

# FINAL JEE-MAIN EXAMINATION – JULY, 2022

(Held On Thursday 28<sup>th</sup> July, 2022)

TIME : 9 : 00 AM to 12 : 00 NOON

## PHYSICS

### SECTION-A

1. The dimensions of  $\left(\frac{B^2}{\mu_0}\right)$  will be :

(if  $\mu_0$  : permeability of free space and  
B : magnetic field)

- (A)  $[M L^2 T^{-2}]$  (B)  $[M L T^{-2}]$   
(C)  $[M L^{-1} T^{-2}]$  (D)  $[M L^2 T^{-2} A^{-1}]$

**Official Ans. by NTA (C)**

**Allen Overseas Ans. (C)**

**Sol.**  $u = \frac{B^2}{2\mu_0}$

u  $\rightarrow$  Energy per unit volume

$$\left[\frac{B^2}{\mu_0}\right] = [u] = \frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$$

2. A NCC parade is going at a uniform speed of 9 km/h under a mango tree on which a monkey is sitting at a height of 19.6 m. At any particular instant, the monkey drops a mango. A cadet will receive the mango whose distance from the tree at time of drop is :

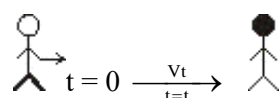
(Given  $g = 9.8 \text{ m/s}^2$ )

- (A) 5 m (B) 10 m  
(C) 19.8 m (D) 24.5 m

**Official Ans. by NTA (A)**

**Allen Overseas Ans. (A)**

**Sol.** Monkey



$$\begin{aligned} \text{Time taken by mango} &= \sqrt{\frac{2n}{g}} \\ &= \sqrt{\frac{2 \times 19.6}{9.8}} = 2 \text{ second} \end{aligned}$$

Distance = vt

$$= 9 \times \frac{5}{18} \times 2 = 5 \text{ m}$$

## TEST PAPER WITH SOLUTION

3. In two different experiments, an object of mass 5 kg moving with a speed of  $25 \text{ ms}^{-1}$  hits two different walls and comes to rest within (i) 3 second, (ii) 5 seconds, respectively. Choose the correct option out of the following :

- (A) Impulse and average force acting on the object will be same for both the cases.  
(B) Impulse will be same for both the cases but the average force will be different.  
(C) Average force will be same for both the cases but the impulse will be different.  
(D) Average force and impulse will be different for both the cases.

**Official Ans. by NTA (B)**

**Allen Overseas Ans. (B)**

**Sol.** Impulse = change in momentum

$$I = \Delta P$$

$$F_{\text{avg}} = \frac{\Delta P}{\Delta t}$$

$$\Delta t_1 = 3 \quad \Delta t_2 = 5$$

$$\Delta P_1 = \Delta P_2$$

$$I_1 = I_2$$

$F_{\text{avg}}$  in case (i) is more than (ii)

4. A balloon has mass of 10 g in air. The air escapes from the balloon at a uniform rate with velocity 4.5 cm/s. If the balloon shrinks in 5 s completely. Then, the average force acting on that balloon will be (in dyne).

- (A) 3 (B) 9 (C) 12 (D) 18

**Official Ans. by NTA (B)**

**Allen Overseas Ans. (B)**

**Sol.**  $F = \frac{dm}{dt} v$

$$= \frac{10 \text{ g}}{5 \text{ s}} \left( 4.5 \frac{\text{cm}}{\text{s}} \right) = 9 \frac{\text{gcm}}{\text{s}^2} = 9 \text{ dyne}$$

5. If the radius of earth shrinks by 2% while its mass remains same. The acceleration due to gravity on the earth's surface will approximately :

(A) decrease by 2% (B) decrease by 4%  
(C) increase by 2% (D) increase by 4%

**Official Ans. by NTA (D)**

**Allen Overseas Ans. (D)**

**Sol.**  $g = \frac{GM}{R^2}$

$$M = \text{constant} \quad g \propto \frac{1}{R^2}$$

$$100 \frac{\Delta g}{g} = -2 \frac{\Delta R}{R} 100$$

$$\% \text{ change} = -2 (-2)$$

$$\% \text{ change in } g = 4\%$$

$$\text{increase by } 4\%$$

6. The force required to stretch a wire of cross-section  $1 \text{ cm}^2$  to double its length will be :

(Given Yong's modulus of the wire  $= 2 \times 10^{11} \text{ N/m}^2$ )

