JEE (Main) QUESTION PAPER 2024

27th January Shift 1

Time : 3 Hours **Total Marks : 300**

General Instructions :

1. *There are three subjects in the question paper consisting of Physics Q. no. 1 to 30.*
2. *This Paper is divided into two sections:*
   - *Section A Consists of 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which ONLY ONE is correct.*
   - *Section B consist of 10 questions, **Numerical Value Type Questions** - In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE**. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.*
3. *There will be only one correct choice in the given four choices in Section A. For each question 4 marks will be awarded for correct choice, 1 mark will be deducted for incorrect choice for Section A questions and zero mark will be awarded for not attempted question.*
4. *For Section B questions, 4 marks will be awarded for correct answer and zero for unattempted and incorrect answer.*

Physics

Section A

Q. 1. A wire of length 10 cm and radius $\sqrt{7}\times10^{-4}$ m is connected across the right gap of meter bridge. When a resistance of 4.5Ω is connected on the left gap by using a resistance box, the balance length is found to be at 60 cm from the left end. If the resistivity of the wire is R $\times 10^{-7}$ Ω m, then value of R is:

(1) 66 **(2)** 70
(3) 35 **(4)** 63

Q. 2. An electric change 10^{-6}μ C is placed at origin (0, 0) m of X–Y co-ordinate system, Two points P and Q are situated at $\left(\sqrt{3},\sqrt{3}\right)$ m and $\left(\sqrt{6},0\right)$ m respectively. The potential difference between the points P and Q will be :

(1) $\sqrt{6}$V **(2)** 0 V
(3) 3 V **(4)** $\sqrt{3}$V

Q. 3. A body of mass 1000 kg is moving horizontally with a velocity 6 m/s. If 200 kg extra mass is added, the final velocity (in m/s) is:

(1) 2 **(2)** 6
(3) 3 **(4)** 5

Q. 4. Position of an ant (S in meters) moving in Y – Z plane is given by $S = 2t^2\hat{j}+5\hat{k}$ (where t is in second). The magnitude and direction of velocity of the ant at $t = 1$ s will be :

(1) 9 m/s in z-direction
(2) 16 m/s in y-direction
(3) 4 m/s in x-direction
(4) 4 m/s in y-direction

Q. 5. A proton moving with a constant velocity passes through a region of space without any change in its velocity . If $\vec{E}$ and $\vec{B}$ represent the electric and magnetic fields respectively, then the region of space may have :

(a) E = 0, B = 0 **(b)** E = 0, B ≠ 0
(c) E ≠ 0, B = 0 **(d)** E ≠ 0, B ≠ 0

Choose the most appropriate answer from the options given below ;

(1) (a), (b) and (c) only
(2) (a), (c) and (d) only
(3) (a), (b) and (d) only
(4) (b), (c) and (d) only

Q. 6. Given below are two statements :

Statements (I): Viscosity of gases is greater than that of liquids

Statements (II): Surface tension of a liquid decreases due to the presence of insoluble impurities.

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

(1) Statement **I** is correct but Statement **II** is incorrect.
(2) Both statement **I** and Statement **II** are correct.

(3) Both statement **I** and statement **II** are incorrect.
(4) Statement **I** is incorrect but Statement **II** is correct.

Q. 7. The acceleration due to gravity on the surface of earth is g. If the diameter of earth reduces to half of its original value and mass remains constant, then acceleration due to gravity on the surface of earth would be :

(1) 4 g **(2)** $\frac{g}{4}$

(3) 2 g **(4)** $\frac{g}{2}$

Q. 8. The radius of third stationary orbit of electron for Bohr's atom is R. The radius of fourth stationary orbit will be :

(1) $\frac{16}{9}R$ **(2)** $\frac{9}{16}R$

(3) $\frac{3}{4}R$ **(4)** $\frac{4}{3}R$

Q. 9. Two bodies of mass 4 g and 25 g are moving with equal kinetic energies. The ratio of magnitude of their linear momentum is :

(1) 4 : 5 **(2)** 3 : 5
(3) 2 : 5 **(4)** 5 : 4

Q. 10. A wire of resistance R and length L is cut into 5 equal parts. If these parts are joined parallely, then resultant resistance will be:

