rho_0 R^2}{8\varepsilon_0 r^3}$ (d) $E = \frac{\rho_0 R^2}{12\varepsilon_0 r^3}$

3. The maximum electric field intensity is

(a) $E_m = \frac{\rho_0 R}{9\varepsilon_0}$ (b) $E_m = \frac{\rho_0 \varepsilon_0}{9R}$

(c) $E_m = \frac{\rho_0 R}{3\varepsilon_0}$ (d) $E_m = \frac{\rho_0 R}{6\varepsilon_0}$

Passage 2 : A uniform and constant magnetic field $\vec{B} = (20\hat{i} - 30\hat{j} + 50\hat{k})$ T exists in space. A charged particle with charge to mass ratio $\left(\frac{q}{m}\right) = \frac{10^3}{19}$ C kg^{-1} enters this region at time t = 0 with a velocity $\vec{v} = (20\hat{i} + 50\hat{j} + 30\hat{k})$ m s^{-1}. Assume that the charged particle always remains in space having the given magnetic field. (Use $\sqrt{2} = 1.4$)

4. During the further motion of the particle in the magnetic field, the angle between the magnetic field and velocity of the particle

(a) remains constant
(b) increases
(c) decreases
(d) may increase or decrease.

5. The frequency of the revolution of the particle in cycles per second will be

(a) $\frac{10^3}{\pi\sqrt{19}}$ (b) $\frac{10^4}{\pi\sqrt{38}}$

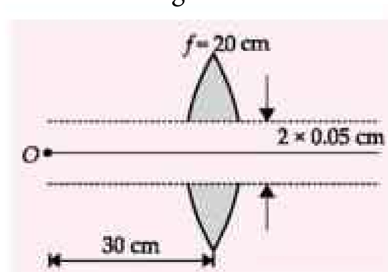
(c) $\frac{10^4}{\pi\sqrt{19}}$ (d) $\frac{10^4}{2\pi\sqrt{19}}$

6. The pitch of the helical path of the motion of the particle will be

(a) $\frac{\pi}{100}$ m (b) $\frac{\pi}{125}$ m

(c) $\frac{\pi}{215}$ m (d) $\frac{\pi}{250}$ m

Passage 3 : A point object O is placed at a distance of 0.3 m from a convex lens (focal length 0.2 m) lens cut into two halves each of which is displaced by 0.0005 m as shown in figure.



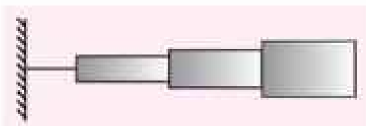
7. What will be the location of the image?

(a) 30 cm, right of lens (b) 60 cm, right of lens
(c) 70 cm, left of lens (d) 40 cm, left of lens

8. If this arrangement will generate more than one image then what will be the total number of images?
(a) 2 (b) 4 (c) 6 (d) 5

9. Find the spacing between the images so formed.
(a) 0.1 cm (b) 0.5 cm (c) 0.3 cm (d) 1 cm

Passage 4 : Four pieces of string each of length L are joined end to end to make a long string of length $4L$. The linear mass density of the string are μ, 4μ, 9μ and 16μ, respectively. One end of the combined string is tied to a fixed support and a transverse wave has been generated at the other end having frequency f (ignore any reflection and absorption). String has been stretched under a tension F.

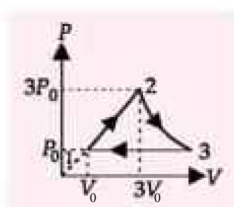


10. Find the time taken by wave to reach from source end to fixed end.
(a) $\frac{25}{12}\times\frac{L}{\sqrt{F/\mu}}$ (b) $\frac{10L}{\sqrt{F/\mu}}$
(c) $\frac{4L}{\sqrt{F/\mu}}$ (d) $\frac{L}{\sqrt{F/\mu}}$

11. Find the ratio of wavelengths of the waves on four strings, starting from right hand side.
(a) 12 : 6 : 4 : 3 (b) 4 : 3 : 2 : 1
(c) 3 : 4 : 6 : 12 (d) 1 : 2 : 3 : 4

12. Find the rate at which energy transferred is maximum for the string having linear mass density
(a) μ (b) 4μ (c) 9μ (d) 16μ

Passage 5 : One mole of an idealmonatomic gas undergoes thermodynamic cycle $1 \to 2 \to 3 \to 1$ as shown in the figure. Initial temperature of gas is $T_0 = 300$ K.



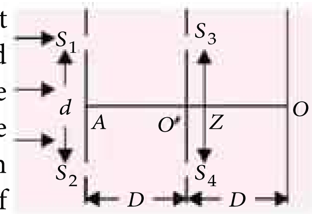
Process $1 \to 2$: $P = \alpha V$
Process $2 \to 3$: PV = constant
Process $3 \to 1$: P = constant.
(Take $\ln|3| = 1.09$)

13. Find the work done during process $1 \to 2$.
(a) 8.23 RT_0 (b) 9.81 RT_0
(c) 10.72 RT_0 (d) 4 RT_0

14. Find the net work done by the cycle.
(a) $3.27RT_0$ (b) $6.83RT_0$
(c) $4.53RT_0$ (d) $5.81RT_0$

15. Determine the heat capacity for the process $3 \to 1$.
(a) 20.75 J/mol-K (b) 10.23 J/mol-K
(c) 22.37 J/mol-K (d) 15.96 J/mol-K

Passage 6 : In the arrangement shown in figure, slit S_3 and S_4 are having a variable separation Z. Point O on the screen is at the common perpendicular bisector of S_1S_2 and S_3S_4.



The distance D is large compared to the separation between the slits.

16. When $Z = \frac{\lambda D}{2d}$ the intensity measured at O is I_0. The intensity at O when $Z = \frac{2\lambda D}{d}$ is
(a) I_0 (b) $2I_0$ (b) $3I_0$ (d) $4I_0$

17. The minimum value of Z for which the intensity at O is zero, is
(a) $\frac{3\lambda D}{2d}$ (b) $\frac{\lambda D}{2d}$ (c) $\frac{\lambda D}{3d}$ (d) $\frac{\lambda D}{d}$

18. If a hole is made at O' on $AO'O$ and the slit S_4 is closed, then the ratio of the maximum to minimum observed on screen at O if $O'S_3$ is equal to $\frac{\lambda D}{4d}$, is
(a) 1 (b) infinity (c) 34 (d) 4

Passage 7 : A motor boat of mass m moves along a lake with velocity v_0. At the moment $t = 0$, the engine of the boat is shut down. Assuming the resistance of water is proportional to the velocity of the boat $\vec{F} = -r\vec{v}$.

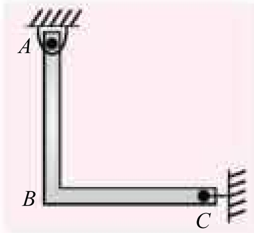
19. How long the motor boat moved with the shut down engine?
(a) r/v (b) r/v_0 (c) $r/2v_0$ (d) ∞

20. The velocity of the motor boat as a function of the distance covered with the shut down engine is
(a) $v = v_0 - \frac{rs}{m}$ (b) $v = \frac{v_0 r}{m}$
(c) $v = v_0 + \frac{rs}{m}$ (d) None of these

21. The mean velocity of the motor boat over the time interval (beginning with the moment $t = 0$), during which its velocity decreases η times is
(a) $\frac{v_0}{2}$ (b) $\frac{\ln v_0}{2\eta}$
(c) $\frac{v_0(\eta-1)}{\eta\ln\eta}$ (d) None of these

COMPREHENSION : STEM QUESTION TYPE

Passage 8 : An L shaped uniform rod of mass $2M$ and length $2L$ ($AB = BC = L$) is held as shown in figure with a string fixed between C and wall so that AB is vertical and BC is horizontal. There is no friction between the hinge and the rod at A.



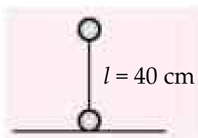
22. The tension in the string is Mg/x. The value of x is __________.

(a) 1/3 (b) 4 (c) 2 (d) 3.

23. The reaction between hinge and rod at point A is $\sqrt{y}\ Mg/2$. The value of y is ________.

(a) 3 (b) 9 (c) 5 (d) 17

Passage 9 : Two balls of mass 60 g are attached with a massless rubber thread, and held in the vertical position as shown in figure. In this position, length of the rubber thread is 40 cm and it is non-stretched. The upper ball is slowly raised vertically upward, until the lower ball just becomes unsupported by the ground. At this time the length of the thread is 1 m. The rubber thread exerts a force which is proportional to its extension. (Take $g = 10\ \text{m s}^{-2}$).



24. The force constant of the rubber thread is $x\ \text{N m}^{-1}$. The value of x is ______.

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

25. Work is done by external agent is y J, while the upper ball was raised? The value of y is ______ J.

(a) 0.26 (b) 0.54 (c) 0.10 (d) 0.30

Passage 10 : A 0.21 H inductor and a 12 Ω resistance are connected in series to a 220 V, 50 Hz AC source.

26. The current in the circuit is x A. The value of x is ______.

(a) $\dfrac{220}{\sqrt{4400}}$ (b) $\dfrac{22}{3\sqrt{5}}$

(c) $\dfrac{220}{\sqrt{4550}}$ (d) $\dfrac{22}{5\sqrt{3}}$

27. The phase angle between the current and the source voltage is $\tan^{-1}\left(\dfrac{n\pi}{4}\right)$. The value of n is ______.

(a) 5 (b) 3 (c) 7 (d) 9

SOLUTIONS

1. (a) : The given charge distribution in the ball is not uniform but varies w.r.t. distance from the centre. In order to calculate the electric field due to it, the ball can be assumed to be made of various concentric spherical shells. Let us consider one such spherical shell having radius r and thickness dr.

Volume of the elementary spherical shell = $4\pi r^2 dr$

Hence, charge contained in this volume.

$$dq = 4\pi r^2 dr\rho = 4\pi r^2 dr\rho_0\left[1-\frac{r}{R}\right] = 4\pi\rho_0\left[1-\frac{r}{R}\right]r^2 dr$$

Hence, charge contained within the volume of a sphere of radius $r(r < R)$ is

$$q = \int dq = 4\pi\rho_0\int_0^r\left[1-\frac{r}{R}\right]r^2 dr = 4\pi\rho_0\left[\frac{r^3}{3}-\frac{r^4}{4R}\right]$$

Now, the electric field E at a distance r from the centre of ball can be calculated as if the charge q is concentrated at the centre of the ball.

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} = \frac{1}{4\pi\varepsilon_0}4\pi\rho_0\left[\frac{r^3}{3}-\frac{r^4}{4R}\right]\frac{1}{r^2}$$

$$E = \frac{\rho_0}{\varepsilon_0}\left[\frac{r}{3}-\frac{r^2}{4R}\right] \quad \text{...(i)}$$

2. (b): For calculating the electric field outside the ball, we should calculate first the total charge present in the ball, *i.e.*,

$$Q = 4\pi\rho_0\int_0^R\left[1-\frac{r}{R}\right]r^2 dr = 4\pi\rho_0\left[\frac{R^3}{3}-\frac{R^4}{4R}\right] = 4\pi\rho_0\left(\frac{R^3}{12}\right)$$

Again to find the electric field outside the ball, total charge Q will be considered to be concentrated at the centre. Hence, electric field at a distance r from the centre of ball is

$$E = \frac{1}{4\pi\varepsilon_0}\left(\frac{4\pi\rho_0 R^3}{12\,r^2}\right) = \frac{\rho_0 R^3}{12\varepsilon_0 r^2}$$

3. (a) : For maximum intensity, $\dfrac{dE}{dr} = 0$

From equation (i), $r_{in} = \dfrac{2}{3}R$

$$\therefore \quad E_m = \frac{\rho_0}{\varepsilon_0}\left[\frac{r_{in}}{3}-\frac{r_{in}^2}{4R}\right]$$

$$= \frac{\rho_0}{\varepsilon_0}\left[\frac{2R}{9}-\frac{4R^2}{36R}\right] = \frac{\rho_0}{\varepsilon_0}\left(\frac{R}{9}\right)$$

4. (a)

5. **(b):** The frequency of revolution of the particle is given by $\upsilon = \frac{qB}{2\pi m} = \frac{(q/m)B}{2\pi}$

$$\upsilon = \frac{10^3}{19} \times \frac{(400+900+2500)^{1/2}}{2\pi} = \frac{10^3}{38\pi}\sqrt{3800} = \frac{10^4}{\pi\sqrt{38}}$$

6. **(d):** As $\vec{B}\cdot\vec{v} = Bv\cos\theta$

$$\therefore \quad v\cos\theta = \frac{\vec{B}\cdot\vec{v}}{B}$$

$$= \frac{(20\hat{i} - 30\hat{j} + 150\hat{k})\cdot(20\hat{i} + 50\hat{j} + 30\hat{k})}{\sqrt{3800}}$$

$$= \frac{(400 - 1500 + 1500)}{\sqrt{3800}} = \frac{400}{\sqrt{3800}} = \frac{40}{\sqrt{38}}$$

The pitch of the helical path is given by

$$\text{Pitch} = \frac{2\pi m}{qB}(v\cos\theta) = \frac{v\cos\theta}{\upsilon}$$

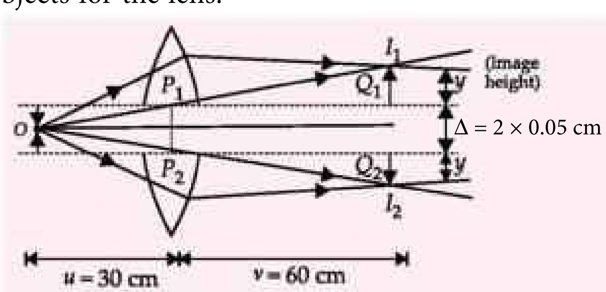
$$\therefore \quad \text{Pitch} = \frac{40}{\sqrt{38}} \times \frac{\pi\sqrt{38}}{10^4} = \frac{40\pi}{10^4} = \frac{\pi}{250}$$

7. **(b):** Each half lens will form an image in the same plane. The optic axes of the lenses are displaced,

$\frac{1}{v} - \frac{1}{(-30)} = \frac{1}{20}$, $v = 60$ cm,

As v is $+ve$, so image is at the right of lens.

8. **(a):** Imagine two arrows (see figure) that act as objects for the lens.



Magnification, $m = \frac{v}{u} = \frac{(+60)}{(-30)} = -2$

Image of height of arrow is $y = 2 \times (0.05) = 0.10$ cm

Thus, two inverted images are formed whose tips are at I_1 and I_2, respectively.

9. **(c):** Spacing between the two point images,

$I_1I_2 = 2y + \Delta = (2 \times 0.1) + 0.1 = 0.3$ cm

10. **(b):** $v_1 = \sqrt{\frac{F}{\mu}}$; $v_2 = \sqrt{\frac{F}{4\mu}} = \frac{1}{2}\sqrt{\frac{F}{\mu}}$

$$v_3 = \sqrt{\frac{F}{9\mu}} = \frac{1}{3}\sqrt{\frac{F}{\mu}} \; ; \; v_4 = \sqrt{\frac{F}{16\mu}} = \frac{1}{4}\sqrt{\frac{F}{\mu}}$$

Total time taken $= \frac{L}{v_1} + \frac{L}{v_2} + \frac{L}{v_3} + \frac{L}{v_4} = \frac{10L}{\sqrt{F/\mu}}$

11. **(c):** Frequency of wave is same on all the four strings.

So, $\lambda_1 = \frac{v_1}{f}$, $\lambda_2 = \frac{v_2}{f}$, $\lambda_3 = \frac{v_3}{f}$, $\lambda_4 = \frac{v_4}{f}$

$$\lambda_4 : \lambda_3 : \lambda_2 : \lambda_1 = \frac{1}{4} : \frac{1}{3} : \frac{1}{2} : 1 = 3 : 4 : 6 : 12$$

12. **(d):** $P_{av} = \left(\sqrt{\mu F}\right)A^2\omega^2 \;\Rightarrow\; P_{av} \propto (\sqrt{\mu})$

So, maximum average power is for string having maximum linear mass density. Thus P_{av} is maximum for 16 μ.

13. **(d):** For process $1 \longrightarrow 2$

$$W_{12} = \int_1^2 \alpha V dV = \alpha\int_{V_0}^{3V_0} V dV = \frac{\alpha}{2}(9V_0^2 - V_0^2)$$

$= 4\alpha V_0^2$ ...(i)

Applying gas law in process $1 \longrightarrow 2$,

$P_0V_0 = RT_0$ or $\alpha V_0^2 = RT_0$

From eq.(i), $W_{12} = 4RT_0$

14. **(d) :** Using gas law, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$$T_2 = \frac{P_2V_2}{P_1V_1}T_1 = \frac{V_2^2}{V_1^2}T_1 = \left(\frac{3V_0}{V_0}\right)^2 T_0 = 9T_0$$

For process $2 \longrightarrow 3$

$$W_{23} = RT_2 \log\left|\frac{P_2}{P_3}\right| = R(9T_0)\log\left|\frac{3P_0}{P_0}\right|$$

$= 9RT_0 \log|3| = 9.81\, RT_0$

For isothermal process : $P_2V_2 = P_3V_3$

Therefore, $V_3 = \frac{P_2V_2}{P_3} = \frac{3P_0}{P_0}(3V_0) = 9V_0$

Also, $W_{31} = P_0(V_1 - V_3) = P_0(V_0 - 9V_0)$

$= -8P_0V_0 = -8RT_0$

Net work done is,

$W_{net} = W_{12} + W_{23} + W_{31}$

$= 4RT_0 + 9.81RT_0 - 8RT_0 = 5.81RT_0$

15. **(a):** For process $1 \longrightarrow 2$

$\Delta U_{12} = C_V(T_2 - T_1) = 4RT_0 + 12RT_0 = 16RT_0$

Since, $\Delta U_{12} = C_{12}(T_2 - T_1) = 8C_{12}T_0$

$C_{12} = 2R = 16.6$ J/mol-K

For the process $2 \longrightarrow 3$: $C_{23} = \infty$

For the process $3 \longrightarrow 1$: $C_{31} = C_P + R$

$C_{31} = 5R/2 = 20.75$ J/mol-K

16. **(b):** Intensity at O is proportional to intensity at S_3 and at S_4.

