# PHYSICS for you

Volume 25 No. 5

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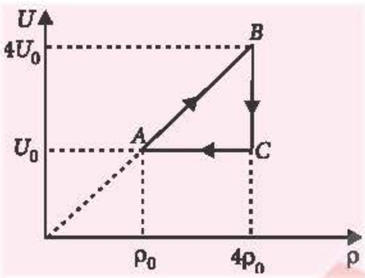
# PHYSICS MUSING

Physics Musing was started in August 2013 issue of Physics For You. The aim of Physics Musing is to augment the chances of bright students preparing for JEE (Main and Advanced) / AIIMS / NEET / Other PMTs with additional study material.
In every issue of Physics For You, 10 challenging problems are proposed in various topics of JEE (Main and Advanced) / various PMTs. The detailed solutions of these problems will be published in next issue of Physics For You.
The readers who have solved five or more problems may send their detailed solutions with their names and complete address. The names of those who send atleast five correct solutions will be published in the next issue.
We hope that our readers will enrich their problem solving skills through "Physics Musing" and stand in better stead while facing the competitive exams.

## PROBLEM Set 46

### MORE THAN ONE OPTIONS CORRECT TYPE

**1.** A monatomic ideal gas is following the cyclic process $ABCA$. Then choose the correct option (s).



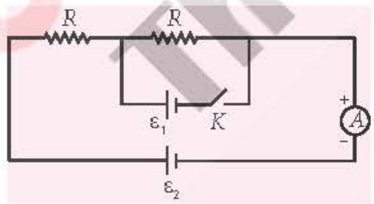

(a) Molar heat capacity for the process $AB$ is $\frac{R}{2}$.

(b) Heat is rejected by the system in path $BC$.

(c) Molar heat capacity for the process $BC$ is $\frac{2}{3}R$.

(d) Work done by the system in the process $CA$ is $\frac{2U_0}{3}\ln 4$.

**2.** In the given circuit, when key $K$ is open, reading of ammeter is $I$. Now key $K$ is closed, then the correct statements are




(a) If $\varepsilon_1 = IR$, reading of the ammeter is $I$.

(b) If $IR < \varepsilon_1 < 2IR$, reading of the ammeter is greater than $I$.

(c) If $\varepsilon_1 = 2IR$, reading of the ammeter will be zero.

(d) Reading of the ammeter will not change.

**3.** The resistivity of a cylindrical conductor carrying steady current along its length varies linearly with the distance from the current carrying end as given by $\rho = \rho_0\left(1+\frac{x}{l}\right)$, where $l$ is the length of the conductor and $x$ is the distance from the current entry end and $\rho_0$ is a positive constant. Then,

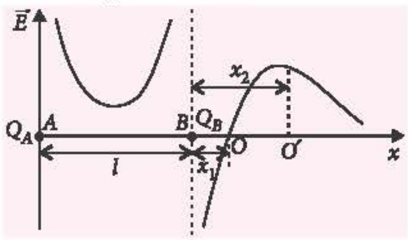
(a) Electric field varies linearly with $x$

(b) Electric potential difference across the length varies linearly with $x$

(c) Volume charge density in the conductor is zero

(d) Volume charge density in the conductor is non zero.

**4.** Two point charges, $Q_A$ and $Q_B$ are positioned at points $A$ and $B$. The electric field strength to the right of charge $Q_B$ on the line that passes through the two charges varies according to a law that is represented schematically in the figure accompanying the problem without employing a definite scale. Assume electric field to be positive if its direction coincides with the positive direction on the $x$-axis. Distance between the charges is $l$. Then,




(a) Charge $Q_A$ is negative and charge $Q_B$ is positive.

(b) Charge $Q_A$ is positive and charge $Q_B$ is negative.

(c) $\left|\frac{Q_A}{Q_B}\right| = \left[\frac{l+x_1}{x_1}\right]^2$

(d) $x_2 = \frac{l}{(Q_A/Q_B)^{1/3}-1}$

By Akhil Tewari, Author Foundation of Physics for JEE Main & Advanced, Professor, IITians PACE, Mumbai.

5. A conducting sphere of radius $R$, carrying charge $Q$ lies inside an uncharged conducting shell of radius $2R$. If they are joined by a metal wire, then

(Here $k = \frac{1}{4\pi\varepsilon_0}$ )

(a) $\frac{Q}{3}$ amount of charge will flow from the sphere to the shell.

(b) $\frac{2Q}{3}$ amount of charge will flow from the sphere to the shell.

(c) $Q$ amount of charge will flow from the sphere to the shell.

(d) $k\frac{Q^2}{4R}$ amount of heat will be produced.

6. A metal cylinder of mass 0.5 kg is heated electrically by a 12 W heater in a room at 15 °C. The cylinder temperature rises to 25 °C in 5 min and finally becomes constant at 45 °C. Assuming that the rate of heat loss of the cylinder is proportional to the excess temperature over the surroundings. Then,

(a) The rate of loss of heat of the cylinder to surrounding at 20° C is 2 W.

(b) The rate of loss of heat of the cylinder to surrounding at 45° C is 12 W.

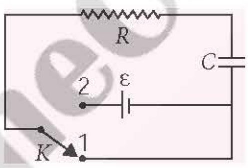
(c) Specific heat capacity of metal is

$$240\left[\ln\left(\frac{3}{2}\right)\right]^{-1} \text{J kg}^{-1}\,{}^\circ\text{C}^{-1}.$$

(d) None of these.

## PARAGRAPH BASED QUESTIONS

### Paragraph I



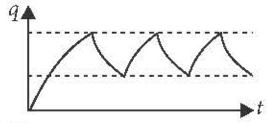

The shown circuit involving a resistor of resistance $R$, capacitor of capacitance $C$ and an ideal cell of emf ε, the capacitor is initially uncharged and the key is in position 1. At $t = 0$ s, the key is pushed to position 2 for $t_0 = RC$ and then key is pushed back to position 1 for $t = RC$. This process is repeated again and again. Assume the time taken to push key from position 1 to 2 and vice versa to be negligible.

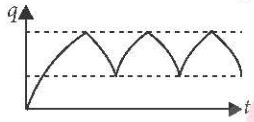
7. The charge on capacitor at $t = 2RC$ is

(a) $C\varepsilon$ (b) $C\varepsilon\left(1-\frac{1}{e}\right)$

(c) $C\varepsilon\left(\frac{1}{e}-\frac{1}{e^2}\right)$ (d) $C\varepsilon\left(1-\frac{1}{e}+\frac{1}{e^2}\right)$

8. The variation of charge on capacitor with time is best represented by

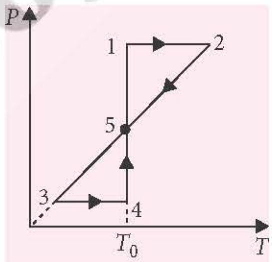
(a) 

(b) 

(c) 

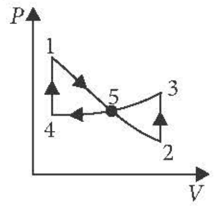
(d) 

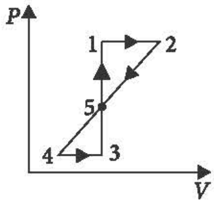
### Paragraph II

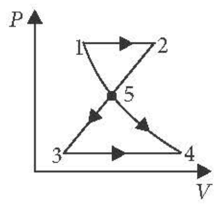


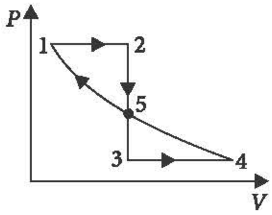

Consider $P$-$T$ graph of cyclic process shown in the figure. Maximum pressure during the cycle is twice the minimum pressure. The heat received by the gas in the process 1-2 is equal to the heat received in the process 3-4. The process is done on one mole of monatomic gas.

9. Correct $P$-$V$ diagram for the given process is

(a) 

(b) 

(c) 

(d) 

10. If the maximum pressure is $P$ then what is the pressure at the point 5 ? (in $P$-$T$ diagram)

(a) $\frac{2P}{3}$ (b) $\frac{4P}{5}$

(c) $\frac{3P}{4}$ (d) None of these.

◆◆

# JEE ADVANCED

## PRACTICE PAPER 2017

Exam on 21st May

### PAPER-I

#### SECTION 1 (Maximum Marks : 15)

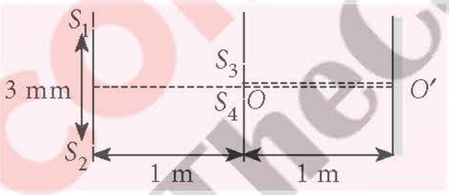
- *This section contains FIVE questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

  **Full Marks :** *+3 If only the bubble corresponding to the correct option is darkened.*

  **Zero Marks :** *0 If none of the bubbles is darkened.*

  **Negative Marks :** *–1 In all other cases.*

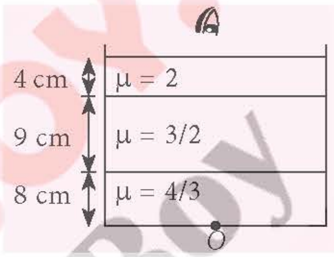
**1.** In the arrangement shown in figure, light of wavelength 6000 Å is incident on slits $S_1$ and $S_2$. Slits $S_3$ and $S_4$ have been opened such that $S_3$ is the position of first maximum above the central maximum and $S_4$ is the closest position, where intensity is same as that of the light used, below the central maximum. The point $O$ is equidistant from $S_1$ and $S_2$ and $O'$ is equidistant from $S_3$ and $S_4$. The intensity of incident light is $I_0$.




The intensity at $O'$ (on the screen) and the intensity of the brightest fringe respectively be

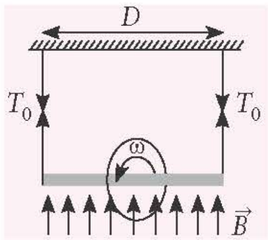
(a) $3I_0$ and $9I_0$ (b) $9I_0$ and $3I_0$
(c) $2I_0$ and $4I_0$ (d) $4I_0$ and $2I_0$

**2.** A tank contains three layers of immiscible liquids. The first layer is of water with refractive index 4/3 and thickness 8 cm. The second layer is an oil with refractive index 3/2 and thickness 9 cm while the third layer is of glycerine with refractive index 2 and thickness 4 cm. Find the apparent depth of the bottom of the container.




(a) 14 cm below the glycerine air interface
(b) 9 cm above the glycerine air interface
(c) 14 cm above the glycerine air interface
(d) 9 cm below the glycerine air interface

**3.** A ring of radius $R$ having uniformly distributed charge $Q$ is mounted on a rod suspended by two identical strings. The tension in strings in equilibrium is $T_0$. Now a vertical magnetic field is switched on and ring is rotated at constant angular velocity ω. The maximum ω with which the ring can be rotated if the strings can withstand a maximum tension of $3T_0/2$ is



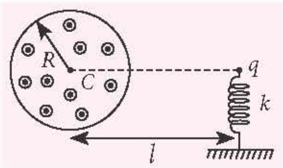

(a) $\frac{DT_0}{BQR}$ (b) $\frac{DT_0}{B^2QR}$ (c) $\frac{2DT_0}{QRB}$ (d) $\frac{DT_0}{QBR^2}$

**4.** From the surface of a wire of radius $a$ carrying a direct current $I$, a positive charge $q$ having mass $m$ escapes with a velocity $v_0$ perpendicular to the surface. The maximum distance ($x_{max}$) of the electron from the axis of the wire before it turns back due to the action of the magnetic field generated by the current will be

(a) $x_{max} = ae^{\frac{2\pi m v_0}{q\mu_0 I}}$ (b) $x_{max} = ae^{-\frac{\pi m v_0}{q\mu_0 I}}$

(c) $x_{max} = ae^{\frac{m v_0}{qI}}$ (d) $x_{max} = ae^{\frac{\pi m v_0}{2q\mu_0 I}}$

**5.** There is a horizontal cylindrical uniform but time-varying magnetic field increasing at a constant rate $dB/dt$ as shown in figure.




A charged particle having charge $q$ and mass $m$ is kept in equilibrium, at the top of a spring of spring constant $k$, in such a way that it is on the horizontal line passing through the center of the magnetic field as shown in the figure. The compression in the spring will be

(a) $\frac{1}{k}\left[mg - \frac{qR^2}{2l}\frac{dB}{dt}\right]$ (b) $\frac{1}{k}\left[mg + \frac{qR^2}{l}\frac{dB}{dt}\right]$

(c) $\frac{1}{k}\left[mg + \frac{2qR^2}{l}\frac{dB}{dt}\right]$ (d) $\frac{1}{k}\left[mg + \frac{qR^2}{2l}\frac{dB}{dt}\right]$

## SECTION 2 (Maximum Marks : 32)

- *This section contains EIGHT questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct.*
- *For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

  **Full Marks :** +4 *If only the bubble(s) corresponding to the correct option(s) is(are) darkened.*

  **Partial Marks :** +1 *For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.*

  **Zero Marks :** 0 *If none of the bubbles is darkened.*

  **Negative Marks :** –2 *In all other cases.*
- *For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (a) and (d) will result in +2 marks; and darkening (a) and (b) will result in –2 marks, as a wrong option is also darkened.*

**6.** A 470 kg communication satellite is released from a space shuttle at a height of 280 km above the surface of the earth. From this height a rocket engine boosts it into a geosynchronous orbit. The correct statement(s) is/are

(Given that mass of the earth = $5.98 \times 10^{24}$ kg and radius of the earth = 6400 km)

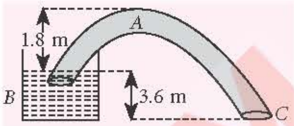
(a) The orbital radius of geosynchronous orbit of satellite is $4.23 \times 10^7$ m

(b) Energy supplied by engine to change the orbit is $1.18 \times 10^{10}$ J

(c) Change in potential energy of the satellite is $-2.36 \times 10^{10}$ J

(d) Firing of engine results in decrease in potential energy and increase in kinetic energy of the satellite.

**7.** A siphon has a uniform circular base of diameter $8/\sqrt{\pi}$ cm with its crest $A$, 1.8 m above the water level. Vessel $B$ is of large cross section as shown in figure ($g$ = 10 m s$^{-2}$ and atmospheric pressure $P_0 = 10^5$ N m$^{-2}$).




If water starts flowing from vessel to ground through siphon, then

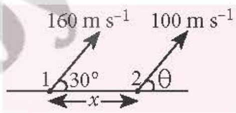
(a) velocity of flow of water through pipe is $6\sqrt{2}$ m s$^{-1}$.

(b) discharge rate of flow through pipe is $96\sqrt{2} \times 10^{-4}$ m$^3$ s$^{-1}$.

(c) velocity of flow of water through pipe is 6 m s$^{-1}$.

(d) pressure of $A$ is $0.46 \times 10^5$ N m$^{-2}$.

**8.** Suppose two particles 1 and 2 are projected in vertical plane simultaneously. Their angles of projection are 30° and θ respectively with the horizontal as shown.




