

**JEE Main July 2021**  
**Question Paper With Text Solution**  
**25 July. | Shift-1**

**PHYSICS**



**JEE Main & Advanced | XI-XII Foundation | VI-X Pre-Foundation**

**Office : Piprali Road, Sikar (Raj.) | Ph. 01572-241911**

**Website : [www.matrixedu.in](http://www.matrixedu.in) ; Email : [smd@matrixacademy.co.in](mailto:smd@matrixacademy.co.in)**

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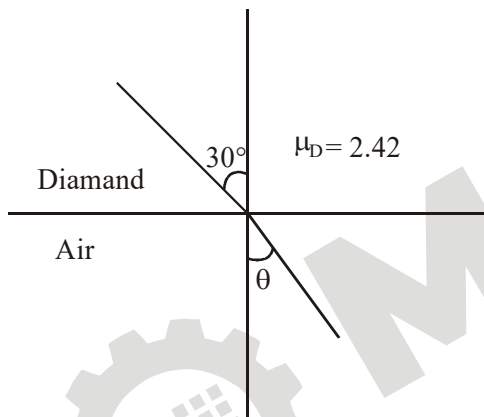
**JEE MAIN JULY 2021 | 25<sup>TH</sup> JULY SHIFT-1****SECTION - A**

1. A ray of laser of a wavelength 630 nm is incident at an angle of  $30^\circ$  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  $30^\circ$
- (2) Angle of refraction is  $24.41^\circ$
- (3) Refraction is not possible
- (4) Angle of refraction is  $53.4^\circ$

Ans. Official Answer NTA (3)

Sol.



For TIR  $\sin \theta_R = \frac{1}{2.42} \Rightarrow \theta_R < 30^\circ$

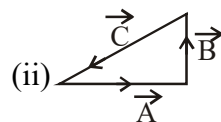
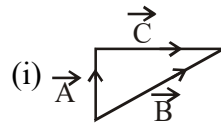
as the incident angle is more than angle for TIR so no refraction at the surface. Ray will be Reflected back into the medium

2. Match List I with List II.

**List I**

(a)  $\vec{C} - \vec{A} - \vec{B} = 0$

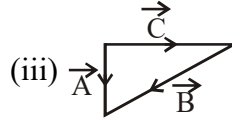
(b)  $\vec{A} - \vec{C} - \vec{B} = 0$

**List II****MATRIX JEE ACADEMY**

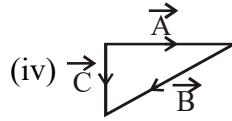
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(c)  $\vec{B} - \vec{A} - \vec{C} = 0$



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



Choose the correct answer from the options given below :

(1)  $a \rightarrow \text{iv}, b \rightarrow \text{iii}, c \rightarrow \text{i}, d \rightarrow \text{ii}$

(2)  $a \rightarrow \text{iii}, b \rightarrow \text{ii}, c \rightarrow \text{iv}, d \rightarrow \text{i}$

(3)  $a \rightarrow \text{i}, b \rightarrow \text{iv}, c \rightarrow \text{ii}, d \rightarrow \text{iii}$

(4)  $a \rightarrow \text{iv}, b \rightarrow \text{i}, c \rightarrow \text{iii}, d \rightarrow \text{ii}$

Ans. Official Answer NTA (1)

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

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

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

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

(a)  $\rightarrow$  (iv) (b)  $\rightarrow$  (iii) (c)  $\rightarrow$  (i) (d)  $\rightarrow$  (ii)

3. 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  $d_0$ ,  $\omega$  and  $a_0$  are constants. The difference between the largest fringe width and the smallest fringe width obtained over time is given as :

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

(2)  $\frac{\lambda D}{d_0^2} a_0$



(3)  $\frac{\lambda D}{d_0 + a_0}$

(4)  $\frac{2\lambda D(d_0)}{(d_0^2 - a_0^2)}$

Ans. Official Answer NTA (1)

