JEE (Main) PHYSICS SOLVED PAPER

2023
06th April Shift 1

General Instructions:

(i) *There are 30 questions in this section.*
(ii) *Section A consists of 20 Multiple choice questions and Section B consists of 10 Numerical value type questions. In Section B, candidates have to attempt any five questions out of 10.*
(iii) *There will be only one correct choice in the given four choices in Section A. For each question for Section A, 4 marks will be awarded for correct choice, 1 mark will be deducted for incorrect choice questions and zero mark will be awarded for not attempted questions.*
(iv) *For Section B questions, 4 marks will be awarded for correct answer and zero for unattempted and incorrect answer.*
(v) *Any textual, printed or written material, mobile phones, calculator etc. is not allowed for the students appearing for the test.*
(vi) *All calculations/ written work should be done in the rough sheet which is provided with Question Paper.*

Section A

Q. 1. The kinetic energy of an electron, α -particle and a proton are given as 4K, 2K and K respectively. The de-Broglie wavelength associated with electron (λ_e) , α-particle (λ_α) and the proton (λ_p) are as follows:

(1) $\lambda_\alpha > \lambda_p > \lambda_e$ **(2)** $\lambda_\alpha = \lambda_p > \lambda_e$
(3) $\lambda_\alpha = \lambda_p < \lambda_e$ **(4)** $\lambda_\alpha < \lambda_p < \lambda_e$

Q. 2. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: Earth has atmosphere whereas moon doesn't have any atmosphere.

Reason R: The escape velocity on moon is very small as compared to that on earth.

In the light of the above statements. choose the correct answer from the options given below:

(1) Both A and R are correct and R is the correct explanation of A
(2) A is false but R is true
(3) Both A and R are correct but R is NOT the correct explanation of A
(4) A is true but R is false

Q. 3. A source supplies heat to a system at the rate of 1000 W. If the system performs work at a rate of 200 W. The rate at which internal energy of the system increases is:

(1) 500 W **(2)** 600 W **(3)** 800 W **(4)** 1200 W

Q. 4. A small ball of mass M and density ρ is dropped in a viscous liquid of density ρ_o. After some time, the ball falls with a constant velocity. What is the viscous force on the ball?

(1) $F = Mg\left(1+\frac{\rho_o}{\rho}\right)$ **(2)** $F = Mg\left(1+\frac{\rho}{\rho_o}\right)$

(3) $F = Mg\left(1-\frac{\rho_o}{\rho}\right)$ **(4)** $F = Mg(1 \pm \rho\rho_o)$

Q. 5. A small block of mass 100 g is tied to a spring of spring constant 7.5 N m^{-1} and length 20 cm. The other end of spring is fixed at a particular point A. If the block moves in a circular path on a smooth horizontal surface with constant angular velocity 5 rad/s about point A, then tension in the spring is:

(1) 0.75 N **(2)** 1.5 N **(3)** 0.25 N **(4)** 0.50 N

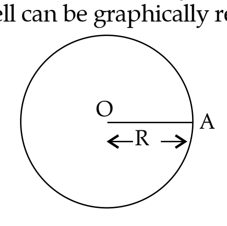
Q. 6. A particle is moving with constant speed in a circular path. When the particle turns by an angle 90° , the ratio of instantaneous velocity to its average velocity is $\pi : x\sqrt{2}$. The value of x will be:

(1) 7 **(2)** 2 **(3)** 1 **(4)** 5

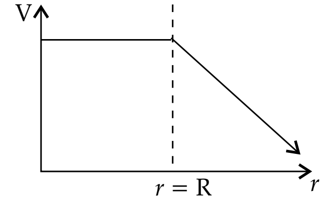
Q. 7. Two resistances are given as $R_1 = (10 \pm 0.5)\ \Omega$ and $R_2 = (15 \pm 0.5)\ \Omega$. The percentage error in the measurement of equivalent resistance when they are connected in parallel is:

(1) 2.33 **(2)** 4.33 **(3)** 5.33 **(4)** 6.33

Q. 8. For a uniformly charged thin spherical shell, the electric potential (V) radially away from the centre (O) of shell can be graphically represented as:



(1)



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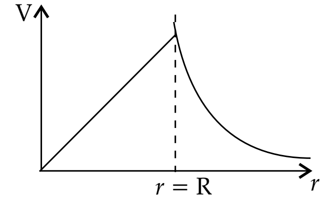
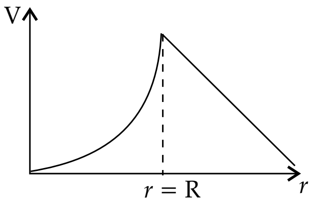
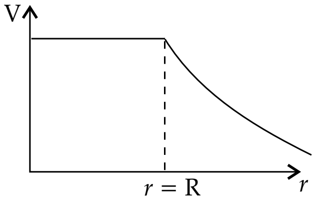


