INDIAN ASSOCIATION OF PHYSICS TEACHERS
NATIONAL STANDARD EXAMINATION IN PHYSICS (NSEP) 2016-17

Date of Examination : 27TH November, 2016

Q. Paper Code : P162

A-1
ONLY ONE OUT OF FOUR OPTIONS IS CORRECT

1. The breakdown field for air is about 2×10^6 volt/m. Therefore, the maximum charge that can be placed on a sphere of diameter 10 cm is :

(a) 2.0×10^{-4} C (b) 5.6×10^{-7} C (c) 5.6×10^{-2} C (d) 2.0×10^{2} C

Ans. (b)

Sol. $$\frac{KQ}{r^2} = 2\times10^6$$

$$\frac{9\times10^9 Q}{(5\times10^{-2})^2} = 2\times10^6$$

$$Q = \frac{2\times10^6\times25\times10^{-4}}{9\times10^9}$$

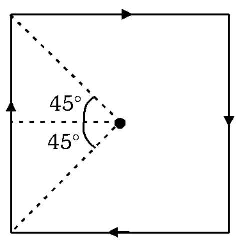
$$= \frac{50}{9}\times10^{-7} = 5.6\times10^{-7}$$

2. A wire in the shape of square frame carries a current I and produces a magnetic field B_s at its centre. Now the wire is bent in the shape of a circle and carries the same current. If B_c is the magnetic field produced at the centre of the circular coil, then B_s/B_c is

(a) $8\pi^2$ (b) $\frac{8\pi^2}{\sqrt{2}}$ (c) $\frac{8\sqrt{2}}{\pi^2}$ (d) $8\pi\sqrt{2}$

Ans. (c)

Sol. $$B_s = 4\left[\frac{\mu_0 I}{4\pi\frac{L}{2}}(\sqrt{2})\right]$$



$$= \frac{2\mu_0 I\sqrt{2}}{\pi L}$$

$$B_c = \frac{\mu_0 I}{2R} \text{ and } 2\pi R = L4;\; R = \frac{4L}{2\pi}$$

$$= \frac{\mu_0 I}{2(L)4}2\pi = \frac{\mu_0 I\pi}{4L}$$

$$\frac{B_s}{B_c} = \frac{2\sqrt{2}/\pi}{\pi} = \frac{2\sqrt{2}}{\pi^2}\cdot4 = \frac{8\sqrt{2}}{\pi^2}$$

3. A solid wooden block with a uniform cross section is floating in water (density ρ_w) with a height h_1 below water. Now a flat slab of stone is placed over the wooden block but the block still floats with a height h_2 below water. Afterwards the stone is removed from the top and pasted at the bottom of the wooden block. The wooden block now floats with a height h_3 under water. Therefore, the density of the stone is

(a) $\frac{h_2 - h_1}{h_3 - h_1}\rho_w$ (b) $\frac{h_2 - h_3}{h_2 - h_1}\rho_w$ (c) $\frac{h_2 - h_1}{h_2 - h_3}\rho_w$ (d) $\frac{h_3}{h_2 - h_1}\rho_w$

Ans. (c)

Sol. $A(h_2 - h_1)\rho_w g = mg$

$A(h_3 - h_1)\rho_w g + v\rho_w g = mg$

$\frac{(h_3 - h_1)mg}{(h_2 - h_1)} + \frac{m\rho_w g}{\sigma} = mg$

$1 - \frac{h_3 - h_1}{h_2 - h_1} = \frac{\rho_w}{\sigma}$

$\frac{h_2 - h_1 - h_3 + h_1}{h_2 - h_1} = \frac{\rho}{\sigma}$

$\sigma = \frac{\rho(h_2 - h_1)}{(h_2 - h_3)}$

4. Two wires made of the same material, one thick and the other thin, are connected to form a composite wire. The composite wire is subjected to some tension. A wave travelling along the wire crosses the junction point. The characteristic that undergoes a change at the junction point is

(a) Frequency only. (b) Speed of propagation only.
(c) Wavelength only. (d) The speed of propagation as well as the wavelength

Ans. (d)

Sol. Conceptual

5. Ultraviolet light of wavelength 300 nm and intensity 1 W/m^2 falls on the surface of a photosensitive material. If one percent of the incident photons produce photoelectrons then the number of photoelectrons emitted per second from an area of 1 cm^2 of the surface is nearly

(a) 1.51×10^{13} (b) 1.51×10^{12} (c) 4.12×10^{13} (d) 2.13×10^{11}

Ans. (b)

Sol. No. of photo $e^- = \frac{IA}{(hc/\lambda)}\left(\frac{\eta}{100}\right)$

$= \frac{1(10^{-4})(300\times10^{-9})}{(6.626\times10^{-34})(3\times10^{8})}\left(\frac{1}{100}\right)$

$= (0.151) \times 10^{13}$

$= 1.51 \times 10^{12}$

6. At a certain height h above the surface of the earth the change in the value of acceleration due to gravity (g) is the same as that at a depth x below the surface. Assuming h and x to be enough small compared to the radius of the earth, x : h is

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

Ans. (b)

Sol. $g' = g\left[1 - \frac{2h}{R}\right]$ (above)

$g' = g\left[1 - \frac{x}{R}\right]$ (below)

$\frac{2h}{R} = \frac{x}{R} \Rightarrow \frac{x}{h} = 2$

7. Two point masses m_1 and m_2 are connected at the ends of a light rigid rod of length l. The moment of inertia of the system about an axis through their centre of mass and perpendicular to the rod is

(a) $\frac{1}{2}\left(\frac{m_1m_2}{m_1+m_2}\right)l^2$ (b) $\left(\frac{m_1m_2}{m_1+m_2}\right)l^2$ (c) $(m_1 + m_2)l^2$ (d) $[m_1^2+m_2^2]\left(\frac{m_1+m_2}{m_1m_2}\right)l^2$

Ans. **(b)**

Sol. $I = \underbrace{\mu}_{\text{reduced mass}} l^2$

8. Two particles of masses m and M are initially at rest and infinitely separated. At a later instant when they are at a finite distance d from each other, their relative velocity of approach is

(a) $\left[\frac{Gm}{2d}\right]^{\frac{1}{2}}$ (b) $\left[\frac{2G(m+M)}{d}\right]^{\frac{1}{2}}$ (c) $\left[\frac{G(m+M)}{2d}\right]^{\frac{1}{2}}$ (d) $\left[\frac{2GM)}{d}\right]^{\frac{1}{2}}$

Ans. **(b)**

Sol. $mv_1 = mv_2$

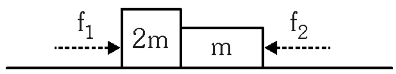
$$-\frac{GMm}{d}+\frac{1}{2}mv_1^2+\frac{1}{2}mv_2^2=0$$

$$v_2=\left(\sqrt{\frac{2G}{d(M+m)}}\right)m$$

$$v_1=\left(\sqrt{\frac{2G}{d(M+m)}}\right)M$$

$$v_{rel} = v_1 + v_2 = \sqrt{\frac{2G(M+m)}{d}}$$

9. Two blocks of masses m and 2m are placed on a smooth horizontal surface as shown. In the first case only a force f_1 is applied from left. Later on only a force f_2 is applied from right. If the force acting at the interface of the two blocks in the two cases is the same, then $f_1 : f_2$ is