(A)  $1 \times 10^7 \text{ N}$  (B)  $1.5 \times 10^7 \text{ N}$   
(C)  $2 \times 10^7 \text{ N}$  (D)  $2.5 \times 10^7 \text{ N}$

**Official Ans. by NTA (C)**

**Allen Overseas Ans. (C)**

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

$$= 2 \times 10^{11} \times 10^{-4} \left( \frac{2\ell - \ell}{\ell} \right)$$

$$= 2 \times 10^7 \text{ N}$$

7. A Carnot engine has efficiency of 50%. If the temperature of sink is reduced by  $40^\circ\text{C}$ , its efficiency increases by 30%. The temperature of the source will be :

(A) 166.7 K (B) 255.1 K  
(C) 266.7 K (D) 367.7 K

**Official Ans. by NTA (C)**

**Allen Overseas Ans. (C)**

**Sol.**  $\eta = 1 - \frac{T_L}{T_H}$

$$\frac{1}{2} = 1 - \frac{T_L}{T_H}$$

$$\frac{1}{2} (1.3) = 1 - \left( \frac{T_L - 40}{T_H} \right)$$

$$\frac{1}{2} (1.3) = \frac{1}{2} + \frac{40}{T_H} \quad T_H = 266.7 \text{ K}$$

8. Given below are two statements :

**Statement I :** The average momentum of a molecule in a sample of an ideal gas depends on temperature.

**Statement II :** The rms speed of oxygen molecules in a gas is  $v$ . If the temperature is doubled and the oxygen molecules dissociate into oxygen atoms, the rms speed will become  $2v$ .

In the light of the above statements, choose the correct answer from the options given below :

(A) Both Statement I and Statement II are true  
(B) Both Statement I and Statement II are false  
(C) Statement I is true but Statement II is false  
(D) Statement I is false but Statement II is true

**Official Ans. by NTA (D)**

**Allen Overseas Ans. (D)**

**Sol.**  $[P_{\text{avg}} = 0]$  (due to random motion)

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

$$T_{\text{new}} = 2T$$

$$M_{\text{new}} = \frac{M}{2}$$

$$\frac{v_{\text{new}}}{v} = \frac{\sqrt{\frac{2T}{M/2}}}{\sqrt{\frac{3T}{M}}}$$

$$v_{\text{new}} = 2v$$

9. In the wave equation

$$y = 0.5 \sin \frac{2\pi}{\lambda} (400t - x) \text{ m}$$

the velocity of the wave will be :

(A) 200 m/s (B)  $200\sqrt{2}$  m/s

(C) 400 m/s (D)  $400\sqrt{2}$  m/s

**Official Ans. by NTA (C)**

**Allen Overseas Ans. (C)**

**Sol.**  $y = 0.5 \sin \left( \frac{2\pi}{\lambda} 400t - \frac{2\pi}{\lambda} x \right)$

$$\omega = \frac{2\pi}{\lambda} 400$$

$$K = \frac{2\pi}{\lambda}$$

$$v = \frac{\omega}{k} \quad [v = 400 \text{ m/s}]$$

10. Two capacitors, each having capacitance  $40 \mu\text{F}$  are connected in series. The space between one of the capacitors is filled with dielectric material of dielectric constant  $K$  such that the equivalence capacitance of the system became  $24 \mu\text{F}$ . The value of  $K$  will be :

(A) 1.5 (B) 2.5

(C) 1.2 (D) 3

**Official Ans. by NTA (A)**

**Allen Overseas Ans. (A)**



$$C_{\text{eq}} = \frac{C(KC)}{C + KC} = \frac{KC}{K + 1}$$

$$24 = \frac{K40}{K + 1}$$

$$[K = 1.5]$$

11. A wire of resistance  $R_1$  is drawn

out so that its length is increased by twice of its original length. The ratio of new resistance to original resistance is:

