JEE (Main) PHYSICS SOLVED PAPER

2021
20th July Shift 1

Time : 1 Hour **Total Marks : 100**

General Instructions :

1. *In Chemistry Section, there are 30 Questions (Q. no. 1 to 30).*
2. *In Chemistry, Section A consists of 20 multiple choice questions & Section B consists of 10 numerical value type questions. In Section B, candidates have to attempt any five questions out of 10.*
3. *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 question.*
4. *For Section B questions, 4 marks will be awarded for correct answer and zero for unattempted and incorrect answer.*
5. *Any textual, printed or written material, mobile phones, calculator etc. is not allowed for the students appearing for the test.*
6. *All calculations / written work should be done in the rough sheet is provided with Question Paper.*

Physics

Section A

Q. 1. The radiation corresponding to $3 \rightarrow 2$ transition of a hydrogen atom falls on a gold surface to generate photoelectrons. These electrons are passed through a magnetic field of 5×10^{-4} T. Assume that the radius of the largest circular path followed by these electrons is 7 mm, the work function of the metal is : (Mass of electron = 9.1×10^{-31} kg)

(1) 0.82 eV **(2)** 0.16 eV
(3) 1.88 eV **(4)** 1.36 eV

Q. 2. If $\vec{A}$ and $\vec{B}$ are two vectors satisfying the relation $\vec{A}\cdot\vec{B} = \left[\vec{A}\times\vec{B}\right]$. Then the value of $\left[\vec{A}-\vec{B}\right]$ will be :

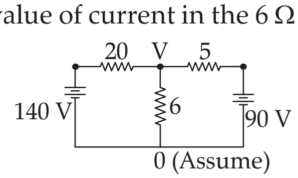
(1) $\sqrt{A^2 + B^2 - \sqrt{2}AB}$

(2) $\sqrt{A^2 + B^2}$

(3) $\sqrt{A^2 + B^2 + \sqrt{2}AB}$

(4) $\sqrt{A^2 + B^2 + \sqrt{2}AB}$

Q. 3. The value of current in the 6 Ω resistance is :



(1) 4 A **(2)** 6 A
(3) 8 A **(4)** 10 A

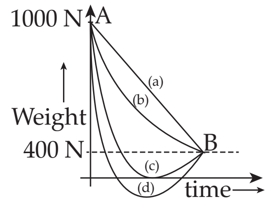
Q. 4. A deuteron and an alpha particle having equal kinetic energy enter perpendicular into a magnetic field. Let r_d and r_α be their respective radii of circular path. The value of $\frac{r_d}{r_\alpha}$ is equal to

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

Q. 5. A radioactive material decays by simultaneous emissions of two particles with half lives of 1400 years and 700 years respectively. What will be the time after which one-third of the material remains ? (Take ln3 = 1.1)

(1) 1110 years **(2)** 340 years
(3) 740 years **(4)** 700 years

Q. 6. A person whose mass is 100 kg travels from Earth to Mars in a spaceship. Neglect all other objects in sky and take acceleration due to gravity on the surface of the Earth and Mars as 10 m/s^2 and 4 m/s^2 respectively. Identify from the below figures, the curve that fits best for the weight of the passenger as a function of time.



(1) b **(2)** a

(3) c **(4)** d

Q. 7. The amount of heat needed to raise the temperature of 4 moles of a rigid diatomic gas from 0°C to 50°C when no work is done is……. (R is the universal gas constant)

(1) 750 R **(2)** 175 R

(3) 500 R **(4)** 250 R

Q. 8. The value of tension in a long thin metal wire has been changed from T_1 to T_2. The lengths of the metal wire at two different values of tension T_1 and T_2 are l_1 and l_2 respectively. The actual length of the metal wire is :

(1) $\frac{T_1 l_2 - T_2 l_1}{T_1 - T_2}$ **(2)** $\sqrt{T_1 T_2 l_1 l_2}$

(3) $\frac{l_1 + l_2}{2}$ **(4)** $\frac{T_1 l_1 - T_2 l_2}{T_1 - T_2}$

Q. 9. A butterfly is flying with a velocity $4\sqrt{2}$ m/s in North-East direction. Wind is slowly blowing at 1 m/s from North to South. The resultant displacement of the butterfly in 3 seconds is :

(1) 15 m **(2)** $12\sqrt{2}$ m

(3) 3 m **(4)** 20 m

Q. 10. A certain charge Q is divided into two parts q and (Q - q). How should the charges Q and q be divided so that q and (Q - q) placed at a certain distance apart experience maximum electrostatic repulsion?

