

FINAL JEE-MAIN EXAMINATION – JANUARY, 2023

(Held On Tuesday 31st January, 2023)

TIME : 3 : 00 PM to 6 : 00 PM

PHYSICS

SECTION-A

1. The H amount of thermal energy is developed by a resistor in 10 s when a current of 4A is passed through it. If the current is increased to 16A, the thermal energy developed by the resistor in 10 s will be:

- (1) H (2) 16H
(3) $\frac{H}{4}$ (4) 4H

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $H = i^2 R t = 4^2 R \times 10 = 160R$

$H' = P R t = 16^2 R \times 10 = 2560R = 16 H$

2. A body is moving with constant speed, in a circle of radius 10 m. The body completes one revolution in 4 s. At the end of 3rd second, the displacement of body (in m) from its starting point is:

- (1) 30 (2) 15π
(3) 5π (4) $10\sqrt{2}$

Official Ans. by NTA (4)

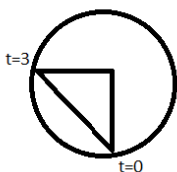
Allen Ans. (4)

Sol.

$$\theta = \frac{3}{4} \times 2\pi = \frac{3\pi}{2}$$

= |Displacement| = $\sqrt{2}R$

= $10\sqrt{2}$ m



3. A microscope is focused on an object at the bottom of a bucket. If liquid with refractive index $\frac{5}{3}$ is poured inside the bucket, then microscope have to be raised by 30 cm to focus the object again. The height of the liquid in the bucket is :

- (1) 75 cm (2) 50 cm
(3) 18 cm (4) 12 cm

Official Ans. by NTA (1)

Allen Ans. (1)

TEST PAPER WITH SOLUTION

Sol. $d = h \left(1 - \frac{1}{\mu}\right)$

$30 = h \left(1 - \frac{3}{5}\right)$

$30 = h \times \frac{2}{5}$

$h = 75$ cm

4. A stone of mass 1 kg is tied to end of a massless string of length 1 m. If the breaking tension of the string is 400 N, then maximum linear velocity, the stone can have without breaking the string, while rotating in horizontal plane, is:

- (1) 20 ms^{-1} (2) 40 ms^{-1}
(3) 400 ms^{-1} (4) 10 ms^{-1}

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $T = \frac{mv^2}{r}$

$v = \sqrt{\frac{Tr}{m}}$

$v = \sqrt{\frac{400 \times 1}{1}} = 20 \text{ ms}^{-1}$

5. For a solid rod, the Young's modulus of elasticity is $3.2 \times 10^{11} \text{ Nm}^{-2}$ and density is $8 \times 10^3 \text{ kg m}^{-3}$. The velocity of longitudinal wave in the rod will be.

- (1) $145.75 \times 10^3 \text{ ms}^{-1}$
(2) $3.65 \times 10^3 \text{ ms}^{-1}$
(3) $18.96 \times 10^3 \text{ ms}^{-1}$
(4) $6.32 \times 10^3 \text{ ms}^{-1}$

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $v = \sqrt{\frac{Y}{\rho}}$

= $\sqrt{\frac{3.2 \times 10^{11}}{8000}}$

= $6.32 \times 10^3 \text{ ms}^{-1}$

6. A long conducting wire having a current I flowing through it, is bent into a circular coil of N turns. Then it is bent into a circular coil of n turns. The magnetic field is calculated at the centre of coils in both the cases. The ratio of the magnetic field in first case to that of second case is:

- (1) $N : n$ (2) $n^2 : N^2$
(3) $N^2 : n^2$ (4) $n : N$

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. Let the length of wire is l , thus the radius of first coil

$$R_1 = \frac{l}{2\pi N} \text{ and the radius of second coil}$$

$$R_2 = \frac{l}{2\pi n}$$

$$\text{So } B_1 = \frac{\mu_0 N i}{2R_1} = \frac{\mu_0 N^2 \pi i}{l}$$

$$\text{And } B_2 = \frac{\mu_0 n i}{2R_2} = \frac{\mu_0 n^2 \pi i}{l}$$

$$\text{So } \frac{B_1}{B_2} = \frac{N^2}{n^2}$$

7. Heat energy of 735 J is given to a diatomic gas allowing the gas to expand at constant pressure. Each gas molecule rotates around an internal axis but do not oscillate. The increase in the internal energy of the gas will be:

- (1) 525 J (2) 441 J
(3) 572 J (4) 735 J

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $Q = nC_p \Delta T$

$$735 = n \times \frac{7R}{2} \times \Delta T$$

$$105 = \frac{n}{2} R \Delta T$$

Since diatomic gas has degree of freedom = 5

$$525 = \frac{5n}{2} R \Delta T$$

$$\Delta U = 525J$$

8. Given below are two statements

Statement I: For transmitting a signal, size of antenna (l) should be comparable to wavelength of signal (at least $l = \frac{\lambda}{4}$ in dimension).

