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NATIONAL STANDARD EXAMINATION IN PHYSICS (NSEP) 2017-18

Examination Date : 26-11-2017 Time: 2 Hrs. Max. Marks : 240

Q. PAPER CODE : P160 HBCSE Olympiad (STAGE - 1)

Write the question paper code mentioned above on YOUR answer sheet (in the space provided), otherwise your answer sheet will NOT be assessed. Note that the same Q. P. Code appears on each page of the question paper.

INSTRUCTIONS TO CANDIDATES

1. Use of mobile phones, smartphones, ipads during examination is **STRICTLY PROHIBITED.**
2. In addition to this question paper, you are given answer sheet along with Candidate's copy.
3. On the answer sheet, make all the entries carefully in the space provided ONLY in **BLOCK** CAPITALS as well as by properly darkening the appropriate bubbles.

   Incomplete/Incorrect/carelessly filled information may disqualify your candidature.
4. On the answer sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Question paper has two parts. In Part A1(Q. Nos 1 to 60) each question has four alternatives, Out of which only one is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

   Q. No.22 (a) ● (c) (d)

   In Part A2 *(Q.* Nos. 61 to 70) each question has four alternatives out of which **any number of alternatives** (1, 2, 3 or 4) may be correct. You have to choose ALL correct alternatives and fill the appropriate bubbles, as shown.

   Q. No.64 (a) ● (c) ●
6. For Part A1, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In Part A2, you get 6 marks if all the correct alternatives are marked. No negative marks in this part.
7. Any rough work should be done only in the space provided.
8. Use of **non-programmable** calculator is allowed.
9. No candidate should leave the examination hall before the completion of the examination.
10. After submitting your answer paper, take away the Candidate's copy for your reference.

    Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the answer sheet.

    Answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED.

    Scratching or overwriting may result in a wrong score.

    DO NOT WRITE ON THE BACK SIDE OF THE ANSWER SHEET.

Read the following instructions after submitting the answer sheet

11. Comments regarding this question paper, if any, may be filled in Google forms only at https://google/forms/9GP03NRgUVuhWJn52 till 28th November, 2017.
12. The answers/solutions to this question paper will be available on our website — www.iapt.org.in by 2nd December, 2017.
13. **CERTIFICATES and AWARDS –**
    Following certificates are awarded by the LAPT to students successful in NSEs
    (i) Certificates to "Centre Top 10%" students
    (ii) Merit Certificates to "Statewise Top 1%" students
    (iii) Merit Certificates and a book prize to "National Top 1%" students
14. Result sheets can be downloaded from our website in the month of February. The "Centre Top 10%" certificates will be dispatched to the Prof-in-charge of the centre by February, 2017**.**
15. List of students (with centre number and roll number only) having score above MAS will be displayed on our website (www.iapt.org.in) by 22nd December, 2017. See the Eligibility Clause in the Student's brochure on our website.
16. Students eligible for the INO Examination on the basis of selection criteria mentioned in Student's brochure will be informed accordingly.

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Total Time : 120 minutes (A–1 and A–2)

A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT

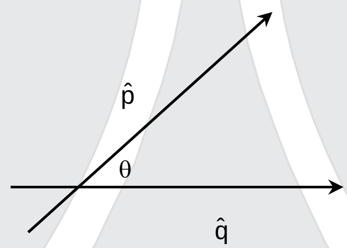
1. Consider two point masses m_1 and m_2 connected by alight rigid rod of length r_0. The moment of inertia of the system about an axis passing through their centre of mass and perpendicular to the rigid rod is given by

(A) $\frac{m_1m_2}{2(m_1+m_2)}r_0^2$ (B) $\frac{m_1m_2}{m_1+m_2}r_0^2$ (C) $\frac{2m_1m_2}{m_1+m_2}r_0^2$ (D) $\frac{m_1^2+m_2^2}{m_1+m_2}r_0^2$

Ans. **(B)**

Sol. ur_0^2

2. Motion of a particle in a plane is described by the non-orthogonal set of coordinates (p, q) with unit vectors $(\hat{p},\hat{q})$ inclined at an angle θ as shown in the diagram. If the mass of the particle is m, its kinetic energy is given by $\left(\dot{x}=\frac{dx}{dt}\right)$

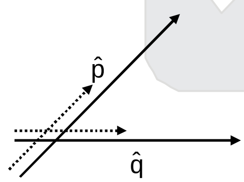


(A) $\frac{1}{2}m(\dot{p}^2+\dot{q}^2+\dot{p}\dot{q}\cos\theta)$ (B) $\frac{1}{2}m(\dot{p}^2+\dot{q}^2-\dot{p}\dot{q}(1-\sin\theta))$

(C) $\frac{1}{2}m(\dot{p}^2+\dot{q}^2+2\dot{p}\dot{q}\cos\theta)$ (D) $\frac{1}{2}m(\dot{p}^2+\dot{q}^2+\dot{p}\dot{q}\cot\theta)$

Ans. **(C)**

Sol.



$\vec{r}=(P\hat{P}+q\hat{q})$

$\vec{v}=\frac{d\vec{r}}{dt}=\frac{dp}{dt}\hat{p}+\frac{dq}{dt}\hat{q}$

$\vec{v}\cdot\vec{v}=\left(\frac{dp}{dt}\right)^2+\left(\frac{dq}{dt}\right)^2+2pq\cos\theta$

K.E. = $\frac{1}{2}m\left(p^2+q^2+2pq\cos\theta\right)$

3. A man is going up in a lift (open at the top) moving with a constant velocity 3 m/s. He throws a ball up at 5 m/sec relative to the lift when the lift is 50 m above the ground. Height of the lift when the ball meets it during its downward journey is (g = 10 m/s^2)

(A) 53 m (B) 58 m (C) 53 m (D) 68 m

Ans. **(A)**

Sol. $T = \frac{2(5)}{10} = 1\text{sec}$

h = 50 + 3(1) = 53m

4. When a body is suspended from a fixed point by a spring, the angular frequency of its vertical oscillations is ω_1. When a different spring is used, the angular frequency is ω_2. The angular frequency of vertical oscillations when both the springs are used together in series is given by

(A) $\omega = \left[\omega_1^2 + \omega_2^2\right]^{\frac{1}{2}}$ (B) $\omega = \left[\frac{\omega_1^2 + \omega_2^2}{2}\right]^{\frac{1}{2}}$ (C) $\omega = \left[\frac{\omega_1^2\omega_2^2}{\left(\omega_1^2 + \omega_2^2\right)}\right]^{\frac{1}{2}}$ (D) $\omega = \left[\frac{\omega_1^2\omega_2^2}{2\left(\omega_1^2 + \omega_2^2\right)}\right]^{\frac{1}{2}}$

Ans. **(C)**

Sol. $\omega_1 = \sqrt{\frac{k_1}{m}}$ $\omega_2 = \sqrt{\frac{k_2}{m}}$

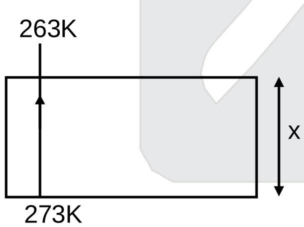
$$\omega = \sqrt{\frac{k_1k_2}{(k_1+k_2)m}} = \sqrt{\frac{1}{m\left(\frac{1}{k_2}+\frac{1}{k_1}\right)}} = \sqrt{\frac{1}{\frac{1}{\omega_2^2}+\frac{1}{\omega_1^2}}} = \frac{\omega_1\omega_2}{\sqrt{\omega_1^2+\omega_2^2}}$$

5. A small pond of depth 0.5 m deep is exposed to a cold winter with outside temperature of 263 K. Thermal conductivity of ice is K = 2.2 W m^{-1} K^{-1} , latent heat L = 3.4 × 10^5 Jkg^{-1} and density ρ = 0.9 × 10^3 kgm^{-3}. Take the temperature of the pond to be 273 K. The time taken for the whole pond to freeze is about.