(1) $\frac{1}{25}R$ **(2)** 5 R

(3) 25 R **(4)** $\frac{1}{5}R$

Q. 11. The average kinetic energy of a monoatomic molecule is 0.414 eV at temperature:
(Use $K_B = 1.38 \times 10^{-23}$ J/ mol-K)

(1) 3000 K **(2)** 3200 K
(3) 1500 K **(4)** 1600 K

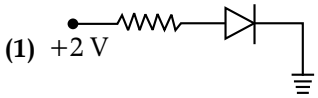
Q. 12. A plane electromagnetic wave propagating in x-direction is described by $E_y = (200\ V\ m^{-1})$ sin $[1.5\times10^7\ t - 0.05\ x]$; The intensity of the wave is :
(Use $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$)

(1) 53.1 Wm^{-2} **(2)** 106.2 Wm^{-2}
(3) 35.4 Wm^{-2} **(4)** 26.6 Wm^{-2}

Q. 13. A train is moving with a speed of 12 m/s on rails which are 1.5 m apart. To negotiate a curve of radius 400 m, the height by which the outer rail should be raised with respect to the inner rail is (Given, $g = 10\ m/s^2$)

(1) 4.8 cm **(2)** 4.2 cm
(3) 6.0 cm **(4)** 5.4 cm

Q. 14. Which of the following circuits is reverse-biased ?

(1)


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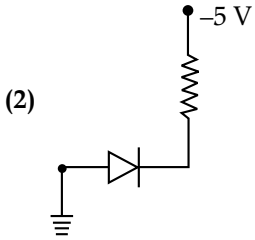

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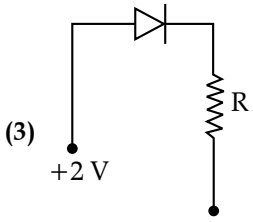
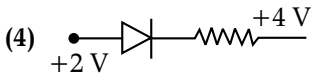


(4)


Q. 15. Given below are two statements :
Statements (I): Planck's constant and angular momentum have same dimensions
Statements (II): Linear momentum and moment of force have same dimensions
In the light of the above statements choose the correct answer from the option given below

(1) Statements **I** is true but statement **II** is false.
(2) Statements **I** is false but statement **II** is true.
(3) Both statement **I** and statement **II** are true.
(4) Both statement **I** and statement **II** are false.

Q. 16. If the refractive index of the material of a prism is $\cot\left(\frac{A}{2}\right)$, where A is the angle of prism then the angle of minimum deviation will be:

(1) $\pi - A$ **(2)** $\pi - 2A$

(3) $\frac{\pi}{2} - 2A$ **(4)** $\frac{\pi}{2} - A$

Q. 17. A convex lens of focal length 40 cm forms an image of an extended source of light on a photoelectric cell, A current I is produced. The lens is replaced by another convex lens having the same diameter but focal length 20 cm. Then photoelectric current now is:

(1) I **(2)** $\frac{I}{2}$

(3) 2 I **(4)** 4 I

Q. 18. Identify the physical quantity that cannot be measured using spherometer:

(1) Specific rotation of liquids
(2) Radius of curvature of concave surface
(3) Thickness of thin plates
(4) Radius of curvature of convex surface

Q. 19. 0.08 kg air is heated at constant volume through 5°C. The specific heat of air at constant volume is 0.17 kcal/kg °C and J = 4.18 joule/cal. The change in its internal energy is approximately

(1) 142 J **(2)** 298 J
(3) 284 J **(4)** 318 J

Q. 20. A rectangular loop of length 2.5 m and width 2 m is placed at 60° to a magnetic field of 4 T. The loop is removed from the field in 10 s. The average emf induced in the loop during this time is :

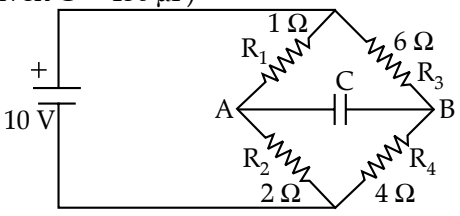
(1) +1 V **(2)** +2 V
(3) – 2 V **(4)** – 1 V

Section B

Q. 21. A particle starts from origin at $t = 0$ with a velocity $5i$ m/s and moves in $x - y$ plane under action of a force which produces a constant acceleration of $\left(3\hat{i}+2\hat{j}\right)$ m/s^2. If the x-coordinate of the particle at that instant is 84 m, then the speed of the particle at this time is $\sqrt{\alpha}$ m/s. The value of α is ..... .