Suppose they collide after a time $t$ in air. Then,

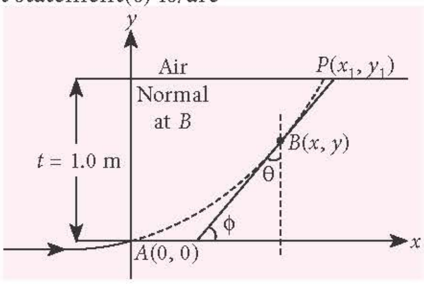
(a) $\theta = \sin^{-1}(4/5)$ and they will have same speed just before the collision

(b) $\theta = \sin^{-1}(4/5)$ and they will have different speed just before the collision

(c) $x < (1280\sqrt{3} - 960)$ m

(d) it is possible that the particles collide when both of them are at their highest point

**9.** A ray of light travelling in air is incident at grazing angle (angle of incidence = 90°) on a long rectangular slab of a transparent medium of thickness $t$ = 1.0 m. The point of incidence is the origin $A(0, 0)$. The medium has a variable index of refraction given by $n(y) = (ky^{3/2} + 1)^{1/2}$, where $k = 1.0$ m$^{-3/2}$. The refractive index of air is 1. The correct statement(s) is/are



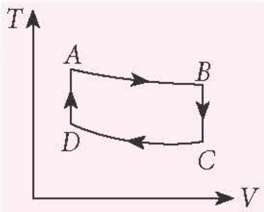

(a) Relation between the slope of the trajectory of the ray at a point $B(x, y)$ in the medium and the incidence angle at that point is $\cot\theta = \frac{dy}{dx}$.

(b) Equation for the trajectory $y(x)$ of the ray in the medium is $4y^{1/2} = \sqrt{k}\,x + C$.

(c) The coordinates $(x_1, y_1)$ of the point $P$ where the ray intersects the upper surface of the slab-air boundary is (4, 1).

(d) The path of the ray will be perpendicular to the boundary.

**10.** One mole of a monatomic ideal gas is taken through the cycle shown in figure.




$A \to B$ adiabatic expansion

$B \to C$ cooling at constant volume

$C \to D$ adiabatic compression

$D \to A$ heating at constant volume

The pressures and temperatures at $A$, $B$, etc., are denoted by $P_A$, $T_A$, $P_B$, $T_B$, etc., respectively. Given $T_A = 1000$ K, $P_B = (2/3)P_A$ and $P_C = (1/3)P_A$.

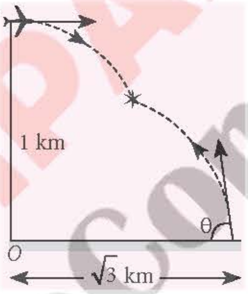
(a) The work done by the gas in the process $A \to B$ is 1869.75 J.

(b) The heat lost by the gas in the process $B \to C$ is – 5297.625 J.

(c) Temperature $T_D$ is 500 K.

(d) Work done from $B \to C$ is 40 J.

**11.** An aircraft is flying horizontally with a constant velocity 200 m s$^{-1}$, at a height 1 km above the ground. At the moment shown, a bomb is released from the aircraft and the cannon-gun below fires a shell with initial speed 200 m s$^{-1}$, at some angle θ.




Both the bomb and the shell collide with each other in air

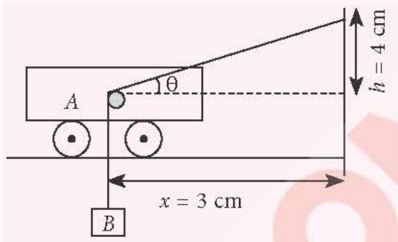
(a) The value of θ at which the projectile shell destroy the bomb in mid-air is 60°.

(b) Position of the collision w.r.t. $O$ is $\left(\frac{2}{3}\sqrt{3}, -\frac{\sqrt{3}}{6}\right)$

(c) They will collide after 10 s

(d) The value of θ at which the projectile shell destroy the bomb in mid-air is 45°

**12.** The string shown in figure is passing over small smooth pulley rigidly attached to trolley $A$. If the speed of trolley is constant and equal to $v_A$ towards right, speed and magnitude of acceleration of block $B$ at the instant shown in figure are $v_B$ and $a_B$, then




(a) $v_B = v_A$, $a_B = 0$ (b) $a_B = 0$

(c) $v_B = \frac{3}{5}v_A$ (d) $a_B = \frac{16v_A^2}{125}$

**13.** A thermostated chamber at a height $h$ above earth's surface maintained at 30°C has a clock fitted with uncompensated pendulum. The maker of the clock for chamber mistakenly designed it to maintain correct time at 20°C. It is found that when the chamber is brought to earth's surface the clock in it clicked correct time. $R_e$ is the radius of Earth. The coefficient of linear expansion of the material of pendulum is

(a) $\frac{h}{R_e}$ (b) $\frac{h}{5R_e}$ (c) $\frac{5R_e}{h}$ (d) $\frac{R_e}{h}$

## SECTION 3 (Maximum Marks : 15)

- *This section contains FIVE questions.*
- *The answer to each question is a SINGLE DIGIT INTEGER ranging from 0 to 9, both inclusive.*
- *For each question, darken the bubble corresponding to the correct integer in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

  **Full Marks :** *+3 If only the bubble corresponding to the correct answer is darkened.*

  **Zero Marks :** *0 In all other cases.*

**14.** In a certain hypothetical radioactive decay process, species $A$ decays into species $B$ and species $B$ decays into species $C$ according to the reactions :

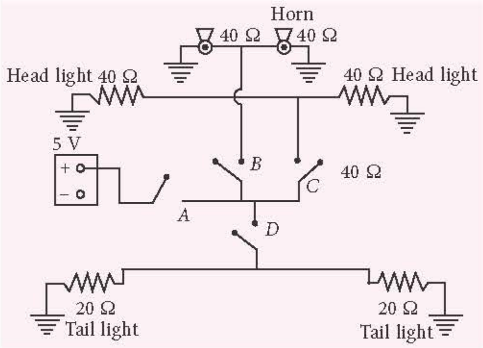
$A \to 2B$ + particles + energy

$B \to 3C$ + particles + energy

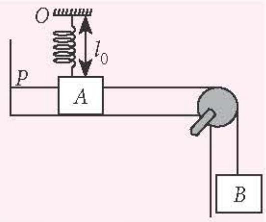
The decay constant for species $A$ is $\lambda_1$ and that for species $B$ is $\lambda_2$. Initial there was $10^x$ moles species $A$ while there was none of $B$ and $C$. It was found that species $B$ reaches its maximum number at a time $t_0$. Find the value of $x$.

(Take $\lambda_1 = 1$ dps, $\lambda_2 = 100$ dps, $N_B = 2$ moles at $t_0 = 2 \ln 10$ s)

**15.** Figure shows an automobile circuit. How much power (in watt) is dissipated by the automobile circuit when switches $A$, $B$, $C$ and $D$ are all closed?




16. A small bar $A$ resting on a smooth horizontal plane is attached by threads to a point $P$ and by means of weightless pulley, to a weight $B$ possessing the same mass as the bar itself.




The bar is also attached to a point $O$ by means of a light non-deformed spring of length $l_0$ and stiffness $k = 5\ mg/l_0$, where $m$ is the mass of the bar. Now the thread $PA$ is burnt and the bar starts moving to the right. Its velocity at the moment when bar is breaking off the plane is given as $\sqrt{\frac{(17+n)gl_0}{16n}}$. The value of $n$ is

17. End $A$ of a rod $AB$ of length $L = 0.5$ m and of uniform cross-sectional area is maintained at same constant temperature. The heat conductivity of the rod is $k = 17\ \text{J s}^{-1}\text{m}^{-1}\text{K}^{-1}$. The other end $B$ of this rod is radiating energy into vacuum and the wavelength with maximum energy density emitted from this end is $\lambda_0 = 75000$ Å. If the emissivity of the end $B$ is $e = 1$, the temperature of the end $A$ is given as $2.11a \times 10^a$ K. (Assuming that except the ends, the rod is thermally insulated) Find the value of $a$.

18. When the soap bubble of radius $R = 0.25$ cm is charged, it experiences an outward electric pressure of magnitude $\frac{\sigma^2}{2\varepsilon_0}$ where its surface charge density $\sigma = 20\ \mu\text{C m}^{-2}$, If $Q$ is the charge on the sphere so that the pressure inside and outside is same, then the surface tension of soap in terms of $\alpha \times 10^{-12}/8\varepsilon_0$ N m$^{-1}$. Find the value of $\alpha$.

## PAPER-II

### SECTION 1 (Maximum Marks : 18)

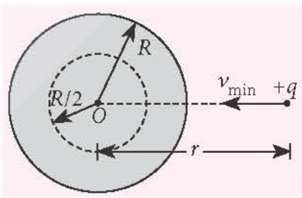
- *This section contains SIX questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

**Full Marks :** *+3 If only the bubble corresponding to the correct option is darkened.*

**Zero Marks :** *0 If none of the bubbles is darkened.*

**Negative Marks :** *–1 In all other cases.*

1. A positive charge $Q$ is uniformly distributed throughout the volume of a dielectric sphere of radius $R$. A point mass having charge $+q$ and mass $m$ is fired toward the centre of the sphere with velocity $v$ from a point which is at distance $r(r > R)$ from the centre of the sphere. The minimum velocity $v$ so that it can penetrate $R/2$ distance of the sphere is




(Neglect any resistance other than electric interaction. Charge on the small mass remains constant throughout the motion.)

(a) $v = \sqrt{\frac{qQ}{2m\pi\varepsilon_0 R}\left[\frac{5}{8} - \frac{R}{r}\right]}$

(b) $v = \sqrt{\frac{qQ}{2m\pi\varepsilon_0 R}\left[1 - \frac{R}{r}\right]}$

(c) $v = \sqrt{\frac{qQ}{2m\pi\varepsilon_0 R}\left[\frac{11}{8} - \frac{R}{r}\right]}$

(d) $v = \sqrt{\frac{qQ}{m\pi\varepsilon_0 R}\left[\frac{11}{8} - \frac{R}{r}\right]}$

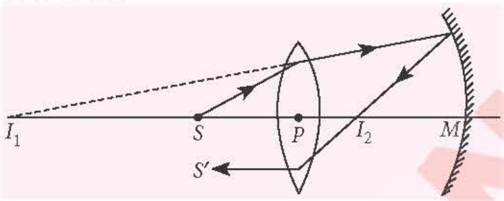
2. When a block of iron floats in mercury at 0°C, fraction $k_1$ of its volume is submerged, while at the temperature 60°C, a fraction $k_2$ is seen to be submerged. If the co-efficient of volume expansion of iron is $\gamma_{Fe}$ and that of mercury is $\gamma_{Hg}$, then the ratio $k_1/k_2$ can be expressed as

(a) $\frac{1+60\gamma_{Fe}}{1+60\gamma_{Hg}}$ (b) $\frac{1-60\gamma_{Fe}}{1+60\gamma_{Hg}}$

(c) $\frac{1+60\gamma_{Fe}}{1-60\gamma_{Hg}}$ (d) $\frac{1+60\gamma_{Hg}}{1+60\gamma_{Fe}}$

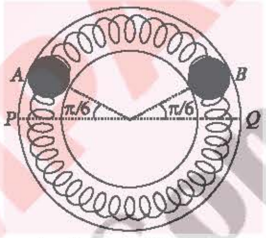
**3.** A potential barrier of 0.50 V exists across a *p-n* junction. If the depletion region is $5.0 \times 10^{-7}$ m wide, an electron with speed $5.0 \times 10^5$ m s$^{-1}$ approaches the *p-n* junction from the *n*-side. The speed of electron enter the *p*-side and electric field intensity in the region is
(a) $2.7 \times 10^4$ m s$^{-1}$ and $2.0 \times 10^8$ V m$^{-1}$ respectively
(b) $5.0 \times 10^3$ m s$^{-1}$ and $1.0 \times 10^7$ V m$^{-1}$ respectively
(c) $2.7 \times 10^5$ m s$^{-1}$ and $1.0 \times 10^6$ V m$^{-1}$ respectively
(d) $5.0 \times 10^6$ m s$^{-1}$ and $2.0 \times 10^5$ V m$^{-1}$ respectively.

**4.** A converging lens of focal length 15 cm and a converging mirror of focal length 20 cm are placed with their principal axes coinciding. A point source *S* is placed on the principal axis at a distance of 12 cm from the lens as shown in figure. It is found that the final beam comes out parallel to the principle axis. The separation between the mirror and the lens is




(a) 50 cm (b) 30 cm (c) 25 cm (d) 40 cm

**5.** Two identical balls *A* and *B* each of mass 0.1 kg, are attached to two identical massless springs. The spring-mass system is constrained to move inside a rigid smooth pipe bent in the form of a circle as shown in figure. The pipe is fixed in a horizontal plane. The centres of the balls can move in a circle of radius $0.06\pi$ m. Each spring has a natural length of 0.06 m and spring constant 0.1 N m$^{-1}$. Initially, both the balls are displaced by an angle $\theta = \pi/6$ radian with respect to the diameter *PQ* of the circle (as shown in figure) and released from rest. The frequency of oscillation of ball *B* and the total energy of the system respectively are




(a) $1/\pi$ s$^{-1}$ and $4.76 \times 10^{-4}$ J
(b) $1/\pi$ s$^{-1}$ and $3.95 \times 10^{-4}$ J
(c) $2/\pi$ s$^{-1}$ and $2.72 \times 10^{-4}$ J
(d) $2/\pi$ s$^{-1}$ and $6.0 \times 10^{-4}$ J

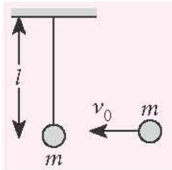
**6.** Two guns, situated on the top of a hill of height 10 m, fire one shot each with the same speed $5\sqrt{3}$ m s$^{-1}$ at some interval of time. One gun fires horizontally and other fires upwards at an angle of 60° with the horizontal. The shots collide in air at a point *P*. Find the time - interval between the firings and the coordinates of the point *P*. (Take origin of the coordinate system at the foot of the hill right below the muzzle and trajectories in *x*-*y* plane).
(a) 1 s and (5, 5) m
(b) 1 s and $(5\sqrt{3}, 3)$ m
(c) 2 s and $(2\sqrt{3}, 2)$ m
(d) 2 s and $(2\sqrt{3}, 1)$ m

## SECTION 2 (Maximum Marks : 32)

- *This section contains EIGHT questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONE OR MORE THAN ONE of these four option(s) is(are) correct.*
- *For each question, darken the bubble(s) corresponding to all the correct option(s) in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*
  **Full Marks :** *+4 If only the bubble(s) corresponding to all the correct option(s) is(are) darkened.*
  **Partial Marks :** *+1 For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened.*
  **Zero Marks :** *0 If none of the bubbles is darkened.*
  **Negative Marks :** *–2 In all other cases.*
- *For example, if (a), (c) and (d) are all the correct options for a question, darkening all these three will result in +4 marks; darkening only (a) and (d) will result in +2 marks; and darkening (a) and (b) will result in –2 marks, as a wrong option is also darkened.*

**7.** *n* drops of a liquid each with surface energy *E* join to form a single drop. Then
(a) Some energy will be released in the process.
(b) Some energy will be absorbed in the process.
(c) The energy released will be $E(n - n^{2/3})$.
(d) The energy absorbed will be $nE(2^{2/3} - 1)$.

