JEE (Main) QUESTION PAPER 2024

29th January Shift 2

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

General Instructions : *Same as 27th Jan Shift 1 2024.*

Physics

Section A

Q. 1. If the distance between object and its two times magnified virtual image produced by a curved mirror is 15 cm, the focal length of the mirror must be:

(1) $\frac{10}{3}$ cm **(2)** –12 cm

(3) –10 cm **(4)** 15 cm

Q. 2. Two particles X and Y having equal charges are being accelerated through the same potential difference. Thereafter they enter normally in a region of uniform magnetic field and describes circular paths of radii R_1 and R_2 respectively. The mass ratio of X and Y is:

(1) $\left(\frac{R_1}{R_2}\right)$ **(2)** $\left(\frac{R_2}{R_1}\right)$

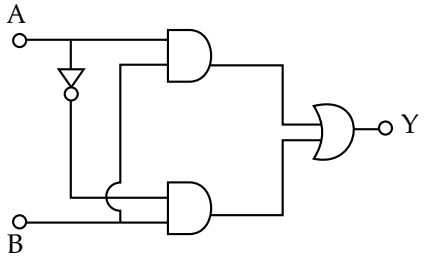
(3) $\left(\frac{R_2}{R_1}\right)^2$ **(4)** $\left(\frac{R_1}{R_2}\right)^2$

Q. 3. The temperature of a gas having 2.0×10^{25} molecules per cubic meter at 1.38 atm: (Given, $k = 1.38 \times 10^{-23}$ JK^{-1}) is :

(1) 300 K **(2)** 500 K

(3) 100 K **(4)** 200 K

Q. 4. The truth table for this given circuit is:



(1)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(2)

A	B	Y
0	0	1
0	1	0
1	0	1
1	1	0

(3)

A	B	Y
0	0	0
0	1	1
1	0	0
1	1	1

(4)

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

Q. 5. In an a.c. circuit, voltage and current are given by:

$V = 100 \sin (100\, t)$ V and

$I = 100 \sin \left(100t + \frac{\pi}{3}\right)$ mA respectively.

The average power dissipated in one cycle is:

(1) 10 W **(2)** 2.5 W

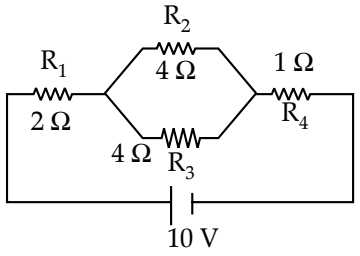
(3) 25 W **(4)** 6 W

Q. 6. A stone of mass 900 g is tied to a string and moved in a vertical circle of radius 1 m making 10 rpm. The tension in the string, when the stone is at the lowest point is (if $\pi^2 = 9.8$ and g = 9.8 m /s):

(1) 17.8 N **(2)** 8.82 N

(3) 97 N **(4)** 9.8 N

Q. 7. In the given circuit, the current in resistance R_3 is:



(1) 2.5 A **(2)** 1 A

(3) 1.5 A **(4)** 2 A

Q. 8. A particle is moving in a straight line. The variation of position 'x' as a function of time 't' is given as $x = (t^3 - 6t^2 + 20t + 15)m$. The velocity of the body when its acceleration becomes zero is:

(1) 6 m/s **(2)** 10 m/s

(3) 8 m/s **(4)** 4 m/s

Q. 9. In Young's double slit experiment, light from two identical sources are superimposing on a screen. The path difference between the two lights reaching at a point on the screen is $\frac{7\lambda}{4}$. The ratio of intensity of fringe at this point with respect to the maximum intensity of the fringe is :

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

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

Q. 10. Two sources of light emit with a power of 200 W. The ratio of number of photons of visible light emitted by each source having wavelengths 300 nm and 500 nm respectively, will be:

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

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

Q. 11. A small liquid drop of radius R is divided into 27 identical liquid drops. If the surface tension is T, then the work done in the process will be:

(1) $4\pi R^2T$ **(2)** $8\pi R^2T$

(3) $3\pi R^2T$ **(4)** $\frac{1}{8}\pi R^2T$

Q. 12. The bob of a pendulum was released from a horizontal position. The length of the pendulum is 10 m. If it dissipates 10 % of its initial energy against air resistance. The speed with which the bob arrives at the lowest point is:

[Use, g : 10 ms^{-2}]

(1) $6\sqrt{5}m/s^{-1}$ **(2)** $5\sqrt{5}ms^{-1}$

(3) $2\sqrt{5}ms^{-1}$ **(4)** $5\sqrt{6}ms^{-1}$

Q. 13. A physical quantity Q is found to depend on quantities a, b, c by the relation $Q = \frac{a^4b^3}{c^2}$

The percentage error in a, b and c are 3%, 4% and 5 % respectively. Then, the percentage error in Q is:

(1) 66% **(2)** 14%

(3) 34% **(4)** 43%

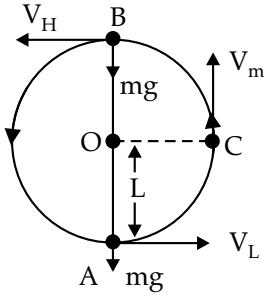
Q. 14. A plane electromagnetic wave of frequency 35 MHz travels in free space along the X-direction. At a particular point (in space and time) $\vec{E} = 9.6\hat{j}$ V/m· The value of magnetic field at this point is :

(1) $9.6\ \hat{j}$ T **(2)** $3.2 \times 10–8\hat{i}$ T

(3) $3.2 \times 10^{-8}\hat{k}$ T **(4)** $9.6 \times 10^{-8}\hat{k}$ T

Q. 15. A bob of mass 'm' is suspended by a light string of length 'L'. It is imparted a minimum horizontal velocity at the lowest point A such that it just completes half circle reaching the top most position B.

The ratio of kinetic energies $\frac{(KE)_A}{(KE)_B}$ is:



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

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

Q. 16. Given below are two statements:

Statement I : Most of the mass of the atom and all its positive charge are concentrated in a tiny nucleus and the electrons revolve around it, is Rutherford's model.

Statement II : An atom is a spherical cloud of positive charges with electrons embedded in it, is a special case of Rutherford's model. In the light of the above statements, choose the most appropriate from the options given below

(1) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are true

(3) Both statement I and statement II are false

(4) Statement I is false but Statement II is true

Q. 17. N moles of a polyatomic gas ($f = 6$) must be mixed with two moles of a monoatomic gas so that the mixture behaves as a diatomic gas. The value of N is:

(1) 4 **(2)** 3

(3) 6 **(4)** 2

Q. 18. A planet takes 200 days to complete one revolution around the Sun. If the distance of the planet from Sun is reduced to one fourth of the original distance, how many days will it take to complete one revolution:

(1) 20 **(2)** 25

(3) 50 **(4)** 100

Q. 19. An electric field is given by $(6\hat{i} + 5\hat{j} + 3\hat{k})$ N/C. The electric flux through a surface area $30\hat{i}$ m^2 lying in YZ-plane (in SI unit) is:

(1) 180 **(2)** 90
(3) 150 **(4)** 60

Q. 20. A wire of length L and radius r is clamped at one end. If its other end is pulled by a force F, its length increases by l. If the radius of the wire and the applied force both are reduced to half of their original values keeping original length constant, the increase in length will become:

(1) 3 times **(2)** 4 times
(3) $\frac{3}{2}$ times **(4)** 2 times

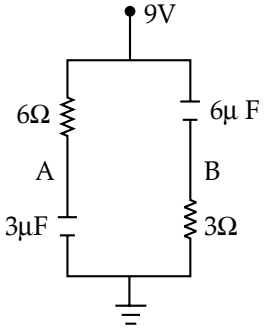
Section B

Q. 21. In a single slit diffraction pattern, a light of wavelength 6000Å is used. The distance between the first and third minima in the diffraction pattern is found to be 3 mm when the screen in placed 50 cm away from slits. The width of the slit is ..... $\times 10^{-4}$ m.

