PHYSICS

SECTION-A

1. For a gas $C_P - C_V = R$ in a state P and $C_P - C_V = 1.10\ R$ in a state Q, T_P and T_Q are the temperatures in two different states P and Q respectively. Then

(1) $T_P = T_Q$

(2) $T_P < T_Q$

(3) $T_P = 0.9\ T_Q$

(4) $T_P > T_Q$

Official Ans. by NTA (4)

Sol. $C_P - C_V = R$ for ideal gas and gas behaves as ideal gas at high temperature

so $T_P > T_Q$

2. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A : Moment of inertia of a circular disc of mass 'M' and radius 'R' about X, Y axes (passing through its plane) and Z-axis which is perpendicular to its plane were found to be I_x, I_y and I_z respectively. The respective radii of gyration about all the three axes will be the same.

Reason R : A rigid body making rotational motion has fixed mass and shape. In the light of the above statements, choose the most appropriate answer from the options given below :

(1) Both **A** and **R** are correct but **R** is NOT the correct explanation of **A**.

(2) **A** is not correct but **R** is correct.

(3) **A** is correct but **R** is not correct.

(4) Both **A** and **R** are correct and **R** is the correct explanation of **A**.

Official Ans. by NTA (2)

Sol. $I_z = I_x + I_y$ (using perpendicular axis theorem)

& $I = mk^2$ (K : radius of gyration)

so $mK_z^2 = mK_x^2 + mK_y^2$

$K_z^2 = K_x^2 + K_y^2$

so radius of gyration about axes x, y & z won't be same hense asseration A is not correct reason R is correct statement (property of a rigid body)

3. What should be the order of arrangement of de-Broglie wavelength of electron (λ_e), an α-particle (λ_α) and proton (λ_p) given that all have the same kinetic energy ?

(1) $\lambda_e = \lambda_p = \lambda_\alpha$

(2) $\lambda_e < \lambda_p < \lambda_\alpha$

(3) $\lambda_e > \lambda_p > \lambda_\alpha$
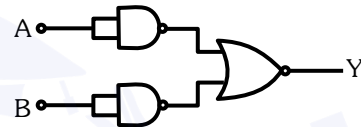
(4) $\lambda_e = \lambda_p > \lambda_\alpha$

Official Ans. by NTA (3)

Sol. $\lambda = \dfrac{h}{p} = \dfrac{h}{\sqrt{2mE}} \propto \dfrac{1}{\sqrt{m}}$

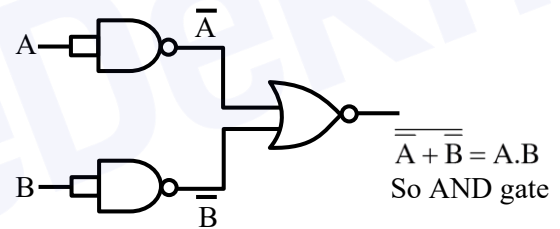$m_\alpha > m_p > m_e$

so $\lambda_e > \lambda_p > \lambda_\alpha$

4. Identify the logic operation carried out.

(1) OR   (2) AND   (3) NOR   (4) NAND

Official Ans. by NTA (2)

Sol.

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

So AND gate

5. A particle of mass 4M at rest disintegrates into two particles of mass M and 3M respectively having non zero velocities. The ratio of de-Broglie wavelength of particle of mass M to that of mass 3M will be :

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

Official Ans. by NTA (4)

Sol. $\lambda = \dfrac{h}{p}$

both the particles will move with momentum same in magnitude & opposite in direction.