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

Ans. **(c)**

Sol. $\frac{f_1(m)}{3m}=\frac{f_2(2m)}{3m}$

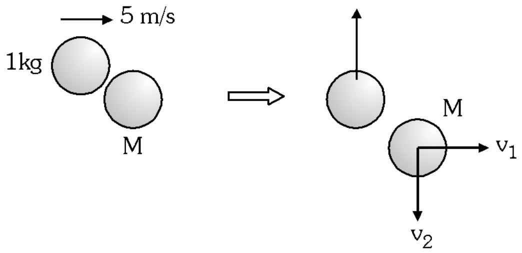
$$\frac{f_1}{f_2}=2$$

10. A ball A of mass 1 kg moving at a speed of 5 m/s strikes tangentially another ball B initially at rest. The ball A then moves at right angles to its initial direction at a speed of 4 m/s. If the collision is elastic, the mass (in kg) of ball B and its momentum after collision (in kg-m/s) respectively are approximately)

(a) 1.2 and 1.8 (b) 2.2 and 3.3 (c) 4.6 and 6.4 (d) 6.2 and 9.1

Ans. **(c)**

Sol.



$(1)(4) = Mv_2$

$1(5) = M(v_1)$

$\Rightarrow \dfrac{v_1}{v_2} = \dfrac{5}{4}$

Now $\dfrac{1}{2}(1)(5)^2 = \dfrac{1}{2}(1)(4)^2 + \dfrac{1}{2}M(v_1^2 + v_2^2)$

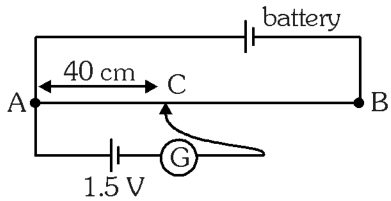
$$\frac{9}{2} = \frac{1}{2}M\left[\frac{25}{M^2} + \frac{16}{M^2}\right]$$

$$M = \frac{41}{9} = 4.55$$

and $p = \sqrt{4^2 + 5^2} = \sqrt{41} = 6.4$

Group of Q.Nos. 11 to 14 is based on the following paragraph.
a nichrome wire AB, 100 cm long and of uniform cross section is mounted on a meter scale, the points A and B coinciding with 0 cm and 100 cm marks respectively. The wire has a resistance S = 50 ohm. Any point C along this wire, between A and B is called a variable point to which one end of an electrical element is connected. In the following questions this arrangement will be referred to as 'wire AB'.

11. The emf of a battery is determined using the following circuit with 'wire AB'. The galvanometer shows zero deflection when one of its terminals is connected to point C. If the internal resistance of the battery is 4 ohm, its emf is



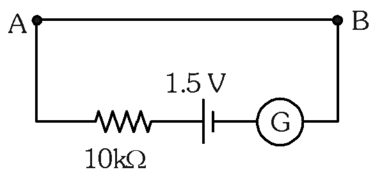
(a) 3.75 volt (b) 4.05 volt
(c) 2.50 volt (d) 9.0 volt

Ans. **(b)**

Sol. $\varepsilon - \left(\dfrac{1.5}{20}\right)\times 4 = \dfrac{50}{20}\times 1.5$

$= 4.05$ volt

12. In the adjacent arrangement it is found that deflection in the galvanometer is 10 divisions. Also the voltage across the 'wire AB' is equal to that across the galvanometer. Therefore, the current sensitivity of the galvanometer isd about



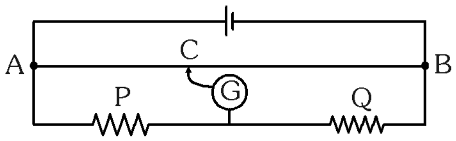
(a) 0.050 div/μA (b) 0.066 div/μA
(c) 0.010 div/μA (d) data insufficient

Ans. **(b)**

Sol. $I = \dfrac{1.5}{10\times 10^3} = 150\mu A$

Current Sensitivity $= \dfrac{10}{150\mu A} = 0.066$

13. The 'wire AB' is now a part of the adjacent circuit. With the resistors P = 50 Ω and Q = 100 Ω, the null point is obtained at C where AC = 33 cm. When the resistors are interchanged, the null point is found at C with AC = 67 cm. The systematic error in this experiment seems to be due to non–coincidence of A and B with cm mark and 100 cm mark respectively. If these end errors and equivalent to 'a' cm and 'b' cm respectively, then they are



(a) 0 and 1 (b) 1 and 0 (c) 0.33 and 0.33 (d) 1 and 1

Ans. **(d)**

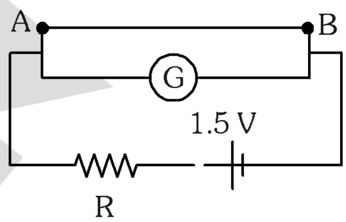
Sol. $\begin{bmatrix}(33+a)(100)=(67+b)(50)\\(67+a)(50)=(33+b)(100)\end{bmatrix}$

$$\left.\begin{array}{l}66+2a=67+b\\67+a=66+2b\end{array}\right]\times 2$$

$$65+3a=68$$

a = 1 and b = 1

14. In the adjacent circuit a resistance R is used. Initially with 'wire AB' not in the circuit, the galvanometer shows a deflection of d divisions. Now, the 'wire AB' is connected parallel to the galvanometer and the galvanometer shows a deflection nearly d/2 dvisions. Therefore



(a) R = G (b) R << G

(c) R >> G (d) $R=\frac{SG}{S+G}$

Ans. **(c)**

Sol. $$\frac{1}{2}\left(\frac{1.5}{G+R}\right)=\frac{1.5}{\frac{GS}{G+S}+R}\times\frac{S}{G+S}$$

S → resistance

above relation true if R >> G

15. Consider a relation connecting three physical quantities A, B and C given by $A = B^nC^m$. The dimensions of A, B and C are [LT], $[L^2T^1]$ and $[LT^2]$ respectively. Therefore, the exponents n and m have values

(a) 2/3 and 1/3 (b) 2 and 3 (c) 4/5 and –1/5 (d) 1/5 and 3/5

Ans. **(d)**

Sol. $LT = (L^2T^{-1})^n\,(LT^2)^m$

$$n=\frac{1}{5},\ m=\frac{3}{5}$$

16. Two identical rooms in a house are connected by an open doorway. The temperatures in the two rooms are maintained at two different values. Therefore,

(a) The room with higher temperature contains more amount of air.

(b) The room with lower temperature contains more amount of air.

(c) Both the rooms contain the same amount of air.

(d) The room with higher pressure contains more amount of air.

Ans. **(b)**

Sol. nT is constant.