Q. 22. In a nuclear fission process, a high mass nuclide (A ≈ 236) with binding energy 7.6 MeV/Nucleon dissociated into middle mass nuclides (A = 118), having binding energy of 8.6 MeV/Nucleon. The energy released in the process would be ..... MeV.

Q. 23. The charge accumulated on the capacitor connected in the following circuit is ..... μC.
(Given C = 150 μF)

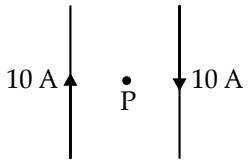


Q. 24. Two coils have mutual inductance 0.002 H. The current changes in the first coil according to the relation $i = i_0 \sin\omega t$, where i_0 = 5A and $\omega = 50\ \pi$ rad/s. The maximum value of emf in the second coil is $\frac{\pi}{\alpha}$ v. The value of α is ..... .

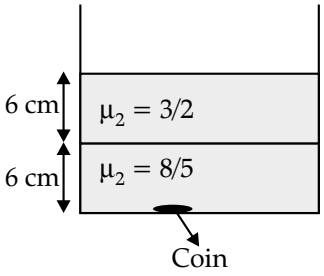
Q. 25. If average depth of an ocean is 4000 m and the bulk modulus of water is 2×10^9 Nm^{-2}, then fractional compression $\frac{\Delta V}{V}$ of water at the bottom of ocean is $\alpha \times 10^{-2}$. The value of α is ..... .
(Given, g = 10 ms^{-2}, ρ= 1000 kg m^{-3})

Q. 26. A particle executes simple harmonic motion with an amplitude of 4 cm. At the mean position, velocity of the particle is 10 cm/s. The distance of the particle from the mean position when its speed becomes 5 cm/s is $\sqrt{\alpha}$ cm, where α = ...

Q. 27. Two long, straight wires carry equal currents in opposite directions as shown in figure. The separation between the wires is 5.0 cm. The magnitude of the magnetic field at point P midway between the wires is ..... μT.
(Given : $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1})



Q. 28. Two immiscible liquid of refractive indices $\frac{8}{5}$ and $\frac{3}{2}$ respectively are put in a beaker as shown in the figure. The height of each column is 6 cm. A coin is placed at the bottom of the beaker. For near normal vision, the apparent depth of the coin is $\frac{\alpha}{4}$ cm. The value of α is ..... .



Q. 29. A thin metallic wire having cross sectional area of 10^{-4} m^2 is used to make a ring of radius 30 cm. A positive charge of 2π C is uniformly distributed over the ring, while another positive charge of 30 pC is kept at the centre of the ring. The tension in the ring is ..... N; provided that the ring does not get deformed (neglect the influence of gravity) (given, $\frac{1}{4\pi\varepsilon_0} = 9\times10^9$ SI units)

Q. 30. Four particles each of mass 1 kg are placed at four corners of a square of side 2 m. Moment of inertia of system about an axis perpendicular to its plane and passing through one of its vertex is ..... kgm^2.

Answer Key

Physics			
Q. No.	**Answer**	**Topic Name**	**Chapter Name**
1	(1)	Meter bridge	Current Electricity
2	(2)	Potential difference	Electric Potential and Capacitance
3	(4)	Conservation of Linear Momentum	Laws of Motion
4	(4)	Motion in a plane	Motion in a plane
5	(3)	Lorentz's Force	Magnetic Effects of Current
6	(4)	Viscocity, Surface tension	Mechanical Properties of Fluid
7	(1)	Acceleration due to Gravity	Gravitation
8	(1)	Bohr's model of Atom	Atoms
9	(3)	Kinetic energy, Linear momentum	Work, energy and Power
10	(1)	Combination of Resistors	Current Electricity
11	(2)	average kinetic energy and its relationship with temperature	Kinetic theory of Gases
12	(1)	Wave propagation	Electromagnetic Waves
13	(4)	Banking of Road	Circular Motion
14	(4)	Biasing of p -n junction diode	Electronic Devices
15	(1)	Dimensional Analysis	Physics and Measurement
16	(2)	Refraction of Light through a Prism	Ray Optics
17	(1)	Photo-electric Effect	Dual nature of matter and Radiation
18	(1)	Spherometer	Experimental Skills
19	(3)	First law of Thermodynamics, Internal Energy	Thermodynamics
20	(1)	Faraday's Law of Electromagnetic Induction	Electromagnetic Induction
21	[673]	Motion in a plane	Kinematics
22	[236]	Binding Energy	Nuclei
23	[400]	Combination of Capacitors	Electrostatic Potential and Capacitance
24	[2]	Mutual Inductance	Electomagnetic Induction
25	[2]	Variation in Pressure	Mechanical Properties of Fluid
26	[12]	Simple Harmonic Motion	Oscillation
27	[160]	Magnetic Field due to a Current Carrying Straight Wire	Magnetic Effects of Current
28	[31]	Real Depth, Apparent depth, Refractive Index	Ray Optics
29	[3]	Linear Charge Distribution	Electrostatics
30	[16]	Moment of Inertia	Rotational Motion