(1) $Q = \frac{q}{2}$ **(2)** $Q = 3q$

(3) $Q = 2q$ **(4)** $Q = 4q$

Q. 11. The entropy of any system is given by

$$S = \alpha^2 \beta \ln\left[\frac{\mu k R}{J\beta^2} + 3\right]$$

Where α and β are the constants μ J, k and R are no. of moles, mechanical equivalent of heat, Boltzmann constant and gas constant respectively. [take $S = \frac{dQ}{T}$]

Choose the incorrect option from the following :

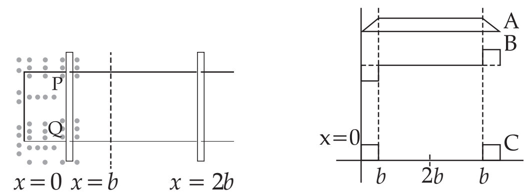
(1) S, β, k and μR have the same dimensions.

(2) α and J have the same dimensions.

(3) S and α have different dimensions.

(4) α and k have the same dimensions.

Q. 12. The arm PQ of a rectangular conductor is moving from $x = 0$ to $x = 2b$ outwards and then inwards from $x = 2b$ to $x = 0$ as shown in the figure. A uniform magnetic field perpendicular to the plane is acting from $x = 0$ to $x = b$. Identify the graph showing the variation of different quantities with distance.



(1) A-Flux, B-EMF, C-Power dissipated

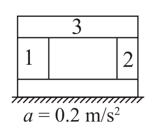
(2) A-Power dissipated, B-Flux, C-EMF

(3) A-Flux, B-Power, dissipated, C-EMF

(4) A-EMF, B-Power dissipated, C-Flux

Q. 13. A steel block of 10 kg rests on a horizontal floor as shown. When three iron cylinders are placed on it as shown, the block and cylinders go down with an acceleration 0.2 m/s^2. The normal reaction R′ by the floor if mass of the iron cylinders are equal and of 20 kg each, is __________

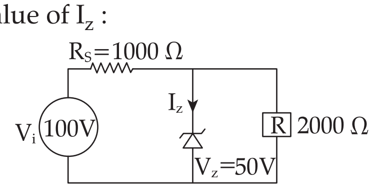
[take g = 10 m/s^2 and μ_s = 0.2]



(1) 714 **(2)** 716

(3) 684 **(4)** 686

Q. 14. For the circuit shown below, calculate the value of I_z :



(1) 0.15 A **(2)** 0.05 A

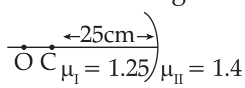
(3) 0.1 A **(4)** 25m A

Q. 15. A nucleus of mass M emits γ-ray photon of frequency 'ν'. The loss of internal energy by the nucleus is :

(1) 0 **(2)** $h\nu\left[1+\frac{h\nu}{2Mc^2}\right]$

(3) $h\nu$ **(4)** $h\nu\left[1-\frac{h\nu}{2Mc^2}\right]$

Q. 16. Region I and II are separated by a spherical surface of radius 25 cm. An object is kept in region I at a distance of 40 cm from the surface. The distance of the image from the surface is



(1) 55.44 cm **(2)** 9.52 cm

(3) 37.58 cm **(4)** 18.23 cm

Q. 17. AC voltage $V(t) = 20\sin\omega t$ of frequency 50 Hz is applied to a parallel plate capacitor. The separation between the plates is 2 mm and the area is 1 m^2. The amplitude of the oscillating displacement current for the applied AC voltage is__________.

[take $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m]

(1) 21.14 μA **(2)** 83.37 μA

(3) 55.58 μA **(4)** 27.79 μA

Q. 18. The normal reaction 'N' for a vehicle of 800 kg mass, negotiating a turn on a 30^o banked road at maximum possible speed without skidding is _________$\times 10^3$ kg m/s^2.

[Given cos30° = 0.87, $\mu_s = 0.2$]

(1) 12.4 **(2)** 7.2

(3) 6.96 **(4)** 10.2

Q. 19. A current of 5A is passing through a non-linear magnesium wire of cross-section 0.04m^2. At every point, the direction of current density is at an angle of 60^o with the unit vector of area of cross-section. The magnitude of electric field at every point of the conductor is :

Resistivity of magnesium = 44×10^{-8} Ωm

(1) 11×10^{-3} V/m **(2)** 11×10^{-5} V/m

(3) 11×10^{-7} V/m **(4)** 11×10^{-2} V/m

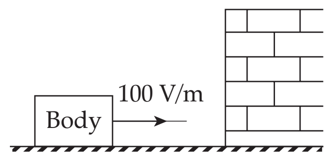
Q. 20. Consider a mixture of gas molecule of types A, B and C having masses $m_A < m_B < m_C$ ratio of their root mean square speeds at normal temperature and pressure is :