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

$$\beta = \frac{\lambda D}{d_0 + a_0 \sin \omega t}$$

$$\beta_{\max} = \frac{\lambda D}{d_0 - a_0}, \quad \beta_{\min} = \frac{\lambda D}{d_0 + a_0}$$

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

4. 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  $\lambda$  is the decay constant)

(1)  $\frac{\ln 2}{\lambda}$

(2)  $\frac{1}{2} \frac{\ln 2}{\lambda}$

(3)  $\frac{\ln \frac{3}{2}}{\lambda}$

(4)  $\frac{2 \ln 2}{\lambda}$

Ans. Official Answer NTA (3)

Sol.  $N = N_0 e^{-\lambda t}$

for  $N = \frac{3N_0}{4} = N_0 e^{-\lambda t_1}$

$$\ln\left(\frac{3}{4}\right) = -\lambda t_1 \dots\dots(1)$$

for  $N = \frac{N_0}{2} = N_0 e^{-\lambda t_2}$



$$\ln\left(\frac{1}{2}\right) = -\lambda t_2 \dots\dots(2)$$

From (1) & (3)

$$-\lambda(t_1 - t_2) = \ln\left(\frac{3}{4}\right) - \ln\left(\frac{1}{2}\right)$$

$$\Rightarrow t_1 - t_2 = \frac{\ln\left(\frac{3}{2}\right)}{\lambda}$$

5. Two wires of same length and radius are joined end to end and loaded. The Young's moduli 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 :

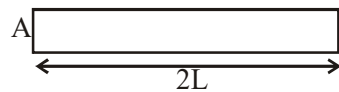
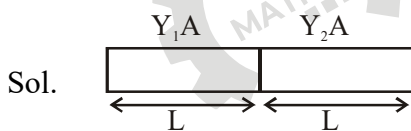
(1)  $Y = \frac{2Y_1Y_2}{Y_1 + Y_2}$

(2)  $Y = \frac{Y_1Y_2}{Y_1 + Y_2}$

(3)  $Y = \frac{Y_1Y_2}{Y_1 + Y_2}$

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

Ans. Official Answer NTA (1)



$Y_{eq}$

$$\frac{F \times L}{AY_1} + \frac{F \times L}{AY_2} = \frac{F \times 2L}{AY_{eq}}$$

$$\Rightarrow \frac{1}{Y_1} + \frac{1}{Y_2} = \frac{2}{Y_{eq}}$$

$$\Rightarrow Y_{eq} = \frac{2Y_1Y_2}{Y_1 + Y_2}$$



6. In Amplitude Modulation, the message signal

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

Carrier signal

$$V_c(t) = 20 \sin(2\pi \times 10^7 t) \text{ volts}$$

The modulated signal now contains the message signal with lower side band and upper side band frequency, therefore the bandwidth of modulated signal is  $\alpha$  kHz.

The value of  $\alpha$  is :

- (1) 200 kHz
- (2) 50 kHz
- (3) 100 kHz
- (4) 0

Ans. Official Answer NTA (1)

Sol.  $2\pi \times 10^5 = 2\pi \times f_m$        $2\pi \times 10^7 = 2\pi \times f_c$

$$f_m = 10^5 \text{ Hz} \qquad f_c = 10^7 \text{ Hz}$$

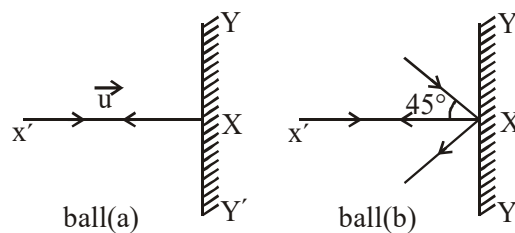
$$= 100 \text{ kHz} \qquad = 10,000 \text{ kHz}$$

Lower side band =  $(10,000 - 100) \text{ kHz} = 9900 \text{ kHz}$

Upper side band =  $(10,000 + 100) \text{ kHz} = 10100 \text{ kHz}$

Band width = 200 kHz

7. 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 :



