JEE (Main) PHYSICS SOLVED PAPER

2022

29th June Shift 2

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

General Instructions :

1. *In Physics Section, there are 30 Questions (Q. no. 1 to 30) having Section A and B.*
2. *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. A small toy starts moving form the position of rest under a constant acceleration. If it travels a distance of 10 m in t s, the distance travelled by the toy in the next t s will be :

(A) 10 m **(B)** 20 m
(C) 30 m **(D)** 40 m

Q. 2. At what temperature a gold ring of diameter 6.230 cm be heated so that it can be fitted on a wooden bangle of diameter 6.241 cm ? Both the diameters have been measured at room temperature (27°C). (Given: coefficient of linear thermal expansion of gold $\alpha_L = 1.4 \times 10^{-5}\ K^{-1}$)

(A) 125.7°C **(B)** 91.7°C
(C) 425.7°C **(D)** 152.7°C

Q. 3. Two point charges Q each are placed at a distance d apart. A third point charge q is placed at a distance x from mid-point on the perpendicular bisector. The value of x at which charge q will experience the maximum Coulomb's force is:

(A) $x = d$ **(B)** $x = \frac{d}{2}$

(C) $x = \frac{d}{\sqrt{2}}$ **(D)** $x = \frac{d}{2\sqrt{2}}$

Q. 4. The speed of light in media 'A' and 'B' are 2.0×10^{10} cm/s and 1.5×10^{10} cm/s respectively. A ray of light enters from the medium B to A at an incident angle 'θ'. If the ray suffers total internal reflection, then

(A) $\theta = \sin^{-1}\left(\frac{3}{4}\right)$ **(B)** $\theta > \sin^{-1}\left(\frac{3}{4}\right)$

(C) $\theta < \sin^{-1}\left(\frac{3}{4}\right)$ **(D)** $\theta > \sin^{-1}\left(\frac{3}{4}\right)$

Q. 5. In the following nuclear reaction, $D \xrightarrow{\alpha} D_1 \xrightarrow{\beta^-} D_2 \xrightarrow{\alpha} D_3 \xrightarrow{\gamma} D_4$. Mass number of D is 182 and atomic number is 74 . Mass number and atomic number of D_4 respectively will be

(A) 174 and 71 **(B)** 174 and 69
(C) 172 and 69 **(D)** 172 and 71

Q. 6. The electric field at a point associated with a light wave is given by

$E = 200[\sin(6 \times 10^{15})t + \sin(9 \times 10^{15})t]\text{Vm}^{-1}$

Given : $h = 4.14 \times 10^{-15}$ eVs.

If this light falls on a metal surface having a work function of 2.50eV, the maximum kinetic energy of the photoelectrons will be

(A) 1.90 eV **(B)** 3.27 eV
(C) 3.60 eV **(D)** 3.42 eV

Q. 7. A capacitor is discharging through a resistor R. Consider in time t_1, the energy stored in the capacitor reduces to half of its initial value and in time t_2, the charge stored reduces to one eighth of its initial value. The ratio t_1/t_2 will be

(A) 1/2 **(B)** 1/3

(C) 1/4 **(D)** 1/6

Q. 8. Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways. The work done by the gas is W_1 if the process is purely isothermal, W_2, if the process is purely adiabatic and W_3 if the process is purely isobaric. Then, choose the correct option

(A) $W_1 < W_2 < W_3$ **(B)** $W_2 < W_3 < W_1$

(C) $W_3 < W_1 < W_2$ **(D)** $W_2 < W_1 < W_3$

Q. 9. Two long current carrying conductors are placed parallel to each other at a distance of 8 cm between them. The magnitude of magnetic field produced at mid-point between the two conductors due to current flowing in them is $300\mu T$. The equal current flowing in the two conductors is :

(A) 30 A in the same direction

(B) 30 A in the opposite direction

(C) 60 A in the opposite direction

(D) 300 A in the opposite direction

Q. 10. The time period of a satellite revolving around earth in a given orbit is 7 hours. If the radius of orbit is increased to three times its previous value, then approximate new time period of the satellite will be

(A) 40 hours **(B)** 36 hours

(C) 30 hours **(D)** 25 hours

Q. 11. The TV transmission tower at a particular station has a height of 125 m. For doubling the coverage of its range, the height of the tower should be increased by

(A) 125 m **(B)** 250 m

(C) 375 m **(D)** 500 m

Q. 12. The motion of a simple pendulum executing S.H.M. is represented by the following equation.

$y = A \sin (\pi t + \phi)$, where time is measured in second. The length of pendulum is

(A) 97.23 cm **(B)** 25.3 cm

(C) 99.4 cm **(D)** 406.1 cm

13. A vessel contains 16 g of hydrogen and 128 g of oxygen at standard temperature and pressure. The volume of the vessel in cm^3 is :

(A) 72×10^5 **(B)** 32×10^5

(C) 27×10^4 **(D)** 54×10^4

Q. 14. Given below are two statements:

Statement I: The electric force changes the speed of the charged particle and hence changes its kinetic energy; whereas the magnetic force does not change the kinetic energy of the charged particle.

Statement II: The electric force accelerates the positively charged particle perpendicular to the direction of electric field. The magnetic force accelerates the moving charged particle along the direction of magnetic field.

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

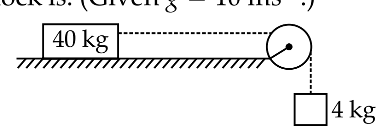
(A) Both statement I and Statement II are correct.

(B) Both statement I and Statement II are incorrect.

(C) Statement I is correct but statement II is incorrect.

(D) Statement I is incorrect but statement II is correct.

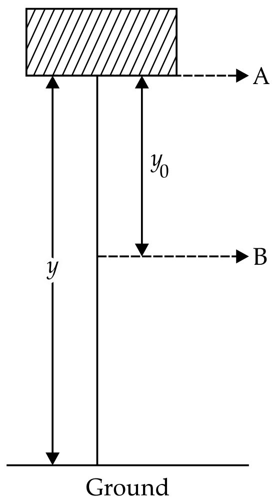
Q. 15. A block of mass 40 kg slides over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below. The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is. (Given $g = 10\ ms^{-2}$.)



(A) $1\ ms^{-2}$ **(B)** $1/5\ ms^{-2}$

(C) $4/5\ ms^{-2}$ **(D)** $8/11\ ms^{-2}$

Q. 16. In the given figure, the block of mass m is dropped from the point 'A'. The expression for kinetic energy of block when it reaches point 'B' is



(A) $\frac{1}{2}mgy_0^2$ **(B)** $\frac{1}{2}mgy^2$

(C) $mg(y-y_0)$ **(D)** mgy_0

Q. 17. A block of mass M placed inside a box descends vertically with acceleration 'a'.

The block exerts a force equal to one-fourth of its weight on the floor of the box. The value of 'a' will be

(A) $\frac{g}{4}$ **(B)** $\frac{g}{2}$

(C) $\frac{3g}{4}$ **(D)** g

Q. 18. If the electric potential at any point (x, y, z)m in space is given by $V = 3x^2$ volt. The electric field at the point (1, 0, 3)m will be :

(A) $3Vm^{-1}$, directed along positive x-axis.
(B) $3Vm^{-1}$, directed along negative x-axis.
(C) $6Vm^{-1}$, directed along positive x-axis.
(D) $6Vm^{-1}$, directed along negative x-axis.

Q. 19. The combination of two identical cells, whether connected in series or parallel combination provides the same current through an external resistance of 2 Ω. The value of internal resistance of each cell is

(A) 2 Ω **(B)** 4 Ω

(C) 6 Ω **(D)** 8 Ω

Q. 20. A person can throw a ball upto a maximum range of 100 m. How high above the ground he can throw the same ball?

(A) 25 m **(B)** 50 m

(C) 100 m **(D)** 200 m

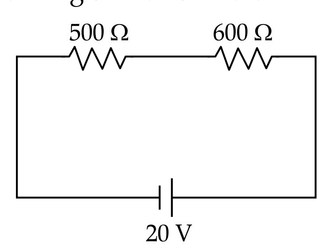
Section B

Q. 21. The Vernier constant of Vernier callipers is 0.1 mm and it has zero error of (−0.05) cm. While measuring diameter of a sphere, the main scale reading is 1.7 cm and coinciding vernier division is 5 . The corrected diameter will be ______ $\times 10^{-2}$ cm

Q. 22. A small spherical ball of radius 0.1 mm and density 10^4 kg m^{-3} falls freely under gravity through a distance h before entering a tank of water. If, after entering the water the velocity of ball does not change and it continue to fall with same constant velocity inside water, then the value of h will be___ m (Given g = 10 ms^{-2}, viscosity of water $= 1.0 \times 10^{-5}$ N-sm^{-2}).

Q. 23. In an experiment to determine the velocity of sound in air at room temperature using a resonance tube, the first resonance is observed when the air column has a length of 20.0 cm for a tuning fork of frequency 400 Hz is used. The velocity of the sound at room temperature is 336 ms^{-1}. The third resonance is observed when the air column has a length of _______ cm

Q. 24. Two resistors are connected in series across a battery as shown in figure. If a voltmeter of resistance 2000 Ω is used to measure the potential difference across 500 Ω resisteor, the reading of the voltmeter will be ______ V



Q. 25. A potential barrier of 0.4 V exists across a p-n junction. An electron enters the junction from the n-side with a speed of 6.0×10^5 ms^{-1}. The speed with which electron enters the p side will be $\frac{x}{3} \times 10^5$ ms^{-1}, the value of x is _____________. (Given mass of electron $= 9 \times 10^{-31}$ kg),
charge on electron $= 1.6 \times 10^{-19}$ C.)

Q. 26. The displacement current of 4.425 μA is developed in the space between the plates of parallel plate capacitor when voltage is changing at a rate of $10^6 Vs^{-1}$. The area of each plate of the capacitor is 40 cm^2. The distance between each plate of the capacitor is $x \times 10^{-3}$ m. The value of x is, (Permittivity of free space, $\varepsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$) _

Q. 27. The moment of inertia of a uniform thin rod about a perpendicular axis passing through one end is I_1. The same rod is bent into a ring and its moment of inertia about a diameter is I_2. If $\frac{I_1}{I_2}$ is $\frac{x\pi^2}{3}$, then the value of x will be _______

Q. 28. The half life of a radioactive substance is 5 years. After x years a given sample of the radioactive substance gets reduced to 6.25% of its initial value. The value of x is ______

Q. 29. In a double slit experiment with monochromatic light, fringes are obtained on a screen placed at some distance from the plane of slits. If the screen is moved by 5×10^{-2} m towards the slits, the change in fringe width is 3×10^{-3} cm. If the distance between the slits is 1 mm, then the wavelength of the light will be________ nm.

Q. 30. An inductor of 0.5 mH, a capacitor of 200 μF and a resistor of 2 Ω are connected in series with a 220 V ac source. If the current is in phase with the emf, the frequency of ac source will be __________ $\times 10^2$ Hz.

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Answer Key

Q. No.	Answer	Topic Name	Chapter Name
Section (A)			
1	C	Motion in a Straight Line	Kinematics
2	D	Thermal Properties of Matter	Properties of Bulk Matter
3	D	Electric Charges and Fields	Electrostatics
4	D	Ray Optics and Optical Instruments	Optics
5	A	Nuclei	Atoms and Nuclei
6	D	Dual Nature of Matter and Radiation	Dual Nature of Matter and Radiation
7	D	Electrostatic Potential and Capacitance	Electrostatics
8	D	Behaviour of Perfect Gas and Kinetic Theory	Behaviour of Perfect Gas and Kinetic Theory
9	B	Magnetic Effect of Current	Magnetic Effects of Current and Magnetism
10	B	Gravitation	Gravitation
11	C	Communication	Communication
12	C	Oscillations	Oscillations and Waves
13	C	Behaviour of Perfect Gas and Kinetic Theory	Behaviour of Perfect Gas and Kinetic Theory
14	C	Electric Charges and Fields	Electrostatics
15	D	Laws of Motion	Laws of Motion
16	D	Work, Energy and Power	Work, Energy and Power
17	C	Laws of Motion	Laws of Motion
18	D	Electrostatic Potential and Capacitance	Electrostatics
19	A	Current Electricity	Current Electricity
20	B	Concept of Vector and Motion in a Plane	Kinematics
Section (B)			
21	180	Units and Measurement	Physical World and Measurement
22	20	Mechanical Properties of Fluids	Mechanical Properties of Fluids
23	104	Waves	Oscillations and Waves
24	8	Current Electricity	Current Electricity
25	14	Work, Energy and Power	Work, Energy and Power
26	8	Electrostatic Potential and Capacitance	Electrostatics
27	8	Motion of System of Particles and Rigid Body	Motion of System of Particles and Rigid Body
28	20	Nuclei	Atoms and Nuclei
29	600	Wave Optics	Optics
30	5	Alternating Current	Electromagnetic Induction and Alternating Current

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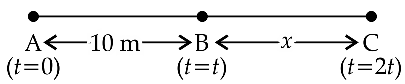
ANSWERS WITH EXPLANATIONS

Physics

Section A

1. Option (C) is correct.

Explanation:



As per given conditions, the acceleration is constant and initial velocity (u) = 0.