(3) 

(4) 

Q. 9. A long straight wire of circular cross-section (radius a) is carrying steady current I. The current I is uniformly distributed across this cross-section. The magnetic field is:

(1) zero in the region $r < a$ and inversely proportional to r in the region $r > a$
(2) inversely proportional to r in the region $r < a$ and uniform throughout in the region $r > a$
(3) directly proportional to r in the region $r < a$ and inversely proportional to r in the region $r > a$
(4) uniform in the region $r < a$ and inversely proportional to distance r from the axis, in the region $r > a$

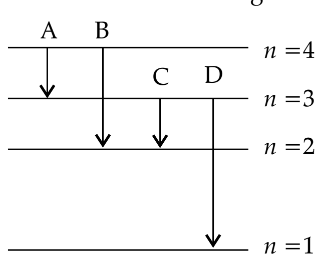
Q. 10. By what percentage will the transmission range of a TV tower be affected when the height of the tower is increased by 21% ?

(1) 12% **(2)** 15% **(3)** 14% **(4)** 10%

Q. 11. The number of air molecules per cm^3 increased from 3×10^{19} to 12×10^{19}. The ratio of collision frequency of air molecules before and after the increase in the number respectively is:

(1) 0.25 **(2)** 0.75 **(3)** 1.25 **(4)** 0.50

Q. 12. The energy levels of an hydrogen atom are shown below. The transition corresponding to emission of shortest wavelength is:



(1) A **(2)** D **(3)** C **(4)** B

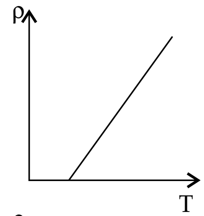
Q. 13. For the plane electromagnetic wave given by $E = E_o \sin(\omega t - kx)$ and $B = B_o \sin(\omega t - kx)$, the ratio of average electric energy density to average magnetic energy density is:

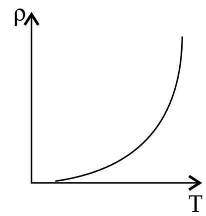
(1) 2 **(2)** $\frac{1}{2}$ **(3)** 1 **(4)** 4

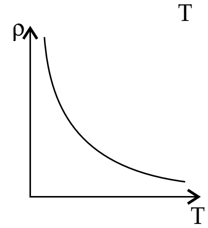
Q. 14. A planet has double the mass of the earth. Its average density is equal to that of the earth. An object weighing W on earth will weigh on that planet:

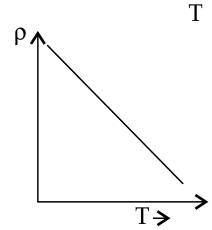
(1) $2^{1/3}$W **(2)** 2W **(3)** W **(4)** $2^{2/3}$W

Q. 15. The resistivity (ρ) of semiconductor varies with temperature. Which of the following curve represents the correct behavior?

(1) 

(2) 

(3) 

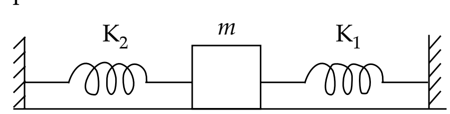
(4) 

Q. 16. A monochromatic light wave with wavelength λ_1 and frequency ν_1 in air enters another medium. If the angle of incidence and angle of refraction at the interface are 45° and 30° respectively, then the wavelength λ_2 and frequency ν_2 of the refracted wave are:

(1) $\lambda_2 = \frac{1}{\sqrt{2}}\lambda_1, \nu_2 = \nu_1$ **(2)** $\lambda_2 = \lambda_1, \nu_2 = \frac{1}{\sqrt{2}}\nu_1$

(3) $\lambda_2 = \lambda_1, \nu_2 = \sqrt{2}\nu_1$ **(4)** $\lambda_2 = \sqrt{2}\lambda_1, \nu_2 = \nu_1$

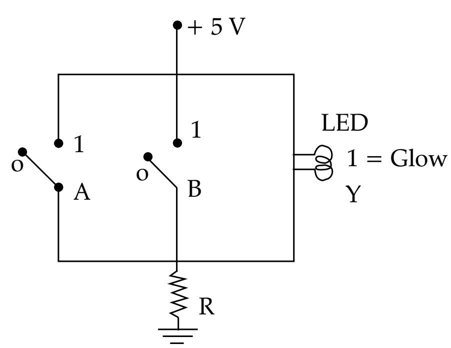
Q. 17. A mass m is attached to two strings as shown in figure. The spring constants of two springs are K_1 and K_2. For the frictionless surface, the time period of oscillation of mass m is:



(1) $2\pi\sqrt{\frac{m}{K_1 - K_2}}$ **(2)** $\frac{1}{2\pi}\sqrt{\frac{K_1 - K_2}{m}}$

(3) $\frac{1}{2\pi}\sqrt{\frac{K_1 + K_2}{m}}$ **(4)** $2\pi\sqrt{\frac{m}{K_1 + K_2}}$

Q. 18. Name the logic gate equivalent to the diagram attached



(1) NOR **(2)** OR
(3) NAND **(4)** AND

Q. 19. The induced emf can be produced in a coil by
A. moving the coil with uniform speed inside uniform magnetic field
B. moving the coil with non uniform speed inside uniform magnetic field
C. rotating the coil inside the uniform magnetic field
D. changing the area of the coil inside the uniform magnetic field

Choose the correct answer from the options given below :

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

Q. 20. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: When a body is projected at an angle 45°, its range is maximum.

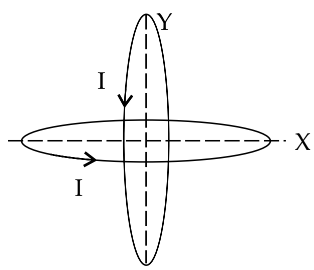
Reason R: For maximum range, the value of sin 2θ should be equal to one.

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

(1) Both A and R are correct but R is NOT the correct explanation of A
(2) A is false but R is true
(3) Both A and R are correct and R is the correct explanation of A
(4) A is true but R is false

Section B

Q. 21. Two identical circular wires of radius 20 cm and carrying current $\sqrt{2}$ A are placed in perpendicular planes as shown in figure. The net magnetic field at the centre of the circular wires is _________ $\times 10^{-8}$ T. (Take π = 3.14)



Q. 22. A steel rod has a radius of 20 mm and a length of 2.0 m. A force of 62.8 kN stretches it along its length. Young's modulus of steel is 2.0×10^{11} N m^{-2}. The longitudinal strain produced in the wire is _______ $\times 10^{-5}$.

Q. 23. The length of a metallic wire is increased by 20% and its area of cross section is reduced by 4%. The percentage change in resistance of the metallic wire is ______.

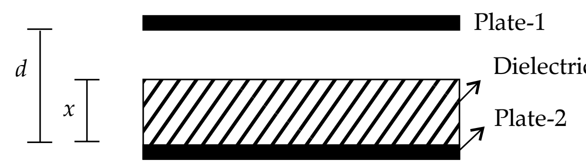
Q. 24. The radius of fifth orbit of the Li^{++} is __________ $\times 10^{-12}$m.

(Take: Radius of hydrogen atom = 0.51 Å)

Q. 25. A particle of mass 10 g moves in a straight line with retardation $2x$, where x is the displacement in SI units. Its loss of kinetic energy for above displacement is $\left(\frac{10}{x}\right)^{-n}$ J. The value of n will be ____________.

Q. 26. An ideal transformer with purely resistive load operates at 12 kV on the primary side. It supplies electrical energy to a number of nearby houses at 120 V. The average rate of energy consumption in the houses served by the transformer is 60 kW. The value of resistive load (R_s) required in the secondary circuit will be ________ mΩ .

Q. 27. A parallel plate capacitor with plate area A and plate separation d is filed with a dielectric material of dielectric constant K = 4. The thickness of the dielectric material is x, where $x < d$.



Let C_1 and C_2 be the capacitance of the system for $x = \frac{1}{3}d$ and $x = \frac{2d}{3}$, respectively. If C_1 = 2μF the value of C_2 is __________ μF.

Q. 28. Two identical solid spheres each of mass 2 kg and radii 10 cm are fixed at the ends of a light rod. The separation between the centres of the spheres is 40 cm. The moment of inertia of the system about an axis perpendicular to the rod passing through its middle point is __________ $\times 10^{-3}$ kg m^2

Q. 29. A person driving car at a constant speed of 15 m s^{-1} is approaching a vertical wall. The person notices a change of 40 Hz in the frequency of his car's horn upon reflection from the wall. The frequency of horn is ______ Hz.

Q. 30. A pole is vertically submerged in swimming pool, such that it gives a length of shadow 2.15 m within water when sunlight is incident at an angle of 30° with the surface of water. If swimming pool is filled to a height of 1.5 m, then the height of the pole above the water surface in centimeters is (n_w = 4/3) ____________.

Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	(4)	de-Broglie Wavelength	Photoelectric Effect
2	(1)	Escape Velocity	Gravitation
3	(3)	First Law of Thermodynamcis	Thermodynamics
4	(3)	Viscous Force	Fluid Mechanics

5	**(1)**	Spring	Laws of Motion
6	**(2)**	Instantaneous Velocity	Motion in 2D
7	**(2)**	Errors in Measurements	Units and Measurements
8	**(4)**	Electric Potential of Shell	Electric Potential and Capacitance
9	**(3)**	Magnetic Field due to current carrying wire	Magnetic Effect of Current
10	**(4)**	Transmission Range	Communication System
11	**(1)**	Collision Frequency	Kinetic Theory of Gases
12	**(2)**	Hydrogen Spectrum	Atoms
13	**(3)**	Energy Density	EM waves
14	**(1)**	Gravitational Acceleration	Gravitation
15	**(3)**	Energy Band	Semiconductor Electronics
16	**(1)**	Refraction of Light	Ray Optics
17	**(4)**	Parallel Spring	Oscillations
18	**(1)**	Logic Gates	Semiconductor Electronics
19	**(2)**	Faraday's Law	Electromagnetic Induction
20	**(3)**	Projectile Motion	Motion in 2D
21	**[628]**	Magnetic field due to loop of wire	Magnetic Effect of Current
22	**[25]**	Strain	Bulk Property of Matter
23	**[25]**	Resistivity and Resistance	Current Electricity
24	**[425]**	Radius of Atoms	Atoms
25	**[2]**	Work Energy Theorem	Work, Energy and Power
26	**[240]**	Transformers	AC Current
27	**[3]**	Dielectric	Electric Potential and Capacitance
28	**[176]**	Moment of Inertia	System of Particles and Rotational Motion
29	**[420]**	Doppler's Effect	Sound Waves
30	**[50]**	Snell's Law	Ray optics

SOLUTIONS

Section A

1. Option (4) is correct.

$$\lambda = \frac{h}{\sqrt{2mK}}$$

Here,

$$m_e = \frac{m}{1840}, \text{K.E}_e = 4K$$

$$m_\alpha = 4m, \text{K.E}_\alpha = 2K$$

$$m_p = m, \text{K.E}_p = K$$

Now,

$$\lambda_e = \frac{h}{\sqrt{2 \times \frac{m}{1840} \times 4K}}$$

$$\lambda_\alpha = \frac{h}{\sqrt{2 \times 4m \times 2K}}$$

$$\lambda_p = \frac{h}{\sqrt{2mK}}$$

Therefore, $\lambda_\alpha < \lambda_p < \lambda_e$

2. Option (1) is correct.

A is correct as there is no atmosphere at moon

R is also correct as the escape velocity of moon is much smaller than earth.

$$V_e = \sqrt{2gr}$$

$$g_{earth} > g_{moon}$$

$$r_{earth} > r_{moon}$$

$$V_{e(earth)} > V_{e(moon)}$$

3. Option (3) is correct.

From Ist law of thermodynamics

$$dQ = dU + dW$$

$$\Rightarrow \quad dU = dQ - dW$$

$$\Rightarrow \quad \frac{dU}{dt} = \frac{dQ}{dt} - \frac{dW}{dt}$$

$$\Rightarrow \quad \frac{dU}{dt} = 1000 - 200 = 800\,W$$

4. Option (3) is correct.

When $F_{net} = 0$ then υ = constant

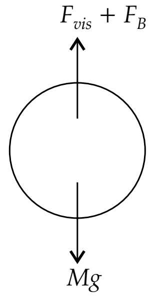
$$F_{vis} + F_B = Mg$$

$$\Rightarrow \quad F_{vis} + \rho_o Vg = \rho Vg$$

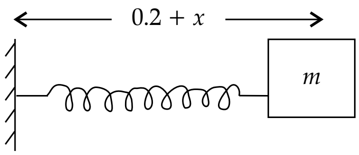
$$\Rightarrow \quad F_{vis} = (\rho - \rho_0)Vg$$

$$= \rho Vg\left(1 - \frac{\rho_o}{\rho}\right)$$

$$= Mg\left(1 - \frac{\rho_o}{\rho}\right)$$



5. Option (1) is correct.



Force acting towards the centre of circular path is spring force

$$F_S = kx$$

and force acting away from the centre of the circular path is given by $= mr\omega^2$