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



Ans. Official Answer NTA (4)

Sol.  $V = 108 \text{ km/hr}$

for ball (a)  $I_1 = 2mu$

for ball (b)  $I_2 = \frac{2mu}{\sqrt{2}} = \sqrt{2}mu$

$$\frac{I_1}{I_2} = \frac{\sqrt{2}}{1}$$

8. 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)  $\frac{v_0 x_1^2}{x_2^2}$

(2)  $\frac{v_0 x_1}{x_2}$

(3)  $\frac{v_0 x_2}{x_1}$

(4)  $\frac{v_0 x_2^2}{x_1^2}$

Ans. Official Answer NTA (3)

Sol. using conservation of angular momentum

$$mv_0 x_1 = mv x_2$$

$$v = \frac{v_0 x_1}{x_2}$$

9. 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)  $T_p = T_Q$

(4)  $T_p = 0.9 T_Q$



Ans. Official Answer NTA (2)

Sol. as  $C_p - C_v = nR$

So in state P gas has less no of moles than in state Q

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

$$\text{so } T_p > T_Q$$

10. What should be the order of arrangement of de-Broglie wavelength of electron ( $\lambda_e$ ), an  $\alpha$ -particle ( $\lambda_\alpha$ ) and proton ( $\lambda_p$ ) 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)  $\lambda_e < \lambda_p < \lambda_\alpha$

Ans. Official Answer NTA (2)

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

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mk}}$$

for same kE

$$\lambda \propto \frac{1}{\sqrt{m}}$$

as  $m_e < m_p < m_\alpha$

so  $\lambda_e < \lambda_p < \lambda_\alpha$

11. 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)  $1:\sqrt{3}$

(2)  $3:1$

(3)  $1:3$

(4)  $1:1$





Ans. Official Answer NTA (4)

Sol.  $\begin{matrix} \text{P} \\ \leftarrow \\ \text{m} \end{matrix} \quad \begin{matrix} \text{P} \\ \rightarrow \\ \text{3u} \end{matrix}$

Both will have same momentum so same de Broglie wave length

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

- (1)  $16.18 \times 10^{12}$
- (2)  $2.67 \times 10^{12}$
- (3)  $6.06 \times 10^{18}$
- (4)  $32.36 \times 10^{12}$

Ans. Official Answer NTA (1)

Sol.  $T_{1/2} = 3 \text{ days} = 3 \times 24 \times 60 \times 60 \text{ sec}, \lambda = \frac{0.639}{T_{1/2}}$

$m = 2 \text{ mg}$   
 $= 2 \times 10^{-3} \text{ gm}$

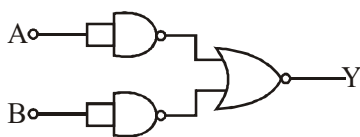
$N = \frac{m}{M} \times N_A$

$= \frac{2 \times 10^{-3}}{198} \times 6.023 \times 10^{23}$

Activity =  $\lambda N$

$= \frac{0.639}{3 \times 24 \times 60 \times 60} \times \frac{2 \times 10^{-3}}{198} \times 6.023 \times 10^{23} = 16.26 \times 10^{12}$

13. Identify the logic operation carried out.

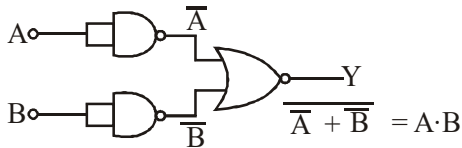


- (1) NOR
- (2) AND
- (3) NAND
- (4) OR

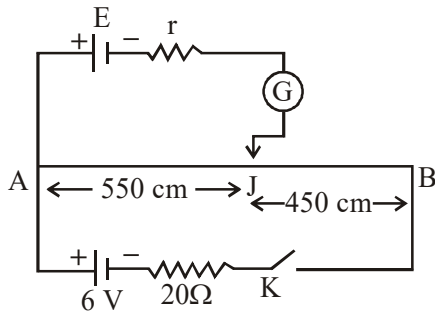
Ans. Official Answer NTA (2)



Sol.



