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INDIAN ASSOCIATION OF PHYSICS TEACHERS

NATIONAL STANDARD EXAMINATION IN PHYSICS (NSEP) 2016-17

Examination Date : 27-11-2016 | **Time: 2 Hrs.** | **Max. Marks : 240**

PAPER CODE : P163 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 gets 3 marks. A wrong one gets a penalty of 1 mark. Part A2 full marks are 6 for each question; you get them when ALL correct answers are marked.
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 hail 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 sent by email only to** iapt.nse@gmail.com till 29th November, 2016.
12. The answers/solutions to this question paper will be available on our website — www.iapt.org.in by 2nd December, 2016.
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, 2016. 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.

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

A – 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT

1. 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)**

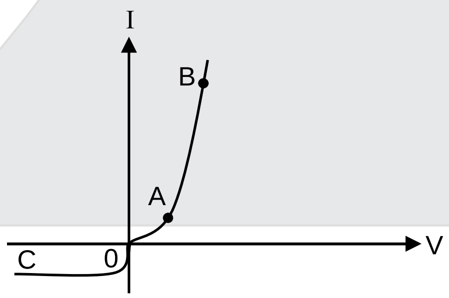
Sol. $f' = \left(\frac{320+2}{320}\right)400$

$f'' = \left(\frac{320-2}{320}\right)400$

$of = 400\left[\frac{322}{320} - \frac{318}{320}\right)$

$\Delta f = \frac{400 \times 4}{320} = 5$

2. 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 directions of Y-axis. Therefore,



(A) only statement (I) is correct

(B) only statements (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. OC is reverse bias while potential of point A is approx 0.7 volt.

Hence answer is (C).

3. 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 behaves as

(A) convex lens of focal length 27 cm
(B) convex 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. $\frac{1}{f} = \frac{2(\mu-1)}{R}$

$\frac{1}{12} = \frac{2(1.5-1)}{R} = \frac{1}{R}$

R = 12 cm

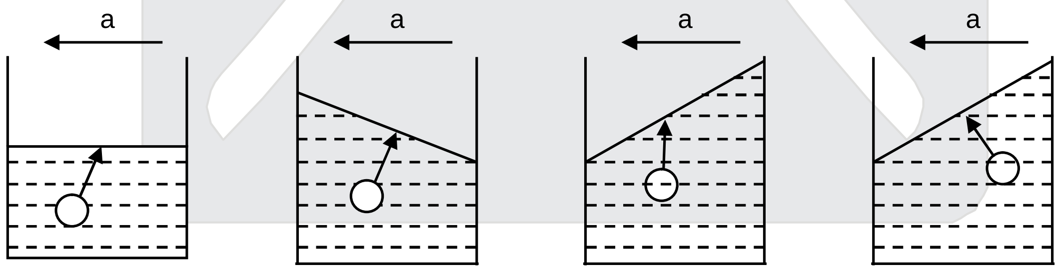
$\frac{1}{f_w} = \frac{2[\mu_r - 1]}{R}$

$\frac{1}{f_w} = \frac{2\left[\frac{1.5}{1.35}-1\right]}{12} = \frac{2\times 0.15}{12\times 1.35}$

$f_w = 54$

$\frac{1}{f_{eq}} = \frac{2}{54} \quad \Rightarrow \quad f_{eq} = 27$ cm

4. 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.

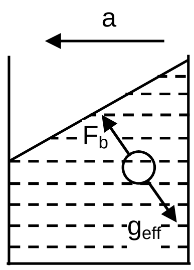


(A) (B) (C) (D)

(A) A (B) B (C) C (D) D

Ans. **(D)**

Sol.



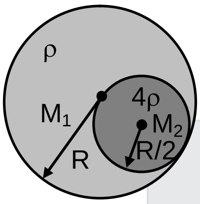
w.r.t. container

5. 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.



$M_1 = \rho \times \frac{4}{3}\pi R^3 = M$

$M_2 = 4\rho \times \frac{4}{3}\frac{\pi R^3}{8} = \frac{M}{2}$

$= \frac{M}{8} \times 4 = \frac{M}{2}$

$X_{cm} = \dfrac{0 + \frac{M}{2} \times \frac{R}{2}}{\frac{3M}{7}} = \frac{R}{6}$

6. 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)**

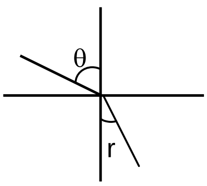
Sol. $V = \dfrac{E}{R + \frac{r}{2}} \times R = \frac{2ER}{2R + r}$

7. The critical angle between a certain transparent medium and air is ϕ. A ray of light traveling 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.



Brawster's law

$\tan\theta = \mu$

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

$\cot r = \frac{1}{\sin\ \phi} \quad \Rightarrow \quad r = \tan^{-1}(\sin\phi)$

8. 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. $R \propto \frac{1}{r^4}$

%R = 4 × 0.1 = 0.4%

9. 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. $V = \frac{fu}{u+f} = \frac{5\times(-30)}{-30+5} = \frac{-5\times 30}{-25} = 6\text{cm}$

10. 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. $w = \frac{D\lambda}{d}$

since $v = f\lambda$

since vacuum is made, λ increased fringe width increases

11. 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.

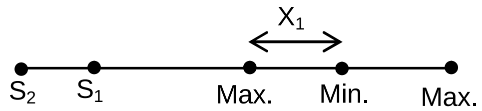
(B) Changing the amplitude of the signal voltage

(C) Changing the frequency of the signal voltage

(D) Replacing the air in the room with a different gas.

Ans. **(B)**

Sol.