Let the time taken from A to B be 't' seconds and in another 't' seconds it goes from B to C.

For A to B, by using II equation of motion, we have:

$$S = ut + \frac{1}{2}at^2$$

$$10 = 0(t) + \frac{1}{2}at^2$$

$$a = \frac{20}{t^2} \quad \text{...(1)}$$

For B to C, again by using II equation of motion, we have:

$$S = ut + \frac{1}{2}at^2$$

$$x = (at)t + \frac{1}{2}at^2 \quad \text{...(2)}$$

$$[\because\ v = u + at \text{ at } u = 0, v = at]$$

By using equation (1) an (2), we have

$$x = \frac{20}{t^2}\times t^2 + \frac{1}{2}\times\frac{20}{t^2}\times t^2$$

$$x = 20 + 10 = 30 \text{ m}$$

> ***Hint :***
> Apply II equation of motion for both cases and put the solved values.

> ***Shortcut :***
> For A to B, by using II equation of motion, we get:
>
> $$S = ut + \frac{1}{2}at^2 = 10$$
>
> $$\frac{1}{2}at^2 = 10 \quad \text{...(1)}$$
>
> Similarly, for A to C, we get:
>
> $$\frac{1}{2}a(2t)^2 = 40 \text{ m} \quad \text{...(2)}$$
>
> Hence, Distance covered between B to $C = AC - AB$
>
> $$= 40 - 10$$
>
> $$= 30 \text{ m}$$

2. Option (D) is correct.

Explanation: **Given:** initial diameter of gold ring = 6.230 cm

final diameter of gold ring = diameter of bangle = 6.241 cm

$$\alpha = 1.4 \times 10^{-5}\ K^{-1}$$

As, $$\frac{\Delta l}{l} = \alpha\,\Delta T$$

Similarly, $$\frac{\Delta D}{D} = \alpha\,\Delta T$$

$$\frac{D_{final} - D_{initial}}{D_{initial}} = \alpha\,(T_{final} - T_{initial})$$

$$\Rightarrow \frac{6.241 - 6.230}{6.230} = 1.4 \times 10^{-5(T - 27)}$$

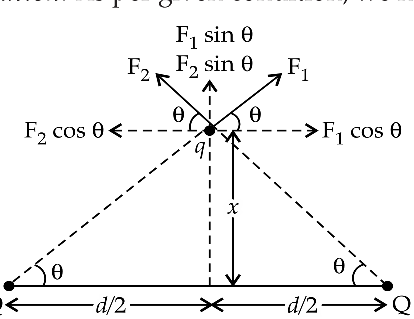
$$\Rightarrow T - 27 = \frac{0.011}{6.230}\times\frac{1}{1.4\times10^{-5}}$$

$$\Rightarrow T = 152.7^\circ \text{ C}$$

> ***Hint :*** use $\frac{\Delta D}{D} = \alpha\,\Delta T$, and put values.
>
> ***Shortcut :*** As, $\Delta D = D\alpha\Delta T$
>
> $$\Delta T = \frac{\Delta D}{D\alpha} = 126.11^\circ \text{ C}$$
>
> $$T = 126.11 + T_{initial} = 153.11^\circ \text{ C}$$

3. Option (D) is correct.

Explanation: As per given condition, we have:



By figure, we can conclude that the net electric force will be 2 F sinθ in vertical direction.

Hence, $F_{net} = 2F\sin\theta$

$$\sin\theta = \frac{x}{\sqrt{\frac{d^2}{4}+x^2}}$$

$$F_{net} = 2\times\frac{1}{4\pi\varepsilon_0}\times\frac{Qx}{\left(\frac{d^2}{4}+x^2\right)^{3/2}}$$

For F_{net} to be maximum, $\frac{d}{dx}F_{net} = 0$

$$\Rightarrow \frac{d}{dx}\left[2\times\frac{1}{4\pi\varepsilon_0}\times\frac{qQx}{\left(\frac{d^2}{4}+x^2\right)^{3/2}}\right] = 0$$

$$\Rightarrow \left(\frac{d^2}{4}+x^2\right)^{-3/2}\frac{d(x)}{dx}+x\frac{d}{dx}\left(\frac{d^2}{4}+x^2\right)^{-3/2} = 0$$

$$\Rightarrow \left(\frac{d^2}{4}+x^2\right)^{-3/2}+x\left(\frac{-3}{2}\right)\left(\frac{d^2}{4}+x^2\right)^{-5/2}(2x) = 0$$

$$\Rightarrow \frac{1}{\left(\frac{d^2}{4}+x^2\right)^{3/2}} = \frac{3x^2}{\left(\frac{d^2}{4}+x^2\right)^{5/2}}$$

$$\Rightarrow \frac{d^2}{4}+x^2 = 3x^2$$

$$\Rightarrow \frac{d^2}{4} = 2x^2$$

$$\Rightarrow d^2 = 8x^2$$

$$\Rightarrow x^2 = \frac{d^2}{8}$$

Hence, $x = \frac{d}{2\sqrt{2}}$

Hint : Either use maximum electric field or electrostatic force = 0.

Shortcut: Net force experienced by the charge q.

$$F = \frac{1}{4\pi\varepsilon_0}\times\frac{Qq\times x}{\left[\left(\frac{d}{2}\right)^2+x^2\right]^{3/2}}$$

For maximum force, $\frac{dF}{dx} = 0$

$$\Rightarrow \frac{d}{dx}\left[\frac{1}{4\pi\varepsilon_0}\frac{Qqx}{\left(\frac{d^2}{4}+x^2\right)^{3/2}}\right] = 0$$

On solving, we get, $x^2 = \frac{d^2}{8}$ (as solved above)

Hence, $x = \frac{d}{2\sqrt{2}}$

4. Option (D) is correct.

Explanation: As, $\mu = \frac{c}{v}$

Hence, $\mu_A = \frac{c}{v_A} = \frac{3\times10^8}{2.0\times10^8} = 1.5$

Similarly, $\mu_B = \frac{c}{v_B} = \frac{3\times10^8}{1.5\times10^8} = 2$

For TIR to take place, the angle of incidence must be greater than the critical angle, i.e., $\theta > i_C$.

Now, $\mu_B \sin i_C = \mu_A \sin 90°$

$2\sin i_C = 1.5\times1$

∴ $\sin i_C = \frac{1.5}{2}$

$$i_C = \sin^{-1}\left(\frac{1.5}{2}\right) = \sin^{-1}\left(\frac{3}{4}\right)$$

Hence, $\theta > \sin^{-1}\left(\frac{3}{4}\right)$

Hint: Use, $\mu = \frac{c}{v}$ & remember condition of TIR.

5. Option (A) is correct.

Explanation: We can write the given reaction as,

$$D = D_4 + 2\alpha + \beta + \gamma$$

Hence, $D_4 = D - 2\alpha - \beta - \gamma$

So, atomic number of D_4 = atomic number of $D - 2\times2+1$

$= 74 - 4 + 1$

$= 71$

Similarly, mass number of D_4 = Mass number of $D - 2\times4$

$= 182 - 8$

$= 174$

> ***Hint:*** Remember:
> During α–decay, atomic number decreases by 2 and mass number decreases by 4.
> During β^-decay, atomic number increases by 1 and mass number remains same.
> During γ–decay, no change in mass number and atomic number takes place.

6. Option (D) is correct.

Explanation: As per given equation, we have,

$$n_1 = \frac{6}{2\pi}\times 10^{15} \text{ and } n_2 = \frac{9}{2\pi}\times 10^{15}$$

Hence, energy of photon of these waves, $E = h\nu$

$$E_1 = 4.14 \times 10^{-15} \times \frac{6}{2\pi}\times 10^{15}\ eV = 3.95\ eV$$

$$E_2 = 4.14 \times 10^{-15} \times \frac{9}{2\pi}\times 10^{15}\ eV = 5.93\ eV$$

Hence, energy of maximum energetic electron,

$$E = E_2 - \phi \quad (\phi = \text{work function})$$
$$= 5.93 - 2.50$$
$$= 3.43\ eV \approx 3.42\ eV$$

> ***Hint*** **: (i)** Compare with standard equation.
> **(ii)** Find maximum frequency using relation, frequency $= \frac{\omega}{2\pi}$
> **(iii)** Use Einstein's equation of photoelectric effect to find maximum kinetic energy i.e., $h\nu = K_{max} + \phi$.

> ***Shortcut*** **:** By Einstein's equation, we have:
> $h\nu = K_{max} + \phi$
> $\phi = h\nu - K_{max}$
> $= 4.14 \times 10^{-15} \times 1.43 \times 10^{15} - 2.5$
> $= 3.42\ eV$

7. Option (D) is correct.

Explanation: For a discharging capacitor, when energy reduces to half, then the charge would become $\frac{1}{\sqrt{2}}$ times of its initial value.

Now, $$\left(\frac{1}{2}\right)^{1/2} = e^{-t_1/\tau} \quad ...(1)$$

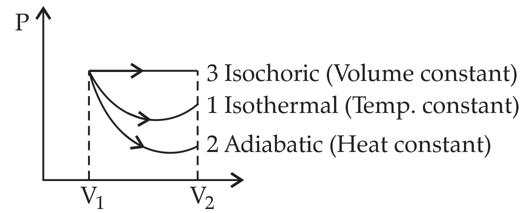
Similarly, $$\left(\frac{1}{2}\right)^{3} = e^{-t_2/\tau} \quad ...(2)$$

On dividing equation (1) by (2), we get:

$$\frac{t_1}{t_2} = \frac{1}{6}$$

8. Option (D) is correct.

Explanation:



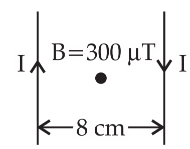
By considering the area under given figure, we have:

$$A_3 > A_1 > A_2$$

Hence, $$W_3 > W_1 > W_2$$

9. Option (B) is correct.

Explanation: As $B_{net} \neq 0$, hence the wires are carrying current in opposite directions.



$$2\times\frac{\mu_o I}{2\pi r} = B$$

$$\frac{\mu_o I\times 2}{2\pi\left(4\times 10^{-2}\right)} = 30 \times 10^{-6}$$

$$I = \frac{30\times 10^{-6}}{10^{-6}} = 30\ A$$

10. Option (B) is correct.

Explanation: By Kepler's III law of motion, we have:

$$T^2 \propto R^3$$

$$\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{R_1}{R_2}\right)^3$$

Hence, $$T_2^{\,2} = \left(\frac{R_2}{R_1}\right)^3 \times T_1^{\,2}$$

$$= \left(\frac{3R}{R}\right)^3 \times (7)^2$$
$$= 27 \times 49$$
$$= 1323$$
$$T = \sqrt{1323} = 36.37 \text{ hours}$$
$$\approx 36 \text{ hours}$$

> ***Hint:*** Remember Kepler's III law of motion & put given values.

11. Option (C) is correct.

Explanation: Let H' be the new height of antenna.

As the range of antenna, $d = \sqrt{2RH}$

Hence, $d_1 = d = \sqrt{2 \times R \times 125}$ ...(1)

$d_2 = 2d = \sqrt{2 \times R \times H'}$ ...(2)

On dividing (1) by (2), we get,

$$\frac{d}{2d} = \sqrt{\frac{125}{H'}}$$

By squaring the above equation, we get,

$$\frac{1}{4} = \frac{125}{H'}$$

$$H' = 500 \text{ m}$$

Hence, increase in height $= H' - H$

$= 500 - 125$

$= 375$ m

> ***Hint:*** The range of an antenna, $d = \sqrt{2RH}$, where R is the radius of the Earth.