14. In the given figure, there is a circuit of potentiometer of length  $AB = 10$  m. The resistance per unit length is  $0.1 \Omega$  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

Ans. Official Answer NTA (1)

Sol.  $R_{AB} = 10 \times 10^2 \times 0.1$   
 $= 100 \Omega$

$$I = \frac{6}{120} = \frac{1}{20} \text{ A}$$

$$\text{So } V_{AB} = 100 \times \frac{1}{20} = 5\text{V}$$

So maximum value of Emf measured = 5V



15. A linearly polarized electromagnetic wave in vacuum is

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

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

- (1) The wavelength is 5.4 m
- (2) The reflected wave will be  $3.1 \cos[(1.8)z + (5.4 \times 10^6)t] \hat{i} \text{ N/C}$
- (3) The transmitted wave will be  $3.1 \cos[(1.8)z - (5.4 \times 10^6)t] \hat{i} \text{ N/C}$
- (4) The frequency of electromagnetic wave is  $54 \times 10^4 \text{ Hz}$

Ans. Official Answer NTA (2)

Sol. as surface is perfectly reflecting so no transmitted wave  
so equation of reflected wave

$$3.1 \cos[(1.8)z + (5.4 \times 10^6)t] \hat{i} \text{ N/C}$$

16. 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 and R is the correct explanation of A.
- (2) Both A and R are correct but R is NOT the correct explanation of A.
- (3) A is not correct but R is correct.
- (4) A is correct but R is not correct.

Ans. Official Answer NTA (1)

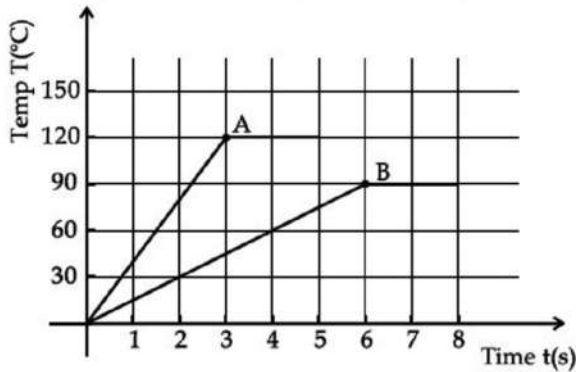
Sol. Assertion is wrong as

$I_x = I_y$  so radius of Gyration will be same for x and y axis

also  $I_z = I_x + I_y$  so for z-axis radius of Gyration will be different from x and y axis



17. 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)  $3/4$   
 (2)  $8/3$   
 (3)  $4/3$   
 (4)  $3/8$

Ans. Official Answer NTA (4)

Sol.  $\frac{dQ}{dt} = ms \left( \frac{dT}{dt} \right)$

$$\frac{dT}{dt} = \left( \frac{1}{ms} \right) \frac{dQ}{dt}$$

as  $\frac{dQ}{dt}$  is same for both so

$$\frac{dT}{dt} \times \frac{1}{S} \text{ (slope of Temp us time graph)}$$

$$\left( \frac{dT}{dt} \right)_A \times \frac{S_B}{S_A} = \frac{\left( \frac{120}{3} \right)}{\left( \frac{90}{6} \right)} = \frac{40}{30} = \frac{8}{3}$$

$$\text{so } \frac{S_A}{S_B} = \frac{3}{8}$$



18. 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  $\frac{T_1}{T_2}$  will be :

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

(2)  $\frac{l_2}{l_1}$

(3)  $\frac{l_1}{l_2}$

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

Ans. Official Answer NTA (1)

Sol. For mono atomic gas

$$y = 5/3$$

for adiabatic process

$$TV^{y-1} = \text{const}$$

$$T_1(A_1)^{5/3-1} = T_2(A_2)^{5/3-1}$$

$$\frac{T_1}{T_2} = \left(\frac{l_2}{l_1}\right)^{2/3}$$

19. Water droplets are coming from an open tap at a particular rate. The spacing between a droplet observed at 4<sup>th</sup> second after its fall to the next droplet is 34.3 m. At what rate the droplets are coming from the tap ? (Take  $g = 9.8 \text{ m/s}^2$ )
- (1) 1 drop/second  
(2) 3 drop/2second  
(3) 2 drop/second  
(4) 1drop/7second