So De-Broglie wavelength of both will be same i.e. ratio 1 : 1

6. Some nuclei of a radioactive material are undergoing radioactive decay. The time gap between the instances when a quarter of the nuclei have decayed and when half of the nuclei have decayed is given as :

(where λ is the decay constant)

(1) $\dfrac{1}{2}\dfrac{l\,n\,2}{\lambda}$

(2) $\dfrac{l\,n\,2}{\lambda}$

(3) $\dfrac{2l\,n\,2}{\lambda}$

(4) $\dfrac{l\,n\,\dfrac{3}{2}}{\lambda}$

Official Ans. by NTA (4)

Sol. $\dfrac{3N_0}{4} = N_0 e^{-\lambda t_1}$

$\dfrac{N_0}{2} = N_0 e^{-\lambda t_2}$

$\ln(3/4) = -\lambda t_1$ .....(i)

$\ln(1/2) = -\lambda t_2$ .....(i)

$\ln(3/4) - \ln(1/2) = \lambda(t_2 - t_1)$ .....(i)

$\Delta t = \dfrac{\ln(3/2)}{\lambda}$

7. Match **List I** with **List II**.

	List I		List II
(a)	$\vec{C} - \vec{A} - \vec{B} = 0$	(i)	
(b)	$\vec{A} - \vec{C} - \vec{B} = 0$	(ii)	
(c)	$\vec{B} - \vec{A} - \vec{C} = 0$	(iii)	
(d)	$\vec{A} + \vec{B} = -\vec{C}$	(iv)	

Choose the correct answer from the options given below :

(1) (a) $\to$ (iv), (b) $\to$ (i) , (c) $\to$ (iii), (d) $\to$ (ii)

(2) (a) $\to$ (iv), (b) $\to$ (iii) , (c) $\to$ (i), (d) $\to$ (ii)

(3) (a) $\to$ (iii), (b) $\to$ (ii) , (c) $\to$ (iv), (d) $\to$ (i)

(4) (a) $\to$ (i), (b) $\to$ (iv) , (c) $\to$ (ii), (d) $\to$ (iii)

Official Ans. by NTA (2)

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

Option (iv)

(b) $\vec{A} = \vec{B} + \vec{C} = \vec{C} + \vec{B}$

Option (iii)

(c) $\vec{B} = \vec{A} + \vec{C}$

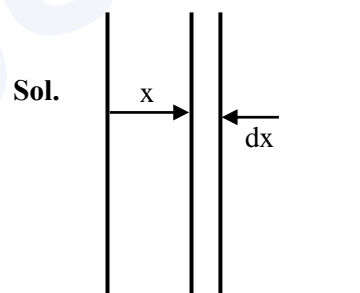Option (i)

(d) $\vec{A} + \vec{B} + \vec{C} = 0$

Option (ii)

8. A parallel plate capacitor with plate area 'A' and distance of separation 'd' is filled with a dielectric. What is the capacity of the capacitor when permittivity of the dielectric varies as :

$\varepsilon(x) = \varepsilon_0 + kx$, for $\left(0 < x \le \dfrac{d}{2}\right)$

$\varepsilon(x) = \varepsilon_0 + k(d - x)$, for $\left(\dfrac{d}{2} \le x \le d\right)$

(1) $\left(\varepsilon_0 + \dfrac{kd}{2}\right)^{2/kA}$

(2) $\dfrac{kA}{2\ln\left(\dfrac{2\varepsilon_0 + kd}{2\varepsilon_0}\right)}$

(3) 0

(4) $\dfrac{kA}{2}\ln\left(\dfrac{2\varepsilon_0}{2\varepsilon_0 - kd}\right)$

Official Ans. by NTA (2)

Sol.

Taking an element of width dx at a distance x ($x < d/2$) from left plate

$dc = \dfrac{(\varepsilon_0 + kx)A}{dx}$

Capacitance of half of the capacitor

$\dfrac{1}{C} = \int_0^{d/2} \dfrac{1}{dc} = \dfrac{1}{A}\int_0^{d/2}\dfrac{dx}{\varepsilon_0 + kx}$

$\dfrac{1}{C} = \dfrac{1}{kA}\ln\left(\dfrac{\varepsilon_0 + kd/2}{\varepsilon_0}\right)$

Capacitance of second half will be same

$$C_{eq} = \frac{C}{2} = \frac{kA}{2\ln\left(\dfrac{2\varepsilon_0 + kd}{2\varepsilon_0}\right)}$$

