

FINAL JEE–MAIN EXAMINATION – JANUARY, 2023

(Held On Sunday 29th January, 2023)

TIME : 9 : 00 AM to 12 : 00 NOON

SECTION-A

1. Match List I with List II :

List-I (Physical Quantity)		List-II (Dimensional Formula)	
A	Pressure gradient	I	$[M^0L^2T^{-2}]$
B	Energy density	II	$[M^1L^{-1}T^{-2}]$
C	Electric Field	III	$[M^1L^{-2}T^{-2}]$
D	Latent heat	IV	$[M^1L^1T^{-3}A^{-1}]$

Choose the **correct** answer from the options given below:

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

Official Ans. by NTA (3)

Ans. (3)

Sol. Pressure gradient = $\frac{dp}{dx} = \frac{[ML^{-1}T^{-2}]}{[L]}$

= $[M^1L^{-2}T^{-2}]$

Energy density = $\frac{\text{energy}}{\text{volume}} = \frac{[ML^2T^{-2}]}{[L^3]}$

= $[M^1L^{-1}T^{-2}]$

Electric field = $\frac{\text{Force}}{\text{charge}} = \frac{[MLT^{-2}]}{[A.T]}$

= $[M^1L^1T^{-3}A^{-1}]$

Latent heat = $\frac{\text{heat}}{\text{mass}} = \frac{[ML^2T^{-2}]}{[M]}$

= $[M^0L^2T^{-2}]$

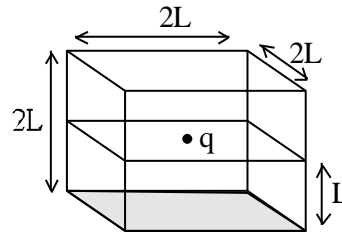
2. In a cuboid of dimension $2L \times 2L \times L$, a charge q is placed at the centre of the surface 'S' having area of $4L^2$. The flux through the opposite surface to 'S' is given by

- (1) $\frac{q}{12\epsilon_0}$ (2) $\frac{q}{3\epsilon_0}$
- (3) $\frac{q}{2\epsilon_0}$ (4) $\frac{q}{6\epsilon_0}$

Official Ans. by NTA (4)

Ans. (4)

Sol. $\phi = \frac{Q/\epsilon_0}{6}$



Flux passing through shaded face = $\frac{q}{6\epsilon_0}$

3. Ratio of thermal energy released in two resistor R and 3R connected in parallel in an electric circuit is :

- (1) 3 : 1 (2) 1 : 1
- (3) 1 : 3 (4) 1 : 27

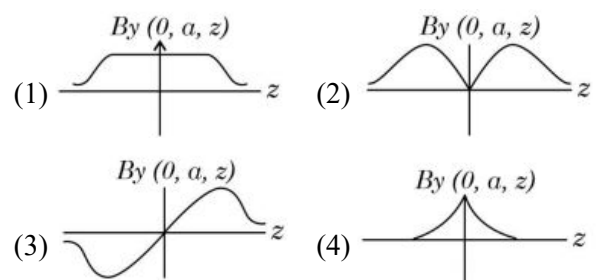
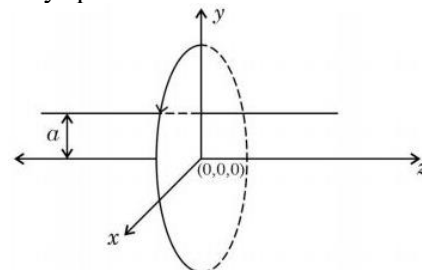
Official Ans. by NTA (1)

Ans. (1)

Sol. $H = \frac{V^2}{R} \times t$

$\frac{H_1}{H_2} = \frac{\frac{V^2t}{R}}{\frac{V^2t}{3R}} = 3 : 1$

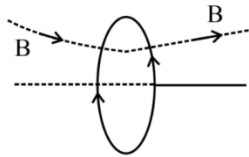
4. A single current carrying loop of wire carrying current I flowing in anticlockwise direction seen from +ve z direction and lying in xy plane in shown in figure. The plot of \hat{j} component of magnetic field (B_y) at a distance 'a' (less than radius of the coil) and on yz plane vs z coordinate look like