(A) 20 days (B) 25 days (C) 30 days (D) 35 days

Ans. **(A)**

Sol.



$$\frac{KA(10)}{x} = L\frac{d}{dt}(\rho Ax)$$

$$\frac{2.2\times(10)}{x} = 3.4\times10^5\times0.9\times10^3\frac{dx}{dt}$$

$$\frac{22}{3.4\times0.9\times10^8}\int_0^t dt = \int_0^{0.5} x\,dx$$

$$\frac{22}{306\times10^6}t = \frac{1}{2}(0.5)^2$$

$$t = \frac{(0.5)^2\times306\times10^6}{44}\text{sec} = \frac{306}{44\times4}\times10^6\text{ sec}$$

$$= \frac{306000\times10^3}{44\times4\times24\times3600} \approx 20\text{ days}$$

6. A body of mass 4 kg moves under the action of a force $\vec{F} = \left(4\hat{i} + 12t^2\hat{j}\right)N$, where t is the time in second. The initial velocity of the particle is $\left(2\hat{i} + \hat{j} + 2\hat{k}\right)ms^{-1}$. If the force is applied for 1 s, work done is :

(A) 4 J (B) 8 J (C) 12 J (D) 16 J

Ans. **(D)**

Sol. $\int \vec{F}dt = \Delta\vec{p}$

$$\int_0^1 (4\hat{i} + 12\hat{t})dt = m(\vec{v}_f - \vec{v}_i)$$

$$\Rightarrow \quad 4\hat{i} + \frac{12}{3}t^3\Big|_0^1\hat{j} = 4(\vec{v}_f - \vec{v}_i)$$

$$\Rightarrow \quad \hat{i} + \hat{j} = \vec{v}_f - (2\hat{i} + \hat{j} + 2\hat{k})$$

$$\Rightarrow \quad \vec{v}_f = 3\hat{i} + 2\hat{j} + 2\hat{k}$$

$$\Rightarrow \quad |\vec{v}_f| = \sqrt{9+4+4} = \sqrt{17}$$

$$|\vec{v}_i| = \sqrt{4+1+4} = 3$$

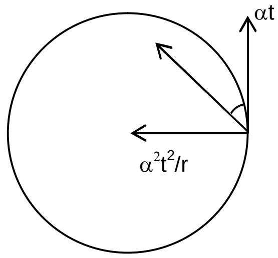
$$\Delta K.E = \frac{1}{2}4(17-9) = 2 \times 8 = 16 \text{ J}$$

7. A racing car moves along circular track of radius b. The car starts from rest and its speed increases at a constant rate α. Let the angle between the velocity and the acceleration be θ at time t. Then ($\cos\theta$) is :

(A) 0 (B) $\alpha t^2/b$ (C) $\frac{b}{\left(b+\alpha t^2\right)}$ (D) $\frac{b}{\left(b^2+\alpha^2t^4\right)^{\frac{1}{2}}}$

Ans. **(D)**

Sol.



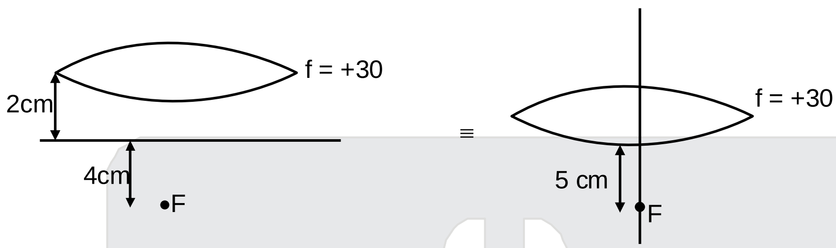
$$\cos\theta = \frac{\alpha}{\sqrt{\alpha^2 + \frac{2\alpha^4t^4}{b^2}}} = \frac{b}{\sqrt{b^2+\alpha^2t^4}}$$

8. A small fish, 4cm below the surface of a lake, is viewed through a thin converging lens of focal length 30 cm held 2 cm above the water surface. Refractive index of water is 1.33. The image of the fish from the lens is at a distance of

(A) 10 cm (B) 8 cm (C) 6 cm (D) 4 cm

Ans. **(C)**

Sol.



water $m = \frac{4}{3}$

$$\frac{1}{v} - \frac{1}{-5} = \frac{1}{30} \Rightarrow \frac{1}{v} = \frac{1}{30} - \frac{6}{30}$$

$$\frac{1}{v} = -\frac{5}{30}$$

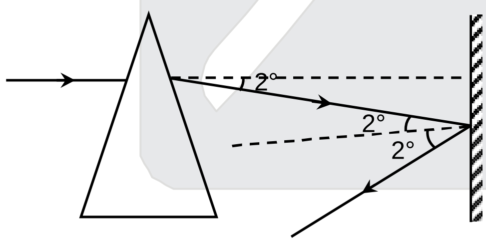
$v = -6\text{cm}$

9. A horizontal ray of light passes through a prism of refractive index 1.5 and apex angle 4° and then strikes a vertical plane mirror placed to the right of the prism. If after reflection, the ray is to be horizontal, then the mirror must be rotated through an angle

(A) 1° clockwise (B) 1° anticlockwise (C) 2° clockwise (D) 2° anticlockwise

Ans. **(A)**

Sol.



$\delta = (1.5 - 1)\ 4° = 2°$

Mirror must be rotated by 1° in clockwise direction (A)

10. An isolated metallic object is charged in vacuum to a potential V_0 using a suitable source, its electrostatic energy being W_0. It is then disconnected from the source and immersed in a large volume of dielectric with dielectric constant K. The electrostatic energy of the sphere in the dielectric is :

(A) $K^2 W_0$ (B) $K\ W_0$ (C) $\frac{W_0}{K^2}$ (D) $\frac{W_0}{K}$

Ans. **(D)**

Sol. $U = \frac{Q^2}{2C}$ since C will become k times

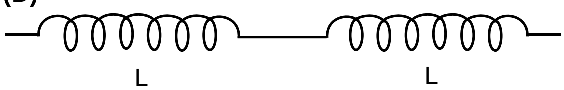
So U will become $\frac{1}{k}$ times

11. Two identical coils each of self-inductance L, are connected in series and are placed so close to each other that all the flux from one coil links with the other. The total self-inductance of the system is :

(A) L (B) 2L (C) 3L (D) 4L

Ans. **(D)**

Sol.



$M = k\sqrt{L_1L_2} = L$

$\phi = LI + LI + 2mI = 4\,LI = L_{eq}I$

$L_{eq} = 4L$

12. A coil 2.0 cm in diameter has 300 turns. If the coil carries a current of 10 mA and lies in a magnetic field 5×10^{-2} T, the maximum torque experienced by the coil is :

(A) 4.7×10^{-2} N–m (B) 4.7×10^{-4} N–m (C) 4.7×10^{-5} N–m (D) 4.7×10^{-8} N–m

Ans. **(C)**

Sol. $\tau_{max} = NiAB$

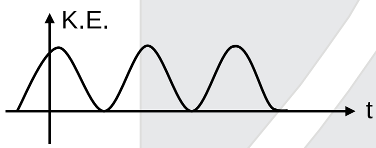
$\tau_{max} = 300 \,.\, 10 \times 10^{-3} \times \dfrac{\pi 4 \times 10^{-4}}{4} \times 5 \times 10^{-2} = 4.7 \times 10^{-5}$

13. A particle performs simple harmonic motion at a frequency f. The frequency at which its kinetic energy varies is :

(A) f (B) 2f (C) 4f (D) $\dfrac{f}{2}$

Ans. **(B)**

Sol. K.E. $= \dfrac{1}{2}m\omega^2 A^2 \sin^2(\omega t + \varphi)$



14. In cases of real images formed by a thin convex lens, the linear magnification is (I) directly proportional to the image distance, (II) inversely proportional to the object distance, (III) directly proportional to the distance of image from the nearest principal focus, (IV) inversely proportional to the distance of the object from the nearest principal focus. From these the correct statements are :

(A) (I) and (II) only. (B) (III) and (IV) only

(C) (I), (II),(III) and (IV) all. (D) None of (I), (II), (III) and (IV).