ANSWERS WITH EXPLANATIONS

1. Option (1) is correct.

$A = \pi\pi^2$

$= \pi \times (\sqrt{7} \times 10^{-4})^2$

$= 7\pi \times 10^{-8}\,m^2$

Now from balanced condition

$\frac{4.5}{60} = \frac{R}{40}$

$\Rightarrow R = 3\,\Omega$

Again $R = \rho\frac{l}{A}$

$\Rightarrow 3 = \frac{\rho \times 0.1}{7\pi \times 10^{-8}}$

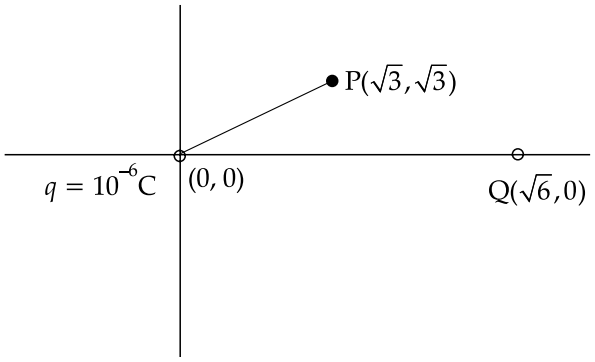
$\Rightarrow 21\pi \times 10^{-8} = 0.1\rho$

$\Rightarrow \rho = \frac{21\pi \times 10^{-8}}{0.1} = 659.4 \times 10^{-8}$

$\Rightarrow \rho = 65.94 \times 10^{-7}\,\Omega m$

On comparing $R = 65.94 \approx 66$

2. Option (2) is correct.



Potential at Q = $\frac{Kq}{\sqrt{6}}$

Potential at P = $\frac{Kq}{\sqrt{6}}$

So, Potential difference = 0

3. Option (4) is correct.

According to the law of Conservation of linear momentum

$1000 \times 6 + 200 \times 0 = 1200 \times v_f$

$\Rightarrow v_f = \frac{1000 \times 6}{1200} = 5\ \text{ms}^{-1}$

4. Option (4) is correct.

$\vec{S} = 2t^2\hat{j} + 5\hat{k}$

At $t = 1s, \vec{v} = \frac{ds}{dt} = 4\hat{j} + 0$

$\vec{v} = 4\vec{j}$ m/s

5. Option (3) is correct.

Force due to electric field $\vec{F}_E = q\vec{E}$

Force due to magnetic field $\vec{F}_B = q(\vec{V} \times \vec{B})$

Case (B) is correct when $\vec{V} \parallel \vec{B}$

Case (D) is correct when $\vec{E} \perp \vec{B} \perp \vec{V}$

So, option (3) is correct.

6. Option (4) is correct.

Viscosity of liquid is greater than that of gases and surface tension of a liquid decreases in the presence of insoluble impurities.