**8.** A simple pendulum consists of a bob of mass *m* and a light string of length *l* as shown in the figure. Another identical ball moving with the small velocity $v_0$ collides with the pendulum's bob and sticks to it. If the new pendulum has mass 2*m*. Then




(a) Time period of the new pendulum is $2\pi\sqrt{\dfrac{l}{g}}$.
(b) The equation of motion for the new pendulum is $\theta_0 = \dfrac{v_0}{2\sqrt{gl}}$.
(c) The equation of motion for the new pendulum is $\theta = \dfrac{v_0}{2\sqrt{gl}}\cos\left[\sqrt{\dfrac{g}{l}}\,t\right]$.

(d) Time period of the new pendulum is $2\pi\sqrt{\frac{2l}{g}}$.

**9.** A light source, which emits two wavelengths $\lambda_1 = 400$ nm and $\lambda_2 = 600$ nm, is used in a Young's double slit experiment. If recorded fringe widths for $\lambda_1$ and $\lambda_2$ are $\beta_1$ and $\beta_2$ and the number of fringes for them within a distance $y$ on one side of the central maximum are $m_1$ and $m_2$, respectively, then

(a) $\beta_2 > \beta_1$
(b) $m_1 > m_2$
(c) From the central maximum, 3rd maximum of $\lambda_2$ overlaps with 5th minimum of $\lambda_1$
(d) The angular separation of fringes for $\lambda_1$ is greater than $\lambda_2$.

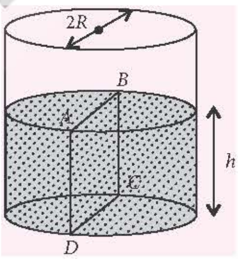
**10.** A sound wave of frequency $\upsilon$ travels horizontally to the right. It is reflected from a large vertical plane surface moving to left with a speed $v$. The speed of sound in medium is $c$. Then

(a) The number of wave striking the surface per second is $\upsilon\frac{(c+v)}{c}$
(b) The wavelength of reflected wave is $\frac{c(c-v)}{\upsilon(c+v)}$
(c) The frequency of the reflected wave is $\upsilon\frac{(c+v)}{(c-v)}$
(d) The number of beats heard by a stationary listener to the left of the reflecting surface is $\frac{v\upsilon}{c-v}$

**11.** A series $R$-$C$ circuit is connected to an $ac$ voltage source. Consider two cases : (A) when $C$ is without a dielectric medium and (B) when $C$ is filled with a 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?

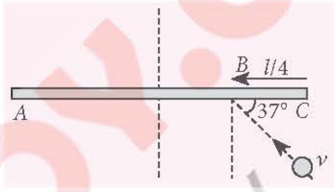
(a) $I_R^A > I_R^B$ (b) $I_R^A < I_R^B$
(c) $V_C^A > V_C^B$ (d) $V_C^A < V_C^B$

**12.** Water is filled up to a height $h$ in a beaker of radius $R$ as shown in the figure. The density of water is $\rho$, the surface tension of water is $T$ and the atmospheric pressure is $P_0$. Consider a vertical section $ABCD$ of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude



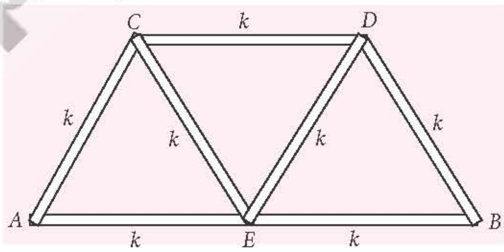

(a) $|2P_0Rh + \pi R^2\rho gh - 2RT|$
(b) $|2P_0Rh + R\rho gh^2 - 2RT|$
(c) $|P_0\pi R^2 + R\rho gh^2 - 2RT|$
(d) $|P_0\pi R^2 + R\rho gh^2 + 2RT|$.

**13.** A rod $AC$ of length $l$ and mass $m$ is kept on a horizontal smooth plane. It is free to rotate and move. A particle of same mass $m$ moving on the plane with velocity $v$ strikes the rod at point $B$ making angle 37° with the rod. The collision is elastic. After collision,




(a) The angular velocity of the rod will be $72/55\ v/l$
(b) The centre of the rod will travel a distance $\pi l/3$ in the time in which it makes half rotation
(c) Impulse of the impact force is $24mv/55$
(d) None of these.

**14.** Seven identical rods of material of thermal conductivity $k$ are connected as shown in the figure. All the rods are of identical length $l$ and cross-sectional area $A$. If the one end $A$ is kept at 100°C and the other end $B$ is kept at 0°C, what would be the temperatures of the junctions $C$, $D$ and $E$ ($\theta_C$, $\theta_D$ and $\theta_E$) in the steady state?




(a) $\theta_C > \theta_E > \theta_D$
(b) $\theta_C = 25°C$, $\theta_D = 37.5°C$ and $\theta_E = 50°C$
(c) $\theta_C = 62.5°C$, $\theta_D = 37.5°C$ and $\theta_E = 50°C$
(d) $\theta_C = 60°C$, $\theta_D = 40°C$ and $\theta_E = 50°C$

## SECTION 3 (Maximum Marks : 12)

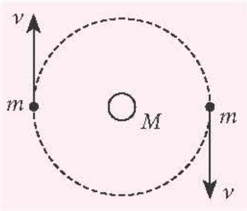
- *This section contains TWO paragraphs.*
- *Based on each paragraph, there are TWO questions.*
- *Each question has FOUR options (a), (b), (c) and (d). ONLY ONE of these four options is correct.*
- *For each question, darken the bubble corresponding to the correct option in the ORS.*
- *For each question, marks will be awarded in one of the following categories :*

**Full Marks :** *+3 If only the bubble corresponding to the correct option is darkened.*

**Zero Marks :** *0 In all other cases.*

## PARAGRAPH 1

A triple star system consists of two stars, each of mass $m$, in the same circular orbit about central star with mass $M = 2 \times 10^{30}$ kg. The two outer stars always lie at opposite ends of a diameter of their common circular orbit.




The radius of the circular orbit is $r = 10^{11}$ m and the orbital period of each star is $1.6 \times 10^7$ s.

[Take $\pi^2 = 10$ and $G = \frac{20}{3} \times 10^{-11}$ Nm$^2$kg$^{-2}$]

**15.** The mass $m$ of the outer star is

(a) $\frac{16}{15} \times 10^{30}$ kg (b) $\frac{11}{8} \times 10^{30}$ kg

(c) $\frac{15}{16} \times 10^{30}$ kg (d) $\frac{8}{11} \times 10^{30}$ kg

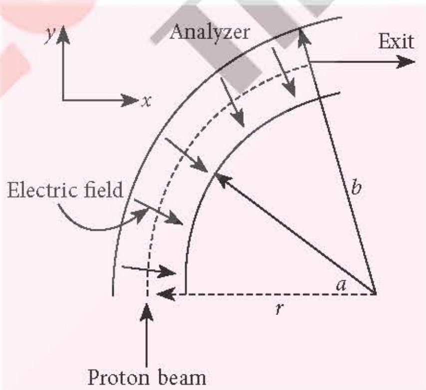
**16.** The total mechanical energy of the system is

(a) $-\frac{1375}{64} \times 10^{35}$ J (b) $-\frac{1375}{64} \times 10^{38}$ J

(c) $-\frac{1375}{64} \times 10^{34}$ J (d) $-\frac{1375}{64} \times 10^{37}$ J

## PARAGRAPH 2

Figure shows an electrostatic analyzer. It can sort out charged particles by speed and charge to mass ratio. Space craft use such analyzers to characterize charged particles in interplanetary space. Two curved metal plates establish an electric field given by $E = E_0\left(\frac{b}{r}\right)$ where $E_0$ is positive constant with unit of electric field. The field points towards the centre of curvature and $r$ is distance from centre. There is no influence of gravity. A beam of Proton (charge $+q$ and mass $m$) enters along $y$-axis and exits along $x$-axis while moving along a circular path.




**17.** Speed with which proton is to be projected is $v$ and centripetal acceleration of electron is $a_c$. The correct statement is

(a) $v = \sqrt{\frac{qE_0 b}{m}}$ and $a_c = \frac{2q}{m} E_0\left(\frac{b}{r}\right)$

(b) $v = \sqrt{\frac{2qE_0 b}{m}}$ and $a_c = \frac{q}{2m} E_0\left(\frac{b}{r}\right)$

(c) $v = \sqrt{\frac{2E_0 b}{2m}}$ and $a_c = \frac{2q}{m} E_0\left(\frac{b}{r}\right)$

(d) $v = \sqrt{\frac{qE_0 b}{m}}$ and $a_c = \frac{q}{m} E_0\left(\frac{b}{r}\right)$

**18.** The incorrect option :

(a) Work done by electric field on proton is zero

(b) If $v = \sqrt{\frac{2qE_0 b}{m}}$ proton may strike outer surface of analyzer.

(c) If $v = \sqrt{\frac{2qE_0 b}{m}}$ proton may strike inner surface of analyzer.

(d) If proton is released with zero initial velocity from inner surface of analyzer it will strike outer surface with velocity $v = \sqrt{\frac{2qE_0 b}{m} \ln\left(\frac{b}{a}\right)}$.

## Solutions

### Paper-I

**1. (a) :** From the given condition,

$$OS_3 = \frac{D\lambda}{d} = \frac{1 \times 6 \times 10^{-7}}{3 \times 10^{-3}} = 2 \times 10^{-4} \text{ m}$$

Let light reaching from $S_1$ and $S_2$ to $S_4$ has phase difference $\phi$ and intensity of incident light is $I_0$.

Resultant intensity at $S_4$, $I = 4I_0 \cos^2\frac{\phi}{2}$

As $I = I_0$, hence, $\frac{I_0}{4I_0} = \cos^2\frac{\phi}{2}$ or $\cos\frac{\phi}{2} = \frac{1}{2} = \cos 60°$

or $\phi = \frac{2\pi}{3}$

For $\phi = \frac{2\pi}{3}$, $OS_4 = \frac{D\lambda}{3d}$

Therefore, $S_3S_4 = OS_3 + OS_4 = \frac{4}{3}\frac{D\lambda}{d} = \frac{8}{3} \times 10^{-4}$ m

Now resultant wave coming out of $S_3$ has intensity $4I_0$ and waves coming out of $S_4$ have intensity $I_0$.

Phase difference at $S_3 = 2\pi$ , phase difference at $S_4 = 2\pi/3$.
These phase differences are relative to the light incident on slits $S_1$ and $S_2$.
Now $S_3$ and $S_4$ are secondary sources of light.
Phase difference at $O' = \frac{4\pi}{3}$, equal to initial phase difference between the light reaching at $O'$

$$= 2\pi - \frac{2\pi}{3} = \frac{4\pi}{3}.$$

Let intensity at $O'$ be $I'$.

$$I' = I_0 + 4I_0 + 2\sqrt{I_0}\sqrt{4I_0}\cos\frac{4\pi}{3} = 3I_0$$

For brightest fringe, $\phi = 2n\pi$, $n = 0, \pm1, \pm2, \ldots.$
Let $I''$ be the intensity of brightest fringe.

$$I'' = I_0 + 4I_0 + 2\sqrt{I_0}\sqrt{4I_0}\cos\phi = 9I_0 \text{ (where } \cos\phi = 1)$$

**2.** **(a) :** Required apparent depth from top,

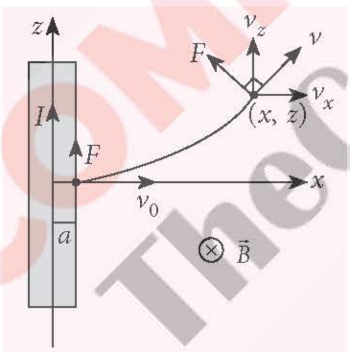
$$d' = \frac{d_1}{\mu_1} + \frac{d_2}{\mu_2} + \frac{d_3}{\mu_3} = \frac{8}{4/3} + \frac{9}{3/2} + \frac{4}{2} = 14 \text{ cm}$$

**3.** **(d)**

**4.** **(a) :** Let at any instant velocity of charge $q$ is $v$, then force on the charge due to magnetic field caused by wire is given by, $\vec{F} = q(\vec{v} \times \vec{B})$

$$ma_x\hat{i} + ma_z\hat{k} = q(v_x\hat{i} + v_z\hat{k}) \times \frac{\mu_0 I}{2\pi x}\hat{j}$$

$$\Rightarrow \quad ma_x\hat{i} + ma_z\hat{k} = qv_x\frac{\mu_0 I}{2\pi x}\hat{k} - qv_z\frac{\mu_0 I}{2\pi x}\hat{i}$$




$$\Rightarrow \quad ma_x = -\frac{q\mu_0 I}{2\pi}\frac{v_z}{x} \quad \Rightarrow \quad a_x = -\frac{q\mu_0 I}{2\pi m}\frac{v_z}{x}$$

[But $v_0^2 = v_x^2 + v_z^2$ or $v_z = \pm\sqrt{v_0^2 - v_x^2}$

Here we have to take $v_z = +\sqrt{v_0^2 - v_x^2}$ because $a_x$ is negative]

$$\Rightarrow \quad v_x\frac{dv_x}{dx} = -\frac{q\mu_0 I}{2\pi m}\frac{\sqrt{v_0^2 - v_x^2}}{x}$$

$$\Rightarrow \quad \int_{v_0}^{0}\frac{v_x dv_x}{\sqrt{v_0^2 - v_x^2}} = -\frac{q\mu_0 I}{2\pi m}\int_{a}^{x_{max}}\frac{dx}{x}$$

$$\Rightarrow \quad \left[-\sqrt{v_0^2 - v_x^2}\right]_{v_0}^{0} = -\frac{q\mu_0 I}{2\pi m}\ln\left(\frac{x_{max}}{a}\right)$$

$$\Rightarrow \quad v_0 = \frac{q\mu_0 I}{2\pi m}\ln\left(\frac{x_{max}}{a}\right) \quad \Rightarrow \quad x_{max} = ae^{\frac{2\pi m v_0}{q\mu_0 I}}$$

**5.** **(d):** $E2\pi l = \pi R^2\left(\frac{dB}{dt}\right)$; $E = \frac{R^2}{2l}\left(\frac{dB}{dt}\right)$

$$qE + mg = kx$$

$$\Rightarrow \quad x = \frac{qR^2}{k2l}\left(\frac{dB}{dt}\right) + \frac{mg}{k}; x = \frac{1}{k}\left[mg + \frac{qR^2}{2l}\frac{dB}{dt}\right]$$

**6.** **(a, b) :** The orbit period of a geosynchronous satellite is one day, *i.e.*, the satellite travels once around the earth in the same time that the earth spins once on its axis. For a satellite around earth,

$$\frac{GM_E m_S}{r^2} = \frac{m_S v^2}{r}$$

As orbital speed of planet is $2\pi r/T$, where $T$ is time period of revolution,

$$\therefore \quad \frac{GM_E}{r^2} = \frac{(2\pi r/T)^2}{r} \quad \text{or} \quad T^2 = \left(\frac{4\pi^2}{GM_E}\right)r^3 = K_E r^3$$

Thus constant, $K_E = \frac{4\pi^2}{GM_E} = 9.89 \times 10^{-14}\ \text{s}^2\ \text{m}^{-3}$

$$r = \sqrt[3]{\frac{T^2}{K_E}} = \sqrt[3]{\frac{(86400)^2}{(9.89\times10^{-14})}} = 4.23 \times 10^7 \text{ m}$$

which is radius of the final orbit from the centre of the earth.
Radius of initial orbit, $R_i = R_E + 280 \times 10^3$ m
$= 6.68 \times 10^6$ m
Total energies in initial and final orbits are

$$E_i = -\frac{GM_E m_S}{2R_i}; \quad E_f = -\frac{GM_E m_S}{2R_f}$$

Thus the energy supplied by the booster to change the orbit is

$$\Delta E = E_f - E_i = -\frac{GM_E m_S}{2}\left[\frac{1}{R_f} - \frac{1}{R_i}\right] = 1.18 \times 10^{10}\text{ J}$$

The change in kinetic energy of satellite is

$$\Delta K = \frac{GM_E m_S}{2}\left[\frac{1}{R_f} - \frac{1}{R_i}\right] = -1.18 \times 10^{10}\text{ J}$$

The change in potential energy of the satellite

$$\Delta U = -GM_E m_S\left(\frac{1}{R_f}-\frac{1}{R_i}\right) = 2.36\times10^{10}\text{ J}$$

Thus the firing of engine results in increase of potential energy and decrease of kinetic energy, but total mechanical energy is increased.