Ans. **(B)**

Sol. $m = \dfrac{v}{u} \Rightarrow \dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f} \Rightarrow 1 - \dfrac{v}{u} = \dfrac{v}{f} \Rightarrow 1 - m = \dfrac{v}{f}$

$m = 1 - \dfrac{v}{f} = \dfrac{f - v}{f}$

and $\dfrac{u}{v} - 1 = \dfrac{u}{f} \Rightarrow \dfrac{u}{v} = \dfrac{1 + u}{f} = \dfrac{f + u}{f}$

$m = \dfrac{v}{u} = \dfrac{f}{f + u}$

$u = -(f + x) \quad \Rightarrow \quad m = \dfrac{f}{f - f - x} = -\dfrac{f}{x}$

$v = f + y \Rightarrow m = \dfrac{f - f - y}{f} = -\dfrac{y}{f}$

$m \propto \dfrac{1}{x}$, $m \propto \dfrac{1}{y}$

15. An infinitely long straight non-magnetic conducting wire of radius a carries a dc current I. The magnetic field B, at a distance r (r < a) from axis of the wire is :

(A) $\frac{\mu_0 I}{2\pi a}$ (B) $\frac{\mu_0 Ir}{2\pi a^2}$ (C) $\frac{2\mu_0 Ir}{\pi a^2}$ (D) $\frac{\mu_0 Ir^2}{2\pi a^3}$

Ans. **(B)**

Sol. $B = \frac{\mu_0 Ir}{2} = \frac{\mu_0 Ir}{2\pi a^2}$

16. A quantity α is defined as $\alpha = \frac{e^2}{4\pi\varepsilon_0 c\hbar}$, where e is electric charge, $\hbar = \frac{h}{2\pi}$ is the reduced Planck's constant and c is the speed of light. The dimensions of α are

(A) $[M^0 L^0 T^0 I^0]$ (B) $[M^1 L^{-1} T^2 I^{-2}]$ (C) $[M^2 L^1 T^{-1} I^0]$ (D) $[M^0 L^3 T^{-1} I^{-2}]$

Ans. **(A)**

Sol. $[\alpha] = \left[\frac{e^2}{\varepsilon_0}\right]\left[\frac{1}{hc}\right]$

$= [Fr^2] \frac{1}{[E\lambda]}$

$= [M^1L^1T^{-2}L^2]\frac{1}{[M^1L^2T^{-2}L^1]} = [M^1L^3T^{-2} \quad M^{-1}L^{-3}T^2] = [M^0 L^0 T^0]$

17. The earth's magnetic field at a certain point is 7.0×10^{-5} T. This field is to be balanced by a magnetic field at the centre of a circular current carrying coil of radius 5.0 cm by suitably orienting it. If the coil has 100 turns then the required current is about

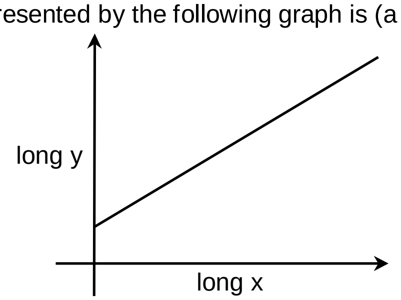
(A) 28 mA (B) 56 mA (C) 100 mA (D) 560 mA

Ans. **(B)**

Sol. $\frac{N\mu_0 I}{2r} = B_E \Rightarrow I = \frac{B_E 2r}{N\mu_0}$

$I = \frac{7\times10^{-5}\times2\times5\times10^{-2}}{10^2\left(4\times\frac{22}{7}\times10^{-7}\right)} = 5.57 \times 10^{-2} = 55.7 \times 10^{-3}A = 55.7$ mA

18. The equation correctly represented by the following graph is (a and b are constants)



(A) x + y = b (B) $ax^2 + by^2 = 0$ (C) x + y = ab (D) $y = ax^b$

Ans. **(D)**

Sol. $\log y = m \log x + C$

$\log y = \log c'x^m$

$y = c'x^m$

$y = ax^b$

19. Which one of the following devices does not respond to the intensity of light incident on it ?

(A) Photoresistor (LDR) (B) Photodiode

(C) Light Emitting Diode (D) Solar Cell

Ans. **(C)**

Sol. Theory based

20. Consider a parallel plate capacitor. When half of the space between the plates is filled with some dielectric material of dielectric constant K as shown in Fig. (1) below, the capacitance is C_1. However, if the same dielectric material fills half the space as shown in Fig. (2), the capacitance is C_2. Therefore, the ratio $C_1 : C_2$ is

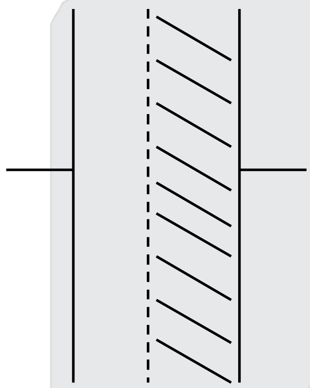


Fig. (1)

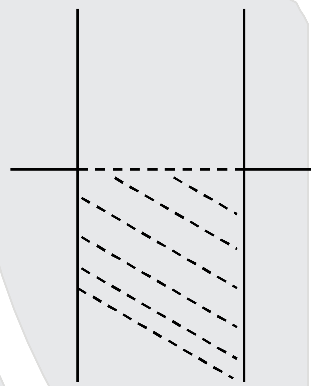


Fig. (2)

(A) 1 (B) $\frac{2K}{K+1}$ (C) $\frac{4K}{(K+1)^2}$ (D) $\frac{K+1}{2}$

Ans. **(C)**

Sol. $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$

$$\frac{1}{\frac{A\varepsilon_0}{\frac{d}{2}}} + \frac{1}{\frac{KA\varepsilon_0}{\frac{d}{2}}}$$

$$= \frac{d}{2A\varepsilon_0} + \frac{d}{2KA\varepsilon_0}$$

$$\frac{1}{C_{eq}} = \frac{d}{2A\varepsilon_0}\left(\frac{K+1}{K}\right)$$

$$C_{eq} = \frac{2KA\varepsilon_0}{d(K+1)}$$

$$\frac{C_{eq}}{C_{eq}'} = \frac{2KA\varepsilon_0}{d(K+1)} \cdot \frac{2d}{A\varepsilon_0(K+1)} = \frac{4K}{(K+1)^2}$$

21. A point source of light is viewed through a plate of glass of thickness t and of refractive index 1.5. The source appears

(A) closer by a distance 2t/3 (B) closer by a distance t/3
(C) farther by a distance t/3 (D) farther by a distance 2t/3

Ans. (B)

Sol. $\Delta y = t\left(1-\frac{1}{\mu}\right) = t\left(1-\frac{2}{3}\right) = \frac{t}{3}$ closer.

22. The fraction of the original number of nuclei of a radioactive atom having a mean life of 10 days, that decays during the 5th day is

(A) 0.15 (B) 0.30 (C) 0.045 (D) 0.064

Ans. (D)

Sol. $T_{av} = 10 \text{ days} = \frac{1}{\lambda}$

No. of decays during 5th day = $N_0e^{-\lambda 4} - N_0e^{-\lambda 5}$

fraction decayed during 5th day = $e^{-4\lambda} - e^{-5\lambda}$

$= e^{-4/10} - e^{-1/2}$

$= e^{-2/5} - e^{-1/2} = 0.0637 \simeq 0.064$

23. The photoelectric threshold wavelength of tungsten is 230 nm. The energy of electrons ejected from its surface by ultraviolet light of wavelength 180 nm is

(A) 0.15 eV (B) 1.5 eV (C) 15 eV (D) 1.5 keV

Ans. (B)

Sol. $\frac{hc}{1800} - \frac{hc}{2300} = \frac{12400\text{eV}[500]}{1800 \times 2300}$ = 1.5eV

24. A slit of width a is illuminated by parallel monochromatic light of wavelength λ. The value of a at which the first minimum of the diffraction pattern will from at $\theta = 30°$ is

(A) $\lambda/2$ (B) λ (C) 2λ (D) 3λ

Ans. (C)

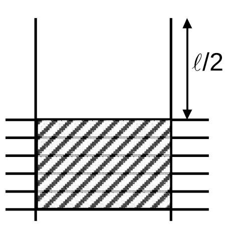
Sol. $a \sin 30° = \lambda \Rightarrow a = 2\lambda$

25. A whistle whose air column is open at both ends has a fundamental frequency 500 Hz. The whistle is dipped in water such that half of it remains out of water. What will be the fundamental frequency now ? (speed of sound in air is 340 ms^{-1})

(A) 250 Hz (B) 125 Hz (C) 500 Hz (D) 1000 Hz

Ans. (C)

Sol.