(A) 9 : 1 (B) 1 : 9

(C) 4 : 1 (D) 3 : 1

**Official Ans. by NTA (A)**

**Allen Overseas Ans. (A)**

**Sol.**  $R_1 = \rho \frac{L_1}{A_1}$

$$R_2 = \rho \left( \frac{3L_1}{A_1/3} \right) = 9\rho \frac{L_1}{A_1}$$

$$\therefore \frac{R_2}{R_1} = 9$$

12. The current sensitivity of a galvanometer can be increased by :

(A) decreasing the number of turns

(B) increasing the magnetic field

(C) decreasing the area of the coil

(D) decreasing the torsional constant of the spring

Choose the most appropriate answer from the options given below :

(A) (B) and (C) only (B) (C) and (D) only

(C) (A) and (C) only (D) (B) and (D) only

**Official Ans. by NTA (D)**

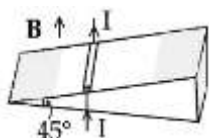
**Allen Overseas Ans. (D)**

**Sol.**  $i = \left( \frac{K}{NAB} \right) \theta$

$$\therefore \frac{d\theta}{dt} = \frac{NAB}{K}$$

13. As shown in the figure, a metallic rod of linear density  $0.45 \text{ kg m}^{-1}$  is lying horizontally on a smooth incline plane which makes an angle of  $45^\circ$  with the horizontal. The minimum current flowing in the rod required to keep it stationary, when  $0.15 \text{ T}$  magnetic field is acting on it in the vertical upward direction, will be :

{Use  $g = 10 \text{ m/s}^2$ }

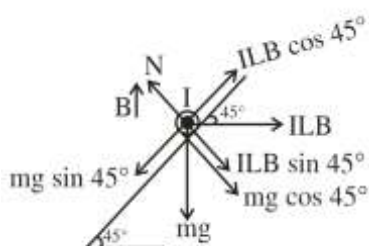


- (A) 30 A (B) 15 A  
(C) 10 A (D) 3 A

**Official Ans. by NTA (A)**

**Allen Overseas Ans. (A)**

**Sol.**



$$mg \sin 45^\circ = ILB \cos 45^\circ$$

$$\therefore I = \left( \frac{m}{L} \right) \frac{g}{B}$$

$$= \frac{(0.45)(10)}{0.15} = 30 \text{ A}$$

14. The equation of current in a purely inductive circuit is  $5 \sin(49\pi t - 30^\circ)$ . If the inductance is  $30 \text{ mH}$  then the equation for the voltage across the inductor, will be :

$$\left\{ \text{Let } \pi = \frac{22}{7} \right\}$$

- (A)  $1.47 \sin(49\pi t - 30^\circ)$  (B)  $1.47 \sin(49\pi t + 60^\circ)$   
(C)  $23.1 \sin(49\pi t - 30^\circ)$  (D)  $23.1 \sin(49\pi t + 60^\circ)$

**Official Ans. by NTA (D)**

**Allen Overseas Ans. (D)**

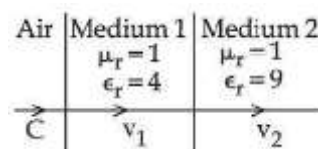
**Sol.**  $v_0 = i_0 X_L$   
 $= i_0 (\omega L)$   
 $= (5)(49\pi)(30 \times 10^{-3})$   
 $= 23.1$

Voltage will lead current by  $90^\circ$ .

$$\therefore V = 23.1 \sin(49\pi t + 60^\circ)$$

15. As shown in the figure, after passing through the medium 1. The speed of light  $v_2$  in medium 2 will be :

(Given  $c = 3 \times 10^8 \text{ ms}^{-1}$ )



- (A)  $1.0 \times 10^8 \text{ ms}^{-1}$  (B)  $0.5 \times 10^8 \text{ ms}^{-1}$   
(C)  $1.5 \times 10^8 \text{ ms}^{-1}$  (D)  $3.0 \times 10^8 \text{ ms}^{-1}$

**Official Ans. by NTA (A)**

**Allen Overseas Ans. (A)**

**Sol.**  $\frac{\mu_2}{\mu_{\text{air}}} = \frac{C}{v_2}$   
 $\therefore \frac{\sqrt{\mu_{r2} \epsilon_{r2}}}{(1)} = \frac{C}{v_2}$   
 $\therefore \sqrt{(1)(9)} = \frac{C}{v_2}$   
 $\therefore v_2 = \frac{C}{3}$