Ans. Official Answer NTA (1)

Sol. Gap b/w drops = t sec  
so for 1st ball – time 4 sec  
& for next ball time is 4 – t  
so  $\frac{1}{2}g(4)^2 - \frac{1}{2}g(4-t)^2 = 34.3$   
 $16 - (4-t)^2 = 7$   
 $(4-t)^2 = 7$   
 $4-t = 3$   
 $t = 1$  sec

in every 1 sec, one drop dropped

1 drop / sec

20. 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 :

$$\epsilon(x) = \epsilon_0 + kx, \text{ for } \left(0 < x \leq \frac{d}{2}\right)$$

$$\epsilon(x) = \epsilon_0 + k(d-x), \text{ for } \left(\frac{d}{2} \leq x \leq d\right)$$

$$(1) \frac{kA}{2} \ln \left( \frac{2\epsilon_0 + kd}{2\epsilon_0} \right)$$

$$(2) \left( \epsilon_0 + \frac{kd}{2} \right)^{2/kA}$$

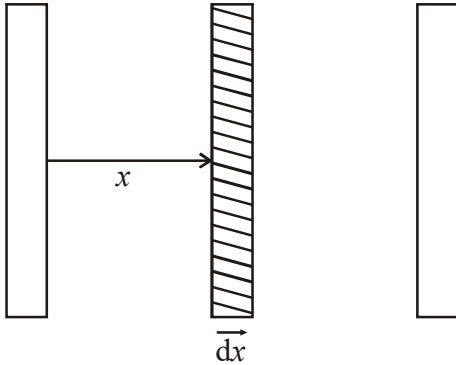
$$(3) 0$$

$$(4) \frac{kA}{2} \ln \left( \frac{2\epsilon_0}{2\epsilon_0 - kd} \right)$$



Ans. Official Answer NTA (1)

Sol.



Given

$$\epsilon = \epsilon_0 \left( 1 + \frac{kx}{d} \right) \text{ for } 0 < x < d/2$$

$$= \epsilon_0 \left( 1 + \frac{k(d-x)}{d} \right) \text{ for } \frac{d}{2} < x < d$$

$$dC = \frac{\epsilon A}{dx} \text{ (here } \epsilon = \text{permittivity at distance } x)$$

as all the elements are in series so

$$\begin{aligned} \frac{1}{C_{eq}} &= \int \frac{1}{dC} \\ &= \frac{1}{\epsilon_0 A} \int_0^{d/2} \frac{d}{1 + \frac{kx}{d}} + \frac{1}{\epsilon_0 A} \int_{d/2}^d \frac{dx}{1 + \frac{k(d-x)}{d}} \end{aligned}$$

$$\Rightarrow C_{eq} = \frac{K\epsilon_0 A}{2d} \ln \left( 1 + \frac{K}{2} \right)$$

**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  $\frac{x}{10}$  m/s. Then the value of x is \_\_\_\_\_,

Ans. Official Answer NTA (25)



$$p_i = p_f$$

$$\Rightarrow 2 \times 4 + 0 = 2 \times 1 + m \times v \quad \text{also}$$

$$\Rightarrow mv = 6$$

$$e = 1 = \frac{v-1}{4}$$

$$\Rightarrow v = 5 \text{ m/sec}$$

$$\& m = 6/5 \text{ kg}$$

$$v_{\text{COM}} = \frac{2 \times 1 + \frac{6}{5} \times 5}{2 + \frac{6}{5}}$$

$$= \frac{2+6}{\left(\frac{16}{5}\right)} = \frac{5}{2} \text{ m/sec} = \frac{25}{10} \text{ m/sec}$$

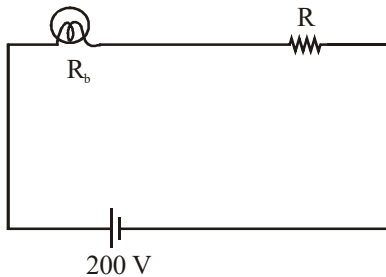
So value of x = 25





2. 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 \_\_\_\_\_  $\Omega$ .