Q. 22. A simple harmonic oscillator has an amplitude A and time period 6π second. Assuming the oscillation starts from its mean position, the time required by it to travel from $x = A$ to $x \frac{\sqrt{3}}{2}$. A will be $\frac{\pi}{x}$s, where x = ...

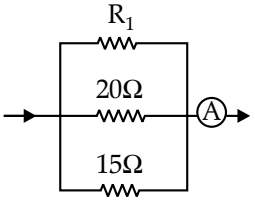
Q. 23. A particle is moving in a circle of radius 50 cm in such a way that at any instant the normal and tangential components of it's acceleration are equal. If its speed at $t = 0$ is 4 m/s, the time taken to complete the first revolution will be $\frac{1}{\alpha}[1-e^{-2\pi}]$ s, where α = ...

Q. 24. In the given figure, the charge stored in 6μF capacitor, when points A and B are joined by a connecting wire is ..... μC.



Q. 25. Two metallic wires P and Q have same volume and are made up of same material. If their area of cross sections are in the ratio 4 : 1 and force F_1 is applied to P, an extension of Δl is produced. The force which is required to produce same extension in Q is F_2 . The value of $\frac{F_1}{F_2}$ is ..... .

Q. 26. In the given circuit, the current flowing through the resistance 20Ω is 0.3 A, while the ammeter reads 0.9 A. The value of R_1 is ..... Ω.



Q. 27. A body of mass 5 kg moving with a uniform speed $3\sqrt{2}$ ms^{-1} in X – Y plane along the line $y = x + 4$. The angular momentum of the particle about the origin will be ..... kgm^2s^{-1}.

Q. 28. A charge of 4.0 μC is moving with a velocity of 1.0×10^6 ms^{-1} along the positive y-axis under a magnetic field $\vec{B}$ of strength $(2\hat{k})$T. The force acting on the charge is $x\hat{i}$ N . The value of x is ..... .

Q. 29. A horizontal straight wire 5 m long extending from east to west falling freely at right angle to horizontal component of earths magnetic field 0.60×10^{-4} Wbm^{-2}. The instantaneous value of emf induced in the wire when its velocity is 10 ms^{-1} is ..... $\times 10^{-3}$V.

Q. 30. Hydrogen atom is bombarded with electrons accelerated through a potential difference of V, which causes excitation of hydrogen atoms. If the experiment is being performed at T = 0 K, the minimum potential difference needed to observe any Balmer series lines in the emission spectra will be $\frac{\alpha}{10}$V , where α = ...

Answer Key

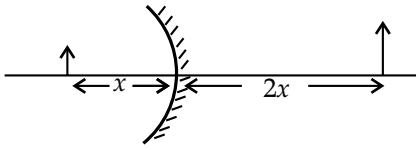
Physics			
Q. No.	**Answer**	**Topic Name**	**Chapter Name**
1	(3)	Spherical Mirrors	Ray Optics
2	(4)	Motion of a Charged Particle in a Uniform Magnetic Field	Magnetic Effects of Current
3	(2)	Ideal Gas	Kinetic Theory of Gases
4	(3)	Logic Gates	Electronic Devices
5	(2)	Power in AC circuit	Alternating Current
6	(4)	Motion in a Vertical Circle	Work, Energy and Power
7	(2)	Combination of Resistors	Current Electricity
8	(3)	Accelerated Motion	Motion in a Straight Line
9	(4)	YDSE	Wave Optics
10	(1)	Photon Flux	Dual Nature of Radiation and Matter
11	(2)	Surface Energy	Mechanical Properties of Fluids
12	(1)	Work-Energy Theorem	Work, Energy and Power
13	(3)	Error	Units and Measurement
14	(3)	Properties of EM Waves	Electromagnetic Waves
15	(2)	Motion in a Vertical Circle	Work, Energy and Power
16	(1)	Atomic Models	Atomic Physics
17	(1)	Specific Heat of Gases	Kinetic Theory of Gases
18	(2)	Kepler's Law	Gravitation
19	(1)	Electric Flux	Electrostatics
20	(4)	Young's Modulus of Elasticity	Mechanical Properties of Solids
21	[2]	Diffraction at a single slit	Wave Optics
22	[2]	Simple Harmonic Oscillator	Simple Harmonic Motion
23	[8]	Circular Motion	Motion in Plane
24	[36]	Combination of Capacitors	Electrostatic Potential and Capacitance
25	[16]	Young's Modulus of Elasticity	Mechanical Properties of Solids
26	[30]	Parallel Combination of Resistors	Current Electricity
27	[60]	Angular Momentum	System of Particles and Rotational Motion
28	[32]	Force on a Moving Charge	Magnetic Effects of Current
29	[3]	Motional EMF	Electromagnetic Induction
30	[121]	Hydrogen Spectrum	Atomic Physics