Official Ans. by NTA (3)

Ans. (3)

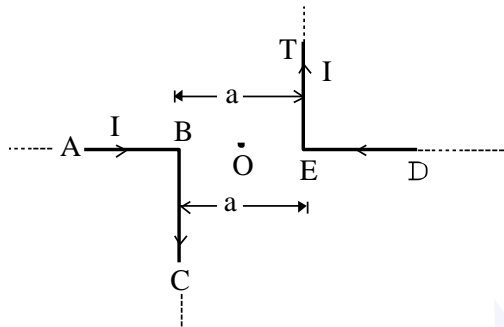
Sol.



$B_y = 0$ in plane of coil

B_y is opposite of each other in $-z$ and $+z$ positions.

5. The magnitude of magnetic induction at mid-point O due to current arrangement as shown in Fig will be :



- (1) $\frac{\mu_0 I}{2\pi a}$ (2) 0
 (3) $\frac{\mu_0 I}{4\pi a}$ (4) $\frac{\mu_0 I}{\pi a}$

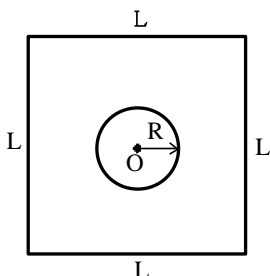
Official Ans. by NTA (4)

Ans. (4)

- Sol. Magnetic field due to current in BC and ET are outward at point 'O'

$$B_0 = \frac{\mu_0 i}{4\pi r} + \frac{\mu_0 i}{4\pi r} = \frac{\mu_0 i}{2\pi r} = \frac{\mu_0 i}{\pi a}$$

6. Find the mutual inductance in the arrangement, when a small circular loop of wire of radius 'R' is placed inside a large square loop of wire of side L ($L \gg R$). The loops are coplanar and their centres coincide :



- (1) $M = \frac{\sqrt{2}\mu_0 R^2}{L}$ (2) $M = \frac{2\sqrt{2}\mu_0 R}{L^2}$
 (3) $M = \frac{2\sqrt{2}\mu_0 R^2}{L}$ (4) $M = \frac{\sqrt{2}\mu_0 R}{L^2}$

Official Ans. by NTA (3)

Ans. (3)

Sol. $\phi = Mi$

$$\phi = (BA)$$

$$\phi = \pi R^2 \left(4 \frac{\mu_0}{4\pi} \frac{i}{\left(\frac{L}{2}\right)} \sqrt{2} \right)$$

$$\Rightarrow M = \frac{2\sqrt{2}\mu_0 R^2}{L}$$

7. Which of the following are true?

- A. Speed of light in vacuum is dependent on the direction of propagation.
 B. Speed of light in a medium is independent of the wavelength of light.
 C. The speed of light is independent of the motion of the source.
 D. The speed of light in a medium is independent of intensity.

Choose the correct answer from the option given below :

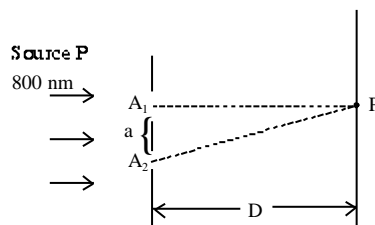
- (1) A and C only (2) B and D only
 (3) B and C only (4) C and D only

Official Ans. by NTA (4)

Ans. (4)

- Sol. Speed of light does not depend on the motion of source as well as intensity.