9. A monoatomic ideal gas, initially at temperature T_1 is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If l_1 and l_2 are the lengths of the gas column, before and after the expansion respectively, then the value of $\dfrac{T_1}{T_2}$ will be :

(1) $\left(\dfrac{l_1}{l_2}\right)^{\frac{2}{3}}$ (2) $\left(\dfrac{l_2}{l_1}\right)^{\frac{2}{3}}$

(3) $\dfrac{l_2}{l_1}$ (4) $\dfrac{l_1}{l_2}$

Official Ans. by NTA (2)

Sol. $PV^r = $ const.

$TV^{r-1} = $ const.

$T(\ell)^{\frac{5}{3}-1} = $ const.

$\dfrac{T_1}{T_2} = \left(\dfrac{\ell_2}{\ell_1}\right)^{2/3}$

10. A ray of laser of a wavelength 630 nm is incident at an angle of 30° at the diamond-air interface. It is going from diamond to air. The refractive index of diamond is 2.42 and that of air is 1. Choose the correct option.

(1) angle of refraction is 24.41°

(2) angle of refraction is 30°

(3) refraction is not possible

(4) angle of refraction is 53.4°

Official Ans. by NTA (3)

Sol. $\sin\theta_C = \dfrac{1}{\mu} = \dfrac{1}{2\mu_2} < \sin\theta_C$

$\sin\theta > \sin\theta_C$

$\theta > \theta_C$

Total internal reflection will happen

11. Two wires of same length and radius are joined end to end and loaded. The Young's modulii of the materials of the two wires are Y_1 and Y_2. The combination behaves as a single wire then its Young's modulus is :

(1) $Y = \dfrac{2Y_1Y_2}{3(Y_1 + Y_2)}$ (2) $Y = \dfrac{2Y_1Y_2}{Y_1 + Y_2}$

(3) $Y = \dfrac{Y_1Y_2}{2(Y_1 + Y_2)}$ (4) $Y = \dfrac{Y_1Y_2}{Y_1 + Y_2}$

Official Ans. by NTA (2)

Sol. In series combination $\Delta l = \ell_1 + \ell_2$

$Y = \dfrac{F/A}{\Delta\ell/\ell} \Rightarrow \Delta\ell = \dfrac{F\ell}{AY}$

$\Rightarrow \Delta\ell \propto \dfrac{\ell}{Y}$

Equivalent length of rod after joing is $= 2\ell$

As, lengths are same and force is also same in series

$\Delta\ell = \Delta\ell_1 + \Delta\ell_2$

$\dfrac{\ell_{eq}}{Y_{eq}} = \dfrac{\ell}{Y_1} + \dfrac{\ell}{Y_2} \Rightarrow \dfrac{2\ell}{Y} = \dfrac{\ell}{Y_1} + \dfrac{\ell}{Y_2}$

$\therefore \; Y = \dfrac{2Y_1Y_2}{Y_1 + Y_2}$

12. The half-life of ^{198}Au is 3 days. If atomic weight of ^{198}Au is 198 g/mol then the activity of 2 mg of ^{198}Au is [in disintegration/second] :

(1) 2.67×10^{12} (2) 6.06×10^{18}

(3) 32.36×10^{12} (4) 16.18×10^{12}

Official Ans. by NTA (4)

Sol. $A = \lambda N$

$\lambda = \dfrac{\ln 2}{t_{1/2}} = \dfrac{\ln 2}{3 \times 24 \times 60 \times 60} \sec^{-1} = 2.67 \times 10^{-6} \sec^{-1}$

N = Number of atoms in 2 mg Au

$= \dfrac{2 \times 10^{-3}}{198} \times 6 \times 10^{23} = 6.06 \times 10^{15}$

$A = \lambda N = 1.618 \times 10^{13} = 16.18 \times 10^{12}$ dps

13. Two billiard balls of equal mass 30 g strike a rigid wall with same speed of 108 kmph (as shown) but at different angles. If the balls get reflected with the same speed then the ratio of the magnitude of impulses imparted to ball 'a' and ball 'b' by the wall along 'X' direction is :