Now, $kx = mr\omega^2$

where $r = (0.2 + x)$

So, $kx = m\omega^2(0.2 + x)$

$$\Rightarrow \quad 7.5 \times x = 0.1 \times (5)^2 (0.2 + x)$$

$$\Rightarrow \quad \frac{15}{2}x = \frac{5}{2}\left(x + \frac{1}{5}\right)$$

$$\Rightarrow \quad x = \frac{1}{10} = 0.1$$

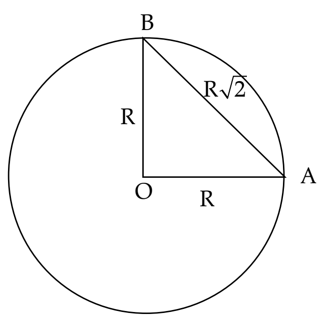
Now tension in the spring

$$T = kx = 7.5 \times 0.1 = 0.75 \text{ N}$$

6. Option (2) is correct.

Instantaneous velocity

$$v = \frac{\text{arc length}}{\text{time}}$$



$$\Rightarrow \quad v = \frac{\frac{\pi R}{2}}{t}$$

$$\Rightarrow \quad t = \frac{\pi R}{2v}$$

Now the average velocity

$$<v> = \frac{R\sqrt{2}}{t} = \frac{R\sqrt{2} \times 2v}{\pi R} = \frac{2\sqrt{2}v}{\pi}$$

Therefore,

$$\frac{v}{<v>} = \frac{v \times \pi}{2\sqrt{2}v} = \frac{\pi}{2\sqrt{2}}$$

So $x = 2$

7. Option (2) is correct.

Given, $R_1 = (10 \pm 0.5)\ \Omega$

$R_2 = (15 \pm 0.5)\ \Omega$

In parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \quad \text{...(i)}$$

$$\Rightarrow \quad \frac{1}{R} = \frac{1}{10} + \frac{1}{15}$$

$$\Rightarrow \quad R = \frac{10 \times 15}{10 + 15} = 6\ \Omega$$

Differentiating equation (i),

$$\frac{\Delta R}{R^2} = \frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}$$

$$\Rightarrow \quad \frac{\Delta R}{R} = \left(\frac{\Delta R_1}{R_1^2} + \frac{\Delta R_2}{R_2^2}\right)R$$

$$\Rightarrow \quad \frac{\Delta R}{R} = \left(\frac{0.5}{100} + \frac{0.5}{225}\right) \times 6$$

$$\Rightarrow \quad \frac{\Delta R}{R} = \frac{13}{300}$$

Now, $\frac{\Delta R}{R} \times 100 = \frac{13}{300} \times 100 = 4.33\%$

8. Option (4) is correct.

For a charged spherical shell, the potential inside the shell is given by, $V = \frac{KQ}{R}$, which is constant inside the shell.

And potential due to charged spherical shell at a point outside the shell is given by,

$$V = \frac{KQ}{r}$$

i.e. $V \propto \frac{1}{r}$

It means potential decreases with increase in distance outside the given shell.

Therefore graph (4) represent the correct relation of distance and potential.

9. Option (3) is correct.

Magnetic field due to long straight wire of circular cross-section of radius 'a' is carrying steady current I is given by

$$B = \frac{\mu_o Ir}{\pi a^2}, r \le a$$

$$B = \frac{\mu_o I}{\pi r^2}, r \ge a$$

10. Option (4) is correct.

Range is given by, $\sqrt{2Rh}$

Initial range, $R_1 = \sqrt{2Rh_1}$

Since height is increased by 21%

$\therefore \quad h_2 = 1.21h_1$

Now, the new range

$$R_2 = \sqrt{2Rh_2} = \sqrt{2R \times 1.21h_1}$$

$$\Rightarrow \quad R_2 = 1.1\sqrt{2Rh_1}$$

$$\Rightarrow \quad R_2 = 1.1\ R_1$$

Therefore, % increase in range

$$\frac{R_2 - R_1}{R_2} \times 100 = \left(\frac{R_2}{R_1} - 1\right) \times 100$$

$$= (1.1 - 1) \times 100$$
$$= 0.1 \times 100 = 10\%$$

11. Option (1) is correct.

$$v = f\lambda$$

$\Rightarrow$ $$f = \frac{v}{\lambda} = \sqrt{2}\pi d^2 n_v v$$

$\therefore$ $$\frac{f_1}{f_2} = \frac{n_{v_1}}{n_{v_2}} = \frac{3 \times 10^{19}}{12 \times 10^{19}} = 0.25 \qquad (\because f \propto n_v)$$

12. Option (2) is correct.

We know that, $E = \dfrac{hc}{\lambda}$

$\therefore$ $\lambda \propto \dfrac{1}{E}$

For minimum wavelength, energy must be maximum which is possible from transition $n = 3$ to $n = 1$.