8. In a Young's double slit experiment, two slits are illuminated with a light of wavelength 800 nm. The line joining A_1P is perpendicular to A_1A_2 as shown in the figure. If the first minimum is detected at P, the value of slits separation 'a' will be :



The distance of screen from slits $D = 5$ cm

- (1) 0.4 mm (2) 0.5 mm
 (3) 0.2 mm (4) 0.1 mm

Official Ans. by NTA (3)

Ans. (3)

Sol. $A_2P - A_1P = \frac{\lambda}{2}$ (Condition of minima)

$$\sqrt{D^2 + a^2} - D = \frac{\lambda}{2}$$

$$D \left(1 + \frac{a^2}{D^2} \right)^{1/2} - D = \frac{\lambda}{2}$$

$$D \left(1 + \frac{1}{2} \times \frac{a^2}{D^2} \right) - D = \frac{\lambda}{2}$$

$$\frac{a^2}{2D} = \frac{\lambda}{2} \Rightarrow a = \sqrt{\lambda D}$$

$$= \sqrt{800 \times 10^{-6} \times 50}$$

$$a = 0.2 \text{ mm}$$

9. A stone is projected at angle 30° to the horizontal. The ratio of kinetic energy of the stone at point of projection to its kinetic energy at the highest point of flight will be :

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

Official Ans. by NTA (4)

Ans. (4)

Sol. $\frac{KE_{\text{POP}}}{KE_{\text{top}}} = \frac{\frac{1}{2} M (u)^2}{\frac{1}{2} M (u \cos 30^\circ)^2} = \frac{4}{3}$

10. A block of mass m slides down the plane inclined at angle 30° with an acceleration $\frac{g}{4}$. The value of coefficient of kinetic friction will be :

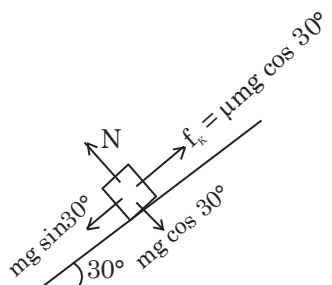
- (1) $\frac{2\sqrt{3}+1}{2}$ (2) $\frac{1}{2\sqrt{3}}$
 (3) $\frac{\sqrt{3}}{2}$ (4) $\frac{2\sqrt{3}-1}{2}$

Official Ans. by NTA (2)

Ans. (2)

Sol. $Mg \sin 30^\circ - \mu mg \cos 30^\circ = ma$

$$\frac{g}{2} - \frac{\sqrt{3}}{2} \cdot \mu g = \frac{g}{4}$$



$$\frac{\sqrt{3}}{2} \mu = \frac{1}{4}$$

$$\mu = \frac{1}{2\sqrt{3}}$$

11. A car is moving on a horizontal curved road with radius 50 m. The approximate maximum speed of car will be, if friction between tyres and road is 0.34. [Take $g = 10 \text{ ms}^{-2}$]

- (1) 3.4 ms^{-1} (2) 22.4 ms^{-1}
 (3) 13 ms^{-1} (4) 17 ms^{-1}

Official Ans. by NTA (3)

Ans. (3)

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

For maximum speed in safe turning,

$$f_s = f_s \text{ max} = \mu mg$$

$$v_{\text{max}} (\text{for safe turning}) = \sqrt{\mu rg}$$

$$= \sqrt{0.34 \times 50 \times 10} \approx 13 \text{ m/s}$$

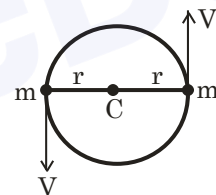
12. Two particles of equal mass 'm' move in a circle of radius 'r' under the action of their mutual gravitational attraction. The speed of each particle will be :

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

Official Ans. by NTA (4)

Ans. (4)

Sol. $\frac{Gm^2}{4r^2} = \frac{mv^2}{r}$



$$v = \sqrt{\frac{Gm}{4r}}$$

13. Surface tension of a soap bubble is $2.0 \times 10^{-2} \text{ Nm}^{-1}$. Work done to increase the radius of soap bubble from 3.5 cm to 7 cm will be : [Take $\pi = \frac{22}{7}$]