17. A vibrator of frequency f is placed near one end of a long cylindrical tube. The tube is fitted with a movable piston at the other end. An observer listens to the sound through a side opening. As the piston is moved through 8.75 cm, the intensity of sound recorded by the observer changes from a maximum to a minimum. If the speed of sound in air is 350 m/s, the frequency f is

(a) 500 Hz (b) 1000 Hz (c) 2000 Hz (d) 4000 Hz

Ans. **(b)**

Sol. $\frac{\lambda}{4} = 8.75$

λ = 35 cm = 0.35 m

$f = \frac{v}{\lambda} = 1000\,\text{Hz}$

18. A heavy metal block is dragged along a rough horizontal surface at a constant speed of 20 km/hr. The coefficient of friction between the block and the surface is 0.6. The block is made of a material whose specific heat is 0.1 cal/g–°C and absorbs 25% of heat generated due to friction. If the block is dragged for 10 min, the rise in temperature of the block is about ($g = 10\ m/s^2$)

(a) 12°C (b) 50°C (c) 210°C (d) Data insufficient

Ans. **(a)**

Sol. Dist. $= \frac{20}{60} \times 10 = \frac{10}{3}\,\text{km} = \frac{10000}{3}\,\text{m}$

heat $= \frac{1}{4}(0.6mg)\left(\frac{10000}{3}\right) = m(4.2)(100)\Delta T$

$\Delta T = \frac{(0.6)(1000)}{(12)(4.2)} = 12°C$

19. A gas is made to undergo a change of state from an initial state to a final state along different paths by adiabatic process only. Therefore

(a) The work done is different for different paths. (b) The work done is the same for all paths.

(c) There is no work as there is no transfer of energy. (d) The total internal energy of the system will not change.

Ans. **(b)**

Sol. There is a unique path.

20. Vectors **A, B, C** lie in XY plane and their resultant is **R**. The magnitudes of **A, B** and **R** are 100, 200 and 200 respectively. The angles made by these vectors with the positive direction of X axis are 60°C, 150° and 90° respectively. Therefore, the magnitude and the angle made by C with positive direction of X axis respectively are

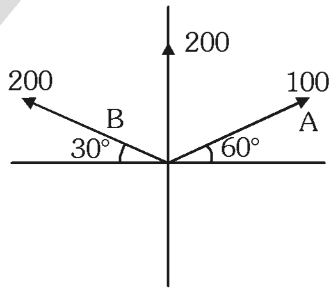
(a) 75, 315° (b) 110, 45° (c) 156, 240° (d) 124, 6.2°

Ans. **(d)**

Sol. $(\vec{C}) = \vec{R} - (\vec{A} + \vec{B})$

$\vec{C} = 200\hat{j} - \left(-100\left(\sqrt{3} - \frac{1}{2}\right)\hat{i} + \left(50\sqrt{3} + 100\right)\hat{j}\right)$

$\vec{C} = 100\left(\sqrt{3} - \frac{1}{2}\right)\hat{i} + \left(100 - 50\sqrt{3}\right)\hat{j}$

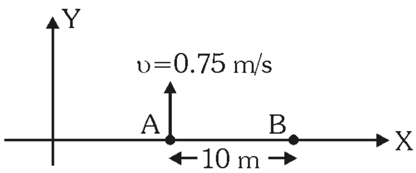


21. Two particles A and B are situated 10 m apart along X axis, B being farther right of A, at t = 0. Particle A is moving at 0.75 m/s parallel to +Y axis while B at 1 m/s along –X axis. After a time t they come closest to each other. Therefore, t is

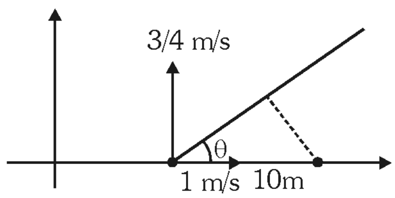
(a) 4.8 s (b) 6.4 s (c) 6.0 s (d) 3.2 s

Ans. **(b)**

Sol.



w.r.t B



$\tan\theta = \dfrac{3}{4}$

$\theta = \dfrac{3}{4}$

$t = \dfrac{10\cos\theta}{\sqrt{1+\dfrac{9}{16}}} = \dfrac{10 \times \dfrac{4}{5}}{\dfrac{5}{4}} = \dfrac{160}{25}$ = 6.4 sec.

22. Out of the following differential equations, one that correctly represents the motion of a second's pendulum is

(a) $\dfrac{d^2x}{dt^2} + \dfrac{x}{\pi} = 0$ (b) $\dfrac{d^2x}{dt^2} + \dfrac{x}{\pi^2} = 0$ (c) $\dfrac{d^2x}{dt^2} + \pi x = 0$ (d) $\dfrac{d^2x}{dt^2} + \pi^2 x = 0$

Ans. **(d)**

Sol. –length of second pendulum = 1m

$\omega^2 = \sqrt{g/\ell} = \sqrt{g}$

$\dfrac{d^2x}{dt^2} = -gx$

$\dfrac{d^2x}{dt^2} + \pi^2 x = 0$

23. A block of mass 2 kg drops vertically from a height of 0.4 m onto a spring whose force constant K is 1960 N/m. Therefore, the maximum compression of the spring is

(a) 0.40 m (b) 0.25 m (c) 0.80 m (d) 0.1 m

Ans. **(d)**

Sol. $mg(0.4 + x) = \dfrac{1}{2}Kx^2$

$2 \times 9.8\ (0.4 + x) = 980\ x^2$

$0.4 + x = 50\ x^2$

$50x^2 - x - 0.4 = 0$

$x = \dfrac{1 \pm \sqrt{1 + 4 \times 0.4 \times 50}}{2.50} = \dfrac{1+9}{100} = \dfrac{1}{100} = 0.1\,m$

24. Two blocks of masses m_1 = 8 kg and m_2 = 7 kg are connected by a light string passing over a light frictionless pulley. The mass m_1 is at rest on the inclined plane and mass m_2 hangs vertically. The angle of inclination is 30°. Therefore, the force of friction acting on m_1 is

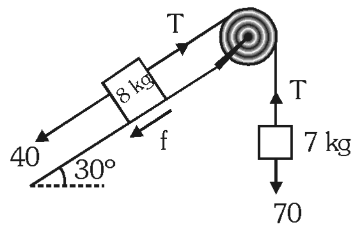
(a) 30 N up the plane (b) 30 N down the plane (c) 40 N up the plane (d) 40 N down the plane

Ans. **(b)**

Sol. T = 70

40 + f = 70

f = 30



25. Two factories are sounding their sirens at 400 Hz each. A man walks from one factory towards the other at a speed of 2 m/s. the speed of sound is 320 m/s. The number of beats heard per second by the man is

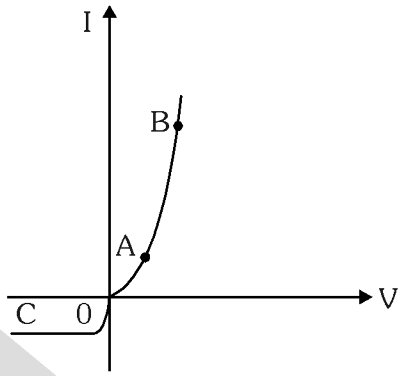
(a) 6 (b) 5 (c) 2.5 (d) 7.5

Ans. (b)

Sol. $f' = \frac{320-2}{320} \times 400$ $f'' = \frac{320+2}{320} \times 400 = \frac{322}{320} \times 400$

$= \frac{318}{320} \times 400 = 5$

26. The adjacent figure shows I-V characteristics of a silicon diode. In this connection three statements are made-(I) the region OC corresponds to reverse bias of the diode, (II) the voltage at point A is about 0.2 volt, and (III) different scales have been used along +ve and –ve direction of Y axis.