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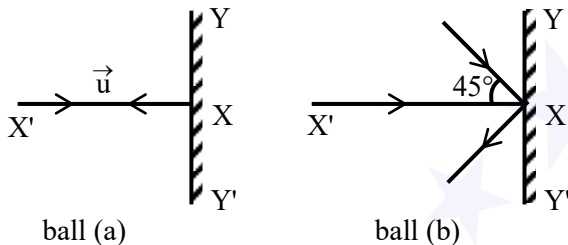
(1) 1 : 1   (2) $\sqrt{2}:1$ (3) 2 : 1   (4) $1 : \sqrt{2}$

Official Ans. by NTA (2)

Sol. Impulse = change in momentum

Ball (a) $|\overrightarrow{\Delta p}| = 2mu = J_1$

Ball (b) $|\overrightarrow{\Delta p}| = 2mu \cos 45° = J_2$

$\dfrac{J_1}{J_2} = \dfrac{1}{\cos 45°} = \sqrt{2}$

14. In the Young's double slit experiment, the distance between the slits varies in time as $d(t) = d_0 + a_0 \sin \omega t$; where d_0, ω and a_0 are constants. The difference between the largest fringe width and the smallest fringe width obtained over time is given as :

(1) $\dfrac{2\lambda D(d_0)}{(d_0^2 - a_0^2)}$ (2) $\dfrac{2\lambda D a_0}{(d_0^2 - a_0^2)}$

(3) $\dfrac{\lambda D}{d_0^2} a_0$ (4) $\dfrac{\lambda D}{d_0 + a_0}$

Official Ans. by NTA (2)

Sol. Fringe Width, $\beta = \dfrac{\lambda D}{d}$

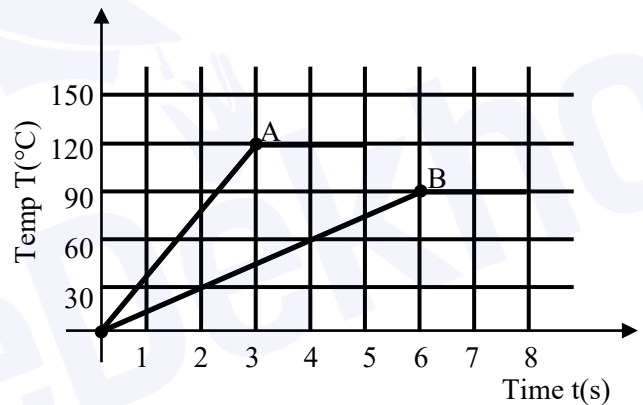$\beta_{max} \Rightarrow d_{min}$ and $\beta_{min} \Rightarrow d_{max}$

$d = d_0 + a_0 \sin \omega t$

$d_{max} = d_0 + a_0$ and $d_{min} = d_0 - a_0$

$\therefore \beta_{min} = \dfrac{\lambda D}{d_0 + a_0}$ and $\therefore \beta_{max} = \dfrac{\lambda D}{d_0 - a_0}$

$\beta_{max} - \beta_{min} = \dfrac{\lambda D}{d_0 - a_0} - \dfrac{\lambda D}{d_0 + a_0} = \dfrac{2\lambda D a_0}{d_0^2 - a_0^2}$

15. Two different metal bodies A and B of equal mass are heated at a uniform rate under similar conditions. The variation of temperature of the bodies is graphically represented as shown in the figure. The ratio of specific heat capacities is :

(1) $\dfrac{8}{3}$ (2) $\dfrac{3}{8}$ (3) $\dfrac{3}{4}$ (4) $\dfrac{4}{3}$

Official Ans. by NTA (2)

Sol. $\left(\dfrac{\Delta Q}{\Delta t}\right)_A = \left(\dfrac{\Delta Q}{\Delta t}\right)_B$