Statement II: In amplitude modulation, amplitude of carrier wave remains constant (unchanged).

In the light of the above statements, choose the most appropriate answer from the options given below.

- (1) Both **Statement I** and **Statement II** are correct
(2) Both **Statement I** and **Statement II** are incorrect
(3) **Statement I** is incorrect but **Statement II** is correct
(4) **Statement I** is correct but **Statement II** is incorrect

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. In amplitude modulation, amplitude of Carrier wave changes and frequency remains same.

Minimum size of antenna is $\frac{\lambda}{4}$

9. The number of turns of the coil of a moving coil galvanometer is increased in order to increase current sensitivity by 50%. The percentage change in voltage sensitivity of the galvanometer will be :

- (1) 100% (2) 50%
(3) 75% (4) 0%

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. Current sensitivity

$$\frac{\theta}{i} = \frac{nAB}{K}$$

$$\text{Voltage sensitivity} = \frac{nAB}{KR}$$

As current sensitivity increases by 50%

So number of turns increases by 50%

Resistance also increases by 50%

Therefore, voltage sensitivity remains constant.

10. If the two metals A and B are exposed to radiation of wavelength 350 nm. The work functions of metals A and B are 4.8 eV and 2.2 eV. Then choose the correct option

- (1) Metal B will not emit photo-electrons
 (2) Both metals A and B will emit photo-electrons
 (3) Both metals A and B will not emit photo-electrons
 (4) Metal A will not emit photo-electrons

Official Ans. by NTA (4)

Allen Ans. (4)

- Sol.** for photo-emission

$$h\nu > \phi$$

$$E \text{ of photon} = \frac{12400}{350 \times 10^{-9}} = \frac{12400}{3500 \text{ \AA}} = \frac{124}{35} = 3.54 \text{ eV}$$

$$\text{for } \phi_1, h\nu < \phi_1 \quad 3.54 \text{ eV} < 4.8 \text{ eV}$$

$$\text{for } \phi_2, h\nu < \phi_2 \quad 3.54 \text{ eV} > 2.2 \text{ eV}$$

So, second plate will be able to emit electron.

11. A body weight W , is projected vertically upwards from earth's surface to reach a height above the earth which is equal to nine times the radius of earth. The weight of the body at that height will be:

- (1) $\frac{W}{91}$ (2) $\frac{W}{100}$
 (3) $\frac{W}{9}$ (4) $\frac{W}{3}$

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $g' = \frac{g_0}{\left(\frac{r}{R}\right)^2} = \frac{g_0}{10^2} = \frac{g_0}{100}$

$$\Rightarrow W' = \frac{W}{100}$$

12. Match List-I with List-II.

	List-I		List-II
A.	Angular momentum	I	$[ML^2T^{-2}]$
B.	Torque	II	$[ML^{-2}T^{-2}]$
C.	Stress	III	$[ML^2T^{-1}]$
D.	Pressure gradient	IV	$[ML^{-1}T^{-2}]$

Choose the correct answer from the options given below:

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

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $[\tau] = [r][F] = [L][MLT^{-2}] = [ML^2T^{-2}]$

$$[\text{Stress}] = \frac{[F]}{[A]} = \frac{[MLT^{-2}]}{L^2} = [ML^{-1}T^{-2}]$$

$$[\text{Pressure gradient}] = \frac{[P]}{[Z]} = \frac{[ML^{-1}T^{-2}]}{L^1} = [ML^{-2}T^{-2}]$$

$$[L] = [\tau][t] = [ML^2T^{-2}][T] = [ML^2T^{-1}]$$

13. An alternating voltage source $V = 260 \sin(628t)$ is connected across a pure inductor of 5 mH. Inductive reactance in the circuit is:

- (1) 3.14Ω (2) 6.28Ω
 (3) 0.5Ω (4) 0.318Ω

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $X_L = \omega L = 200\pi \times 5 \times 10^{-3}$

$$= \pi \Omega$$

$$= 3.14 \Omega$$

14. Match List-I with List-II.

	List-I		List-II
A.	Microwaves	I	Physiotherapy
B.	UV rays	II	Treatment of cancer
C.	Infra-red rays	III	Lasik eye surgery
D.	X-rays	IV	Aircraft navigation

Choose the correct answer from the option given below:

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

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. UV rays are used for Lasik eye surgery. IR is used for physiotherapy. X-rays are used for cancer treatment. And Microwaves are used for aircraft navigation.