$X_1 = \lambda/2$

Since x_1 depends on λ then

Now $v = f\lambda$

if frequency change, λ changes

medium change then v change

amplitude change then no effect on λ

12. A particle at rest explodes into two fragments of masses m_1 and m_2 ($m_1 > m_2$) which move apart with nonzero velocities. If λ_1 and λ_2 are their de-Broglie wavelengths respectively, then

(A) $\lambda_1 > \lambda_2$ (B) $\lambda_1 < \lambda_2$ (C) $\lambda_1 = \lambda_2$ (D) data insufficient

Ans. **(C)**

Sol. We know

$P = \frac{h}{\lambda}$

$\Rightarrow \quad \lambda = \frac{h}{P}$

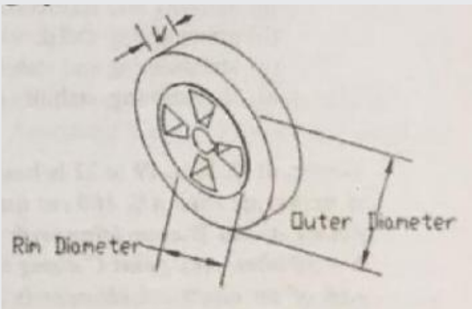
Since particle is initial in rest then after explodes two particle has same momentum then

$P_1 = P_2$

$\lambda_1 = \lambda_2$

Group of Q. No. 13 to 18 is based on the following paragraph.

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 mentioned above are conventional units used in everyday life.

13. 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 statements A and B is true.

Ans. **(C)**

Statement 1 is incorrect due to continuous contact of tyre at the ground.

Statement 2 is correct.

14. 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 (C) 11.36 (D) 10.35 cm

Ans. **(C)**

Sol. $\underbrace{\left[(L)\frac{16.5}{100}\right]}_{\text{area of contact}} \quad \underbrace{\left[\frac{2\times 10}{10^{-4}}\right]}_{\text{pressure of air}} \quad \underbrace{\times 4}_{\text{no of tyres}} \quad = \quad \underbrace{(1500)g}_{\text{weight of car with of pressure}}$

L = 11.36 cm

15. 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. $\frac{(11.36+2.5)}{100} \times \frac{2 \times 10}{10^{-4}} \times 4 = (1500 + 5m)g$

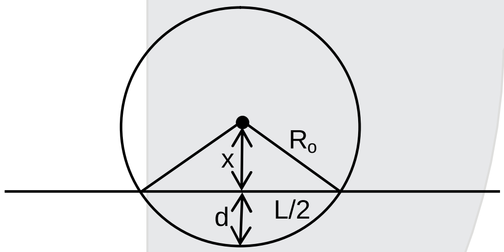
$m \approx 66kg$

16. 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.



$x = \sqrt{R_0^2 - \frac{L^2}{4}}$

$d = R_0 - \sqrt{R_0^2 - \frac{L^2}{4}}$

$d_i = 0.60$ cm $[L_i = 11.36]$

$d_f = 0.90$ $[L_f = 11.36 + 2.5]$

$d_f - d_i = 3$mm

17. The mass of air in a tyre is about

(A) 24 g (B) 49 g (C) 32 g (D) 64 g

Ans. **(D)**

Sol. h = 10.7 cm

$R_o = \frac{55.4}{2}$ cm

$V_{air} = [\pi R_0^2 - \pi[R_0 - h]^2]w$

$m_{air} = V_{air}$ (2 × 1.29)

$\approx$ 64 gm

18. 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) streamlining and acceleration

(C) streamlining and stability (D) streamlining, stability and acceleration

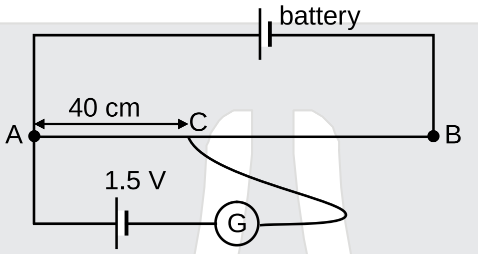
Ans. **(A)**

Sol. Since width increases, stability is increased and acceleration also increased.

Group of Q. 19 to 22 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 on end of and electrical element is connected. In the following questions this arrangement will be referred to as 'wire AB'.

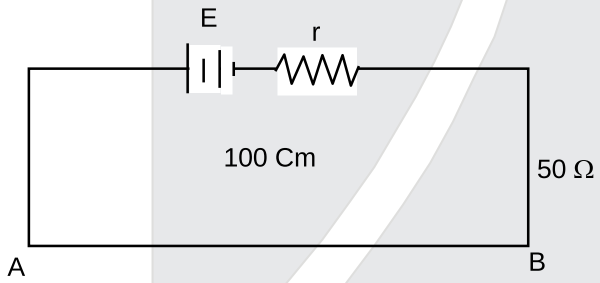
19. The emf of a battery is determined using the following circuit with 'wire AB' , The galvanometer shows zero deflection when one of its terminals is connected to point C. If the internal resistance of the battery is 4 ohm, its emf is



(A) 3.75 volt (B) 4.05 volt (C) 2.50 volt (D) 9.0 volt

Ans. (B)

Sol.



Current is AB = $\frac{E}{50+4}$

Potential gradient

$$x = \left(\frac{E}{50+4}\right)\frac{50}{100}$$

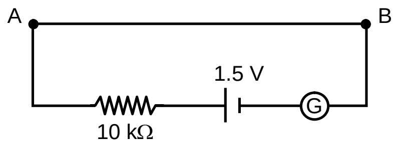
For Balancing length

$$v = x\ell$$

$$1.5 = \left(\frac{E}{50+4}\right)\frac{1}{2}\times 40$$

$$E = 4.05$$

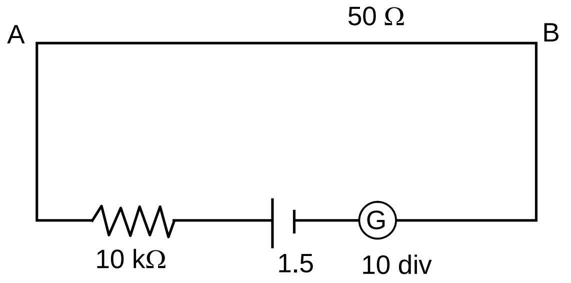
20. In the circuit adjacent arrangement it is found that deflection in the galvanometer is 10 divisions. Also the voltage across the 'wire AB' is equal to the across the galvanometer. Therefore, the current sensitivity of the galvanometer is about.



(A) 0.050 div/μA. (B) 0.066 div/μA (C) 0.0140 div/μA (D) data insufficient

Ans. (B)

Sol.