(1) $v_A = v_B \neq v_C$ **(2)** $\frac{1}{v_A} > \frac{1}{v_B} > \frac{1}{v_C}$

(3) $v_A = v_B = v_C = 0$ **(4)** $\frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_c}$

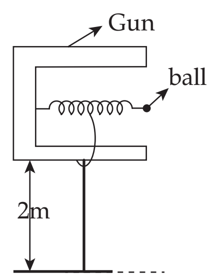
Section B

Q. 21. A body having specific charge 8 μC/g is resting on a frictionless plane at a distance 10 cm from the wall (as shown in the figure). It starts moving towards the wall when a uniform electric field of 100 V/m is applied horizontally toward the wall. If the collision of the body with the wall is perfectly elastic, then the time period of the motion will be _________*s*.



Q. 22. In a spring gun having spring constant 100 N/m a small ball 'B' of mass 100 g is put in its barrel (as shown in figure) by compressing the spring through 0.05 m. There should be a box placed at a distance '*d*' on the ground so that the ball falls in it. If the ball leaves the gun horizontally at a height of 2 m above the ground. The value of *d* is__________m.

(g = 10 m/s^2).



Q. 23. A rod of mass M and length L is lying on a horizontal frictionless surface. A particle of mass '*m*' travelling along the surface hits at one end of the rod with velocity '*u*' in a direction perpendicular to the rod. The collision is completely elastic. After collision, particle comes to rest. The ratio of masses $\left(\frac{m}{M}\right)$ is $\frac{1}{x}$. the value of '*x*' will be.........

Q. 24. An object viewed from a near point distance of 25 cm, using a microscopic lens with magnification '6', gives an unresolved image. A resolved image is observed at infinite distance with a total magnification double the earlier using an eyepiece along with the given lens and a tube of length 0.6 m, if the focal length of the eyepiece is equal to_____cm.

Q. 25. In an LCR series circuit, an inductor 30 mH and a resistor 1 Ω are connected to an AC source of angular frequency 300 rad/s. The value of capacitance for which, the current leads the voltage by 45° is $\frac{1}{x} \times 10^{-3}$ F. Then the value of x is_____________.

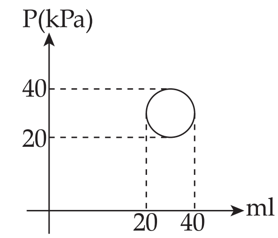
Q. 26. The frequency of a car horn encountered a change from 400 Hz to 500 Hz, when the car approaches a vertical wall. If the speed of sound is 330 m/s. Then the speed of car is ______ km/h.

Q. 27. A carrier wave $V_c(t) = 160 \sin(2\pi \times 10^6 t)$ volts is made to vary between $V_{max} = 200$ V and $V_{min} = 120$ V by a message signal $V_m(t) = A_m \sin(2\pi \times 10^3 t)$ volts. The peak voltage Am of the modulating signal is__________.

Q. 28. A circular disc reaches from top to bottom of an inclined plane of length 'L'. When it slips down the plane, it takes time 't_1'.when it rolls down the plane, it takes time t_2. The value of $\frac{t_2}{t_1}$ is $\sqrt{\frac{3}{x}}$. The value of x will be_______.

Q. 29. The amplitude of wave disturbance propagating in the positive x-direction is given by $\frac{1}{(1+x)^2}$ at time $t = 0$ and $\frac{1}{1+(x-2)^2}$ at $t = 1$ s, where x and y are in metres. The shape of wave does not change during the propagation. The velocity of the wave will be_____m/s.