Therefore,

(a) only statement (I) is correct

(b) only statement (I) and (II) are correct

(c) only statements (I) and (III) are correct

(d) all statements (I), (II) and (III) are correct

Ans. (c)

Sol. Conceptual

27. Two identical lenses made of the same material of refractive index 1.5 have the focal length 12 cm. These lenses are kept in contact and immersed in a liquid of refractive index 1.35. The combination behave as

(a) convex lens of focal length 27 cm (b) concave lens of focal length 6 cm

(c) convex lens of focal length 9 cm (d) convex lens of focal length 6 cm

Ans. (a)

Sol. $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$

$= \frac{1}{54} + \frac{1}{54} = \frac{1}{27} = 27\text{cm}$

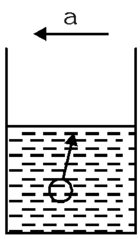
$= \frac{1}{F} = \left(\frac{1.5}{4} - 1\right)\frac{2}{R}$

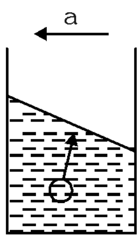
$= \frac{1}{12} = \frac{1}{2} = \frac{2}{R} \quad = \frac{1}{6} = \frac{1}{2} = \frac{2}{R}$

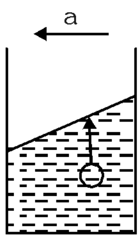
$\frac{1}{F} = \left(\frac{1.5}{1.35} - 1\right)\left(\frac{1}{6}\right) = \frac{1}{54}$

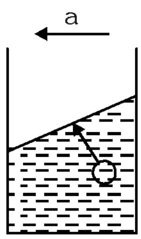
$\frac{1}{F} = \frac{1}{54} + \frac{1}{54} = \frac{2}{54} = \frac{1}{27}$

28. A cup of water is placed in a car moving at a constant acceleration a to the left. Inside the water is a small air bubble. The figure that correctly shows the shape of the water surface and the direction of motion of the air bubble is

(A) 

(B) 

(C) 

(D) 

(a) A (b) B (c) C (d) D

Ans. (d)

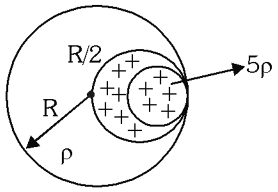
Sol. Conceptual

29. A sphere of radius R made up of Styrofoam (light polystyrene material) has a cavity of radius R/2. The centre of the cavity is situated at a distance of R/2 from the centre of the Styrofoam sphere. The cavity is filled with a solid material of density five times that of Styrofoam. Now, the centre of mass is seen to be located at a distance x from the centre of Styrofoam sphere, therefore x is

(a) R/2 (b) R/3 (c) R/4 (d) R/6

Ans. **(d)**

Sol.



$$x_{cm} = \frac{5\rho\frac{4}{3}\pi\left(\frac{R}{2}\right)^3\frac{R}{2} + \rho\left[\frac{4}{3}\pi R^3 - \frac{4}{3}\pi\left(\frac{R}{2}\right)^3\right]\left(-\frac{R}{14}\right)}{\rho\frac{4}{3}\pi R^3\frac{7}{8} + 5\rho\frac{4}{3}\pi\left(\frac{R}{2}\right)^3}$$

$$= 5\rho\frac{\frac{4}{3}\frac{\pi R^4}{16} - \rho\frac{4}{3}\pi R^4\frac{7}{8}\times\frac{R}{14}}{\frac{4}{3}\pi R^3\left[\frac{7}{8}+\frac{5}{8}\right]}$$

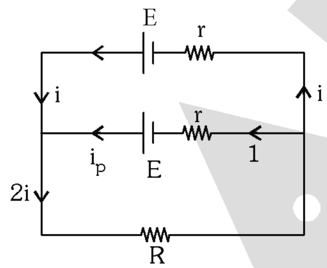
$$= \frac{\frac{5}{16}-\frac{1}{16}}{\frac{12}{8}} = \frac{1}{6}$$

30. A resistor R is connected to a parallel combination of two identical batteries each with emf E and an internal resistance r. The potential drop across the resistance R is

(a) $\frac{2ER}{2R+r}$ (b) $\frac{ER}{R+2r}$ (c) $\frac{ER}{2R+r}$ (d) $\frac{2ER}{R+2r}$

Ans. **(a)**

Sol.



$$-i_2r + E = -i_1r + E$$

$$-2iR - ir + E = 0$$

$$\boxed{\frac{E}{2R+r} = i}$$

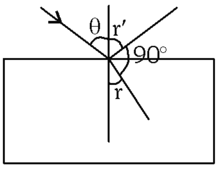
$$2iR = 2R\ \frac{E}{2R+r}$$

31. The critical angle between a certain transparent medium and air is ϕ. A ray of light travelling through air enters the medium at an angle of incidence equal to its polarizing angle θ. Therefore, the angle of refraction is

(a) $\tan^{-1}(\sin\theta)$ (b) $\tan^{-1}(\sin\phi)$ (c) $\sin^{-1}(\tan\theta)$ (d) $\sin^{-1}(\tan\phi)$

Ans. (b)

Sol.



$\theta = r'$

$r + r' + 90 = 180$

$r + r' = 90°$

$r' = 90° - r$

$\sin\theta = \mu \sin r$

$\sin\theta = \mu \sin(90 - r')$

$\sin\theta = \mu \cos r'$

$\sin\theta = \mu \cos\theta$

$\mu = \tan\theta$

$90 - r \quad \sin\phi = \dfrac{1}{\tan\theta}$

$\sin\phi = \dfrac{1}{\tan(90 - r)}$

$\sin\phi = \dfrac{1}{\cot r}$

$\sin\phi = \tan r$

$\boxed{r = \tan^{-1}/\sin\phi}$

32. If a copper wire is stretched to make its radius decrease by 0.1% , the percentage change in its resistance is approximately

(a) –0.4% (b) +0.8% (c) +0.4% (d) +0.2%

Ans. (c)

Sol. $R = \rho\dfrac{\ell}{A}$

$= \rho\dfrac{\text{Volume}}{A^2}$

$R \propto \dfrac{1}{r^4}$

$\dfrac{\Delta R}{R} = \dfrac{4\,\Delta r}{r}$

33. Consider a manual camera with a lens having a focal length of 5 cm. It is focused at infinity. For catching the picture of an object at a distance of 30 cm, one would

(a) move the lens out by about 1 cm (b) move the lens out by about 5 cm

(c) move the lens in by about 1 cm (d) find it impossible to catch the picture

Ans. (a)

Sol. $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{5}$

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

$\dfrac{1}{v} = -\dfrac{1}{30} + \dfrac{1}{5} = \dfrac{6-1}{30} = \dfrac{5}{30}$

34. Initially interference is observed with the entire experimental set up inside a chamber filled with air. Now the chamber is evacuated. With the same source of light used, a careful observer will find that
(a) The interference pattern is almost absent as it is very much diffused
(b) There is no change in the interference pattern
(c) The fringe width is slightly decreased
(d) The fringe width is slightly increased

Ans. (d)

Sol. Fringe width = $\frac{\lambda D}{d}$

35. Two identical loudspeakers, placed close to each other inside a room, are supplied with the same sinusoidal voltage. One can imagine a pattern around the loudspeakers with areas of increased and decreased sound intensity alternately located. Which of the following actions will NOT change the locations of these areas?
(a) Moving one of the speakers.
(b) Changing the amplitude of the signal voltage
(c) Changing the frequency of the signal voltage.
(d) Replacing the air in the room with a different gas

Ans. (b)

Sol. Changing the amplitude of signal voltage will not change the location of maxima and minima.