$R_G = 50\Omega$

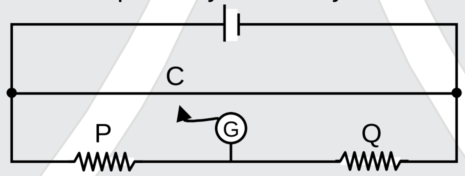
$I = \frac{1.5}{10100}$

Current sensitivity = $\frac{\text{Deflection}}{\text{Current}}$

$\frac{10}{1.5} \times 10100$

$\frac{10 \times 0.010100}{1.5} = 0.067 \frac{\text{Div}}{\mu A}$

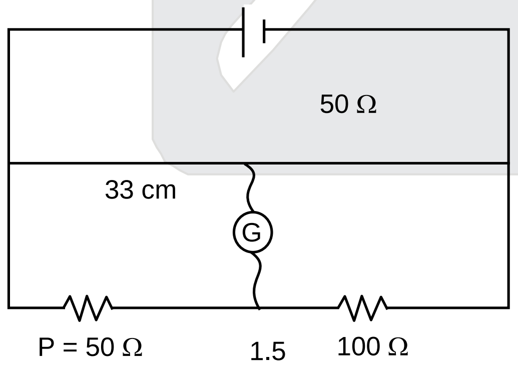
21. The 'wire AB' is now a part of the adjacent circuit. With the resistors P = 50 Ω and Q = 100 Ω, the null point is obtained at C where AC = 33 cm. When the resistors are interchanged, the null point is found at C with AC = 67 cm. The systematic error in this experiment seems to be due to non-coincidence of A and B with 0 cm mark and 100 cm mark respectively. If these end errors are 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.



For Case …(i)

$\frac{33+a}{67+b} = \frac{1}{2}$

For Case …(ii)

$\frac{67+a}{33+b} = \frac{2}{1}$

66 + 2a = 67 + b

66 + 2b = 67 + a

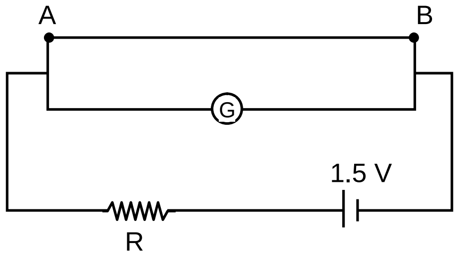
2a – b = 1

–a + 2b = 1

3b = 3

b = 1, a = 1

22. 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 divisions. Therefore



(A) R = G (B) R << G (C) R >> G (D) $R = \frac{SG}{S+G}$

Ans. **(C)**

Sol. Current through G is Case – I

$$I_0 = \frac{E}{R+G}$$

Current through G is Case - II

$$I_1 = \frac{E}{\left(\frac{GS}{S+G}+R\right)} \times \frac{S}{(S+G)}$$

R >> G $\quad I_1 = \frac{I_0}{2}$

23. 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. $\Delta g_h = -g\left(\frac{2h}{R}\right)$, h<<R

$$\Delta g_x = -g\left(\frac{x}{R}\right)$$

$\Delta g_h = \Delta g_x$

$\Rightarrow \quad 2h = x$

$\Rightarrow \quad \frac{x}{h} = \frac{2}{1}$

24. 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) $\frac{1}{2}\left(\frac{m_1m_2}{m_1+m_2}\right)\ell^2$ (B) $\left(\frac{m_1m_2}{m_1+m_2}\right)\ell^2$

(C) $(m_1+m_2)\ell^2$ (D) $\left[m_1^2+m_2^2\right]\left(\frac{m_1+m_2}{m_1+m_2}\right)\ell^2$

Ans. **(B)**

Sol. $I = \mu\ell^2$

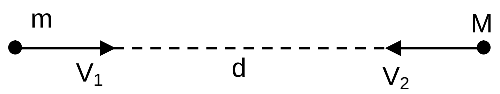
$$= \left(\frac{m_1 m_2}{m_1+m_2}\right)\ell^2$$

25. 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.

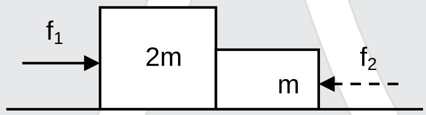


$$0 + 0 = -\frac{GmM}{d} + \frac{1}{2}mv_1^{\,2} + \frac{1}{2}Mv_2^{\,2}$$

$$\frac{GMm}{d} = \frac{1}{2}\frac{mM}{m+M}(V_{re\ell})^2$$

$$V_{re\ell} = \left(\frac{2G(M+m)}{d}\right)^{1/2}$$

26. 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. Case-I : $a_1 = \frac{f_1}{3m}$

$N_1 = ma_1 = \frac{f_1}{3}$

Case-II : $a_2 = \frac{f_2}{3m}$

$N_2 = 2ma_2 = \frac{2f_2}{3}$

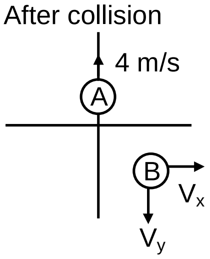
$\because$ $N_1 = N_2 \Rightarrow \frac{f_1}{3} = \frac{2f_2}{3}$ $\frac{f_1}{f_2} = \frac{2}{1}$

27. 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, then 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. Before collision After collision



For conservation of momentum along x –axis

$5 + 0 = mv_x$

Now along y-axis

$0 + 0 = 4 - mv_y$

Total Kinetic energy will remain same

$$\frac{1}{2}15^2 = \frac{1}{2}116+\frac{1}{2}m\left(v_x^2+v_y^2\right)$$

$$\frac{1}{2}\times 9=\frac{1}{2}m\left(\frac{25}{m^2}+\frac{16}{m^2}\right)$$

$$9 = \frac{41}{m} \qquad m \approx 4.6 \text{ kg}$$

$$\text{Momentum } = m\sqrt{\frac{25}{m^2}+\frac{16}{m^2}}=6.4\,\text{kgm/s}$$

28. Consider a relation connecting three physical quantities A, B and C given by $A = B^n C^m$. 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. $A = B^n C^m$

$LT = (L^2T^{-1})^n (LT^2)^m$

$2n + m = 1$

$-n + 2m = 1$

$5m = 3$

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

29. 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. $n=\frac{PV}{RT}$

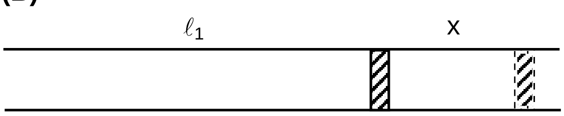
$n\propto\frac{1}{T}$

30. 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.