$\frac{v}{4\frac{\ell}{2}} = \frac{v}{2\ell} = 500\text{Hz}$

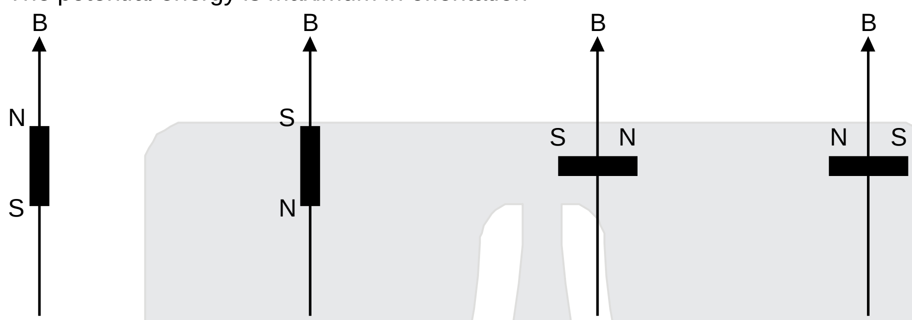
26. The physical quantity that has unit volt-second is

(A) energy (B) electric flux (C) magnetic flux (D) inductance

Ans. **(C)**

Sol. $\text{Li} = \frac{\text{Li}^2}{\text{i}} = \frac{\text{Vq}}{\text{i}} = \text{volt} - \text{second}$

27. Consider different orientations of a bar magnet lying in a uniform magnetic field as shown below. The potential energy is maximum in orientation



(1) (2) (3) (3)

(A) 1 (B) 2 (C) 3 (D) 4

Ans. **(B)**

Sol. $U = -\vec{M}\cdot\vec{B}$

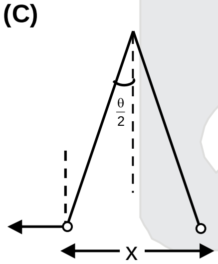
U is max when $\theta = 180°$

28. Two identical charged spheres suspended from a common point by two light strings of length l, are initially at a distance d(<< l) apart due to their mutual repulsion. The charges begin to leak from both the spheres at a constant rate. As a result, the spheres approach each other with a velocity ν. If x denotes the distance between the spheres, the ν varies as

(A) x^{-1} (B) $x^{1/2}$ (C) $x^{-1/2}$ (D) x

Ans. **(C)**

Sol.



$$\frac{kq^2}{x^2} = T\sin\frac{\theta}{2}$$

$$mg = T\cos\frac{\theta}{2} \qquad q^2 = \frac{mgx^3}{2k\ell}$$

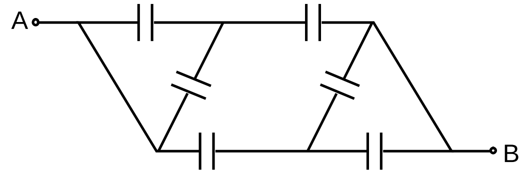
$$\frac{kq^2}{mgx^2} = \tan\frac{\theta}{2} \qquad q = \left(\frac{mg}{2k\ell}\right)^{\frac{1}{2}} x^{\frac{3}{2}} \qquad q^{\frac{-1}{3}} = \left(\frac{mg}{2k\ell}\right)^{-\frac{1}{6}} x^{-\frac{1}{2}}$$

$$\frac{2kq^2}{mgx^2} = \frac{x}{\ell} \quad \Rightarrow \quad x^3 = \frac{2k\ell q^2}{mg}$$

$$2v = \frac{(\text{const})(c)2}{3} q^{-1/3} \quad \Rightarrow \quad x = (\text{const})q^{\frac{2}{3}}$$

$$2v = 2v = (\text{const})x^{-\frac{1}{2}} \quad \Rightarrow \quad \frac{dx}{dt} = (\text{const})\frac{2}{3}q^{-\frac{1}{3}}$$

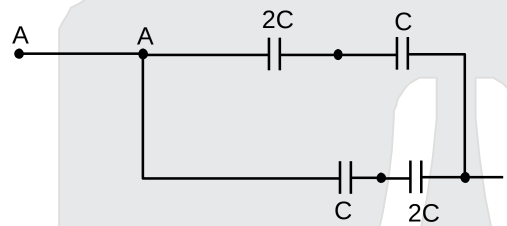
29. A network of six identical capacitors, each of capacitance C is formed as shown below. The equivalent capacitance between the point A and B is



(A) 3C (B) 6C (C) 3C/2 (D) 4C/3

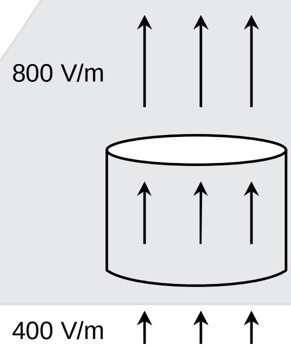
Ans. **(D)**

Sol. Rearrange the circuit



$C_{eq} = \frac{2C}{3} \times 2$

30. A cylinder on whose surfaces there is a vertical electric field of varying magnitude as shown. The electric field is uniform on the top surface as well as on the bottom surface therefore, this cylinder encloses



(A) no net charge

(B) net positive charge

(C) net negative charge

(D) There is not enough information to determine whether or not there is net charge inside the cylinder.

Ans. **(B)**

Sol. Consider a Gaussian surface

$\phi = (800 - 400)A = \frac{q_{in}}{\varepsilon_0}$

$q_{in} = 400\varepsilon_0 A$

31. Two identical solid block A and B are made of two different materials. Block A floats in a liquid with half of its volume submerged. When block B is pasted over A, the combination is found to just float in the liquid. The ratio of the densities of the liquid, material of A and material of B is given by

(A) 1 : 2 : 3 (B) 2 : 1 : 4 (C) 2 : 1 : 3 (D) 1 : 3 : 2

Ans. **(C)**

Sol. $\frac{\rho A}{\rho \ell} = \frac{1}{2} \quad \Rightarrow \quad \frac{\rho A}{\rho B} = \frac{1}{3}$

$\rho_A Vg + \rho_B Vg = \rho \ell_2 Vg$

$\rho_A + \rho_B = 2\rho_e$

$\rho_B = 3\rho_A$

$\rho_\ell = 2\rho_A$

$\rho_\ell : \rho_A : \rho_B = = 2 : 1 : 3$

32. In an X ray tube the electrons are expected to strike the target with a velocity that is 10% of the velocity of light. The applied voltage should be

(A) 517.6 V (B) 1052 V (C) 2.559 kV (D) 5.680 kV

Ans. **(C)**

Sol. $v_e = 0.1C = 0.3 \times 10^8$ m/s

Assuming non-relatioistic case :

$$v = \frac{9.1 \times 9 \times 10^{-17}}{2 \times 1.6 \times 10^{-19}} = \frac{81.9}{3.2} \times 100$$

= 2559 volt

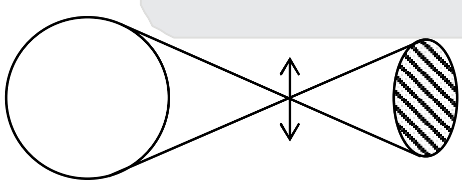
= 2.559 kv

33. When observed from the earth the angular diameter of the sun is 0.5 degree. The diameter of the image of the sun when formed in a concave mirror of focal length 0.5 m will be about

(A) 3.0 mm (B) 4.4 mm (C) 5.6 mm (D) 8.8 mm

Ans. **(B)**

Sol.