$I = k\cos^2\delta/2$, where k is constant, δ is phase difference.

$$\delta = \frac{2\pi}{\beta}\times\frac{Z}{2} = \frac{\pi Z}{\beta},\ \text{where } \beta \text{ is fringe width, } \beta = \frac{\lambda D}{d}$$

When $Z = \lambda D/2d$, $\delta = \frac{\pi d}{\lambda D}\times\frac{\lambda D}{2d} = \frac{\pi}{2}$

$I = I_0 = k\cos^2(\pi/4)$; $k = 2I_0$. When $Z' = \frac{2\lambda D}{d}$

Phase difference $\delta' = \frac{2\pi}{\beta}\frac{Z'}{2} = \frac{2\pi d}{\lambda D}\times\frac{2\lambda D}{2d} = 2\pi$

Required intensity at O is

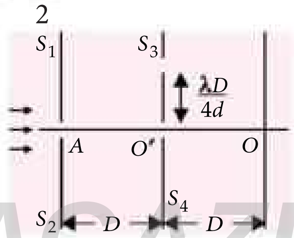
$I' = k\cos^2\delta'/2 = 2I_0\cos^2(\pi) = 2I_0$

17. (d): Intensity at O is zero if $\frac{\delta}{2} = \frac{\pi}{2}$

i.e., $\delta = \frac{2\pi}{\beta}\frac{Z}{2} = \pi \Rightarrow Z = \beta = \frac{\lambda D}{d}$

18. (c): Intensity at $S_3 = (A_0^2 + A_0^2 + 2A_0^2\cos\phi)$

where $\phi = \frac{2\pi}{\beta}\frac{\lambda D}{4d} = \frac{2\pi d}{\lambda D}\times\frac{\lambda D}{4d} = \frac{\pi}{2}$



$I_{S_3} = A_0^2(2 + 2\cos\pi/2) = 2A_0^2$

Amplitude of wave at S_3,

$A_{S_3} = \sqrt{2}A_0$

Maximum intensity at O'

$= \left(A_0 + \sqrt{2}A_0\right)^2$

Maximum intensity at $O = \left(\sqrt{2}A_0 - A_0\right)^2$

$$\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2 = \left(\sqrt{2}+1\right)^4 = 34$$

19. (d): Given, $F = -rv$

$$\therefore \quad m\left(\frac{dv}{dt}\right) = -rv \quad \text{or} \quad \frac{dv}{v} = \frac{-r}{m}dt$$

Integrating above equation, we get $\int_{v_0}^{v}\frac{dv}{v} = -\frac{r}{m}\int_0^t dt$

$$\Rightarrow |\ln v|_{v_0}^{v} = \frac{-rt}{m} \Rightarrow (\ln v - \ln v_0) = -\frac{rt}{m} \text{ or } \ln\frac{v}{v_0} = -\frac{rt}{m}$$

which gives $v = v_0 e^{-rt/m}$ ...(i)

The boat stops moving when, $v = 0$

$0 = v_0 e^{-rt/m}$ which gives $t = \infty$.

20. (a): Again we have, $\frac{dv}{dt} = -\frac{r}{m}v$

or $\quad v\frac{dv}{ds} = -\frac{r}{m}v \quad \therefore \quad dv = -\frac{r}{m}ds$

Integrating both sides of above equation, we get

$$\int_{v_0}^{v} dv = -\frac{r}{m}\int_0^s ds \quad \Rightarrow \quad |v|_{v_0}^{v} = -\frac{r}{m}s$$

or $\quad v - v_0 = \frac{-r}{m}s$ or $v = v_0 - \frac{rs}{m}$ ...(ii)

21. (c): The time at which $v = \frac{v_0}{\eta}$ (given)

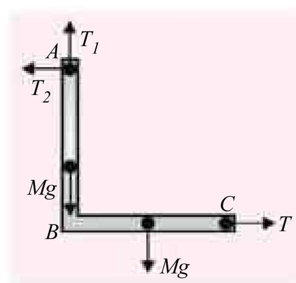
From eqn. (i), $\frac{v_0}{\eta} = v_0 e^{-rt/m}$ or $t = \frac{m\ln\eta}{r}$

The average velocity over this time interval

$$v_{av} = \frac{\int_0^t v\,dt}{\int_0^t dt} = \frac{\int_0^t v_0 e^{-rt/m}dt}{\left(\frac{m\ln\eta}{r}\right)} = \frac{v_0(\eta-1)}{\eta\ln\eta}$$

22. (c): Taking torque about A : $T \times L\ Mg \times \frac{L}{2}$

$\Rightarrow T = \frac{Mg}{2}$



23. (d): $T_1 = 2Mg$, $T_2 = T = \frac{Mg}{2}$

Net reaction $= \sqrt{T_1^2 + T_2^2}$

$= \sqrt{(2Mg)^2 + (Mg/2)^2} = \frac{\sqrt{17}Mg}{2}$

24. (a): $kx = mg$; $x = 100 - 40 = 60$ cm $= 0{\cdot}6$ m

$k(0{\cdot}6) = \left(\frac{60}{1000}\right)10 \Rightarrow k = 1\ \text{N m}^{-1}$

25. (b): $W = mgx + \frac{1}{2}mv^2\,kx^2$

$= \left(\frac{60}{1000}\right)(10)(0.6) + \frac{1}{2}(1)(0.6)^2 = 0{\cdot}36 + 0{\cdot}18 = 0{\cdot}54$ J

26. (b): Here,

$X_L = \omega L = 2\pi f L = 2\pi \times 50 \times 0.21 = 21\pi\ \Omega$

So, $Z = \sqrt{R^2 + X_L^2} = \sqrt{12^2 + (21\pi)^2}$

$= \sqrt{12^2 + (21\times 22/7)^2} = \sqrt{4500} = 30\sqrt{5}\Omega$

$\therefore \quad I = \frac{V}{Z} = \frac{220}{30\sqrt{5}} = \frac{22}{3\sqrt{5}}$ A

27. (c): $\phi = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{21\pi}{12}\right) = \tan^{-1}\left(\frac{7\pi}{4}\right)$

i.e., the current will lag the applied voltage.

WORD GRID

Readers are requested to send their responses of word grid. Be the Winner!

Find and encircle the words in the given grid, running in one of the possible directions; horizontal, vertical or diagonal by reading the clues given below.

V	A	S	P	E	W	B	S	T	G	T	E	N	S
E	Q	P	O	D	E	D	E	O	I	E	R	G	O
L	S	A	M	P	L	I	T	U	D	E	P	T	U
O	O	N	A	O	S	P	E	T	I	N	V	S	N
C	U	G	G	W	P	O	S	A	P	E	F	G	D
I	N	S	N	E	I	L	L	A	O	R	A	D	S
T	D	T	I	R	R	E	A	N	R	G	R	O	W
Y	O	O	T	R	A	D	I	A	T	I	O	N	O
R	T	R	U	A	L	I	D	O	R	N	L	O	N
E	T	M	D	D	P	A	I	M	E	T	L	T	E
S	D	E	E	C	R	D	A	A	A	O	I	H	W
O	E	R	I	L	A	I	D	S	D	G	N	I	T
N	C	I	S	X	R	A	Y	S	M	U	G	N	O
A	R	D	N	R	L	B	A	T	I	F	A	G	N
N	E	I	E	A	A	A	D	R	T	E	S	L	A
C	A	A	T	Y	M	T	G	A	T	Z	E	R	O
E	S	N	N	S	I	I	T	I	A	I	E	I	H
R	E	D	I	O	P	C	H	N	N	N	G	N	M
S	S	A	B	N	C	T	E	T	C	C	N	G	S

Across

1. Reason of clear nights are colder than cloudy nights.
2. Coolis tube is used to produce rays.
3. Intensity of light is related to.
4. The colour deviates least when passing through prism.
5. When a force is perpendicular to the direction of the motion of the body, the work done on the body.

Down

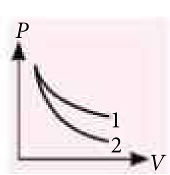
1. Two equal and opposite charges separated by some distance constitute.
2. The quantity which is not conserved in a nuclear reaction.
3. If a glass prism is dipped in water, its dispersive power.
4. The motion which is combination of rotational motion and the translational motion of a rigid body.
5. The thermodynamic process in which there is no flow of heat between system and surroundings.

*Please send entries of solutions both with words and scanned copy of the grid by 10th of every month.

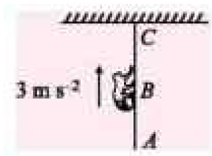
Quiz CLUB

Unlock Your Knowledge!

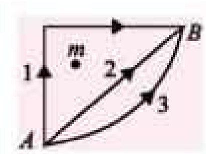
1. Why the hair of shaving brush clings together when removed from water ?
2. What is the full form of LASER?
3. Who discovered the inelastic scattering of light by molecules?
4. What does power factor measure in an A.C. circuit?
5. A charged particle is moving an circular path with velocity v in a magnetic field B, what will be change in radius if the velocity of charged particle is doubled and strength of magnetic field is halved?
6. In the Geiger-Marsden scattering experiment, what should be the impact parameter in case of head-on-collision?
7. What is the dielectric constant of metal?
8. Which phenomena confirms the transverse nature of light?
9. What is the path of electrons in the presence of an electric field?
10. Which device is used in satellites to recharge their batteries?
11. Which is the best metal to use for photoemission?
12. How much the time is required in emitting a photo-electron?
13. In a wheat stone bridge, what will be the deflection in galvanometer, if the battery and galvanometer are interchanged?
14. By how much amount kinetic energy has to be increased, for increasing the angular velocity of an object by 10%?
15. P-V plots of two gases during adiabatic processes are shown in figure. Plots 1 and 2 should correspond respectively to Helium and Argon. True or False.



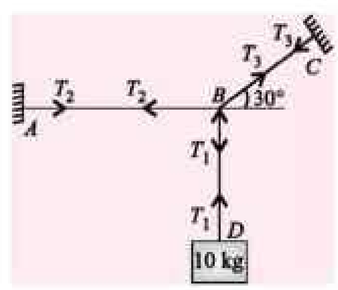
16. A monkey of mass m is climbing up a rope with an acceleration of $a > 0$ m s^{-2}. T_{AB} is 0 or < 1 or >1? (Take g = 10 m s^{-2})



17. If W_1, W_2 and W_3 represent the work done in moving a particle from A to B along there different paths 1, 2 and 3 respectively (as shown) in the gravitational field of a point mass m, find the correct relation between W_1, W_2 and W_3.



18. The 10 kg block is in equilibrium. Find T_1/T_3.



19. A transverse wave is travelling in a string then equation of the wave is equal to the shape of string at an instant t. True or False.
20. Diffraction pattern is obtained using red light. What will happen if it is replaced by violet light?

Readers can send their responses at editor@mtg.in or post us with complete address by 10th of every month. Winners' names and answers will be published in next issue.

CBSE warm-up!

CLASS-XI

Chapterwise practice questions for CBSE Exams as per the latest pattern and reduced syllabus by CBSE for the academic session 2023-24.

Series-1 Units and Measurement / Kinematics

Time Allowed : 3 hours
Maximum Marks : 70

General Instructions

(1) There are 33 questions in all. All questions are compulsory.
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
(3) All the sections are compulsory.
*(4) **Section A** contains sixteen questions, twelve MCQs and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.*
(5) There is no overall choice. However, an internal choice has been provided in one question in Section B, two questions in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary

i. $c = 3 \times 10^8$ m/s	ii. $m_e = 9.1 \times 10^{-31}$ kg	iii. $e = 1.6 \times 10^{-19}$ C
iv. $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}	v. $h = 6.63 \times 10^{-34}$ Js	vi. $\varepsilon_0 = 8.854 \times 10^{-12}$ C^{2}N^{-1}m^{-2}
vii. Avogadro's number = 6.023×10^{23} per gram mole		

SECTION A

1. In case of a projectile motion, what is the angle between the velocity and acceleration at the highest point?
(a) 0° (b) 45° (c) 90° (d) 180°

2. The motion of a particle along a straight line is described by equation $x = 8 + 12t - t^3$ where x is in metre and t in second. The retardation of the particle when its velocity becomes zero is
(a) 24 m s^{-2} (b) zero
(c) 6 m s^{-2} (d) 12 m s^{-2}

3. Choose the wrong statement.
(a) The motion of an object along a straight line is a rectilinear motion.
(b) The speed in general is less than the magnitude of the velocity.
(c) The slope of the displacement-time graph gives the velocity of the body.
(d) The area under the velocity-time graph gives the displacement of the body.

4. One of the combination from the fundamental physical constants is hc/G. The unit of this expression is
(a) kg^2 (b) m^3
(c) s^{-1} (d) none of these

5. The magnitude of the x-component of vector $\vec{A}$ is 3 and the magnitude of vector $\vec{A}$ is 5. What is the magnitude of the y-component of vector $\vec{A}$?
(a) 3 (b) 4 (c) 5 (d) 8

6. On an open ground, a motorist follows a track that turns to his left by an angle of 60° after every 500 m. Starting from a given turn, the displacement of the motorist at the third turn is

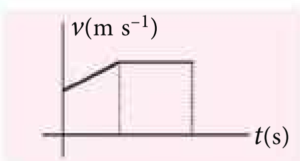
(a) 500 m (b) $500\sqrt{3}$ m
(c) 1000 m (d) $1000\sqrt{3}$ m

7. The correct order in which the dimensions of time decreases in the following physical quantities is

1. Stefan's constant
2. Coefficient of volume expansion
3. Work done
4. Velocity gradient

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

8. For a body moving along a straight line, the following v-t graph is obtained.



According to the graph, the displacement during

(a) uniform acceleration is greater than that during uniform motion.
(b) uniform acceleration is less than that during uniform motion.
(c) uniform acceleration is equal to that during uniform motion.
(d) uniform motion is zero.

9. A body is projected vertically upwards with a velocity of 10 m s^{-1}. It reaches maximum height h at time t. In time $t/2$, the height covered is

(a) $\frac{h}{2}$ (b) $\frac{2}{5}h$ (c) $\frac{3}{4}h$ (d) $\frac{5}{8}h$

10. What is approximately the centripetal acceleration (in units of acceleration due to gravity on earth, g = 10 m s^{-2}) of an air-craft flying at a speed of 400 m s^{-1} through a circular arc of radius 0.6 km ?

(a) 26.7 (b) 16.9 (c) 13.5 (d) 30.2

11. Three measurements are made as 18.425 cm, 7.21 cm and 5.0 cm. The sum of measurements upto correct number of significant figure is

(a) 30.635 cm (b) 30.64 cm
(c) 30.63 cm (d) 30.6 cm

12. In projectile motion, the physical quantity that remains invariant throughout is

(a) vertical component of velocity
(b) horizontal component of velocity
(c) kinetic energy of the projectile
(d) potential energy of the projectile

For question numbers 13-16, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is NOT the correct explanation of A.
(c) A is true but R is false.
(d) A is false and R is also false.

13. **Assertion (A) :** The displacement - time graph of a body moving with uniform acceleration is a straight line.
Reason (R) : The displacement is proportional to time.

14. **Assertion (A) :** Dimensions of coefficient of viscosity are [ML^{-1}T^{-1}].
Reason (R) : Coefficient of viscosity is force acting per unit area per unit velocity gradient.

15. **Assertion (A) :** The equations of motion in scalar form can be applied only if acceleration is along the direction of velocity.
Reason (R) : If the acceleration of a body is constant then its motion is known as uniform motion.

16. **Assertion (A) :** If the speed of a body is constant, the body cannot have a path other than a circular or straight line path.
Reason (R) : It is not possible for a body to have a constant speed in an accelerated motion.

SECTION B

17. Calculate the length of the arc of a circle of radius 31.0 cm which subtends an angle of $\pi/6$ at the centre.

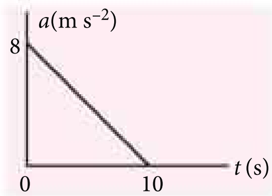
18. Distinguish between distance and displacement.

OR

Can a body be at rest as well as in motion at the same time? Explain.

19. A body is moving with a uniform velocity of 10 m s^{-1}, on a circular path of diameter 2.0 m. Calculate (i) the difference between the magnitude of the displacement of the body and the distance covered in half a round and (ii) the magnitude of the change in velocity of the body in half a round.

20. A particle starts from rest. Its acceleration a versus time t is shown in the figure. Find the maximum speed of the particle.



21. (i) A motor car is travelling at 30 m s^{-1} on a circular road of radius 500 m. It is increasing its speed at the rate of 2 m s^{-2}, what is the acceleration?

(ii) If both the speed and radius of the circular path of a body are doubled, how will the centripetal acceleration change?