Q. 30. In the reported figure, heat energy absorbed by a system in going through a cyclic process is_______πJ.



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Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	1	Photoelectric Effect	Dual Nature of Radiation and Matter
2	1	Vector Law of Addition	Vector
3	4	KCL	Electric Circuit Analysis
4	1	Moving Charge Particle in an Uniform Magnetic Field	Magnetic Effect of Electric Current
5	3	Half Lives	Radioactivity
6	3	Acceleration Due to Gravity	Gravitation
7	3	Isochoric Process	First Law of Thermodynamics
8	1	Stress and Strain	Properties of Solid
9	1	Vector	Motion in One Dimensions
10	3	Electrostatic Force	Electrostatics
11	4	Dimension	Dimensional Analysis
12	1	Faradays Law	Electromagnetic Inductions
13	4	Normal Reactions	Newton's Laws of Motion
14	4	Zerner Diode	Semiconductor Devices
15	2	Kinetic Energy of Nuclie	Nuclie
16	3	Refraction Through Spherical Surfaces	Optics
17	4	Displacement Current	Electromagnetic Waves
18	4	Banking With Friction	Circular Motion
19	2	Current Density	Electric Current
20	4	Root Mean Square Speed	Kinetic Theory of Gases
21	1	Time Period	Simple Harmonic Motion
22	1	Conservation of Energy	Projectile Motion
23	4	Elastic Collision	System of Particles
24	25	Optical Instrument	Optics
25	3	LCR	A.C Circuit Analysis
26	132	Reflection of Sound	Doppler Effect
27	40	Modulating Signal	Communication
28	2	Rolling on an Inclined Plane	Rotational Mechanics
29	2	Velocity of Wave	Travelling Waves
30	100	Cyclic Process	Thermodynamics

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ANSWERS WITH EXPLANATIONS

Physics

Section A

1. **Option (1) is correct.**
Magnetic field = 5×10^{-4} T
Radius = 7 mm = 7×10^{-3} m
Using the relation for transition of energy

$$E = 13.6\left[\frac{1}{4}-\frac{1}{9}\right]$$
$$= \frac{5}{36}(13.6) \text{ eV} = 1.89 \text{ eV}$$

The charged particle enters in a magnetic field of radius 'r'

$$r = \frac{mv}{qB}$$
$$p = mv = rqB$$
$$p = 7 \times 10^{-3} \times 1.6 \times 10^{-19} \times 5 \times 10^{-4}$$
$$p = 3136 \times 10^{-52}$$
$$KE = \frac{p^2}{2m}$$
$$\Rightarrow \quad KE = \frac{3136\times10^{-52}}{2\times9.1\times10^{-31}}$$
$$= \frac{3136\times10^{-52}}{2\times9.1\times10^{-31}\times1.6\times10^{-19}} \text{eV}$$
$$= 107.69 \times 10^{-2} \text{eV}$$
$$= 1.077 \text{ eV}$$

Use photoelectric equation

$$\text{Work function} = E - KE$$
$$= [1.89 - 1.077]\text{eV}$$
$$= 0.813\text{eV}$$

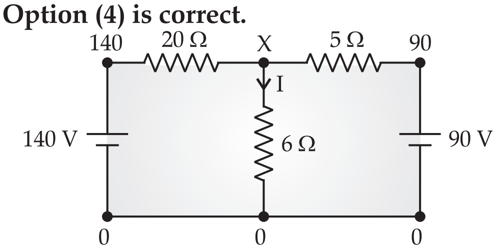
2. **Option (1) is correct.**

$$\vec{A}.\vec{B} = \vec{A}\times\vec{B} \qquad \text{[given]}$$
$$|\vec{A}||\vec{B}|\cos\theta = |\vec{A}||\vec{B}|\sin\theta\,\hat{n}$$

This is possible only when θ = 45°

$$|\vec{A}-\vec{B}| = \sqrt{A^2+B^2+2A(-B)\cos\theta}$$
$$= \sqrt{A^2+B^2-2AB\cos45°}$$
$$= \sqrt{A^2+B^2-\sqrt{2}AB}$$

3. **Option (4) is correct.**



Using KCL at point 'X'

$$\frac{X-140}{20}+\frac{X-90}{5}+\frac{X-0}{6} = 0$$
$$\frac{X}{20}-7+\frac{X}{5}-18+\frac{X}{6} = 0$$
$$X = 60 \text{ volt}$$

Now, $\quad I = \frac{X}{6} = \frac{60}{6} = 10$ A

4. **Option (1) is correct.**
Using the expression

$$r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$$

Kinetic energy of deuteron and alpha particle are equal, therefore

$$K_d = K_\alpha \qquad \text{(given)}$$
$$\frac{r_d}{r_\alpha} = \sqrt{\frac{m_d}{m_\alpha}\frac{q_\alpha}{q_d}}$$
$$\Rightarrow \quad \frac{r_d}{r_\alpha} = \sqrt{\frac{2}{4}\left(\frac{2}{1}\right)} = \sqrt{2}$$