12. Option (C) is correct.

Explanation: As the time period of SHM,

$T = 2\pi\sqrt{\frac{l}{g}}$ and, $\omega = \frac{2\pi}{T}$

Hence, $\omega = \frac{2\pi}{2\pi}\sqrt{\frac{g}{l}}$

$$\omega = \sqrt{\frac{g}{l}}$$

$$l = \frac{g}{\omega^2}$$

By comparing with above equation, we get;

$$\omega = \pi$$

Hence, $l = \frac{g}{\pi^2} \approx 99.4$ cm

> ***Hint:*** Remember the relation between ω, T, l and g.

13. Option (C) is correct.

Explanation: For given vessel, the total number of moles,

$$n = n_{H_2} + n_{O_2}$$

$$= \frac{16}{2} + \frac{128}{32}$$

$$= 8 + 4$$

$$= 12 \text{ moles}$$

Now, by using Ideal Gas Equation, we have;

$$PV = nRT$$

$$1 \times 10^5 \times V = 12 \times 8.314 \times 273$$

$$V = \frac{12 \times 8.314 \times 273}{10^5} \text{m}^3$$

$$\approx 27 \times 10^4 \text{ m}^3$$

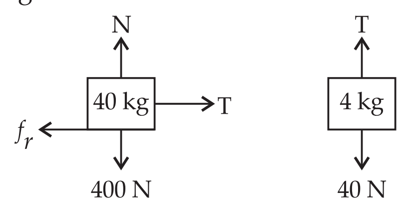
> ***Hint:*** **1.** Remember, number of moles $= \frac{\text{given weight}}{\text{Molecular weight}}$
>
> **2.** Apply Ideal Gas Equation.

14. Option (C) is correct.

Explanation: Statement I is correct while statement II is incorrect as electric field accelerates the particle in the direction of electric field i.e., $\vec{F} = q\vec{E} = m\vec{a}$ and magnetic field accelerates the particles perpendicular to the magnetic field i.e., $\vec{F} = q\vec{v} \times \vec{B} = m\vec{a}$

15. Option (D) is correct.

Explanation: The *FBD* (free body diagram) of given figure are as follows:



Hence, $f_r = \mu N$

$= 0.02 \times 400$

$= 8\ N$

Then, $40 - T = 4\,a$

$$a = \frac{32}{44} = \frac{8}{11} \text{m/s}^2$$

16. Option (D) is correct.

Explanation: By law of conservation of energy, loss in potential energy = gain in kinetic energy

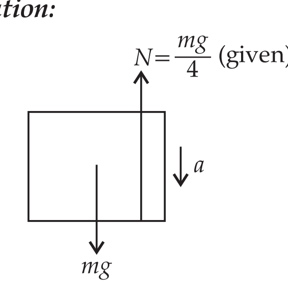
Hence, $-(mg\,(y - y_o) - mgy) = KE - 0$

$\Rightarrow \quad KE = mgy_o$

> ***Hint:*** Remember law of conservation of energy.

17. Option (C) is correct.

Explanation:



By using above figure and Newton's II law of motion, we have;

$$mg - \frac{mg}{4} = ma$$

$$\Rightarrow \quad g - \frac{g}{4} = a$$

$$\Rightarrow \quad a = \frac{3g}{4}$$

> ***Hint:*** Remember the direction of forces and acceleration.

18. Option (D) is correct.

Explanation: The relation between electric field E and potential difference V is, $E = \frac{-dV}{dx}$

Hence, $$\vec{E} = \frac{-dV}{dx}\text{I}$$

$$\vec{E} = -6x\hat{i}$$

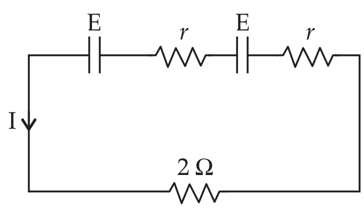
Hence, electric field $\vec{E}$ at (1, 0, 3) is

$$\vec{E} = 6\hat{i} \text{ V/m}$$

> ***Hint:*** Remember, the relation among potential difference and electric field.

19. Option (A) is correct.

Explanation: **Case A:** When cells are connected in series, then,

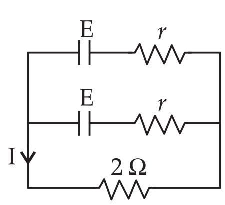


equivalent EMF, $E = 2E$

equivalent resistance, $r = 2r$

And, current, $I = \frac{E}{r+R} = \frac{2E}{2r+2}$ ...(1)

Case B: When cells are connected in parallel, then



equivalent EMF, $E = E$

equivalent resistance, $r = \frac{r}{2}$

And, current, $I = \frac{E}{r+R} = \frac{E}{\frac{r}{2}+2}$ ...(2)

As both current are same, hence both equations are equal, then,

$$\frac{2E}{2r+2} = \frac{E}{\frac{r}{2}+2}$$

$$r = 2\,\Omega$$

20. Option (B) is correct.

Explanation: For maximum range, $R = \frac{u^2}{g}$

Hence, $$\frac{u^2}{g} = 100$$

$$u^2 = 100\text{ g} \quad \ldots(1)$$

For maximum, height, $H = \frac{u^2}{2g}$ …(2)

By using equations (1) in (2), we have;

$$H = \frac{100g}{2g} = 50 \text{ m}$$

Section B

21. Correct answer is [180].

Explanation: Since the zero error is negative, we will have to add 0.05 cm

Now, the corrected diameter will be

$= 1.7\text{ cm} + 5 \times 0.1\text{ mm} + 0.05\text{ cm}$

$= 1.7\text{ cm} + 0.05\text{ cm} + 0.05\text{ cm}$

$= 1.8\text{ cm}$

$= 180 \times 10^{-2}\text{ cm}$

So the correct answer is 180 as per question.

22. Correct answer is [20].

Explanation: As the terminal speed,

$$v = \sqrt{2gh} = \frac{2}{9}\frac{r^2 g(\rho - \rho')}{\eta}$$

$$= \frac{2}{9} \times \frac{10^{-8} \times 10 \times 9000}{10^{-5}}$$

$$= \frac{2}{9} \times 9 \times 10$$

$$\sqrt{2gh} = 20$$

$$\Rightarrow \quad h = \frac{400}{2g}$$

$$h = 20 \text{ m}$$

23. Correct answer is [104].

Explanation: First resonance occurs when,

$$l_1 + e = \frac{\lambda}{4} \quad \ldots(1)$$

where, l_1 = length of air column and e = end correction.

$$\lambda = \frac{v}{\nu} = \frac{336}{400} = 0.84 \text{ m}$$

$$= 84 \text{ cm}$$

Hence, $l_1 + e = \frac{84}{4}$ (By using equation(1)

$$l_1 + e = 21$$

$$e = 21 - l_1$$

$$e = 21 - 20$$

$$e = 1 \text{ cm}$$

Third resonance will occur, when,

$$l_2 + e = \frac{5\lambda}{4}$$

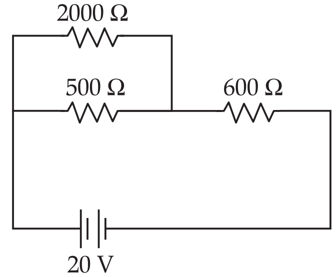
$$l_2 + 1 = 5 \times 21$$

$$l_2 = 105 - 1$$

$$l_2 = 104 \text{ cm}$$

24. Correct answer is [8].

Explanation: As per question the required figure will be as follow:



2000Ω and 500Ω are in parallel, hence,

$$\frac{1}{R} = \frac{1}{2000} + \frac{1}{500}$$

$$\frac{1}{R} = \frac{500 + 2000}{2000 \times 500}$$

$$\frac{1}{R} = \frac{2500}{1000000}$$

$$R = 400\Omega$$

This R and 600 Ω are in series, hence, the net resistance,

$$R = 400 + 600$$

$$R = 1000 \ \Omega$$

$$\text{Circuit current, } I = \frac{20}{600 + 400} = \frac{20}{1000}$$

$$I = \frac{1}{50} \text{ A}$$

Now, the reading of the voltmeter,

$$V = IR \quad \ldots(1)$$

$$V = \frac{1}{50} \times 400$$

$$V = 8 \text{ volts}$$

25. Correct answer is [14].

Explanation: By using Work-Energy theorem, we have,

$$W = K_{\text{initial}} - K_{\text{final}}$$

$$qV = \frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2$$

$$1.6 \times 10^{-19} \times 0.4 = \frac{1}{2}m[v_i^2 - v_f^2]$$

$$1.6 \times 10^{-19} \times 0.4 = \frac{1}{2} \times 9 \times 10^{-31} \times \left[36 \times 10^{10} - \frac{x^2}{9} \times 10^{10}\right]$$

$$1.6 \times 0.4 \times 10^{-19} = \frac{1}{2} \times 9 \times 10^{-31} \times 10^{10} \times \left[36 - \frac{x^2}{9}\right]$$

$$\Rightarrow \quad \left[36 - \frac{x^2}{9}\right] = \frac{1.6 \times 0.4 \times 10^{-19} \times 2}{9 \times 10^{-31} \times 10^{10}}$$

$$\Rightarrow \quad \frac{324 - x^2}{9} = \frac{1.6 \times 0.4 \times 2 \times 10^2}{9}$$

$$\Rightarrow \quad 324 - x^2 = 128$$

$$\Rightarrow \quad x^2 = 196$$

$$x = \pm 14$$

Hence, $x = 14$ m/s, as speed can't be negative.

26. Correct answer is [8].

Explanation: As the displacement current,

$$I_d = \varepsilon_0 \frac{d\phi_E}{dt}$$

$$I_d = \varepsilon_0 \frac{d}{dt}(EA)$$

$$I_d = \frac{\varepsilon_0 A}{d} \times \frac{dV}{dt}$$

$$4.425 \times 10^{-6} = \frac{8.85 \times 10^{-12} \times 40 \times 10^{-4} \times 10^6}{d}$$

$$d = \frac{8.85 \times 40 \times 10^{-10}}{4.425 \times 10^{-6}}$$

$$d = 8 \times 10^{-3} \text{ m}$$

Hence, $x = 8$

27. Correct answer is [8].

Let 'l' be the length of rod and 'r' be the radius of the ring.

Explanation:

$$I_1 = \frac{ml^2}{3}$$

$$I_2 = \frac{mr^2}{2}$$

$$\& \ 2\pi r = l$$

Hence,
$$I_2 = \frac{m\left(\frac{l}{2\pi}\right)^2}{2}$$

So,
$$\frac{I_1}{I_2} = \frac{\frac{ml^2}{3}}{\frac{ml^2}{4\pi^2 \times 2}}$$

$$\frac{I_1}{I_2} = \frac{ml^2}{3} \times \frac{4\pi^2 \times 2}{ml^2}$$

$$\frac{I_1}{I_2} = \frac{8}{3}\pi^2$$

Hence, $x = 8$

28. Correct answer is [20].

Explanation: As, $\frac{N}{N_0} = \left[\frac{1}{2}\right]^{\frac{T}{T_{1/2}}}$

$$\Rightarrow \quad \frac{6.25}{100} = \left[\frac{1}{2}\right]^{\frac{x}{5}}$$

$$\Rightarrow \quad \frac{1}{16} = \left[\frac{1}{2}\right]^{\frac{x}{5}}$$

$$\Rightarrow \quad \left[\frac{1}{2}\right]^4 = \left[\frac{1}{2}\right]^{\frac{x}{5}}$$

$$\frac{x}{5} = 4$$

$$x = 20 \text{ years}$$

29. Correct answer is [600].

Explanation: Fringe width,

$$\beta = \frac{\lambda D}{d}$$

$$\Rightarrow \quad 3 \times 10^{-5} = \frac{\lambda \times 5 \times 10^{-2}}{1 \times 10^{-3}}$$

$$\Rightarrow \quad \lambda = \frac{3 \times 10^{-5} \times 10^{-3}}{5 \times 10^{-2}}$$

$$\lambda = 0.6 \times 10^{-6} \text{ m}$$

$$\Rightarrow \quad \lambda = 600 \times 10^{-9} \text{ nm}$$

Hence, the required answer is 600

30. Correct answer is [5].

Explanation: Frequency,

$$f = \frac{1}{2\pi\sqrt{LC}}$$, where, L = Inductance
C = Capacitance

$$f = \frac{1}{2 \times 3.14\sqrt{0.5 \times 10^{-3} \times 200 \times 10^{-6}}}$$

$$f = \frac{1}{2 \times 3.14} \times \frac{10^4}{\sqrt{10}}$$

$$f = 5.03 \times 10^2 \text{ Hz}$$

$$f \approx 5.0 \times 10^2 \text{ Hz}$$

Hence, required answer is 5.