$D_I = \frac{5}{10} \times 0.5 \times \frac{\pi}{180} = \frac{\pi}{180 \times 4} = 4.36\text{mm} \approx 4.4\text{mm}$

34. The decimal number that is represented by the binary number $(100011.101)_2$ is

(A) 23.350 (B) 35.625 (C) 39.245 (D) 42.455

Ans. **(B)**

Sol. $1 \times 2^5 + 1 \times 2^1 + 1 \times 2^\circ + 1 \times 2^{-1} + 0 \times 2^{-2} + 1 \times 2^{-3}$

= 32 + 2 + 1 + 0.5 + 0.125 = 35. 625

35. The excess pressure inside a soap bubble is equal to 2 mm of kerosene (density 0.8 g cm^{-3}). If the diameter of the bubble is 3.0 cm, the surface tension of soap solution is

(A) 39.2 dyne cm^{-1} (B) 45.0 dyne cm^{-1} (C) 51.1 dyne cm^{-1} (D) 58.8 dyne cm^{-1}

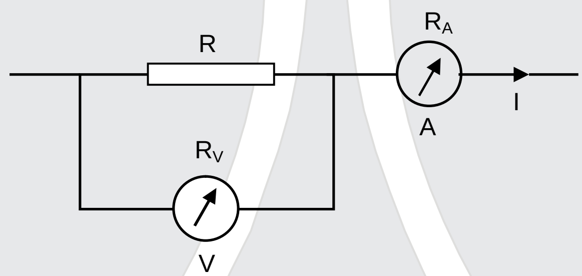
Ans. **(D)**

Sol. $\frac{4T}{R} = \rho g(2mm)$

$\Rightarrow \quad \frac{8T}{d} = \rho g\ (2\ mm)$

$\Rightarrow \quad T = \frac{0.8 \times 980 \times 3 \times (.2)}{8} = 9.8 \times 6 = 58.8$

36. Let V and I be the readings of the voltmeter and the ammeter respectively as shown in the figure. Let R_V and R_A be their corresponding resistance Therefore,



(A) $R = \frac{V}{I}$ (B) $R = \frac{V}{I - \left(\frac{V}{R_V}\right)}$ (C) $R = R_V - R_A$ (D) $R = \frac{V(R + R_A)}{IR_A}$

Ans. **(B)**

Sol. $\frac{RR_v}{R + R_v}.I = V$

$\frac{RR_v}{R + R_v} \frac{V}{I} \Rightarrow \frac{I}{V} = \frac{1}{R} + \frac{1}{R_v}$

$\Rightarrow \frac{I}{v} - \frac{1}{R_v} = \frac{1}{R}$

$\Rightarrow R = \frac{1}{\frac{I}{v} - \frac{1}{R_v}} = \frac{V}{I - \frac{v}{R_v}}$

37. A man stands at rest in front of a large wall. A sound source of frequency 400 Hz is placed between him and the wall. The source is now moved towards the wall at a speed of 1 m/s. The number of beats heard per second will be(speed of sound in air is 345 m/s)

(A) 0.8 (B) 0.58 (C) 1.16 (D) 2.32

Ans. **(D)**

Sol. $\Delta f = \frac{c}{c - u}.f - \frac{c}{c + u} f = \frac{cf 2u}{c^2 - u^2} = \frac{2uf}{c}$

$\Delta f = \frac{2.1.400}{345} = \frac{800}{345} = 2.32$

38. A hollow sphere of inner radius 9 cm and outer radius 10 cm floats half submerged in a liquid of specific gravity 0.8. The density of the material of the spere is

(A) 0.84g cm^{-3} (B) 1. 48g cm^{-3} (C) 1. 84g cm^{-3} (D) 1.24g cm^{-3}

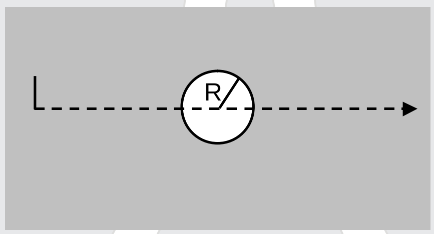
Ans. **(B)**

Sol. $\frac{4}{3}\pi\left(1000r^3 - 729r^3\right)\rho = \frac{2}{3}\pi 1000r^3 0.8\rho\omega$

$271\rho = 4\omega\rho_\omega$

$\rho = 1.48\rho_\omega = 1.48$ gm/cm^3

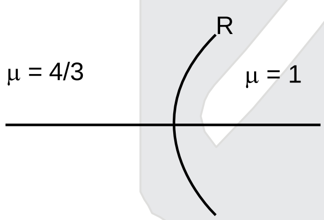
39. Rays from an object immersed in water (μ = 1.33) traverse a spherical air bubble of radius R. If the object is located far away from the bubble, its image as seen by the observer located on the other side of the bubble will be



(A) virtual, erect and diminished (B) real, inverted and magnified
(C) virtual, erect and magnified (D) real, inverted and diminished

Ans. **(A)**

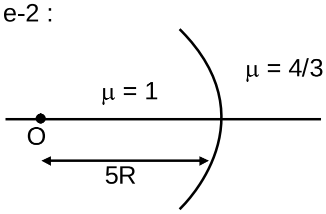
Sol. e-1



$$\frac{1}{v} - \frac{\frac{4}{3}}{-\infty} = \frac{1-\frac{4}{3}}{R} = -\frac{1}{3R} \Rightarrow v = -3R$$

$$m_1 = \frac{-\frac{3R}{1}}{-\frac{\infty}{\frac{4}{3}}} = +0$$

e-2 :



$$\frac{4}{3v} - \frac{1}{-5R} = \frac{\frac{4}{3}-1}{-R}$$

$$\frac{4}{3v} + \frac{1}{5R} = -\frac{1}{3R} \Rightarrow \frac{4}{3v} = -\frac{1}{3R} - \frac{1}{5R} = -\frac{8}{15R}$$

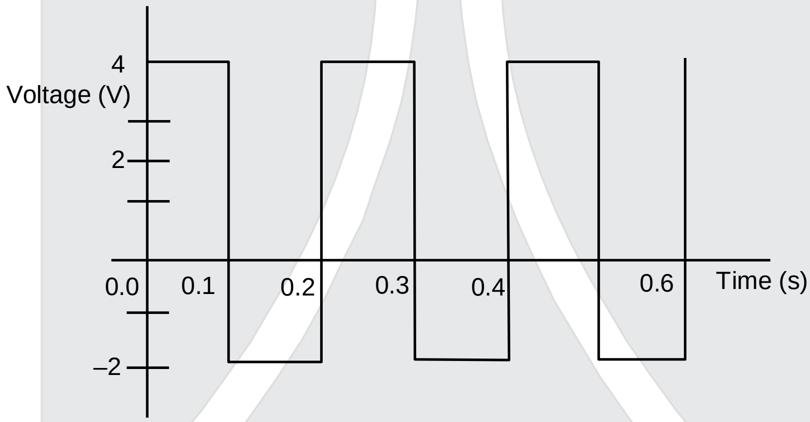
$$v = -\frac{5R}{2}$$

$$m_2 = \frac{-\frac{5R}{2(4/3)}}{-\frac{5R}{1}} = +\frac{3}{8}$$

$m_1m_2 \approx +0$

image is virtual, erect and diminished.

40. A 10 ohm resistor is connected to a supply voltage alternating between +4V and –2V as shown in the following graph. The average power dissipated in the resistor per cycle is



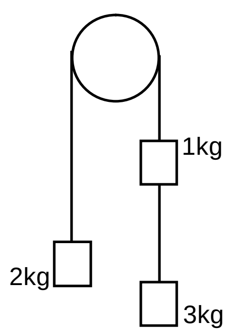
(A) 1.0 W (B) 1.2 W (C) 1.4W (D) 1.6W

Ans. **(A)**

Sol. R = 10Ω

$$P_{av} = \frac{\frac{(4)^2}{10} \times 0.1 + \frac{(2)^2}{10} \times 10.1}{0.2} = \frac{1.6 + 0.4}{2} = 1 \text{ watt}$$

41. In the following arrangement the pulley is assumed to be light and the string inextensible. The acceleration of the system can be determined by considering conservation of a certain physical quantity. The physical quantity conserved and the acceleration respectively, are



(A) energy and g/3 (B) linear momentum and g/2

(C) angular momentum and g/3 (D) mass and g/2

Ans. **(A)**

Sol. No dissipative forces so total mech energy is conserved

$(3 + 1)gx - 2gx = \frac{1}{2}(3+1+2)v^2$

$\Rightarrow \quad 2gx = 3v^2$

$\Rightarrow \quad 2gv = 6v\frac{dv}{2dt}$

$\Rightarrow \quad \frac{dv}{dt} = \frac{g}{3}$

42. Two cells each of emf E and internal resistance r_1 and r_2 respectively are connected in series with an external resistance R. The potential difference between the terminals of the first cell will be zero when R is equal to

(A) $\frac{r_1 + r_2}{2}$ (B) $\sqrt{r_1^2 - r_2^2}$ (C) $r_1 - r_2$ (D) $\frac{r_1 r_2}{r_1 + r_2}$

Ans. **(C)**

Sol. $\varepsilon_1 - \left\{\frac{\varepsilon_1 + \varepsilon_2}{r_1 + r_2 + R}\right\} r_1 = 0$

$r_1 + r_2 + R = 2r_1 \quad \Rightarrow \quad R = r_1 - r_2$

43. A student uses a convex lens to determine the width of a slit. For this he fixes the positions of the object and the screen and moves the lens to get a real image on the screen. The images of the slit width are found to be 2.1 cm and 0.48 cm wide respectively when the lens is moved through 15 cm. Therefore, the slit width and the focal length of the lens respectively, are.

