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JEE (Main)

PAPER-1 (B.E./B. TECH.)

2023

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 30 January, 2023 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

Resonance Eduventures Ltd.

Reg. Office & Corp. Office : CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Raj.) - 324005

Ph. No.: +91-744-2777777, 2777700 | **FAX No. :** +91-022-39167222

To Know more : sms **RESO** at **56677** | **Website :** www.resonance.ac.in | **E-mail :** contact@resonance.ac.in | **CIN :** U80302RJ2007PLC024029

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PART : PHYSICS

1. Speed of an electron Bohr's 7th orbit for Hydrogen atom is 3.6×10^6 m/s. The corresponding speed of the electron in 3rd orbit, in m/s is :

(1) 3.6×10^6 (2) 7.5×10^6 (3) 1.8×10^6 (4) 8.4×10^6

Ans. **(4)**

Sol. $V = V_0 \frac{z}{n}$ m/s

$3.6 \times 10^6 = V_0 \frac{(1)}{7}$ ....(1) [z = 1 for H-atom]

$V_{3rd} = V_0 \frac{1}{3}$ ..(2)

(2)/(1)

$V_{3rd} = V_0 \frac{1}{3}$

$3.6 \times 10^6 = \frac{7}{3} \times 3.6 \times 10^6 = 8.4 \times 10^6$ m/s

2. A sinusoidal carrier voltage is amplitude modulated. The resultant amplitude modulated wave has maximum and minimum amplitude of 120 V and 80 V respectively. The amplitude of each sideband is:

(1) 10 V (2) 5 V (3) 20 V (4) 15 V

Ans. **(1)**

Sol. Given $A_C + A_m = 120$ ....(1)

$A_C - A_m = 80$ ....(2)

Form equation (1) + (2)

$2A_C = 200 \Rightarrow A_C = 100$ mV

So $A_m = 20$ mV

Side band amplitude $= \frac{\mu A_C}{2} = \frac{\frac{A_m}{A_C} \times A_C}{2} = \frac{20}{2} = 10$ mV

3. The charge flowing in a conductor changes with time as $Q(t) = \alpha t - \beta t^2 + \gamma t^3$. Where α, β and γ are constants. Minimum value of current is:

(1) $\alpha - \frac{\gamma^2}{3\beta}$ (2) $\beta - \frac{\alpha^2}{3\gamma}$ (3) $\alpha - \frac{\beta^2}{3\gamma}$ (4) $\alpha - \frac{3\beta^2}{\gamma}$

Ans. **(3)**

Sol. $i = \frac{dq}{dt} = \alpha - 2\beta t + 3\gamma t^2$

$di/dt = -2\beta + 2\gamma y$

$di/dt = 0$

$-2\beta + 6\gamma t = 0$

$t = \beta/3\gamma$

$d^2i/dt^2 = 6\gamma$ which is he

$i_{min} = \alpha - 2\beta\left(\frac{\beta}{3\gamma}\right) + 3\gamma\left(\frac{\beta}{3\gamma}\right)^2 = \alpha - \frac{2\beta^2}{3\gamma} + \frac{\beta^2}{3\gamma} \Rightarrow i_{min} = \alpha - \frac{\beta^2}{3\gamma}$

4. Choose the correct relationship between Poisson ratio (σ), Bulk modulus (K) and modulus of rigidity (η) of given solid object:

(1) $\sigma = \dfrac{3K+2\eta}{6K+2\eta}$ (2) $\sigma = \dfrac{6K-2\eta}{3K-2\eta}$ (3) $\sigma = \dfrac{3K-2\eta}{6K+2\eta}$ (4) $\sigma = \dfrac{6K-2\eta}{3K-2\eta}$

Ans. **(3)**

Sol. As we know

$Y = 2\eta\,(1+\sigma)$ …(i)