$mS_A \left(\dfrac{\Delta T}{\Delta t}\right)_A = mS_B \left(\dfrac{\Delta T}{\Delta t}\right)_B$

$\dfrac{S_A}{S_B} = \dfrac{\left(\dfrac{\Delta T}{\Delta t}\right)_A}{\left(\dfrac{\Delta T}{\Delta t}\right)_B} = \dfrac{90/6}{120/3} = \dfrac{15}{40} = \dfrac{3}{8}$

16. A linearly polarized electromagnetic wave in vacuum is

$E = 3.1 \cos\left[(1.8)z - (5.4 \times 10^6)t\right]\hat{i} \; N/C$

is incident normally on a perfectly reflecting wall at $z = a$. Choose the correct option

(1) The wavelength is 5.4 m

(2) The frequency of electromagnetic wave is 54×10^4 Hz.

(3) The transmitted wave will be $3.1\cos\left[(1.8)z - (5.4 \times 10^6)t\right]\hat{i}$ N/C

(4) The reflected wave will be $3.1\cos\left[(1.8)z + (5.4 \times 10^6)t\right]\hat{i}$ N/C

Official Ans. by NTA (4)

Sol. Reflected wave will have direction opposite to incident wave.

17. In the given figure, there is a circuit of potentiometer of length AB = 10 m. The resistance per unit length is 0.1 Ω per cm. Across AB, a battery of emf E and internal resistance 'r' is connected. The maximum value of emf measured by this potentiometer is :
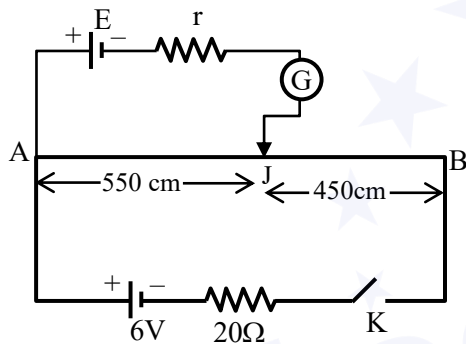
(1) 5 V   (2) 2.25 V   (3) 6 V   (4) 2.75 V

Official Ans. by NTA (1)

Sol. Max. voltage that can be measured by this potentiometer will be equal to potential drop across AB

$R_{AB} = 10 \times 0.1 \times 100 = 100$ ohm.

$\therefore V_{AB} = \dfrac{6}{20 + 100} \times 100 = 6 \times \dfrac{100}{120} = 5V$

18. In amplitude modulation, the message signal

$V_m(t) = 10 \sin(2\pi \times 10^5 t)$ volts and

Carrier signal

$V_C(t) = 20 \sin(2\pi \times 10^7 t)$ volts

The modulated signal now contains the message signal with lower side band and upper side band frequency, therefore the bandwidth of modulated signal is α kHz. The value of α is :

(1) 200 kHz   (2) 50 kHz

(3) 100 kHz   (4) 0

Official Ans. by NTA (1)

Sol. Bandwidth = $2 \times f_m$

= 2×10^5 HZ = 200 KHZ

19. Water droplets are coming from an open tap at a particular rate. The spacing between a droplet observed at 4th second after its fall to the next droplet is 34.3 m. At what rate the droplets are coming from the tap ? (Take g = 9.8 m/s^2)

(1) 3 drops / 2 seconds   (2) 2 drops / second

(3) 1 drop / second   (4) 1 drop / 7 seconds

Official Ans. by NTA (3)

Sol. In 4 sec. 1st drop will travel

$\Rightarrow \dfrac{1}{2} \times (9.8) \times (4)^2 = 78.4$ m

$\therefore$ 2nd drop would have travelled

$\Rightarrow 78.4 - 34.3 = 44.1$ m.