15. The radius of electron's second stationary orbit in Bohr's atom is R . The radius of 3rd orbit will be

- (1) $\frac{R}{3}$ (2) $2.25R$
(3) $3R$ (4) $9R$

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $R = 0.529 \frac{n^2}{Z} \text{Å}$

$$\frac{R_3}{R_2} = \frac{9}{4}$$

$$R_3 = \frac{9}{4} R_2$$

$$R_3 = 2.25R$$

16. Under the same load, wire A having length 5.0 m and cross section $2.5 \times 10^{-5} \text{ m}^2$ stretches uniformly by the same amount as another wire B of length 6.0 m and a cross section of $3.0 \times 10^{-5} \text{ m}^2$ stretches. The ratio of the Young's modulus of wire A to that of wire B will be:

- (1) 1 : 4 (2) 1 : 1
(3) 1 : 10 (4) 1 : 2

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $\Delta L_1 = \Delta L_2$

$$\frac{F_1 L_1}{A_1 Y_1} = \frac{F_2 L_2}{A_2 Y_2}$$

$$\frac{5}{2.5 \times 10^{-5} \times Y_1} = \frac{6}{3 \times 10^{-5} \times Y_2}$$

$$\frac{Y_1}{Y_2} = 1$$

17. Considering a group of positive charges, which of the following statements is correct?

- (1) Net potential of the system cannot be zero at a point but net electric field can be zero at that point.
(2) Net potential of the system at a point can be zero but net electric field can't be zero at that point.
(3) Both the net potential and the net field can be zero at a point.
(4) Both the net potential and the net electric field cannot be zero at a point.

Official Ans. by NTA (1)

Allen Ans. (1)

- Sol.** Since potential of positive charge is always positive & electric field is a vector. So two electric field can be get cancelled if it has same magnitude & opposite direction.

18. A body of mass 10 kg is moving with an initial speed of 20 m/s. The body stops after 5 s due to friction between body and the floor. The value of the coefficient of friction is: (Take acceleration due to gravity $g = 10 \text{ ms}^{-2}$)

- (1) 0.2 (2) 0.3
(3) 0.5 (4) 0.4

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $v = u + at$

$$\Rightarrow 0 = 20 + (-\mu g)(5)$$

$$\Rightarrow \mu = 0.4$$

19. A hypothetical gas expands adiabatically such that its volume changes from 08 litres to 27 litres. If the ratio of final pressure of the gas to initial pressure of the gas is $\frac{16}{81}$. Then the ratio of $\frac{C_P}{C_V}$ will be.

- (1) $\frac{4}{3}$ (2) $\frac{3}{1}$
(3) $\frac{1}{2}$ (4) $\frac{3}{2}$

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. For adiabatic process

$$PV^\gamma = \text{Constant, where } \gamma = \frac{C_P}{C_V}$$

$$\frac{P_1}{P_2} = \left(\frac{V_2}{V_1}\right)^\gamma$$

$$\frac{81}{16} = \left(\frac{27}{8}\right)^\gamma$$

$$\left(\frac{3}{2}\right)^4 = \left(\frac{3}{2}\right)^{3\gamma} \Rightarrow \gamma = \frac{4}{3}$$

20. Given below are two statements:

Statement I: In a typical transistor, all three regions emitter, base and collector have same doping level.

Statement II: In a transistor, collector is the thickest and base is the thinnest segment.

In the light of the above statements, choose the **most appropriate** answer from the options given below.

- (1) Both **Statement I** and **Statement II** are correct
(2) Both **Statement I** and **Statement II** are incorrect
(3) **Statement I** is incorrect but **Statement II** is correct
(4) **Statement I** is correct but **Statement II** is incorrect

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. Statement-I is false but Statement-II is true.

SECTION-B

21. A series LCR circuit consists of $R=80\Omega$, $X_L=100\Omega$, and $X_C=40\Omega$. The input voltage is $2500 \cos(100 \pi t)$ V. The amplitude of current, in the circuit, is _____ A.

Official Ans. by NTA (25)

Allen Ans. (25)

Sol. $Z = \sqrt{R^2 + (X_L - X_C)^2}$
 $\sqrt{80^2 + (100 - 40)^2} = 100 \Omega$
 $i_0 = \frac{V_0}{Z} = 25 A$

22. Two light waves of wavelengths 800 and 600 nm are used in Young's double slit experiment to obtain interference fringes on a screen placed 7 m away from plane of slits. If the two slits are separated by 0.35 mm, then shortest distance from the central bright maximum to the point where the bright fringes of the two wavelength coincide will be _____ mm.