7. **(a, b, d)**

8. **(b, c, d) :** If they collide, their vertical components of velocities should be same *i.e.*,

$100\sin\theta = 160\sin 30° \Rightarrow \sin\theta = 4/5$

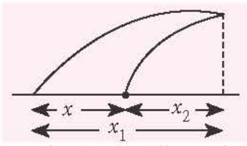
Their vertical components will always be same.

Horizontal components :

$160\cos 30° = 80\sqrt{3}$ m s$^{-1}$

and $100\cos\theta = 100\times 3/5$

$= 60$ m s$^{-1}$




They are not same, hence their velocities will not be same at any time. So (b) is correct.

$x = x_1 - x_2 = 160\cos 30°t - 100\cos\theta\, t$

$\Rightarrow x = (80\sqrt{3} - 60)t$

Time of flight, $T = \dfrac{2\times160\times\sin 30°}{g} = 16$ s

Now $t < T$ as they to collide in air

$\Rightarrow \dfrac{x}{80\sqrt{3}-60} < 16 \Rightarrow x < (1280\sqrt{3} - 960)$ m

Since their times of flight are same, they will simultaneously reach their maximum height. So, it is possible to collide at highest point for certain values of $x$.

9. **(a, c) :** The slope of tangent at point $B$ is, $\tan\phi = \dfrac{dy}{dx}$

The angle of incidence at $B$ is $\theta = 90° - \phi$.

Hence, $\tan(90° - \theta) = \dfrac{dy}{dx} \Rightarrow \cot\theta = \dfrac{dy}{dx}$ ...(i)

From Snell's law at $A$ and $B$, we have

$$1\sin 90° = n(y)\sin\theta, \sin\theta = \frac{1}{n(y)} = \frac{1}{(ky^{3/2}+1)^{1/2}}$$

$$\therefore \cot\theta = \frac{\sqrt{1-(1/ky^{3/2}+1)}}{1/(ky^{3/2}+1)^{1/2}} = k^{1/2}y^{3/4} \quad ...(ii)$$

From eqns. (i) and (ii), $\dfrac{dy}{dx} = \sqrt{k}y^{3/4}$

$\Rightarrow 4y^{1/4} = \sqrt{k}x + C$ ...(iii)

Now we substitute boundary conditions in eqn. (iii) $x = 0$, $y = 0$, hence $C = 0$. The required trajectory is

$$y = k^2\left(\frac{x}{4}\right)^4$$

At point $P$, $y = 1$ m, $k = 1.0$ m$^{-3/2}$, we get $x = 4$ m

$\therefore$ The coordinates of $P$ are (4, 1).

From Snell's law, $n_A\sin i_A = n_P\sin i_P$

As $n_A = n_P = 1$ so $i_P = i_A = 90°$

The ray will emerge parallel to boundary.

10. **(a, b, c) :** For $A \to B$, $T_A^\gamma P_A^{1-\gamma} = T_B^\gamma P_B^{1-\gamma}$

where $\gamma = 5/3$ for a monatomic gas.

$$T_B = T_A\left(\frac{P_B}{P_A}\right)^{1-\frac{1}{\gamma}} = 1000\left(\frac{2}{3}\right)^{2/5} = 850\text{ K}$$

Work done in an adiabatic process is given by

$$W = \frac{nR(T_A - T_B)}{\gamma - 1} = \frac{1\times8.31(1000-850)}{(5/3)-1} = 1869.75\text{ J}$$

$\because$ Process $B \to C$ is isochoric.

Hence $W = 0$ and $\dfrac{P_C}{T_C} = \dfrac{P_B}{T_B}$

$$\therefore T_C = \frac{P_C}{P_B}\times T_B = \frac{(1/3)P_A}{(2/3)P_A}T_B = \frac{T_B}{2} = \frac{850}{2} = 425\text{ K}$$

From first law of thermodynamics,

$$Q = \Delta U + W = nC_V\Delta T + 0 = n\frac{3}{2}R(T_C - 850)$$

Hence, $Q = 1\times\dfrac{3}{2}\times 8.31(425 - 850) = -5297.625$ J

Negative sign implies that the system has lost heat.

Process $D \to A$ is isochoric

$$\frac{P_D}{P_A} = \frac{T_D}{T_A} \quad\text{or}\quad P_D = P_A\frac{T_D}{T_A}$$

Process $C \to D$ is adiabatic.

Therefore, $\left(\dfrac{T_D}{T_C}\right)^\gamma = \left(\dfrac{P_D}{P_C}\right)^{\gamma-1} = \left(\dfrac{P_AT_D}{P_CT_A}\right)^{\gamma-1}$

$$\therefore T_D^{1/\gamma} = T_C\left[\frac{P_A}{P_CT_A}\right]^{1-1/\gamma}$$

$$\Rightarrow T_D^{3/5} = T_C\left[\frac{P_A}{(1/3)P_A\times1000}\right]^{2/5} = 425\left(\frac{3}{1000}\right)^{2/5}$$

$T_D = 500$ K

11. **(a) :** Suppose the shell destroys the bomb at time $t$. Then for horizontal motion,

$t(200 + 200\cos\theta) = \sqrt{3}\times 1000$

$\therefore t(1 + \cos\theta) = 5\sqrt{3}$ ...(i)

For vertical motion,

$$\frac{1}{2}gt^2 + (200\sin\theta)t - \frac{1}{2}gt^2 = 1000$$

$\therefore \sin\theta t = 5$ ...(ii)

From eqns. (i) and (ii), $\dfrac{\sin\theta}{1+\cos\theta} = \dfrac{1}{\sqrt{3}}$

On solving, we get $\theta = 60°$.

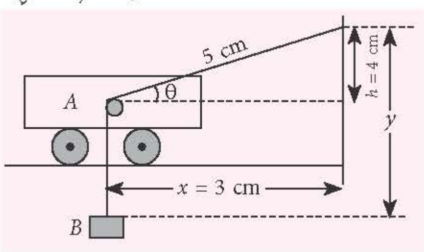
Putting value of θ in eqn. (ii), we get $t = \frac{10\sqrt{3}}{3}$ s

If $(x, y)$ is the coordinate of point of collision,

$$x = 200\,t = \frac{2000\sqrt{3}}{3}\text{ m} = \frac{2\sqrt{3}}{3}\text{ km}$$

$$y = 200\sin\theta t - \frac{1}{2}gt^2 = 1000 - \frac{500\sqrt{3}}{3} = \left(1 - \frac{\sqrt{3}}{6}\right)\text{ km}$$

**12. (c, d) :** $(y - h) + \sqrt{x^2 + h^2} = l$ = constant




or $\frac{dy}{dt} + \frac{x}{\sqrt{x^2+h^2}}\frac{dx}{dt} = 0$ or $\frac{dy}{dt} = -\frac{x}{\sqrt{x^2+h^2}}\frac{dx}{dt}$

$\therefore \frac{d^2y}{dt^2} = \frac{v_A^2 h^2}{(x^2+h^2)^{3/2}}$ $\therefore v_B = \frac{3}{5}v_A$ and $a_B = \frac{16}{125}v_A^2$

**13. (b) :** Variation of acceleration due to gravity with altitude

$$g_h = g\left(1 - \frac{2h}{R_e}\right) \quad \text{or} \quad \Delta g = \frac{2hg}{R_e}$$

$$T_h = 2\pi\sqrt{\frac{l}{g - \Delta g}} = 2\pi\sqrt{\frac{l}{g}}\left(1 - \frac{\Delta g}{g}\right)^{-1/2} = T\left(1 + \frac{\Delta g}{2g}\right)$$

Variation of $l$ with temperature = $\Delta l$

$$T_\theta = 2\pi\sqrt{\frac{l + \Delta l}{g}} = T\left(1 + \frac{\Delta l}{2l}\right)$$

The clock shows correct time if $T_h = T_\theta$

$$\therefore \frac{\Delta l}{2l} = \frac{\Delta g}{2g}$$

Linear expansivity = $\frac{\Delta l}{l(\Delta\theta)}$, where $\Delta\theta = 30 - 20 = 10°C$

Linear expansivity = $\frac{\Delta l}{10l} = \frac{\Delta g}{10g} = \frac{2h}{10R_e} = \frac{h}{5R_e}$

**14. (4) :** $\frac{dN_A}{dt} = -\lambda_1 N_A$ and $\frac{dN_B}{dt} = -2\frac{dN_A}{dt} - \lambda_2 N_B$

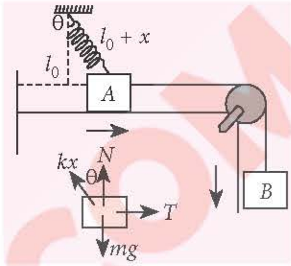
Now when $N_B$ is maximum, at that time

$$\frac{dN_B}{dt} = 0 \Rightarrow 2\lambda_1 N_A - \lambda_2 N_{B\max} = 0$$

or $N_0 = \frac{\lambda_2 N_{B\max}}{2\lambda_1} e^{\lambda_1 t} = 10{,}000$ moles

**15. (5)**

**16. (2) :** Let $x$ be the elongation produced in spring and θ be the angle between spring and vertical at the instant when block $A$ breaks off the plane.




$$\Rightarrow \cos\theta = \frac{l_0}{l_0 + x} \quad \text{...(i)}$$

$$N + kx\cos\theta = mg$$

$$\Rightarrow kx\cos\theta = mg \quad (\text{as } N = 0) \quad \text{...(ii)}$$

Let $d$ is the distance covered by $A$ and $B$ and $v$ is the speed acquired by them.

From eqns. (i) and (ii), using $k = \frac{5mg}{l_0}$

$$\Rightarrow \frac{5mg}{l_0} \times \frac{l_0 x}{l_0 + x} = mg$$

$$\Rightarrow x = \frac{1}{4}l_0 \Rightarrow d = \sqrt{(l_0 + x)^2 - l_0^2} = \frac{3l_0}{4}$$

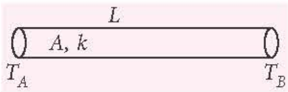
Using energy conservation,

$$mgd = 2\left(\frac{1}{2}mv^2\right) + \frac{1}{2}kx^2$$

$$\Rightarrow mg\frac{3l_0}{4} = mv^2 + \frac{1}{2}\frac{5mg}{l_0}\frac{l_0^2}{16} \Rightarrow v = \sqrt{\frac{19gl_0}{32}}$$

∴ The value of $n$ is 2

**17. (2) :** $T_B\lambda_0 = b$, $T_B = \frac{b}{\lambda_0}$




$b = 2.89 \times 10^{-3}$ m K,

$\lambda_0 = 75000$ Å $= 75 \times 10^{-7}$ m, $\sigma = 5.67 \times 10^{-8}$ W m$^{-2}$ K$^{-4}$

$$\frac{kA(T_A - T_B)}{L} = \sigma A T_B^4$$

$$T_A = T_B + \frac{L\sigma T_B^4}{k} \Rightarrow T_A = \frac{b}{\lambda_0} + \frac{L\sigma}{k} \times \frac{b^4}{\lambda_0^4}$$

Substituting values, we get $T_A = 422.1$ K ∴ $a = 2$

**18. (1) :** The pressure inside and outside the charged soap bubble is same if $\frac{\sigma^2}{2\varepsilon_0} = \frac{4T}{R}$; $T = \frac{\sigma^2 R}{8\varepsilon_0}$

$$T = \frac{\sigma^2 R}{8\varepsilon_0} = \frac{(2\times10^{-5})^2 \times 0.25\times10^{-2}}{8\varepsilon_0} = \frac{1\times10^{-12}}{8\varepsilon_0}\text{ N m}^{-1}$$

∴ The value of α is 1.

## Paper-II

1. **(c) :** Using conservation of mechanical energy $\Delta KE + \Delta PE = 0$,

$$\left(0-\frac{1}{2}mv^2\right)+q(V_f-V_i)=0$$

or $\frac{1}{2}mv^2 = q(V_f - V_i)$ ...(i)

$$V_i=\frac{Q}{4\pi\varepsilon_0 r} \text{ and } V_f=\frac{Q}{8\pi\varepsilon_0 R}\left[3-\frac{r^2}{R^2}\right]$$

where $r=\frac{R}{2}$; hence $V_f=\frac{11Q}{32\pi\varepsilon_0 R}$

Putting the values of $V_i$ and $V_f$ in eqn. (i)

$$\frac{1}{2}mv^2=\frac{11qQ}{32\pi\varepsilon_0 R}-\frac{qQ}{4\pi\varepsilon_0 r}$$

or $v^2=\frac{qQ}{2m\pi\varepsilon_0 R}\left[\frac{11}{8}-\frac{R}{r}\right]$

$$\Rightarrow \quad v=\sqrt{\frac{qQ}{2m\pi\varepsilon_0 R}\left[\frac{11}{8}-\frac{R}{r}\right]}$$

2. **(a) :** $\because$ Upthrust due to liquid = Weight of floating body

(Volume dipped) × $\rho_L g$ = (Volume of body) × $\rho_S \times g$

$\therefore \quad (k_1 V)\rho_L = V\rho_s \Rightarrow k_1=\frac{\rho_S}{\rho_L}$ at temperature 0°C

Similarly $k_2=\frac{\rho'_S}{\rho'_L}$ at temperature 60°C

$$\therefore \quad \frac{k_1}{k_2}=\frac{\rho_S}{\rho'_S}\times\frac{\rho'_L}{\rho_L}$$

or $\frac{k_1}{k_2}=\frac{\rho'_S(1+\gamma_{Fe}\times 60)}{\rho'_S}\times\frac{\rho'_L}{\rho'_L(1+\gamma_{Hg}\times 60)}$

or $\frac{k_1}{k_2}=\frac{1+60\gamma_{Fe}}{1+60\gamma_{Hg}}$

3. **(c) :** The electric field is $E = V/d$

$$\Rightarrow \quad E=\frac{0.50}{5.0\times10^{-7}}=1.0\times10^6 \text{ V m}^{-1}$$

Suppose the electron has a speed $v_1$ when it enters the depletion layer and $v_2$ when it comes out of it. As the potential energy increases by $q \times 0.50$ V, using principle of conservation of energy,

$$\frac{1}{2}mv_1^2 = q\times V+\frac{1}{2}mv_2^2$$

Solving this, $v_2 = 2.7 \times 10^5$ m s$^{-1}$.