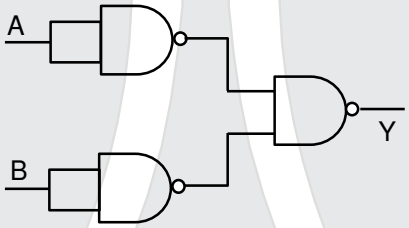
$Y = 3K\,(1-2\sigma)$ …(ii)

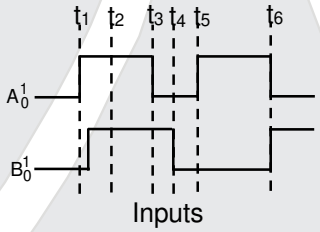
From equation (i) and (ii)

$2\eta\,(1+\sigma) = 3K\,(1-2\sigma)$; $2\eta + 2\eta\sigma = 3K - 6K\sigma$; $2\eta\sigma + 6K\sigma = 3K - 2\eta$

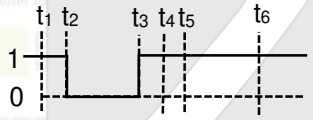
$\sigma = \dfrac{3K-2\eta}{6K+2\eta}$

5. The output waveform of the given logical circuit for the following inputs A and B as shown below is:





(1)



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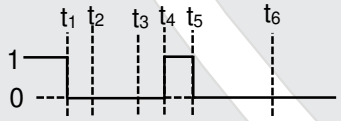

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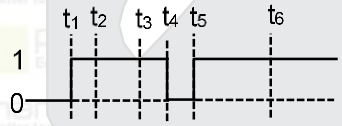

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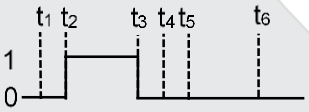
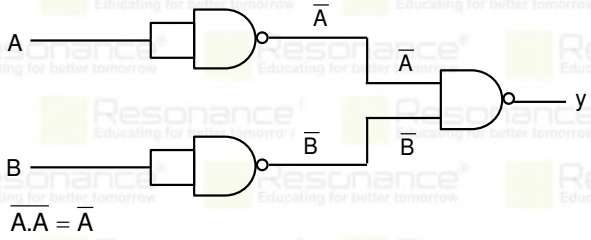


Ans. **(3)**

Sol.



$\overline{A.A} = \overline{A}$

$y = \overline{\overline{A}.\overline{B}}$

$y = A + B$

6. A small object at rest, absorbs a light pules of power 20 mW and duration 300 ns. Assuming speed of light is 3×10^8 m/s, the momentum of the object become equal to:

(1) 2×10^{-17} kg m/s (2) 1×10^{-17} kg m/s (3) 3×10^{-17} kg m/s (4) 0.5×10^{-17} kg m/s

Ans. **(1)**

Sol. We know momentum p = E/C

E = Energy

C = speed of light

$$p = \frac{P \times t}{C}$$

$$p = \frac{20 \times 10^{-3} \times 300 \times 10^{-9}}{3 \times 10^8}$$

$p = 2 \times 10^{-17}$ N.S

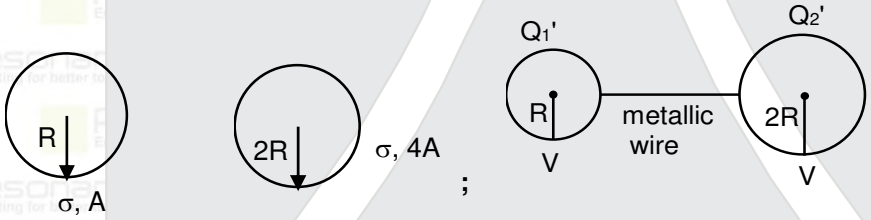
7. Two isolated metallic solid spheres of radii R and 2R are charged such that both have same charge density σ. The spheres are then connected by a thin conducting wire. If the new charge density of the bigger sphere is σ'. The ratio $\frac{\sigma'}{\sigma}$ is