Ans. Official Answer NTA (50)



$$R_b = \frac{(100)^2}{200}$$

$$= 50 \Omega$$

Now as rated voltage of bulb is 100 V

So we have to divide the supply voltage 200 V into half.

For that we have to connect same amount of resistance in series to divide 200 V into 100 V and 100 V.

$$\text{So } R = 50 \Omega$$

3. 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  $60^\circ$  to the vertical will be ( $g = 10 \text{ m/s}^2$ ) \_\_\_\_\_ m/s.

Ans. Official Answer NTA (2)

Sol. Using work energy

$$-mg(L - L \cos 60^\circ) = \frac{1}{2}mv^2 - \frac{1}{2}m(3)^2$$

$$\Rightarrow v = 2 \text{ m/sec.}$$



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  $2\mu\Omega$ . The magnetic field is slowly switched off such that its magnitude changes in time as

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

The energy dissipated by the coil before the magnetic field is switched off completely is

$$E = \text{————— mJ.}$$

Ans. Official Answer NTA (80)

Sol.  $\vec{\phi} = \vec{B} \cdot \vec{A}$       Area =  $\pi(1)^2$   
 $= \pi \text{ m}^2$

$$= \pi \times \frac{4}{\pi} \times 10^{-3} \left( 10 - \frac{t}{100} \right)$$

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

$$\varepsilon = \frac{-d\phi}{dt} = 4 \times 10^{-3} \times \frac{1}{100}$$

$$E = 4 \times 10^{-5} \text{ v}$$

$$\text{Power} = \frac{E^2}{R} = \frac{16 \times 10^{-10}}{2 \times 10^{-6}}$$

$$= 8 \times 10^{-4} \text{ watt}$$

At  $t = 100$  sec,  $B = 0$  so

For 100 sec, Heat dissipated

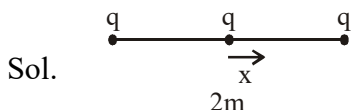
$$= 8 \times 10^{-4} \times 100$$

$$= 8 \times 10^{-2} \text{ J}$$

$$= 80 \text{ mJ}$$

5. 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 ' $x$ ' ( $x \ll 1$  m). The particle executes SHM. Its angular frequency of oscillation will be \_\_\_\_\_  $\times 10^5$  rad/s if  $q^2 = 10 \text{ C}^2$ .

Ans. Official Answer NTA (6)



$$f_{\text{net}} = \frac{kq^2}{(1-x)^2} - \frac{kq^2}{(1+x)^2}$$



$$= kq^2 \left[ \frac{(1+x)^2 - (1-x)^2}{(1-x^2)^2} \right] \quad (\text{as } x \text{ is very small so } 1-x^2 \approx 1)$$

$$f_{\text{net}} = kq^2 [4x] = ma$$

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

$$\text{So Angular frequency } \omega = \sqrt{\frac{4kq^2}{m}} = \sqrt{\frac{4 \times 9 \times 10^9 \times 10}{10^{-3} \times 10^{-3}}}$$

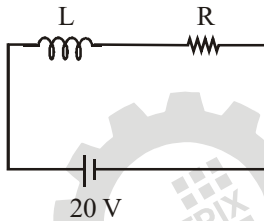
$$= 6 \times 10^4$$

$$= 60 \times 10^5 \text{ rad/sec}$$

6. 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  $\frac{x}{100}$  mA. Then x is equal to \_\_\_\_\_. (Take  $e^{-1} = 0.37$ )

Ans. Official Answer NTA (74)

Sol.