ANSWERS WITH EXPLANATIONS

Section A

1. Option (3) is correct.

Virtual and magnified image is given by concave mirror.



Let the distance of object be x.

$$m = -\frac{v}{u}$$

$$\Rightarrow \quad 2 = \frac{v}{x} \Rightarrow v = 2x$$

According to the question,

$x + 2x = 15$ $\quad u = -5$ cm

$x = 5$ cm $\quad v = 10$ cm

Applying Mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \quad \frac{1}{10} - \frac{1}{5} = \frac{1}{f}$$

$$\Rightarrow \quad \frac{1-2}{10} = \frac{1}{f}$$

$$\Rightarrow \quad f = -10 \text{ cm}$$

2. Option (4) is correct.

$$r = \frac{mv}{qB} = \frac{p}{qB}$$

The Kinetic energy of the particle

$$K = \frac{p^2}{2m}$$

$$p = \sqrt{2mK}$$

If charged particle is accelerated by potential V_1 then $K = qV$

Now, $$R = \frac{\sqrt{2mK}}{qB}$$

$$\Rightarrow \quad R = \frac{\sqrt{2mqV}}{qB}$$

Therefore, $R \propto \sqrt{m}$

$$\Rightarrow \quad m \propto R^2$$

So, $$\frac{m_1}{m_2} = \left(\frac{R_1}{R_2}\right)^2$$

3. Option (2) is correct.

$$P = 1.38 \text{ atm} = 1.38 \times 10^5 \text{ Pa}$$

$$\frac{N}{V} = 2.0 \times 10^{25} \text{ molecules/m}^3$$

Since,

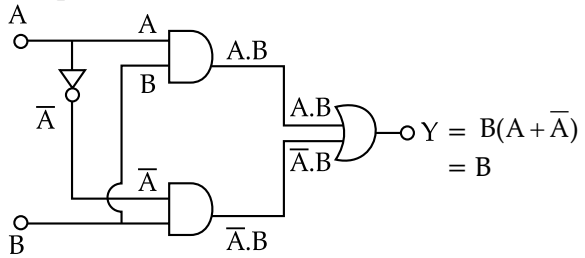
$$PV = NkT$$

$$\Rightarrow \quad T = \frac{PV}{Nk}$$

$$= \frac{1.38\times10^5}{2.0\times10^{25}\times1.38\times10^{-23}}$$

$$= 500 \text{ K}$$

4. Option (3) is correct.



$$Y = A.B + \vec{\bar{A}}.B$$

$$= B(A + \bar{A}) = B$$

5. Option (2) is correct.

Average power in AC circuit is given by:

$$P_{av} = V_{rms} I_{rms} \cos\phi$$

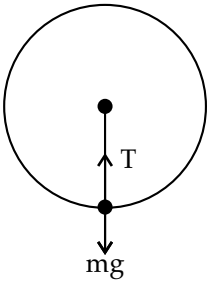
$$P_{av} = \frac{V_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}} \cos\phi$$

