FINAL JEE–MAIN EXAMINATION – JUNE, 2022

(Held On Friday 24th June, 2022) **TIME : 3 : 00 PM to 6 : 00 PM**

PHYSICS | TEST PAPER WITH SOLUTION

SECTION-A

1. Identify the pair of physical quantities that have same dimensions :

(A) velocity gradient and decay constant

(B) wien's constant and Stefan constant

(C) angular frequency and angular momentum

(D) wave number and Avogadro number

Official Ans. by NTA (A)

Allen Ans. (A)

Sol. Velocity gradient $= \frac{dV}{dx} = \frac{1}{S}$

$\lambda = \frac{1}{S}$

2. The distance between Sun and Earth is R. The duration of year if the distance between Sun and Earth becomes 3R will be :

(A) $\sqrt{3}$ years (B) 3 years

(C) 9 years (D) $3\sqrt{3}$ years

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. $T' = T\left(\frac{3R}{R}\right)^{3/2} = 3\sqrt{3}\,T$

3. A stone of mass m, tied to a string is being whirled in a vertical circle with a uniform speed. The tension in the string is :

(A) the same throughout the motion

(B) minimum at the highest position of the circular path

(C) minimum at the lowest position of the circular path

(D) minimum when the rope is in the horizontal position

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. Theory

4. Two identical charged particles each having a mass 10 g and charge 2.0×10^{-7} C area placed on a horizontal table with a separation of L between then such that they stay in limited equilibrium. If the coefficient of friction between each particle and the table is 0.25, find the value of L. [Use $g = 10\ ms^{-2}$]

(A) 12 cm (B) 10 cm

(C) 8 cm (D) 5 cm

Official Ans. by NTA (A)

Allen Ans. (A)

Sol. $\frac{kq^2}{L^2} = \mu mg \Rightarrow L = \sqrt{\frac{k}{\mu mg}}q$

5. A Carnot engine take 5000 kcal of heat from a reservoir at 727°C and gives heat to a sink at 127°C. The work done by the engine is :

(A) 3×10^6 J (B) Zero

(C) 12.6×10^6 J (D) 8.4×10^6 J

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. $L = \frac{WD}{Q_H}$

$\Rightarrow WD = Q_H\left(1 - \frac{T_L}{T_H}\right)$

$= 5 \times 10^3\left(1 - \frac{400}{1000}\right)$

$= 3000$ kcal

6. Two massless springs with spring constants 2 k and 2 k, carry 50 g and 100 g masses at their free ends. These two masses oscillate vertically such that their maximum velocities are equal. Then, the ratio of their respective amplitudes will be :

(A) 1 : 2 (B) 3 : 2

(C) 3 : 1 (D) 2 : 3

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. $V_{max} = \omega A$

$\Rightarrow \frac{A_1}{A_2} = \frac{\omega_2}{\omega_1} = \sqrt{\frac{9}{2} \times \frac{1}{2}} = \frac{3}{2}$

7. What will be the most suitable combination of three resistors A = 2Ω, B = 4Ω, C = 6 Ω so that $\left(\frac{22}{3}\right)\Omega$ is equivalent resistance of combination?

(A) Parallel combination of A and C connected in series with B.

(B) Parallel combination of A and B connected in series with C.

(C) Series combination of A and C connected in parallel with B.

(D) Series combination of B and C connected in parallel with A.

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. $\Rightarrow \frac{4}{3}+6=\frac{22}{3}$

8. The soft-iron is a suitable material for making an electromagnet. This is because soft-iron has :

(A) low coercively and high retentively

(B) low coercively and low permeability

(C) high permeability and low retentively

(D) high permeability and high retentively

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. Theory

9. A proton, a deuteron and an α-particle with same kinetic energy enter into a uniform magnetic field at right angle to magnetic field. The ratio of the radii of their respective circular paths is :

(A) $1:\sqrt{2}:\sqrt{2}$ (B) $1:1:\sqrt{2}$

(C) $\sqrt{2}:1:1$ (D) $1:\sqrt{2}:1$

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. $R=\frac{\sqrt{2km}}{qB}\propto\frac{\sqrt{m}}{q}$

$\frac{\sqrt{m}}{e}:\frac{\sqrt{2m}}{e}:\frac{\sqrt{4m}}{2e}$

$1:\sqrt{2}:1$

10. Given below are two statements :

Statement-I : The reactance of an ac circuit is zero. It is possible that the circuit contains a capacitor and an inductor.

Statement-II : In ac circuit, the average poser delivered by the source never becomes zero.