$2\ell_1 = n\lambda$

$2\ell_1 + 2x = n\lambda + \frac{\lambda}{2}$

$x=\frac{\lambda}{4}=\frac{v}{4f}$

$\Rightarrow f=\frac{v}{4x}=\frac{350}{4(8.75)\times10^{-2}}$

$= 1000\ H_Z$

31. 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–^{0}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) 12ºC (B) 50ºC (C) 211ºC (D) data insufficient

Ans. **(A)**

Sol. $\mu mgd \times \frac{25}{100} = ms\Delta\theta$ $\quad\quad d = \frac{20\times10^3}{60}\times10 = \frac{1}{3}\times10^3$

$0.6\times10\times\frac{20}{6}\times10^3\times\frac{25}{100} = 0.1 \times 4.2 \times 10^3\Delta\theta$

$\Delta\theta = \frac{5}{0.42} \approx 12°C$

32. 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 done as there is no transfer of energy
(D) The total internal energy of the system will not change

Ans. **(B)**

Sol. Same

33. 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. $E = \frac{KQ}{r^2}$

$2 \times 10^6 = \frac{9\times10^9 Q\times4}{\left(\frac{10}{2}\times10^{-2}\right)^2} \quad\Rightarrow\quad Q = 5.6 \times 10^{-7}C$

34. A wire in the shape of a 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) $\frac{8\pi}{\sqrt{2}}$

Ans. **(C)**

Sol. $B_s = \frac{2\sqrt{2}\mu_0 I}{\pi a}$

$4a = 2\pi r$

$r = \frac{2a}{\pi}$

$B_c = \frac{\mu_0 I}{4\pi r} \times 2\pi = \frac{\mu_0 I\times\pi}{2\times2a}$

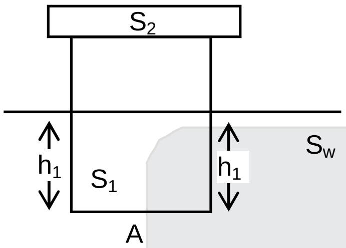
$\frac{B_s}{B_c} = \frac{2\sqrt{2}\times4}{\pi^2}$

35. A solid wooden block with a uniform cross sections 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. Afterward 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.



$\rho_1 HAg = \rho_w h_1 Ag$

$h_1 = \frac{\rho_1 H}{\rho_w}$ ...(i)

$\rho_1 HAg + \rho_2 Vg = \rho_w Ah_2 g$

$h_2 = \frac{\rho_1 AH + \rho_2 V}{\rho_w A}$ ...(ii)

$\rho_w Vg + \rho_w Ah_3 g = \rho_w Ah_2 g$

$V = A(h_2 - h_3)$

$h_2 = \frac{\rho_1 AH + \rho_2 A(h_2 - h_3)}{\rho_w A}$

$h_2 = \frac{(h_1 s_w) + S_2(h_2 - h_3)}{S_w}$

$\rho_w h_2 - h_1 \rho_w = \rho_2(h_2 - h_3)$

$\rho_2 = \frac{(h_2 - h_1)}{h_2 - h_3}\ \rho_w$

36. 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)**

37. 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. **(A)**

Sol. $\frac{(IA)}{100} = \frac{Nhc}{\lambda}$

$\frac{1\times10^{-4}}{100} = N\times\frac{12400}{3000} \times 1.6 \times 10^{-19}$

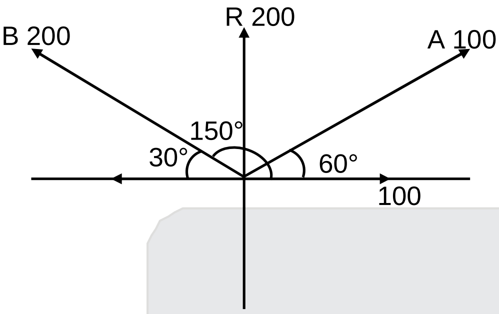
$N = 1.5 \times 10^{12}$ (approx)

38. 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 60º, 150º and 90º respectively. Therefore the magnitude and the angle made by C with positive direction of X axis respectively are

(A) 75, 315º (B) 110, 45º (C) 156, 240º (D) 124, 6.2º

Ans. **(D)**

Sol.



$\left(\frac{100}{2}\hat{i} - 200 \times \frac{\sqrt{3}}{2}\hat{i} + c_x\hat{i}\right) = 0$

$C_x = \left(100\sqrt{3} - 50\right)\hat{i}$

$C_x = 50(2\sqrt{3} - 1)$

$C_y = \left(200 - 50\sqrt{3} - 100\right)\hat{j}$

$= \left(100 - 50\sqrt{3}\right)\hat{j}$

$= 50\left(2 - \sqrt{3}\right)\hat{j}$

$= 50\left(\sqrt{3} + 2\right)$

$C = 50\sqrt{12 + 1 - 4\sqrt{3} + 3 + 4 + 4\sqrt{3}}$

$= 50\sqrt{20} = 2\sqrt{5}$

$= 100\sqrt{5}$

$50\sqrt{20 - 8\sqrt{3}}$

$= 100\sqrt{5 - 2\sqrt{3}}$

$= 124$

$\tan\alpha = \frac{C_y}{C_x} = \frac{50 \times (2 - \sqrt{3})}{50(2\sqrt{3} - 1)} = 0.109$

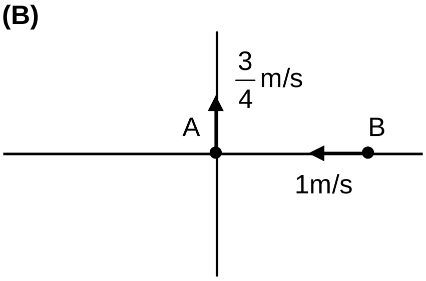
$\alpha = \tan^{-1}(0.109) = 6.2°$

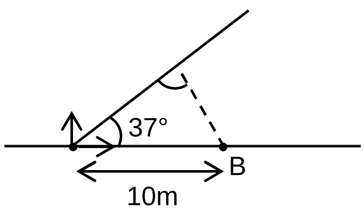
39. Two particles A and B are situated 10 m apart along X axis, B being farther right of A, at t = 0. Particle A is moving at 0.75 m/s parallel to +Y axis while B at 1 m/s along –X axis. After a time t they come closest to each other. Therefore, t is

(A) 4.8 s (B) 6.4 s (C) 6.0 s (D) 3.2 s

Ans. **(B)**

Sol.