16. In normal adjustment, for a refracting telescope, the distance between objective and eye piece is  $30 \text{ cm}$ . The focal length of the objective, when the angular magnification of the telescope is 2, will be:

- (A) 20 cm (B) 30 cm  
(C) 10 cm (D) 15 cm

Official Ans. by NTA (A)

Allen Overseas Ans. (A)

Sol.  $f_0 + f_e = 30$

$$m = \frac{f_0}{f_e}$$

$$2 = \frac{f_0}{f_e} \Rightarrow f_0 = 2f_e$$

$$\text{So } f_0 + \frac{f_0}{2} = 30$$

$$f_0 = 20 \text{ cm}$$

17. The equation  $\lambda = \frac{1.227}{x} \text{ nm}$  can be used to find the

de-Broglie wavelength of an electron. In this equation x stands for :

Where,

m = mass of electron

P = momentum of electron

K = Kinetic energy of electron

V = Accelerating potential in volts for electron

(A)  $\sqrt{mK}$

(B)  $\sqrt{P}$

(C)  $\sqrt{K}$

(D)  $\sqrt{V}$

Official Ans. by NTA (D)

Allen Overseas Ans. (D)

Sol.  $\lambda = \frac{h}{mv}$  (de-Broglie's wavelength)

$$\lambda = \frac{h}{\sqrt{2m(K \cdot E)}}$$

$$h = \frac{h}{\sqrt{2mqV}}$$

Putting the values of m ; q

$$\text{We get } \lambda = \frac{1.227}{\sqrt{V}} \text{ nm}$$

18. The half life period of a radioactive substance is 60 days. The time taken for  $\frac{7}{8}$ th of its original mass to disintegrate will be :

(A) 120 days

(B) 130 days

(C) 180 days

(D) 20 days

Official Ans. by NTA (C)

Allen Overseas Ans. (C)

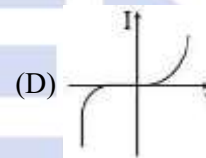
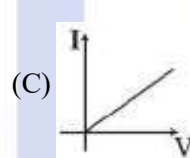
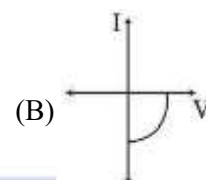
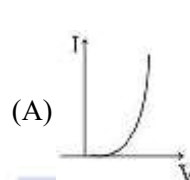
Sol.  $\frac{7}{8}$  disintegrates means  $\frac{1}{8}$  remains

$$\text{Or } \left(\frac{1}{2}\right)^3$$

$\therefore$  3 half lives

= 180 days

19. Identify the solar cell characteristics from the following options :



Official Ans. by NTA (B)

Allen Overseas Ans. (B)

Sol. Conceptual / theory

20. In the case of amplitude modulation to avoid distortion the modulation index ( $\mu$ ) should be :

(A)  $\mu \leq 1$

(B)  $\mu \geq 1$

(C)  $\mu = 2$

(D)  $\mu = 0$

Official Ans. by NTA (A)

Allen Overseas Ans. (A)

Sol.  $\mu = \frac{A_m}{A_c}$

$\mu \leq 1$  to avoid distortion

because  $\mu > 1$  will result in interference between carrier frequency & message frequency.

### SECTION-B

1. If the projection of  $2\hat{i} + 4\hat{j} - 2\hat{k}$  on  $\hat{i} + 2\hat{j} + \alpha\hat{k}$  is zero. Then, the value of  $\alpha$  will be

**Official Ans. by NTA (5)**

**Allen Overseas Ans. (5)**

**Sol.**  $\vec{a} \cdot \vec{b} = 0$

$$\therefore \vec{a} \cdot \vec{b} = 0$$

$$\therefore 2 \times 1 + 4 \times 2 - 2 \times \alpha = 0$$

$$\therefore \alpha = \boxed{5}$$

2. A freshly prepared radioactive source of half life 2 hours 30 minutes emits radiation which is 64 times the permissible safe level. The minimum time, after which it would be possible to work safely with source, will be \_\_\_\_\_ hours.