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 in false.

(D) Statement I is false but Statement II is true.

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. if R = 0, P = 0

11. Potential energy as a function of r is given by $U=\frac{A}{r^{10}}-\frac{B}{r^{5}}$, where r is the interatomic distance, A and B are positive constants. The equilibrium distance between the two atoms will be :

(A) $\left(\frac{A}{B}\right)^{\frac{1}{5}}$ (B) $\left(\frac{B}{A}\right)^{\frac{1}{5}}$

(C) $\left(\frac{2A}{B}\right)^{\frac{1}{5}}$ (D) $\left(\frac{B}{2A}\right)^{\frac{1}{5}}$

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. $\frac{-10A}{r^{11}}+\frac{5B}{r^{6}}=0$

$r^{5}=\frac{10A}{5B}=\frac{2A}{B}$

12. An object of mass 5 kg is thrown vertically upwards from the ground. The air resistance produces a constant retarding force of 10 N throughout the motion. The ratio of time of ascent to the time of descent will be equal to : [Use g = 10 ms^{-2}]

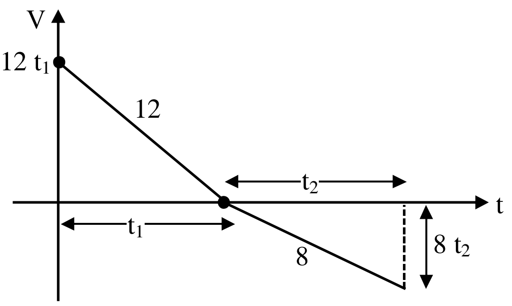
(A) 1 : 1 (B) $\sqrt{2}:\sqrt{3}$

(C) $\sqrt{3}:\sqrt{2}$ (D) 2 : 3

Official Ans. by NTA (B)

Allen Ans. (B)

Sol.



$6t_1^2 = 4t_2^2$

13. A fly wheel is accelerated uniformly from rest and rotates through 5 rad in the first second. The angle rotated by the fly wheel in the next second, will be :

(A) 7.5 rad (B) 15 rad

(C) 20 rad (D) 30 rad

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. $5 = \frac{1}{2}\alpha(1)^2$

$\theta = \frac{1}{2}\alpha(2)^2$

$\theta - 5 = 15$

14. A 100 g of iron nail is hit by a 1.5 kg hammer striking at a velocity of 60 ms^{-1}. What will be the rise in the temperature of the nail if one fourth of energy of the hammer goes into heating the nail? [Specific heat capacity of iron = 0.42 Jg^{-1} $°C^{-1}$]

(A) 675°C (B) 1600°C

(C) 160.7°C (D) 6.75°C

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. $\frac{1}{2} \times 1.5 \times 60^2 \times \frac{1}{4} = 0.1 \times 420 \times \Delta T$

15. If the charge on a capacitor is increased by 2 C, the energy stored in it increases by 44%. The original charge on the capacitor is (in C) :

(A) 10 (B) 20

(C) 30 (D) 40

Official Ans. by NTA (A)

Allen Ans. (A)

Sol. $U \propto q^2$

$\Rightarrow q_f = 1.2\ q$

$q_f - q = 2$

$\Rightarrow 1.2\ q - q = 2$

$q = 10$

16. A long cylindrical volume contains a uniformly distributed charge of density ρ. The radius of cylindrical volume is R. A charge particle (q) revolves around the cylinder in a circular path. The kinetic of the particle is :

(A) $\frac{\rho q R^2}{4\varepsilon_0}$ (B) $\frac{\rho q R^2}{2\varepsilon_0}$

(C) $\frac{q\rho}{4\varepsilon_0 R^2}$ (D) $\frac{4\varepsilon_0 R^2}{q\rho}$

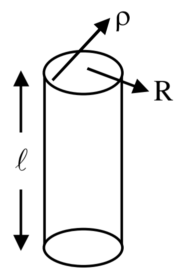
Official Ans. by NTA (A)

Allen Ans. (A)

Sol. $E = 2\pi r\ell = \frac{\rho\pi r^2 \ell}{\varepsilon_0}$

$qE = \frac{q\rho R^2}{2\varepsilon_0 r} = \frac{mv^2}{r}$

$mv^2 = \frac{q\rho R^2}{2\varepsilon_0}$



17. An electric bulb is rated as 200 W. What will be the peak magnetic field at 4 m distance produced by the radiations coming from this bulb? Consider this bulb as a point source with 3.5% efficiency.