$t = \frac{10\cos 37°}{\sqrt{1^2 + (3/4)^2}} = 6.4$ sec.

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

(A) $\frac{d^2x}{dt^2}+\frac{x}{\pi}=0$ (B) $\frac{d^2x}{dt^2}+\frac{x}{\pi^2}=0$ (C) $\frac{d^2x}{dt^2}+\pi x=0$ (D) $\frac{d^2x}{dt^2}+\pi^2 x=0$

Ans. **(D)**

Sol. T = 2sec.

$\omega = \frac{2\pi}{2} = \pi$

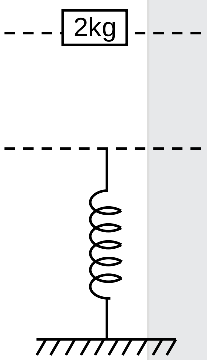
$\frac{d^2x}{dt^2}+\omega^2 x=0$

41. 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.



$mg(h + x) - \frac{kx^2}{2} = 0 + 0$

$2mg(h+x) = kx^2$

$2 \times 2g\ (0.4) + 40x = 1960x^2$

$(g = 9.8\ m/s^2)$

$x = 0.1$ m

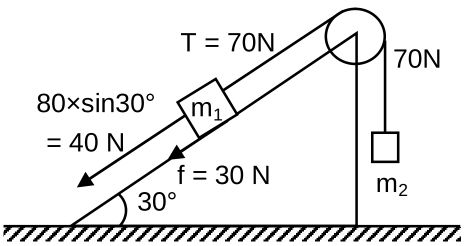
42. Two blocks of masses m_1 = 8 kg and m_2 = 7 kg are connected by a light string passing over a light frictionless pulley. The mass m_1 is at rest on the inclined plane and mass m_2 hangs vertically. The angle of inclination is 30º. Therefore, the force of friction acting on m_1 is

(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.



43. 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 uniform magnetic field and move along circular paths of radii R_1 and R_2 respectively. Therefore 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. $R_1 = \dfrac{\sqrt{2m_1qv}}{qB}$

$R_2 = \dfrac{\sqrt{2m_2qv}}{qB}$

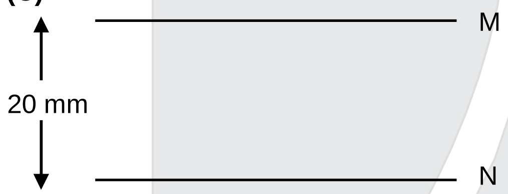
$\dfrac{R_1}{R_2} = \sqrt{\dfrac{m_1}{m_2}} \qquad \Rightarrow \qquad \dfrac{m_1}{m_2} = \left(\dfrac{R_1}{R_2}\right)^2$

44. 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.



$\left(\dfrac{\mu_0 I_1 I_2}{2\pi d}\right) = \lambda g$

$\dfrac{4\pi \times 10^{-7} \times 200 \times I_2}{2\pi \times 20 \times 10^{-3}} = 10^{-2} \times 10$

$2 \times 10^{-6} \times I_2 = 10^{-4}$

$I_2 = \dfrac{10^{-4}}{2 \times 10^{-6}} = \dfrac{100}{2} = 50A$

45. An unpolarized 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, the angle between the transmission axes of the first two polarizers is

(A) 30º (B) 19º (C) 45º (D) 90º

Ans. **(A)**

Sol. $\dfrac{I_0}{2}\cos^2\theta \sin^2\theta = I$

$\dfrac{32 W/m^2}{2} \cos^2\theta \sin^2\theta = 3$

$4\cos^2\theta \sin^2\theta = \dfrac{3}{16} \times 4$

$(\sin 2\theta)^2 = \dfrac{3}{4}$

$\sin 2\theta = \dfrac{\sqrt{3}}{2}, \qquad \sin 2\theta = -\dfrac{\sqrt{3}}{2}$

$2\theta = 60° \qquad 2\theta = 120°$

$\theta = 30° \qquad \theta = 60°$

Ans. (A) (option not given)

46. An electron is injected directly 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)**

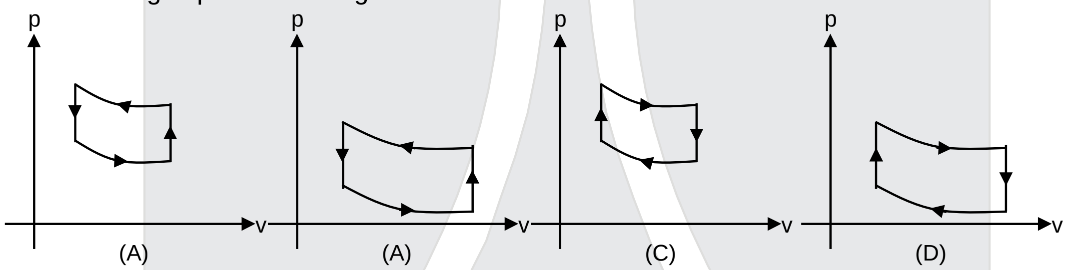
Sol. $E = \dfrac{2\times10^{-6}}{2\times8.85\times10^{-12}} = \dfrac{2\times10^{6}}{16.70}\times2$

$F = \dfrac{16\times2\times10^{6}\times10^{-19}}{16.7\times10} = \dfrac{10\times10^{5}\times10^{-19}\times2}{2}$

$F = 2 \times 10^{-14}$

$\dfrac{2\times10^{-6}}{8.85\times10^{-12}}\times1.6\times10^{-19}\times d$; $d = \dfrac{8.85\times10^{-12}}{2\times10^{-8}}$; $d = 4.42 \times 10^{-4}$ m