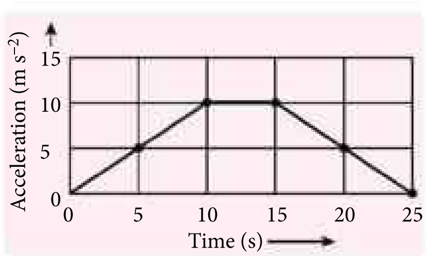
SECTION C

22. Two tall buildings face each other and are at a distance of 180 m from each other. With what velocity must a ball be thrown horizontally from a window 55 m above the ground in one building, so that it enters a window 10.9 m above the ground in the second building?

OR

An astronaut is rotating in a rotor of radius 4 m. If he can withstand acceleration of 10 g, then what is the maximum number of permissible revolutions? (g = 10 m s^{-2})

23. The following plot gives the variation of acceleration (m s^{-2}) with time (s) for an object that started from rest at time t = 0 s. Find the velocity at time t = 15 s (v_{15}) and at 25 s (v_{25}).



24. The depth x to which a bullet penetrates in a human body depends on coefficient of elasticity (η) and kinetic energy E. Establish the relation between these quantities using the method of dimensions.

25. Point P, Q and R are in a vertical line such that $PQ = QR$. A ball at P is allowed to fall freely. What is the ratio of the times of descent through PQ and QR?

26. An object is in uniform motion along a straight line. What will be position-time graph for the motion of the object if

(i) x_0 = +ve, v = +ve

(ii) x_0 = +ve, v = −ve

(iii) x_0 = −ve, v = + ve and

(iv) both x_0 and v are negative?

The letters x_0 and v represent position of the object at time t = 0 and uniform velocity of the object at time t respectively.

27. A particle is projected over a triangle from one end of a horizontal base and grazing the vertex falls on the other end of the base. If α and β be the base angle and θ the angle of projection, prove that $\tan\theta = \tan\alpha + \tan\beta$.

28. Draw the velocity-time graph for uniformly accelerated motion. Show that slope of the velocity-time graph gives acceleration of the object.

OR

A cyclist is riding with a speed of 27 km h^{-1}. As he approaches a circular turn on the road of radius 80 m, he applies brakes and reduces his speed at the constant rate of 0.50 m s^{-1} every second. Find the net acceleration of the cyclist on the circular turn.

SECTION D

29. Read the following paragraph and answer the questions that follow.

When an object is moving with variable acceleration, then the object possesses different acceleration at different instants. The acceleration of object at given instant of time is known as instantaneous acceleration.

(i) If the object is moving with velocity $v = (3t^2 + 6)$ cm s^{-1}. Find the change in velocity of the object during the time interval between t_1 = 2 s and t_2 = 4 s.

(a) 38 cm s^{-1} (b) 36 cm s^{-1}
(c) 40 cm s^{-1} (d) 48 cm s^{-1}

(ii) Find the instantaneous acceleration at t_2 = 4 s.

(a) 20 cm s^{-1} (b) 24 cm s^{-1}
(c) 30 cm s^{-1} (d) 32 cm s^{-1}

(iii) A ball is thrown up in air. What is the acceleration of ball at highest point?

(a) 0 (b) ∞
(c) 9.8 m s^{-2} (d) none of these

(iv) If the given object moving with variable acceleration $a = 8t^3 + 4t + 2$. Find the velocity of the object in 4 seconds.

(a) 276 m s^{-2} (b) 300 m s^{-2}
(c) 452 m s^{-2} (d) 552 m s^{-2}

OR

If the velocity of a particle is given by $v^2 = \sqrt{180-16x}$ m/s, what will be its acceleration?

(a) 9.8 m s^{-2} (b) zero
(c) -8 m s^{-2} (d) none of these

30. Read the following paragraph and answer the questions, that follow.

The process of splitting up a vector into two or more vectors is known as resolution of a vectors. The vectors into which a given vector is splitted are known as component vectors. When a vector is splitted into two or three component vectors at right angles to each other, the component vectors are called rectangular components of a vector.

(i) If $\hat{n}$ is a unit vector in the direction of the vector $\vec{A}$, then

(a) $\hat{n} = \frac{\vec{A}}{|\vec{A}|}$ (b) $\hat{n} = \frac{|\vec{A}|}{\vec{A}}$
(c) $\hat{n} = |\vec{A}|\vec{A}$ (d) $\hat{n} = \vec{A}$

(ii) If $\vec{A}$ is a vector of magnitude 5 units due east. What is the magnitude and direction of a vector $-5\vec{A}$?

(a) 5 units due east (b) 25 units due west
(c) 5 units due west (d) 25 units due east

(iii) Find unit vectors along $\vec{A} = \hat{i} + \hat{j} - 2\hat{k}$ and $\vec{B} = \hat{i} + 2\hat{j} - \hat{k}$.

(a) $\frac{\hat{i} - 2\hat{j} + \hat{k}}{\sqrt{6}}$ (b) $\frac{\hat{i} + 2\hat{j} + \hat{k}}{\sqrt{6}}$
(c) $\frac{\hat{i} + 2\hat{j} - \hat{k}}{\sqrt{6}}$ (d) $\frac{\hat{i} + 2\hat{j}}{\sqrt{6}}$

OR

A vector $\vec{A}$ is along the positive z-axis and its vector product with another vector $\vec{B}$ is zero, then vector $\vec{B}$ could be

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

(iv) The angle subtended by the vector $\vec{A} = (4\hat{i} + 3\hat{j} + 12\hat{k})$ with the x-axis is

(a) $\sin^{-1}\left(\frac{3}{13}\right)$ (b) $\sin^{-1}\left(\frac{4}{13}\right)$
(c) $\cos^{-1}\left(\frac{4}{13}\right)$ (d) $\cos^{-1}\left(\frac{3}{13}\right)$

SECTION E

31. Explain the principle of homogeneity of dimensions. How it can be used for deducing relation among the physical quantities. Explain with the help of a suitable example.

OR

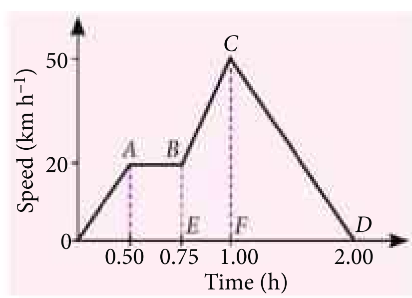
Einstein's mass - energy relation emerging out of his famous theory of relativity relates mass (m) to energy (E) as $E = mc^2$, where c is speed of light in vacuum. At the nuclear level, the magnitudes of energy are very small. The energy at nuclear level is usually measured in MeV, where 1 MeV = 1.6×10^{-13} J; the masses are measured in unified atomic mass unit (u), where 1 u = 1.67×10^{-27} kg.

(a) Show that the energy equivalent of 1 u is 939 MeV.

(b) A student writes the relation as 1 u = 931.5 MeV. The teacher points out that the relation is dimensionally incorrect. Write the correct relation.

32. (i) How is the velocity-time graph of accelerated motion helpful in studying the motion of the object in one dimension?

(ii) A train moves from one station to another in two hours time. Its speed-time graph during the motion is shown in figure. (a) Determine the maximum acceleration during the journey. (b) Also calculate the distance covered during the time interval from 0.75 hour to 1 hour.



OR

An insect trapped in a circular groove of radius 12 cm moves along the groove steadily and completes 7 revolutions in 100 s. (a) What is the angular speed, and the linear speed of the motion? (b) Is the acceleration vector a constant vector? What is its magnitude?

33. A car is moving at a constant speed of 40 km h^{-1} along a straight road which heads towards a large vertical wall and makes a sharp 90° turn by the side of the wall. A fly flying at a constant speed of

100 km h^{-1}, starts from the wall towards the car at an instant when the car is 20 km away, flies until it reaches the glass pane of the car and returns to the wall at the same speed. It continues to fly between the car and the wall till the car makes the 90° turn.

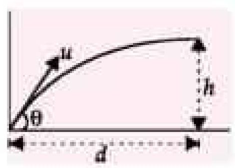
(a) What is the total distance the fly has travelled during this period?

(b) How many trips has it made between the car and the wall?

OR

(i) A ball is kicked at an angle 30° with the vertical. If the horizontal component of its velocity is 20 m s^{-1}, find the maximum height and horizontal range. Use $g = 10$ m s^{-2}.

(ii) If a stone is to hit at a point which is at a distance d away and at a height h above the point from where the stone starts as shown in the figure then what is the value of initial speed u if stone is launched at an angle θ?



SOLUTIONS

1. (c) : At the highest point, velocity is acting horizontally and acceleration (= acceleration due to gravity) is acting vertically downwards. Therefore, at the highest point the angle between velocity and acceleration is 90°.

2. (d) : Given : $x = 8 + 12t - t^3$

Velocity, $v = \frac{dx}{dt} = 12 - 3t^2$;

Acceleration, $a = \frac{dv}{dt} = -6t$

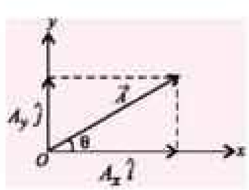
When $v = 0$, $12 - 3t^2 = 0$ or $t = 2$ s

$a|_{t=2\,s} = -12$ m s^{-2} ∴ Retardation = 12 m s^{-2}

3. (b) : The speed in general is greater than the magnitude of the velocity.
All the other statements are correct.

4. (a) : $\frac{hc}{G} = \frac{(\text{J s})(\text{m s}^{-1})}{(\text{N m}^2\,\text{kg}^{-2})} = \frac{(\text{N m s})(\text{m s}^{-1})}{(\text{N m}^2\ \text{kg}^{-2})} = \text{kg}^2$

5. (b) : $\vec{A} = A_x\hat{i} + A_y\hat{j}$



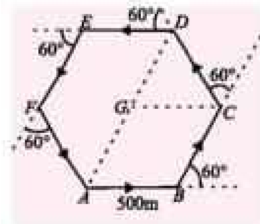
Also $A = \sqrt{A_x^2 + A_y^2}$

Here, $A = 5$, $A_x = 3$;

∴ $5 = \sqrt{(3)^2 + A_y^2}$

Squaring both sides, we get
$25 = 9 + A_y^2$ or $A_y = 4$

6. (c) : The path followed by the motorist is a regular hexagon *ABCDEF* of side length 500 m as shown in the figure. Let the motorist start from *A* and takes the third turn at *D*.



Therefore, the magnitude of this displacement is
$AD = AG + GD = 500$ m + 500 m = 1000 m

7. (a) : 1. Stefan's coefficient

$= \frac{\text{Energy}}{\text{Time} \times \text{Area} \times (\text{Temperature})^4}$

$= \frac{[ML^2T^{-2}]}{[T][L^2][K]^4} = [ML^0T^{-3}K^{-4}]$

2. Coefficient of volume expansion,

$= \frac{\text{Change in volume}}{\text{Original volume} \times \text{Temperature}}$

$= \frac{[L^3]}{[L^3][K]} = [M^0L^0T^0K^{-1}]$

3. Work done = Force × Distance = $[MLT^{-2}][L]$
$= [ML^2T^{-2}]$

4. Velocity gradient $= \frac{\text{Velocity}}{\text{Distance}}$

$= \frac{[LT^{-1}]}{[L]} = [T^{-1}] = [M^0L^0T^{-1}]$

The correct order is (a) : 2, 4, 3, 1.

8. (b) : According to the graph, area under v-t graph during uniform acceleration is less than that during uniform motion.
So, the displacement during uniform acceleration is less than that during the uniform motion.

9. (c) : $u = 10$ m s^{-1}, $v = 0$ m s^{-1}, $s = h$, $t = t$

$v = u + at$ ∴ $a = \frac{-10}{t}$ m s^{-2}

$s = ut + \frac{1}{2}at^2$ ∴ $h = 10\,t - \frac{1}{2}\left(\frac{10}{t}\right)t^2$

$= 10t - 5t = 5t$ ...(i)

In time $t = t/2$

$s = 10\left(\frac{t}{2}\right) + \frac{1}{2}\left(\frac{-10}{t}\right)\left(\frac{t}{2}\right)^2 = 5t - \frac{5t}{4} = \frac{15}{4}t$

Using eqn (i), $s = \frac{3}{4}h$

Note : We can assume $a = -g = -10$ m s^{-2}

10. (a) : Here, $v = 400$ m s^{-1}, $r = 0.6$ km $= 0.6 \times 10^3$ m, $g = 10$ m s^{-2}

Centripetal acceleration,

$$a_c = \frac{v^2}{r} = \frac{(400\,\text{m s}^{-1})^2}{0.6\times10^3\ \text{m}} = 26.7\times 10\ \text{m s}^{-2}$$

In the units of g (= 10 m s^{-2}), the centripetal acceleration is 26.7.

11. (d) : Sum of the measurements is correct only upto one place of decimal corresponding to the least number of decimal places.

18.425 + 7.21 + 5.0 = 30.635 = 30.6 cm

12. (b) : In projectile motion, the acceleration along x-axis is zero, so the velocity along x-axis always remains constant.

13. (d) : The displacement of a body moving in straight line with constant acceleration is given by, $s = ut + \frac{1}{2}at^2$. This is a equation of a parabola, not straight line. Therefore the displacement-time graph is a parabola. The displacement time graph will be straight line, if and only if acceleration of body is zero or body is moving with uniform velocity.

14. (a) : Coefficient of viscosity is force acting per unit area per unit velocity gradient *i.e.*,

$$[\eta] = \frac{[F]}{[A][(dv/dr)]} = \frac{[\text{MLT}^{-2}]}{[\text{L}^2][\text{LT}^{-1}\text{L}^{-1}]} = [\text{ML}^{-1}\text{T}^{-1}]$$

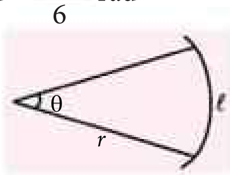
15. (b) : Since velocity and acceleration are vector quantities, therefore given equation is a vector equations, $\vec{v} = \vec{u} + \vec{a}t$. This equation is valid in scalar form when acceleration direction is same as velocity.

16. (d) : If the speed of a body is constant, all curved paths are possible. When the acceleration is zero, then body moves with a constant speed in a straight line. When the magnitude of acceleration is constant but its direction changes to remain perpendicular to the direction of motion, then the body moves with a constant speed on a circular path. If both the magnitude and direction of acceleration are changing, remaining perpendicular to the direction of motion, the body moves with a constant speed on same curved path. In uniform circular motion a body has constant speed, but its direction keeps on changing, due to which it has non-zero acceleration.

17. Given, r = 31 cm and $\theta = \frac{\pi}{6}\ \text{rad} = \frac{3.14}{6}\ \text{rad}$

We know, $\theta = \frac{\ell}{r} \Rightarrow \ell = r\theta$

$\therefore\quad \ell = 31\times\frac{3.14}{6} = 16.2$ cm.



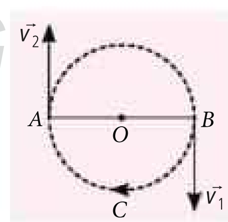
18.

Distance	Displacement
Distance is the length of the actual path traversed by a body, irrespective of its motion.	Displacement is the shortest distance between the initial and final positions of a body in a given direction.
Distance between two points may be same or different for different paths chosen.	Displacement between two given points is always same.
It is a scalar quantity.	It is a vector quantity.
Distance covered may be positive or zero.	Displacement covered may be positive, negative or zero.

OR

Yes, objects may be at rest relative to one object and at the same time it may be in motion relative to another object. For example, a passenger sitting in a moving train is at rest with respect to her fellow passengers but she is in motion with respect to the objects outside the train. Rest and motion are relative terms.

19. (i) In figure, let A and B be the initial and final positions of the body after half a round.



Distance covered = Half circumference

$= \pi r = 3.14 \times 1.0 = 3.14$ m

Magnitude of displacement

$= AB = 2.0$ m

Required difference = 3.14 – 2.0 = 1.14 m.

(ii) Let $\vec{v}_1$ and $\vec{v}_2$ be the velocity vectors at A and B. Then $\Delta\vec{v} = \vec{v}_2 - \vec{v}_1 = 10 - (-10) = 20$ m s^{-1}.

20. The area under the acceleration-time graph gives change in velocity.

$\therefore\quad v - u$ = area under $a - t$ graph

or $v - u = \frac{1}{2}\times 8\times 10 = 40.$

Here, $u = 0$

$\therefore\quad v = 40$ m s^{-1}

21. (i) $a_t = \frac{dv}{dt} = 2$ m s^{-2}

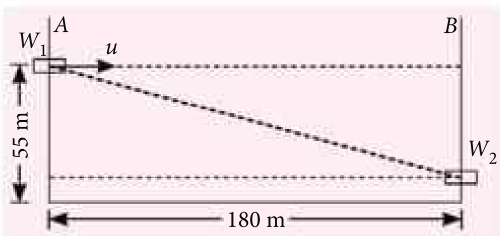
$$a_r = \frac{v^2}{r} = \frac{30\times30}{500} = 1.8\ \text{m s}^{-2}$$

So, $a = \sqrt{a_r^2 + a_t^2} = \sqrt{(1.8)^2 + (2)^2} = 2.7$ m s^{-2}

(ii) Original centripetal acceleration, $a = \dfrac{v^2}{r}$

New centripetal acceleration, $a' = \dfrac{(2v)^2}{2r} = 2a$

22. In figure, A and B are two tall buildings which are 180 m apart. W_1 and W_2 are the two windows in A and B respectively.