(A) 1.19×10^{-8} T (B) 1.71×10^{-8} T

(C) 0.84×10^{-8} T (D) 3.36×10^{-8} T

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. $\frac{\eta P}{4\pi r^2} = \frac{cB_0^2}{2\mu_0}$

$B_0 = \sqrt{\frac{\mu_0}{4\pi}\frac{\eta P}{c}}\frac{1}{r}$

$\Rightarrow B_0 = \frac{1}{4}\sqrt{\frac{10^{-7} \times 4 \times 3.5}{3 \times 10^8}} = 1.71 \times 10^{-8}$ T

18. The light of two different frequencies whose photons have energies 3.8 eV and 1.4 eV respectively, illuminate a metallic surface whose work function is 0.6 eV successively. The ratio of maximum speeds of emitted electrons for the two frequencies respectivly will be :

(A) 1 : 1 (B) 2 : 1

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

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. $\sqrt{\frac{3.8-0.6}{1.4-0.6}}=\sqrt{\frac{3.2}{0.8}}=2$

19. Two light beams of intensities in the ratio of 9 : 4 are allowed to interfere. The .ratio of the intensity of maxima and minima will be :

(A) 2 : 3 (B) 16 : 81

(C) 25 : 169 (D) 25 : 1

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. $\sqrt{\frac{I_1}{I_2}}=\sqrt{\frac{9}{4}}=\frac{3}{2}$

$$\left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2=5^2=25$$

20. In Bohr's atomic model of hydrogen, let K. P and E are the kinetic energy, potential energy and total energy of the electron respectively. Choose the correct option when the electron undergoes transitions to a higher level :

(A) All K. P and E increase.

(B) K decreases. P and E increase.

(C) P decreases. K and E increase.

(D) K increases. P and E decrease.

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. Based on theory

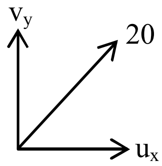
SECTION-B

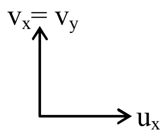
1. A body is projected from the ground at an angle of 45° with the horizontal. Its velocity after 2s is 20 ms^{-1}. The maximum height reached by the body during its motion is _______m. (use g = 10ms^{-2})

Official Ans. by NTA (20)

Allen Ans. (20)

Sol.





$v_y = v_x - 20$

$$\sqrt{(u_x-20)^2+u_x^2}=20$$

$\Rightarrow 2u_x^2-40u_x=0$

$\therefore u_x = 20$

2. An antenna is placed in a dielectric medium of dielectric constant 6.25. If the maximum size of that antenna is 5.0 mm. it can radiate a signal of minimum frequency of ______GHz.

(Given $\mu_r = 1$ for dielectric medium)

Official Ans. by NTA (6)

Allen Ans. (6)

Sol. $C'=\frac{C}{\sqrt{\mu_r\varepsilon_r}}=\frac{3\times10^8}{\sqrt{6.25}}=\frac{3\times10^8}{2.5}$

$f\lambda = 1.25\times10^8$ s

$\Rightarrow f(5\times10^{-3}\times4)=1.25\times10^8$

f = 6.25 GHz

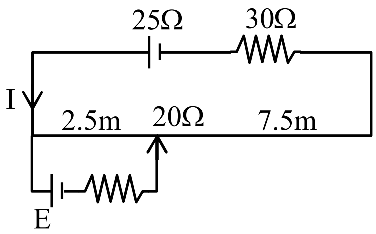
So $f\approx 6$

3. A potentiometer wire of length 10 m and resistance 20 Ω is connected in series with a 25 V battery and an external resistance 30 Ω. A cell of emf E in secondary circuit is balanced by 250 cm long potentiometer wire. The value of E (in volt) is $\frac{x}{10}$. The value of x is ______.

Official Ans. by NTA (25)

Allen Ans. (25)

Sol.



$$I = \frac{25}{50} = \frac{1}{2} A$$

$\therefore \Delta V = 10$ V

10 m $\to$ 10V

2.5m $\to$ 2.5V

4. Two travelling waves of equal amplitudes and equal frequencies move in opposite directions along a string. They interfere to produce a stationary wave whose equation is given by

$$y = (10 \cos \pi x \sin \frac{2\pi t}{T}) \text{ cm}$$

The amplitude of the particle at x = $\frac{4}{3}$ cm will be ______ cm.