5. **Option (3) is correct.**
Half lives of A into B is 1400 years.
Half lives of A into C is 700 years

$$A \xrightarrow{\lambda_1} B \qquad A \xrightarrow{\lambda_2} C$$
$$[T_{1/2}]_{AB} = \frac{\log_e 2}{\lambda_1} \qquad [T_{1/2}]_{AC} = \frac{\log_e 2}{\lambda_2}$$
$$\lambda_{net} = \lambda_1 + \lambda_2 = \frac{ln 2}{1400}+\frac{ln 2}{700}$$

$$= ln\,2\left[\frac{3}{1400}\right]$$

Use the expression

$$N = N_0 e^{-\lambda t}$$

$$\frac{N_0}{3} = N_0 e^{-\lambda_{net} t}$$

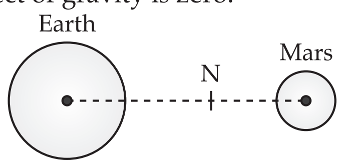
$$\log_e 3 = \lambda_{net}\, t$$

$$\Rightarrow \quad 1.1 = 0.693\left[\frac{3}{1400}\right]t$$

$$t = 740 \text{ years (approx)}$$

6. Option (3) is correct.

In below figure, N is the neutral point where the effect of gravity is zero.



At Earth's surface W $= 100(10) = 1000$ N

At Mars surface W $= 100(4) = 400$ N

In the given figure, only in curve (c) we get a neutral point.

7. Option (3) is correct.

Using first law of thermodynamics

$$\delta Q = \delta W + dU$$

Here, $\delta W = 0$

$$\delta Q = dU = nC_V\Delta T = 4\left[\frac{5}{2}R\right][50]$$

$$= 500\,R$$

8. Option (1) is correct.

Using the expression

$$\frac{T}{A} = Y\frac{\delta l}{l}$$

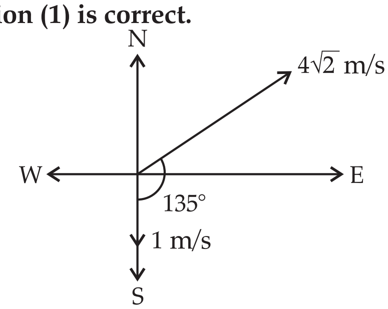
Now, $$T_1 = \frac{k[l_1 - l]}{l} \quad \text{...(i)}$$

And, $$T_2 = \frac{k[l_2 - l]}{l} \quad \text{...(ii)}$$

On solving (i) and (ii)

$$l = \frac{T_1 l_2 - T_2 l_1}{T_1 - T_2}$$

9. Option (1) is correct.



$$|\vec{A}| = 4\sqrt{2} \text{ m/s}$$

$$|\vec{B}| = 1 \text{ m/s}$$

$$|\vec{A} + \vec{B}| = \sqrt{A^2 + B^2 + 2AB\cos 135°}$$

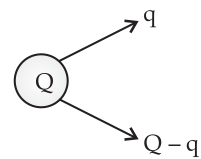
$$= \sqrt{(4\sqrt{2})^2 + (1)^2 + 2(4\sqrt{2})(1)\left(\frac{-1}{\sqrt{2}}\right)}$$

$$= \sqrt{25} = 5 \text{ m/s}$$

The resultant displacement of the butterfly in 3 seconds

$$S = 5 \times 3 = 15 \text{ m}$$

10. Option (3) is correct.



$$F = \frac{kq(Q-q)}{r^2}$$

$$\frac{dF}{dq} = 0 \text{ for maxima and minima}$$

$$\frac{k}{r^2}[-2q + Q] = 0$$

Now, $$\left(\frac{df^2}{dq^2}\right) < 0$$

$$Q = 2q$$

Hence, for maximum force

$$Q = 2q$$

11. Option (4) is correct.

$$S = \alpha^2\beta\, ln\left[\frac{\mu kR}{J\beta^2} + 3\right] \quad \text{...(i)}$$

$$\frac{\mu kR}{J\beta^2} \rightarrow \text{dimensionless}$$

$$S = \frac{Q}{T} = \frac{\text{Joule}}{\text{Kelvin}}$$

$$\Rightarrow \quad [S] = \frac{ML^2T^{-2}}{\theta} = ML^2T^{-2}\theta^{-1}$$

Ideal gas equation, PV = μRT

$$\mu R = \frac{PV}{T}$$

$[\mu R] = ML^2T^{-2}\theta^{-1}$

k $\rightarrow$ Boltzmann constant $[k] = ML^2T^{-2}\theta^{-1}$

J $\rightarrow$ dimensionless constant

12. Option (1) is correct.

As the rod moves from $x = 0$ to $x = b$ the flux increase, emf induced and power dissipated is constant.

From $x = b$ to $x = 2b$ no flux is change so induced emf and power dissipated is zero.