Vertical downward distance to be covered by the ball or = Height of W_1 – Height of W_2 = 55 – 10.9 = 44.1 m
Initial vertical velocity of ball, $u_y = 0$

As $\quad y = u_y t + \dfrac{1}{2}gt^2$

$\therefore \quad 44.1 = 0 + \dfrac{1}{2} \times 9.8\, t^2$ or $t^2 = \dfrac{44.1 \times 2}{9.8} = 9$ or $t = 3$ s

Required horizontal velocity

$$= \frac{\text{Horizontal distance}}{\text{Time}} = \frac{180 \text{ m}}{3 \text{ s}} = 60 \text{ m s}^{-1}.$$

OR

In case of uniform circular motion,

$$a_r = \frac{v^2}{r} = \omega^2 r \quad [\text{as } v = r\omega]$$

or $\quad a_r = (2\pi f)^2 r \qquad [\text{as } \omega = 2\pi f]$

or $\quad f = \dfrac{1}{2\pi}\sqrt{\dfrac{a_r}{r}}$

$$f = \frac{1}{2\pi}\sqrt{\frac{10 \times 10}{4}} \quad i.e. \quad f_{max} = \left[\frac{5}{2\pi}\right]\frac{\text{rev}}{\text{sec}}$$

23. Change in velocity = area under $a - t$ curve
$v_{15} = 1/2 \times 10 \times 10 + 10\,(15 - 10) = 100$ m s^{-1}
$v_{25} = 100 + 50 = 150$ m s^{-1}

24. Let $x = k\eta_a E_b$ ...(i)

$[M^0L^1T^0] = [M^{-1}LT^{-2}]_a\,[ML^2T^{-2}]_b$

$= M^{a+b}\,L^{-a+2b}\,T^{-2a-2b}$

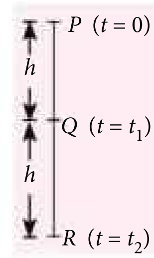
Applying principle of homogeneity of dimensions,

$a + b = 0,$
$-a + 2b = 1,$
$-2a - 2b = 0$

Solving, we get $a = -\dfrac{1}{3},\ b = \dfrac{1}{3}.$

$\therefore \quad$ From (i), $x = k\eta^{-1/3} E^{1/3} \propto (E/\eta)^{1/3}$

25. Let t_1 and t_2 be the times of descent through PQ and QR respectively.



Let $PQ = QR = h$
For P to Q,

$$h = \frac{1}{2}gt_1^2$$

For P to R,

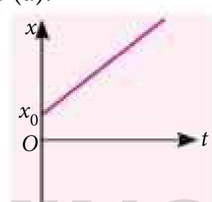
$$2h = \frac{1}{2}g\,(t_1 + t_2)^2$$

$$\therefore \quad \frac{1}{2} = \frac{t_1^2}{(t_1 + t_2)^2} \quad \text{or} \quad \frac{1}{\sqrt{2}} = \frac{t_1}{t_1 + t_2}$$

Hence $t_1 : t_2 = 1 : (\sqrt{2} - 1)$

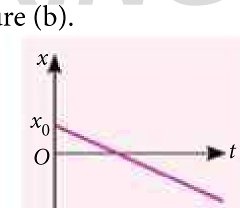
26. The position of the object at any time t while moving with uniform velocity along a straight line is given by, $x = x_0 + vt$

(i) If x_0 = + ve and v = +ve, position-time graph will be as shown in figure (a).



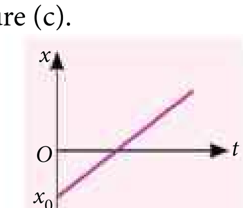
(a)

(ii) If x_0 = + ve and v = –ve, position-time graph will be as shown in figure (b).



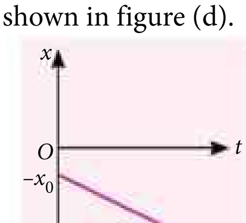
(b)

(iii) If x_0 = –ve and v = +ve, position-time graph will be as shown in figure (c).



(c)

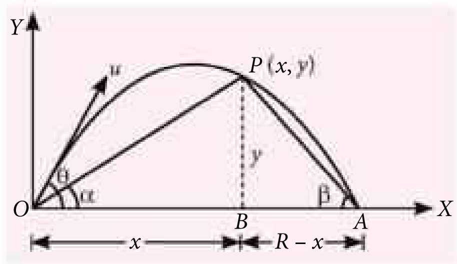
(iv) If both x_0 and v are negative, the position-time graph will be as shown in figure (d).



(d)

27. The situation is as shown in figure

If R is the range of the particle, then from the figure, we have



$$\tan\alpha+\tan\beta=\frac{y}{x}+\frac{y}{R-x}=\frac{yR}{x(R-x)} \quad ...(i)$$

Also, the trajectory of the particle is

$$y=x\tan\theta-\frac{1}{2}g\frac{x^2}{u^2\cos^2\theta}=x\tan\theta\left[1-\frac{gx}{2u^2\cos^2\theta\tan\theta}\right]$$

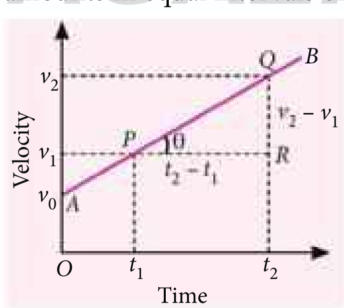
$$=x\tan\theta\left[1-\frac{g}{u^2\sin2\theta}x\right]=x\tan\theta\left[1-\frac{x}{R}\right] \quad ...(ii)$$

From equation (i) and (ii), we get

$\tan\theta = \tan\alpha + \tan\beta$.

28. Velocity-time graph for uniformly accelerated motion :

When a body moves with a uniform acceleration, its velocity changes by equal amounts in equal intervals of time. So, the velocity-time graph for a uniformly accelerated motion is a straight line inclined to the time-axis, as shown in figure.



Slope of velocity-time graph

$$AB=\tan\theta=\frac{QR}{PR}=\frac{v_2-v_1}{t_2-t_1}$$

$$=\frac{\text{Change in velocity}}{\text{Time interval}}=\text{Acceleration}$$

Hence, the slope of the velocity-time graph gives the acceleration of the object.

OR

Here, $v=27\text{ km h}^{-1}=27\times\frac{5}{18}\text{ m s}^{-1}$

$v=\frac{15}{2}\text{ m s}^{-1}=7.5\text{ m s}^{-1}$, $r=80\text{ m}$

Centripetal acceleration, $a_c=\frac{v^2}{r}$

$$a_c=\frac{(7.5\text{ m s}^{-1})^2}{80\text{ m}}\approx0.7\text{ m s}^{-2}$$

Tangential acceleration, $a_t = -0.5\text{ m s}^{-2}$

Magnitude of the net acceleration is

$$a=\sqrt{(a_c)^2+(a_t)^2}=\sqrt{(0.7)^2+(-0.5)^2}\approx0.86\text{ m s}^{-2}$$

29. (i) (b) : Given, v = 3*t*2 + 6

When $t_1 = 2$ s, $v_1 = 3\times2^2+6 = 18$ cm s^{-1}

When $t_2 = 4$ s, $v_2 = 3\times4^2+6 = 54$ cm s^{-1}

Change in velocity = $v_2 - v_1 = 54 - 18 = 36$ cm s^{-1}

(ii) (b) : Instantaneous acceleration,

$$a_i=\frac{dv}{dt}=\frac{d}{dt}(3t^2+6)=6t$$

At t = 4 s, $a_1 = 6\times4 = 24$ m s^{-2}

(iii) (a) : When a ball is thrown up in air, acceleration of ball at highest point is zero.

(iv) (d) : Acceleration, $a=\frac{dv}{dt} \Rightarrow dv=adt$

Integrating both sides

$$\int dv=\int_0^4 adt \Rightarrow v=\int_0^4(8t^3+4t+2)dt$$

$$v=8\left[\frac{t^4}{4}\right]_0^4+4\left[\frac{t^2}{2}\right]_0^4+2\,[t]_0^4$$

$v = 2[4^4 - 0^4] + 2[4^2 - 0^2] + 2[4 - 0] \Rightarrow v = 552$ m s^{-2}

OR

(c) : Acceleration, $a=\frac{dv}{dt}=\frac{dv}{dx}\times\frac{dx}{dt}=v\frac{dv}{dx}$

Given, $v^2 = (180 - 16x)$;

Differentiating it w.r.t. x, we have $2v\frac{dv}{dx}=-16$

So, acceleration, $a=v\frac{dv}{dx}=-\frac{16}{2}=-8\text{ m/s}^2$

30. (i) (a) : $\hat{n}=\frac{\vec{A}}{|\vec{A}|}$

(ii) (b) : $\vec{A}=5$ units due east.

$\therefore -5\vec{A}$ = –5 (5 units due east) = – 25 units due east = 25 due west

(iii) (c) : Unit vector along $\vec{A}$,

$$\hat{A}=\frac{\vec{A}}{|\vec{A}|}=\frac{\hat{i}+\hat{j}-2\hat{k}}{\sqrt{1^2+1^2+(-2)^2}}=\frac{\hat{i}+\hat{j}-2\hat{k}}{\sqrt{6}}$$

Unit vector along $\vec{B}$,

$$\hat{B}=\frac{\vec{B}}{|\vec{B}|}=\frac{\hat{i}+2\hat{j}-\hat{k}}{\sqrt{1^2+2^2+(-1)^2}}=\frac{\hat{i}+2\hat{j}-\hat{k}}{\sqrt{6}}$$

OR

The vector product of two non-zero vectors is zero if they are in the same direction or in the opposite direction. Hence, vector $\vec{B}$ must be parallel or antiparallel to vector $\vec{A}$, *i.e.* along $\pm z$-axis.

(iv) (c) : The angle subtended by vector $\vec{A}$ with x - axis is

$$\cos\alpha = \frac{A_x}{A} = \frac{4}{\sqrt{4^2+3^2+(12)^2}} = \frac{4}{13} \text{ or, } \alpha = \cos^{-1}\left(\frac{4}{13}\right)$$

31. *Refer to answer 26, Page no. 25, Class-11, MTG 100 percent Physics.*

OR

Refer to answer 27, Page no. 25, Class-11, MTG 100 percent Physics.

32. (i) *Refer to answer 11, Page no. 52, Class-11, MTG 100 percent Physics.*

(ii) *Refer to answer 17, Page no. 52, Class-11, MTG 100 percent Physics.*

OR

Refer to answer 22, Page no. 108, Class-11, MTG 100 percent Physics.

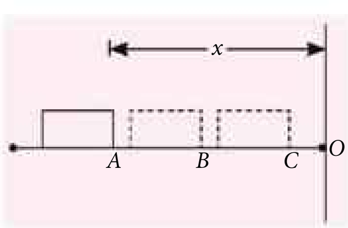
33. (a) The time taken by the car to cover 20 km before the turn is $\frac{20\text{ km}}{40\text{ km/h}} = \frac{1}{2}\text{ h}$. The fly moves at a constant speed of 100 km/h during this time. Hence, the total distance covered by it is $100\ \frac{\text{km}}{\text{h}} \times \frac{1}{2}\text{ h} = 50$ km.

(b) Suppose the car is at a distance x away (at A) when the fly is at wall (at O). The fly hits the glass pane at B, taking a time t. Then

$AB = (40\text{ km/h})t$ and $OB = (100\text{ km/h})t$

Thus, $x = AB + OB = (140\text{ km/h})t$

or $\quad t = \frac{x}{140\text{ km/h}}$ or $OB = \frac{5}{7}x$



The fly returns to the wall and during this period the car moves the distance BC. The time taken by the fly in this return path is

$$\left(\frac{5x/7}{100\text{ km/h}}\right) = \frac{x}{140\text{ km/h}}$$

Thus, $BC = \frac{40x}{140} = \frac{2}{7}x$ or $OC = OB - BC = \frac{3}{7}x$.

If at the beginning of the round trip (wall to the car and back) the car is at a distance x away, it is $\frac{3}{7}x$ away when the next trip again starts.

Distance of the car at the beginning of the 1st trip = 20 km.

Distance of the car at the beginning of the 2nd trip

$= \frac{3}{7} \times 20\text{ km}$.

Distance of the car at the beginning of the 3rd trip

$= \left(\frac{3}{7}\right)^2 \times 20\text{ km}$.

Distance of the car at the beginning of the 4th trip

$= \left(\frac{3}{7}\right)^3 \times 20\text{ km}$.

Distance of the car at the beginning of the nth trip

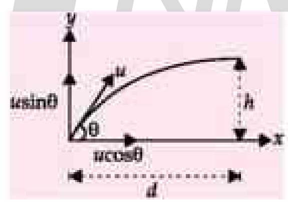
$= \left(\frac{3}{7}\right)^{n-1} \times 20\text{ km}$.

Trips will go on till the car reaches the turn that is the distance reduces to zero. This will be the case when n becomes infinity. Hence, the fly makes an infinite number of trips before the car takes the turn.

OR

(i) *Refer to answer 20, Page no. 108, Class-11, MTG 100 percent Physics.*

(ii)



Motion along horizontal direction

$d = u\cos\theta \times t$ or $t = d/(u\cos\theta)$ ...(i)

Motion along vertical direction

$$h = (u\sin\theta)t - \frac{1}{2}gt^2 \quad \text{...(ii)}$$

Substitute the value of t in equation (ii), we get

$$h = u\sin\theta \times \left(\frac{d}{u\cos\theta}\right) - \frac{1}{2}g\left(\frac{d^2}{u^2\cos^2\theta}\right)$$

or $\quad h = d\tan\theta - \frac{1}{2}g\left(\frac{d^2}{u^2\cos^2\theta}\right)$

or $\quad \frac{1}{2}\frac{gd^2}{u^2\cos^2\theta} = d\tan\theta - h;\ u^2 = \frac{gd^2}{2(d\tan\theta - h)\cos^2\theta}$

or $\quad u = \frac{d}{\cos\theta}\sqrt{\frac{g}{2(d\tan\theta - h)}}$

MONTHLY TEST DRIVE

XI

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Time Taken : 60 Min.

System of Particles and Rotational Motion

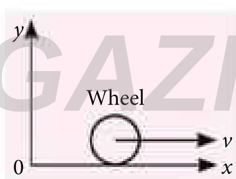
Total Marks : 120

NEET

Only One Option Correct Type

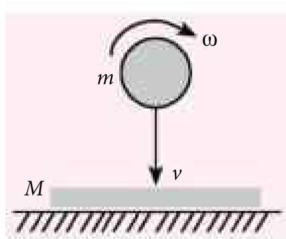
1. A solid cylinder of mass 2 kg and radius 50 cm rolls up an inclined plane of angle inclination 30°. The centre of mass of cylinder has speed of 4 m s^{-1}. The distance travelled by the cylinder on the incline surface will be (Take g = 10 m s^{-2})
(a) 2.2 m (b) 1.6 m (c) 1.2 m (d) 2.4 m

2. Given $v_{CM} = 2$ m s^{-1}, $m = 2$ kg, R = 4 m. Find angular momentum of ring about its origin if it is in pure rolling.



(a) 32 kg m^2 s^{-1}
(b) 24 kg m^2 s^{-1}
(c) 16 kg m^2 s^{-1} (d) 8 kg m^2 s^{-1}

3. A solid ball of mass m and radius r spinning with angular velocity ω falls on a horizontal slab of mass M with rough upper surface (coefficient of friction μ) and smooth lower surface. Immediately after collision, the normal component of velocity of the ball remains half of its value just before collision and it stops spinning. The velocity of the sphere in horizontal direction immediately after the impact is _______ ms^{-1}. (given : $R\omega = 5$).



(a) 5 m/s (b) 4 m/s
(c) 3 m/s (d) 2 m/s

4. Four small objects each of mass m are fixed at the corners of a rectangular wire-frame of negligible mass and of sides a and b ($a > b$). If the wire frame is now rotated about an axis passing along the side of length b, then the moment of inertia of the system for this axis of rotation is
(a) $2ma^2$ (b) $4ma^2$
(c) $2m(a^2 + b^2)$ (d) $2m(a^2 - b^2)$

5. A solid sphere rolls down without slipping on an inclined plane at angle 60° over a distance of 10 m. The acceleration (in m s^{-2}) is
(a) 4 (b) 5 (c) 6 (d) 7

6. A gymnast takes turns with her arms and legs stretched. When she pulls her arms and legs in, then
(a) the angular velocity decreases
(b) the moment of inertia decreases
(c) the angular velocity stays constant
(d) the angular momentum increases.

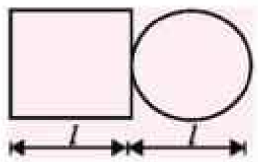
7. Find moment of inertia of a ring about its diameter and about an axis in the plane of the ring and tangential to it.
(a) $\frac{5}{2}MR^2$ (b) $\frac{7}{2}MR^2$ (c) $\frac{3}{2}MR^2$ (d) $\frac{MR^2}{2}$

8. A solid sphere is rotating in free space. If the radius of the sphere is increased keeping mass same which one of the following will not be affected?
(a) moment of inertia
(b) angular momentum
(c) angular velocity
(d) rotational kinetic energy.

9. A circular disc reaches, from top to bottom, of an inclined plane of length S. When it slips down the plane, it takes time t_1. When it rolls down the plane, it takes time t_2. Calculate the ratio $\frac{t_2}{t_1}$.