7. Option (1) is correct.

$g = \frac{GM}{R^2}$

$g' = \frac{GM}{\left(\frac{R}{2}\right)^2} = \frac{4GM}{R^2}$

$\frac{g'}{g} = \frac{4GM}{R^2} \times \frac{R^2}{GM} = 4$

$\Rightarrow g' = 4g$

8. Option (1) is correct.

We have $R = R_0 \frac{n^2}{z}$

$R = R_0 \times \frac{3^2}{1} = 9R_0$

$R' = R_0 \times \frac{4^2}{1} = 16R_0$

On comparing $\frac{R'}{R} = \frac{16}{9}R$

9. Option (3) is correct.

$\frac{p_1^2}{2m_1} = \frac{p_2^2}{2m_2} \Rightarrow \frac{p_1}{p_2} = \sqrt{\frac{m_1}{m_2}}$

$\Rightarrow \frac{p_1}{p_2} = \sqrt{\frac{4}{25}} \Rightarrow \frac{p_1}{p_2} = \frac{2}{5}$

10. Option (1) is correct.

$\frac{1}{R_{eq}} = \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} + \frac{1}{\frac{R}{5}} \Rightarrow R_{eq} = \frac{R}{25}$

11. Option (2) is correct.

$\frac{3}{2} \times T \times 1.38 \times 10^{-23} = 0.414\ \text{eV}$

$T = 0.414 \times 1.6 \times 10^{-19}$

$T = 3200\ \text{K}$

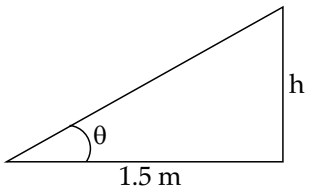
12. Option (1) is correct.

$I = \frac{\varepsilon_0}{2} E_0^2 C$

$= \frac{8.85 \times 10^{-22}}{2} \times (200)^2 \times 3 \times 10^8$

$= 53.10\ \text{Wm}^{-2}$

13. Option (4) is correct.



$v^2 = Rg\tan\theta$

Or, $\tan\theta = \frac{(12)^2}{400 \times 10}$

Or, $\frac{h}{1.5} = 3.6$ cm

Or, $h = 5.4$ cm

14. Option (4) is correct.

In option (4), p-end is connected to lower potential and n-end is connected to higher potential.

15. Option (1) is correct.

(I) Dimensional formula of Planck's constant and angular momentum are same i.e., $[M^1 L^2 T^{-1}]$

(II) Dimensional formula of Linear momentum $[M^1 L^1 T^{-1}]$

Dimensional formula of moment of force $[M^1 L^2 T^{-2}]$

16. Option (2) is correct.

$$\mu = \cot\left(\frac{A}{2}\right) = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\frac{\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\cos\left(\frac{A}{2}\right) = \sin\left(\frac{A+\delta_m}{2}\right)$$

$$\sin\left(\frac{\pi}{2}-\frac{A}{2}\right) = \sin\left(\frac{A+\delta_m}{2}\right)$$

$$\left(\frac{\pi}{2}-\frac{A}{2}\right) = \left(\frac{A+\delta_m}{2}\right)$$

$(\pi - 2A) = \delta_m$

$\delta_m = 180 - 2A$

17. Option (1) is correct.

The number of photons reaching the cathode depends upon the aperture of the lens. So, the number of photons reaching the photo sensitive metal is same in both cases. Therefore, photo current will be the same.

18. Option (1) is correct.

A Spherometer is the instrument used for precise measurement of the radius of curvature of a sphere, cylinder and lens.

19. Option (3) is correct.

$Q = ms\Delta T = \Delta U$

$= 0.08 \times 0.17 \times 10^3 \times 4.18 \times 5$

$= 0.28424 \times 10^3 \text{ J} = 284 \text{ J}$

20. Option (1) is correct.

Area $A = 2.5 \times 2 = 5 \text{ m}^2$

$\phi_{initial} = 4 \times 5 \times \cos 60° = 4 \times 5 \times \frac{1}{2} = 10 \text{ Wb}$

$\phi_{final} = 0$

$$\varepsilon = -\frac{\Delta\phi}{\Delta t} = -\frac{0-10}{10} = 1 \text{ volt}$$

21. Correct answer is [673].

(i) $84 = 5t + \frac{3}{2}t^2$

$3t^2 + 10t - 168 = 0$

$$t = \frac{-10 + \sqrt{100 + 4 \times 3 \times 168}}{6}$$

$t = 6\text{s}$

(ii) $\vec{v} = \vec{u} + \vec{a}t$

$= 5\hat{i}(3\hat{i} + 2\hat{j})6 = 23\hat{i} + 12\hat{j}$

(iii) $v = \sqrt{(23)^2 + (12)^2} = \sqrt{673} \text{ m/s}$

22. Correct answer is [236].

$X^{236} \rightarrow 2Y^{118}$

$Q = (BE)_P - (BE)_R$

$= (8.6 \times 236) - (236 \times 7.6) = 236 \text{ MeV}$

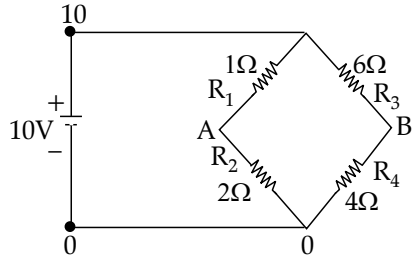
23. Correct answer is [400].