36. A particle at rest explodes into two fragments of masses m_1 and m_1 ($m_1 > m_2$) which move apart with nonzero velocities. If λ_1 and λ_2 are their de Broglie wavelengths respectively, the
(a) $\lambda_1 > \lambda_2$
(b) $\lambda_1 < \lambda_2$
(c) $\lambda_1 = \lambda_2$
(d) data insufficient

Ans. (c)

Sol. Momentum is conserved. The momentum at each particle is equal in magnitude $\lambda = \left(\frac{h}{p}\right)$.

37. Two particles of masses m_1 and m_2 carry identical charges. Starting from rest they are accelerated through the same potential difference. Then they enter into a region of unifrom magnetic field and move along circular paths R_1 and R_2 respectively. Therefores, the ratio of their masses $m_1 : m_2$ is–
(a) $R_1 : R_2$
(b) $R_1^2 : R_2^2$
(c) $R_2^2 : R_1^2$
(d) $\sqrt{R_1} : \sqrt{R_2}$

Ans. (b)

Sol. $R = \frac{mv}{qB}$ $\qquad$ $\frac{1}{2}m_1 r_1^2 = qv_0$

$R_1 = \left[\frac{\sqrt{2m_1 qv_0}}{qB}\right]$ $\qquad$ $\frac{1}{2m_1}(m_1 v_1)^2 = qv_0$

$R_2 = \frac{\sqrt{2m_2 qv_0}}{qB}$ $\qquad$ $(m_1 v_1) = \sqrt{2m_1 qv_0}$

$$\left(\frac{m_1}{m_2}\right) = \left(\frac{R_1}{R_2}\right)^2$$

38. A fixed horizontal wire M carries 200 A current. Another wire N running parallel to M carries a current I and remains suspended in a vertical plane below M at a distance of 20 mm. Both the wires have a linear mass density 10^{-2} kg/m. Therefore, the current I is–
(a) 20 A
(b) 4.9 A
(c) 49 A
(d) 200 A

Ans. (c)

Sol. $\frac{\mu_0 i_1 i_2}{2\pi r} = mg$

$$\frac{2\times10^{-7}\times200\times i}{20\times10^{-3}} = (\lambda)g$$

$$i = \frac{10^{-2}\times10\times20\times10^{-3}}{400\times10^{-7}}$$

$$i = \frac{1}{2}\times\frac{10^{-5}}{10^{-7}} = \frac{100}{2} = 50$$

39. An upolarized light of intensity 32 W/m^2 passes through three polarizers, such that the transmission axis of last polarizer is crossed with that of the first. If the intensity of emergent light is 3 W/m^2, then the angle between the transmission axes of the first two polarizers is–

(a) 30°   (b) 19°   (c) 45°   (d) 90°

Ans. **(a)**

Sol. $I_0 = 32$

$I_1 = 16$

$I_2 = 16 \cos^2 \theta$

$I_3 = (16 \cos^2 \theta)(\sin^2 \theta) = 3$

Solving $\theta = 30°$

40. An electron in injected direetly towards the centre of a large metal plate having a uniform surface charge density of -2.0×10^{-6} C/m^2. The initial kinetic energy of the electron is 1.6×10^{-17} J. The electron is observed to stop as it just reaches the plate. Therefore, the distance between the plate and the point from where the electron was injected is–

(a) 4.4×10^{-4} m   (b) 4.4 m   (c) 4.4×10^{-2} m   (d) Data insufficient

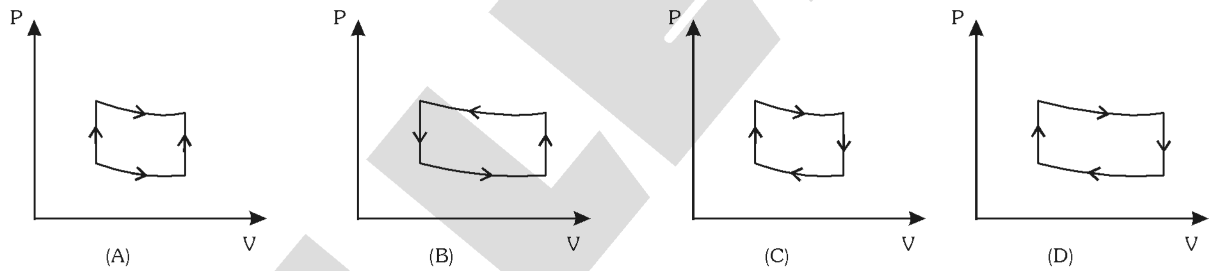
Ans. **(a)**

Sol. Loss in K.E. = Gain in P.E.

$$\frac{1}{2}mv^2 = (eE)d$$

$$E = \left(\frac{\sigma}{\varepsilon_0}\right)$$

41. Graphs (drawn with the same scale) showing the variation of pressure with volume for a certain gas undergoing four different cyclic processes A, B, C and D are given below. The cyclic process in which the gas performs the greatest amount of work is–



(a) A   (b) B   (c) C   (d) D

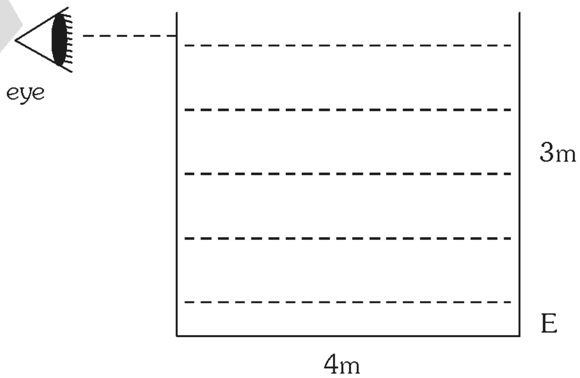
Ans. **(d)**

Sol. Area under p-v graph

= W.D. by gas

42. A rectangular metal tank filled with a certain liquid is as shown in the figure. The observer, whose eye is in level with the top of the tank, can just see the corner E of the tank.