47. 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

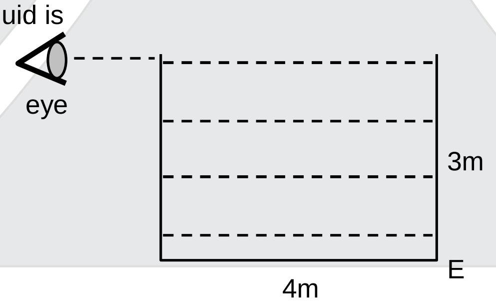


(A) A (B) B (C) C (D) D

Ans. **(D)**

Sol. greatest area in clockwise direction

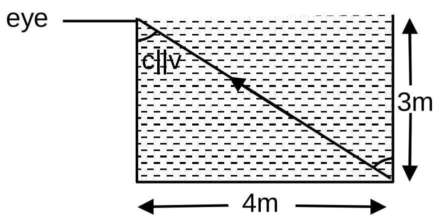
48. A rectangular metal tank filled with a certain liquid is as shown in the figure. The observer, whose eye is in level with the top of the tank can just see the corner E of the tank. Therefore, the refractive index of the liquid is



(A) 1.67 (B) 1.50 (C) 1.33 (D) 1.25

Ans. **(D)**

Sol.

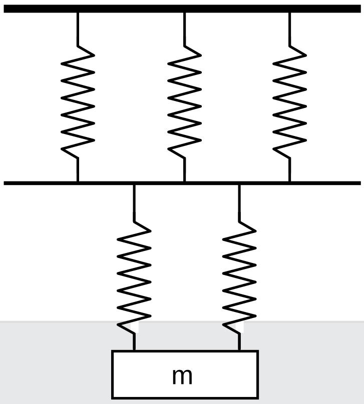


$\tan\theta = \dfrac{4}{3} \Rightarrow \theta = 53° =$ critical angle

$\sin c = \dfrac{n_r}{n_d}$

$\dfrac{4}{5} = \dfrac{1}{\mu} \Rightarrow \qquad \mu = \dfrac{5}{4} = 1.25$

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



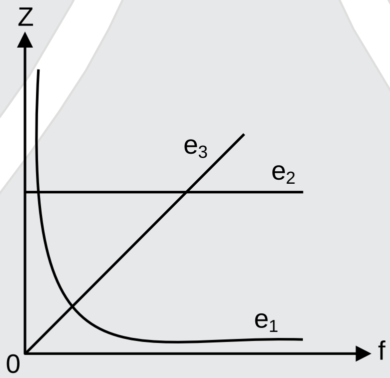
(A) $\frac{1}{2\pi}\sqrt{\frac{3k}{2m}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{2k}{3m}}$ (C) $\frac{1}{2\pi}\sqrt{\frac{5k}{6m}}$ (D) $\frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

Ans. **(D)**

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

$f = \frac{1}{2\pi}\sqrt{\frac{k_{eq}}{m}} = \frac{1}{2\pi}\sqrt{\frac{6k}{5m}}$

50. The impedance (Z) of three electrical components e_1, e_2 and e_3 has frequency (f) dependence as shown by the following three curves.



The 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. $X_C = \frac{1}{\omega C}$ $\Rightarrow$ $X_C \propto \frac{1}{\omega}$

$\Rightarrow$ hyperbolic graph for capacitor

$X_L = \omega L$ $\Rightarrow$ $X_L \propto \omega$

$\Rightarrow$ straight line with positive slope is inductor.

$e_1 \rightarrow$ C

$e_2 \rightarrow$ R

$e_3 \rightarrow$ L

51. 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. $\frac{0.693}{\lambda_1} = \frac{1}{\lambda_2}$ (both have equal number of nuclei

$\Rightarrow \quad \frac{\lambda_1}{\lambda_2} = 0.693$

$\Rightarrow \quad \lambda_1 < \lambda_2$

$\Rightarrow$ E_2 will decay faster.

52. 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 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

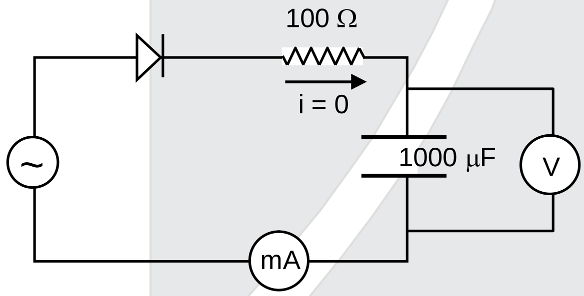
(B) rms voltage of the ac source

(C) average voltage of the ac source over a half cycle

(D) average voltage of the ac source over a full cycle.

Ans. (C)

Sol.



In this state the circuit will work as half wave rectifier and the voltage across capacitor will be equal to average value of voltage of ac source over a half cycle.

53. 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. There are two views

I^{st} : If displacement amplitude remains same than

$I \propto f^2$

$\Rightarrow \quad \frac{I_1}{I_2} = \frac{f_1^2}{f_2^2} = \frac{1}{9}$

$\frac{I_{1200H_2}}{I_{400H_2}} = \frac{9}{1}$

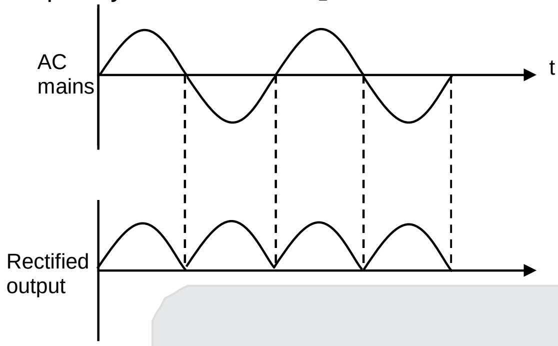
II^{st} : If pressure amplitude remains same than $\frac{I_{1200H_2}}{I_{400H_2}} = \frac{1}{1}$

54. 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. frequency doubles = $100H_2$



55. 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) $\frac{ke^2}{2}\left(\frac{R_2}{R_1^2}-\frac{R}{R_2^2}\right)$

Ans. (C)