$$P_{av} = \frac{100\times100\times10^{-3}}{2} \times \frac{1}{2}$$

$$= \frac{10}{4} = 2.5 \text{ W}$$

6. Option (4) is correct.

$$\omega = \frac{20\neq}{60} = \frac{\neq}{3} \frac{rad}{s}$$



Force acting on stone at bottom point

$$T - mg = mr\omega^2$$

$$T = mg + mr\omega^2$$

$$= m(g + r\omega)^2$$

$$= 0.9\left(9.8 + 1\times\frac{\pi^2}{9}\right)$$

$$T = 0.9\left(9.8 + \frac{9.8}{9}\right)$$

$$T = 9.8 \text{ N}$$

7. Option (2) is correct.

$$R_{eq} = R_1 + \frac{R_2R_3}{R_2+R_3} + R_4$$

$$= 2 + \frac{4\times4}{4+4} + 1$$

$$= 2 + 2 + 1 = 5\Omega$$

$$I = \frac{V}{R_{eq}} = \frac{10}{5} = 2\text{A}$$

Current in R_3 is

$$I' = \frac{I}{2} = \frac{2}{2} = 1\text{A}$$

8. Option (3) is correct.

Given that,

$$x = (t^3 - 6t^2 + 20t + 15)$$

$$v = \frac{dx}{dt} = (3t^2 - 12t + 20)$$

and acceleration is

$$a = \frac{dv}{dt}$$

$$a = \frac{dv}{dt} = \frac{d}{dt}(3t^2 - 12t + 20)$$

$\Rightarrow$ $a = 6t - 12$

Putting the value of $a = 0$

$\Rightarrow$ $a = 6t - 12$

$\Rightarrow$ $6t - 12 = 0$

$t = 2$ s

At, $t = 2$ s, $a = 0$

Now velocity at time $t = 2$ s

$v = 3t^2 - 12t + 20$

$\Rightarrow$ $v_t = 3 \times 4 - 12 \times 2 + 20$

$= 12 - 24 + 20$

$= 8$ m/s

9. Option (4) is correct.

Path difference,

$$\Delta x = \frac{7\lambda}{4}$$

Now, $\frac{\Delta x}{\lambda} = \frac{\phi}{2\pi}$

$\Rightarrow$ $\phi = \frac{2\pi \times \Delta x}{\lambda} = \frac{2\pi \times 7\lambda}{\lambda \times 4}$

$\Rightarrow$ $\phi = \frac{7}{2} \neq$

Now, Resultant Intensity,

$$I_R = 4I_0 \cos^2 \frac{\phi}{2}$$

$$I_R = 4I_0 \cos^2\left(\frac{7\pi}{4}\right)$$

$I_R = 2I_0$

And $I_{max} = 4I_0$

Therefore,

$$\frac{I_R}{I_{\max}} = \frac{2I_0}{4I_0} = \frac{1}{2}$$

10. Option (1) is correct.

We know that a source of power 'P' watt produces photons per second at a rate

$$n = \frac{\text{Power of source}}{\text{Energy of photon}}$$

$$n = \frac{P}{\frac{hc}{\lambda}} = \frac{P\lambda}{hc}$$

$n \propto \lambda$

Therefore,

$$\frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{300 \times 10^{-9}}{500 \times 10^{-9}} = \frac{3}{5}$$

11. Option (2) is correct.

From volume conservation

$V_i = V_f$

$\Rightarrow$ $\frac{4}{3}\pi R^3 = 27 \times \frac{4}{3}\pi r^3$

$\Rightarrow$ $R = 3r$

$\Rightarrow$ $r = \frac{R}{3}$

Now, $W = T \times$ change in surface area (Δs)

$\Delta s = 27 \times 4\pi r^2 - 4\pi R^2$

$= 27 \times 4\pi\left(\frac{R}{3}\right)^2 - 4\pi R^2$

$= 4\pi R^2(3 - 1) = 8\pi R^2$

$W = 8\pi R^2 T$

12. Option (1) is correct.

Applying W-E theorem

$W_{\text{Total}} = \Delta K$

$\Rightarrow$ $0.9\, mgl = \frac{1}{2}mv^2$

$\Rightarrow$ $v = \sqrt{2 \times 0.9 \times 10 \times 10}$

$= 6\sqrt{5}$ m/s

13. Option (3) is correct.

$$Q = \frac{a^4 b^3}{c^2}$$

% error is given by

$$\frac{\Delta Q}{Q} \times 100 = 4\frac{\Delta a}{a} \times 100 + 3\frac{\Delta b}{b} \times 100 + 2\frac{\Delta c}{c} \times 100$$