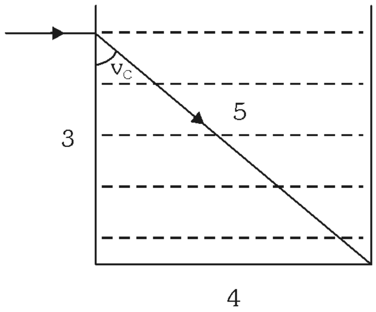
Therefore, the refractive index of the liquid is–



(a) 1.67   (b) 1.50   (c) 1.33   (d) 1.25

Ans. **(d)**

Sol. $\mu = \frac{1}{\sin i_c} = \frac{5}{4} = 1.25$



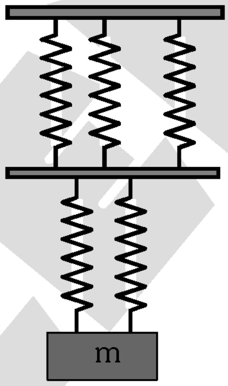
43. As shown in the figure, a block of mass m is suspended from a support with the help of a system of identical springs. The force constant of each spring is k. Therefore, the frequency of oscillations of the block is–

(a) $\frac{1}{2\pi}\sqrt{\frac{3k}{2m}}$

(b) $\frac{1}{2\pi}\sqrt{\frac{2k}{3m}}$

(c) $\frac{1}{2\pi}\sqrt{\frac{5k}{6m}}$

(d) $\frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

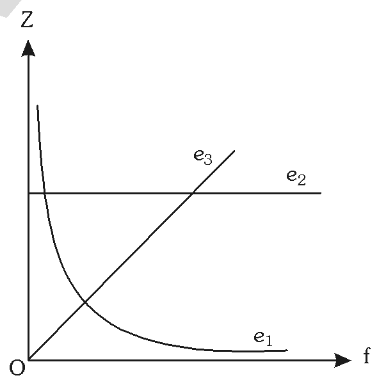


Ans. **(d)**

Sol. $k_{eq} = \frac{3 \times 2k}{3+2} = \frac{6k}{5}$

$\nu = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

44. The impendance (Z) of three electrical components e_1, e_2 and e_3 has frequency (f) dependence as shown by the following three curves. Three components e_1, e_2, e_3 are respectively–



(a) R, L, C (b) R, C, L (c) L, R, C (d) C, R, L

Ans. **(d)**

Sol. $e_1 \rightarrow c, x_C = \dfrac{1}{\omega_C}$

$e_2 \rightarrow R \rightarrow R \rightarrow$ constant

$e_3 \rightarrow L \rightarrow x_L = WL$

45. The half-life period of a radioactive element E_1 is equal to the mean lifetime of another radioactive element E_2. Initially both the elements have the same number of atoms. Therefore,

(a) E_2 will decay faster
(b) E_1 will decay faster
(c) E_1 and E_2 will decay at the same rate
(d) Data insufficient

Ans. (a)

Sol. Half life of 1^{st} is greater

$\therefore$ 2^{nd} will decay faster.

46. A simple pendulum has a bob of mass m and a light string of length *l*. The string is replaced by a uniform rod of mass m and of the same length *l*. The time period of this pendulum is–

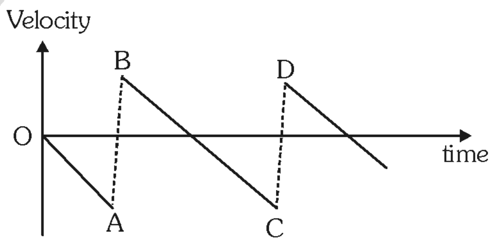
(a) $2\pi(l/g)^{1/2}$
(b) $2\pi(8l/9g)^{1/2}$
(c) $2\pi(9l/8g)^{1/2}$
(d) $2\pi(2l/3g)^{1/2}$

Ans. (b)

Sol. Time period of physical pendulum $= 2\pi\sqrt{\dfrac{I}{Mgx}}$

$$T = 2\pi\sqrt{\frac{\frac{m\ell^2}{3} + m\ell^2}{2mg \times \frac{3\ell}{4}}}$$

47. A tennis ball is released from a height and allowed to fall onto a hard surface. The adjacent graph shows the variation of velocity of the ball with time from the instant of release. The point of upward maximum velocity of the ball is indicated by point–

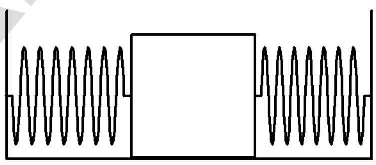


(a) A
(b) B
(c) C
(d) D

Ans. (b)

Sol. Velocity just after 1^{st} collosion.

48. The diagram shows an oscillating block connected to two identical springs. The frequency of oscillations can be increased substantially by–

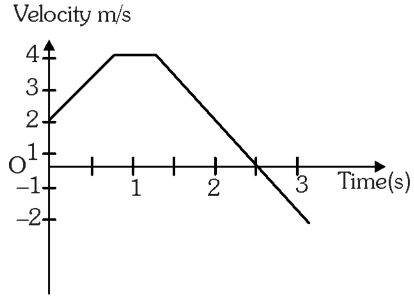


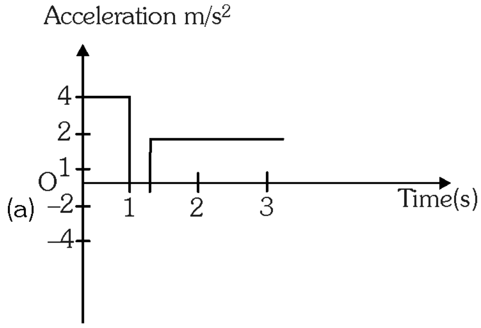
(a) Increasing the amplitude of the oscillations.
(b) Fixing an extra mass to the block.
(c) Using softer pair of springs.
(d) Using harder pair of springs.

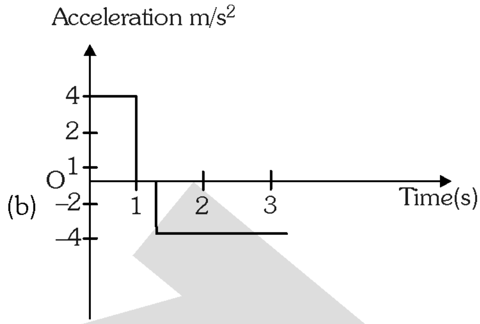
Ans. (d)

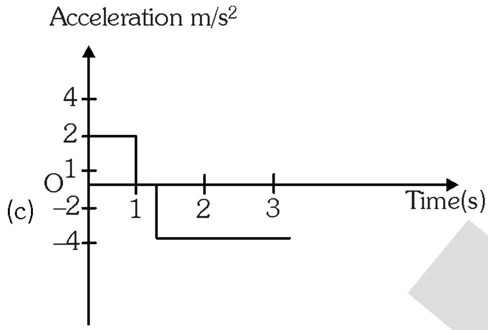
Sol. $\nu = \dfrac{1}{2\pi}\sqrt{\dfrac{2K}{m}}$

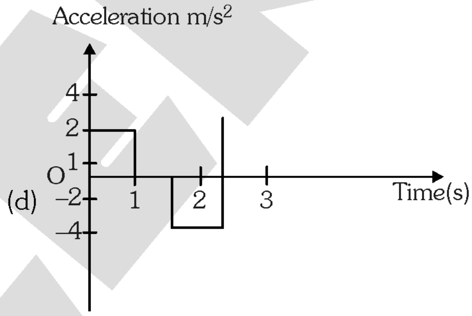
49. The variation of velocity with time of a toy car moving along a straight line is as in adjacent figure. Which of the following graph correctly represents the variation of accleration with time for the toy car?