Sol. $F = \frac{ke^2}{r^2}$

$\frac{ke^2}{r^2} = \frac{mv^2}{r}$ T.E. = $\frac{ke^2}{2r} + -\frac{ke^2}{r}$

$mv^2 = \frac{ke^2}{r}$ $T.E_i = mv^2 = \frac{-ke^2}{2r_1}$

$\Rightarrow$ $\frac{1}{2}mv^2 = \frac{ke^2}{2r}$ $T.E_f = \frac{-ke^2}{2r_2}$

decrease = $T.E._i - T.E._f = \frac{-ke^2}{2r_1} - \left(\frac{-ke^2}{2r_2}\right) = \frac{ke^2}{2}\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$

56. 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. $13.6 \times 4 \times \left(\frac{1}{16}-\frac{1}{36}\right) = 13.6 \times \left(\frac{1}{4}-\frac{1}{9}\right)$

ΔE in 6 to 4 in He+

matches with ΔE in H of 3 to 2

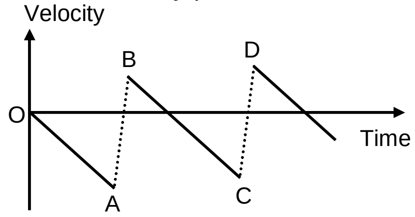
57. A simple pendulum has a bob of mass m and a light string of length ℓ. The string is replaced by a uniform rod of mass m and of the same length ℓ. The time period of this pendulum is

(A) $2\pi(\ell/g)^{1/2}$ (B) $2\pi(8\ell/9g)^{1/2}$ (C) $2\pi(9\ell/8g)^{1/2}$ (D) $2\pi(2\ell/3g)^{1/2}$

Ans. (B)

Sol. $T = 2\pi\sqrt{\frac{m\frac{\ell^2}{3}+m\ell^2}{2mg\frac{3\ell}{4}}} = 2\pi\sqrt{\frac{8\ell}{9g}}$

58. A tennis ball is released from a height and allowed to fall onto a hard surface. The graph below 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

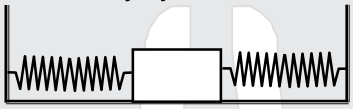


(A) A (B) B (C) C (D) D

Ans. **(B)**

Sol. The velocity immediately after 1st impact

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



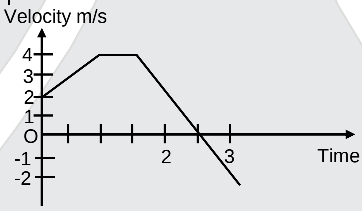
(A) Increasing the amplitude of the oscillations (B) Fixing an extra mass to the block
(C) Using softer pair of springs (D) Using harder pair of springs.

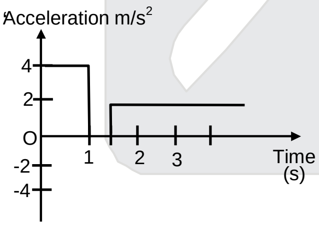
Ans. **(D)**

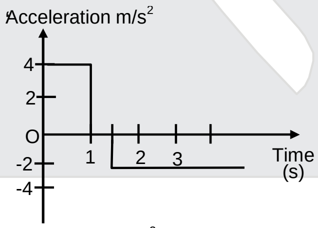
Sol. $f = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$ $f\uparrow\ k\uparrow$

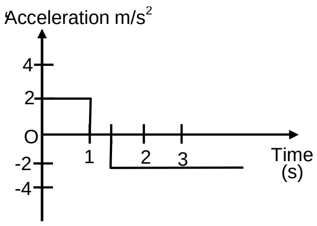
using harder pair of springs

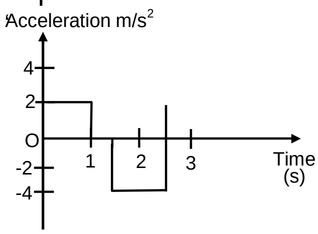
60. The variation of velocity with time of a toy car moving along a straight line is as shown below. Which of the following graphs correctly represents the variation of acceleration with time for the toy car ?



(A)


(B)


(C)


(D)


Ans. **(D)**

Sol. for 0 to 1 seconds velocity increases linearly

$$a = \frac{4-2}{1-0} = 2m/s^2$$

Ĝ= a vs t graph is st. line parallel to x–axis (+ve acceleration)

for 1 to 1.5 sec. $v \rightarrow$ cost $\Rightarrow a = 0$

for $t > 1.5$ sec. a is negative

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 particle moves in XY Plane according to the relations x = kt and y = kt(1 –pt) where k and p are positive constants and t is time. Therefore,
(A) the trajectory of the particle is parabola
(B) the particle has constant velocity along X axis
(C) the force acting on the particle remains in the same direction even if both k and p are negative constants.
(D) the particle has a constant acceleration along –Y axis

Ans. **(ABCD)**

Sol. $x = Kt$ $\qquad$ $y = Kt(1 - pt)$
$V_x = K$ $\qquad$ $V_y = (K - 2Kpt)$
$a_x = 0$ $\qquad$ $a_y = (-2Kp)$

$y = x - \frac{px^2}{K}$

62. A charge q is situated at the origin. Let E_A, E_B and E_C be the electric fields 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 is done in moving a test charge q_1 from B to C.
(C) $2|E_A| = 3||E_B|$
(D) $E_B = -E_C$

Ans. **(ABC)**

Sol. $\vec{E}_A \cdot \vec{E}_B = 0$
Potential at B = potential at C

63. A uniform spherical charge distribution of radius R produces electric fields 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) $\frac{r_2}{r_1}$ $\qquad$ (B) $\left[\frac{r_1}{r_2}\right]^2$ $\qquad$ (C) $\frac{R^3}{r_1^2 r_2}$ $\qquad$ (D) $\frac{r_1 r_2^2}{R^3}$

Ans. **(CD)**

Sol. Electric field at outside point is equal to $\frac{Kq}{r^2}$

Electric field at inside point is equal to $\frac{\rho r}{3\varepsilon_0}$

r_2 is in inside and r_1 is in outside

then $\frac{E_1}{E_2}$ is equal to $\frac{R^3}{r_1^2 r_2}$

If both are inside point then $\frac{E_1}{E_2} = \frac{r_1}{r_2}$

If both are outside point then $\frac{E_1}{E_2} = \left(\frac{r_2}{r_1}\right)^2$