(1) 5/3 (2) 9/4 (3) 5/6 (4) 4/3

Ans. **(3)**

Sol. $Q_1 = \sigma \times 4\pi R^2 = \sigma A$

$Q_2 = \sigma \times 4\pi(2R)^2 = 4\sigma A$



$$Q_2' = \left(\frac{R_2}{R_1 + R_2}\right)(Q_{\text{total}}) = \left(\frac{2R}{R + 2R}\right)(\sigma A + 4\sigma A) = \frac{2}{3} \times 5\sigma A$$

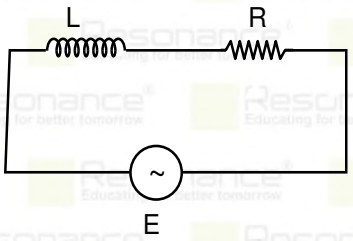
$$Q_2' = \frac{10}{3}\sigma A \; ; \; \sigma' = \frac{Q_2'}{4A} = \frac{10}{4 \times 3}\sigma = \frac{5}{6}\sigma \Rightarrow \frac{\sigma'}{\sigma} = \frac{5}{6}$$

8. In a series LR circuit with $X_L = R$, power factor is P_1. If a capacitor of capacitance C with $X_C = X_L$ is added to the circuit the power factor becomes P_2. The ratio of P_1 to P_2 will be:

(1) 1 : 2 (2) 1 : 3 (3) 1 : 1 (4) 1 : $\sqrt{2}$

Ans. **(4)**

Sol.



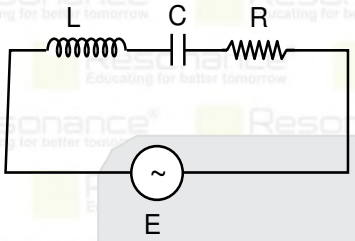
If $X_L = R$ (given)

Then power factor

$P_1 = \cos\theta_1 = \dfrac{R}{Z}$

$Z = \sqrt{R^2 + (X_L - X_C)^2} \Rightarrow Z = \sqrt{R^2 + R^2} = \sqrt{2}\,R \Rightarrow P_1 = \dfrac{R}{\sqrt{2}R} = \dfrac{1}{\sqrt{2}}$

Now a capacitor is added in the same circuit



$X_L = X_C$ (given)

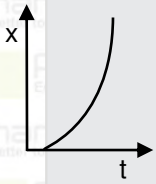
This the resentence condition Z = R

$P_2 = \cos\theta_2 = \dfrac{R}{R} = 1, \quad \dfrac{P_1}{P_2} = \dfrac{1}{\sqrt{2}}$

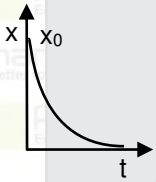
9. Match Column-I with Column-II:

Column-I : (x-t graphs)

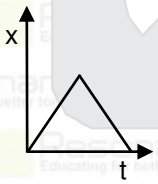
(A)



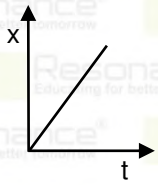
(B)



(C)

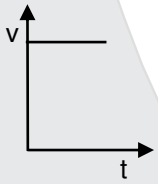


(D)

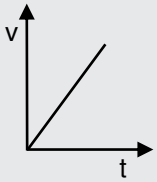


Column-II: (v-t graphs)

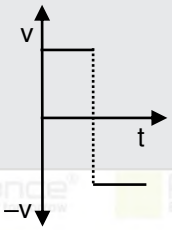
(I)



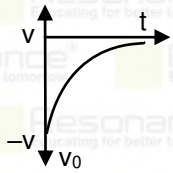
(II)



(III)



(IV)



Choose the correct answer from the options given below:

(1) A-I, B-III, C-IV, D-II (2) A-II, B-IV, C-III, D-I (3) A-II, B-III, C-IV, D-I (4) A-I, B-II, C-III, D-IV

Ans. **(2)**

10. The figure represents the momentum time (p-t) curve for a particle moving along an axis under the influence of the force. Identify the regions on the graph where the magnitude of the force is maximum and minimum respectively? If $(t_3 - t_2)t_1$