JEE (Main) PHYSICS SOLVED PAPER

2021

24^{th} February 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. Four identical particles of equal masses 1 kg made to move along the circumference of a circle of radius 1 m under the action of their own mutual gravitational attraction. The speed of each particle will be :

(1) $\sqrt{\frac{(1+2\sqrt{2})G}{2}}$ **(2)** $\sqrt{G(1+2\sqrt{2})}$

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

Q. 2. Consider two satellites S_1 and S_2 with periods of revolution 1 hr, and 8 hr, respectively revolving around a planet in circular orbits. The ratio of angular velocity of satellite S_1 to the angular velocity of satellite S_2 is

(1) 8 : 1 **(2)** 1 : 8
(3) 2 : 1 **(4)** 1 : 4

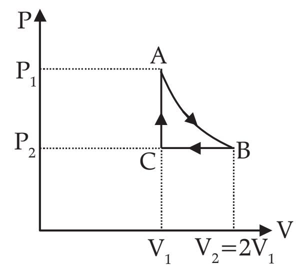
Q. 3. *n* mole of a perfect gas undergoes a cyclic process ABCA (see figure) consisting of the following processes –

$A \rightarrow B$: Isothermal expansion at temperature T so that the volume is doubled from V_1 to $V_2 = 2V_1$ and pressure changes from P_1 to P_2.

$B \rightarrow C$: Isobaric compression at pressure P_2 to initial volume V_1.

$C \rightarrow A$: Isochoric change leading to change of pressure from P_2 to P_1.

Total workdone in the complete cycle ABCA is :



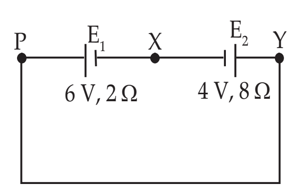
(1) 0 **(2)** $nRT\left(\ln 2+\frac{1}{2}\right)$

(3) $nRT \ln 2$ **(4)** $nRT\left(\ln 2-\frac{1}{2}\right)$

Q. 4. Two equal capacitors are first connected in series and then in parallel. The ratio of the equivalent capacities in the two cases will be :

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

Q. 5. A cell E_1 of emf 6 V and internal resistance 2 Ω is connected with another cell E_2 of emf 4 V and internal resistance 8 Ω (as shown in the figure). The potential difference across points X and Y is



(1) 3.6 V **(2)** 10.0 V
(3) 5.6 V **(4)** 2.0 V

Q. 6. If Y, K and η are the values of Young's modulus, bulk modulus and modulus of rigidity of any material respectively. Choose the correct relation for these parameters.

(1) $K = \dfrac{Y\eta}{9\eta - 3Y} N/m^2$

(2) $\eta = \dfrac{3YK}{9K + Y} N/m^2$

(3) $Y = \dfrac{9K\eta}{3K - \eta} N/m^2$

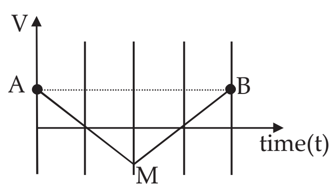
(4) $Y = \dfrac{9K\eta}{2\eta + 3K} N/m^2$

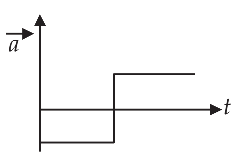
Q. 7. Two stars of masses m and $2m$ at a distance d rotate about their common centre of mass in free space. The period of revolution is

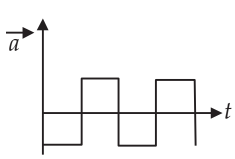
(1) $2\pi\sqrt{\dfrac{d^3}{3Gm}}$ **(2)** $\dfrac{1}{2\pi}\sqrt{\dfrac{3Gm}{d^3}}$

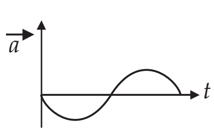
(3) $\dfrac{1}{2\pi}\sqrt{\dfrac{d^3}{3Gm}}$ **(4)** $2\pi\sqrt{\dfrac{3Gm}{d^3}}$

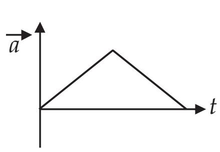
Q. 8. If the velocity-time graph has the shape AMB, what would be the shape of the corresponding acceleration-time graph ?



(1)


(2)


(3)


(4)


Q. 9. Given below are two statements :

Statement – I: Two photons having equal linear momenta have equal wavelengths.

Statement-II: If the wavelength of photon is decreased, then the momentum and energy of a photon will also decrease.

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

(1) Statement-I is false but Statement-II is true
(2) Both Statement-I and Statement-II are true
(3) Both Statement-I and Statement-II are false
(4) Statement-I is true but Statement-II is false

Q. 10. A current through a wire depends on time as $i = \alpha_0 t + \beta t^2$

Where $\alpha_0 = 20$ A/s and $\beta = 8$ As^{-2}. Find the charge crossed through a section of the wire in 15 s.

(1) 2100 C **(2)** 260 C
(3) 2250 C **(4)** 11250 C

Q. 11. Match List I with List II

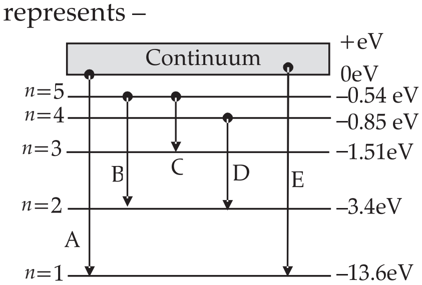
List-I	List-II
(a) Isothermal	(i) Pressure constant
(b) Isochoric	(ii) Temperature constant
(c) Adiabatic	(iii) Volume constant
(d) Isobaric	(iv) Heat content is constant

Choose the correct answer from the options given below :

(1) (a) – (ii), (b) – (iv), (c) – (iii), (d) – (i)
(2) (a) – (ii), (b) – (iii), (c) – (iv), (d) – (i)
(3) (a) – (i), (b) – (iii), (c) – (ii), (d) – (iv)
(4) (a) – (iii), (b) – (ii), (c) – (i), (d) – (iv)

Q. 12. In the given figure, the energy levels of hydrogen atom have been shown along with some transitions marked A, B, C, D and E.

The transitions A, B and C respectively represents –



(1) The series limit of Lyman series, third member of balmer series and second member of paschen series

(2) The first member of the Lyman series, third member of Balmer series and second member of paschen series

(3) The ionization potential of hydrogen, second member of Balmer series and third member of Paschen series

(4) The series limit of Lyman series, second member of Balmer series and second member of Paschen series.

Q. 13. The focal length f is related to the radius of curvature r of the spherical convex mirror by

(1) $f = r$ **(2)** $f = -\frac{1}{2}r$

(3) $f = +\frac{1}{2}r$ **(4)** $f = -r$

Q. 14. Moment of inertia (M.I.) of four bodies, having same mass and radius, are reported as:

I_1 = M.I. of thin circular ring about its diameter,

I_2 = M.I. of circular disc about an axis perpendicular to disc and going through the centre,

I_3 = M.I. of solid cylinder about its axis and

I_4 = M.I. of solid sphere about its diameter.

Then –

(1) $I_1 = I_2 = I_3 < I_4$ **(2)** $I_1 + I_2 = I_3 + \frac{5}{2}I_4$

(3) $I_1 + I_3 < I_2 + I_4$ **(4)** $I_1 = I_2 = I_3 > I_4$

Q. 15. The workdone by a gas molecule in an isolated system is given by, $W = \alpha\beta^2 e^{-\frac{x^2}{\alpha kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature. α and β are constants. Then the dimensions of β will be:

(1) $[M^0LT^0]$ **(2)** $[M^2LT^2]$

(3) $[MLT^{-2}]$ **(4)** $[ML^2T^{-2}]$

Q. 16. If an emitter current is changed by 4 mA, the collector current changes by 3.5 mA. The value of β will be:

(1) 7 **(2)** 0.875

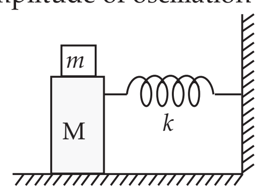
(3) 0.5 **(4)** 3.5

Q. 17. In a Young's double slit experiment, the width of the one of the slit is three times the other slit. The amplitude of the light coming from a slit is proportional to the slit-width. Find the ratio of the maximum to the minimum intensity in the interference pattern.

(1) 4 : 1 **(2)** 2 : 1

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

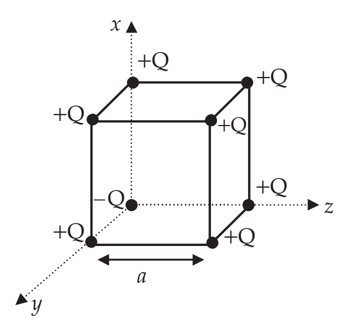
Q. 18. In the given figure, a mass M is attached to a horizontal spring which is fixed on one side to a rigid support. The spring constant of the spring is k. The mass oscillates on a frictionless surface with time period T and amplitude A. When the mass is in equilibrium position, as shown in the figure, another mass m is gently fixed upon it. The new amplitude of oscillation will be:



(1) $A\sqrt{\frac{M}{M+m}}$ **(2)** $A\sqrt{\frac{M}{M-m}}$

(3) $A\sqrt{\frac{M-m}{M}}$ **(4)** $A\sqrt{\frac{M+m}{M}}$

Q. 19. A cube of side 'a' has point charges +Q located at each of its vertices except at the origin where the charge is – Q. The electric field at the centre of cube is



(1) $\frac{2Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(2) $\frac{Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(3) $\frac{-2Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(4) $\frac{-Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

Q. 20. Each side of a box made of metal sheet in cubic shape is 'a' at room temperature 'T', the coefficient of linear expansion of the metal sheet is 'α'. The metal sheet is heated uniformly, by a small temperature ΔT, so that its new temeprature is $T + \Delta T$. Calculate the increase in the volume of the metal box

(1) $\frac{4}{3}\pi a^3 \alpha \Delta T$ (2) $4\pi a^3 \alpha \Delta T$

(3) $3a^3 \alpha \Delta T$ (4) $4a^3 \alpha \Delta T$

Section B

Q. 21. A resonance circuit having inductance and resistance 2×10^{-4} H and 6.28 Ω respectively oscillates at 10 MHz frequency. The value of quality factor of this resonator is________. [$\pi = 3.14$]

Q. 22. A ball with a speed of 9 m/s collides with another identical ball at rest. After the collision, the direction of each ball makes an angle of 30° with the original direction. The ratio of velocities of the balls after collision is $x : y$, where x is _________.

Q. 23. An audio signal $v_m = 20\sin 2\pi(1500t)$ amplitude modulates a carrier $v_c = 80 \sin 2\pi\,(100{,}000t)$. The value of percent modulation is ________.

Q. 24. The coefficient of static friction between a wooden block of mass 0.5 kg and a vertical rough wall is 0.2. The magnitude of horizontal force that should be applied on the block to keep it adhered to the wall will be ______ N. [$g = 10\ \text{ms}^{-2}$]

Q. 25. An inclined plane is bent in such a way that the vertical cross-section is given by $y = \frac{x^2}{4}$ where y is in vertical and x in horizontal direction. If the upper surface of this curved plane is rough with coefficient of friction $\mu = 0.5$, the maximum height in cm at which a stationary block will not slip downward is _____ cm.

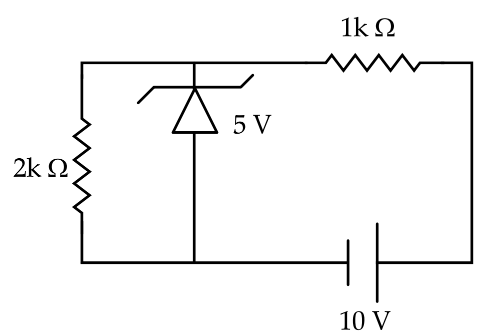
Q. 26. An electromagnetic wave of frequency 5 GHz, is travelling in a medium whose relative electric permittivity and relative magnetic permeability both are 2. Its velocity in this medium is _______ $\times 10^7$ m/s.

Q. 27. A hydraulic press can lift 100 kg when a mass 'm' is placed on the smaller piston. It can lift _______ kg when the diameter of the larger piston is increased by 4 times and that of the smaller piston is decreased by 4 times keeping the same mass 'm' on the smaller piston.

Q. 28. A common transistor radio set requires 12 V (D.C.) for its operation. The D.C. source is constructed by using a transformer and a rectifier circuit, which are operated at 220 V (A.C.) on standard domestic A.C. supply. The number of turns of secondary coil are 24, then the number of turns of primary are ________.