64. A metallic wire of length ℓ is held between two supports under some tension. The wire is cooled through $\theta°$. 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

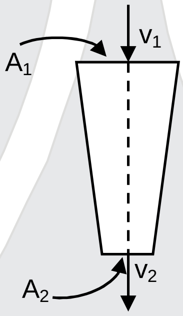
(A) $\sqrt{Y}$ (B) $\sqrt{\theta}$ (C) $\frac{1}{\ell}$ (D) $\sqrt{\frac{\alpha}{\rho}}$

Ans. **(ABCD)**

Sol. $f = \frac{n}{2\ell}\sqrt{\frac{T}{\mu}}$; $\frac{\frac{T}{A}}{\frac{\Delta\ell}{\ell}} = \gamma$

$$\frac{\frac{T}{A}}{\frac{\ell\alpha\Delta\theta}{\ell}} = \gamma \quad \Rightarrow \quad T = A\alpha\gamma\theta \quad \therefore \; f = \frac{1}{2\ell}\sqrt{\frac{A\alpha\gamma\theta\ell}{m}} = \frac{1}{2\ell}\sqrt{\frac{\alpha\gamma\theta}{\rho}}$$

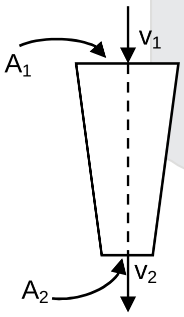
65. Water is flowing through a vertical tube with varying cross section as shown. The rate of flow is 52.5 mℓ/s. Given that speed of flow v_1 = 0.35 m/s and area of cross section A_2 = 0.5 cm^2. Which of the following is/are true ?



(A) A_1 = 1.0 cm^2, v_2 = 0.70 m/s (B) A_1 = 1.5 cm^2, v_2 = 1.05 m/s
(C) h = 5 cm (D) h = 10 cm

Ans. **(BC)**

Sol.



$A_1V_1 = A_2V_2$ = 52.5 ml/s (continuity)
on solving
A_1 = 1.5 cm^2, V_2 = 1.05 m/s
Using Bernoulli's equation at point 1 and 2, we get
h = 5 cm

Note : Assume that pipe is open from both given ends.

66. A simple laboratory power supply consists of a transformer, bridge rectifier and a filter capacitor 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. **(BC)**

Sol. since efficiency of half wave is less than full wave, output power decreased and since energy is only passing through one path, ripple increase.

67. 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 ideal components. Each of the circuits is connected to the same sinusoidal voltage source. Then

(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

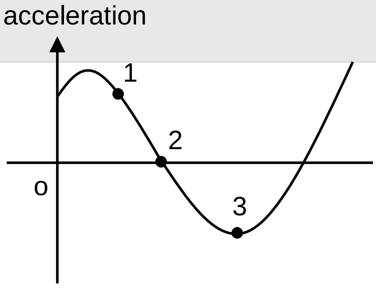
(D) resonance curve for circuit B is more sharp than that for circuit A

Ans. **(AC)**

Sol. $w_1 = \frac{1}{\sqrt{LC}}$; $w_2 = \frac{1}{\sqrt{2C\frac{L}{2}}}$

Sharpness depends upon quality factor

68. 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

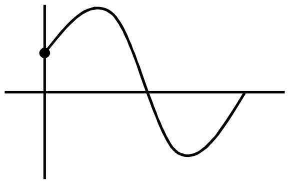
(B) the displacement of the particle at point 1 is negative

(C) the velocity of the particle at point 2 is positive

(D) the potential energy at point 3 is maximum

Ans. **(ABCD)**

Sol.



At t = 0 acceleration is positive

$\therefore$ particle is between left extreme and mean position.

$\therefore$ displacement is negative at t = 0 and point 1

At point 2 particle is at mean position as acceleration is zero & is going towards right extreme.

At point 3 particle is at right extreme

$\therefore$ potential energy is maximum

69. Which of the following physical quantities have dimensions identical to each other ?

(A) the Young's modulus Y.

(B) $\epsilon_0 E^2$ where E is the electric field intensity and ϵ_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. **(ABC)**

Sol. $$\frac{\frac{T}{A}}{\frac{\Delta\ell}{\ell}} = \gamma$$

(a) $\gamma = \text{stress} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$

(b) $U = \frac{1}{2}\varepsilon_0 E^2 = \text{Pressure} = ML^{-1}T^{-2}$

(c) $\frac{B^2}{\mu_0} = ML^{-1}T^{-2}$

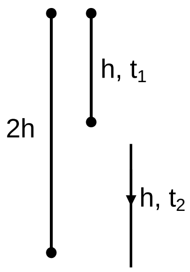
(d) u = KT

70. A small ball bearing is released at the top of a long vertical column of glycerine of height 2h. The bal 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 height. Therefore,

(A) $t_1 < t_2$ (B) $t_1 > t_2$ (C) $W_1 = W_2$ (D) $W_1 < W_2$

Ans. **(BD)**

Sol.



Time t_1 will be more then t_2 because speed increases from zero to terminal speed in t_1 duration and ball covers a distance h.

Work done against viscous force depends on magnitude of viscous force and displacement ball. viscous force increases from zero to maximum value and then remains constant

- X – X – X – X – X – X – X –

Physical constants you may need

Magnitude of charge on electron e = 1.60×10^{-19} C

Mass of electron $m_e = 9.10 \times 10^{-31}$ kg

Universal gravitational constant G = 6.67×10^{-11} Nm^2/kg^2

Permittivity of free space £$_0$ = 8.85 × 10-12 C^2/Nm^2

Universal gas constant R = 8.31 J/mol K

Planck constant h = 6.62×10^{-34} Js

Stefan constant ± =5.67×10^{-8} W/m^2K^4

Boltzmann constant k = 1.38×10^{-23} J/K

Mass of proton $m_p = 1.67 \times 10^{-27}$ kg

Faraday constant = 96500 C/mol

Boiling point of Nitrogen = 77.4 K

Boiling point of oxygen = 90.19 K

Boiling point of hydrogen = 20.3 K

Boiling point of helium = 4.20 K