(1) c and b (2) a and b (3) b and c (4) c and a

Ans. **(1)**

Sol. From Newton's 2nd law

$F = \frac{dP}{dt}$

i.e. slope of P & t graph gives force

for F_{max} = slope is maximum

F_{min} = slop is minimum

11. A person has been using spectacles of power-1.0 Dioptre for distant vision and a separate reading glass of power 2.0 Dioptres. What is the least distance of distinct vision for this person:

(1) 10 cm (2) 40 cm (3) 30 cm (4) 50 cm

Ans. **(4)**

Sol. Let x be the near point distance

$$\frac{1}{-x} - \frac{1}{-25} = \frac{1}{50}$$

$$\frac{1}{25} - \frac{1}{50} = \frac{1}{x}$$

x = 50 cm

12. The height of liquid column raised in a capillary tube of certain radius when dipped in liquid A vertically is 5 cm. If the tube is dipped in a similar manner in another liquid B of surface tension and density double the values of liquid A, the height of liquid column raised in liquid B would be _____m.

(1) 0.20 (2) 0.5 (3) 0.10 (4) 0.05

Ans. **(4)**

Sol. We know $h = \frac{2T\cos\theta}{\rho g R}$

$$h_A = \frac{2T\cos\theta}{\rho g R} \quad \ldots(1)$$

$$h_B = \frac{2(2T)\cos\theta}{2\rho g R} \quad \ldots(2)$$

From equation (1) and (2)

h_B = 5 cm

h_B = 0.05 m

13. Heat is given to an ideal gas in an isothermal process.

A. Internal energy of the gas will decrease. B. Internal energy of the gas will increase.

C. Internal energy of the gas will not change. D. The gas will do positive work.

E. The gas will do negative work.

Choose the correct answer from the options given below:

(1) C and D only (2) B and D only (3) A and E only (4) C and E only

Ans. **(1)**

Sol. In isothermal process

$\Delta T = 0$

$\Delta U = f/2\ nR\Delta T$

$\Delta U = 0$

$\Delta Q = W$

14. The magnetic moments associated with two closely wound circular coils A and B of radius $r_A = 10$ cm and $r_B = 20$ cm respectively are equal if: (Where N_A, I_A and $N_B.I_B$ are number of turn and current of A and B respectively)

(1) $2N_AI_A = N_BI_B$ (2) $N_A = 2N_B$ (3) $N_AI_A = 4N_BI_B$ (4) $4N_AI_A = N_BI_B$

Ans. **(3)**

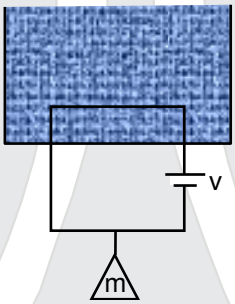
Sol. $\vec{M} = Ni\vec{A}$

$M_A = M_B$

$N_AI_A\pi(1)^2 = N_BI_B\,\pi(2)^2$

$N_AI_B = 4N_BI_B$

15. A massless square loop, of wire of resistance 10Ω, supporting a mass of 1g, hangs vertically with one of its sides in a uniform magnetic field of 10^3 G, directed outwards in the shaded region. A dc voltage V is applied to the loop. For what value of V, the magnetic force will exactly balance the weight of the supporting mass of 1g? (If sides of the loop = 10 cm, g = 10 ms^{-2})



(1) $\frac{1}{10}$ V (2) 1V (3) 100 V (4) 10 V

Ans. **(4)**

Sol. Given B = 10^3 Gauss = $10^3 \times 10^{-4}$T

B = 0.1 T, R = 10Ω, ℓ = 10 cm, m = 1 gm.