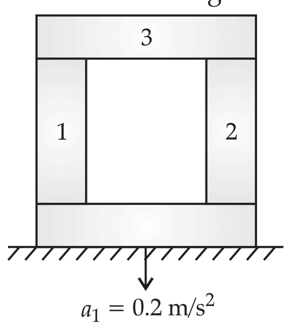
So, A $\rightarrow$ flux

B $\rightarrow$ emf

C $\rightarrow$ power dissipated

13. Option (4) is correct.

Mass of a steel block is 10 kg.

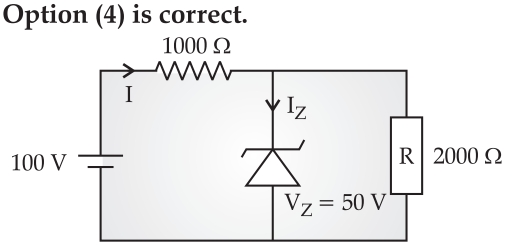


Mass of all cylinder M = 20 × 3 + 10 = 70 kg

The force equation in vertical direction

$$Mg - N = Ma$$
$$70 \times 10 - N = 70 \times 0.2$$
$$N = 70[10 - 0.2] = 686 \text{ N}$$

14. Option (4) is correct.



Voltage across load resistance is 50V

$$(I - I_z) = \frac{V_Z}{R} = \frac{50}{2000} = 25 \text{ mA}$$

And, $$I = \frac{V_Z}{R_S} = \frac{50}{1000} = 50 \text{ mA}$$

$$I_z = I - (I - I_z) = 50 - 25 = 25 \text{ mA}$$

15. Option (2) is correct.

Apply conservation of momentum;

$$\vec{p}_\gamma + \vec{p}_{Nu} = 0$$

$\vec{p}_{Nu} \rightarrow$ momentum of decayed nuclei

Momentum of γ ray $[p_\gamma] = \frac{h\nu}{c}$

Energy of γ ray $= h\nu$

$$\text{K.E. of nuclei} = \frac{(p_{Nu})^2}{2M} = \frac{1}{2M}\left[\frac{h\nu}{c}\right]^2$$

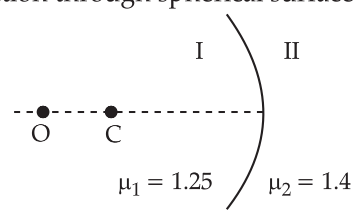
Loss in internal energy $= E_\gamma + K.E_{Nu}$

$$= h\nu + \frac{1}{2M}\left[\frac{h\nu}{c}\right]^2$$

16. Option (3) is correct.

Radius (R) = 25 cm

Refraction through spherical surface

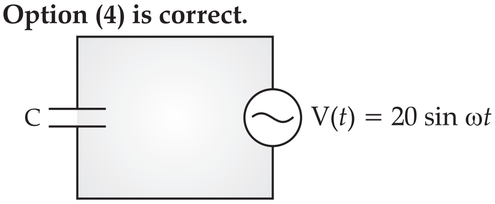


$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{1.4}{v} - \frac{1.25}{-40} = \frac{1.4 - 1.25}{-25}$$

$$v = -37.58 \text{ cm}$$

17. Option (4) is correct.



Frequency = 50 Hz

d = 2 mm, A = 1 m^2

$$C = \frac{A\varepsilon_0}{d} = \frac{1 \times 8.85 \times 10^{-12}}{2 \times 10^{-3}}$$

$$= 4.425 \times 10^{-9} \text{ F}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi(50)(4.425 \times 10^{-9})}$$

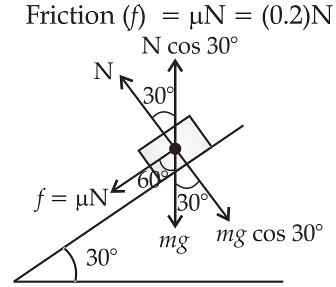
$$= 0.7193 \times 10^6 \ \Omega$$

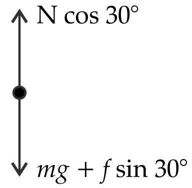
$$\text{displacement current } (I_d) = \frac{V_0}{X_C} = \frac{20}{0.7193 \times 10^6}$$