$\Rightarrow$ $\frac{\Delta Q}{Q} \times 100 = 4 \times 3\% + 3 \times 4\% + 2 \times 5\%$

$\Rightarrow$ $\frac{\Delta Q}{Q} \times 100 = 12\% + 12\% + 10\% = 34\%$

$\Rightarrow$ % error $= 34\%$

14. Option (3) is correct.

$$B = \frac{E}{C} = \frac{9.6}{3 \times 10^8} = 3.2 \times 10^{-8}$$

Direction of E, B and C are mutually perpendicular.

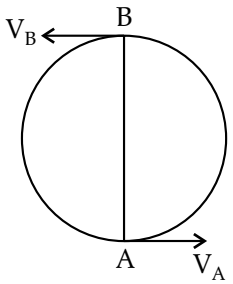
C is along X

E is along Y

Therefore B is along Z.

So, $\vec{B} = 3.2 \times 10^{-8}\hat{k}$T

15. Option (2) is correct.



$$V_B = \sqrt{gL} \qquad \Rightarrow V^2_B = gL$$

$$V_A = \sqrt{5gL} \qquad \Rightarrow V^2_A = 5gL$$

$$\frac{K.E_A}{K.E_B} = \frac{\frac{1}{2}mV_A^2}{\frac{1}{2}mV_B^2} = \frac{5gL}{gL}$$

$$\Rightarrow \quad \frac{K.E_A}{K.E_B} = \frac{5}{1}$$

16. Option (1) is correct.

Statement-I is correct.
Rutherford Gold foil experiment proves that most of the mass of atom is at centre (Nucleus) and electron revolve around it.
Statement-II is wrong.
Atom is spherical cloud of +ve charge with electron embeded into it. This statement belongs to Thomson model.

17. Option (1) is correct.

No. of moles of mono atomic gas = 2
No. of moles of Non-linear poly atomic gas = N
Specific heat of a diatomic gas = $\frac{5}{2}R$

Now,

$$\frac{n_1\frac{f_1}{2}R + n_2\frac{f_2}{2}R}{n_1+n_2} = \frac{5}{2}R$$

$$\Rightarrow \quad \frac{N\times\frac{6}{2}R + 2\times\frac{3}{2}R}{N+2} = \frac{5}{2}R$$

$$\Rightarrow \quad (3N + 3)\,2 = 5N + 10$$

$$\Rightarrow \quad N = 4$$

18. Option (2) is correct.

According to Kepler's 3rd law

$$T^2 \propto a^3$$

Here, $T_1 = 200$ days

$$a_1 = a$$

$$a_2 = \frac{a}{4}$$

Now, $$\frac{T_1^2}{T_2^2} = \frac{a_1^3}{a_2^3}$$

$$\Rightarrow \quad \frac{(200)^2}{T_2^2} = \frac{(a)^3}{\left(\frac{a}{4}\right)^3} \Rightarrow \left(\frac{200}{T_2}\right)^2 = (4)^3$$

$$\Rightarrow \quad \frac{200}{T_2} = \sqrt{64}$$

$$\Rightarrow \quad T_2 = \frac{200}{8} = 25 \text{ days}$$

19. Option (1) is correct.

Given that,

$$\vec{E} = (6\hat{i} + 5\hat{j} + 3\hat{k})\frac{N}{C}$$

$$d\vec{A} = (30\hat{i})m^2$$

Now, $\phi = EdA\cos\theta$

$$\Rightarrow \quad \phi = \vec{E}.\vec{dA}$$

$$\Rightarrow \quad \phi = (6\hat{i} + 5\hat{j} + 3\hat{k}).(30\hat{i})$$

$$\Rightarrow \quad \phi = 180\frac{N-m^2}{C}$$

20. Option (4) is correct.

$$\Delta l = \frac{FL}{AY}$$

Where $A = \pi r^2$

Now, $$\Delta l = \frac{Fl}{\pi r^2 Y}$$

Therefore, $\Delta l_1 = \frac{FL}{\pi r^2 Y}$

and, $$\Delta l_2 = \frac{FL}{2\times\pi\left(\frac{r}{2}\right)^2 Y}$$

$$\Delta l_2 = \frac{2FL}{\pi r^2 Y}$$

Now, $$\frac{\Delta l_1}{\Delta l_2} = \frac{\frac{FL}{\pi r^2 Y}}{\frac{2FL}{\pi r^2 Y}}$$