$V_B = \frac{4}{4+6} V = 4V$

$V_A = \frac{2}{2+1}10V = \frac{20}{3}V$

$Q = C(V_A - V_B)$

$= 150 \times \frac{8}{3}\mu C = 400\,\mu C$



24. Correct answer is [2].

$\phi_2 = Mi_2$

$$\varepsilon_2 = -\frac{d\phi_2}{dt} = -Mi_0\omega\cos\omega t$$

$\varepsilon_{2_{max}} = Mi_0\omega$

$= (0.002)(5)(50\pi) = (0.5)\pi = \frac{\pi}{2}$

On comparing $\alpha = 2$.

25. Correct answer is [2].

$$\beta = \frac{-dP}{\frac{dV}{V}}$$

$$\Rightarrow \frac{dV}{V} = \frac{-dP}{\beta}$$

$$\frac{dV}{V} = -\frac{\rho g h}{\beta}$$

$$= -\frac{1000 \times 10 \times 4000}{2 \times 10^9} = -2 \times 10^{-2}$$

On comparing $\alpha = 2$ (magnitude)

26. Correct answer is [12].

Given $V_m = A\omega = 10$

$\Rightarrow 4\omega = 10$

$\Rightarrow \omega = \frac{5}{2}$

$V = \omega\sqrt{A^2 - a^2}$

$\Rightarrow 5 = \frac{5}{2}\sqrt{4^2 - x^2}$

$\Rightarrow 2 = \sqrt{16 - x^2}$

$\Rightarrow 4 = 16 - x^2$

$\Rightarrow x^2 = 12$

$\Rightarrow x = \sqrt{12} = 2\sqrt{3}$ cm

27. Correct answer is [160].

$$B_P = 2\left[\frac{\mu_0 I}{2\pi d}\right] = \frac{\mu_0 \times 10^{-7} \times 10}{\pi \times 2.5 \times 10^{-2}}$$

$$= \frac{4 \times 10^{-7} \times 10^4}{25} T = \frac{4}{25} \times 10^{-3}$$

$T = 160\ \mu T$

28. Correct answer is [31].

Apparent depth of the coin

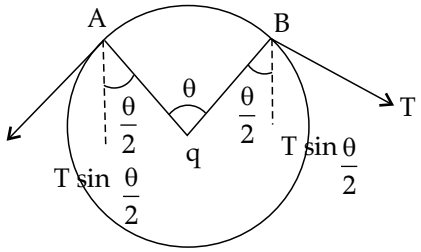
$$= \frac{t_1}{\frac{\mu_1}{\mu_0}} + \frac{t_2}{\frac{\mu_2}{\mu_0}} = \frac{6 \times 1}{\frac{3}{2}} + \frac{6 \times 1}{\frac{8}{5}}$$

$$= 4 + \frac{15}{4} = \frac{31}{4}$$

The apparent depth is given as $\frac{\alpha}{4}$

So, on comparing $\alpha = 31$

29. Correct answer is [3].



Linear charge density $\lambda = \frac{2\pi}{2\pi r} = \frac{1}{0.3} = \frac{10}{3}$ C/m

$F = 2T \sin\frac{\theta}{2}$

$$\Rightarrow \frac{k \times q \times \frac{10}{3} \times r\theta}{r^2} = 2T\frac{\theta}{2}$$

$$\Rightarrow T = \frac{kq \times 10}{3r}$$

$$\Rightarrow T = \frac{9 \times 10^9 \times 30 \times 10^{-12} \times 10}{3 \times 0.3} = 3N$$

30. Correct answer is [16].

$I = 0 + 1 \times 2^2 + 1 \times 2^2 + 1 \times (2\sqrt{2})^2$

$= 0 + 4 + 4 + 8 = 16\ kg\ m^2$

❐❐❐