13. Option (3) is correct.

Electric energy density $= \dfrac{1}{2}\varepsilon_0 E_{rms}^2$

Magnetic energy density $= \left(\dfrac{B_{rms}^2}{2\mu_0}\right)$

Now,

$$\frac{\text{Electric energy density}}{\text{Magnetic energy density}} = \frac{\frac{1}{2}\varepsilon_0 E_{rms}^2}{\frac{B_{rms}^2}{2\mu_0}}$$

$$= \frac{E_{rms}^2}{B_{rms}^2} \times \varepsilon_0\mu_0 = \left(\frac{E_{rms}}{B_{rms}}\right)^2 \times \varepsilon_0\mu_0$$

$$= \frac{C^2}{C^2} = 1 \qquad \left(\because C^2 = \frac{1}{\mu_0\varepsilon_0} \ \& \ \frac{E}{B} = C\right)$$

14. Option (1) is correct.

Weight of object on earth $= W = mg = \dfrac{GMm}{R^2}$

$$M = \rho \times \frac{4}{3}\pi R^3$$

$\Rightarrow$ $$\rho = \frac{3m}{4\pi R^3} \qquad \text{...(i)}$$

Now the mass of planet,

$$M_1 = 2M = \rho \times \frac{4}{3}\pi R^3$$

$$\rho = \frac{6M}{4\pi R'^3} \qquad \text{...(ii)}$$

from (i) & (ii),

$$\frac{3M}{4\pi R^3} = \frac{6M}{4\pi R'^3}$$

$\Rightarrow$ $$\frac{1}{R^3} = \frac{2}{R'^3}$$

$\Rightarrow$ $$R'^3 = 2R^3$$

$\Rightarrow$ $$R' = (2)^{1/3}R$$

Now,

$$g' = \frac{G2M}{R'2} = \frac{2 \times GM}{(2)^{2/3}R^2}$$

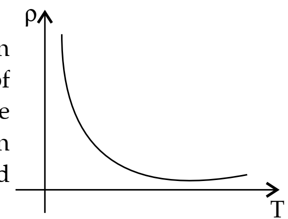
$\Rightarrow$ $$g' = 2^{1-2/3} \times g$$

$\Rightarrow$ $$g' = 2^{1/3}g$$

$\Rightarrow$ $$mg' = 2^{1/3} \times mg$$

$\Rightarrow$ $$W' = 2^{1/3}W$$

15. Option (3) is correct.



With increase in temperature of semiconductor the number density of electron and holes increases and resistivity decreases.

Mathematically,

$$\rho = \frac{m}{ne^2\tau}$$

As, $n \propto T$

So, $\rho \propto \dfrac{1}{n} \propto \dfrac{1}{T}$

16. Option (1) is correct.

We know that, when light enters from one medium to another medium, frequency remains the same.

Therefore, $\nu_1 = \nu_2$

Now, applying Snell's law at interface

$$\mu_1 \sin i = \mu_2 \sin r$$

$\Rightarrow$ $$1 \sin 45° = \mu_2 \sin 30°$$

$\Rightarrow$ $$\frac{1}{\sqrt{2}} = \mu_2 \times \frac{1}{2}$$

$\Rightarrow$ $$\mu_2 = \sqrt{2}$$

Now, $$\frac{\mu_1}{\mu_2} = \frac{\lambda_2}{\lambda_1}$$

$\Rightarrow$ $$\frac{1}{\sqrt{2}} = \frac{\lambda_2}{\lambda_1}$$

$\Rightarrow$ $$\lambda_2 = \frac{\lambda_1}{\sqrt{2}}$$

17. Option (4) is correct.

As the springs are in parallel

Then, $F = -(K_{eq})\,x$

$\Rightarrow$ $F = -(K_1 + K_2)x$

Now, $$a = \frac{F}{m} = -\frac{(K_1 + K_2)x}{m}$$

and, $$a = -\omega^2 x = -\frac{(K_1 + K_2)x}{m}$$

Therefore, $$\omega = \sqrt{\frac{K_1 + K_2}{m}}$$

$\therefore$ $$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{K_1 + K_2}}$$

18. Option (1) is correct.

From the given circuit,

when switch A is closed $\Rightarrow$ LED will not glow

when switch B is closed $\Rightarrow$ LED will not glow
when both A & B are closed $\Rightarrow$ LED will not glow
when both A & B are open $\Rightarrow$ LED will glow
Hence it is a "NOR" gate.

19. Option (2) is correct.

$$\varepsilon = \frac{d\theta}{dt}$$

The emf can be induced by changing the flux.

Now, $\phi = \vec{B}.d\vec{A}$

And flux depends upon area and magnetic field.
Hence by changing the area the emf can be produced.
By rotating the coil, flux can be changed and hence emf can be induced.