Official Ans. by NTA (48)

Allen Ans. (48)

Sol. $n_1 \frac{\lambda_1 D}{d} = n_2 \frac{\lambda_2 D}{d}$
 $800n_1 = 600n_2 \Rightarrow \frac{n_1}{n_2} = \frac{3}{4}$

Minimum $n_1 = 3$ & $n_2 = 4$

Minimum separation = $\frac{3 \times 800 \text{ nm} \times 7 \text{ m}}{0.35 \text{ mm}} = 48$

23. A water heater of power 2000 W is used to heat water. The specific heat capacity of water is $4200 \text{ J kg}^{-1} \text{ K}^{-1}$. The efficiency of heater is 70%. Time required to heat 2 kg of water from 10°C to 60°C is _____ s.

(Assume that the specific heat capacity of water remains constant over the temperature range of the water).

Official Ans. by NTA (300)

Allen Ans. (300)

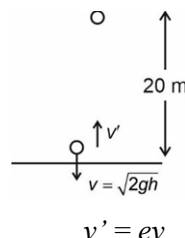
Sol. $P \times t \times \eta = ms \Delta T$
 $2000 \times t \times 0.7 = 2 \times 1000 \times 4.2 \times 50$
 $t = 300 \text{ s}$

24. A ball is dropped from a height of 20 m. If the coefficient of restitution for the collision between ball and floor is 0.5, after hitting the floor, the ball rebounds to a height of _____ m.

Official Ans. by NTA (5)

Allen Ans. (5)

Sol.



$$h' = \frac{(v')^2}{2g} = \frac{e^2 v^2}{2g} = e^2 h = (0.5)^2 \times 20$$

$$= \frac{20}{4} = 5 \text{ m}$$

$$h' = 5 \text{ m}$$

25. Two discs of same mass and different radii are made of different materials such that their thicknesses are 1 cm and 0.5 cm respectively. The densities of materials are in the ratio 3:5. The moment of inertia of these discs respectively about their diameters will be in the ratio of $\frac{x}{6}$. The value of x is _____.

Official Ans. by NTA (5)

Allen Ans. (5)

Sol.



Mass of both disc is equal

So $\Rightarrow M_1 = M_2$

$$\Rightarrow (\pi r_1^2) h_1 \rho_1 = (\pi r_2^2) h_2 \rho_2$$

$$\Rightarrow r_1^2 \times \frac{h_1}{h_2} \times \frac{\rho_1}{\rho_2} = r_2^2$$

$$\Rightarrow r_1^2 \times 2 \times \frac{\rho_1}{\rho_2} = r_2^2 \quad \frac{\rho_1}{\rho_2} = \frac{3}{5}$$

$$\Rightarrow \frac{\rho_2}{\rho_1} = \frac{5}{3}$$

$$\Rightarrow \frac{r_1^2}{r_2^2} = \left(\frac{\rho_2}{2\rho_1} \right) = \left(\frac{5}{6} \right)$$

Ratio of M.O.I = $\frac{\frac{1}{4} M r_1^2}{\frac{1}{4} M r_2^2} = \left(\frac{r_1^2}{r_2^2} \right) = \left(\frac{5}{6} \right)$

26. If the binding energy of ground state electron in a hydrogen atom is 13.6 eV, then, the energy required to remove the electron from the second excited state of Li^{2+} will be: $x \times 10^{-1}$ eV. The value of x is _____.

Official Ans. by NTA (136)

Allen Ans. (136)