$$= 27.81 \ \mu A$$
$$\simeq 27.79 \ \mu A$$

18. Option (4) is correct.

Friction (f) = μN = (0.2)N





Equation of motion in vertical direction

$N \cos 30° - \mu N \cos 60° = mg$

$$N = \frac{800 \times 10}{\cos 30° - 0.2 \times \cos 60°}$$

$= 10.4 \times 10^3 \text{ kg m/s}^2 \simeq 10.2 \times 10^3 \text{ kg m/s}^2$

19. Option (2) is correct.

Electric current (I) = 5A

Cross-section area (A) = 0.04 m^2

Angle (θ) = 60°

Resistivity (ρ) = 44×10^{-8} ωm

$$\text{Current density (J)} = \frac{I}{A\cos\theta}$$

$$= \frac{5A}{0.04 \cos 60°} = 250 \text{ A/m}^2$$

The magnitude of electric field 'E' = ρJ

$= 44 \times 10^{-8} \times 250$

$= 11 \times 10^{-5}$ V/m

20. Option (4) is correct.

$$\text{Root mean square speed } v_{rms} = \sqrt{\frac{3RT}{M}}$$

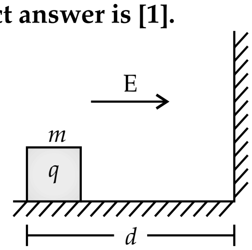
$M_A < M_B < M_C$

So, $v_A > v_B > v_C$

Hence $\frac{1}{v_A} < \frac{1}{v_B} < \frac{1}{v_C}$

Section B

21. The correct answer is [1].



Electric force, F = qE

$ma = qE$

$$a = \frac{qE}{m}$$

Use second equation of motion

$$d = ut + \frac{1}{2}at^2 \qquad [\because u = 0 \text{ m/s}]$$

$$d = \frac{1}{2}at^2 = \frac{1}{2}\left[\frac{qE}{m}\right]t^2$$

$$t = \sqrt{\frac{2d}{\frac{qE}{m}}} = \sqrt{\frac{2 \times 0.1}{8 \times 10^{-3}(100)}}$$

$$= \sqrt{\frac{2000}{8000}} = \frac{1}{2}$$

It will take same time to return back its initial position.

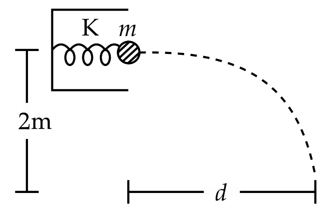
$$\text{Time period (T)} = 2\left(\frac{1}{2}\right) = 1 \text{ s.}$$

22. The correct answer is [1].

Spring constant (k) = 100 N/m

mass of a ball = 100 g = 100×10^{-3} kg

Δx = 0.05 m



$$\text{Potential energy in the spring} = \frac{1}{2}k\Delta x^2$$

Apply the law of conservation of energy

$$\frac{1}{2}k\Delta x^2 = \frac{1}{2}mv^2$$

$$v = \Delta x\sqrt{\frac{k}{m}}$$

$$= 0.05\sqrt{\frac{100}{100 \times 10^{-3}}}$$

$$= 0.5\sqrt{10} \text{ m/s}$$

Height = (2m)

From 2nd equation of motion,

$$h = \frac{1}{2}gt^2$$

or, $$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 2}{10}} = \frac{2}{\sqrt{10}}$$

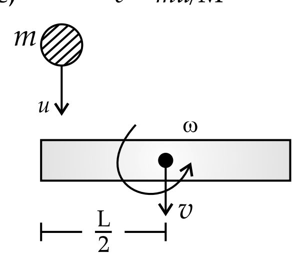
Now, $$d = vt = [0.5\sqrt{10}]\left[\frac{2}{\sqrt{10}}\right] = 1 \text{ m}$$

23. The correct answer is [4].

Conservation of linear momentum

$mu = Mv$

Therefore, $v = mu/M$ ...(i)



Conservation of angular momentum

$$mu\frac{L}{2} = I\omega$$

$$mu\frac{L}{2} = \frac{ML^2}{12}\omega$$

or, $$\omega = \frac{6mu}{ML} \quad ...(ii)$$

As, Coefficient of restitution for perfectly elastic collision, $e = 1$.

$$\Rightarrow \quad e = \frac{V_2 - V_1}{u_1 - u_2} = \frac{\left(\nu + \omega\frac{L}{Z}\right) - 0}{u - 0}$$