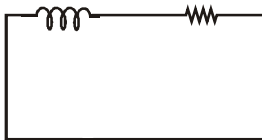


After a long time

$$\text{Current } I_0 = \frac{20}{R} = \frac{20}{10^4} \text{ A}$$

$$I_0 = 2 \text{ mA}$$

Now



$$I = I_0 e^{(-t/\tau)} \quad \left[ \tau = \frac{L}{R} \right]$$

$$\tau = \frac{10 \times 10^{-3}}{10 \times 10^3}$$

$$\tau = 10^{-6}$$

$$\Rightarrow I = 2 \times e^{-\frac{10^{-6}}{10^{-6}}}$$

**MATRIX JEE ACADEMY**

Office : Piprali Road, Sikar (Raj.) | Ph. 01572-241911

Website : www.matrixedu.in ; Email : smd@matrixacademy.co.in



$$I = 2 \times e^{-1} = 2 \times 0.37 \text{ mA}$$

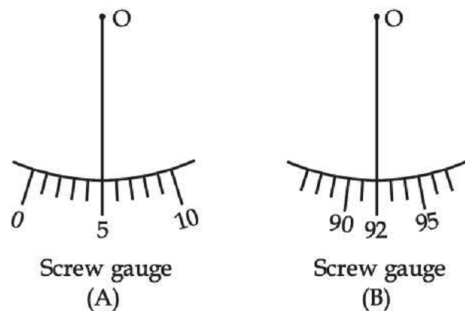
$$= \frac{74}{100} \text{ mA}$$

$$x = 74$$

7. 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.



Ans. Official Answer NTA (13)

Sol. for Student A

$$\text{Error} = +5$$

for Student B

$$\text{Error is } -8$$

$$\text{Difference in circular scale reading} = 13$$

8. The value of aluminium susceptibility is  $2.2 \times 10^{-5}$ . The percentage increase in the magnetic field if space within a current carrying toroid is filled with Aluminium is  $\frac{x}{10^4}$ .

Then the value of x is \_\_\_\_\_.



Ans. Official Answer NTA (22)

Sol.  $B = \mu_0 \eta i$

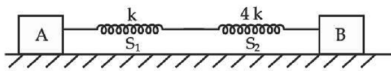
$$B' = \mu_0 \mu_r \eta i = \mu_0 B \quad (\text{After})$$

$$\frac{B' - B}{B} = (\mu_r - 1) \frac{B}{B} = \mu_r - 1 = x = 2.2 \times 10^{-5} \quad [1 + x = \mu]$$

$$\text{Given } \frac{B' - B}{B} \times 100 = \frac{x}{10^4} = 2.2 \times 10^{-5} \times 100$$

$$\Rightarrow x = 22$$

9. 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  $k = 20 \text{ N/m}$ .



Ans. Official Answer NTA (10)

$$\text{Sol. } k_{\text{eq}} = \frac{k_1 k_2}{k_1 + k_2} = 0.8k$$

$$\mu = \frac{m_1 m_2}{m_1 + m_2} = 160 \text{ gm}$$

$$\omega = \sqrt{\frac{k_{\text{eq}}}{\mu}} = 10 \text{ rad / sec}$$



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  $\alpha$  and  $\beta$  are dimensional constants.

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

$t = \text{—————}$  seconds.

Ans. Official Answer NTA (10)

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

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

$$\hat{i} = \vec{r} \times \vec{p}$$

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

at  $t = 0$

$$r = 0$$

so  $L = 0$  about origin

Now for  $\hat{i}$  to be zero again,  $\vec{r}$  and  $\vec{v}$  should be  $0^\circ$  or  $180^\circ$  making angle.

$$\hat{i} = m(\vec{r} \times \vec{v}) = 0$$

$$\Rightarrow 10\alpha t^2 5\beta \hat{k} + 20\alpha t 5\beta(t-5)(-\hat{k}) = 0$$

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

$$\Rightarrow t = 2t - 10$$

$$\Rightarrow t = 10 \text{ sec}$$