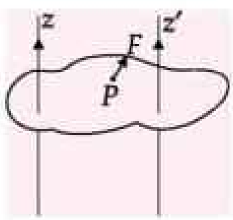
(a) $\sqrt{\frac{3}{2}}$ (b) $\frac{1}{2}$ (c) 1 (d) $\frac{1}{\sqrt{3}}$

10. If the density of material of a square plate and a circular plate shown in figure is same, the centre of mass of the composite system will be



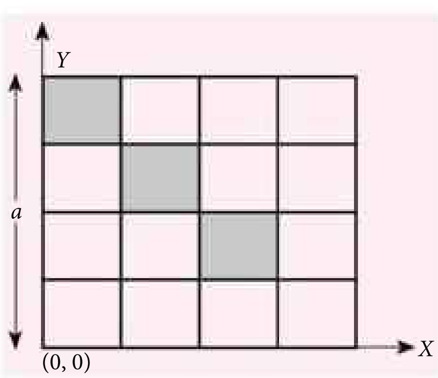
(a) inside the square plate
(b) inside the circular plate
(c) at the point of contact
(d) outside the system

11. Figure shows a lamina in *x*-*y* plane. Two axes *z* and *z*' pass perpendicular to its plane. A force *F* acts in the plane of lamina at point *P* as shown. Which of the following statements is incorrect? (The point *P* is closer to *z*'-axis than the *z*-axis).



(a) Torque τ caused by F about z axis is along $\hat{k}$.
(b) Torque τ' caused by F about z' axis is along $-\hat{k}$.
(c) Torque caused by F about z axis is greater in magnitude than that about z' axis.
(d) Total torque is given as $\tau = \tau + \tau'$.

12. From a uniform square plate, the shaded portions are removed as shown in the figure. The coordinates of centre of mass of the remaining plate are (*X*- and *Y*-axes and origin are shown in the figure).



(a) $\left(\frac{12a}{104}, \frac{55a}{104}\right)$ (b) $\left(\frac{55a}{104}, \frac{66a}{104}\right)$

(c) $\left(\frac{55a}{104}, \frac{49a}{104}\right)$ (d) $\left(\frac{49a}{104}, \frac{49a}{104}\right)$

Assertion & Reason Type

Directions : In questions 13 to 15, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. Assertion : Value of radius of gyration of a body depends on axis of rotation.
Reason : Radius of gyration is root mean square distance of particle of the body from the axis of rotation.

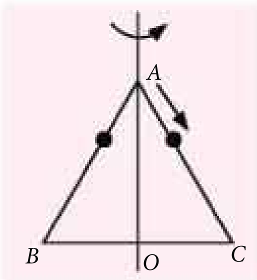
14. Assertion : The centre of mass of a proton and an electron, related from their respective positions remains at rest.
Reason : The centre of mass remain at rest, if no external force is applied.

15. Assertion : When a body is dropped from a height explodes in mid air, but its centre of mass keeps moving in vertically downward direction.
Reason : Explosion occur under internal forces only. External force is zero.

JEE MAIN / ADVANCED

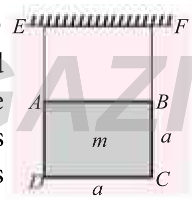
Only One Option Correct Type

16. An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at A. The triangle is set rotating about the vertical axis AO. Then the beads are released from rest simultaneously and allowed to slide down, one along AB and the other along AC as shown. Neglecting frictional effects, the quantities that are conserved as the beads slide down, are



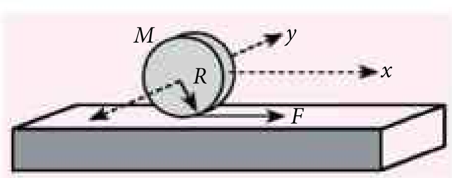
(a) angular velocity and total energy (kinetic and potential)
(b) total angular momentum and total energy
(c) angular velocity and moment of inertia about the axis of rotation
(d) total angular momentum and moment of inertia about the axis of rotation.

17. A thin, uniform square plate $ABCD$ of side a and mass m is suspended in vertical plane as shown in the figure. AE and BF are two massless inextensible strings. The line AB is horizontal. Find the tension in the string AE just after BF is cut.



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

18. A uniform cylindrical disc of radius R and mass M is pulled over a horizontal frictionless surface by a constant force F. The force is applied by means of a string wound around the disc as shown in the figure. If it starts from rest at $t = 0$, the linear and angular displacements respectively at time t are

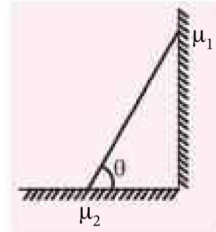


(a) $\left(\frac{F}{M}\right)t^2, \left(\frac{F}{M}\right)t^2$ (b) $\left(\frac{F}{2M}\right)t, \left(\frac{F}{2MR}\right)t^2$

(c) $\left(\frac{F}{M}\right)t^2, \left(\frac{F}{MR}\right)t^2$ (d) $\left(\frac{2F}{M}\right)t^2, \left(\frac{2F}{MR}\right)t^2$

More than One Option Correct Type

19. In the figure, a ladder of mass m is shown leaning against a wall. It is in static equilibrium making an angle θ with the horizontal floor. The coefficient of friction between the wall and the ladder is μ_1 and that between the floor and the ladder is μ_2. The normal reaction of the wall on the ladder is N_1 and that of the floor is N_2. If the ladder is about to slip, then



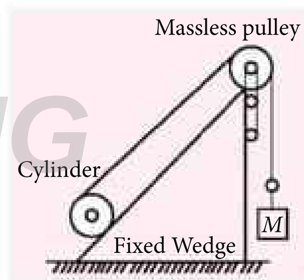
(a) $\mu_1 = 0, \ \mu_2 \neq 0$ and $N_2 \tan\theta = \frac{mg}{2}$

(b) $\mu_1 \neq 0, \ \mu_2 = 0$ and $N_1 \tan\theta = \frac{mg}{2}$

(c) $\mu_1 \neq 0, \ \mu_2 \neq 0$ and $N_2 = \frac{mg}{1+\mu_1\mu_2}$

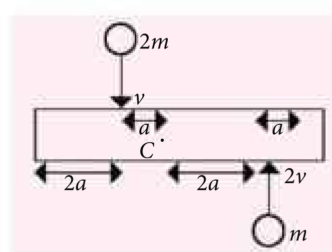
(d) $\mu_1 = 0, \ \mu_2 \neq 0$ and $N_1 \tan\theta = \frac{mg}{2}$

20. A cylinder and a variable mass M are arranged on a fixed wedge using a light string and a massless pulley. There is enough friction between cylinder and the wedge to prevent any slipping.



(a) Only one value of M is possible for which cylinder can remain in equilibrium.
(b) There is a range of value of M for which cylinder can remain in equilibrium.
(c) For a certain value of M, the cylinder starts to roll up the plane. In this situation, magnitude of friction force on the cylinder by the wedge will be greater than tension in the string.
(d) For a certain value of M, the cylinder starts to roll down the plane. In this situation, magnitude of friction force on the cylinder by the wedge will be greater than tension in the string.

21. A uniform bar of length $6a$ and mass $8m$ lies on a smooth horizontal table. Two point masses m and $2m$ moving in the same

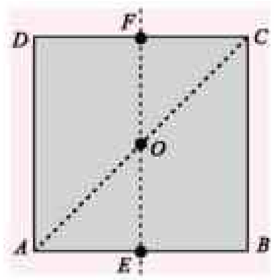


horizontal plane with speed $2v$ and v respectively, strike the bar [as shown in the figure] and stick to the bar after collision. Denoting angular velocity (about the centre of mass), total energy and centre of mass velocity by ω, E and v_c respectively, we have after collision

(a) $v_c = 0$ (b) $\omega = \frac{3v}{5a}$

(c) $\omega = \frac{v}{5a}$ (d) $E = \frac{3}{5}mv^2$

22. For the given uniform square lamina $ABCD$, whose centre is O



(a) $\sqrt{2}I_{AC} = I_{EF}$

(b) $I_{AD} = 4I_{EF}$

(c) $I_{AC} = I_{EF}$

(d) $I_{AC} = \sqrt{2}\,I_{EF}$

23. A bar of length l carrying a small mass m at one of its ends rotates with a uniform angular speed ω in a vertical plane about the mid-point of the bar. During the rotation, at some instant of time when the bar is horizontal, the mass is detached from the bar but the bar continues to rotate with same ω. The mass moves vertically up, comes back and reaches the bar at the same point. At that place, the acceleration due to gravity is g.

(a) This is possible if the quantity $\frac{\omega^2 l}{2\pi g}$ is an integer.

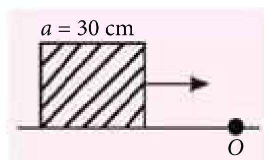
(b) The total time of flight of the mass is proportional to ω^2.

(c) The total distance travelled by the mass in air is proportional to ω^2.

(d) The total distance travelled by the mass in air and its total time of flight are both independent of its mass.

Integer / Numerical Value Type

24. A cubical block of side 30 cm is moving with velocity 2 m s^{-1} on a smooth horizontal surface. The surface has a bump at a point O as shown in figure. The angular velocity (in rad s^{-1}) of the block immediately after it hits the bump, is _____.

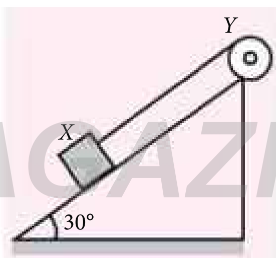


25. A ceiling fan rotates about its own axis with some angular velocity. When the fan is switched off, the angular velocity becomes $\left(\frac{1}{4}\right)^{th}$ of the original in time t and n revolution are made in that time. The number of revolutions made by the fan during the time interval between switch off and rest are (Angular retardation is uniform) $\frac{x}{15}n$, where the value of x is ______.

26. A metre stick is balanced on a knife edge at its centre. When two coins, each of mass 5 g are put one on top of the other at the 12.0 cm mark, the stick is found to be balanced at 45.0 cm. The mass of the metre stick is ______ g

Comprehension Type

A block X of mass 0.5 kg is held by a long massless string on a frictionless inclined plane of inclination 30° to the horizontal. The string is wound on a uniform solid cylindrical drum Y of mass 2 kg and of radius 0.2 m as shown in figure. The drum is given an initial angular velocity such that the block X starts moving up the plane. Based on the above facts, answer the following questions.



27. The tension in the string during the motion is given by

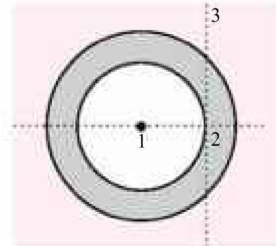
(a) T = 16.3 N (b) T = 13.6 N
(c) T = 6.3 N (d) T = 1.63 N

28. It is observed that at a certain instant of time, the magnitude of the angular velocity possessed by Y is 10 rad s^{-1}. The distance travelled by X from that instant of time until it comes to rest is

(a) 2.11 m (b) 12.1 m
(c) 1.22 m (d) 11.2 m

Matrix Match Type

29. From a uniform disc of mass M and radius R, a concentric disc of radius R/2 is cut out. For the remaining annular disc : I_1 is the moment of inertia about axis '1', I_2 about '2', I_3 about '3' and I_4 about '4'. Axes '1' and '2' are perpendicular to the disc and '3' and '4' are in the plane of the disc. Axes '2', '3' and '4' intersect at a common point.



Column I		Column II	
I	I_1 is equal to	(P)	$\frac{21}{32}MR^2$
II	I_2 is equal to	(Q)	$I_1/2$
III	$I_3 + I_4$ is equal to	(R)	$\frac{15}{32}MR^2$
IV	$I_2 - I_3$ is equal to	(S)	None of these

(a) I → (R), II → (P), III → (P), IV → (Q)
(b) I → (P), II → (Q), III → (R), IV → (S)
(c) I → (P), II → (P), III → (R), IV → (S)
(d) I → (S), II → (P), III → (Q), IV → (P)

30. Match the column I with column II and choose the correct option from given below.

Column I		Column II	
(A)	Angular impulse	(P)	$\vec{r}\cdot\vec{F}$
(B)	Torque	(Q)	$\vec{r}\times\vec{p}$
(C)	Angular momentum	(R)	$I\alpha$
(D)	Work done	(S)	$I\omega$

(a) (A) → (P, Q), (B) → (S), (C) → (R, S), (D) → (Q)
(b) (A) → (Q, R), (B) → (P), (C) → (P, S), (D) → (R)
(c) (A) → (R), (B) → (Q, S), (C) → (P, Q), (D) → (S)
(d) (A) → (Q, S), (B) → (R), (C) → (Q, S), (D) → (P)

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted ……
No. of questions correct ……
Marks scored in percentage ……

Check your score! If your score is

> 90%	EXCELLENT WORK !	You are well prepared to take the challenge of final exam.
90-75%	GOOD WORK !	You can score good in the final exam.
74-60%	SATISFACTORY !	You need to score more next time
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.

CBSE warm-up!

CLASS-XII

Chapterwise practice questions for CBSE Exams as per the latest pattern and reduced syllabus by CBSE for the academic session 2023-24.

Series-1 Electrostatics

Time Allowed : 3 hours
Maximum Marks : 70

General Instructions

(1) There are 33 questions in all. All questions are compulsory.
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
(3) All the sections are compulsory.
*(4) **Section A** contains sixteen questions, twelve MCQs and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.*
(5) There is no overall choice. However, an internal choice has been provided in one question in Section B, two questions in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary

i. $c = 3 \times 10^8$ m/s
ii. $m_e = 9.1 \times 10^{-31}$ kg
iii. $e = 1.6 \times 10^{-19}$ C
iv. $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}
v. $h = 6.63 \times 10^{-34}$ Js
vi. $\varepsilon_0 = 8.854 \times 10^{-12}$ C^{2}N^{-1}m^{-2}
vii. Avogadro's number = 6.023×10^{23} per gram mole

SECTION A

1. A one paisa coin is made up of aluminium and weighs 0.75 g. It has a square shape and its diagonal measures 17 mm. It is electrically neutral and contains equal amounts of positive and negative charges. The magnitude of these charges is
(Atomic mass of Al = 26.98 g)
(a) 3.47×10^4 C
(b) 3.47×10^2 C
(c) 1.67×10^{20} C
(d) 1.67×10^{22} C

2. Which of the statements is false in the case of polar molecules?
(a) Centers of positive and negative charges are separated in the absence of external electric field.
(b) Centers of positive and negative charges are separated in the presence of external electric field.
(c) Do not possess permanent dipole moments.
(d) Ionic molecule HCl is the example of polar molecule.

3. The electric potential at a point in free space due to a charge Q coulomb is $Q \times 10^{11}$ volts. The electric field at that point is
(a) $12\pi\varepsilon_0 Q \times 10^{22}$ V m^{-1}
(b) $4\pi\varepsilon_0 Q \times 10^{22}$ V m^{-1}
(c) $12\pi\varepsilon_0 Q \times 10^{20}$ V m^{-1}
(d) $4\pi\varepsilon_0 Q \times 10^{20}$ V m^{-1}

4. The expression for electric field intensity at a point outside uniformly charged thin plane sheet is (d is the distance of point from plane sheet)

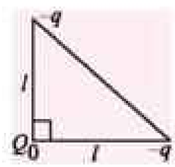
(a) independent of d.
(b) directly proportional to $\sqrt{d}$.
(c) directly proportional to d.
(d) directly proportional to $1/\sqrt{d}$.

5. A cube of side b has a charge q at each of its vertices. The potential due to this charge array at the centre of the cube is

(a) zero (b) $\frac{4q}{\sqrt{3}\pi\varepsilon_0 b}$

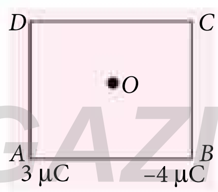
(c) $\frac{q}{\pi\varepsilon_0 b}$ (d) $\frac{4q}{\pi\varepsilon_0 b}$

6. Three charges Q_0, $-q$ and $-q$ are placed at the vertices of an isosceles right angled triangle as shown in the figure. The net electrostatic potential energy is zero if Q_0 is equal to



(a) $\frac{q}{4}$ (b) $\frac{2q}{\sqrt{32}}$ (c) $\sqrt{2}q$ (d) $+q$

7. Four point charges are placed at the corners of a square $ABCD$ of side 10 cm, as shown in figure. The force on a charge of 1 μC placed at the centre of square is

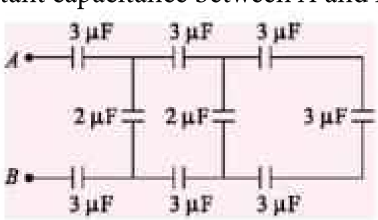


(a) 7 N (b) 8 N (c) 2 N (d) zero

8. If a linear isotropic dielectric is placed in an electric field of strength E, then the polarization P is
(a) independent of E
(b) inversely proportional to E
(c) directly proportional to $\sqrt{E}$
(d) directly proportional to E

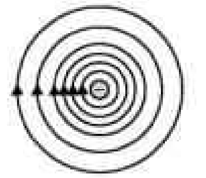
9. The net electric charge enclosed by a Gaussian surface of dipole is
(a) 0 C (b) 1 C (c) 2 C (d) 3 C

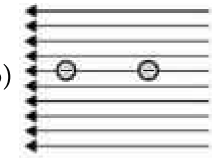
10. The resultant capacitance between A and B is

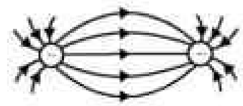


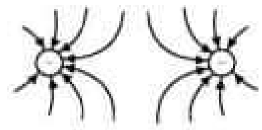
(a) 1 μF (b) 3 μF (c) 2 μF (d) 1.5 μF

11. Which of the following represents the electric field lines due to a combination of two negative charges?

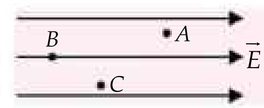
(a) 

(b) 

(c) 

(d) 

12. A, B and C are three points in a uniform electric field. The electric potential is



(a) maximum at C
(b) same at all the three points A, B and C
(c) maximum at A
(d) maximum at B

For Questions 13 to 16, two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

(a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.
(b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(c) If Assertion is true but Reason is false.
(d) If both Assertion and Reason are false.