Time for 2nd drop

$\dfrac{1}{2}(9.8)t^2 = 44.1$

$\boxed{t = 3\sec}$

$\therefore$ each drop have time gap of 1 sec

$\therefore$ 1 drop per sec

20. The minimum and maximum distances of a planet revolving around the Sun are x_1 and x_2. If the minimum speed of the planet on its trajectory is v_0 then its maximum speed will be :

(1) $\dfrac{v_0 x_1^2}{x_2^2}$ (2) $\dfrac{v_0 x_2^2}{x_1^2}$ (3) $\dfrac{v_0 x_1}{x_2}$ (4) $\dfrac{v_0 x_2}{x_1}$

Official Ans. by NTA (4)

Sol. Angular momentum conservation equation

$v_0 x_2 = v_1 x_1$

$v_1 = \dfrac{v_0 x_2}{x_1}$

SECTION-B

1. A body of mass 2 kg moving with a speed of 4 m/s. makes an elastic collision with another body at rest and continues to move in the original direction but with one fourth of its initial speed. The speed of the two body centre of mass is $\dfrac{x}{10}$ m/s. Then the value of x is_____.

Official Ans. by NTA (25)

Sol. $p_i = p_f$

$2 \times 4 = 2 \times 1 + m_2 \times v_2$

$m_2 v_2 = 6$ ....(i)

by coefficient of restitution

$1 = \dfrac{v_2 - 1}{4} \Rightarrow v_2 = 5 \text{ m/s}$

by (i)

$m_2 \times 5 = 6$

$m_2 = 1.2 \text{ kg}$

$v_{cm} = \dfrac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$

$v_{cm} = \dfrac{2 \times 1 + 1.2 \times 5}{2 + 1.2} = \dfrac{8}{3.2} = \dfrac{25}{10}$

$\boxed{x = 25}$

2. Student A and Student B used two screw gauges of equal pitch and 100 equal circular divisions to measure the radius of a given wire. The actual value of the radius of the wire is 0.322 cm. The absolute value of the difference between the final circular scale readings observed by the students A and B is _____.

[Figure shows position of reference 'O' when jaws of screw gauge are closed]

Given pitch = 0.1 cm.

Screw gauge (A)   Screw gauge (B)
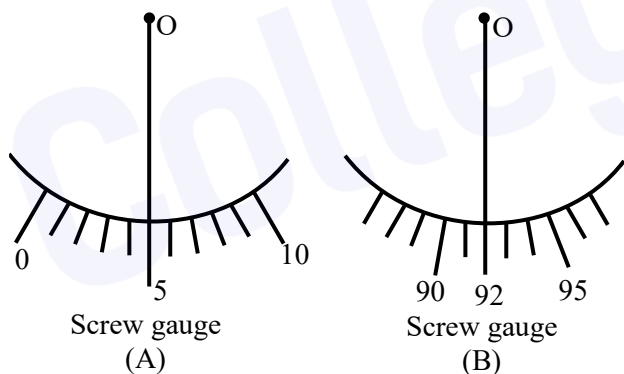
Official Ans. by NTA (13)

Sol. For (A)

Reading = MSR + CSR + Error

$0.322 = 0.300 + \text{CSR} + 5 \times \text{LC}$

$0.322 = 0.300 + \text{CSR} + 0.005$

$\text{CSR} = 0.017$

For B

Reading = MSR + CSR + Error

$0.322 = 0.200 + \text{CSR} + 0.092$

$\text{CSR} = 0.030$

Difference = $0.030 - 0.017 = 0.013$ cm

Division on circular scale = $\dfrac{0.013}{0.001} = 13$

3. An inductor of 10 mH is connected to a 20 V battery through a resistor of 10 kΩ and a switch. After a long time, when maximum current is set up in the circuit, the current is switched off. The current in the circuit after 1 μs is $\dfrac{x}{100}$ mA. Then x is equal to _____. (Take $e^{-1} = 0.37$)

Official Ans. by NTA (74)

Sol. $I_{max} = \dfrac{V}{R} = \dfrac{20V}{10K\Omega} = 2mA$

For LR – decay circuit

$I = I_{max} \, e^{-Rt/L}$

$I = 2mA \, e^{\frac{-10 \times 10^3 \times 1 \times 10^{-6}}{10 \times 10^{-3}}}$