Ans. **(c)**

Sol. $a = \tan\theta$

50. An ac source (sinusoidal source with frequency 50 Hz) is connected in series with a rectifying diode, a 100 Ω resistor, a 1000 μF capacitor and a milliammeter. After some time the milliammeter reads zero. The voltage measured across the capacitor with a dc voltmeter is–

(a) the peak voltage of the ac source
(b) rms voltage of the ac source.
(c) average voltage of the ac source over a half cycle.
(d) average voltage of the ac source over a full cycle.

Ans. **(a)**

Sol. There is no current in milliammeter it means charge on capacitor is constant.

51. The frequency of the sound produced by a siren increases from 400 Hz to 1200 Hz while its amplitude remains the same. Therefore, the ratio of the intensity of the 1200 Hz wave to that of the 400 Hz wave is–

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

Ans. **(d)**

Sol. $I = \frac{1}{2}\rho\omega^2 A^2 v = \frac{1200}{400} = \frac{3}{1}$

$I \propto v^2$

OR $\frac{9}{1}$

52. The fundamental frequency of the output of a bridge rectifier driven by ac mains is–

(a) 50 Hz (b) zero (c) 100 Hz (d) 25 Hz

Ans. (c)

Sol. Full wave rectifier is bridge rectifier.

53. The force of attraction between the positively charged nucleus and the electron in a hydrogen atom is given by $f = k\frac{e^2}{r^2}$. Assume that the nucleus is fixed. The electron, initially moving in an orbit of radius R_1 jumps into an orbit of smaller radius R_2. The decrease in the total energy of the atom is–

(a) $\frac{ke^2}{2}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ (b) $\frac{ke^2}{2}\left(\frac{R_1}{R_2^2}-\frac{R_2}{R_1^2}\right)$ (c) $\frac{ke^2}{2}\left(\frac{1}{R_2}-\frac{1}{R_1}\right)$ (d) $\frac{ke^2}{2}\left(\frac{R_2}{R_1^2}-\frac{R_1}{R_2^2}\right)$

Ans. (c)

Sol. $= E = \frac{-ke^2}{2R}$

$$= \Delta E = E_1 - E_2 = \frac{+ke^2}{2}\left[\frac{1}{R_2}-\frac{1}{R_1}\right]$$

54. It is observed that some of the spectral lines in hydrogen spectrum have wavelengths almost equal to those of the spectral lines in He^+ ion. Out of the following the transitions in He^+ that will make this possible is–

(a) n = 3 to n = 1 (b) n = 6 to n = 4 (c) n = 5 to n = 3 (d) n = 3 to n = 2

Ans. (b)

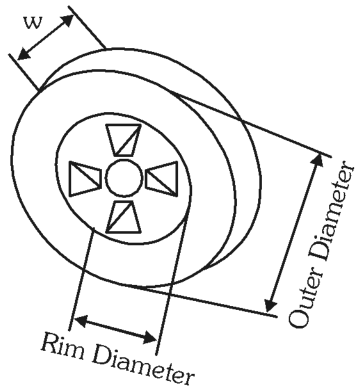
Sol. $= \frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$

$$= \frac{1}{\lambda} = R\times 4\left(\frac{1}{4^2}-\frac{1}{6^2}\right) = R\times\frac{4}{4}\left(\frac{1}{2^2}-\frac{1}{3^2}\right)$$

Group of Q. Nos. 55 to 60 is based on the followig pragraph.

A wheel of a car is made up of two parts (1) the central metal rim, and (2) the rubber tyre. The width of the tyre W = 16.5 cm and height h = 10.7 cm. The rim overlaps the tyre, The total weight of the car is 1500 kg distributed evenly. The tyres are inflated with air to a pressure 2.0 kg/cm^2. The density of air at pressure of 1.0 kg/cm^2 and at room temperature equals 1.29 g/litre. The outer diameter of the tyre is 55.4 cm and that of the rim is 40 cm.

Ignore the thickness of rubber and use the dimensions given here. Note that the units metioned above are conventional units used in everyday life.



55. Consider the following two statements about a tyre of a car.

Statement A : 'The horizontal road surface is exactly tangential to the tyre.'

Statement B: 'The tyre is inflated with excess pressure.'

Which of the following alternatives is correct ?

(a) Statement A is the result of Statement B (b) Statement B cannot be true

(c) Statement A cannot be true (d) Neither of the Statement A and B is ture.

Ans. (a)

Sol. Conceptual

56. The left side front tyre was observed to be in contact with the road over a length L cm. The value of L is

(a) 8.85 cm (b) 9.35 cm (c) 11.36 cm (d) 10.35 cm

Ans. **(c)**

Sol. $1500 = 4 \times 2 \times L \times \omega$

$$L = \frac{1500}{8 \times 16.5} = 11.36\,\text{cm}$$

$\therefore$ (c)

57. When five persons occupy the seats L increases by 2.5 cm. The average weight of a person is

(a) 66 kg (b) 60 kg (c) 62 kg (d) 64 kg

Ans. **(a)**

Sol. $5m = 4 \times 2 \times 2.5 \times 16.5$

$m = 4 \times 16.5 = 66$ kg

58. If five persons occupy the seats, the centre of the wheel is lowered by about

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

Ans. **(c)**

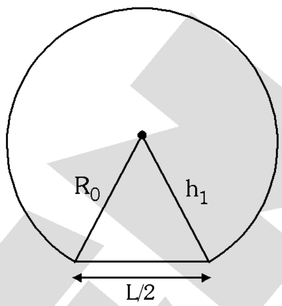
Sol. $$h_1 = \sqrt{R_0^2 - \frac{L^2}{4}}$$

$$h_2 = \sqrt{R_0^2 - \frac{(L + \Delta L)^2}{2}}$$

From above questions

$L = 11.36$; $\Delta L = 2.5$

$\Delta h = h_1 - h_2 \simeq 3\text{mm}$



59. The mass of air in a tyre is about

(a) 24 g (b) 49 g (c) 32 g (d) 62 g

Ans. **(b)**

Sol. $\text{Volume} = \pi\left[(27.7)^2 - (20)^2\right]16.5$

$= 19.029$ litre

Mass of air $= 19.029 \times 2 \times 1.29$

$= 49.095$ gram

60. The tyres of racing cars are very wide. Their width is nearly three times the above value. This large width is for

(a) stability and acceleration. (b) stream lining and acceleration

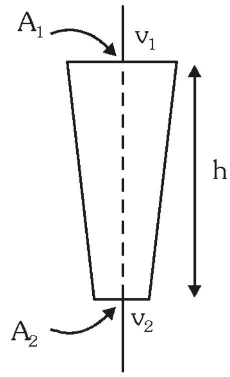
(c) streamlining and stability (d) streamlining, stability and accelearation

Ans. **(a)**

Sol. Conceptual

A-2
ONE OR MORE THAN ONE OPTIONS ARE CORRECT

61. Water is flowing through a vertical tube with varying cross section as shown. The rate of flow is 52.5 ml/s. Given that speed of flow $\upsilon_1 = 0.35$ m/s arid area of cross section $A_2 = 0.5\ \text{cm}^2$. Which of the following is/are true?



(a) $A_1 = 1.0\ \text{cm}^2$, $\upsilon_2 = 0.70$ m/s.

(b) $A_1 = 1.5\ \text{cm}^2$, $\upsilon_2 = 1.05$ m/s.