13. **Assertion (A) :** The surface densities of two spherical conductors of different radii are equal. Then the electric field intensities near their surface are also equal.
Reason (R) : Surface density is equal to charge per unit area.

14. **Assertion (A) :** Conductors having equal positive charge and volume, must also have same potential.
Reason (R) : Potential depends only on charge and volume of conductor.

15. **Assertion (A) :** A point charge is lying at the centre of a cube of each side . The electric flux emanating from each surface of the cube is $1/6^{th}$ of total flux.
Reason (R) : According to Gauss theorem, total electric flux through a closed surface enclosing a charge is equal to $1/\varepsilon_0$ times the magnitude of the charge enclosed.

16. **Assertion (A) :** The capacity of a conductor, under given circumstances, remains constant irrespective of the charge present on it.

Reason (R) : Capacity depends on size and shape of conductor and also on the surrounding medium.

SECTION B

17. There are three metals A, B and C. When A and B are kept in front of each other they experience attractive force. When A and C are kept in front of each other they also experience attractive force. What will happen when B and C are kept in front of each other?

18. Define 'intensity of electric field' at a point. At what points is the electric dipole field intensity parallel to the line joining the two charges?

19. Two capacitors of equal capacitance when connected in series have a net capacitance C_1 and when connected in parallel have a net capacitance C_2. What is the value of C_1/C_2.

20. How do the expressions for electric field just outside a sheet of charge and a charged conductor differ?

OR

Can you say that earth is an equipotential surface?

21. A potential difference of 250 volt is applied across the plates of a capacitor 10 pF. Calculate the charge on the plates of the capacitor.

SECTION C

22. Derive an expression for the potential energy of an electric dipole in a uniform electric field. Explain conditions for stable and unstable equilibrium.

23. (i) Why no two electric field lines intersect each other?

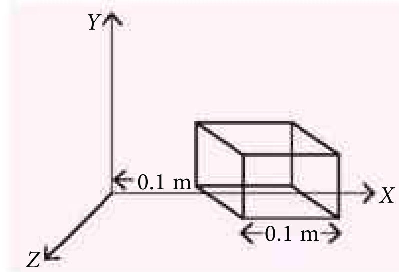
(ii) Give four properties of electric lines of force.

OR

Twenty seven drops of same size are charged at 220 V each. They combine to form a bigger drop. Calculate the potential of the bigger drop.

24. The electric field components due to a charge inside the cube of side 0.1 m are $E_x = \alpha x$, where $\alpha = 500\ \text{N C}^{-1}\ \text{m}^{-1}$, $E_y = E_z = 0$.

Calculate the flux through the cube and the charge inside the cube.



25. Three concentric spherical metallic shells A, B and C of radii a, b and c ($a < b < c$) have surface charge densities σ, $-\sigma$ and σ respectively.

(i) Find the potential of the three shells A, B and C.

(ii) If the shell A and C are at the same potential, obtain the relation between the radii a, b and c.

OR

Explain, using suitable diagrams, the difference in the behaviour of a (i) conductor and (ii) dielectric in the presence of external electric field. Define the terms polarization of a dielectric and write its relation with susceptibility.

26. Two small spheres each having mass m kg and charge q coulomb are suspended from a point by insulating threads each l metre long, but of negligible mass. If θ is the angle, each string makes with the vertical when equilibrium has been attained, show that $q^2 = (4mgl^2 \sin^2\theta . \tan\theta)4\pi\varepsilon_0$.

27. An electric dipole with moment $\vec{p}$ is placed in a uniform electric field of intensity $\vec{E}$. Write the expression for the torque $\vec{\tau}$ experienced by the dipole. Identify two pairs of perpendicular vectors in the expression. Show diagrammatically the orientation of the dipole in the field for which the torque is (i) maximum, (ii) half the maximum value, (iii) zero.

28. A slab of material of dielectric constant k has the same area as the plates of a parallel plate capacitor but has a thickness $(3/4)d$, where d is the separation of the plates. How is the capacitance changed when the slab is inserted between the plates?

MONTHLY TEST DRIVE CLASS XII ANSWER KEY

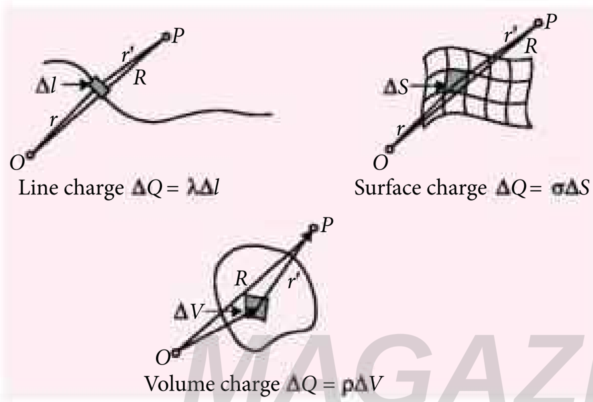
1.	(a)	2.	(c)	3.	(a)	4.	(d)	5.	(a)
6.	(a)	7.	(a)	8.	(d)	9.	(b)	10.	(c)
11.	(a)	12.	(c)	13.	(b)	14.	(b)	15.	(d)
16.	(d)	17.	(b)	18.	(c)	19.	(b,c)	20.	(b,c)
21.	(a, c)	22.	(a, c, d)	23.	(a, b)	24.	(5)	25.	(2)
26.	(2. 7)	27.	(a)	28.	(c)	29.	(a)	30.	(d)

SECTION D

Case Study Based Questions

29. Read the following paragraph and answer the questions that follow.

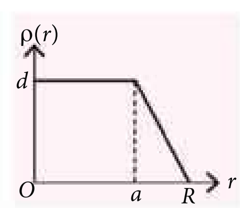
In practice, we deal with charges much greater in magnitude than the charge on an electron, so we can ignore the quantum nature of charges and imagine that the charge is spread in a region in a continuous manner. Such a charge distribution is known as continuous charge distribution. There are three types of continuous charge distribution : (i) Line charge distribution (ii) Surface charge distribution (iii) Volume charge distribution as shown in figure.



(i) **Statement 1 :** Gauss's law can't be used to calculate electric field near an electric dipole.
Statement 2 : Electric dipole don't have symmetrical charge distribution.
(a) Statement 1 and statement 2 are true.
(b) Statement 1 is false but statement 2 is true.
(c) Statement 1 is true but statement 2 is false.
(d) Both statements are false.

(ii) An electric charge of 8.85×10^{-13} C is placed at the centre of a sphere of radius 1 m. The electric flux through the sphere is
(a) 0.2 N C^{-1} m^2 (b) 0.1 N C^{-1} m^2
(c) 0.3 N C^{-1} m^2 (d) 0.01 N C^{-1} m^2

(iii) The electric field within the nucleus is generally observed to be linearly dependent on r. So,



(a) $a = 0$
(b) $a = R/2$
(c) $a = R$
(d) $a = 2R/3$

OR

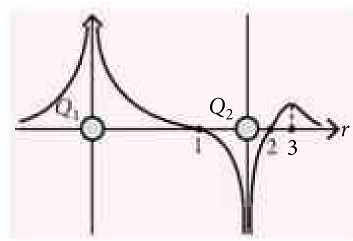
What charge would be required to electrify a sphere of radius 25 cm so as to get a surface charge density of $\frac{3}{\pi}$ C m^{-2} ?
(a) 0.75 C (b) 7.5 C (c) 75 C (d) zero

(iv) The SI unit of linear charge density is
(a) C m (b) C m^{-1} (c) C m^{-2} (d) C m^{-3}

30. Read the following paragraph and answer the questions that follow.

Electrostatic Potential :

The potential at any observation point P of a static electric field is defined as the work done by the external agent (or negative of work done by electrostatic field) in slowly bringing a unit positive point charge from infinity to the observation point. Figure shows the potential variation along the line of charges. Two point charges Q_1 and Q_2 lie along a line at a distance from each other.



(i) At which of the points 1, 2 and 3 is the electric field is zero?
(a) 1 (b) 2
(c) 3 (d) Both (a) and (b)

(ii) The signs of charges Q_1 and Q_2 respectively are
(a) positive and negative (b) negative and positive
(c) positive and positive (d) negative and negative

(iii) Which of the two charges Q_1 and Q_2 is greater in magnitude?
(a) Q_2
(b) Q_1
(c) Same
(d) Can not be determined

(iv) Which of the following statement is not true?
(a) Electrostatic force is a conservative force.
(b) Potential energy of charge q at a point is the work done per unit charge in bringing a charge from any point to infinity.
(c) When two like charges lie infinite distance apart, their potential energy is zero.
(d) Both (a) and (c).

OR

Positive and negative point charges of equal magnitude are kept at $\left(0, 0, \frac{a}{2}\right)$ and $\left(0, 0, \frac{-a}{2}\right)$

respectively. The work done by the electric field when another positive point charge is moved from $(-a, 0, 0)$ to $(0, a, 0)$ is

(a) positive
(b) negative
(c) zero
(d) depends on the path connecting the initial and final positions.

SECTION E

31. (i) The dimensions of an atom are of the order of an Angstrom. Thus there must be large electric fields between the protons and electrons. Why the electrostatic field inside a conductor is zero?

(ii) Derive the expression for the torque acting on an electric dipole, when it is held in a uniform electric field. Identify the orientation of the dipole in the electric field, in which it attains a stable equilibrium.

OR

(i) The two metallic spheres of radii R_1 and R_2 have equal surface densities of charge. Find the ratio of electric fields on their surfaces.

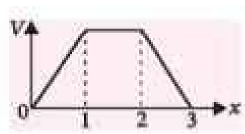
(ii) Show that the electric field due to a infinitely long sheet of charge is $\frac{\sigma}{\varepsilon_0}$.

32. (a) When a parallel plate capacitor is connected across a *dc* battery, explain briefly how the capacitor gets charged.

(b) A parallel plate capacitor of capacitance '*C*' is charged to '*V*' volt by a battery. After some time the battery is disconnected and the distance between the plates is doubled. Now a slab of dielectric constant $1 < k < 2$ is introduced to fill the space between the plates. How will the following be affected?

(i) The electric field between the plates of the capacitor?
(ii) The energy stored in the capacitor.
Justify your answer in each case.

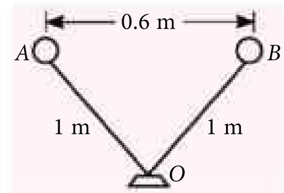
(c) The electric potential as a function of distance '*x*' is shown in the figure. Draw a graph of the electric field *E* as a function of *x*.



OR

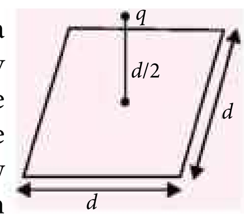
(i) How many electronic charges drawn form one coulomb of charge?

(ii) Two identical helium filled balloons *A* and *B* fastened to a weight 5 gram by threads float in equilibrium as shown in figure. Calculate the charge on each balloon, assuming that they carry equal charges.



33. (a) Define electric flux. Is it a scalar or a vector quantity?

A point charge *q* is at a distance of *d*/2 directly above the centre of a square of side *d*, as shown in the figure. Use Gauss' law to obtain the expression for the electric flux through the square.



(b) If the point charge is now moved to a distance '*d*' from the centre of the square and the side of the square is doubled, explain how the electric flux will be affected.

OR

(a) Draw a graph to show the variation of *E* with perpendicular distance *r* from the line of charge.

(b) Find the work done in bringing a charge *q* from perpendicular distance r_1 to r_2 $(r_2 > r_1)$.

SOLUTIONS

1. (a) : Mass of the coin = 0.75 g,
Atomic mass of aluminium = 26.98 g
Number of Al atoms in the coin,

$$N = \frac{6.02 \times 10^{23}}{26.98} \times 0.75 = 1.67 \times 10^{22}$$

As atomic number (*Z*) of Al is 13, each atom of Al contain 13 protons and 13 electrons. Magnitude of positive and negative charges in one paisa coin

$= NZe = 1.67 \times 10^{22} \times 13 \times 1.6 \times 10^{-19}\ \text{C} = 3.47 \times 10^{4}\ \text{C}$

2. (c) : Polar molecules have permanent dipole moment.

3. (b) : Here, $V = \frac{Q}{4\pi\varepsilon_0 r} = Q \times 10^{11}$

$\therefore\ 4\pi\varepsilon_0 r = 10^{-11}$

Now, $E = \frac{Q}{4\pi\varepsilon_0 r^2} = \frac{Q \times 4\pi\varepsilon_0}{(4\pi\varepsilon_0 r)^2}$

$$= \frac{4\pi\varepsilon_0 Q}{(10^{-11})^2} = 4\pi\varepsilon_0 Q \times 10^{22}\ \text{Vm}^{-1}$$

4. (a) : Electric field intensity outside sheet is $\frac{\sigma}{2\varepsilon_0}$.
So it is independent of *d*.

5. (b) : All the eight charges are symmetrically situated at the eight vertices of the cube, each at a distance *r* equal to half the longest diagonal from the centre.
Length of the longest diagonal of the cube,

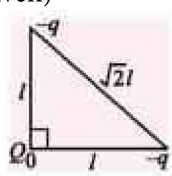
$$d = \sqrt{b^2 + b^2 + b^2} = \sqrt{3}b \text{. Hence, } r = \frac{d}{2} = \frac{\sqrt{3}}{2}b$$

Potential at the centre of the cube due to all the eight charges is,

$$V = 8 \times \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r} = 8 \times \frac{1}{4\pi\varepsilon_0} \times \frac{q}{\frac{\sqrt{3}}{2}b} = \frac{4q}{\sqrt{3}\pi\varepsilon_0 b}$$

6. (b) : The net potential energy = 0 (given)

$$U_{\text{Total}} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{\sqrt{2}l} - \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{2qQ_0}{l} = 0$$



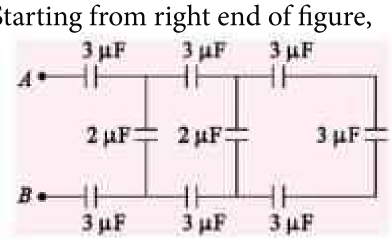
$$\therefore \quad Q_0 = \frac{q}{2\sqrt{2}} \Rightarrow Q_0 = \frac{2q}{4\sqrt{2}} = \frac{2q}{\sqrt{32}}$$

7. (d) : Forces of repulsion on 1 μC charge at *O* due to 3 μC charges, at *A* and *C* are equal and opposite. So they cancel each other.
Similarly, forces of attraction on 1 μC charge at *O* due to −4 μC charges at *B* and *D* are also equal and opposite. So they also cancel each other.
Hence the net force on the charge of 1 μC at *O* is zero.

8. (d) : For linear isotropic dielectric,
Polarisation, $P = \chi_e E$
where χ_e is a constant characteristic of the dielectric and is known as the electric susceptibility of the dielectric medium.

9. (a) : The net electric charge enclosed by a Gaussian surface of dipole is zero, as the number of lines coming out cancels with the number of lines going in.
So, $\oint \vec{E} \cdot d\vec{A} = 0$

10. (a) : Starting from right end of figure,



$$\frac{1}{C_S} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{3}{3} = 1 \quad \text{or} \quad C_S = 1\,\mu\text{F}$$

$C_P = 1 + 2 = 3$ μF and so on.
Finally, the equivalent resistance between *A* and *B* is C_{AB}

$$\text{or} \quad \frac{1}{C_{AB}} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = 1 \quad \text{or} \quad C_{AB} = 1\,\mu\text{F}$$

11. (d)

12. (d) : In the direction of electric field, electric potential decreases. ∴ $V_B > V_C > V_A$

13. (b) : As $\sigma_1 = \sigma_2$ (Given)

$$\therefore \quad \frac{q_1}{4\pi r_1^2} = \frac{q_2}{4\pi r_2^2}, \text{ or, } \frac{q_1}{q_2} = \frac{r_1^2}{r_2^2}$$

[Let r_1 and r_2 be two different radii]
Then the ratio of electric field intensities near the surface of spherical conductors,

$$\frac{E_1}{E_2} = \frac{q_1}{4\pi\varepsilon_0 r_1^2} \times \frac{4\pi\varepsilon_0 r_2^2}{q_2} = \frac{q_1}{q_2} \times \frac{r_2^2}{r_1^2} = \frac{q_1}{q_2} \times \frac{q_2}{q_1} = 1$$

i.e. $E_1 = E_2$

14. (d) : Electric potential of a charged conductor depends not only on the amount of charge and volume but also on the shape of the conductor. Hence if their shapes are different, they may have different electric potential.

15. (b) : The electric flux through the cube, $\phi = q/\varepsilon_0$.
A cube has six faces of equal area. Therefore, electric flux through each face = $\frac{1}{6}\phi = \frac{1}{6}(q/\varepsilon_0)$.

16. (a) : Charge present on a conductor determines its potential. Capacity is a function of size and shape of the conductor and of the surrounding medium. Capacitance in case of parallel plate capacitor $C = \frac{K\varepsilon_0 A}{d}$, where *K* is dielectric constant of medium, *A* is area of plates and *d* is distance between them.

17. If *A* is positively charged, then *B* can be negatively charged or neutral as charged body attracts a neutral body also. Similarly, *C* can also be negatively charged or neutral . If *B* and *C* are both negatively charged they will repel each other. If *B* is negatively charged and *C* is neutral they will attract each other. If both are neutral then they will neither attract or repel.