$$1 = \frac{v + \frac{\omega L}{2}}{u}$$

$$u = v + \frac{\omega L}{2}$$

Now, from equations (i), (ii) and (iii) we have,

$$u = \frac{mu}{M} + \frac{3mu}{M} = \frac{4mu}{M}$$

$$\frac{m}{M} = \frac{1}{4}$$

so, $x = 4$

24. The correct answer is [25].

For simple microscope

$$m = 1 + \frac{D}{f_o}$$

$$6 = 1 + \frac{25}{f_o}$$

$$f_0 = 5 \text{ cm}$$

For compound microscope

$$m = \frac{LD}{f_o f_e}$$

$$12 = \frac{60 \times 25}{5 f_e}$$

$$f_e = 25 \text{ cm}$$

25. The correct answer is [3].

Inductor (L) $= 30 \text{ mH} = 30 \times 10^{-3}$ H

Resistor (R) $= 1\ \Omega$

Angular frequency $\omega = 300$ rad/s

Angular phase $\phi = 45°$

Use this expression

$$\tan\phi = \frac{X_C - X_L}{R} = 1$$

$$X_C - X_L = R$$

$$\frac{1}{\omega C} - \omega L = R$$

$$\frac{1}{\omega C} = R + \omega L$$

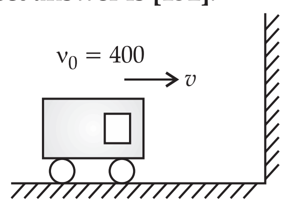
$$\Rightarrow \quad \frac{1}{\omega C} = 1 + 300(30 \times 10^{-3}) = 10\ \Omega$$

So, $$C = \frac{1}{10\omega}$$

$$= \frac{1}{10 \times 300} = \frac{1}{3} \times 10^{-3} \text{ F}$$

$$x = 3$$

26. The correct answer is [132].



Case I :

When wall treated as an observer

$$\nu_1 = \nu_0\left[\frac{c}{c - v}\right] \quad ...(i)$$

Case II :

Wall as a source

$$\nu_2 = \nu_1\left[\frac{c + v}{c}\right] \quad ...(ii)$$

or, $$\nu_2 = \nu_0\left[\frac{c + v}{c - v}\right]$$ ......using equation (i)

Substituting the given values

$$500 = 400\left[\frac{c + v}{c - v}\right] \quad \text{(Here, C = 330 m/s)}$$

$$v = \frac{330}{9} \times \frac{18}{5} = 132 \text{ km/h}$$

27. The correct answer is [40].

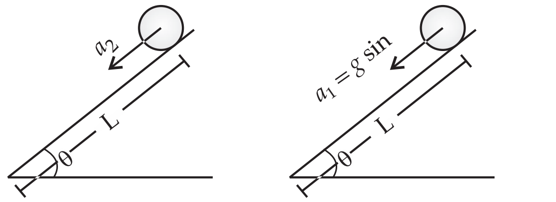
Using the relation

$$V_{maxi.} = V_M + V_C$$

$$200 = V_M + 160$$

$$A_m = V_M = 40$$

28. The correct answer is [2].



When disc rolls down When disc slips down

Case 1 :

$$a_1 = g\sin\theta \quad \text{...(i)}$$

Case 2 :

$$a_2 = \frac{g\sin\theta}{1+\frac{I}{MR^2}}$$

$$a_2 = \frac{g\sin\theta}{1+\frac{MR^2}{2MR^2}} = \frac{2}{3}g\sin\theta \quad \text{...(ii)}$$

Using 2nd equation of motion for case 1 and case 2,

Case 1 :

$$L = \frac{1}{2}a_1t_1^2 \quad \text{...(iii)}$$

$$t_1 = \sqrt{\frac{2L}{a_1}}$$

Case 2 :

$$L = \frac{1}{2}a_2t_2^2$$

$$t_2 = \sqrt{\frac{2L}{a_2}} \quad \text{...(iv)}$$

Now, from equations (i), (ii), (iii) and (iv)

Now, $$\frac{t_2}{t_1} = \sqrt{\frac{a_1}{a_2}} = \sqrt{\frac{3}{2}}$$

$$x = 2$$

29. The correct answer is [2].

Equation of a wave

at $t = 0$, $$y = \frac{1}{1+x^2}$$

at $t = t$, $$y = \frac{1}{1+(x-vt)^2}$$

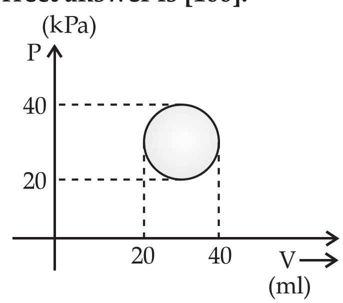
at $t = 1$, $$y = \frac{1}{1+(x-v)^2} \quad \text{...(i)}$$

Compare (i) with given equation

$$y = \frac{1}{1+(x-2)^2}$$

So, $v = 2$ m/s

30. The correct answer is [100].



In cyclic process

$$\Delta U = 0$$

From first law of thermodynamics

$$\delta Q = \delta W + \Delta U$$

$$\delta Q = \delta W = \text{Area} = \pi r_1 r_2$$

$\Rightarrow \pi[10 \times 10^3]\,[10 \times 10^{-3}] = 100\pi$ J.

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