- (1) $0.72 \times 10^{-4} \text{ J}$ (2) $5.76 \times 10^{-4} \text{ J}$
 (3) $18.48 \times 10^{-4} \text{ J}$ (4) $9.24 \times 10^{-4} \text{ J}$

Official Ans. by NTA (3)

Ans. (3)

Sol. Surface area of soap bubble = $2 \times 4\pi R^2$

$$\text{Work done} = \text{change in surface energy} \times T_s$$

$$= T_s \times 8\pi \times (R_2^2 - R_1^2)$$

$$= 2 \times 10^{-2} \times 8 \times \frac{22}{7} \times 49 \times \frac{3}{4} \times 10^{-4}$$

$$= 18.48 \times 10^{-4} \text{ J}$$

14. Given below are two statements. One is labelled as **Assertion A** and the other is labelled as **Reason R**.
Assertion A : If dQ and dW represent the heat supplied to the system and the work done on the system respectively. Then according to the first law of thermodynamics $dQ = dU - dW$.

Reason R : First law of thermodynamics is based on law of conservation of energy.

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

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

Official Ans. by NTA (3)

Ans. (3)

Sol. First law of thermodynamics is based on law of conservation of energy and it can be written as $dQ = dU - dW$.

where dW is work done on the system

15. A bicycle tyre is filled with air having pressure of 270 kPa at 27°C . The approximate pressure of the air in the tyre when the temperature increases to 36°C is

- (1) 270 kPa (2) 262 KPa
- (3) 278 kPa (4) 360 kPa

Official Ans. by NTA (3)

Ans. (3)

Sol. Taking volume constant : $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$$\Rightarrow P_2 = \frac{P_1}{T_1} \times T_2 = \frac{270 \times (309)}{300}$$

$$= 278 \text{ kPa}$$

16. A person observes two moving trains, 'A' reaching the station and 'B' leaving the station with equal speed of 30 m/s. If both trains emit sounds with frequency 300 Hz, (Speed of sound : 330 m/s) approximate difference of frequencies heard by the person will be :

- (1) 33 Hz (2) 55 Hz
- (3) 80 Hz (4) 10 Hz

Official Ans. by NTA (2)

Ans. (2)

Sol. $f_1 = 300 \left(\frac{330 - 0}{330 - (-30)} \right) = 275$

$$f_2 = 300 \left(\frac{330 - 0}{330 - (30)} \right) = 330$$

$$\Delta f = 330 - 275 = 55 \text{ Hz.}$$

17. If the height of transmitting and receiving antennas are 80 m each, the maximum line of sight distance will be :

Given : Earth's radius = 6.4×10^6 m.

- (1) 32 km (2) 28 km
- (3) 36 km (4) 64 km

Official Ans. by NTA (4)

Ans. (4)

Sol. Maximum line of sight distance between two antennas, $d_M = \sqrt{2Rh_T} + \sqrt{2R.h_R}$

$$d_M = 2 \times \sqrt{2 \times 6.4 \times 10^6 \times 80} = 64 \text{ km}$$

18. The threshold wavelength for photoelectric emission from a material is 5500 \AA . Photoelectrons will be emitted, when this material is illuminated with monochromatic radiation from a

- A. 75 W infra-red lamp
- B. 10 W infra-red lamp
- C. 75 W ultra-violet lamp
- D. 10 W ultra-violet lamp

Choose the correct answer from the options given below :

- (1) B and C only (2) A and D only
- (3) C only (4) C and D only

Official Ans. by NTA (4)

Ans. (4)

Sol. $\lambda < 5500 \text{ \AA}$ for photoelectric emission

$$\lambda_{uv} < 5500 \text{ \AA}$$

19. If a radioactive element having half-life of 30 min is undergoing beta decay, the fraction of radioactive element remains undecayed after 90 min. will be :