Q. 29. An unpolarized light beam is incident on the polarizer of a polarization experiment and the intensity of light beam emerging from the analyzer is measured as 100 Lumens. Now, if the analyzer is rotated around the horizontal axis (direction of light) by 30° in clockwise direction, the intensity of emerging light will be________ Lumens.

Q. 30. In connection with the circuit drawn below, the value of current flowing through 2 kΩ resistor is _______ $\times 10^{-4}$ A.



□□□

Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	1	The Universal Law of Gravitation	Gravitation
2	1	Orbital Velocity of a Satellite	Gravitation
3	4	Work and Internal Energy	Thermodynamics
4	2	The Combination of Capacitors in Series and Parallel	Electrostatics
5	3	Potential Difference and EMF of a Cell	Current Electricity
6	1	Young's Modulus, Bulk Modulus, Modulus of Rigidity	Properties of Solids and Liquids Elastic
7	1	Centripetal Force and its applications	Laws of Motion
8	1	Velocity-Time, Position-Time Graph	Kinematics
9	4	Matter Waves-Wave Nature of Particle	Dual Nature of Matter and Radiation
10	4	Electric Current	Current Electricity
11	2	The Second Law of Thermodynamics Reversible and Irreversible Processes	Thermodynamics
12	1	Hydrogen Spectrum	Atoms and Nuclei
13	3	Mirror Formula	Optics
14	4	Moment of Inertia	Rotational Motion
15	3	Dimensional analysis and its Applications	Physics and Measurement
16	1	Characteristics of a Transistor: Transistor as an amplifier (Common Emitter Configuration) and Oscillator	Electronic Devices
17	1	Young's Double-Slit Experiment and Expression For Fringe Width	Wave Optics
18	1	Spring -Restoring Force and Force Constant: Energy in S.H.M. - Kinetic and Potential Energies	Oscillations and Waves
19	3	Electric Field: Electric Field due to a Point Charge	Electrostatics
20	3	Thermal Expansion	Properties of Solids and Liquids
21	2000	Quality Factor	Electromagnetic Induction and alternating Currents
22	1	Law of Conservation of Linear Momentum and its applications	Laws of Motion
23	25	Amplitude and Frequency Modulation	Communication Systems
24	25	Static and Kinetic Friction	Laws of Motion
25	25	Static and Kinetic Friction, Laws of Friction	Laws of Motion
26	15	Electromagnetic Waves and Their Characteristics, Transverse Nature of Electromagnetic Waves	Electromagnetic Waves
27	25600	Pascal's Law and its applications	Properties of Solids and Liquids Elastic
28	440	AC Generator and Transformer	Electromagnetic Induction and Alternating Currents
29	75	Polarization	Wave Optics
30	25	Zener Diode as a Voltage Regulator	Electronic Devices

JEE (Main) PHYSICS SOLVED PAPER

2021

24th February Shift 1

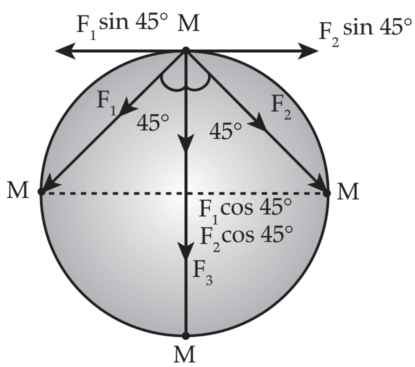
ANSWERS WITH EXPLANATIONS

Physics

Section A

1. Option (4) is correct.

There are three gravitational forces on each masses.



So, $F_g = F_1 \cos 45° + F_2 \cos 45° + F_3$

$$\Rightarrow \quad F_g = \frac{2GMM}{\left(R\sqrt{2}\right)^2} \cos 45° + \frac{GMM}{(2R)^2}$$

$$\Rightarrow \quad F_g = \frac{2GMM}{\left(2R^2\sqrt{2}\right)} + \frac{GMM}{4R^2}$$

$$\Rightarrow \quad F_g = \frac{GM^2}{R^2}\left(\frac{1}{\sqrt{2}} + \frac{1}{4}\right)$$

This gravitational force will be balanced by centripetal force.

Hence, $$\frac{GM^2}{R^2}\left(\frac{1}{\sqrt{2}} + \frac{1}{4}\right) = \frac{Mv^2}{R}$$

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

$$\Rightarrow \quad v = \sqrt{\frac{GM}{R}\left(\frac{1}{4} + \frac{1}{\sqrt{2}}\right)}$$

As per the question,

$M = 1$ kg

$R = 1$ m

So, $$v = \sqrt{G\left(\frac{1}{4} + \frac{1}{\sqrt{2}}\right)}$$

$$\Rightarrow \quad v = \sqrt{\frac{G\left(1+2\sqrt{2}\right)}{4}}$$

$$\Rightarrow \quad v = \frac{1}{2}\sqrt{G\left(1+2\sqrt{2}\right)}$$

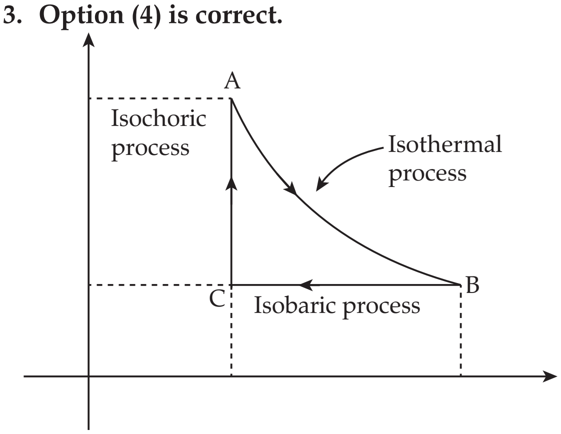
2. Option (1) is correct.

Let time period of revolutions are $T_1 = 1$ hr and $T_2 = 8$ hr

Since, $T \propto \frac{1}{\omega}$

$$\Rightarrow \quad \frac{\omega_1}{\omega_2} = \frac{T_2}{T_1} = \frac{8}{1}$$

3. Option (4) is correct.



As A → B is isothermal process

$$\Rightarrow \quad W_{AB} = nRT \ln\left(\frac{V_2}{V_1}\right)$$

$$= nRT \ln\left(\frac{2V_1}{V_1}\right)$$

$$= nRT \ln (2)$$

As B → C is isobaric process

$$\Rightarrow \quad W_{BC} = P \,\Delta V$$

$$= nR \,\Delta T$$

$$= nR\left(\frac{T}{2} - T\right)$$

$$= -nR\frac{T}{2}$$

As C → A is isochoric process

⇒ $W_{CA} = 0$

Work done by gas in complete cycle ABCA

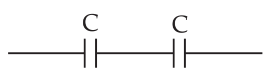
$$W = W_{AB} + W_{BC} + W_{CA}$$

$$= nRT\ln(2) + \left(-nR\frac{T}{2}\right) + 0$$

$$W = nRT\left(\ln(2) - \frac{1}{2}\right)$$

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

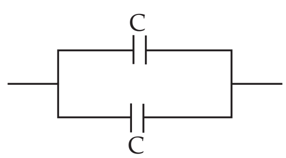
Case I : Series connection,



$$\frac{1}{C_1} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C}$$

$$\Rightarrow \quad C_1 = \frac{C}{2}$$

Case II : Parallel connection,

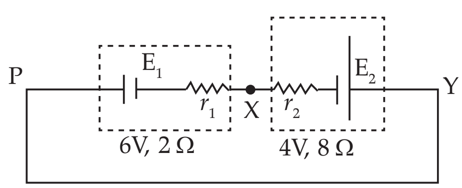


$$C_2 = C + C$$
$$= 2C$$

Hence, the required ratio,

$$\frac{C_1}{C_2} = \frac{1}{4}$$

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



$$E_1 = 6\text{ V}$$
$$r_1 = 2\,\Omega$$
$$E_2 = 4\text{ V}$$
$$r_2 = 8\,\Omega$$
$$R_{eq} = r_1 + r_2 = 8\,\Omega + 2\,\Omega$$
$$= 10\,\Omega$$

$$E_{eq} = E_1 - E_2$$
$$E_{eq} = (6 - 4)\text{ V}$$
$$E_{eq} = 2\text{ V}$$
$$I = \frac{E_{eq}}{R_{eq}} = \frac{2\text{ V}}{10\,\Omega}$$
$$I = 0.2\text{ A}$$

Hence, the potential difference across X and Y

$$V = E_2 + Ir_2$$

(∵ direction of flow of current is anti clock)

$$\Rightarrow \quad V = 4 + 0.2 \times 8$$
$$\Rightarrow \quad V = (4 + 1.6)\text{ V}$$
$$\Rightarrow \quad V = 5.6\text{ V}$$

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

Given,

Young's modulus = Y

Bulk modulus = K

Modulus of rigidity = η

We know, relation between young modulus and bulk modulus,

$$Y = 3K(1 - 2\sigma)$$

$$\Rightarrow \quad 1 - 2\sigma = \frac{Y}{3K}$$

$$\Rightarrow \quad \sigma = \frac{1}{2}\left(1 - \frac{Y}{3K}\right) \qquad \text{...(i)}$$

And, relation between young modulus and modulus of rigidity,

$$Y = 2\eta(1 + \sigma)$$

$$\Rightarrow \quad \sigma = \frac{Y}{2\eta} - 1 \qquad \text{...(ii)}$$

From equation (i) and (ii)

$$\frac{1}{2}\left(1 - \frac{Y}{3K}\right) = \frac{Y}{2\eta} - 1$$

$$\Rightarrow \quad \frac{Y}{2\eta} + \frac{Y}{6K} = \frac{1}{2} + 1$$

$$\Rightarrow \quad \frac{Y}{2\eta} + \frac{Y}{6K} = \frac{3}{2}$$

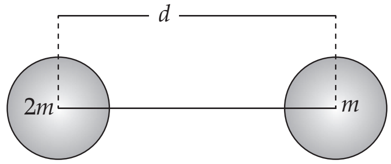
$$\Rightarrow \quad \frac{1}{6K} = \frac{3}{2Y} - \frac{1}{2\eta}$$

$$\Rightarrow \quad \frac{1}{6K} = \frac{3\eta - Y}{2Y\eta}$$

$$\Rightarrow \quad K = \frac{2Y\eta}{6(3\eta - Y)} = \frac{Y\eta}{9\eta - 3Y}$$

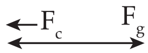
$$\Rightarrow \quad K = \frac{Y\eta}{9\eta - 3Y}\text{ N/m}^2$$

7. Option (1) is correct.



$$X_{com} = \frac{2m \times 0 + m.d}{2m + m} = \frac{d}{3}$$

Now, applying force balance equation



$$F_c = F_g$$

$$\Rightarrow \quad \frac{(2m)v^2}{X_{com}} = \frac{G(2m)\cdot m}{d^2}$$

$$\Rightarrow \quad \frac{2m\left(\omega\frac{d}{3}\right)^2}{\left(\frac{d}{3}\right)} = \frac{2Gm^2}{d^2}$$

$$\Rightarrow \quad \omega^2 = \frac{\frac{2Gm^2}{d^2}}{2m\frac{d}{3}}$$

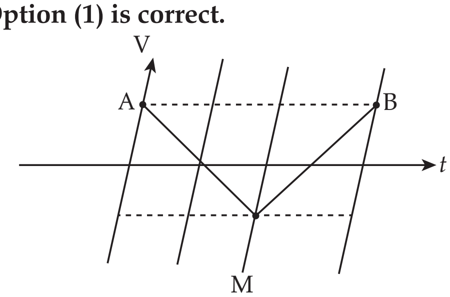
$$\Rightarrow \quad \omega = \sqrt{\frac{2Gm^2}{d^2\cdot 2} \times \frac{3}{md}}$$

$$\Rightarrow \quad \omega = \sqrt{\frac{3Gm}{d^3}}$$

$$\Rightarrow \quad \frac{2\pi}{T} = \sqrt{\frac{3Gm}{d^3}}$$

$$\Rightarrow \quad T = 2\pi\sqrt{\frac{d^3}{3Gm}}$$

8. Option (1) is correct.



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

So, a can be positive and negative.