$\therefore$ F = iℓB

mg = iℓB

$1 \times 10^{-3} \times 10 = \frac{V}{R} \times 10 \times 10^{-2} \times 10^{-1}$

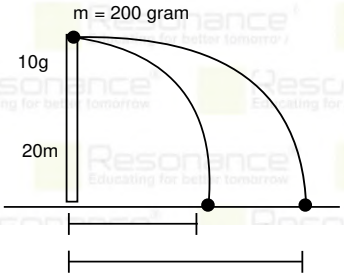
V = 10 Volt

16. A ball of mass 200 g rests on a vertical post of height 20 m. A bullet of mass 10 g, travelling in horizontal direction, hits the centre of the ball. After collision both travels independently. The ball hits the ground at a distance 30 m and the bullet at a distance of 120 m from the foot of the post. The value of initial velocity of the bullet will be (if g = 10 m/s^2):

(1) 400 m/s (2) 360 m/s (3) 60 m/s (4) 120 m/s

Ans. **(2)**

Sol.



Time of Flight = 1/2 g T^2 = H

$20 = 1/2 \times 10 \times T^2$

$t = 2$ sec.

speed after collision of ball $30 = V \times 2 \Rightarrow V = 15$ m/ sec.

speed after collision of bullet $120 = V' \times 2 \Rightarrow V' = 60$ m/sec.

an It is elastic collision so initial if momentum final momenta

$10 \times 10^{-3} \times u = 10 \times 10^{-3} \times 60 + 200 \times 10^{-3} \times 15$

$10u = 600 + 3000$

$u = \dfrac{3600}{10} = 360$

17. The pressure (P) and temperature (T) relationship of an ideal gas obeys the equation PT^2 = constant. The volume expansion coefficient of the gas will be:

(1) $3T^2$ (2) $\dfrac{3}{T^2}$ (3) $\dfrac{3}{T^3}$ (4) $\dfrac{3}{T}$

Ans. **(4)**

Sol. If $PT^2 = C$ ...(1)

From ideal gas equation

$PV = nRT$

$P = \dfrac{nRT}{V}$

Put value of P in equation (1)

$\left(\dfrac{nRT}{V}\right)T^2 = C$

$\dfrac{T^3}{V} = C'$ ...(2)

Differentiating the equation with respect to T

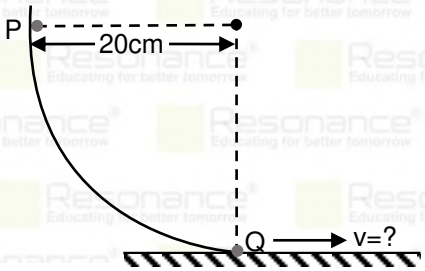
$-\dfrac{T^3}{V^2}\dfrac{dV}{dT} + \dfrac{1}{V}3T^2 = 0$; $\dfrac{dV}{dT} = \dfrac{3T^2}{V} \times \dfrac{V^2}{T^3}$

$dV = \dfrac{3}{T}VdT$; $dV = \gamma VdT$

Compare both equation

$\gamma = \dfrac{3}{T}$

18. As per the given figure, a small ball P slides down the quadrant of a circle and hits the other ball Q of equal mass which is initially at rest. Neglecting the effect of friction and assume the collision to be elastic, the velocity of ball Q after collision will be:($g = 10$ m/s^2)



(1) 4 m/s (2) 0 (3) 0.25 m/s (4) 2 m/s

Ans. **(4)**

Sol. Energy conservation for object P b/w point 1 and 2,

$mgh = \frac{1}{2} mv\, v_{p_2}^2$

$v_{p_2} = \sqrt{2gh}$

$= \sqrt{2\times10\times0.2}$

$v_{p_2} = 2$ m/r

momentum conservation of the collision

$m_p v_{p_2} = m_Q v_{Q_2}$

$m \times 2 = m v_{Q_2}$

$v_{Q_2} = 2$m/s

19. Electric field in a certain region is given by $\vec{E} = \left(\frac{A}{x^2}\hat{i} + \frac{B}{y^3}\hat{j}\right)$. The SI unit of A and B are:

(1) Nm^2C^{-1}; Nm^3C^{-1} (2) Nm^3C; Nm^2C (3) Nm^2C; Nm^3C (4) Nm^3C^{-1}; Nm^2C^{-1}