20. Option (3) is correct.

Range of projectile is given by,

$$R = \frac{2u^2 \sin\theta\cos\theta}{g}$$

$$R = \frac{u^2 \sin 2\theta}{g}$$

$$R \propto \sin 2\theta$$

For maximum value of range sin 2θ should be maximum & maximum value of sin 2θ = sin 90° = 1

$\Rightarrow$ $2\theta = 90°$

$\Rightarrow$ $\theta = 45°$

Section B

21. The correct answer is (628).

The magnetic field due to horizontal circular current carrying loop is given by $\frac{\mu_o i}{2r}$ along y-axis. And due to verticle loop is along x-axis having same magnitude.

$$\vec{B}_x = \frac{\mu_o i}{2r}$$

$$\vec{B}_y = \frac{\mu_o i}{2r}$$

$$\vec{B} = \vec{B}_x + \vec{B}_y$$

$$|\vec{B}| = \sqrt{(B_x)^2 + (B_y)^2}$$

$$\Rightarrow \quad B_{net} = \sqrt{\left(\frac{\mu_o i}{2r}\right)^2 + \left(\frac{\mu_o i}{2r}\right)^2}$$

$$\Rightarrow \quad B_{net} = \frac{\mu_o i}{2r} \times \sqrt{2}$$

$$\Rightarrow \quad B_{net} = \frac{4\pi \times 10^{-7} \times \sqrt{2} \times \sqrt{2}}{2 \times 0.2}$$

$20 \times 3.14 \times 10^{-7} = 628 \times 10^{-8}$ T

22. The correct answer is (25).

Given, $r = 20 \times 10^{-3}$

$l = 2$ m

$F = 62.8 \times 10^3$ N

$Y = 2.0 \times 10^{11}$ N m^{-2}

Now from Hook's law

$$\sigma = YE$$

$$\Rightarrow \quad \frac{F}{A} = YE$$

$$\Rightarrow \quad \frac{62.8 \times 10^3}{\pi(20 \times 10^{-3})^2} = 2 \times 10^{11} \times E$$

$$\Rightarrow \quad \frac{62.8 \times 10^3}{3.14 \times 400 \times 10^{-6}} = 2 \times 10^{11} \times E$$

$$\Rightarrow \quad \frac{62.8 \times 10^3}{3.14 \times 400 \times 10^{-6} \times 2 \times 10^{11}} = E$$

$$\Rightarrow \quad E = 25 \times 10^{-5}$$

23. The correct answer is (25).

Let, R_1 be the initial resistance
R_2 be the final resistance.

Now, $R_1 = \rho\frac{l}{A}$

$$R_2 = \rho\frac{1.2l}{0.96A} = \rho\frac{l}{A} \times \frac{1.2}{0.96}$$

$$R_2 = \rho\frac{l}{A} \times 1.25$$

So, The percentage change

$$\Delta R\% = \frac{R_2 - R_1}{R_1} \times 100 = \frac{\left(\rho\frac{l}{2} \times 1.25 - \rho\frac{l}{A}\right)}{\rho\frac{l}{A}} \times 100$$

$= (1.25 - 1) \times 100 = 0.25 \times 100 = 25\%$

24. The correct answer is (425).

For hydrogen like ion with z protons in the nucleus

$$r_n = \frac{n^2 a_0}{z}$$

For $n = 5$

$$r_5 = \frac{(5)^2 \times 0.51 \times 10^{-10}}{3}$$

$\Rightarrow$ $r_5 = 4.25 \times 10^{-10}$ m

$= 425 \times 10^{-12}$ m

25. The correct answer is (2).

Given, $m = 10^{-2}$ kg

$a = -2x$

From work energy theorem,

Change in K.E. = work done by retarding force

$$= \int F.dx = \int_0^x mx(2x)dx = mx^2$$

Now, $$mx^2 = \left(\frac{10}{x}\right)^{-n}$$

$$10^{-2} \times x^2 = \left(\frac{10}{x}\right)^{-n}$$

$$\left(\frac{10}{x}\right)^{-2} = \left(\frac{10}{x}\right)^{-n}$$

$\therefore$ $n = 2$

26. The correct answer is (240).

Given, $V_P = 12 \times 10^3$ V

$V_S = 120$ V

$P_S = 60 \times 10^3$ W

Now, $P = Vi$

$\Rightarrow P_S = V_S i_S$

$\Rightarrow 60 \times 10^3 = 120 \times i_S$

$$\Rightarrow \quad i_S = \frac{60 \times 10^3}{120} = 500\,\text{A}$$

So, $V_S = i_S R_L$

$$R_L = \frac{V_S}{i_S} = \frac{120}{500} = 240 \times 10^{-3}\,\Omega$$

$$= 240\text{ m}\Omega$$

27. The correct answer is (3).

Given, $C_1 = 2\mu\text{F}$ and $K = 4$

$$\Rightarrow \quad C_1 = \frac{\varepsilon_0 A}{\left(\frac{\frac{d}{3}}{K} + \frac{2d}{3}\right)} = \frac{\varepsilon_0 A}{\left(\frac{d}{3 \times 4} + \frac{2d}{3}\right)}$$