(A) 1 cm, 9.3 cm (B) 1 cm, 10.5 cm (C) 2 cm, 12.8 cm (D) 2 cm, 15.2 cm

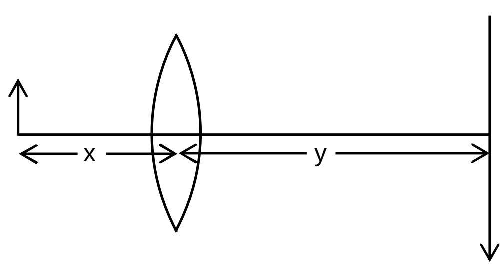
Ans. **(A)**

Sol. $h_0 = \sqrt{h_1 h_2} = \sqrt{2.1 \times 0.48}$

$= \sqrt{0.7 \times 3 \times 0.16 \times 3}$

$= 3 \times 0.4 \times \sqrt{0.7}$

$= 1.2 \times \sqrt{0.7} = 1$ cm



For case I

$$\frac{h_i}{h_0} = \frac{2.1}{1} = 2.1 cm = \frac{y}{x}$$

$y = 2.1x$ ...(i)

$y - x = 15$ cm

$2.1x - x = 15$

$1.1\ x = 15$

$$x = \frac{150}{11} cm = 13.6$$

$$\frac{1}{2.1x} - \frac{1}{-x} = \frac{1}{f}$$

$$\frac{2.1+1}{2.1x} = \frac{1}{f}$$

$$\Rightarrow \quad f = \frac{2.1x}{3.1} = \frac{21}{31} \times \frac{150}{11} cm \simeq 9.3 \text{ cm}$$

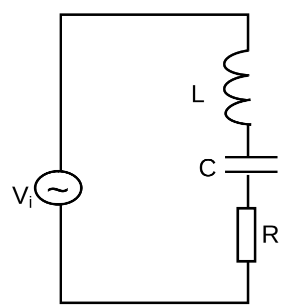
44. A particle rests in equilibrium under two forces of repulsion whose centres are at distance of a and b from the particle. The forces vary as the cube of the distance. The forces per unit mass are k and k' respectively. If the particle be slightly displaced towards one of them the motion is simple harmonic with the time period equal to

(A) $\dfrac{2\pi}{\sqrt{3\left(\frac{k}{a^3}+\frac{k'}{b^3}\right)}}$ (B) $\dfrac{2\pi}{\sqrt{\left(\frac{k}{a^3}+\frac{k'}{b^3}\right)}}$ (C) $\dfrac{2\pi}{\sqrt{\left(\frac{k}{a^4}+\frac{k'}{b^4}\right)}}$ (D) $\dfrac{2\pi}{\sqrt{3\left(\frac{k}{a^4}+\frac{k'}{b^4}\right)}}$

Ans. **(D)**

Sol. **Deleted**

45. In the following circuit the current is in phase with the applied voltage. Therefore, the current in the circuit and the frequency of the source voltage respectively, are



(A) $\dfrac{v_i}{R}$ and $\dfrac{1}{2\pi\sqrt{LC}}$ (B) zero and $\dfrac{1}{\sqrt{LC}}$ (C) $\sqrt{\dfrac{C}{L}}v_i$ and $\dfrac{2}{\pi\sqrt{LC}}$ (D) $4\sqrt{\dfrac{C}{LR^2}}$ and $\dfrac{2}{\sqrt{LC}}$

Ans. **(A)**

Sol. $f = \frac{1}{2\pi\sqrt{LC}}$ the circuit is in resonance with the applied voltage.

$i = \frac{v_i}{R}$

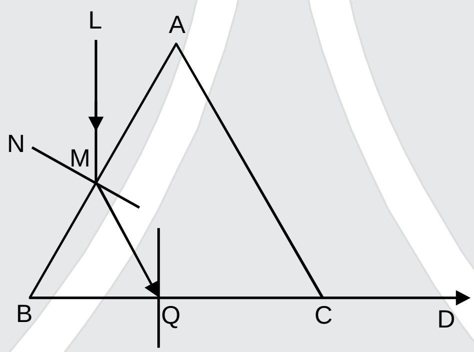
46. In and atom an electron excites to the fourth orbit. When it jumps back to the energy levels a spectrum is formed. Total number of spectral lines in this spectrum would be

(A) 3 (B) 4 (C) 5 (D) 6

Ans. **(A)**

Sol. Since there is only one atom, so number of line will be 3

47. The following figure shows the section ABC of an equilateral triangular prism. A ray of light enters the prism along LM and emerges along QD. If the refractive index of the material of the prism is 1.6, angle LMN is



(A) 35.6° (B) 37 .4° (C) 39.4° (D) 41.3°

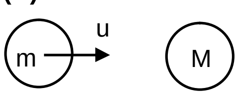
Ans. **(A)**

Sol. **Deleted**

48. A ball of mass m hits directly another ball of mass M at rest and is brought to rest by the impact. One third of the kinetic energy of the ball is lost due to collision. The coefficient of restitutions is

(A) 1/3 (B) ½ (C) 2/3 (D) $\sqrt{\frac{2}{3}}$

Ans. **(C)**



Sol.

$mu = Mv$ ...(i)

$$\frac{p_f^2}{2M} = \frac{2}{3}\frac{p_i^2}{2m}$$

$$\frac{m}{M} = \frac{2}{3} = \frac{v}{u} = e$$

49. An object 1 cm long lies along the principal axis of a convex lens of focal length 15 cm, the centre of the object being at a distance of 20 cm from the lens. Therefore , the size of the image is

(A) 0.3cm (B) 3 cm (C) 9 cm (D) 12 cm

Ans. **(C)**

Sol. u = –20 f = + 15

$$\frac{1}{v} + \frac{1}{20} = \frac{1}{15} \Rightarrow \frac{1}{V} = \frac{4}{60} - \frac{3}{60} \Rightarrow V = 60$$

$$\left|\frac{dv}{du}\right| = \left|\frac{v^2}{u^2}\right| = 9$$

du = 1cm

dv = 9 cm

50. Acidified water from certain reservoir kept at a potential V falls in the form of small droplets each of radius r through a hole into a hollow conducting sphere of radius a. The sphere is insulated and is initially at zero potential. If the drops continue to fall until the sphere is half full, the potential acquired by the sphere is

(A) $\frac{a^2V}{2r^2}$ (B) $\sqrt{\frac{a}{r}}\frac{V}{2}$ (C) $\frac{a^3V}{2r^3}$ (D) $\frac{aV}{r}$

Ans. **(A)**

Sol. $\frac{1}{4\pi\epsilon_0}\frac{q}{r} = v$

$$n\left(\frac{4}{3}\pi r^3\right) = \frac{2}{3}\pi a^3 \quad \Rightarrow \quad n = \frac{a^3}{2r^3}$$

$$v^1 = \frac{1}{4\pi\epsilon_0}\frac{n.q}{a} = v_r \frac{a^3}{2r^3}\frac{1}{a}$$

$$v^1 = \left(\frac{a^2}{2r^2}\right)v$$

Group of question Nos 51 to 55 are based on the following paragraph and its subsequent continuation of after some question.

The following question are concerned with experiments of the characterization and use of a moving coil galvanometer.

The series combination of variable resistance R, one 100 Ω resistor and moving coil galvanometer is connected to a mobile phone charger having negligible internal resistance. The zero of the galvanometer lies at the centre and the pointer can move 30 division full scale on either side depending on the direction of current. The reading of the galvanometer is 10 divisions and the voltages across the galvanometer and 100 Ω resistor are respectively 12 mV and 16 mV.