4. **(d):** Let us first locate the image of $S$ formed by the lens $L$. Here $u = -12$ cm and $f = 15$ cm. We have,

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \text{ or } \frac{1}{v}=\frac{1}{f}+\frac{1}{u}=\frac{1}{15}-\frac{1}{12} \text{ or } v=-60 \text{ cm.}$$

The image $I_1$ acts as the source for the mirror. The mirror forms an image $I_2$ of the source $I_1$. This image $I_2$ then acts as the source for the lens and the final beam comes out parallel to the principal axis. Clearly $I_2$ must be at the focus of the lens. We have,

$$I_1I_2 = I_1P + PI_2 = 60 \text{ cm} + 15 \text{ cm} = 75 \text{ cm}$$

Suppose the distance of the mirror from $I_2$ is $x$ cm. For the reflection from the mirror,

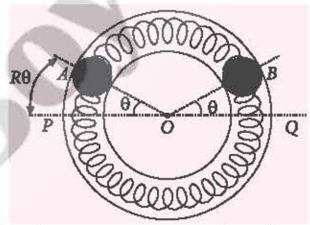
$u = MI_1 = -(75 + x)$cm, $v = -x$ cm and $f = -20$ cm.

Using $\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{x}+\frac{1}{75+x}=\frac{1}{20}$

This gives $x = 25$ or $-60$.

Taking $x = 25$, the separation between the lens and the mirror is $(15 + 25)$ cm = 40 cm

5. **(b):** Initially, both the balls are displaced by an angle $\theta = \pi/6$ radian with respect to the diameter $PQ$ of the circle and released from rest. It results into compression of spring in upper segment and an equal elongation of spring in lower segment. Let it be $x$. $PA$ and $QB$ denote $x$ in the figure.




Compression = $R\theta$ = elongation = $x$

$\therefore$ Force exerted by each spring on each ball = $2kx$

$\therefore$ Total force on each ball due to two springs = $4kx$

$\therefore$ Restoring torque about origin $O = -(4kx)R$

$\therefore$ $\tau = -4k(R\theta)R$, where $\theta$ = Angular displacement

or $\tau = -4kR^2\theta$ ...(i)

Since torque $\tau$ is proportional to $\theta$, each ball executes angular SHM about the centre $O$.

Again, $\tau = -4kR^2\theta$

or $I\alpha = -4kR^2\theta$ where $\alpha$ = angular acceleration

or $(mR^2)\alpha = -4kR^2\theta$ or $\alpha=-\left(\frac{4k}{m}\right)\theta$

$$\therefore \quad \text{Frequency } \upsilon=\frac{1}{2\pi}\sqrt{\left|\frac{\alpha}{\theta}\right|}=\frac{1}{2\pi}\sqrt{\frac{4k}{m}}$$

$$=\frac{1}{2\pi}\sqrt{\frac{4\times0.1}{0.1}}=\frac{1}{\pi}\text{ s}^{-1} \quad \text{...(ii)}$$

Let the velocity at mean position = $v$

In stretched position, PE = $2\left[\frac{1}{2}k(2x)^2\right]$

or PE = $4kx^2$

KE at mean position = $2\left[\frac{1}{2}mv^2\right]$ or KE = $mv^2$

Since the energy of the system is conserved, KE of system = PE of the system

or $mv^2 = 4kx^2 \Rightarrow v = 2x\sqrt{\frac{k}{m}} = 2R\theta\sqrt{\frac{k}{m}}$

or $v = 2\times(0.06)\left(\frac{\pi}{6}\right)\sqrt{\frac{0.1}{0.1}}$ or $v = 0.0628 \text{ m s}^{-1}$

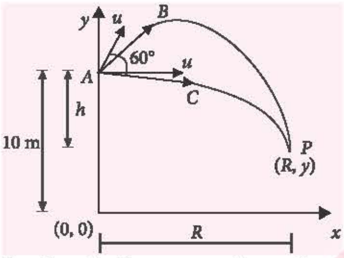
Total energy = KE at mean position

$\therefore \quad E = \left(\frac{mv^2}{2}+\frac{mv^2}{2}\right)$, for the system

or $E = mv^2$ or $E = (0.1)\times(0.0628)^2$

or $E = 3.95\times10^{-4}$ J

6. **(b) :** Bullets fired by the two guns follow different parabolic path till they collide in air at point $P$. $ACP$ and $ABP$ denote their paths.




Let $t_1$ = Time taken by first bullet in reaching $P$.

$t_2$ = Time taken by second bullet in reaching $P$.

$R = (u\cos 60°)t_2$ for $ABP$

$R = (u\,t_1)$ for $ACP$

$\therefore \quad \frac{ut_2}{2} = ut_1$ or $t_2 = 2t_1$

$h = -(u\sin 60°)t_2 + \frac{1}{2}gt_2^2$ for $ABP$

$h = \frac{1}{2}gt_1^2$ for $ACP$

$\therefore \quad \frac{-u\times\sqrt{3}t_2}{2}+\frac{1}{2}gt_2^2 = \frac{1}{2}gt_1^2$

or $\frac{-5\sqrt{3}\times\sqrt{3}t_2}{2}+\frac{10t_2^2}{2} = \frac{10t_1^2}{2}$

or $t_1 = 1$ s or $t_2 = 2t_1 = 2$ s

$\therefore$ The time-interval between the firings $= (t_2 - t_1) = (2-1) = 1$ s

Now $R = ut_1 = 5\sqrt{3}$ m for path $ACP$

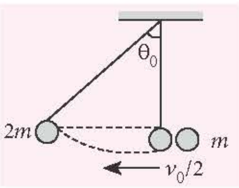
Again $h = \frac{1}{2}gt_1^2 = 5$ m for path $ACP$

$\therefore$ $y$-coordinate of $P = 10 - h = 10 - 5 = 5$ m

Hence, coordinates of $P = (R, y) = (5\sqrt{3}, 5)$ m

7. **(a, c)**

8. **(a, b) :** The time period of simple harmonic pendulum is independent of mass, so it would be same as that $T = 2\pi\sqrt{l/g}$. After collision, the combined mass acquires a velocity of $v_0/2$, as a result of this velocity, the mass $2m$ moves up and at an angel $\theta_0$ with vertical, it stops, this is the extreme position of bob.




From work-energy theorem, $\Delta K = W_{total}$

$$0 - \frac{2m}{2}\left(\frac{v_0}{2}\right)^2 = -2mgl(1-\cos\theta_0)$$

$$\frac{v_0^2}{8gl} = 1-\cos\theta_0 = 2\sin^2\frac{\theta_0}{2}$$

$$\sin\frac{\theta_0}{2} = \frac{v_0}{4\sqrt{gl}}$$

If $\theta_0$ is small, $\sin\frac{\theta_0}{2} \simeq \frac{\theta_0}{2} \Rightarrow \theta_0 = \frac{v_0}{2\sqrt{gl}}$

9. **(a, b, c) :** Fringe width, $\beta = \frac{\lambda D}{d}$

$\beta_1 = \frac{\lambda_1 D}{d}$ and $\beta_2 = \frac{\lambda_2 D}{d}$

$\therefore \quad \frac{\beta_2}{\beta_1} = \frac{\lambda_2}{\lambda_1}$; $\because \quad \lambda_2 > \lambda_1$ so $\beta_2 > \beta_1$

Number of fringes within a distance $y$ on one side of the central maximum is $m = \frac{y}{\beta}$

Since $y$ is same for $\lambda_1$ and $\lambda_2$

$\therefore \quad m_1\beta_1 = m_2\beta_2$ or $\frac{1}{2}\;\frac{2}{1}$

$\because \quad \beta_2 > \beta_1$ so $m_1 > m_2$

3rd maxima of $\lambda_2$ is at $= \frac{3\lambda_2 D}{d} = (1800)\frac{D}{d}$

5th minima of $\lambda_1$ is at $= (2\times5-1)\frac{\lambda_1 D}{2d} = (1800)\frac{D}{d}$

So, 3rd maximum of $\lambda_2$ overlaps with 5th minimum of $\lambda_1$.

Angular separation of fringes, $\theta = \frac{\lambda}{d}$

The angular separation of fringes for $\lambda_1$ and $\lambda_2$ is

$\theta_1 = \frac{\lambda_1}{d}$ and $\theta_2 = \frac{\lambda_2}{d} \Rightarrow \frac{\theta_1}{\theta_2} = \frac{\lambda_1}{\lambda_2}$

As $\lambda_1 < \lambda_2 \quad \therefore \quad \theta_1 < \theta_2$

Thus the angular separation of fringes for $\lambda_1$ is lesser than $\lambda_2$.

10. **(a, b, c)**

11. **(b, c) :** Case (A) : $Z_A = \sqrt{R^2+\left(\frac{1}{\omega C}\right)^2}$

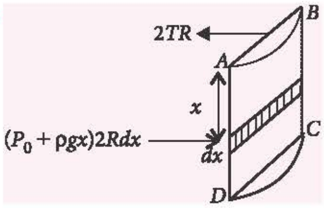
Case (B) : $Z_B = \sqrt{R^2+\left(\frac{1}{\omega KC}\right)^2}$

So $Z_B < Z_A$

$$I_R^A = \frac{V}{Z_A} \quad \text{and} \quad I_R^B = \frac{V}{Z_B} \quad \text{Clearly } I_R^A < I_R^B$$

Since current in case ($B$) is greater, so potential across $R$ will increase in case ($B$) and thus across capacitor will decrease. Hence $V_C^A > V_C^B \quad (\because V_R^2 + V_C^2 = V_0^2)$

**12. (b):**



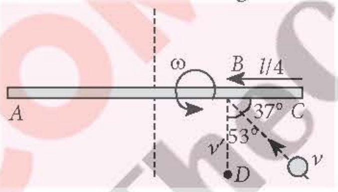

Consider water on one side of the vertical section $ABCD$ as the system. Note that this is the half cylinder. Draw the forces on this half cylinder by another half cylinder. At a depth below $x$ from the top surface consider a strip of width $dx$. Force on this strip is $(P_0 + \rho g x)(2Rdx)$.

Total force on one half cylinder by the other half cylinder is

$$F = \int_0^h (P_0 + \rho g x) 2R dx - 2RT = 2P_0 Rh + R\rho g h^2 - 2RT$$

**13. (a, b, c) :** The ball has $v'$ component of its velocity perpendicular to the length of the rod immediately after the collision.

$u$ is the velocity of $CM$ of the rod and $\omega$ is angular velocity of the rod just after collision. The ball strikes the rod with a speed of $v\cos 53°$ in the perpendicular direction and its component along the length of the rod after the collision is unchanged.




At the point of collision,

velocity of separation = velocity of approach

$$\frac{3v}{5} = \left(\frac{\omega l}{4} + u\right) + v' \qquad \text{...(i)}$$

Conserving linear momentum (of rod + particle) in the direction perpendicular to the rod,

$$mv\frac{3}{5} = mu - mv' \qquad \text{...(ii)}$$

Conserving angular momentum about point $D$,

$$0 = 0 + \left[mu\frac{l}{4} - \frac{ml^2}{12}\omega\right] \Rightarrow u = \frac{\omega l}{3} \qquad \text{...(iii)}$$

From eqn. (i), (ii) and (iii)

$$\Rightarrow u = \frac{24v}{55}, \ \omega = \frac{72v}{55l}$$

Time taken to rotate by $\pi$ angle, $t = \frac{\pi}{\omega}$

In the same time, distance travelled $= ut =$ —

Using impulse-momentum equation on the rod,

$$\text{Impact force} = \int N dt = mu = \frac{24mv}{55}$$

**14. (a, c)**

**15. (b) :** $F_{mm}$ = Gravitational force between two outer stars

$$= \frac{Gm^2}{4r^2}$$

$F_{mM}$ = Gravitational force between central star and outer star $= \frac{GmM}{r^2}$

For circular motion of outer star,

$$\frac{mv^2}{r} = F_{mm} + F_{mM}$$

$$\therefore \ v^2 = \frac{G(m + 4M)}{4r}$$

$T$ = period of orbital motion $= \frac{2\pi r}{v}$

$$m = \frac{16\pi^2 r^3}{GT^2} - 4M = \left(\frac{150}{16} - 8\right)10^{30}$$

$$= \frac{11}{8} \times 10^{30} \text{ kg}$$

**16. (b) :** Total mechanical energy = KE + PE

$$= 2\left(\frac{1}{2}mv^2\right) - \frac{2GMm}{r} - \frac{Gm^2}{2r} = -\frac{Gm}{r}\left[M + \frac{m}{4}\right]$$

Substituting value we get,

$$E = -\frac{1375}{64} \times 10^{38} \text{ J}$$

**17. (d):** $qE = \frac{mv^2}{r} \quad \Rightarrow \quad v = \sqrt{\frac{qE_0 b}{m}}$

$$a_c = \frac{qE}{m} = \frac{q}{m}E_0\left(\frac{b}{r}\right)$$

**18. (c) :** Centrifugal force = electrostatic force in the reference frame of proton.

$$\frac{1}{2}mv^2 = qE_0 b\int_a^b \frac{dr}{r} \quad \Rightarrow \quad v = \sqrt{\frac{2qE_0 b}{m}\ln\left(\frac{b}{a}\right)}$$

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# PRACTICE PAPER

# AIIMS

**Exam on 28th May**



**1.** In a semiconducting material, $\left(\frac{1}{5}\right)^{\text{th}}$ of the total current is carried by the holes and the remaining is carried by the electrons. The drift speed of electrons is twice that of holes at this temperature, the ratio between the number densities of electrons and holes is

(a) 21 : 6 (b) 5 : 1 (c) 3 : 8 (d) 2 : 1

**2.** A ball is projected from the ground at an angle θ with the horizontal. After 1 s it is moving at an angle 45° with the horizontal and after 2 s, it is moving horizontally. The velocity of projection of the ball is ($g = 10$ m s$^{-2}$)

(a) $5\sqrt{3}$ m s$^{-1}$ (b) $10\sqrt{3}$ m s$^{-1}$
(c) $10\sqrt{5}$ m s$^{-1}$ (d) $20\sqrt{5}$ m s$^{-1}$

**3.** Two identical mass $M$ moving with velocity $u_1$ and $u_2$ collide perfectly inelastically. The loss in energy is