- (1) $\frac{1}{8}$ (2) $\frac{1}{16}$
- (3) $\frac{1}{4}$ (4) $\frac{1}{2}$

Official Ans. by NTA (1)

Ans. (1)

Sol. $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}} = \left(\frac{1}{2}\right)^{\frac{90}{30}}$

$\frac{N}{N_0} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

20. Which of the following statement is not correct in the case of light emitting diodes?

- A. It is a heavily doped p-n junction.
- B. It emits light only when it is forward biased.
- C. It emits light only when it is reverse biased.
- D. The energy of the light emitted is equal to or slightly less than the energy gap of the semiconductor used.

Choose the correct answer from the options given below :

- (1) C and D (2) A
- (3) C (4) B

Official Ans. by NTA (3)

Ans. (3)

Sol. LED works in forward biasing and light energy maybe slightly less or equal to band gap.

SECTION-B

21. A radioactive element ${}_{92}^{242}\text{X}$ emits two α -particles, one electron and two positrons. The product nucleus is represented by ${}_{\text{p}}^{234}\text{Y}$. The value of P is _____

Official Ans. by NTA (87)

Ans. (87)

Sol. $P = 92 - 2 - 2 + 1 - 1 - 1$

$P = 92 - 5$

$P = 87$

22. Two simple harmonic waves having equal amplitudes of 8 cm and equal frequency of 10 Hz are moving along the same direction. The resultant amplitude is also 8 cm. The phase difference between the individual waves is _____ degree.

Official Ans. by NTA (120)

Ans. (120)

Sol. $2A \cos\left(\frac{\Delta\phi}{2}\right) = A$

$\cos\left(\frac{\Delta\phi}{2}\right) = \frac{1}{2}$

$\frac{\Delta\phi}{2} = 60^\circ$

23. A body cools from 60°C to 40°C in 6 minutes. If, temperature of surroundings is 10°C. Then, after the next 6 minutes, its temperature will be _____ °C.

Official Ans. by NTA (28)

Ans. (28)

Sol. By average form of Newton's law of cooling

$\frac{20}{6} = k(50 - 10)$... (i)

$\frac{40 - T}{6} = K\left(\frac{40 + T}{2} - 10\right)$ (ii)

From equation (i) and (ii)

$\frac{20}{40 - T} = \frac{40}{10 + T/2}$

$10 + \frac{T}{2} = 80 - 2T$

$\frac{5T}{2} = 70 \Rightarrow T = 28^\circ\text{C}$

24. A solid sphere of mass 2kg is making pure rolling on a horizontal surface with kinetic energy 2240 J. The velocity of centre of mass of the sphere will be _____ ms⁻¹.

Official Ans. by NTA (40)

Ans. (40)

Sol. $KE = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$2240 = \frac{1}{2}2(v)^2 + \frac{1}{2}\frac{2}{5}(2)R^2\left(\frac{v}{R}\right)^2$

$0 = v^2 + \frac{2}{5}v^2$

$\Rightarrow v = 40\text{ m/s}$

25. A 0.4 kg mass takes 8s to reach ground when dropped from a certain height 'P' above surface of earth. The loss of potential energy in the last second of fall is _____ J. [Take g = 10 m/s²]

Official Ans. by NTA (300)

Ans. (300)

Sol. Displacement is 8th sec.

$S_8 = 0 + \frac{1}{2} \times 10 \times (2 \times 8 - 1)$

$S_8 = 5 \times 15$

$\Delta U = 0.4 \times 10 \times 5 \times 15$

$\Delta U = 20 \times 15 = 300$

26. A tennis ball is dropped on to the floor from a height of 9.8 m. It rebounds to a height 5.0 m. Ball comes in contact with the floor for 0.2s. The average acceleration during contact is ____ ms^{-2} .
[Given $g = 10 \text{ ms}^{-2}$]

Official Ans. by NTA (120)

Ans. (120)

Sol.