$$\Rightarrow \quad 2\mu F = \frac{\varepsilon_0 A \times 12}{9d} = \frac{4}{3}\frac{\varepsilon_0 A}{d}$$

$$\Rightarrow \quad 2\mu F = \frac{4}{3}\frac{\varepsilon_0 A}{d} \qquad \left(\text{for } x = \frac{1}{3}d\right)$$

$$\Rightarrow \quad \frac{\varepsilon_0 A}{d} = \frac{3}{2}\mu\text{F}$$

Now,
$$C_2 = \frac{\varepsilon_0 A}{\left(\frac{\frac{2d}{3}}{K} + \frac{d}{3}\right)} \qquad \left(\text{for } x = \frac{2d}{3}\right)$$

$$\Rightarrow \quad C_2 = \frac{\varepsilon_0 A}{\left(\frac{2d}{12} + \frac{d}{3}\right)}$$

$$\Rightarrow \quad C_2 = \frac{\varepsilon_0 A}{\left(\frac{2d}{12} + \frac{d}{3}\right)}$$

$$\Rightarrow \quad C_2 = \frac{12\varepsilon_0 A}{2d + 4d} = \frac{2\varepsilon_0 A}{d} = \frac{3}{2} \times 2$$

$$= 3\ \mu\text{F}$$

28. The correct answer is (176).

$$r_1 = r_2 = r = 10\text{ cm} = 0.1\text{ m}$$

$$m_1 = m_2 = m = 2\text{ kg}$$

From parallel axis theorem

$$I = I_{cm} + md^2$$

Total moment of inertia

$$I = 2(I_{cm} + md^2)$$

$$\Rightarrow \quad I = 2\left(\frac{2}{5}mr^2 + md^2\right)$$

$$\left(\because I_{\text{sphere}} = \frac{2}{5}mr^2\right)$$

Putting the values

$$I = \frac{4}{5} \times 2 \times (0.1)^2 + 2 \times (2) \times (0.20)^2$$

$$= \frac{8}{5} \times 10^{-2} + 16 \times 10^{-2}$$

$$= 17.6 \times 10^{-2}$$

$$\Rightarrow \quad I = 176 \times 10^{-3}\text{ kg m}^2$$

29. The correct answer is (420).

Given, $V_0 = 15\text{ m s}^{-1}$

$f - f_0 = 40\text{ Hz}$

Now,
$$f = \left(\frac{V + V_0}{V - V_0}\right) f_0$$

$$\Rightarrow \quad f = \left(\frac{330 + 15}{330 - 15}\right) f_0$$

$$\Rightarrow \quad f = \frac{345}{315} f_0$$

According to the question,

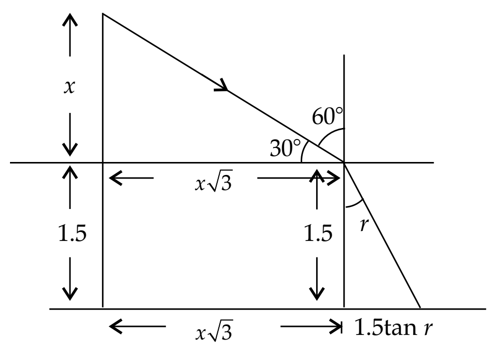
$$f - f_0 = \frac{345}{315} f_0 - f_0$$

$$\Rightarrow \quad 40\text{Hz} = f_0\left(\frac{345 - 315}{315}\right)$$

$$\Rightarrow \quad 40\text{Hz} = f_0\left(\frac{30}{315}\right)$$

$$\Rightarrow \quad f_0 = \frac{40 \times 315}{30} = 420\text{ Hz}$$

30. The correct answer is (50).



Applying Snell's law,

$$\mu_1 \sin i = \mu_2 \sin r$$

$$\Rightarrow \quad 1 \sin 60 = \frac{4}{3} \times \sin r$$

$$\Rightarrow \quad \frac{\sqrt{3}}{2} = \frac{4}{3} \times \sin r$$

$$\Rightarrow \quad \sin r = \frac{3\sqrt{3}}{8}$$

If angle r is small then

$$\sin r = \tan r = \frac{3\sqrt{3}}{8}$$

Given, the length of shadow is 2.15 m

$$\therefore \quad x\sqrt{3} + 1.5 \tan r = 2.15$$

$$\Rightarrow \quad x\sqrt{3} + 1.5 \times \frac{3\sqrt{3}}{8} = 2.15$$

$$\Rightarrow \quad x = \frac{8 \times 2.15 - 4.5\sqrt{3}}{8\sqrt{3}}$$

$$\Rightarrow \quad x \approx 0.5\text{ m}$$

$$= 50\text{ cm}$$