18. The electric field intensity at a point is the force experienced by a unit positive charge placed at that point. The dipole field intensity is parallel to the line joining the charges at axial position.

19. In series, $C_1 = \frac{C}{n}$

In parallel, $C_2 = nC$

$\therefore \quad \frac{C_1}{C_2} = \frac{C/n}{nC} = \frac{1}{n^2}$.

20. The field due to charge conductor is twice that due to sheet of charge.

$E_{\text{sheet}} = \frac{\sigma}{2\varepsilon_0}, E_{\text{conductor}} = \frac{\sigma}{\varepsilon_0}$

OR

Yes, as earth is a conductor, so its surface is equipotential.

21. Here, $V = 250$ V, $C = 10$ pF $= 10 \times 10^{-12}$ F $= 10^{-11}$ F

$\therefore \quad Q = CV = 10^{-11} \times 250 = 2.5 \times 10^{-9}$ C

22. Since net force on electric dipole in uniform electric field is zero, so no work is done in moving the electric dipole in uniform electric field, however some work is done in rotating the dipole against the torque acting on it. So, small work done in rotating the dipole by an angle $d\theta$ in uniform electric field E is

$$dW = \tau\, d\theta = pE \sin\theta\, d\theta$$

Hence, net work done in rotating the dipole from angle θ_i to θ_f in uniform electric field is

$$W = \int_{\theta_i}^{\theta_f} pE \sin\theta\, d\theta = pE\,[-\cos\theta]_{\theta_i}^{\theta_f}$$

or $\quad W = pE\,[-\cos\theta_f + \cos\theta_i] = pE\,[\cos\theta_i - \cos\theta_f]$

If initially, the dipole is placed at an angle $\theta_i = 90°$ to the direction of electric field, and is then rotated to the angle $\theta_f = \theta$, then net work done is

$$W = pE\,[\cos 90° - \cos\theta]$$

or $\quad W = -\,pE\cos\theta$

This gives the work done in rotating the dipole through an angle θ in uniform electric field, which gets stored in it in the form of potential energy *i.e.*, $U = -\,pE\cos\theta$

This gives potential energy stored in electric dipole of moment p when placed in uniform electric field at an angle θ with its direction.

(i) When $\theta = 0°$, then $U_{\text{min}} = -pE$

So, potential energy of an electric dipole is minimum, when it is placed with its dipole moment p parallel to the direction of electric field E and so it is called its most stable equilibrium position.

(ii) When $\theta = 180°$, then $U_{\text{max}} = +\,pE$

So, potential energy of an electric dipole is maximum, when it is placed with its dipole moment p anti parallel to the direction of electric field E and so it is called its most unstable equilibrium position.

23. (i) No two electric lines of force can intersect each other because at the point of intersection, we can draw two tangent to the lines of force. This would means two directions of electric field intensity at the same point which is not possible.

(ii) Some properties of electric lines of force are as follows.

(i) Electric field lines are continuous curves. They start fom positively charged body and end at a negatively charged body.

(ii) Tangent to the electric field lines at any point gives the direction of electric field intensity at that point.

(iii) No two electric field lines of force can intersect each other.

(iv) Electric field lines pass through dielectrics.

OR

Here : $n = 27$; Potential, $V = 220$ V

Potential at the surface of a solid charged sphere

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$\frac{4}{3}\pi r^3 \times n = \frac{4}{3}\pi r'^3 \quad \text{or} \quad r' = rn^{1/3} \qquad \text{...(i)}$$

Potential of bigger drop, $V_n = \frac{1}{4\pi\varepsilon_0}\cdot\frac{nq}{r'}$

$$V_n = \frac{1}{4\pi\varepsilon_0}\frac{nq}{rn^{1/3}} \quad \text{(using (i))}$$

$$\therefore \quad V_n = Vn^{2/3} \qquad \text{...(ii)}$$

Putting the values of n and V in equation (ii), we get

$$V_n = 220 \times (27)^{2/3} \quad \text{or} \quad V_n = 1980 \text{ V}$$

24. Flux is only along x-axis.

Flux through the left face

$\phi_1 = E_x . A .\cos 180°$

$\phi_1 = 500 \times 0.1 \times 10^{-2} \times 1 = -0.5$ N m^2 C^{-1}

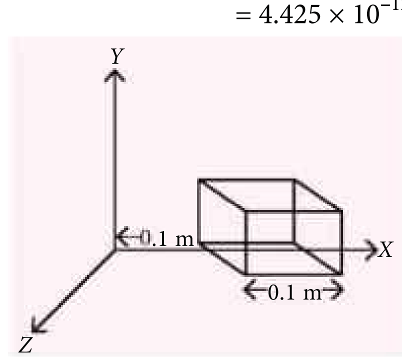
Flux through the right face

$\phi_2 = E_x . A .\cos\theta° = 500 \times 0.2 \times 10^{-2} \times 1 = 1$ N m^2 C^{-1}

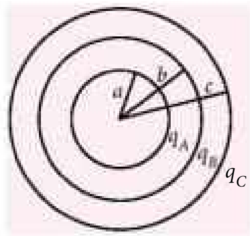
Net flux, $\phi = \phi_1 + \phi_2 = -0.5 + 1 = 0.5$ N m^2 C^{-1}

Charge inside the cube $= \varepsilon_0 \phi = 8.854 \times 10^{-12} \times 0.5$

$= 4.425 \times 10^{-12}$ C.



25. (i) Potential of any shell will be due to all the charges present in the system.



$$V_A = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_A}{a} + \frac{q_B}{b} + \frac{q_C}{c}\right]$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{(4\pi a^2)\sigma}{a} + \frac{(4\pi b^2)(-\sigma)}{b} + \frac{(4\pi c^2)(\sigma)}{c}\right]$$

$$= \frac{\sigma}{\varepsilon_0}(a - b + c)$$

$$V_B = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_A}{b} + \frac{q_B}{b} + \frac{q_C}{c}\right]$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{(4\pi a^2)\sigma}{b} + \frac{(4\pi b^2)(-\sigma)}{b} + \frac{(4\pi c^2)\sigma}{c}\right]$$

$$= \frac{\sigma}{\varepsilon_0}\left[\frac{a^2}{b} - b + c\right]$$

$$V_C = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_A}{c} + \frac{q_B}{c} + \frac{q_C}{c}\right]$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{(4\pi a^2)\sigma}{c} + \frac{(4\pi b^2)(-\sigma)}{c} + \frac{(4\pi c^2)\sigma}{c}\right]$$

$$= \frac{\sigma}{\varepsilon_0}\left[\frac{a^2}{c} - \frac{b^2}{c} + c\right]$$

(ii) If $V_A = V_C$

$$\frac{\sigma}{\varepsilon_0}(a - b + c) = \frac{\sigma}{\varepsilon_0}\left(\frac{a^2}{c} - \frac{b^2}{c} + c\right)$$

$$a - b + c = \frac{a^2}{c} - \frac{b^2}{c} + c$$

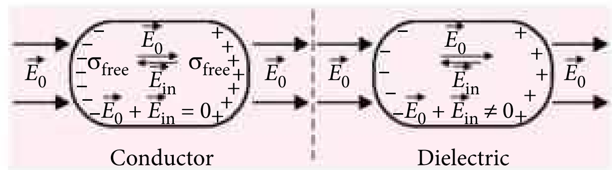
$$a + b = c$$

OR

(i) When a conductor is placed in an external electric field, the free charges present inside the conductor redistribute themselves in such a manner that the electric field due to induced charges opposes the external field within the conductor. This happens until a static situation is achieved *i.e.*, when the two fields cancel each other and the net electrostatic field in the conductor becomes zero.

(ii) Dielectrics are non-conducting substances *i.e.*, they have no charge carriers. Thus, in a dielectric, free movement of charges is not possible. It turns out that the external field induces dipole moment by reorienting molecules of the dielectric. The collective effect of all the molecular dipole moments is the net charge on the surface of the dielectric which produce a field that opposes the external field, unlike a conductor in an external electric field. However, the opposing field so induced does not exactly cancel the external field. It only reduces it. The extent of the effect depends on the nature of the dielectric.

The effect of electric field on a conductor and a dielectric is shown in the figure.



The dipole moment per unit volume is called polarisation and is denoted by P. For linear isotropic dielectrics, $P = \chi E$

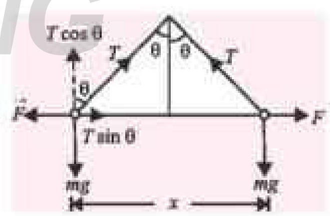
where χ is electric susceptibility of the dielectric medium.

26. $T\cos\theta = mg$ ...(i)

$$T\sin\theta = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{x^2} \quad \text{...(ii)}$$

Dividing (i) by (ii), we get

$$\tan\theta = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{x^2 mg} \quad \text{...(iii)}$$



As $\sin\theta = \frac{x/2}{l} = \frac{x}{2l}$

or $x = 2l\sin\theta$

So using it in equation (iii)

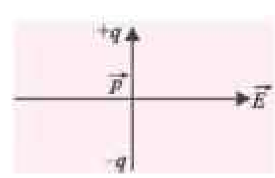
$q^2 = (4mgl^2 \sin^2\theta \tan\theta)\, 4\pi\varepsilon_0$

27. Expression for torque on dipole in uniform electric field is $\tau = pE\sin\theta$ or $\vec{\tau} = \vec{p} \times \vec{E}$

So, two pairs of perpendicular vectors are: (a) torque $\vec{\tau}$ and electric dipole moment $\vec{P}$ (b) torque $\vec{\tau}$ and electric field intensity $\vec{E}$.

(i) Torque is maximum, when $\theta = 90°$ between $\vec{P}$ and $\vec{E}$ *i.e.*, when electric dipole is perpendicular to direction of field $\tau_{max} = pE$

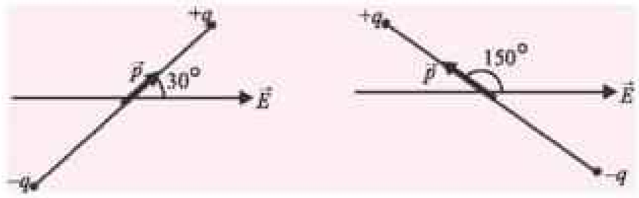
(ii) $\tau = \frac{1}{2}\tau_{max}$



or $pE\sin\theta = \frac{1}{2}pE$

$\sin\theta = \frac{1}{2}$; $\theta = 30°$ or $150°$

So, torque is half the maximum value for $\theta = 30°$ or $150°$ between $\vec{P}$ and $\vec{E}$.



(iii) Torque is zero, when $\theta = 0°$ or $180°$ between $\vec{p}$ and $\vec{E}$. *i.e.*, when dipole is placed parallel or antiparallel to direction of electric field.

28. $\dfrac{C}{C_0} = \dfrac{\dfrac{\varepsilon_0 AK}{(K(d-t)+t)}}{\dfrac{\varepsilon_0 A}{d}} = \dfrac{Kd}{K(d-t)+t}$

or $\dfrac{C}{C_0} = \dfrac{Kd}{K\left(d-\dfrac{3}{4}d\right)+\dfrac{3}{4}d} = \dfrac{K}{\dfrac{K}{4}+\dfrac{3}{4}}$; $C = \dfrac{4K}{(K+3)}C_0$.

29. (i) (a) : Gauss's law is applicable for any closed surface. Gauss's law is most useful in situation where the charge distribution has spherical or cylindrical symmetry or is distributed uniformly over the plane. Whereas electric dipole is a system of two equal and opposite point charges separated by a very small and finite distance.

So both statements are correct.

(ii) (b) : According to Gauss's law, the electric flux through the sphere is

$$\phi = \frac{q_{in}}{\varepsilon_0} = \frac{8.85\times10^{-13}\,\text{C}}{8.85\times10^{-12}\,\text{C}^2\,\text{N}^{-1}\,\text{m}^{-2}} = 0.1\,\text{N C}^{-1}\,\text{m}^2$$

(iii) (c) : For uniformly volume charge density,

$E = \dfrac{\rho r}{3\varepsilon_0}$; $E \propto r$

OR

(a) : $r = 25$ cm $= 0.25$ m, $\sigma = \dfrac{3}{\pi}$ C m^{-2}

As, $\sigma = \dfrac{q}{4\pi r^2} \Rightarrow q = 4\pi\times(0.25)^2\times\dfrac{3}{\pi} = 0.75$ C

(iv) (b) : The line charge density at a point on a line is the charge per unit length of the line at that point

$\lambda = \dfrac{dq}{dL}$

Thus, the SI unit for λ is C m^{-1}.

30. (i) (c) : As $\dfrac{-dV}{dr} = E_r$, the negative of the slope of V versus r curve represents the component of electric field along r. Slope of curve is zero only at point 3.
Therefore, the electric field vector is zero at point 3.

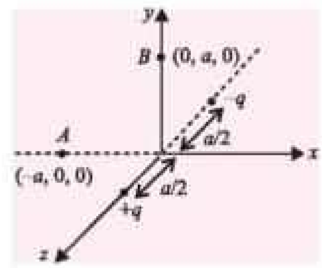
(ii) (a) : Near positive charge, net potential is positive and near a negative charge, net potential is negative. Thus, charge Q_1 is positive and Q_2 is negative.

(iii) (b) : From the figure, it can be seen that net potential due to two charges is positive everywhere in the region left to charge Q_1. Therefore the magnitude of potential due to charge Q_1 is greater than due to Q_2.

(iv) (b)

OR

(c) : It can be seen that potential at the points both A and B are zero. When the charge is moved from A to B, work done by the electric field on the charge will be zero.



31. (i) *Refer to answer 28, Page no. 32, Class-12, MTG 100 percent Physics.*

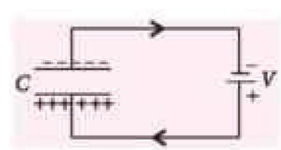
(ii) *Refer to answer 22, Page no. 31-32, Class-12, MTG 100 percent Physics.*

OR

(i) *Refer to answer 17, Page no. 44, Class-12, MTG 100 percent Physics.*

(ii) *Refer to answer 20, Page no. 44-45, Class-12, MTG 100 percent Physics.*

32. (a) Consider a parallel plate capacitor is connected across a battery as shown in figure.



Then the electric current will flow through the circuit. As the charges reach the plate, the insulating gap does not allow the charges to move further; hence, positive charges get deposited on one side of the plate and negative charges get deposited on the other side of the plate. As the voltage begins to develop, the electric charges begins to resist the deposition of further charges. Thus the current flowing through the circuit gradually becomes less and then zero till the voltage of the capacitor is exactly equal but opposite to the voltage of the battery. This is how capacitor gets charged.

(b) (i) The electric field between the plates is $E = \dfrac{V}{d}$

The distance between plates is doubled, $d = 2d$

$\therefore\ E' = \frac{V'}{d'} = \left(\frac{V}{k}\right) \times \frac{1}{2d} = \frac{1}{2}\left(\frac{E}{k}\right)$

Therefore, if the distance between the plates is double, the electric field will reduce to one half.

(ii) As the capacitance of the capacitor

$$C' = \frac{\varepsilon_0 kA}{d'} = \frac{\varepsilon_0 kA}{2d} = \frac{1}{2}C \quad \text{... (i)}$$

Energy stored in the capacitor is $U = \frac{Q^2}{2C}$

New energy, $U' = \frac{Q^2}{2C'} = \frac{Q^2}{2(1/2)C} = 2\left(\frac{Q^2}{2C}\right) = 2U$

Therefore, when the distance between the plates is doubled, the capacitance reduces to half and the energy stored in the capacitor becomes double.

(c) Electric field $E = -\frac{dV}{dx}$ ...(i)

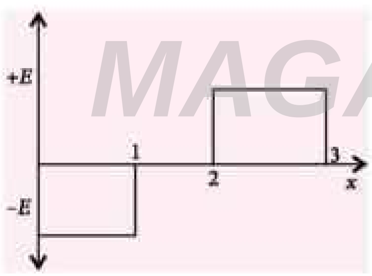
For $x = 0$ to 1, $V = kx$

$x = 1$ to 2, $V = k$

$x = 2$ to 3, $V = -kx$

where k is some constant

So, using (i) the variation of electric field is shown in figure.

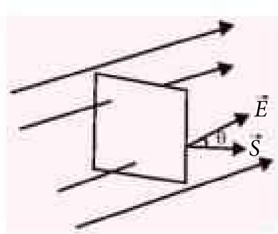


OR

(i) *Refer to answer 14, Page no. 7, Class-12, MTG 100 percent Physics.*

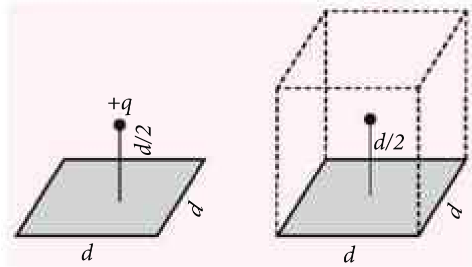
(ii) *Refer to answer 5, Page no. 49, Class-12, MTG 100 percent Physics.*

33. (a) Electric flux linked with a surface is the number of electric lines of force cutting through a surface normally and is measured as surface integral of electric field over that surface S *i.e.*, $\phi = \int_S \vec{E} \cdot d\vec{S}$



It is a scalar quantity.