$I = 2mA \, e^{-1}$

$I = 2 \times 0.37 \text{ mA}$

$I = \dfrac{74}{100} \text{ mA}$

$\boxed{x = 74}$

4. A circular conducting coil of radius 1 m is being heated by the change of magnetic field $\vec{B}$ passing perpendicular to the plane in which the coil is laid. The resistance of the coil is 2 μΩ. The magnetic field is slowly switched off such that its magnitude changes in time as

$$B = \dfrac{4}{\pi} \times 10^{-3} T \left(1 - \dfrac{t}{100}\right)$$

The energy dissipated by the coil before the magnetic field is switched off completely is E = _____ mJ.

Official Ans. by NTA (80)

Sol. $\phi = \vec{B}.\vec{S}$

$\phi = \dfrac{4}{\pi} \times 10^{-3} \left(1 - \dfrac{t}{100}\right).\pi R^2$

$\phi = 4 \times 10^{-3} \times (1)^2 \left(1 - \dfrac{t}{100}\right)$

$$\varepsilon = \frac{-d\phi}{dt}$$

$$\varepsilon = \frac{-d}{dt}\left(4\times10^{-3}\left(1-\frac{t}{100}\right)\right)$$

$$\varepsilon = 4\times10^{-3}\left(\frac{1}{100}\right) = 4\times10^{-5}\,\mathbf{V}$$

When B = 0

$$1 - \frac{t}{100} = 0$$

t = 100 sec

$$\text{Heat} = \frac{\varepsilon^2}{R}t$$

$$\text{Heat} = \frac{(4\times10^{-5})^2}{2\times10^{-6}}\times100 \text{ J}$$

$$\text{Heat} = \frac{16\times10^{-10}\times100}{2\times10^{-6}}\text{ J}$$

Heat = 0.08 J

Heat = 80 mJ

5. In the reported figure, two bodies A and B of masses 200 g and 800 g are attached with the system of springs. Springs are kept in a stretched position with some extension when the system is released. The horizontal surface is assumed to be frictionless. The angular frequency will be _____ rad/s when k = 20 N/m.
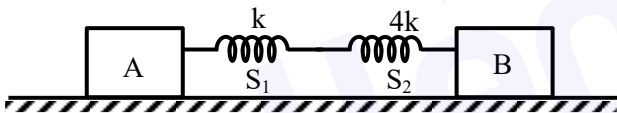
Official Ans. by NTA (10)

Sol. $\omega = \sqrt{\dfrac{k_{eq}}{\mu}}$

μ = reduced mass

springs are in series connection

$$k_{eq} = \frac{k_1 k_2}{k_1 + k_2}$$

$$k_{eq} = \frac{k \times 4k}{5k} = \frac{4k}{5}$$

$$k_{eq} = \frac{4\times20}{5}\text{ N/m} = 16\text{ N/m}$$

$$\mu = \frac{m_1 m_2}{m_1 + m_2} = \frac{0.2\times0.8}{0.2+0.8} = 0.16\text{ kg}$$

$$\omega = \sqrt{\frac{16}{0.16}} = \sqrt{100} = 10$$

6. The value of aluminium susceptibility is 2.2×10^{-5}. The percentage increase in the magnetic field if space within a current carrying toroid is filled with aluminium is $\dfrac{x}{10^4}$. Then the value of x is _____.

Official Ans. by NTA (22)

Sol. B = μ.(H+I)

$$B = \mu.H\left(1+\frac{I}{H}\right)$$

B = B₀(1+x)

B–B₀ = B₀x

$$\frac{B - B_0}{B_0} = x$$

$$\frac{B - B_0}{B_0}\times100 = 100x$$

$$= 2.2\times10^{-3} = \frac{22}{10^4}$$

7. A particle of mass 1 mg and charge q is lying at the mid-point of two stationary particles kept at a distance '2 m' when each is carrying same charge 'q'. If the free charged particle is displaced from its equilibrium position through distance 'x' (x << 1 m). The particle executes SHM. Its angular frequency of oscillation will be _____ × 10⁵ rad/s if q² = 10 C².