**Official Ans. by NTA (15)**

**Allen Overseas Ans. (15)**

**Sol.**  $A = A_0 \times 2^{-t/T}$

$$\frac{A_0}{64} = A_0 \times 2^{-t/T}$$

$$\therefore t = 6T = 6 \times 2.5 = \boxed{15} \text{ hours}$$

3. In a Young's double slit experiment, a laser light of 560 nm produces an interference pattern with consecutive bright fringes' separation of 7.2 mm. Now another light is used to produce an interference pattern with consecutive bright fringes' separation of 8.1 mm. The wavelength of second light is \_\_\_\_\_ nm.

**Official Ans. by NTA (630)**

**Allen Overseas Ans. (630)**

**Sol.**  $\beta \propto \lambda$

$$\lambda_2 = \frac{9}{8} \lambda_1$$

$$\therefore \beta_2 = \frac{9}{8} \beta_1 = \frac{9}{8} \times 560 = \boxed{630} \text{ nm}.$$

4. The frequencies at which the current amplitude in an LCR series circuit becomes  $\frac{1}{\sqrt{2}}$  times its maximum value, are 212 rad s<sup>-1</sup> and 232 rad s<sup>-1</sup>. The value of resistance in the circuit is  $R = 5 \Omega$ . The self inductance in the circuit is \_\_\_\_\_ mH.

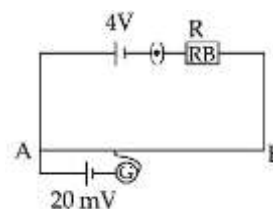
**Official Ans. by NTA (250)**

**Allen Overseas Ans. (250)**

**Sol.** Band width =  $232 - 212 = \frac{R}{L}$

$$\therefore L = \frac{5}{20} = \boxed{250} \text{ mH}$$

5. As shown in the figure, a potentiometer wire of resistance  $20 \Omega$  and length 300 cm is connected with resistance box (R.B.) and a standard cell of emf 4 V. For a resistance 'R' of resistance box introduced into the circuit, the null point for a cell of 20 mV is found to be 60 cm. The value of 'R' is \_\_\_\_\_  $\Omega$ .



**Official Ans. by NTA (780)**

**Allen Overseas Ans. (780)**

**Sol.**  $E = \frac{AC}{AB} (V_A - V_B)$



$$\therefore 20 \times 10^{-3} = \frac{60}{300} \times \frac{4 \times 20}{R + 20}$$

$$\therefore R = \boxed{780} \Omega$$

6. Two electric dipoles of dipole moments  $1.2 \times 10^{-30} \text{ cm}$  and  $2.4 \times 10^{-30} \text{ cm}$  are placed in two difference uniform electric fields of strengths  $5 \times 10^4 \text{ NC}^{-1}$  and  $15 \times 10^4 \text{ NC}^{-1}$  respectively. The ratio of maximum torque experienced by the electric dipoles will be  $\frac{1}{x}$ . The value of  $x$  is \_\_\_\_\_.

**Official Ans. by NTA (6)**

**Allen Overseas Ans. (6)**

**Sol.**  $|\tau|_{\max} = PE$

$$\frac{\tau_1}{\tau_2} = \frac{P_1 E_1}{P_2 E_2} = \frac{1.2 \times 10^{-30} \times 5 \times 10^4}{2.4 \times 10^{-30} \times 15 \times 10^4} = \frac{1}{6}$$

Hence  $x = 6$

7. The frequency of echo will be \_\_\_\_\_ Hz if the train blowing a whistle of frequency 320 Hz is moving with a velocity of 36 km/h towards a hill from which an echo is heard by the train driver. Velocity of sound in air is 330 m/s.

**Official Ans. by NTA (340)**

**Allen Overseas Ans. (340)**

- Sol.** The hill will be a secondary source.