If a is positive, then

$$v = mt + c$$

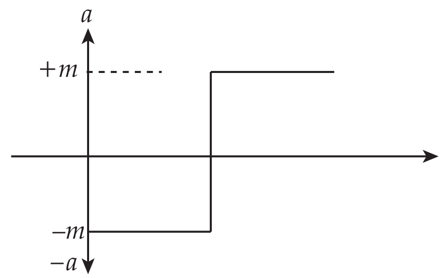
If a is negative, then

$$\Rightarrow \quad v = -mt + c$$

So, $\frac{dv}{dt} = m$ for $a > 0$

and $\frac{dv}{dt} = -m$ for $a < 0$

Hence,



9. Option (4) is correct.

Linear momentum of photon

$$p = \frac{h}{\lambda}$$

Energy of a photon

$$E = \frac{hc}{\lambda}$$

So, Two photons having equal linear momenta have equal wavelengths and if we will decrease the wavelength, then momentum and energy of the photon will increase.

Hence, statement (I) is true and statement (II) is false.

10. Option (4) is correct.

Given,

$$i = \alpha_0 t + \beta t^2$$

$$\Rightarrow \quad \frac{dQ}{dt} = \alpha_0 t + \beta t^2$$

$$\Rightarrow \quad dQ = (\alpha_0 t + \beta t^2)\, dt$$

Now, integrating both sides with respect to their limits.

$$\int_0^Q dQ = \int_0^t \left(\alpha_0 t + \beta t^2\right) dt$$

$$\Rightarrow \quad Q = \left[\frac{\alpha_0 t^2}{2} + \frac{\beta t^3}{3}\right]_0^t$$

$$\Rightarrow \quad Q = \frac{\alpha_0 t^2}{2} + \frac{\beta t^3}{3}$$

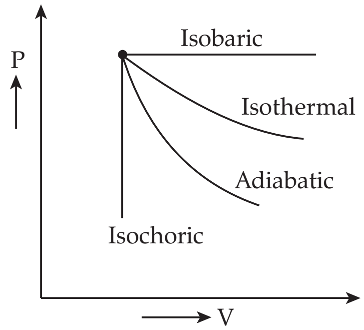
Now, substituting the given values,

$$Q = \frac{20 \times 15^2}{2} + \frac{8 \times 15^3}{3}$$

$$Q = \left(2250 + \frac{225 \times 15 \times 8}{3}\right)C$$

$$\Rightarrow \quad Q = (2250 + 9000)\ C = 11250\ C$$

11. Option (2) is correct.



Hence, from the above diagram, we can conclude that,

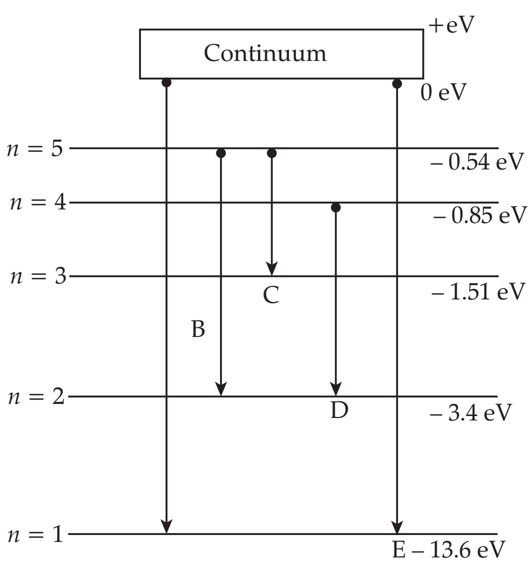
Isothermal – Temperature constant

Isobaric – Pressure is constant

Isochoric – Volume is constant

Adiabatic – $\Delta Q = 0$, Heat content is constant

12. Option (1) is correct.



<u>For transition A,</u>

$$n_1 > 5$$
$$n_2 = 1$$

Hence, it is the series limit of lyman series.

<u>For the transition of B,</u>

$$n_1 = 5$$
$$n_2 = 2$$

Hence, it represents the third member of balmer series.

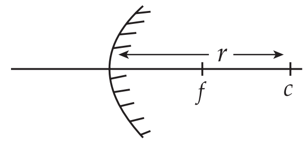
<u>For the transition C,</u>

$$n_1 = 5$$
$$n_2 = 3$$

Hence, it represents the second member of paschen series.

13. Option (3) is correct.

For spherical convex mirror

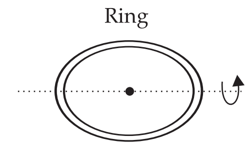


$$f = +\frac{r}{2}$$

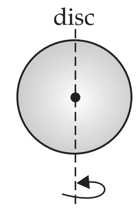
14. Option (4) is correct.

Let the masses of 4 bodies are M and radius = R

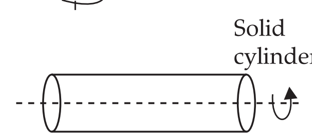
$$I_1 = \frac{1}{2}MR^2$$



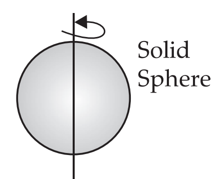
$$I_2 = \frac{1}{2}MR^2$$



$$I_3 = \frac{1}{2}MR^2$$



$$I_4 = \frac{2}{5}MR^2$$



So, $I_1 = I_2 = I_3 > I_4$

15. Option (3) is correct.

Given,

$$W = \alpha\beta^2 e^{-\frac{x^2}{\alpha kT}}$$

We know that exponents are dimensionless quantities

So, $$\frac{x^2}{\alpha kT} = [M^0L^0T^0]$$

$$\Rightarrow \quad \frac{[L^2]}{\alpha[ML^2T^{-2}K^{-1}][K]} = [M^0L^0T^0]$$

$$\Rightarrow \quad \alpha = [M^{-1}T^2]$$

Dimension of work = $[ML^2T^{-2}]$

$$\Rightarrow \quad \alpha\beta^2 = [ML^2T^{-2}]$$

$$\Rightarrow \quad \beta^2[M^{-1}T^2] = [ML^2T^{-2}]$$

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

$$\Rightarrow \quad \beta^2 = [M^2 T^{-4} L^2]$$
$$\beta = [MT^{-2} L]$$
$$\beta = [M L T^{-2}]$$

16. Option (1) is correct.

Given,

$$\text{Emitter current } (I_E) = 4 \text{ mA}$$
$$\text{Collector current } (I_C) = 3.5 \text{ mA}$$
$$\beta = ?$$
$$I_B = I_E - I_C$$
$$= (4 - 3.5)\text{mA}$$
$$= 0.5 \text{ mA}$$
$$\beta = \frac{I_C}{I_B} = \frac{3.5}{0.5}$$
$$= 7$$

17. Option (1) is correct.

Given,

Let the width of the slit be ω

So, $\omega_1 = 3\omega_2$

Since, $A \propto \omega$

Ratio of maximum to minimum intensity

$$\frac{I_{max}}{I_{min}} = ?$$

$$I = A_1^2 + A_2^2 + 2A_1A_2 \cos\phi$$

For maximum intensity $\cos\phi = 1$

For minimum intensity $\cos\phi = -1$

So, $I_{max} = (A_1 + A_2)^2$

$I_{min} = (A_1 - A_2)^2$

Since, $A_1 = A$ and $A_2 = 3A$

So, $\dfrac{A_1}{A_2} = \dfrac{\omega_1}{\omega_2}$

Hence, $\dfrac{I_{max}}{I_{min}} = \dfrac{(A+3A)^2}{(A-3A)^2}$

$$\Rightarrow \frac{I_{max}}{I_{min}} = \frac{(4A)^2}{(-2A)^2}$$

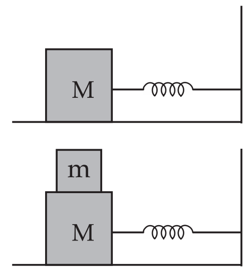
$$\Rightarrow \frac{I_{max}}{I_{min}} = \frac{16}{4} = \frac{4}{1}$$

Hence $\dfrac{I_{max}}{I_{min}} = \dfrac{4}{1}$

18. Option (1) is correct.

As per the condition, there is are no impulsive forces, so momentum always be conserve.

$$MA\left(\frac{2\pi}{T_1}\right) = (m+M)A_1\left(\frac{2\pi}{T_2}\right) \qquad \text{...(i)}$$



$$T_1 = 2\pi\sqrt{\frac{M}{K}}$$

$$T_2 = 2\pi\sqrt{\frac{M+m}{K}}$$

Now, substituting the value of T_1 and T_2 in equation (i).

$$MA\left(\frac{2\pi}{2\pi\sqrt{\frac{M}{K}}}\right) = (m+M)A_1\left(\frac{2\pi}{2\pi\sqrt{\frac{M+m}{K}}}\right)$$

$$\Rightarrow \quad A_1 = \frac{MA\sqrt{\frac{K}{M}}}{(m+M)\sqrt{\frac{K}{M+m}}}$$

$$\Rightarrow \quad A_1 = A\sqrt{\frac{M}{M+m}}$$

19. Option (3) is correct.

For the reduction of the problem, we can replace –Q charge at origin by +Q and –2Q.

Now, the electric field due to +Q charge of the corners at the centre of the cube will be zero.

Hence, the net electric field at the centre due to –2Q charge of the origin will work.

$$\vec{E} = \frac{kq\vec{r}}{r^3} = \frac{1(-2Q)\frac{a}{2}(\hat{x}+\hat{y}+\hat{z})}{4\pi\varepsilon_0\left(\frac{a}{2}\sqrt{3}\right)^3}$$

$$\vec{E} = \frac{-2Q(\hat{x}+\hat{y}+\hat{z})}{3\sqrt{3}\pi a^2\varepsilon_0}$$

20. Option (3) is correct.

Length of metal sheet of cube = a

Room temperature = T

Coefficient of liner expansion of metal sheet = α

Increase in temperature = ΔT

New temperature = $T + \Delta T$

Now, $\Delta V = V \cdot \gamma \cdot \Delta T$

$\Rightarrow \quad \Delta V = a^3 \cdot \gamma \cdot \Delta T$

$\Rightarrow \quad \Delta V = a^3 (3\alpha) \cdot \Delta T \qquad (\because \gamma = 3\alpha)$

$\Rightarrow \quad \Delta V = 3a^3 \alpha \Delta T$

Section B

21. Correct answer is [2000].

Inductance (L) = 2×10^{-4} H

Resistance (R) = 6.28 Ω

Frequency of oscillation (f) = 10 MHz

Quality factor (Q) = ?

$\Rightarrow \quad Q = \frac{X_L}{R}$

$\Rightarrow \quad Q = \frac{\omega L}{R}$

$\Rightarrow \quad Q = \frac{2\pi f L}{R} = \frac{2\pi \times 10 \times 10^6 \times 2 \times 10^{-4}}{6.28}$

$\Rightarrow \quad Q = 2000$

Hence, the value of quality factor for resonator be 2000.

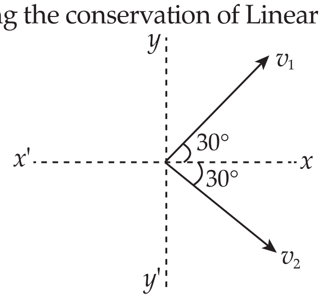
22. Correct answer is [1].

As per question, the balls are identical, so, $m_1 = m_2 = m$

Initial speed of first ball $u_1 = 9$ m/s

Initial speed of second ball $u_2 = 0$

Applying the conservation of Linear Momentum



Momentum along y – axis

$$0 = mv_1 \sin 30° - mv_2 \sin 30°$$

$$v_1 = v_2 \Rightarrow v_1 : v_2 = 1 : 1$$

Momentum along x – axis

$$mu_1 + 0 = mv_1 \cos 30° + mv_2 \cos 30°$$

or, $9 = v_1 \times \frac{\sqrt{3}}{2} + v_1 \times \frac{\sqrt{3}}{2}$

or, $\quad v_1 = v_2 = 3\sqrt{3}$

$\Rightarrow v_1 : v_2 = 1 : 1$

Hence, the ratio of velocities of ball after collision is $x : y = 1 : 1$, where $x = 1$.

23. Correct answer is [25].

$v_m = 20 \sin 2\pi(1500t)$;

$v_c = 80 \sin 2\pi\,(100{,}000t)$

Percent modulation = ?

Modulation index $= \frac{A_m}{A_c}$

$= \frac{20}{80}$

$= \frac{1}{4}$

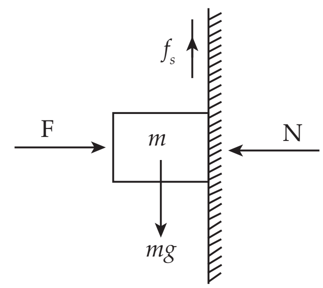
Hence, value of percent modulation index

$= \frac{1}{4} \times 100$

$= 25\ \%$

24. Correct answer is [25].

Applying force balance equation in vertical and horizontal direction.