(a) $\frac{M}{2}(u_2 - u_1)^2$ (b) $\frac{M}{8}(u_1 - u_2)^2$
(c) $\frac{M}{4}(u_1 - u_2)^2$ (d) Zero

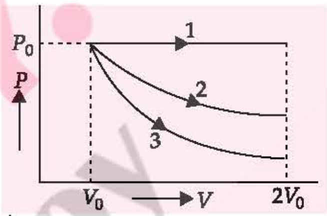
**4.** A car starts from rest and covers distance $x$ along straight line before its speed becomes $v$. The speed $v$ reached by a car of mass $m$ driven with constant power $P$ is given by

(a) $v = \frac{3xP}{m}$ (b) $v = \left(\frac{3xP}{m}\right)^{1/2}$
(c) $v = \left(\frac{3xP}{m}\right)^{1/3}$ (d) $v = \left(\frac{3xP}{m}\right)^{2}$

**5.** A heater coil is cut into two equal parts and only one part is now used in the heater. The heat generated will now be

(a) one fourth (b) halved
(c) doubled (d) four times

**6.** A gas is expanded from volume $V_0$ to $2V_0$ under three different processes, as shown in the figure. Then,




(a) Process 2 is isobaric
(b) Process 3 is isothermal
(c) Process 3 is adiabatic
(d) Process 1 is isothermal

**7.** Two particles of masses $m_1$ and $m_2$ are connected to a rigid massless rod of length $r$ to constitute a dumbbell which is free to move in the plane. The moment of inertia of the dumb bell about an axis perpendicular to the plane passing through the centre of mass is

(a) $\frac{m_1 m_2 r^2}{m_1 + m_2}$ (b) $(m_1 + m_2) r^2$
(c) $\frac{m_1 m_2 r^2}{m_1 - m_2}$ (d) $(m_1 - m_2) r^2$

**8.** The half life of radium is 1620 years and its atomic weight is 226 g mol$^{-1}$. The number of atoms that will decay from its 1 g sample per second will be (Avogdro's number $N_A = 6.023 \times 10^{23}$)

(a) $3.61 \times 10^{10}$ (b) $3.6 \times 10^{12}$
(c) $3.11 \times 10^{15}$ (d) $31.1 \times 10^{15}$

**9.** A vector $\vec{Q}$ which has a magnitude of 8 is added to the vector $\vec{P}$ which lies along $x$-axis. The resultant of two vectors lies along $y$-axis and has magnitude twice that of $\vec{P}$. The magnitude of $\vec{P}$ is

(a) $\frac{6}{\sqrt{5}}$ (b) $\frac{8}{\sqrt{5}}$ (c) $\frac{12}{\sqrt{5}}$ (d) $\frac{16}{\sqrt{5}}$

**10.** The velocity of sound waves in air is 330 m s$^{-1}$. For sound of particular frequency in air, a path difference of 40 cm is equivalent to a phase difference of $1.6\pi$. The frequency of the wave is

(a) 165 Hz (b) 150 Hz (c) 660 Hz (d) 330 Hz

11. The work done in placing a charge of $8 \times 10^{-18}$ C on a condenser of capacity 100 μF is
(a) $16 \times 10^{-32}$ J (b) $3.1 \times 10^{-26}$ J
(c) $4 \times 10^{-10}$ J (d) $32 \times 10^{-32}$ J

12. A prism of refractive index 1.5 is placed in water of refractive index 1.33. The refracting angle of a prism is 60°. The angle of minimum deviation in water is (Given sin34° = 0.56)
(a) 4° (b) 8° (c) 12° (d) 16°

13. The ratio of minimum to maximum wavelength in Balmer series is
(a) 5 : 9 (b) 5 : 36 (c) 1 : 4 (d) 3 : 4

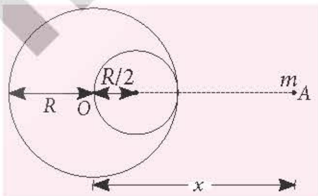
14. A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement $x$ is proportional to
(a) $x^2$ (b) $e^x$ (c) $x$ (d) $\log e^x$

15. In an experiment of simple pendulum, the errors in the measurement of length of the pendulum $L$ and time period $T$ are 3% and 2% respectively. The maximum percentage error in the value of $\frac{L}{T^2}$ is
(a) 5% (b) 7% (c) 8% (d) 1%

16. If velocity of light $c$, graviational constant $G$ and Planck's constant $h$ are chosen as fundamental units, the unit of mass would be
(a) $\sqrt{hc/G}$ (b) $\sqrt{hG/c}$
(c) $\sqrt{G/hc}$ (d) $\sqrt{c/Gh}$

17. A vessel of depth $x$ is half filled with oil of refractive index $\mu_1$ and the other half is filled with water of refractive index $\mu_2$. The apparent depth of the vessel when viewed from above is
(a) $\frac{x(\mu_1+\mu_2)}{2\mu_1\mu_2}$ (b) $\frac{x_1\mu_2}{2(\mu_1+\mu_2)}$
(c) $\frac{x\mu_1\mu_2}{(\mu_1+\mu_2)}$ (d) $\frac{2x(\mu_1+\mu_2)}{\mu_1\mu_2}$

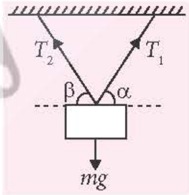
18. A spherical mass of radius $R/2$ is taken out from a uniform sphere of radius $R$ and mass $M$ as shown in figure. The force which this sphere having a cavity will exert on a mass $m$ placed at distance $x$ (where $x > R$) from the centre $O$ is




(a) $\frac{GMmR}{x^3}$ (b) $\frac{GMm}{(R^2+x^2)}$
(c) $GMm\left[\frac{1}{x^2}-\frac{1}{2(2x-R)^2}\right]$
(d) $GMm\left[\frac{1}{x^2}-\frac{1}{(2x-R)^2}\right]$

19. Initial angular velocity of a circular disc of mass $M$ is $\omega_1$. Then two small spheres each of mass $m$ are attached gently to two diametrically opposite points on the edge of the disc. The final angular velocity of the disc is
(a) $\left(\frac{M+m}{M}\right)\omega_1$ (b) $\left(\frac{M+m}{m}\right)\omega_1$
(c) $\left(\frac{M}{M+4m}\right)\omega_1$ (d) $\left(\frac{M}{M+2m}\right)\omega_1$

20. A body of mass $m$ is suspended by two strings making angles $\alpha$ and $\beta$ with the horizontal. Tensions in the two strings are




(a) $T_1 = \frac{mg\cos\beta}{\sin(\alpha+\beta)} = T_2$
(b) $T_1 = \frac{mg\sin\beta}{\sin(\alpha+\beta)} = T_2$
(c) $T_1 = \frac{mg\cos\beta}{\sin(\alpha+\beta)}$, $T_2 = \frac{mg\cos\alpha}{\sin(\alpha+\beta)}$
(d) None of these

21. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon
(a) the rates at which currents are changing in the two coils.
(b) relative position and orientation of the two coils.
(c) the materials of the wires of the coils.
(d) the currents in the two coils.

22. The coordinates of a moving particle at any time $t$ are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time $t$ is given by
(a) $3t\sqrt{\alpha^2+\beta^2}$ (b) $3t^2\sqrt{\alpha^2+\beta^2}$
(c) $t^2\sqrt{\alpha^2+\beta^2}$ (d) $\sqrt{\alpha^2+\beta^2}$

23. The energy of radiation is 207 eV. The type of radiation is [Given, $hc$ = 1242 eV nm]
(a) Infrared (b) Ultraviolet
(c) Visible (d) Microwaves

24. The two slits at a distance of 1 mm are illuminated by the light of wavelength $6.5 \times 10^{-7}$ m. The interference fringes are observed on a screen placed at a distance of 1 m. The distance between third dark fringe and fifth bright fringe will be

(a) 0.65 cm (b) 4.8 mm
(c) 1.63 mm (d) 3.25 cm

**25.** 14 g of a gas occupy a volume of $4 \times 10^{-3}$ m$^3$ at a temperature 27°C. After the gas is heated at constant pressure, its density becomes $7 \times 10^{-4}$ g cm$^{-3}$. The temperature to which the gas was heated is
(a) 1127 °C (b) 1227 °C
(c) 1287 °C (d) 1327 °C

**26.** A galvanometer of resistance 25 Ω measures $10^{-3}$ A. Shunt required to increase range upto 2 A is
(a) 12.5 Ω (b) 0.0125 Ω
(c) 0.125 Ω (d) 1.25 Ω

**27.** A particle is released from the top of two inclined rough surfaces of height $h$ each. The angle of inclination of the two planes are 30° and 60° respectively. All other factors (*e.g.*, coefficient of friction, mass of block etc.) are same in both the cases. Let $K_1$ and $K_2$ be the kinetic energies of the particle at the bottom of the plane in two cases. Then
(a) $K_1 = K_2$ (b) $K_1 > K_2$
(c) $K_1 < K_2$ (d) Data insufficient

**28.** If a charge $q$ is placed at the centre of the line joining two equal charges $Q$ such that the system is in equilibrium then the value of $q$ is
(a) $Q/2$ (b) $-Q/2$ (c) $Q/4$ (d) $-Q/4$

**29.** A mass $M$ is attached to a horizontal spring, executes SHM with an amplitude $A_1$. When the mass $M$ passes through its mean position then a smaller mass $m$ is placed over it and both of them move together with amplitude $A_2$. The ratio of $\left(\frac{A_1}{A_2}\right)$ is
(a) $\frac{M}{M+m}$ (b) $\frac{M+m}{M}$
(c) $\left(\frac{M}{M+m}\right)^{1/2}$ (d) $\left(\frac{M+m}{M}\right)^{1/2}$

**30.** The inductance between points $A$ and $D$ is

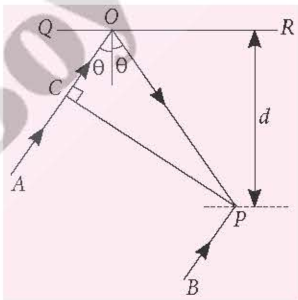

(a) 3.66 H (b) 9 H (c) 0.66 H (d) 1 H.

**31.** For a given liquid, if $h$ is the height of capillary rise and $r$ be the radius of capillary tube, then which of the following relation will be correct?
(a) $hr$ = constant (b) $h/r^2$ = constant
(c) $hr^2$ = constant (d) $h/r$ = constant

**32.** The plane face of a planoconvex lens is silvered. If μ be the refractive index and $R$ is the radius of curvature of curved surface, then the system will behave like a concave mirror of radius of curvature
(a) $\mu R$ (b) $\frac{R}{(\mu-1)}$
(c) $\frac{R^2}{\mu}$ (d) $\left[\frac{(\mu+1)}{(\mu-1)}R\right]$

**33.** A body has a time period $T_1$ under the action of one force and $T_2$ under the action of another force, the square of the time period when both the forces are acting in the same direction simultaneously is
(a) $T_1^2 T_2^2$ (b) $T_1^2 / T_2^2$
(c) $T_1^2 + T_2^2$ (d) $T_1^2 T_2^2 / (T_1^2 + T_2^2)$

**34.** In the figure, $CP$ represents a wavefront and $AO$ and $BP$, the corresponding two rays. The condition on θ for constructive interference at $P$ between the ray $BP$ and the reflected ray $OP$.




(a) $\cos\theta = 3\lambda/2d$
(b) $\cos\theta = \lambda/4d$
(c) $\sec\theta - \cos\theta = \lambda/d$
(d) $\sec\theta - \cos\theta = 4\lambda/d$

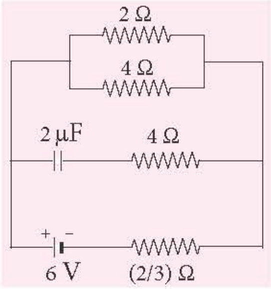
**35.** The radius of gyration of a solid cylinder of mass $M$ and radius $R$ about its own axis is
(a) $\frac{R}{\sqrt{2}}$ (b) $\frac{R}{2}$ (c) $\frac{R}{\sqrt{3}}$ (d) $\frac{R}{3}$

**36.** When $p$-$n$ junction diode is forward biased, then
(a) the depletion region is reduced and barrier height is increased
(b) the depletion region is widened and barrier height is reduced.
(c) both the depletion region and barrier height are reduced
(d) both the depletion region and barrier height are increased.

**37.** Pick out the correct statements
(i) Susceptibility of a diamagnetic substance is high and positive.
(ii) In paramagnetic substance, the intrinsic magnetic moment is not zero.
(iii) When a paramagnetic substance is heated, it becomes ferromagnetic.
(iv) Spin exchange interaction is present in the absence of external magnetic field.

(a) (i) and (iii) (b) (iii) and (iv)
(c) (ii) and (iii) (d) (ii) and (iv)

**38.** In the given figure, the current in 2 Ω resistor is:




(a) 1 A (b) 2 A (c) 3/2 A (d) 4/3 A

**39.** Two wires $A$ and $B$ of the same material have their lengths in the ratio of 1 : 2 and their diameters in the ratio of 2 : 1. If they are stretched with the same force, the ratio of the increase in the length of $A$ to that of $B$ will be
(a) 1 : 2 (b) 4 : 1 (c) 1 : 8 (d) 1 : 4

**40.** According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photoelectrons from a metal versus the frequency, of the incident radiation gives a straight line whose slope (Assume photoelectrons are emitted.)
(a) depends on the nature of the metal used
(b) depends on the intensity of the radiation
(c) depends both on the intensity of the radiation and the metal used
(d) is the same for all metals and independent of the intensity of the radiation.

**Directions :** In the following questions (41-60), 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.

**41. Assertion :** At a fixed temperature, silicon will have a minimum conductivity when it has a smaller acceptor doping.
**Reason :** The conductivity of an intrinsic semiconductor is slightly higher than that of a lightly doped $p$-type semiconductor.

**42. Assertion :** Photoelectric effect demonstrates the wave nature of light.
**Reason :** The number of photoelectrons is proportional to the frequency of light.

**43. Assertion :** Parallax method is used for measuring distances of nearby stars only.
**Reason :** With increase of distance of star parallactic angle becomes too small to be measured accurately.

**44. Assertion :** The restoring couple in a moving coil galvanometer is because of current in the coil.
**Reason :** Current in the moving coil galvanometer produces a resultant force which is responsible for the restoring couple.

**45. Assertion :** Current through an inductor lags behind the applied alternating emf across it by $\pi/2$.
**Reason :** If frequency of ac is doubled, resistance offered by inductor becomes twice.

**46. Assertion :** Two balls of different masses are thrown vertically upward with same speed. They will pass through their point of projection in the downward direction with the same speed.
**Reason :** The maximum height and downward velocity attained at the point of projection are independent of the mass of the ball.

**47. Assertion :** For angular projection, when angle of projection $\theta = \tan^{-1}(1)$, the horizontal range is four times the maximum height.
**Reason :** The horizontal range of projectile is directly proportional to square of velocity and inversely proportional to acceleration due to gravity.

**48. Assertion :** A current flows in a conductor only when there is an electric field within the conductor.
**Reason :** The drift velocity of electron in presence of electric field decreases.