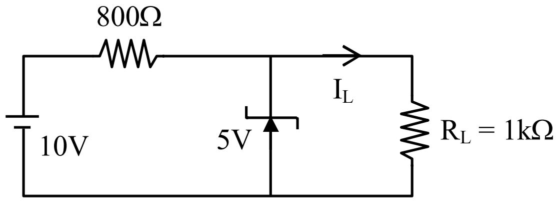
Official Ans. by NTA (5)

Allen Ans. (5)

Sol. $10 \cos\left(\frac{4\pi}{3}\right)$

5. In the given circuit- the value of current I_L will be ______ mA.

(When R_L = 1kΩ)



Official Ans. by NTA (5)

Allen Ans. (5)

Sol. $I_L = \frac{5}{1000} = 5\text{mA}$

6. A sample contains 10^{-2} kg each of two substances A and B with half lives 4 s and 8 s respectively. The ratio of then atomic weights is 1 : 2. The ratio of the amounts of A and B after 16 s is $\frac{x}{100}$. the value of x is ______.

Official Ans. by NTA (25)

Allen Ans. (50)

Sol. $N_t = N_0 (0.5)^{\frac{t}{t_{1/2}}}$

$$= \frac{m}{M} \times N_A (0.5)^{\frac{t}{t_{1/2}}}$$

$$\frac{N_1}{N_2} = \frac{M_2}{M_1} (0.5)^{t\left[\frac{1}{T_A} - \frac{1}{T_B}\right]}$$

$$= 2(0.5)^{16 \times \frac{1}{8}} = \frac{2}{4} = \frac{1}{2} = \frac{x}{100}$$

7. A ray of ligh is incident at an angle of incidence 60° on the glass slab of refractive index $\sqrt{3}$. After refraction, the light ray emerges out from other parallel faces and lateral shift between incident ray and emergent ray is $4\sqrt{3}$ cm. The thickness of the glass slab is ______ cm.

Official Ans. by NTA (12)

Allen Ans. (12)

Sol. $\ell = t\sin i\left[1-\frac{\cos i}{\sqrt{\mu^2-\sin^2 i}}\right]$

$\Rightarrow 4\sqrt{3} = t\sin 60°\left[1-\frac{\cos 60°}{\sqrt{3-\frac{3}{4}}}\right]$

8. A circular coil of 1000 turns each with area $1m^2$ is rotated about its vertical diameter at the rate of one revolution per second in a uniform horizontal magnetic field of 0.07T. The maximum voltage generation will be _______V.

Official Ans. by NTA (440)

Allen Ans. (440)

Sol. $\in_{max} = BAN\omega$

$= 0.07 \times 1 \times 10^3 \times 2\pi$

$= 140\pi \approx 440$

9. A monoatomic gas performs a work of $\frac{Q}{4}$ where Q is the heat supplied to it. The molar heat capacity of the gas will be ________R during this transformation.

Where R is the gas constant.

Official Ans. by NTA (2)

Allen Ans. (2)

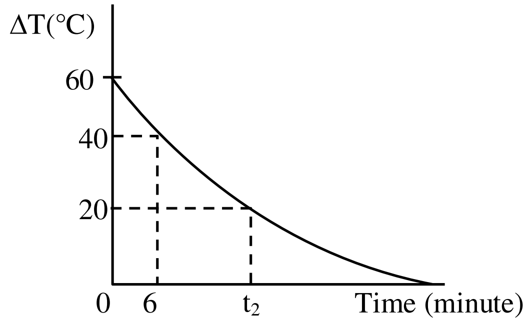
Sol. $\Delta Q = \Delta E + WD \Rightarrow Q = \Delta E + \frac{Q}{4}$

$\Rightarrow n\frac{3R}{2}\Delta T = \Delta E = \frac{3Q}{4}$

$\therefore n\Delta T = \frac{Q}{2R}$

$\therefore$ C = 2R

10. In an experment ot verify Newton's law of cooling, a graph is plotted between, the temperature difference (ΔT) of the water and surroundings and time as shown in figure. The initial temperature of water is taken as 80°C. The value of t_2 as mentioned in the graph will be _______.



Official Ans. by NTA (16)

Allen Ans. (16)

Sol. $T - T_0 (T_i - T_0)\ e^{-\frac{Bt}{ms}}$

$6\lambda = \ln 1.5$

$40 = 60e^{-\lambda(6)} \Rightarrow 6\lambda = \ln 1.5$

$20 = 60e^{-\lambda t_2} \Rightarrow t_2\lambda = \ln 3$

$\frac{t_2}{6} = \frac{\ln 3}{\ln 1.5}$

$\therefore t_2 = 16.25$ min

So ≈ 16