Force balance in vertical direction

$f_s = mg \qquad$ ...(i)

$F = N \qquad$ ...(ii)

From equation (i) and (ii)

$f_s = \mu N = mg$

$N = \frac{mg}{\mu} = \frac{0.5 \times 10}{0.2}$

$F = N = 25$ N

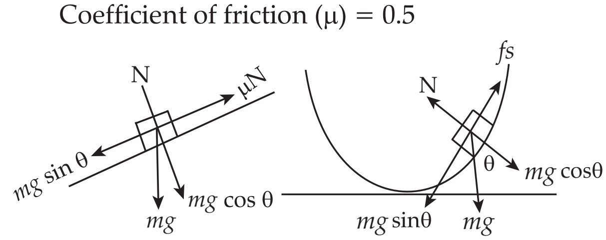
Hence, the magnitude of horizontal force be 25 N

25. Correct answer is [25].

Given, equation of vertical cross – section

$y = \frac{x^2}{4}$

Coefficient of friction (μ) = 0.5



Now, applying the force balance equation,

$mg \sin\theta = \mu N = f_s$

$\Rightarrow \quad mg \sin\theta = \mu\, mg \cos\theta$

$\Rightarrow \quad \tan\theta = \mu \qquad$ ...(i)

Now, $y = \frac{x^2}{4}$

$$\tan\theta = \frac{dy}{dx} = \frac{2x}{4} = \frac{x}{2}$$

From equation (i)

$\Rightarrow \quad \tan\theta = \mu = \frac{x}{2}$

$\Rightarrow \quad x = 2\mu = 2 \times 0.5$

$\Rightarrow \quad x = 1$

Hence, $y = \frac{x^2}{4}$

$$y = \frac{1}{4}$$

$$y = 0.25 \text{ m}$$

or $y = 25$ cm

26. Correct answer is [15].

Given,

Frequency of electromagnetic wave (f) = 5 GHz

$$\mu_r = 2$$
$$\varepsilon_r = 2$$

Velocity of wave, $v = \frac{c}{n}$

Since, $n = \sqrt{\mu_r \varepsilon_r}$

$$n = \sqrt{2 \times 2} = 2$$

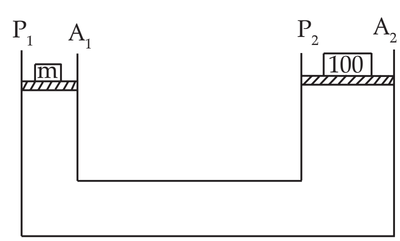
Now, $v = \frac{c}{n} = \frac{3\times10^8}{2}$

$$v = 1.5 \times 10^8 \text{ m/s}$$
$$v = 15 \times 10^7 \text{ m/s}$$

Hence, the velocity in this medium is 15×10^7 m/s

So, $x = 15$

27. Correct answer is [25600].



Let pressure be P_1 and P_2 and area be A_1 and A_2

So, $P_1 = P_2$

$\Rightarrow \quad \frac{F_1}{A_1} = \frac{F_2}{A_2}$

Case I

$\Rightarrow \quad \frac{mg}{A_1} = \frac{100g}{A_2}$ ...(i)

Case II

$$A_1' = \frac{A_1}{16}$$
$$A_2' = 16A_2$$

Now, $\frac{mg16}{A_1} = \frac{Mg}{16A_2}$ ...(ii)

From (i) and (ii), we get

$$\frac{16\times100g}{A_2} = \frac{Mg}{16A_2}$$

$$M = 25{,}600 \text{ kg}$$

28. Correct answer is [440].

Given,

Primary voltage (V_p) = 220 V

Secondary voltage (V_s) = 12 V

Number of turns in secondary coil (N_s) = 24

Number of turns in primary coil (N_p) = ?

For the transformer ratio

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$N_p = \frac{V_p}{V_s} \times N_s$$

$$N_p = \frac{220\times24}{12} = 440$$

29. Correct answer is [75].

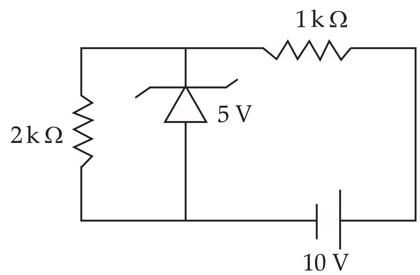
Given,

$$I_0 = 100 \text{ Lumens}$$
$$\theta = 30°$$
$$I = I_0 \cos^2\theta$$

So, $I = 100 \cos^2(30°)$

$$= 100 \times \left(\frac{\sqrt{3}}{2}\right)^2$$
$$= 25 \times 3$$
$$= 75 \text{ Lumens.}$$

30. Correct answer is [25].



For the zener diode, after 5 V, change in current will be zero.

$$i = \frac{5}{2 \times 10^3} \text{ A}$$

$$i = 2.5 \times 10^{-3} \text{ A}$$

$$i = 25 \times 10^{-4} \text{A}$$

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JEE (Main) PHYSICS SOLVED PAPER

2021
16^{th} March 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

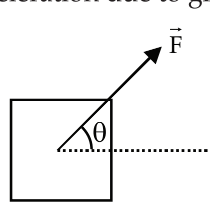
Q. 1. A 25 m long antenna is mounted on an antenna tower. The height of the antenna tower is 75 m. The wavelength (in meter) of the signal transmitted by this antenna would be :

(1) 200 **(2)** 400

(3) 100 **(4)** 300

Q. 2. A block of mass m slides along a floor while a force of magnitude F is applied to it at an angle θ as shown in figure. The coefficient of kinetic friction is μ_K. Then, the block's acceleration 'a' is given by :

(g is acceleration due to gravity)



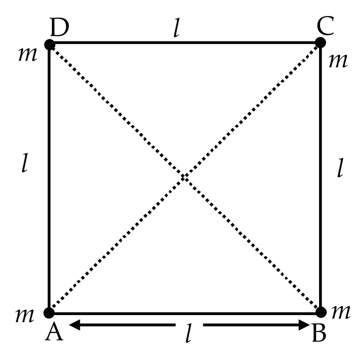
(1) $\frac{F}{m}\cos\theta - \mu_K\left(g - \frac{F}{m}\sin\theta\right)$

(2) $\frac{F}{m}\cos\theta - \mu_K\left(g + \frac{F}{m}\sin\theta\right)$

(3) $\frac{F}{m}\cos\theta + \mu_K\left(g - \frac{F}{m}\sin\theta\right)$

(4) $-\frac{F}{m}\cos\theta - \mu_K\left(g - \frac{F}{m}\sin\theta\right)$

Q. 3. Four equal masses, m each are placed at the corners of a square of length (l) as shown in the figure. The moment of inertia of the system about an axis passing through A and parallel to DB would be :



(1) ml^2 **(2)** $3\,ml^2$

(3) $\sqrt{3}\,ml^2$ **(4)** $2\,ml^2$

Q. 4. The stopping potential in the context of photoelectric effect depends on the following property of incident electromagnetic radiation :

(1) Amplitude **(2)** Phase

(3) Frequency **(4)** Intensity

Q. 5. One main scale division of a vernier callipers is 'a' cm and n^{th} division of the vernier scale coincide with $(n-1)^{th}$ division of the main scale. The least count of the callipers in mm is :

(1) $\left(\frac{n-1}{10n}\right)a$ **(2)** $\frac{10a}{n}$

(3) $\frac{10na}{(n-1)}$ **(4)** $\frac{10a}{(n-1)}$

Q. 6. A plane electromagnetic wave of frequency 500 MHz is travelling in vacuum along y–direction.

At a particular point in space and time, $\vec{B} = 8.0 \times 10^{-8}\,\hat{z}\,T$. The value of electric field at this point is :

(speed of light $= 3 \times 10^8$ ms^{-1})

$\hat{x}, \hat{y}, \hat{z}$ are unit vectors along x, y and z directions.

(1) $2.6\hat{x}\frac{V}{m}$ **(2)** $-2.6\hat{y}\frac{V}{m}$

(3) $24\hat{x}\frac{V}{m}$ **(4)** $-24\hat{x}\frac{V}{m}$

Q. 7. The maximum and minimum distances of a comet from the Sun are 1.6×10^{12} m and 8.0×10^{10} m respectively. If the speed of the comet at the nearest point is 6×10^4 ms^{-1}, the speed at the farthest point is :

(1) 1.5×10^3 m/s **(2)** 4.5×10^3 m/s

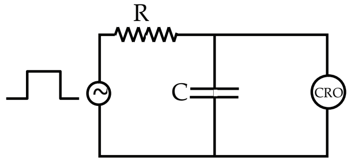
(3) 3.0×10^3 m/s **(4)** 6.0×10^3 m/s

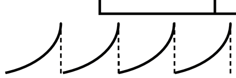
Q. 8. A block of 200 g mass moves with a uniform speed in a horizontal circular groove, with vertical side walls of radius 20 cm. If the block takes 40 s to complete one round, the normal force by the side walls of the groove is :

(1) 6.28×10^{-3} N **(2)** 0.0314 N

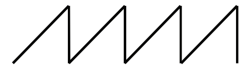
(3) 9.859×10^{-2} N **(4)** 9.859×10^{-4} N

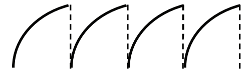
Q. 9. An RC circuit as shown in the figure is driven by a AC source generating a square wave. The output wave pattern monitored by CRO would look close to :



(1) 

(2) 

(3) 

(4) 

Q. 10. In thermodynamics, heat and work are :

(1) Intensive thermodynamics state variables

(2) Extensive thermodynamics state variables

(3) Path functions

(4) Point functions

Q. 11. A conducting wire of length 'l', area of cross–section A and electric resistivity ρ is connected between the terminals of a battery. A potential difference V is developed between its ends, causing an electric current. If the length of the wire of the same material is doubled and the area of cross–section is halved, the resultant current would be :

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

(3) $4\frac{VA}{\rho l}$ **(4)** $\frac{1}{4}\frac{VA}{\rho l}$

Q. 12. The pressure acting on a submarine is 3×10^5 Pa at a certain depth. If the depth is doubled, the percentage increase in the pressure acting on the submarine would be :

(Assume that atmospheric pressure is 1×10^5 Pa density of water is 10^3 kg m^{-3}, g = 10 ms^{-2})

(1) $\frac{200}{3}\%$ **(2)** $\frac{5}{200}\%$

(3) $\frac{200}{5}\%$ **(4)** $\frac{3}{200}\%$

Q. 13. A bar magnet of length 14 cm is placed in the magnetic meridian with its north pole pointing towards the geographic north pole. A neutral point is obtained at a distance of 18 cm from the center of the magnet. If B_H = 0.4 G, the magnetic moment of the magnet is (1 G = 10^{-4} T)

(1) 28.80 J T^{-1} **(2)** 2.880 J T^{-1}

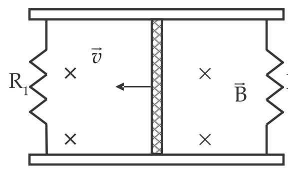
(3) 2.880×10^3 J T^{-1} **(4)** 2.880×10^2 J T^{-1}

Q. 14. The volume V of an enclosure contains a mixture of three gases, 16 g of oxygen, 28 g of nitrogen and 44 g of carbon dioxide at absolute temperature T. Consider R as universal gas constant. The pressure of the mixture of gases is :

(1) $\frac{4RT}{V}$ (2) $\frac{88RT}{V}$

(3) $\frac{5}{2}\frac{RT}{V}$ (4) $\frac{3RT}{V}$

Q. 15. A conducting bar of length L is free to slide on two parallel conducting rails as shown in the figure.



Two resistors R_1 and R_2 are connected across the ends of the rails. There is a uniform magnetic field $\vec{B}$ pointing into the page. An external agent pulls the bar to the left at a constant speed v.