51. The figure of merit of the galvanometer is microampere per division is :

(A) 16 (B) 20 (C) 32 (D) 10

Ans. **(A)**

52. The resistance of the galvanometer is ohm is :

(A) 50Ω (B) 75 Ω (C) 100 Ω (D) 80 Ω

The series combination of the galvanometer with a resistance of R is connected across an ideal voltage supply of 12 V and this time the galvanometer shows full scale deflection of 30 divisions.

Ans. **(B)**

53. The value of R is nearly

(A) 12.5 kΩ (B) 25 kΩ (C) 75 kΩ (D) 100 kΩ

Ans. **(B)**

54. A 24 Ω resistance is connected to a 5 V battery with internal resistance of 1Ω. A 25 kΩ resistance is connected in series with the galvanometer and this combination is used to measure the voltage across the 24 Ω resistance. The number of divisions shown in the galvanometer is

(A) 6 (B) 8 (C) 10 (D) 12

Ans. **(D)**

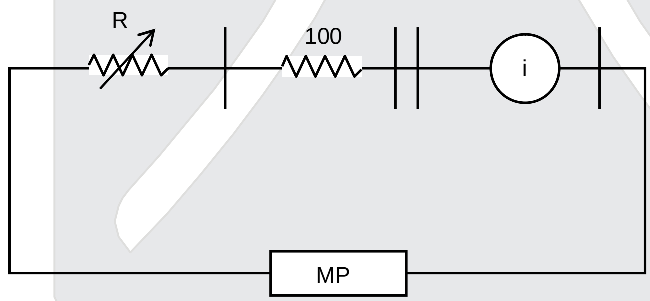
55. Now a 1000 μF capacitor is charged using the 12 V supply and is discharged through the galvanometer-resistance combination used in the previous question. The current i (in ampere) at different time t (in second) are recorded. A graph of (In i) against (t) is plotted. The slope of the graph is

(A) –0.02 s^{-1} (B) –0.01 s^{-1} (C) – 0.04 s^{-1} (D) + 0.04 s^{-1}

Ans. **(C)**

Sol. **51 to 55**

Case-1

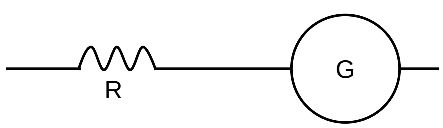


$10\, i_0\, G = 12 \times 10^{-3}$

$10\, i_0\, (100) = 16 \times 10^{-3} \Rightarrow 10^3\, i_0 = 16 \times 10^{-3} \Rightarrow i_0 = 16 \times 10^{-6}$ A

$\frac{G}{100} = \frac{3}{4} \Rightarrow G = 75\Omega$

Case-2

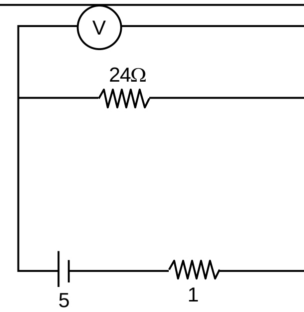


$30\, i_0\, (R + G) = 12$

$R + G = \frac{12}{30 i_0} = \frac{2}{5 \times 16 \times 10^{-6}} = \frac{2 \times 10^6}{80} = 2.5 \times 10^4\Omega = 25k\Omega$

$R = 25k\Omega - 75\Omega$

Case-3



$30\, i_0 (R + G) = 12$

$n i_0 (R + G) = \left(\frac{5}{25}\right)24$

$n = 12$

$i = i_0\, e^{-t/r\tau}$

$\ell n\, i = \ell n\, i_0 - t/\tau$

slope $= -\frac{1}{e} = -\frac{1}{(25\times10^3)(10^{-3})} = -\frac{1}{25} = -0.04\text{sec}^{-1}$

56. If Newton's inverse square law of gravitation had some dependence on radial distance other than r^{-2}, which on of kepler's three laws of planetary motion would remain unchanged ?

(A) First law on nature of orbits

(B) Second law on constant areal velocity

(C) Third law on dependence of orbital time period on orbit's semi major axis

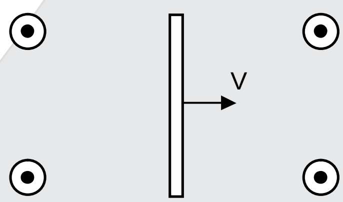
(D) None of the above

Ans. **(B)**

Sol. As the magnitude of force does not matter. The torque would still be zero.

57. A neutral metal bar moves at a constant velocity v to the right through a region of uniform magnetic field directed out the page, as shown.

Therefore,



(A) positive charges accumulate to the left side and negative charges to the right side of the rod

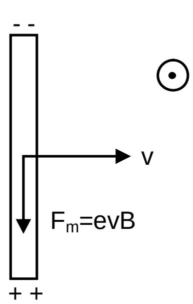
(B) negative charges accumulate to the left side and positive charges to the right side of the rod.

(C) positive charges accumulate to the top end and negative charges to the bottom end of the rod

(D) negative charges accumulate to the top end and positive charges to the bottom end of the rod

Ans. **(D)**

Sol.



58. Two moles of hydrogen are mixed with n moles of helium. The root mean square speed of gas molecules in the mixture is $\sqrt{2}$ times the speed of sound in the mixture. Then n is.

(A) 3 (B) 2 (C) 1.5 (D) 2.5

Ans. **(B)**

Sol. $V_{rms} = \sqrt{\frac{3RT}{M_{mix.}}}$

$V_{sound} = \sqrt{\frac{\gamma RT}{M_{mix.}}}$

$v_{rms} = \sqrt{2}\, V_{sound}$

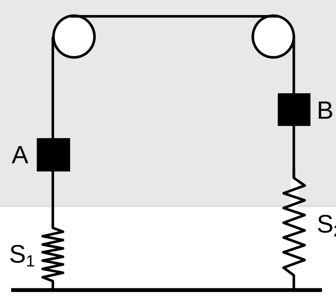
$\sqrt{\frac{3RT}{M_{mix.}}} = \sqrt{2}\sqrt{\frac{\gamma RT}{M_{mix}}}$

$r = \frac{3}{2}$

$r_{mix} = \frac{n_1 C_{P_1} + n_2 C_{P_2}}{n_1 C_{v_1} + n_2 C_{v_2}}$

$\frac{3}{2} = \frac{2\times\frac{7R}{2} + n\times\frac{5R}{2}}{2\times\frac{5R}{2} + n\times\frac{3R}{2}} \Rightarrow \frac{3}{2} = \frac{14+5n}{10+3n} \Rightarrow 30 + 9n = 28 + 10n \Rightarrow n = 2$

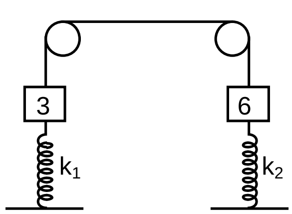
59. In the figure shown below masses of blocks A and B are 3 kg and 6 kg respectively. The force constants of springs S_1 and S_2 are 160 N/m and 40 N/m respectively. Length of the light string connecting the blocks is 8 m. The system is released from rest with the springs at their natural lengths. The maximum elongation of spring S_1 will be :



(A) 0.294 m (B) 0.490 m (C) 0.588 m (D) 0.882 m

Ans. **(A)**

Sol.



$6g(x) - 3g(x) = \frac{1}{2}k_2x^2 + \frac{1}{2}k_1x^2$

$6g = (k_1 + k_2)x$

$= \dfrac{6 \times 9.8}{200} = \dfrac{3 \times 9.8}{100}$

$u^2 = 0.294m$

60. Two particles A and B of equal masses have velocities $\vec{V}_A = 2\hat{i} + \hat{j}$ and $\vec{V}_B = -\hat{i} + 2\hat{j}$. The particles move with accelerations $\vec{a}_A = -4\hat{i} - \hat{j}$ and $\vec{a}_B = -2\hat{i} + 3\hat{j}$ respectively. The centre of mass of the two particles move along

(A) a straight line (B) a parabola (C) a circle (D) an ellipse

Ans. **(B)**

Sol. $\bar{v}_{cm} = \dfrac{\hat{i} + 3\hat{j}}{2}$ $\bar{a}_{cm} = \dfrac{-6\hat{i} + 2\hat{j}}{2}$

$= -3\hat{i} + \hat{j}$

A 2

In Q. Nos. 61 to 70 any number of options (1 or 2 or 3 or all 4) may be correct. You are to identify all of them correctly to get 6 marks. Even if one answer identified is incorrect or one correct answer is missed, you get zero marks.