$$\Rightarrow \quad \frac{\Delta l_1}{\Delta l_2} = \frac{1}{2}$$

$$\Rightarrow \quad \Delta l_2 = 2\Delta l_1$$

Therefore the increase in length is 2 times.

Section B

21. Correct answer is 2.

Position of 3rd minima is given by

$$y_3 = \frac{3\lambda D}{a}$$

and $$y_1 = \frac{\lambda D}{a}$$

According to the question

$$y_3 - y_1 = 3 \text{ mm}$$

$$\Rightarrow \frac{3\lambda D}{a} - \frac{\lambda D}{a} = 3 \times 10^{-3} \text{ m}$$

$$\Rightarrow \frac{2\lambda D}{a} = 3 \times 10^{-3} \text{ m}$$

$$\Rightarrow a = \frac{2 \times 6000 \times 10^{-10} \times 50 \times 10^{-2}}{3 \times 10^{-3}}$$

$$a = 2 \times 10^{-4} \text{ m}$$

22. Correct answer is [2].

Given than,

$$T = 6\pi$$

Now, $$x = A \sin\left(wt + \frac{\pi}{2}\right)$$

$$x = A \cos \omega t$$

where, $$x = \frac{\sqrt{3}}{2}A$$

So, $$\frac{\sqrt{3}}{2}A = A\cos\left(\frac{2\pi}{6\pi} \times t\right)$$

$$\Rightarrow \frac{\sqrt{3}}{2} = \cos\left(\frac{1}{3} \times t\right)$$

$$\Rightarrow \frac{\pi}{6} = \frac{t}{3}$$

$$\Rightarrow t = \frac{3\pi}{6} = \frac{\pi}{2}$$

$$\therefore x = 2$$

23. Correct answer is 8.

Given that $a_t = a_c$

Now, $$a_t = a_c = \frac{v^2}{R} = \frac{v^2}{0.5} = 2v^2$$

$$\Rightarrow a_t = a_c = 2v^2$$

$$\Rightarrow \frac{dv}{dt} = 2v^2$$

$$\Rightarrow \frac{dv}{v^2} = 2dt$$

Taking integration both sides

When $t = 0 \quad v = 4$ m/s

& $t = t \quad v = v$

$$\Rightarrow \int_4^v \frac{dv}{v^2} = \int_0^t 2dt$$

$$\Rightarrow \left[-\frac{1}{v}\right]_4^v = 2[t]_0^t$$

$$\Rightarrow -\frac{1}{v} + \frac{1}{4} = 2t$$

$$\Rightarrow \frac{1}{v} = 0.25 - 2t$$

$$\Rightarrow v = \frac{1}{0.25 - 2t}$$

$$\Rightarrow \frac{ds}{dt} = \frac{1}{0.25 - 2t}$$

$$\Rightarrow \int_0^{2\pi R} ds = \int_0^T \left(\frac{1}{0.25 - 2t}\right) dt$$

$$\Rightarrow 2\pi R = \frac{1}{2} ln \frac{0.25}{0.25 - 2t}$$

$$\Rightarrow 2\pi = ln \frac{0.25}{0.25 - 2t}$$

$$\Rightarrow \frac{0.25}{0.25 - 2t} = e^{2\pi}$$

$$\Rightarrow t = \frac{1}{8}(1 - e^{2\pi})$$

$$\therefore \alpha = 8$$

24. Correct answer is [36].

In the steady state, 6Ω and 3Ω are in series.