**49. Assertion :** If a pendulum is suspended in a lift and lift is falling freely, then its time period becomes infinite.
**Reason :** Free falling body has acceleration equal to acceleration due to gravity.

**50. Assertion :** If objective and eye lenses of a microscope are interchanged, then it can work as telescope.
**Reason :** The objective lens of telescope has small focal length.

**51. Assertion :** In Young's double slit experiment, interference pattern disappears when one of the slits is closed.
**Reason :** Interference occurs due to superposition of light waves from two coherent sources.

**52. Assertion :** Colours are seen in thin layers of oil on the surface of water.

**Reason :** White light is composed of several colours.

**53. Assertion :** When a stationary bomb exploded into two pieces, their speeds are in the inverse ratio of their masses.

**Reason :** Explosion does not violate law of conservation of linear momentum.

**54. Assertion :** Light can travel in vacuum whereas sound cannot do so.

**Reason :** Light is an electromagnetic wave whereas sound is mechanical wave.

**55. Assertion :** When a solid sphere is heated, increase in its surface area is maximum.

**Reason :** Surface area involves expansion in three dimensions.

**56. Assertion :** When two coils are wound on each other, the mutual induction between the coils is maximum.

**Reason :** Mutual induction does not depend on the orientation of the coils.

**57. Assertion :** Static crashes are heard on radio, when lightning flash occurs in the sky.

**Reason :** Electromagnetic waves having frequency of radio wave range interfere with radio waves.

**58. Assertion :** The angular velocity of a planet orbiting around the Sun increases when it is nearest to the Sun.

**Reason :** Angular momentum of a body is proportional to angular velocity.

**59. Assertion :** When radius of circular wire carrying current is doubled, its magnetic moment becomes four times.

**Reason :** Magnetic moment depends on area of the loop.

**60. Assertion :** When a spring is cut into two equal parts, the spring constant of each part of spring is doubled.

**Reason :** Spring constant is inversely proportional to length of spring.

## SOLUTIONS

**1. (d) :** Current carried by the holes, $I_h = \frac{1}{5}I$

where $I$ is the total current

Current carried by the electrons, $I_e = \frac{4}{5}I$

As $v_e = 2v_h$

where $v_e$ and $v_h$ are the drift speeds of electrons and holes respectively.

$\therefore\ I_e = n_eAe\,v_e\ ;\quad I_h = n_hAe\,v_h$

where $n_e$ and $n_h$ are the number densities of electrons and holes respectively.

$$\therefore\ \frac{I_e}{I_h} = \frac{n_eAev_e}{n_hAev_h} \quad \text{or} \quad \frac{n_e}{n_h} = \frac{I_e}{I_h} \times \frac{v_h}{v_e}$$

$$\frac{n_e}{n_h} = \frac{\frac{4}{5}I}{\left(\frac{1}{5}I\right)} \times \left(\frac{v_h}{2v_h}\right) = 2 \quad \Rightarrow \quad \frac{n_e}{n_h} = \frac{2}{1}$$

**2. (c) :** Let $\alpha$ be the angle which the instantaneous velocity of a projectile makes with the horizontal at time $t$ during its flight. Then

$$\tan\alpha = \frac{v_y}{v_x} = \frac{u\sin\theta - gt}{u\cos\theta} \qquad \text{...(i)}$$

When $\alpha = 45°$ and $t = 1$ s, then from eqn. (i),

$$u\cos\theta = u\sin\theta - g \times 1 \qquad \text{...(ii)}$$

When $\alpha = 0°$ and $t = 2$ s. Then,

$$u\sin\theta - g \times 2 = 0 \text{ or } u\sin\theta = 2g$$

From eqn. (ii), $u\cos\theta = 2g - g = g$

$$\therefore\ u^2(\cos^2\theta + \sin^2\theta) = g^2 + (2g)^2 = 5g^2$$

or $u = \sqrt{5}g = \sqrt{5} \times 10 = 10\sqrt{5}$ m s$^{-1}$

**3. (c) :** Loss of kinetic energy in a perfectly inelastic collision is

$$\Delta K = \frac{1}{2}\frac{m_1m_2}{(m_1 + m_2)}(u_1 - u_2)^2$$

Here, $m_1 = m_2 = M$

$$\therefore\ \Delta K = \frac{1}{2}\frac{M \times M}{(M + M)}(u_1 - u_2)^2 = \frac{M}{4}(u_1 - u_2)^2$$

**4. (c) :** $P = Fv = \left(m\frac{dv}{dt}\right)v$ = constant

$$\text{or } v\left(\frac{dv}{dx}\right)\left(\frac{dx}{dt}\right) = \frac{P}{m};\quad v^2\frac{dv}{dx} = \frac{P}{m}$$

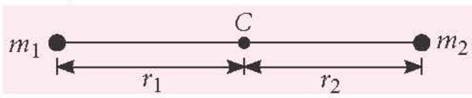
$$v^2dv = \frac{P}{m}dx$$

Integrating both sides, we get

$$\frac{v^3}{3} = \frac{P}{m}x\ ;\quad v = \left(\frac{3xP}{m}\right)^{1/3}$$

**5. (c)** **6. (c)**

**7. (a) :** Suppose $C$ is centre of mass of the dumb-bell. $r_1$ and $r_2$ are distances of $m_1$ and $m_2$ from $C$ as shown in figure therefore, moment of inertia of dumbbell about the given axis is



$$I = m_1r_1^2 + m_2r_2^2 \quad ...(i)$$

Also $\quad r = r_1 + r_2$

and $\quad m_1r_1 = m_2r_2 = m_2(r - r_1)$

$$(m_1 + m_2)r_1 = m_2r; \quad r_1 = \frac{m_2r}{m_1 + m_2}$$

Similarly, $r_2 = \dfrac{m_1r}{m_1 + m_2}$

From eqn. (i), $I = \dfrac{m_1m_2r^2}{m_1 + m_2}$

**8. (a) :** Number of atoms in 1 g of sample,

$$N = \frac{6.023 \times 10^{23}}{226}$$

$$\lambda = \frac{0.693}{T_{1/2}} = \frac{0.693}{1620 \text{ years}} = \frac{0.693}{1620 \times 3.1536 \times 10^7 \text{ s}}$$

$$R = \lambda N = \frac{0.693 \times 6.023 \times 10^{23}}{1620 \times 3.1536 \times 10^7 \text{ s} \times 226}$$

$= 3.61 \times 10^{10}$ dps.

**9. (b) :** Let $\theta$ be the angle between $\vec{P}$ and $\vec{Q}$ and $\beta$ be the angle between the resultant of $\vec{P}$ and $\vec{Q}$ and $\vec{P}$. Then $\beta = 90°$. $Q = 8$ and $R = 2P$

$$\tan\beta = \frac{Q\sin\theta}{P + Q\cos\theta} \quad \text{or} \quad \infty = \frac{8\sin\theta}{P + 8\cos\theta}$$

or $\quad P + 8\cos\theta = 0$ or $\cos\theta = -P/8$

As $\quad R^2 = P^2 + Q^2 + 2PQ\cos\theta$

$\therefore \quad 4P^2 = P^2 + 8^2 + 2P \times 8 \times (-P/8)$

or $\quad 5P^2 = 64$ or $P = \dfrac{8}{\sqrt{5}}$

**10. (c) :** Here, velocity of sound, $v = 330$ m s$^{-1}$

Phase difference $= \dfrac{2\pi}{\lambda} \times$ Path difference

$$1.6\pi = \frac{2\pi}{\lambda} \times 40; \ \lambda = 50 \text{ cm} = 0.5 \text{ m}$$

$$\upsilon = \frac{v}{\lambda} = \frac{330}{0.5} = 660 \text{ Hz}$$

**11. (d)**

**12. (b) :** Here, ${}^a\mu_g = 1.5 = \dfrac{3}{2}$, ${}^a\mu_w = 1.33 = \dfrac{4}{3}$

$A = 60°$

As $\ {}^a\mu_w \times {}^w\mu_g = {}^a\mu_g$

or $\ {}^w\mu_g = \dfrac{{}^a\mu_g}{{}^a\mu_w} = \dfrac{(3/2)}{(4/3)} = \dfrac{9}{8}$

$${}^w\mu_g = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}; \quad \frac{9}{8} = \frac{\sin\left(\frac{60° + \delta_m}{2}\right)}{\sin\left(\frac{60°}{2}\right)}$$

or $\sin\left(\dfrac{60° + \delta_m}{2}\right) = \dfrac{9}{8} \times \sin 30° = \dfrac{9}{8} \times \dfrac{1}{2} = \dfrac{9}{16} = 0.56$

or $\dfrac{60° + \delta_m}{2} = \sin^{-1}(0.56) = 34°$

or $\delta_m = 68° - 60° = 8°$

**13. (a)**

**14. (a) :** Given : Retardation $\propto$ displacement

or $\quad \dfrac{dv}{dt} = -kx$

or $\quad \left(\dfrac{dv}{dx}\right)\left(\dfrac{dx}{dt}\right) = -kx$ or $dv(v) = -kx\,dx$

or $\quad \int_{v_1}^{v_2} v\,dv = -k\int_0^x x\,dx$ or $\dfrac{v_2^2}{2} - \dfrac{v_1^2}{2} = -\dfrac{kx^2}{2}$

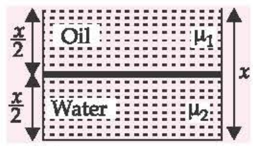
or $\quad \dfrac{mv_2^2}{2} - \dfrac{mv_1^2}{2} = -\dfrac{mkx^2}{2}$

or $\quad (K_2 - K_1) = -\dfrac{mk}{2}x^2$

*i.e.*, Loss of kinetic energy is proportional to $x^2$.

**15. (b)** **16. (a)**

**17. (a) :** As refractive index,




$$\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$$

$\therefore$ Apparent depth of the vessel when viewed from above is

$$d_{apparent} = \frac{x}{2\mu_1} + \frac{x}{2\mu_2} = \frac{x}{2}\left(\frac{1}{\mu_1} + \frac{1}{\mu_2}\right) = \frac{x(\mu_1 + \mu_2)}{2\mu_1\mu_2}$$

**18. (c) :** Mass of the sphere, $M = \dfrac{4}{3}\pi R^3\rho$

Mass of cavity $M' = \dfrac{4}{3}\pi\left(\dfrac{R}{2}\right)^3\rho = \dfrac{M}{8}$

Gravitational force on the particle at $A$ due to sphere of mass $M$ radius $R$ is

$$F_1 = \frac{GMm}{x^2}$$

Gravitational force on the particle at $A$ due to cavity is

$$F_2 = \frac{G(M/8)m}{(x - R/2)^2} = \frac{GMm}{8(x - R/2)^2}$$

Force on the particle at $A$ due to sphere with cavity is

$$F = F_1 - F_2 = \frac{GMm}{x^2} - \frac{GMm}{8(x-R/2)^2} = GMm\left[\frac{1}{x^2} - \frac{1}{2(2x-R)^2}\right]$$

**19. (c) :** Angular momentum of the system is conserved

$$\therefore \quad \frac{1}{2}MR^2\omega_1 = 2mR^2\omega + \frac{1}{2}MR^2\omega$$

or $\quad M\omega_1 = (4m + M)\omega$

or $\quad \omega = \left(\frac{M}{M+4m}\right)\omega_1$

**20. (c)**

**21. (b) :** Mutual inductance of the pair of coils depends on relative position and orientation of the two coils.

**22. (b) :** $x = \alpha t^3 \qquad \therefore \frac{dx}{dt} = v_x = 3\alpha t^2$

Again $y = \beta t^3 \quad \therefore \frac{dy}{dt} = v_y = 3\beta t^2 \quad \because v^2 = v_x^2 + v_y^2$

$\therefore \quad v^2 = (3\alpha t^2)^2 + (3\beta t^2)^2 = (3t^2)^2(\alpha^2 + \beta^2)$

or $\quad v = 3t^2\sqrt{\alpha^2 + \beta^2}$

**23. (b)**

**24. (c) :** Position of fifth bright fringe, $x_5 = \frac{5D\lambda}{d}$

Position of third dark fringe,

$$x_3 = (2\times3-1)\frac{D\lambda}{2d} = \frac{5D\lambda}{2d}$$

Required distance,

$$x_5 - x_3 = \left(5 - \frac{5}{2}\right)\frac{D\lambda}{d} = \frac{5}{2}\frac{D\lambda}{d}$$

$$= \frac{5\times1\times6.5\times10^{-7}}{2\times1\times10^{-3}} \approx 1.63 \text{ mm.}$$

**25. (b) :** Volume at 27°C (= 300 K) = $4 \times 10^{-3}$ m$^3$. Let it be heated to temperature $x$ K.

$$\text{Volume at } x \text{ K} = \frac{14}{7\times10^{-4}} \text{ cm}^3 = 2\times10^4 \text{ cm}^3 = 2\times10^{-2} \text{ m}^3$$

Since pressure is constant, so $\frac{V}{T}$ = constant

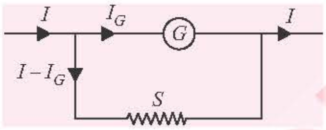
$$\therefore \quad \frac{4\times10^{-3}}{300} = \frac{2\times10^{-2}}{x}$$

or $\quad x = \frac{(2\times10^{-2})\times300}{(4\times10^{-3})} = 1500$ K or 1227 °C

**26. (b) :** Here, $I_G = 10^{-3}$ A, $I = 2$ A

Galvanometer resistance $G = 25\ \Omega$

Shunt resistance $S$ = ?



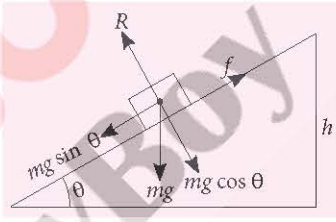

From figure, $I_G G = (I - I_G)S$ or $S = \frac{GI_G}{I - I_G}$

Substituting the values, we get

$$S = \frac{(25\ \Omega)\times(10^{-3}\text{ A})}{2\text{ A} - 10^{-3}\text{ A}} = \frac{25\times10^{-3}}{1.999}$$

$$= 12.5\times10^{-3}\ \Omega = 0.0125\ \Omega.$$

**27. (c) :** As is known, on sliding down a rough inclined plane, work done against friction,




$$W = \mu R \times s = \mu mg\cos\theta \times \left(\frac{h}{\sin\theta}\right)$$

$W = \mu mgh\cot\theta$ ...(i)

$\because \cot\theta_1 = \cot 30° = \sqrt{3}$ and $\cot\theta_2 = \cot 60° = \frac{1}{\sqrt{3}}$

From eqn. (i), $W_1 > W_2$

Now $\quad K = mgh - W \qquad \therefore K_1 < K_2$

**28. (d)**

**29. (d) :** As $T_1 = 2\pi\sqrt{\frac{M}{k}}$ ...(i)

When a mass $m$ is placed on mass $M$, the new system is of mass $(M + m)$ attached to the spring. New time period of oscillations

$$T_2 = 2\pi\sqrt{\frac{(m+M)}{k}} \quad \text{...(ii)}$$

Consider $v_1$ is the velocity of mass $M$ passing through mean position and $v_2$ velocity of mass $(m + M)$ passing through mean position.