$f_1$  = frequency of the car w.r.t. the hill

$$f_1 = \left( \frac{v}{v - v_s} \right) f = \left( \frac{330}{330} \right) \times 320 = 330 \text{ Hz}$$

$f_2$  = Frequency of the sound reflected by hill w.r.t. the car (echo)

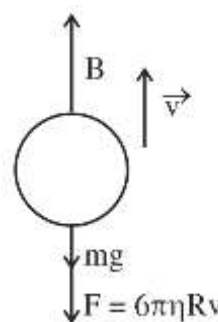
$$f_2 = \left( \frac{v + v_0}{v} \right) f_1 = \frac{(330 + 10)}{330} \times 330 = 340 \text{ Hz}$$

8. The diameter of an air bubble which was initially 2 mm, rises steadily through a solution of density  $1750 \text{ kg m}^{-3}$  at the rate of  $0.35 \text{ cms}^{-1}$ . The coefficient of viscosity of the solution is \_\_\_\_\_ poise (in nearest integer). (the density of air is negligible).

**Official Ans. by NTA (11)**

**Allen Overseas Ans. (11)**

- Sol.** As the bubble is rising steadily the net force acting on it will be zero



(Because of density of air the value of  $mg$  can be neglected)

$$\text{So } B = F \Rightarrow \frac{4\pi}{3} R^3 \rho g = 6\pi\eta Rv$$

Putting  $R = 1 \text{ mm} = 10^{-3} \text{ m}$

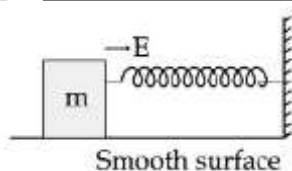
$$\rho = 1.75 \times 10^3 \text{ kg / m}^3$$

$$g = 10 \text{ m / s}^2$$

$$v = 0.35 \times 10^{-2} \text{ m / s}$$

$$\eta = \frac{10}{9} \square 1.11 \text{ SI unit} = 11 \text{ poise (CGS)}$$

9. A block of mass 'm' (as shown in figure) moving with kinetic energy  $E$  compresses a spring through a distance 25 cm when, its speed is halved. The value of spring constant of used spring will be  $nE \text{ Nm}^{-1}$  for  $n =$  \_\_\_\_\_.



**Official Ans. by NTA (24)**

**Allen Overseas Ans. (24)**

**Sol.** Using work – energy theorem

$$W_{\text{net}} = (K_f - K_i)$$

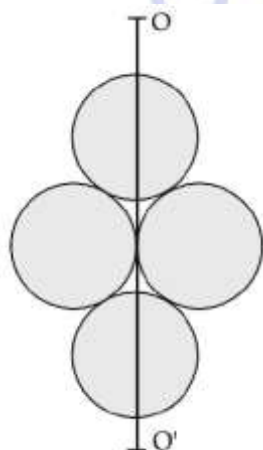
$$\Rightarrow -\frac{1}{2}Kx^2 = \frac{1}{2}m\left(\frac{v}{2}\right)^2 - \frac{1}{2}mv^2 = \frac{E}{4} - E$$

$$\Rightarrow \frac{1}{2}Kx^2 = \frac{3E}{4} \Rightarrow K = \frac{3E}{2x^2}$$

$$\Rightarrow K = \frac{3E}{2 \times \left(\frac{1}{4}\right)^2} = 24E$$

$$n = 24$$

- 10.** Four identical discs each of mass 'M' and diameter 'a' are arranged in a small plane as shown in figure. If the moment of inertia of the system about OO' is  $\frac{x}{4}Ma^2$ . Then, the value of x will be \_\_\_\_\_.

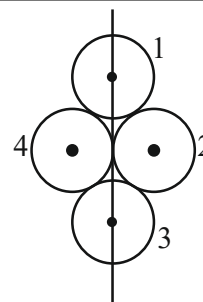


**Official Ans. by NTA (3)**

**Allen Overseas Ans. (3)**

**Sol.**  $I_1 = I_3 = \frac{MR^2}{4}$

$$I_2 = \frac{MR^2}{4} + MR^2 = \frac{5}{4}MR^2 = I_4$$



$$\text{So } I = I_1 + I_2 + I_3 + I_4$$

$$= \frac{MR^2}{2} + \frac{5}{2}MR^2$$

$$= 3MR^2, \text{ Putting } R = \frac{a}{2}$$

$$I = \frac{3Ma^2}{4}, \text{ So } x = 3$$