Ans. **(1)**

Sol. $E = \frac{A}{x^2}$

$\Rightarrow NC^{-1} = \frac{A}{m^2}$

$[A] = Nm^2C^{-1}$

$E = \frac{B}{y^3}$

$NC^{-1} = \frac{B}{m^3}$

$[B] = Nm^3C^{-1}$

20. If the gravitational field in the space is given as $\left(-\frac{K}{r^2}\right)$ Taking the reference point to be at r = 2 cm with gravitational potential V = 10 J/kg. Find the gravitational potential at r = 3 cm in SI unit (Given, that K = 6 Jcm/kg)

(1) 11 (2) 10 (3) 12 (4) 9

Ans. **(1)**

Sol. Given $\rightarrow E = \frac{-K}{r^2}$

$\frac{-dV}{dr} = -\frac{-K}{r^2}$

$\Rightarrow \int_{10}^{V} dV = \int_{2}^{3} \frac{K dr}{r^2}$

$\Rightarrow V - 10 = K\left[-\frac{1}{2r^1}\right]_2^3$

$$V - 10 = K\left(\frac{1}{2} - \frac{1}{3}\right)$$

$$V - 10 = K\frac{(3-2)}{6}$$

$$V - 10 = K \times \frac{1}{6}$$

$$V - 10 = 6 \times \frac{1}{6}$$

$$V = 10 + 1 = 11$$

21. In an experiment for estimating the value of focal length of converging mirror, image of an object placed at 40 cm from the pole of the mirror is formed at distance 120 cm from the pole of the mirror. These distances are measured with a modified scale in which there are 20 small divisions in 1 cm. The value of error in measurement of focal length of the mirror is $\frac{1}{K}$ cm. The value of K is

Ans. **32**

Sol. $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$-\frac{1}{120} + \frac{1}{-40} = \frac{1}{f}$$

$$f = -\frac{(120 \times 40)}{160} = -30 \text{ cm}$$

$$\frac{\Delta f}{f^2} = \frac{\Delta v}{v^2} + \frac{\Delta u}{u^2} \Rightarrow \Delta v = \Delta u = \frac{1}{20}\text{ cm} \Rightarrow \frac{\Delta f}{30^2} = \Delta u\left(\frac{1}{40^2} + \frac{1}{120^2}\right)$$

$$\Delta f = 30^2 \times \frac{1}{20}\left(\frac{1}{40^2} + \frac{1}{120^2}\right) \Rightarrow \Delta f = \frac{1}{32}$$

22. In a screw gauge, there are 100 divisions on the circular scale and the main scale moves by 0.5 mm on a complete rotation of the circular scale. The zero of circular scale lies 6 divisions below the line of graduation when two studs are brought in contact with each other. When a wire is placed between the studs, 4 linear scale divisions are clearly visible while 46th division the circular scale coincide with the reference line. The diameter of the wire is_____$\times 10^{-2}$ mm.

Ans. **NTA Ans. 22 & Reso Ans 220**

Sol. $\text{L.C} = \frac{\text{Pitch}}{\text{Number of divsion on circular scale}} = \frac{0.5 \text{ mm}}{100} = 0.005 \text{ mm}$

Since pitch is 0.5 mm, so there must be 0.5 mm mark on the main scale
The zero of circular scale lies 6 divisions below the line of graduation
So, Zero error is positive then
Zero error = 6 CSD = 6 × 0.005 mm = 0.03 mm
Measured thickness = MSR + (CSR) (L.C)
= (4 × 0.5 mm) + (46)(0.005 mm) = 2.23 mm
Actual thickness = Measured thickness – zero error = 2.23 mm – (0.03 mm) = 2.20 mm
= 220 × 10^{-2} mm

23. A thin uniform rod of length 2m, cross sectional area 'A' and density 'd' is rotated about an axis passing through the centre and perpendicular to its length with angular velocity ω. If value of ω in terms of its rotational kinetic energy E is $\sqrt{\frac{\alpha E}{Ad}}$ then value of a is_____.