Using, law of conservation of linear momentum

$Mv_1 = (m + M)v_2$

$M(A_1\omega_1) = (m + M)(A_2\omega_2)$

($\because v_1 = A_1\omega_1$ and $v_2 = A_2\omega_2$)

$$\therefore \quad \frac{A_1}{A_2} = \frac{(m+M)}{M}\frac{\omega_2}{\omega_1}$$

$$= \left(\frac{m+M}{M}\right) \times \frac{T_1}{T_2} \qquad \left(\because\ \omega_1 = \frac{2\pi}{T_1} \text{ and } \omega_2 = \frac{2\pi}{T_2}\right)$$

$$\frac{A_1}{A_2} = \sqrt{\frac{m+M}{M}} \qquad \text{(Using eqn. (i) and (ii))}$$

**30. (d)**

**31. (a) :** The height $h$ to which the liquid rises in a capillary tube is given by $h = \frac{2S\cos\theta}{r\rho g}$

Since $S$, $\cos\theta$, $\rho$ and $g$ are constants,

$\therefore \quad hr = \text{constant}$

**32. (b) :** Focal of the plano-convex lens is given by

$$\frac{1}{f_L} = (\mu - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right) = \frac{\mu - 1}{R}$$

When the plane surface of the plano-convex lens is silvered, the system acts as a combination a plane mirror and a plano-convex lens. Its effective focal length $F_L$ is given by

$$\frac{1}{F_L} = \frac{1}{f_L} + \frac{1}{f_m} + \frac{1}{f_L} = \frac{2}{f_L} + \frac{1}{\infty} = \frac{2(\mu-1)}{R} + 0$$

or $\quad F_L = \frac{R}{2(\mu - 1)} \qquad [\because f_m = \infty]$

Radius of curvature $= 2F_L = \frac{R}{(\mu - 1)}$

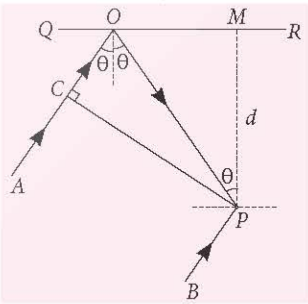
**33. (d):** $F_1 = \frac{m4\pi^2 a}{T_1^2}$; $F_2 = \frac{m4\pi^2 a}{T_2^2}$

$$F = F_1 + F_2 = \frac{4\pi^2 ma}{T_1^2} + \frac{4\pi^2 ma}{T_2^2} = 4\pi^2 ma\left(\frac{1}{T_1^2} + \frac{1}{T_2^2}\right)$$

or $\quad \frac{4\pi^2 ma}{T^2} = 4\pi^2 ma\left[\frac{1}{T_1^2} + \frac{1}{T_2^2}\right]$

or $\quad \frac{1}{T^2} = \frac{1}{T_1^2} + \frac{1}{T_2^2}$ or $T^2 = \frac{T_1^2 T_2^2}{T_1^2 + T_2^2}$

**34. (b):** In $\Delta OPM$, $\frac{PM}{OP} = \cos\theta$ or $OP = \frac{d}{\cos\theta}$




In $\Delta COP$, $\quad \cos 2\theta = \frac{OC}{OP} = \frac{OC}{d/\cos\theta}$

or $\quad OC = \frac{d\cos 2\theta}{\cos\theta}$

The ray after reflection from mirror $QR$ suffers extra path difference of $\frac{\lambda}{2}$. Therefore, the net path difference between two rays reaching point $P$ is,

$$= CO + OP + \frac{\lambda}{2} = \frac{d\cos 2\theta}{\cos\theta} + \frac{d}{\cos\theta} + \frac{\lambda}{2}$$

$$= \frac{d}{\cos\theta}(\cos 2\theta + 1) + \frac{\lambda}{2}$$

$$= \frac{d}{\cos\theta} \times 2\cos^2\theta + \frac{\lambda}{2} = 2d\cos\theta + \frac{\lambda}{2}$$

For constructive interference

$2d\cos\theta + \frac{\lambda}{2} = n\lambda$ or $2d\cos\theta = (2n-1)\frac{\lambda}{2}$

or $\cos\theta = (2n-1)\frac{\lambda}{4d}$

For $n = 1$, $\cos\theta = \frac{\lambda}{4d}$

**35. (a)** **36. (c)**

**37. (d) :** In paramagnetic substances, intrinsic magnetic moment is not zero. Further, in the absence of external magnetic field, spin exchange interaction is present.

**38. (b) :** In steady state, there will be no current through the capacitor branch of network. Total resistance of the circuit is

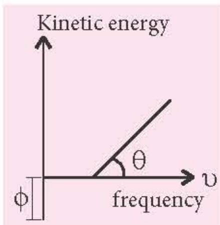
$$R = \frac{2 \times 4}{2+4} + \frac{2}{3} = 2\ \Omega$$

Current in the circuit, $I = \frac{6}{2} = 3\text{ A}$

Current through $2\ \Omega$ resistor $= 3 \times \frac{4}{(2+4)} = 2\text{ A}$

**39. (c)**

**40. (d):**



According to Einstein's equation,

Kinetic energy = $h\upsilon - \phi$

where kinetic energy and $\upsilon$ (frequency) are variables, compare it with equation, $y = mx + c$.

$\therefore$ slope of line = $h$

$h$ is Planck's constant.

Hence the slope is same for all metals and independent of the intensity of radiation.

**41. (c)**

**42. (d)** The number of photoelectrons depends on the intensity and not on frequency of light.

**43. (a) :** As distance of star from the earth increases, parallactic angle decreases and it may become too small to be measured accurately, when star is far off.

**44. (d) :** The restoring couple in moving coil galvanometer is due to twist produced in the suspension wire when the coil is rotated on passing the current in it. On passing the current in the coil of moving coil galvanometer, resultant force on coil is zero but a torque acts on it which rotates the coil.

**45. (b)**

**46. (a) :** $h = ut - \frac{1}{2}gt^2$ and $v^2 = u^2 - 2gh$.

The above equations are independent of mass.

**47. (b)**

**48. (c) :** Before the presence of electric field, the free electrons move randomly in the conductor, so their drift velocity is zero and therefore there is no current in the conductor. In the presence of electric field, each electron in the conductor experiences a force in a direction opposite to the electric field. Now the free electrons are accelerated from negative end to the positive end of the conductor and hence a current starts to flow from the conductor.

**49. (b) :** If a pendulum is suspended in a lift and lift is moving downward with some acceleration $a$, then time period of pendulum is given by, $T = 2\pi\sqrt{\frac{l}{g-a}}$

In the case of free fall, $a = g$ then $T = \infty$

*i.e.*, the time period of pendulum becomes infinite.

**50. (d) :** A microscope cannot work as a telescope by interchanging its two lenses. These two lenses have short focal lengths and so the difference $(f_e - f_o)$ is small. In a telescope, the objective lens has much larger focal length than the eyepiece.

**51. (a) :** When one of the slits is closed, there appears general illumination from a single source. Interference does not take place.

**52. (b) :** Colours are seen in thin layer of oil on the surface of water, because of interference of light. When white light falls on a thin film of a liquid it will appear bright having colour whose wavelength satisfies the relation $2\mu t \cos r = (2n + 1)\lambda/2$. The colour of the film will depend upon the thickness of the film and the angle of refraction.

**53. (a) :**

**54. (a) :** Light being electromagnetic wave do not require any material medium for its propagation. Hence light can travel in vacuum. On the other hand sound is a mechanical wave and requires a material medium for its propagation. Hence sound cannot travel in vacuum.

**55. (d) :** On heating, increase in volume is maximum as it involves three dimensional expansion.

**56. (c) :** The manner in which the two coils are oriented, determines the coefficient of coupling between them *i.e.*, $K = \sqrt{\frac{M}{L_1 L_2}}$,

where $L_1$ and $L_2$ are self inductance of two coils. When the two coils are wound on each other, the coefficient of coupling is maximum and hence mutual inductance between the coil is maximum.

**57. (a)**

**58. (b) :** According to law of conservation of angular momentum, $L = I\omega$ = constant.

If a planet while orbiting comes close to sun moment of inertia of planet $I$ decreases. To conserve angular momentum $L$, $\omega$ increases.

**59. (a) :** Magnetic dipole moment of the current loop

= Ampere turns × Area of the coil

So $M = NI\pi r^2$

$M_1 = NI\pi(2r)^2 = 4NI\pi r^2 = 4M$

So magnetic moment becomes four times when radius is doubled.

**60. (a) :** For a given force, as spring constant $k = F/x$ or $k \propto 1/x$.

When $x' = x/2$, $k' = F/x/2 = 2\,F/x = 2k$.

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MtG

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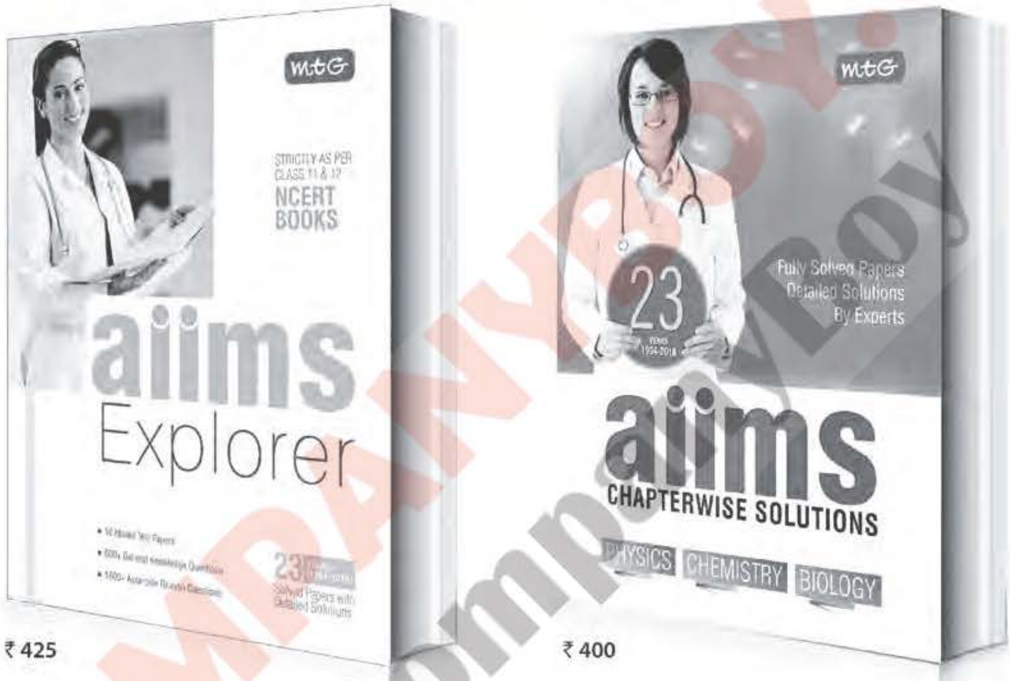


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# FULL LENGTH PRACTICE PAPER

# BITSAT

Exam date : 16th to 30th May 2017

## SECTION-I (PHYSICS)

1. The diffusivity is given by $K/S\rho$, where $K$ is coefficient of thermal conductivity, $S$ is specific heat and $\rho$ is density. Then dimensional formula of diffusivity is
(a) $[L^2T^{-1}]$ (b) $[LT^{-1}]$ (c) $[L^2T^2]$ (d) $[LT^{-3}]$

2. Sound from two identical sources $S_1$ and $S_2$ reach a point $P$. When the sounds reach directly, and in the same phase, the intensity at $P$ is $I_0$. The power of $S_1$ is now reduced by 60%, and the phase difference between $S_1$ and $S_2$ is varied continuously. The maximum and minimum intensities recorded at $P$ are now $I_{max}$ and $I_{min}$. Then,
(a) $I_{max} = 0.64I_0$ (b) $I_{min} = 0.36I_0$
(c) $I_{max}/I_{min} = 16$ (d) $I_{max}/I_{min} = 1.64/0.36$

3. A deutron of atomic mass 2.0147 amu and negligible kinetic energy is absorbed by a $Li^6$ nucleus of mass 6.0169 amu, the intermediate nucleus disintegrates spontaneously into two $\alpha$-particles, each of mass 4.0039 amu. The energy transferred to each $\alpha$-particle is
(a) 12.08 MeV (b) 11.08 MeV
(c) 6.04 MeV (d) 5.54 MeV

4. A block of mass 0.50 kg is moving with a speed of 2.00 m $s^{-1}$ on a smooth surface. It strikes another mass of 1.00 kg and then move together as a single body. The energy loss during the collision is
(a) 0.16 J (b) 1.00 J (c) 0.67 J (d) 0.34 J

5. A plate of thickness $t$ made of a material of refractive index $\mu$ is placed in front of one of the slits in a double slit experiment. What should be the minimum thickness $t$ which will make the intensity at the centre of the fringe pattern zero ?
(a) $(\mu-1)\frac{\lambda}{2}$ (b) $(\mu-1)\lambda$
(c) $\frac{\lambda}{2(\mu-1)}$ (d) $\frac{\lambda}{(\mu-1)}$

6. A parachutist after bailing out falls 50 m without friction. When parachute opens, it decelerates at 2 m $s^{-2}$. He reaches the ground with a speed of 3 m $s^{-1}$. At what height, did he bail out?
(a) 293 m (b) 111 m (c) 91 m (d) 182 m

7. The kinetic energy given to a body is $K$ so that it moves from the surface of earth to infinity. If only 20% of this kinetic energy is given to the same body on the surface of earth, it rises to a height $nR$, where $R$ is the radius of the earth. Then $n$ is equal to
(a) 1 (b) 3/4 (c) 1/2 (d) 1/4

8. A particle moves on a straight line as such its product of acceleration and velocity is constant. The distance moved by particle in time $t$ is proportional to
(a) $t$ (b) $\sqrt{t}$ (c) $t^{3/2}$ (d) $t^2$

9. A Carnot engine whose sink is at 300 K has an efficiency of 40%. By how much should the temperature of source be increased so as to increase its efficiency by 50% of original efficiency ?
(a) 380 K (b) 275 K (c) 325 K (d) 250 K

10. If two balls are projected at an angle of 60° and 45° and the total heights reached are same, then their initial velocities are in the ratio of
(a) $\sqrt{3}:\sqrt{2}$ (b) $\sqrt{2}:\sqrt{3}$
(c) 3 : 2 (d) 2 : 3

11. The half life of radioactive radon is 3.8 day. The time at the end of which $(1/20)^{th}$ of the radon sample will remain undecayed is (given $\log_{10}e = 0.4343$)
(a) 3.8 days (b) 16.5 days
(c) 33 days (d) 76 days.

12. The plate separation in a parallel plate condenser is $d$ and plate area is $A$. If it is charged to $V$ volt and battery is disconnected then the work done in increasing the plate separation to $2d$ will be
(a) $\frac{3}{2}\frac{\varepsilon_0 AV^2}{d}$ (b) $\frac{\varepsilon_0 AV^2}{d}$
(c) $\frac{2\varepsilon_0 AV^2}{d}$ (d) $\frac{\varepsilon_0 AV^2}{2d}$