Let us assume that the given square be one face of the cube of edge d cm. As charge of q is at distance of $d/2$ above the centre of a square, so it is enclosed by the cube. Hence by Gauss's theorem, electric flux linked with the cube is



$\phi = \frac{q}{\varepsilon_0}$

So, the magnitude of the electric flux through the square is $\phi_{sq} = \frac{\phi}{6} = \frac{q}{6\varepsilon_0}$

(b) Here distance of point charge becomes doubled and also sides of square gets doubled.

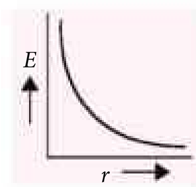
Same kind of symmetry is still here with sides of cube $2d$, hence electric flux through the square will not be affected *i.e.*, $\phi_{sq} = \frac{q}{6\varepsilon_0}$.

Hence there will be no change in electric flux.

OR

(a) Since $E = \frac{\lambda}{2\pi\varepsilon_0 r} \Rightarrow E \propto \frac{1}{r}$

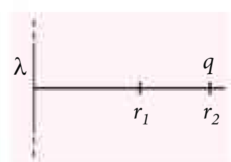
Therefore plot of E versus r will be as shown.



(b) As per the situation charge q is kept at a distance r_2 from line charge.

$E_{(r_2)} = \frac{\lambda}{2\pi\varepsilon_0 r_2}$ and $E'_{(r_1)} = \frac{\lambda}{2\pi\varepsilon_0 r_1}$

Work done in moving charge q form r_2 to r_1,



$$W = \int_{r_2}^{r_1} \vec{F} \cdot d\vec{r} = \int_{r_2}^{r_1} \frac{q\lambda}{2\pi\varepsilon_0 r} dr \cos 0°$$

$$= \frac{q\lambda}{2\pi\varepsilon_0} \int_{r_2}^{r_1} \frac{dr}{r} = \frac{q\lambda}{2\pi\varepsilon_0} \left[\ln r\right]_{r_2}^{r_1} = \frac{q\lambda}{2\pi\varepsilon_0} \ln \frac{r_1}{r_2}$$

UNSCRAMBLED WORDS

APRIL 2023

1- e-POUND	2- h - LIMITING
3-f - INELASTIC	4-J - POWER
5-c -ELECTRICITY	6-a - LATENT HEAT
7-d- ADIABATIC	8-i - AMPLITUDE
9-b -MICROSCOPE	10-g -BORON

Winner: *Yuvraj (W.B.)*

MONTHLY TEST DRIVE

XII

This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Time Taken : 60 Min.

Electromagnetic Induction/Alternating Current

Total Marks : 120

NEET

Only One Option Correct Type

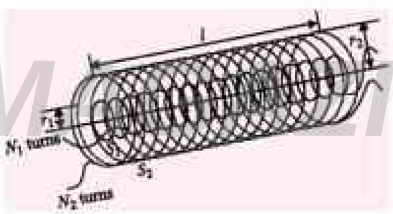
1. A circular coil with a cross-sectional area of 4 cm^2 has 10 turns. It is placed at the centre of a long solenoid that has 15 turns/cm^{-1} and a cross-sectional area of 10 cm^2, as shown in the figure. The axis of the coil coincides with the axis of the solenoid. What is their mutual inductance?

(a) 7.54 μH

(b) 8.54 μH

(c) 9.54 μH

(d) 10.54 μH



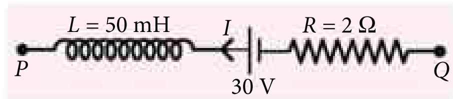
2. A pure resistive circuit element X when connected to an ac supply of peak voltage 200 V gives a peak current of 5 A which is in phase with the voltage. A second circuit element Y, when connected to the same ac supply also gives the same value of peak current but the current lags behind by 90°. If the series combination of X and Y is connected to the same supply, what will be the rms value of current?

(a) $\frac{10}{\sqrt{2}}$ A (b) $\frac{5}{\sqrt{2}}$ A (c) $\left(\frac{5}{2}\right)$ A (d) 5 A

3. A transmitting station transmits radiowaves of wavelength 360 m. The inductance of coil required with a condenser of capacity 1.20 μF in the resonant circuit to receive them is

(a) 3.04×10^{-8} H (b) 2.04×10^{-8} H
(c) 4.04×10^{-8} H (d) 6.04×10^{-8} H

4. A part of a complete circuit is shown in the figure. At some instant, the value of current I is 1 A and it is decreasing at a rate of 10^2 A s^{-1}. The value of the potential difference $V_P - V_Q$, at that instant, is



(a) 28 V (b) 23 V (c) 36 V (d) 33 V

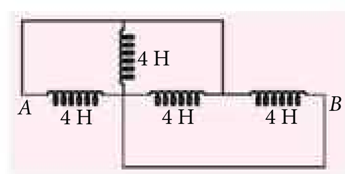
5. In a LCR oscillatory circuit, find the energy stored in inductor at resonance if voltage of source is 10 V, resistance is 10 Ω and inductance = 1 H.

(a) 0.5 J (b) 2 J (c) 4 J (d) 10 J

6. A conducting rod of length L is moving in a uniform magnetic field (B) with a velocity v without rotation. The velocity of the rod is perpendicular to the rod, and the motion of the rod is confined to a plane perpendicular to the magnetic field. What is the induced emf developed across the rod?

(a) BLv (b) Bv^2L (c) BL/v (d) BL^2v

7. The equivalent inductance between A and B is



(a) 1 H (b) 4 H (c) 0.8 H (d) 16 H

8. A transformer of 100% efficiency has 200 turns in primary and 40000 turns in the secondary. It is connected to a 220 V main supply and the secondary feeds to a 100 kΩ resistance. Calculate the output potential difference and the power delivered to load.

(a) 44 kW (b) 4.4 kW
(c) 22.6 kW (d) 19.36 kW

9. For a given frequency, the inductive reactance of a coil at 100 H is 25 Ω. For the same frequency, the inductive reactance at 200 H will be

(a) 25 Ω (b) 50 Ω (c) 100 Ω (d) zero

10. An alternating voltage $V = 200\sqrt{2}\sin(100t)$ volt is connected to a 1 μF capacitor through an a.c. ammeter. The reading of the ammeter is
(a) 40 mA (b) $20\sqrt{2}$ mA
(c) 20 mA (d) $10\sqrt{2}$ mA

11. If a magnet is dropped through a vertical hollow copper tube then
(a) the time taken to reach the ground is longer than the time taken if the tube was made out of plastic
(b) the magnet will get attracted and stick to the copper tube
(c) the time taken to reach the ground is longer than the time taken if the tube was made out of the stainless steel
(d) the time taken to reach the ground does not depend on the radius of the copper tube

12. Two *LC* circuits have same resonant frequency f_0. When connected in series (assume all the elements to be in series), find the new resonant frequency.
(a) $2f_0$ (b) $f_0/2$ (c) f_0 (d) $4f_0$

Assertion & Reason Type

Directions : In questions 13 to 15, a statement of assertion is followed by a statement of reason. Mark the correct choice as :
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

13. **Assertion :** The induced e.m.f. will be same in two identical loops of copper and aluminium, when rotated with same speed in the same magnetic field.
Reason : Induced e.m.f. is proportional to rate of change of magnetic field while induced current depends on resistance of wire.

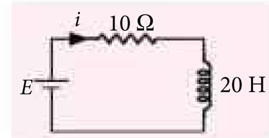
14. **Assertion :** When capacitive reactance is smaller than the inductive reactance in *LCR* series circuit, e.m.f. leads the current.
Reason : The phase angle is the angle between the alternating e.m.f. and alternating current of the circuit.

15. **Assertion :** The core of transformer is made laminated in order to increase the eddy currents.
Reason : The sensitivity of transformer increases with increase in the eddy currents.

JEE MAIN / JEE ADVANCED

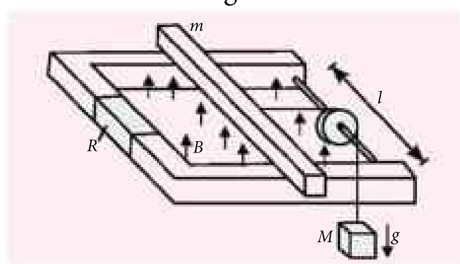
Only One Option Correct Type

16. A 20 Henry inductor coil is connected to a 10 ohm resistance in series as shown in figure. The time at which rate of dissipation of energy (Joule's heat) across resistance is equal to the rate at which magnetic energy is stored in the inductor, is



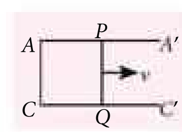
(a) $\frac{1}{2}\ln 2$ (b) ln 2 (c) $\frac{2}{\ln 2}$ (d) 2 ln 2

17. A bar of mass *m* is pulled horizontally across parallel rails by a massless string that passes over an ideal pulley and is attached to a suspended object of mass *M* as shown in figure.



The uniform magnetic field has a magnitude *B* and the distance between the rails is *l*. the rails are connected at one end by a load resistor *R*. Assume that the suspended object is released with the bar at rest at $t = 0$ and no friction exists between rails and bar, calculate the terminal velocity obtained by the bar.
(a) $\frac{2MgR}{B^2l^2}$ (b) $\frac{MgR}{B^2l^2}$ (c) $\frac{mgR}{B^2l^2}$ (d) $\frac{2mgR}{Bl^2}$

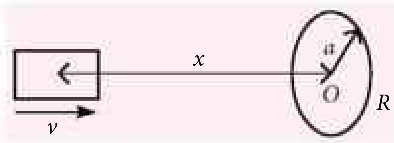
18. **Statement -1 :** In the arrangement shown, the conducting rod *PQ* is moved on the smooth conducting rails with a steady velocity *v*. Electrical resistance of rod and rails is zero. The lesser the value of *R* the more is the force required to move it with the same velocity



Statement -2 : Lower resistor causes more power to be dissipated.
(a) Statement-1 is false, Statement-2 is true.
(b) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1.
(c) Statement-1 is true, Statement-2 is true; Statement-2 is not the correct explanation of Statement-1.
(d) Statement-1 is true, Statement-2 is false.

More than One Option Correct Type

19. A small bar magnet of dipole moment M is moving with speed v along x direction towards a small closed circular conducting loop of radius 'a' with its centre O at $x = 0$ (see figure). Assume $x >> a$ and the coil has a resistance R. Then which of the following statement(s) is/are true?



(a) Magnetic field at the centre O of the circular coil due to the bar magnet is $\frac{M}{x^3}$.

(b) Induced EMF is proportional to $\frac{1}{x^4}$.

(c) The magnetic moment μ due to induced current in the coil is proportional to a^4.

(d) The heat produced is proportional to $\frac{1}{x^6}$.

20. A series RC circuit is connected to AC voltage source. Consider two cases;
(A) when C is without a dielectric medium and
(B) when C is filled with dielectric of constant 4.
The current I_R through the resistor and voltage V_C across the capacitor are compared in the two cases. Which of the following is/are true?

(a) $I_R^A > I_R^B$ (b) $I_R^A < I_R^B$
(c) $V_C^A > V_C^B$ (d) $V_C^A < V_C^B$

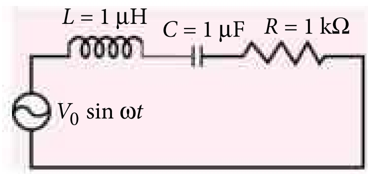
21. A current carrying infinitely long wire is kept along the diameter of a circular wire loop, without touching it. The correct statement(s) is(are)

(a) the emf induced in the loop is zero if the current is constant
(b) the emf induced in the loop is finite if the current is constant
(c) the emf induced in the loop is zero if the current decreases at a steady state
(d) the emf induced in the loop is finite if the current decreases at a steady state.

22. Two different coils have self-inductances $L_1 = 8$ mH and $L_2 = 2$ mH. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same constant rate. At a certain instant of time, the power is given to the two coils is the same. At that time, the current, the induced voltage and the energy stored in the first coil are i_1, V_1 and W_1 respectively. Corresponding values for the second coil at the same instant are i_2, V_2 and W_2 respectively. Then

(a) $\frac{i_1}{i_2} = \frac{1}{4}$ (b) $\frac{i_1}{i_2} = 4$ (c) $\frac{W_1}{W_2} = \frac{1}{4}$ (d) $\frac{V_1}{V_2} = 4$

23. In the circuit shown, $L = 1$ μH, $C = 1$ μF and $R = 1$ kΩ. They are connected in series with an a.c. source $V = V_0 \sin \omega t$ as shown. Which of the following options is/are correct?



(a) At ω ~ 0, the current flowing through the circuit becomes nearly zero.
(b) The frequency at which the current will be in phase with the voltage is independent of R.
(c) The current will be in phase with the voltage if $\omega = 10^4$ rad s^{-1}.
(d) At $\omega >> 10^6$ rad s^{-1}, the circuit behaves like a capacitor.

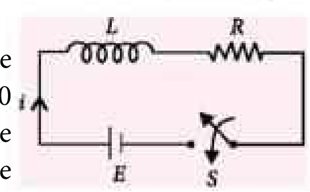
Integer/Numerical Value Type

24. Two concentric circular coils, C_1 and C_2, are placed in the XY plane. C_1 has 500 turns and a radius of 1 cm. C_2 has 200 turns and radius of 20 cm. C_2 carries a time dependent current $I(t) = (5t^2 - 2t + 3)$ A where t is in s. The emf induced in C_1 (in mV), at the instant $t = 1$ s is $\frac{4}{x}$. The value of x is ______.

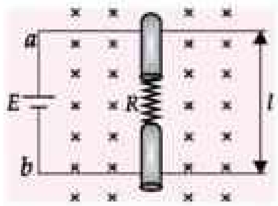
25. The circuit shown in the figure consists of a charged capacitor of capacity 3 μF and a charge of 30 μC. At time $t = 0$, when the key is closed, the value of current flowing through the 5 MΩ resistor is 'x' μA.

The value of 'x' to the nearest integer is ______.

26. Consider the LR circuit shown in the figure. If the switch S is closed at $t = 0$ then the amount of charge that passes through the battery between $t = 0$ and $t = \frac{L}{R}$ is equal to $\frac{EL}{xR^2}$ when the value of x is _____.



Comprehension Type



In figure shown, the rod has a resistance R, the horizontal rails have negligible friction. A battery of emf E and negligible internal resistance is connected between points a and b. The rod is released from rest.

27. The velocity of the rod as function of time is

(a) $\frac{E}{Bl}(1-e^{-t/\tau})$ (b) $\frac{E}{Bl}(1+e^{-t/\tau})$

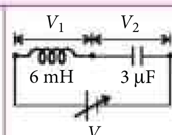
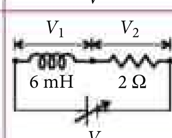
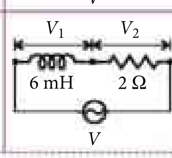
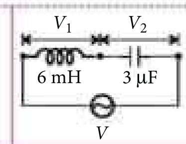
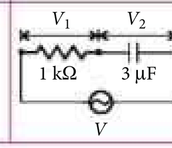
(c) $\frac{3}{2}\frac{E}{Bl}(1-e^{-t/\tau})$ (d) $\frac{E}{2Bl}(1-e^{-t/\tau})$

28. After some time, the rod will approach a terminal speed. Find an expression for it.

(a) $\frac{3}{2}\frac{E}{Bl}$ (b) $\frac{E}{2Bl}$ (c) $\frac{E}{Bl}$ (d) $\frac{2E}{Bl}$

Matrix Match Type

29. You are given many resistances, capacitors and inductors. These are connected to a variable DC voltage source (the first two circuits) or an AC voltage source of 50 Hz frequency (the next three circuits) in different ways as shown in Column II. When a current I (steady state for DC or rms for AC) flows through the circuit, the corresponding voltage V_1 and V_2, (indicated in circuits) are related as shown in column I. Match the two.

Column I		Column II	
(I)	$I \neq 0$, V_1 is proportional to I	(P)	
(II)	$I \neq 0$, $V_2 > V_1$	(Q)	
(III)	$V_1 = 0$, $V_2 = V$	(R)	
(IV)	$I \neq 0$, V_2 is proportional to I	(S)	
		(T)	

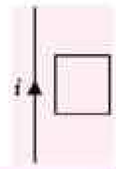
(a) (I) → (R, S, T); (II) → (Q, R, S, T); (III) → (P, Q); (IV) → (Q, R, S, T)

(b) (I) → (P, Q, R); (II) → (P, Q); (III) → (R, S); (IV) → (R, S, T)

(c) (I) → (R, S, T); (II) → (Q, R, S); (III) → (Q, T); (IV) → (Q, S, T)

(d) (I) → (P, Q, R, S); (II) → (P, Q); (III) → (Q, R); (IV) → (R, S, T)

30. A square loop is placed near a long straight current carrying wire as shown in figure. Match the following table.



Column I		Column II	
(I)	If current is increased,	(P)	induced current in loop is clockwise
(II)	If current is decreased,	(Q)	induced current in loop is anticlockwise
(III)	If loop is moved away from the wire	(R)	wire will attract the loop
(IV)	If loop is moved toward the wire	(S)	wire will repel the loop

(a) (I) → (P); (II) → (Q, S,); (III) → (R, S); (IV) → (P, Q)

(b) (I) → (Q); (II) → (R, S); (III) → (P, Q); (IV) → (S)

(c) (I) → (R); (II) → (P, Q); (III) → (Q, R); (IV) → (Q, R)

(d) (I) → (Q, S); (II) → (P, R); (III) → (P, R); (IV) → (Q, S)

◆◆

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74-60%	SATISFACTORY !	You need to score more next time
< 60%	NOT SATISFACTORY!	Revise thoroughly and strengthen your concepts.