Official Ans. by NTA (6000)

Sol.
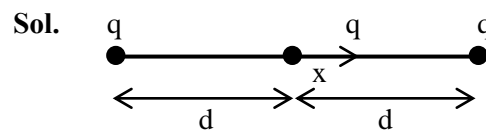
Net force on free charged particle

$$F = \frac{kq^2}{(d+x)^2} - \frac{kq^2}{(d-x)^2}$$

$$F = -kq^2\left[\frac{4dx}{(d^2-x^2)^2}\right]$$

$$a = -\frac{4kq^2 d}{m}\left(\frac{x}{d^4}\right)$$

$$a = -\left(\frac{4kq^2}{md^3}\right)x$$

So, angular frequency

$$\omega = \sqrt{\frac{4kq^2}{md^3}}$$

$$\omega = \sqrt{\frac{4 \times 9 \times 10^9 \times 10}{1 \times 10^{-6} \times 1^3}}$$
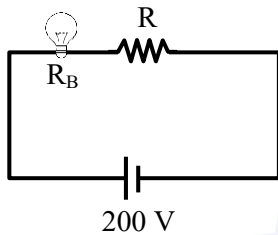
$$\omega = 6 \times 10^8 \text{ rad/sec}$$

8. An electric bulb rated as 200 W at 100 V is used in a circuit having 200 V supply. The resistance 'R' that must be put in series with the bulb so that the bulb delivers the same power is _____ Ω.

Official Ans. by NTA (50)

Sol. Power, $P = \dfrac{V^2}{R_B}$

$$R_B = \frac{V^2}{P} = \frac{100 \times 100}{200}$$

$$R_B = 50\Omega$$

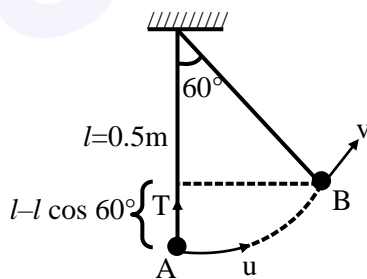To produce same power, same voltage (i.e. 100 V) should be across the bulb

Hence, $R = R_B$

$R = 50 \ \Omega$

9. A pendulum bob has a speed of 3 m/s at its lowest position. The pendulum is 50 cm long. The speed of bob, when the length makes an angle of 60° to the vertical will be (g = 10 m/s^2) _____ m/s.

Official Ans. by NTA (2)

Sol.

Applying work energy theorem :

$w_g + w_T = \Delta K$

$$-mgl(1-\cos60°) = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$v^2 = u^2 - 2gl(1-\cos60°)$

$$v^2 = 9 - 2 \times 10 \times 0.5 \left(\frac{1}{2}\right)$$

$v^2 = 4$

$v = 2$ m/s

10. A particle of mass 'm' is moving in time 't' on a trajectory given by

$$\vec{r} = 10 \ \alpha t^2 \hat{i} + 5\beta(t-5)\hat{j}$$

Where α and β are dimensional constants.

The angular momentum of the particle becomes the same as it was for t = 0 at time t = _____ seconds.

Official Ans. by NTA (10)

Sol. $\vec{r} = 10\alpha t^2\hat{i} + 5\beta(t-5)\hat{j}$

$\vec{v} = 20\alpha t\hat{i} + 5\beta\hat{j}$

$\vec{L} = m(\vec{r} \times \vec{v})$

$= m[10\alpha t^2\hat{i} + 5\beta(t-5)\hat{j}] \times [20\alpha t\hat{i} + 5\beta\hat{j}]$

$\vec{L} = m[50\alpha\beta t^2\hat{k} - 100\alpha\beta(t^2-5t)\hat{k}]$

At $t = 0$, $\vec{L} = \vec{0}$

$50\alpha\beta t^2 - 100\alpha\beta(t^2-5t) = 0$

$t - 2(t-5) = 0$

$t = 10$ sec