Ans. **3**

Sol. $I = \frac{ML^2}{12} = \frac{(d \times A \times 2) \times (2 \times 2)}{12} = \frac{2Ad}{3}$

$K.E = \frac{1}{2} I\omega^2 = \frac{1}{2} \times \frac{2Ad}{3} \times \omega^2 = E$

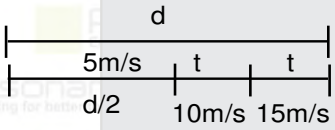
$\omega = \sqrt{\frac{3E}{Ad}}$

So $\alpha = 3$

24. A horse rider covers half the distance with 5 m/s speed. The remaining part of the distance was travelled with speed 10 m/s for half the time and with speed 15 m/s for other half of the time. The mean speed of the rider averaged over the whole time of motion is $\frac{x}{7}$ m/s. The value of x is_____.

Ans. **50**

Sol.



$\text{arg. velocity} = \frac{d}{\frac{d/2}{5} + 2t}$

$\Rightarrow \frac{d}{2} = 10t + 15t$

$d = 50t$

$\therefore 2t = \frac{d}{25}$

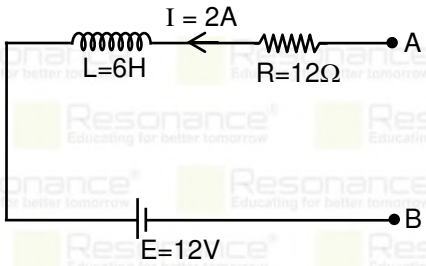
$\text{avg velocity} = \frac{d}{\frac{d/2}{5} + \frac{d}{25}} = \frac{d}{d\left[\frac{1}{10} + \frac{1}{25}\right]}$

$= \frac{250}{35} = \frac{50}{7}$

$\Rightarrow \frac{x}{7} = \frac{50}{7}$

$x = 50$

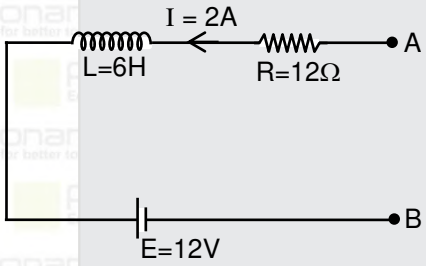
25.



As per the given figure, if $\frac{dI}{dt} = -1$ A/s then the value of V_{AB} at this instant will be_____V.

Ans. **30.00**

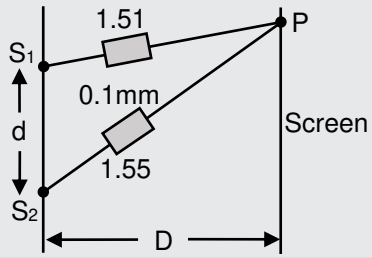
Sol. According to Kirchhoff's voltage law



$$V_B + 12 + L\frac{dt}{dt} + iR = V_A$$

$$V_A - V_B = 12 - 6 \times 1 + 2 \times 12 = 30\ V$$

26. In Young's double slit experiment, two slits S_1 and S_2 are 'd' distance apart and the separation from slits to screen is D (as shown in figure). Now if two transparent slabs of equal thickness 0.1 mm but refractive index 1.51 and 1.55 are introduced in the path of beam (λ = 4000Å) from S_1 and S_2 respectively. The central bright fringe spot will shift by_____ number of fringes.