(c) h = 5 cm.

(d) h = 10 cm.

Ans. **(b,c)**

Sol. $52.5 = A_1 v_1$

$$A_1 = \frac{52.5}{35}\text{cm}^2 = 1.5\ \text{cm}^2$$

$$v_2 = \frac{A_1 v_1}{A_2} = \frac{1.5}{0.5} \times 0.35 = 1.05\ \text{m/s}$$

$$\frac{1}{2}\rho v_1^2 + \rho g h = \frac{1}{2}\rho v_2^2$$

$$v_2^2 - v_1^2 = 2gh$$

$$h = \frac{v_2^2 - v_1^2}{2g} = \frac{0.98}{2 \times 9.8} = \frac{0.1}{2} = 0.05\ \text{m} = 5\ \text{cm}$$

62. A simple laboratory power supply consists of a transformer, bridge rectifier and a filter capacitor. It drives a suitable load If due to some reason one of the diodes in the rectifier circuit becomes open, then

(a) output voltage of power supply falls to zero.

(b) output voltage of power supply decreases to some nonzero value.

(c) ac ripple in the output increases.

(d) ripple frequency decreases.

Ans. **(b, d)**

Sol. Conceptual.

63. Circuit A is a series LCR circuit with $C_A = C$ and $L_A = L$. Another circuit B has $C_B = 2C$ and $L_B = L/2$. Both the circuits have the same resistance and the capacitor and the inductance are assumed to be ideal components. Each of the circuits is connected to the same sinusoidal voltage source. Therefore,

(a) both the circuits have the same resonant frequency.

(b) both the circuits carry the same peak current.

(c) resonance curve for circuit A is more sharp than that for circuit B.

(d) resonance curve for circuit B is more sharp than that for circuit A.

Ans. **(a,c)**

Sol. for $= \dfrac{1}{2\pi\sqrt{LC}}$

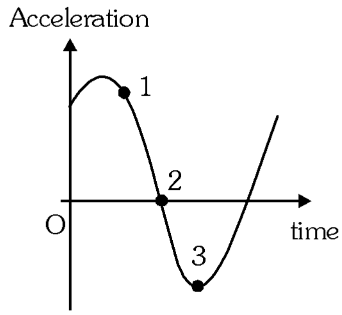
for A $\quad f_1 = \dfrac{1}{2\pi\sqrt{LC}}$

for B $\quad f_2 = \dfrac{1}{2\pi\sqrt{\dfrac{L}{2} \times 2C}} = f_1$

Peak current $= \dfrac{e_0}{R}$ = saw

$$Q = \frac{wL}{R} \Rightarrow Q \propto L$$

64. The variation of acceleration with time for a particle performing simple harmonic motion along straight line is as in adjacent figure. Therefore,



(a) the particle has a non-zero displacement initially.
(b) the displacement of the particle at point 1 is negative.
(c) the velocity of the particle at point 2 is positive.
(d) the potential energy at point 3 is maximum.

Ans. **(a,b,c,d)**

Sol. $a = \frac{dv}{dt}$

$v = \frac{dx}{dt}$

65. Which of the following physical quantities have dimensions identical to each other?
(a) The Young's modulus Y.
(b) $\in_0 E^2$ where E is the electric field intensity and $\in_0$ is the permittivity of free space.
(c) $\frac{B^2}{\mu_0}$ where B is the magnetic field and μ_0 is the permeability of free space.
(d) KT where k is Boltzmann's constant and T is the absolute temperature.

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

Sol. Energy per unit vol = $\frac{1}{2}QE^2 = \frac{B^2}{2\mu_0} = Y$

66. A small ball bearing is released at the top of a long vertical column of glycerin of height 2h. The ball bearing falls through a height h in a time t_1 and then the remaining height with the terminal velocity in time t_2. Let W_1 and W_2 be the work done against viscous drag over these heights. Therefore,

(a) $t_1 < t_2$ (b) $t_1 > t_2$ (c) $W_1 = W_2$ (d) $W_1 < W_2$

Ans. **(b,d)**

Sol. Conceptual.

67. A particle moves in XY plane according to the relations x = kt and y = kt(1 – pt) where k and p are possitive constants and t is time. Therefore,
(a) the trajectory of the particle is a parabola.
(b) the particle has a constant velocity along X axis.
(c) the force acting on the particle remains in the same direction even if book k and p are negative constants.
(d) the particle has a constant acceleration along –Y axis.

Ans. **(a,b,c,d)**

Sol. x = kt   y = kE (1 – Pt)

$t = \frac{x}{k}$

$y = \frac{kx}{k}\left(1 - P\frac{x}{k}\right)$

$y = x - \frac{Px^2}{k}$

68. A charge q is situated at the origin. Let E_A, E_B and E_C be the electric field at the points A(2, –3, –1), B(–1, –2, 4) and C(2, –4, 1). Therefore,

(a) $E_A \perp E_B$ (b) no work is done in moving a test charge q_0 from B to C

(c) $2|E_A| = 3|E_B|$ (d) $E_B = -E_C$

Ans. **(abc)**

Sol. $\vec{E}=\frac{KQ\vec{R}}{R^3}$

$R_A = 2\hat{i}-3\hat{j}-\hat{k}$

$R_B = -\hat{i}-2\hat{j}-4\hat{k}$

$R_C = 2\hat{i}-4\hat{j}+\hat{k}$

$\vec{R}_A \cdot \vec{R}_B = -2+6-4=0$

$\vec{R}_A \perp \vec{R}_B$

$|R_A| = \sqrt{14}$, $|R_B| = \sqrt{21}$, $|R_C| = \sqrt{21}$

69. A uniform spherical charge distribution of radius R produces electric field E_1 and E_2 at two points at distances r_1 and r_2 respectively from the centre of the distribution. Out of the following the possible expression/s for $\frac{E_1}{E_2}$ is / are

(a) $\frac{r_2}{r_1}$ (b) $\left[\frac{r_1}{r_2}\right]^2$ (c) $\frac{R^3}{r_1^2 r_2}$ (d) $\frac{r_1 r_2^3}{R^3}$

Ans. **(c,d)**

Sol. $E_1 = \frac{kq}{r_1^2}$ $\frac{E_1}{E_2} = \frac{r_2^2}{r_1^2}$

$E_1 = \frac{kqr_1}{R^3}$ $E_2 = \frac{kqr_2}{R^3}$

$\frac{E_1}{E_2} = \frac{r_1}{r_2}$

$\frac{E_1}{E_2} = \frac{R^3}{r_1^2 r_2}$

70. A metallic wire of length l is held between two supports under some tension. The wire is cooled throutgh $\theta°$. Let Y be the Young's modulus, ρ the density and α the thermal coefficient of linear expansion of the material of the wire. Therefore, the frequency of oscillations of the wire varies as–

(a) $\sqrt{Y}$ (b) $\sqrt{\theta}$ (c) $\frac{1}{l}$ (d) $\sqrt{\frac{\alpha}{\rho}}$

Ans. **(a,b,c,d)**

Sol. $v = \frac{1}{2\ell}\sqrt{\frac{F}{\rho}}$

$v = \frac{1}{2\ell}\sqrt{\frac{YA \times Q}{\rho}}$

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