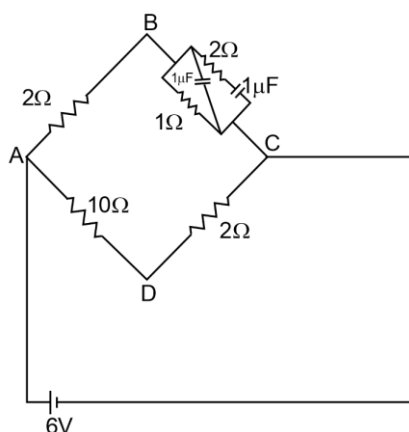
Sol. $E_B = 13.6 \frac{z^2}{n^2}$

For Li^{2+} ,

$z = 3, n = 3$

$E_B = 13.6 \left(\frac{3^2}{3^2} \right) = 13.6 \text{ eV}$

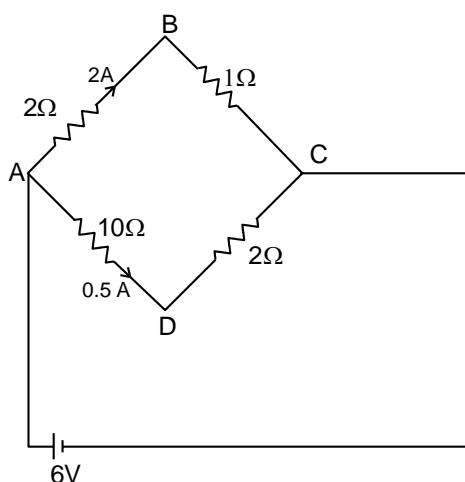
27. For the given circuit, in the steady state, $|V_B - V_D| = \text{_____ V}$.



Official Ans. by NTA (1)

Allen Ans. (1)

Sol.



In steady state the capacitors will act as the open wire. Hence the circuit will be as above. If $V_c = 0\text{V}$ then the potential at points A, B, C and D will be

$V_a = 6 \text{ V}$

$V_a - V_b = 4 \text{ V}$

$V_b = 2 \text{ V}$

$V_a - V_d = 10 \times 0.5$

$V_d = 1 \text{ V}$

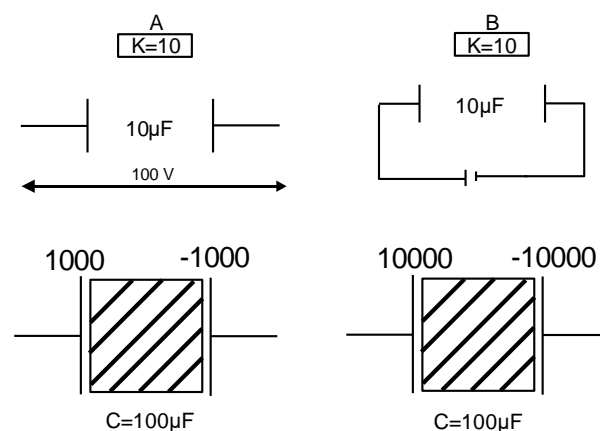
$V_b - V_d = 1 \text{ V}$

28. Two parallel plate capacitors C_1 and C_2 each having capacitance of $10 \mu\text{F}$ are individually charged by a 100 V D.C. source. Capacitor C_1 is kept connected to the source and a dielectric slab is inserted between its plates. Capacitor C_2 is disconnected from the source and then a dielectric slab is inserted in it. Afterwards the capacitor C_1 is also disconnected from the source and the two capacitors are finally connected in parallel combination. The common potential of the combination will be _____ V. (Assuming Dielectric constant = 10)

Official Ans. by NTA (55)

Allen Ans. (55)

Sol.



$$V = \frac{1000 + 10000}{100 + 100} = \frac{11000}{200} = 55\text{V}$$

29. The displacement equations of two interfering waves are given by

$$y_1 = 10 \sin \left(\omega t + \frac{\pi}{3} \right) \text{ cm,}$$

$y_2 = 5 [\sin(\omega t) + \sqrt{3} \cos \omega t] \text{ cm}$ respectively. The amplitude of the resultant wave is _____ cm.

Official Ans. by NTA (20)

Allen Ans. (20)

Sol. $y_1 = 5 [\sin(\omega t) + \sqrt{3} \cos(\omega t)]$

$$= 10 \sin \left(\omega t + \frac{\pi}{3} \right)$$

$$y_2 = 10 \sin \left(\omega t + \frac{\pi}{3} \right)$$

$$y_1 + y_2 = y_{\text{resultant}} = 10 \sin \left(\omega t + \frac{\pi}{3} \right) + 10 \sin \left(\omega t + \frac{\pi}{3} \right)$$

$$y_{\text{resultant}} = 20 \sin \left(\omega t + \frac{\pi}{3} \right)$$

Amplitude = 20

30. Two bodies are projected from ground with same speeds 40 ms^{-1} at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body was projected at an angle of 60° , with horizontal then sum of the maximum heights, attained by the two projectiles, is _____ m. (Given $g = 10 \text{ ms}^{-2}$)

Official Ans. by NTA (80)

Allen Ans. (80)

Sol. If angle of projection for projectile 1 is 60° then angle of projectile 2 is 30° for same range

$$H_1 = \frac{u^2 \sin^2 60^\circ}{2g}, \quad H_2 = \frac{u^2 \sin^2 30^\circ}{2g}$$

$$H_1 + H_2 = \frac{u^2}{2g} = \frac{40^2}{2 \times 10} = 80 \text{ m}$$