Ans. **10**

Sol. $(1.55 - 1.51)10^{-4} = \frac{dy}{D}$

$$y = \frac{D}{d}(0.04 \times 10^{-4})$$

$$n\beta = D/d \times 0.04 \times 10^{-4}$$

$$\frac{n\lambda D}{d} = \frac{D}{d} \times 0.04 \times 10^{-4}$$

$$n = \frac{0.04\times10^{-4}}{\lambda} = \frac{0.04\times10^{-4}}{4\times10^{-7}} = 10$$

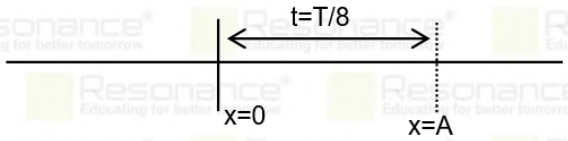
$$n = 10$$

27. The general displacement of a simple harmonic oscillator is $x = A\sin\omega t$. Let T be its time period. The slope of its potential energy (U) - time (t) curve will be maximum when $t = T/\beta$. The value of β is_____.

Ans. **8**

Sol. $x = A\sin\omega t$

So Here we can see particle is at mean position and going towards right



So the potential Energy will be maximum at x = A (Extreme position)

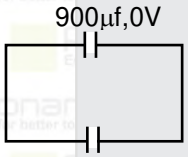
So time taken by particle to travel x = 0 to x = A in $\frac{T}{8}$, T = Time period.

$\frac{T}{\beta} = \frac{T}{8}$ Hence $\beta = 8$

28. A capacitor of capacitance 900 uF is charged by a 100 V battery. The capacitor is disconnected from the battery and connected to another uncharged identical capacitor such that one plate of uncharged capacitor connected to positive plate and another plate of uncharged capacitor connected to negative plate of the charged capacitor. The loss of energy in this process is measured as $x \times 10^{-2}$ J. The value of x is_____.

Ans. **225**

Sol. As we know



$$\Delta H = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1-V_2)^2$$

$$\Delta H = \frac{1}{2}\times\frac{900\times900\times10^{-6}\times10^{-6}}{(900+900)\times10^{-6}}(100-0)^2$$

$$\Delta H = \frac{1}{2}\times\frac{900\times10^{-6}}{2}(100-0)^2$$

$\Delta H = 225 \times 10^{-2}$ J

29. A point source of light is placed at the centre of curvature of a hemispherical surface. The source emits a power of 24 W. The radius of curvature of hemisphere is 10 cm and the inner surface is completely reflecting. The force on the hemisphere due to the light falling on it is _____$\times10^{-8}$ N.

Ans. **4**

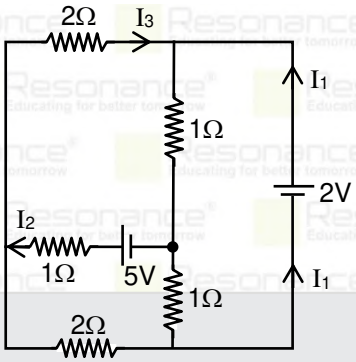
Sol. For perfectly reflecting surface

$$F = \frac{2P'}{C}$$

P' = Power received by surface

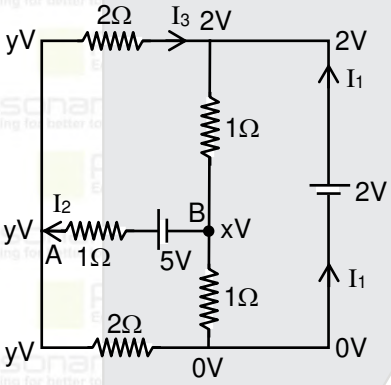
$$P' = \frac{P}{4\pi R^2}\times\pi R^2 = \frac{24}{4} = 6W, \quad F = \frac{2\times6}{3\times10^8} = 4\times10^{-8}\ N$$

30. In the following circuit, the magnitude of current I_1, is_____A.



Ans. **NTA Answer 1 & Reso Answer is 1.5A**

Sol.



Junction law at A

$$\frac{y}{2}+\frac{y-2}{2}+\frac{y-x-5}{1}=0$$

$2y - x = 6$ .....(1)

Junction law at B

$$\frac{x+5-y}{1}+\frac{x}{1}+\frac{x-2}{1}=0$$

$3x - y = -3$ .....(2)

From (1) & (2)

$x = 0, y = 3$

Now $I_1 = -\frac{1}{2}+2 = 1.5A$

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