$$v_i = \sqrt{2gh_i}$$

$$= \sqrt{2 \times 10 \times 9.8} \downarrow$$

$$= 14 \text{ m/s} \downarrow$$

$$v_f = \sqrt{2gh_f}$$

$$= \sqrt{2 \times 10 \times 5} \uparrow$$

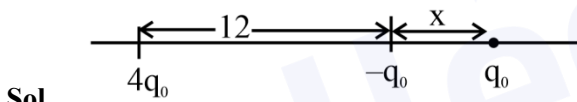
$$= 10 \text{ m/s} \uparrow$$

$$|\bar{a}_{\text{avg}}| = \left| \frac{\Delta \vec{v}}{\Delta t} \right| = \frac{24}{0.2} = 120 \text{ m/s}^2$$

27. A point charge $q_1 = 4q_0$ is placed at origin. Another point charge $q_2 = -q_0$ is placed at $x = 12 \text{ cm}$. Charge of proton is q_0 . The proton is placed on x-axis so that the electrostatic force on the proton is zero. In this situation, the position of the proton from the origin is ____ cm.

Official Ans. by NTA (24)

Ans. (24)



$$\frac{q_0}{x^2} = \frac{4q_0}{(x+12)^2}$$

$$x+12 = 2x$$

$$x = 12$$

Distance from origin = $x + 12 = 24 \text{ cm}$.

28. In a metre bridge experiment the balance point is obtained if the gaps are closed by 2Ω and 3Ω . A shunt of $X\Omega$ is added to 3Ω resistor to shift the balancing point by 22.5 cm. The value of X is ____

Official Ans. by NTA (2)

Ans. (2)

Sol.

$$\frac{2}{\left(\frac{3x}{3+x}\right)} = \frac{40+22.5}{60-22.5} = \frac{62.5}{37.5} = \frac{5}{3}$$

$$\frac{6}{5} = \frac{3x}{3+x}$$

$$6+2x = 5x \Rightarrow x = 2$$

29. A certain elastic conducting material is stretched into a circular loop. It is placed with its plane perpendicular to a uniform magnetic field $B = 0.8 \text{ T}$. When released the radius of the loop starts shrinking at a constant rate of 2 cm^{-1} . The induced emf in the loop at an instant when the radius of the loop is 10 cm will be ____ mV.

Official Ans. by NTA (10)

Ans. (10)

Sol.

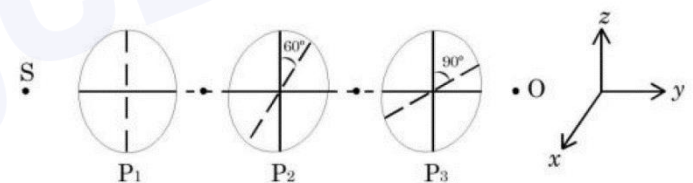
$$\text{EMF} = \frac{d}{dt}(B\pi r^2)$$

$$= 2B\pi r \frac{dr}{dt} = 2 \times \pi \times 0.1 \times 0.8 \times 2 \times 10^{-2}$$

$$= 2\pi \times 1.6 = 10.06 \text{ [round off } 10.06 = 10]$$

30. As shown in figures, three identical polaroids P_1 , P_2 and P_3 are placed one after another. The pass axis of P_2 and P_3 are inclined at angle of 60° and 90° with respect to axis of P_1 . The source S has an intensity of $256 \frac{\text{W}}{\text{m}^2}$. The intensity of light at point

O is ----- $\frac{\text{W}}{\text{m}^2}$.



Official Ans. by NTA (24)

Ans. (24)

- Sol.** By first polaroid P_1 intensity will be halved then P_2 and P_3 will make intensity $\cos^2(60^\circ)$ and $\cos^2(30^\circ)$ times respectively.

$$\text{Intensity out} = \frac{256}{2} \times \frac{1}{4} \times \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{256 \times 3}{2 \times 4 \times 4} = 24$$