61. A ray is incident on a refracting surface of RI μ at an angle of incidence i and the corresponding angle of refraction is r. The deviation of the ray after refraction is given by δ = i-r. Then, one may conclude that

(A) r increases with I

(B) δ increases with i

(C) δ decreases with I

(D) the maximum value of δ is $\cos^{-1}\left(\frac{1}{\mu}\right)$

Ans. **(ABD)**

Sol. δ = i – r when i $\uparrow$, r $\uparrow$, $\delta\uparrow$

$\delta_{max} = 90 - \sin^{-1}\frac{1}{u} = \cos^{-1}\frac{1}{u}$

62. In a series R-C circuit the supply voltage (Vs) is kept constant at 2V and the frequency f of the sinusoidal voltage is varied from 500 Hz to 2000 Hz. The voltage across the resistance R = 1000 ohm is measured each time as V_R. For the determination of the C a student wants to draw a linear graph and try to get C from the slope. Then she may draw a graph of

(A) f^2 against V_R^2

(B) $\frac{1}{f^2}$ against $\frac{V_S^2}{V_R^2}$

(C) $\frac{1}{f^2}$ against $\frac{1}{V_R^2}$

(D) f against $\frac{V_R}{\sqrt{V_s^2 - V_R^2}}$

Ans. **(BCD)**

Sol. $V_R = \frac{VR}{\sqrt{R^2 + \left(\frac{1}{2\pi fc}\right)^2}}$

$R^2 + \left(\frac{1}{2\pi fc}\right)^2 = \frac{v^2}{v_R^2}R^2$

$\left(\frac{1}{2\pi fc}\right) = \sqrt{\frac{v^2 - v_R^2}{v_R^2}}R$

$2\pi fc\ (R) = \frac{v_R}{\sqrt{v^2 - v_R^2}}$

Graph between f & $\frac{v_R}{\sqrt{v^2 - v_R^2}}$ is a straight line.

$\frac{1}{f^2}$ vs $\frac{1}{v_R^2}$ is also straight line

63. Two balls A and B moving in the same direction collide. The mass of B is p times that of A. Before the collision the velocity of A was q times that of B. After the collision A comes to rest. If e be the coefficient of restitution then which of the following conclusion/s is/are correct ?

(A) $e = \frac{p+q}{pq-p}$

(B) $e = \frac{p+q}{pq+q}$

(C) $p \geq \frac{q}{q-2}$

(D) $p \geq 1$

Ans. **(ACD)**

Sol.

$mqu + mpu = mp\, v_f$

$$v_f = \frac{(q+p)u}{p}$$

$$e = \frac{(q+p)\frac{u}{p}}{qu - u} = \frac{q+p}{pq-p}$$

$e \leq 1$

$$\frac{q+p}{pq-p} \leq 1$$

$$p \geq \frac{q}{q-2}$$

64. A convex lens and concave lens are kept in contact and the combination is used for the formation of image of a body by keeping it at different places on the principal axis. The image formed by this combination of lenses can be :

(A) Magnified, inverted and real
(B) Diminished, inverted and real
(C) Diminished, erect and virtual
(D) Magnified, erect and virtual

Ans. **(ABCD)**

Sol. Combination may behave converging
In that case (a), (b) & (d) are possible .
If combination behaves like diverging c will be correct. So all the options are correct.

65. In a bipolar junction transistor
(A) the most heavily doped region is the emitter
(B) the level of doping is the same in both the emitter and the collector
(C) its base is the thinnest part
(D) when connected in common emitter configuration a base current is generally of the order of μA

Ans. **(ACD)**

Sol. (ACD) based on practical information.

66. A particle starting form rest at the highest point slides down the outside of a smooth vertical circular track of radius 0.3 m. When it leaves the track its vertical fall is h and the linear velocity is v. The angle made by the radius at that position of the particle with the vertical is θ. Now consider the following observation : ($g = 10$ m/s^2)

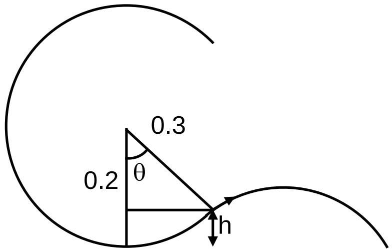
(I) h = 0.1 m and cos θ = 2/3. (II) h = 0.2 m and cosθ = 1/3. (III) v = $\sqrt{2}$ m/s^{-1}. (IV) After leaving the circular track the particle will describe a parabolic path.

Therefore,

(A) (I) and (III) both are correct
(B) only (II) is incorrect
(C) only (III) is correct
(D) (IV) is correct

Ans. **(ABD)**

Sol.



$v = \sqrt{2g(2R - h)}$ If h = 0.1

= $\sqrt{2.10(0.5)} = \sqrt{10}$

$\cos\theta = \dfrac{2}{3}$

$v\sqrt{2g(0.6 - 0.2)}$ If h = 0.2

= $\sqrt{2 \cdot 10 \cdot (0.4)} = 2\sqrt{2}m/s$

$\cos\theta = \dfrac{1}{3}$

(a) and (d) are correct.

67. A small bar magnet is suspended by a thread. A torque is applied and the magnet is found to execute angular oscillations. The time period of oscillations

(A) decreases with the moment of the magnet

(B) increases with the increase of the horizontal component of the earth's magnetic filed

(C) will remain unchanged even if another magnet is kept at a distance

(D) depends on the mass of the magnet

Ans. **(AD)**

Sol. $T = 2\pi\sqrt{\dfrac{I}{MB}}$

$I\uparrow, T\uparrow$ | $B\uparrow, T\uparrow$ | $I = \dfrac{m\ell^2}{12}$

So correct options are (A,D)

68. Two identical rods made of two different metals A and B with thermal conductivities K_A and K_B respectively are joined end to end. The free end of A is kept at a temperature T_1 while the free end of B is kept at a temperature T_2 (< T_1). Therefore, in the steady state

(A) the temperature of the junction will be determined only by K_A and K_B

(B) if the lengths of the rods are doubled the rate of heat flow will be halved.

(C) if the temperature at the two free ends are interchanged the junction temperature will change

(D) the composite rod has an equivalent thermal conductivity of $\dfrac{2K_AK_B}{K_A + K_B}$

Ans. **(BCD)**

Sol. $\dfrac{T_1 - T_j}{\frac{L}{k_A A}} = \dfrac{T_2 - T_j}{\frac{L}{k_B A}}$

$\Rightarrow \quad (T_1 - T_j)k_A = (T_2 - T_j)k_B$

So T_j depends on k_A, k_B & T_1, T_2

$\dfrac{L}{k_A A} + \dfrac{L}{k_B A} = \dfrac{2L}{k_{eq} A} \quad \Rightarrow \quad k_{eq} = \dfrac{2k_A k_B}{k_A + k_B}$

B, C, D are correct.

69. If a system is made to undergo a change from an initial state to a final state by adiabatic process only, then

(A) the work done is different for different paths connecting the two states

(B) there is no work done since there is no transfer of heat

(C) the internal energy of the system will change

(D) the work done is the same for all adiabatic paths.

Ans. (CD)

Sol. Adiabatic process $\Delta Q = 0$ $\quad$ du = –dw $\quad$ du : depends on initial and final position.

(C, D)

70. A body of mass 1.0 kg moves in X-Y plane under the influence of a conservative force. Its potential energy is given by U = 2x + 3y where (x, y) denote the coordinates of the body. The body is at rest at (2, –4) initially. All the quantities have SI units. Therefore, the body

(A) moves along a parabolic path

(B) moves with a constant acceleration

(C) never crosses the X axis

(D) has a speed of $2\sqrt{13}$ m/s at time t = 2s.

Ans. (BCD)

Sol. $F = -2\hat{i} - 3\hat{j}$

$\bar{a} = -2\hat{i} - 3\hat{j}$

(b) correct

(d) $\bar{v} = 2\sqrt{4+9} = 2\sqrt{13}$