Therefore,

$$V_{6\Omega} = V_{6\mu F} = 6\text{V}$$

Now, $$Q = CV$$

$$= 6 \times 6 = 36 \ \mu\text{C}$$

25. Correct answer is [16].

According to question,

$$\Delta l_1 = \Delta l_2 = \Delta l$$

$$\Rightarrow \frac{F_1 l_1}{A_1 Y} = \frac{F_2 l_2}{A_2 Y}$$

$$\frac{F_1 l_1}{A_1} = \frac{F_2 l_2}{A_2}$$

$$\Rightarrow \frac{F_1}{F_2} = \frac{l_2}{A_2} \times \frac{A_1}{\mu} \quad \text{...(i)}$$

As volume of wires are some

$$A_1 l_1 = A_2 l_2$$

and $$\frac{A_1}{A_2} = \frac{4}{1}$$

and $\frac{A_1}{A_2} = \frac{l_2}{l_1} = \frac{4}{1}$

Putting values in (i)

$$\frac{F_1}{F_2} = \frac{A_1}{A_2} \times \frac{l_2}{l_1} = \frac{4}{1} \times \frac{4}{1}$$

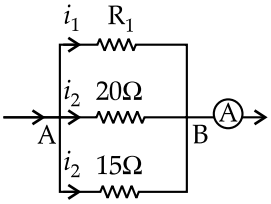
$$\Rightarrow \quad \frac{F_1}{F_2} = \frac{16}{1}$$

$$\Rightarrow \quad \frac{F_1}{F_2} = 16$$

26. Correct answer is [30].

As all the resistors are in parallel, the potential difference across each will be same

Now, V across 20Ω



$V = i_2 \times 20$

$V = 0.3 \times 20 = 6\text{V}$

$$i_3 = \frac{V}{R_3} = \frac{6}{15} = 0.4\text{ A}$$

From KCL

$$i = i_1 + i_2 + i_3$$

$$i_1 = 0.9 - 0.4 - 0.3 = 0.2\text{ A}$$

$$\therefore \quad V = i_1 R_1$$

$$\Rightarrow \quad R_1 = \frac{V}{i_1} = \frac{6}{0.2} = 30\ \Omega$$

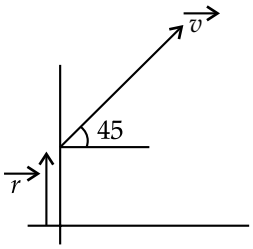
27. Correct answer is [60].

Given that

$$m = 5\text{ kg}$$

$$v = 3\sqrt{2}\text{ m/s}$$

splitting $\vec{v}$ along horizontal direction



$$\overrightarrow{v_x} = \vec{v}_{\cos\theta}$$

$$= 3\sqrt{2} \times \cos 45$$

$$= 3\sqrt{2} \times \frac{1}{\sqrt{2}} = 3\text{ m/s}$$

Now, angular momentum (L) = mvr

$$\Rightarrow \quad L = 5 \times 3 \times 4 \qquad (\because x = 0, y = 4)$$

$$= 60\text{ kg m}^2\text{s}^{-1}$$

28. Correct answer is [32].

Force acting on charge particle moving in a uniform magnetic field is given by

$$\vec{F} = q(\vec{v} \times \vec{B})$$

or $|\vec{F}| = qvB\sin\theta$

putting the values,

$$|\vec{F}| = 4 \times 10^{-6} \times 4 \times 10^6 \times 2$$

$$= 32\text{ N}$$

29. Correct answer is [3].

We know that, when a rod of length l moves perpendicular to magnetic field B, with a velocity V, then induced emf produced in it is given by $e = BVl$

putting the values,

$$e = 0.60 \times 10^{-4} \times 10 \times 5$$

$$= 3 \times 10^{-3}\text{ V}$$

30. Correct answer is [121].

$$\text{E} = -\frac{13.6}{n^2}$$

At absolute zero temperature, the electron is in ground state.

$$\therefore \quad \Delta E = E_3 - E_1$$

$$= 13.6\left(1 - \frac{1}{3^2}\right) = 13.6\left(\frac{8}{9}\right)$$

$$= 12.1\text{ eV} = \frac{121}{10}\text{eV}$$

$$\therefore \quad \alpha = 121$$

❐❐❐