The correct statement about the directions of induced currents I_1 and I_2 flowing through R_1 and R_2 respectively is :

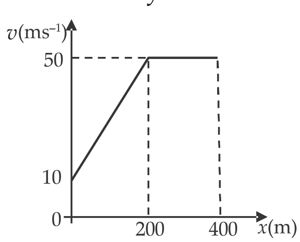
(1) I_1 is in clockwise direction and I_2 is in anticlockwise direction

(2) Both I_1 and I_2 are in clockwise direction

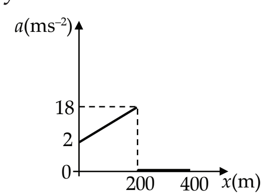
(3) I_1 is in anticlockwise direction and I_2 is in clockwise direction

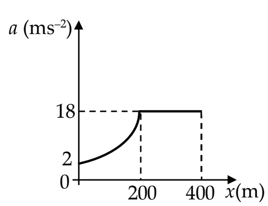
(4) Both I_1 and I_2 are in anticlockwise direction

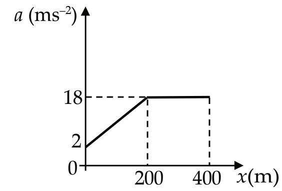
Q. 16. The velocity–displacement graph describing the motion of a bicycle is shown in the figure.

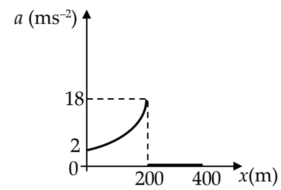


The acceleration–displacement graph of the bicycle's motion is best described by :

(1)


(2)


(3)


(4)


Q. 17. For changing the capacitance of a given parallel plate capacitor, a dielectric material of dielectric constant K is used, which has the same area as the plates of the capacitor. The thickness of the dielectric slab is $\frac{3}{4}d$, where 'd' is the separation between the plate of parallel plate capacitor.

The new capacitance (C′) in terms of original capacitance (C_0) is given by the following relation :

(1) $C' = \frac{4K}{K+3}C_0$ **(2)** $C' = \frac{4}{3+K}C_0$

(3) $C' = \frac{3+K}{4K}C_0$ **(4)** $C' = \frac{4+K}{3}C_0$

Q. 18. For an electromagnetic wave travelling in free space, the relation between average energy densities due to electric (U_e) and magnetic (U_m) fields is :

(1) $U_e \neq U_m$ **(2)** $U_e = U_m$

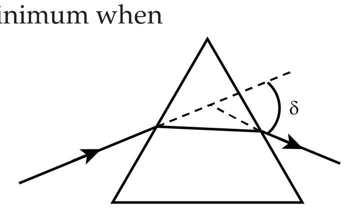
(3) $U_e > U_m$ **(4)** $U_e < U_m$

Q. 19. Time period of a simple pendulum is T inside a lift when the lift is stationary. If the lift moves upwards with an acceleration $\frac{g}{2}$, the time period of pendulum will be :

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

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

Q. 20. The angle of deviation through a prism is minimum when



(A) Incident ray and emergent ray are symmetric to the prism

(B) The refracted ray inside the prism becomes parallel to its base

(C) Angle of incidence is equal to that of the angle of emergence

(D) When angle of emergence is doubled the angle of incidence

Choose the correct answer from the options given below :

(1) Only statement (D) is true

(2) Statements (A), (B) and (C) are true

(3) Statements (B) and (C) are true

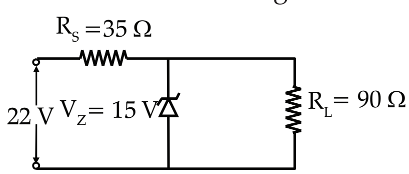
(4) Only statements (A) and (B) are true

Section B

Q. 21. A fringe width of 6 mm was produced for two slits separated by 1 mm apart. The screen is placed 10 m away. The wavelength of light used is 'x' nm.

The value of 'x' to the nearest integer is ________.

Q. 22. The value of power dissipated across the zener diode (V_z = 15 V) connected in the circuit as shown in the figure is $x \times 10^{-1}$ watt.



The value of x, to the nearest integer, is _____.

Q. 23. The resistance $R = \frac{V}{I}$, where V = (50 ± 2) V and I = (20 ± 0.2) A. The percentage error in R is 'x' %.

The value of x to the nearest integer is

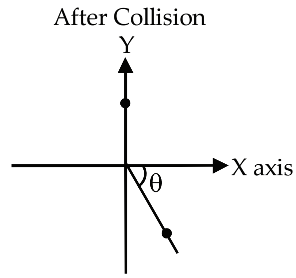
Q. 24. A sinusoidal voltage of peak value 250 V is applied to a series LCR circuit, in which R = 8 Ω, L = 24 mH and C = 60 μF. The value of power dissipated at resonant conditions is 'x' kW.

The value of x to the nearest integer is _____.

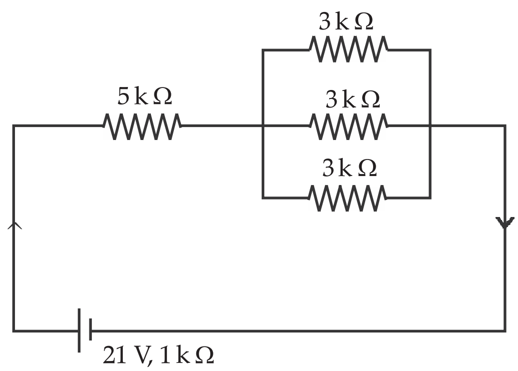
Q. 25. A ball of mass 10 kg moving with a velocity $10\sqrt{3}$ ms^{-1} along X–axis, hits another ball of mass 20 kg which is at rest. After collision, the first ball comes to rest and the second one disintegrates into two equal pieces. One of the pieces starts moving along Y–axis at a speed of 10 m/s. The second piece starts moving at a speed of 20 m/s at an angle θ (degree) with respect to the X–axis.

The configuration of pieces after collision is shown in the figure.

The value of θ to the nearest integer is _____.

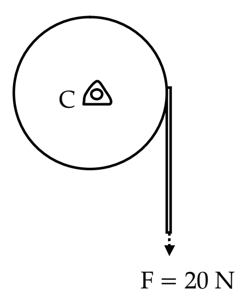


Q. 26. In the figure given, the electric current flowing through the 5 kΩ resistor is 'x' mA.



The value of x to the nearest integer is _____.

Q. 27. Consider a 20 kg uniform circular disk of radius 0.2 m. It is pin supported at its center and is at rest initially. The disk is acted upon by a constant force F=20 N through a massless string wrapped around its periphery as shown in the figure



Suppose the disk makes n number of revolutions to attain an angular speed of 50 rad s^{-1}.

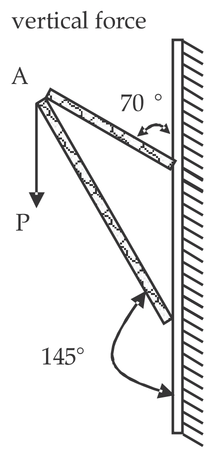
The value of n, to the nearest integer is _____.

In one complete revolution, the disk rotates by 6.28 rad

Q. 28. The first three spectral lines of H–atom in the Balmer series are given $\lambda_1, \lambda_2, \lambda_3$ considering the Bohr atomic model, the wavelengths of first and third spectral lines $\left(\frac{\lambda_1}{\lambda_3}\right)$ are related by a factor of approximately 'x' $\times 10^{-1}$.

The value of x, to the nearest integer, is _____.

Q. 29. Consider a frame that is made up of two thin massless rods AB and AC as shown in the figure. A vertical force $\vec{P}$ of magnitude 100 N is applied at point A of the frame.



Suppose the force is $\vec{P}$ resolved parallel to the arms AB and AC of the frame.

The magnitude of the resolved component along the arm AC is x N.

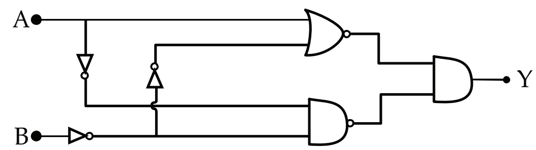
The value of x, to the nearest integer, is _____.

[Given: $\sin(35°)=0.573$, $\cos(35°)=0.819$

$\sin(110°)=0.939$, $\cos(110°)=-0.342$]

Q. 30. In the logic circuit shown in the figure, if input A and B are 0 to 1 respectively, the output at Y would be 'x'.

The value of x is ________.



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Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	3	Antenna Analysis	Communications
2	1	Friction	Newton's Laws of Motion
3	2	MOI System of Particles	Rotational Mechanics
4	3	Photoelectric Effect	Dual Nature of Radiation and Matter
5	2	Vernier Callipers	Units and Measurements
6	4	Electromagnetic Wave	Electromagnetic Wave
7	3	Keplers Second Law	Gravitations
8	4	Horizontal Circular Motion	Circular Motions
9	2	RC Circuit	AC Circuit Analysis
10	3	Heat and Work	Thermodynamics
11	4	Electric Current	Current Electricity
12	1	Pressure	Fluid Mechanics
13	2	Magnet Moment	Magnetism
14	3	Mixture of Gases	Kinetic Theory of Gases
15	1	Induced Current	Electromagnet Inductions
16	1	Graphs	Motion in One Dimensions
17	1	Charging Capacitor	Capacitor
18	2	Energy Density	Electromagnetic Wave
19	3	Time Period	Simple Harmonic Motion
20	2	Minimum Angle of Deviations Optics	Prism
21	600	Fringe Width	Wave Optics
22	5	Zener Diode	Semiconductor Devices
23	5	Percentage Error	Units And Measurements
24	4	LCR Circuit	AC Circuit Analysis
25	30	Collisions	System of Particles
26	3	Electric Circuit	Current Electricity
27	20	Angular Displacement	Rotational Mechanics
28	15	Spectral Lines	Atomic Structure
29	82	Resolved Component	Newton's Laws of Motion
30	0	Logic Gates	Electronic Circuit

JEE (Main) PHYSICS SOLVED PAPER

2021
16^{th} March Shift 1

ANSWERS WITH EXPLANATIONS

Physics

Section A

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

Given,

Height of the antenna is

$H = 25$ m

Since, the length of the antenna is 1/4 of the wavelength, the transmission and reception conversion efficiency of the antenna is the highest.

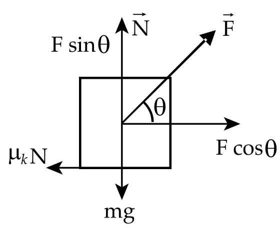
$$H = \frac{\lambda}{4} \Rightarrow \lambda = 4H$$

Therefore,

$\lambda = 4 \times 25 = 100$ m

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

Free body diagram of the block



For equilibrium in the vertical direction

$F \sin\theta + N = mg$

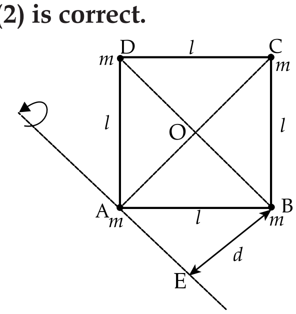
$N = mg - F\sin\theta$ ...(i)

Also, $F\cos\theta - \mu_k N = ma$ ...(ii)

Solving (i) and (ii)

$$a = \frac{F}{m}\cos\theta - \mu_k\left[g - \frac{F}{m}\sin\theta\right]$$

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



In ΔABC, $\angle B = 90°$

$AC^2 = AB^2 + BC^2$

$AC^2 = l^2 + l^2$

$AC = \sqrt{2l^2} \Rightarrow \sqrt{2}l$

Length of the diagonal of a square

$$d = BE = AO = \frac{AC}{2} = \frac{l}{\sqrt{2}}$$

Moment of Inertia about the axis passing through A.

$$I = m(0)^2 + m(d)^2 + m(d)^2 + m(AC)^2$$

$$I = 2md^2 + m(AC)^2 = 2m\left[\frac{l}{\sqrt{2}}\right]^2 + m\left[\sqrt{2}l\right]^2$$

$$\Rightarrow \quad 2m\frac{l^2}{2} + 2ml^2 \Rightarrow 3ml^2$$

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

Using Einstein's photoelectric equation

$h\nu = h\nu_0 + eV$

$$V = \frac{h\nu}{e} - \frac{h\nu_0}{e}$$

Where $V \rightarrow$ Stopping potential

V depends on frequency

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

Given

1 MSD = a cm

n VSD = $(n - 1)$MSD

$$1 \text{ VSD} = \frac{(n-1)}{n}\text{ MSD}$$

Since,

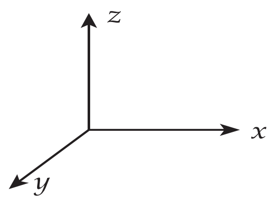
$$LC = 1\text{ MSD} - 1\text{ VSD}$$
$$= 1\text{ MSD} - \frac{(n-1)}{n}\text{ MSD} \Rightarrow \frac{\text{MSD}}{n}$$

$$LC = \frac{a}{n}\text{ cm} = \frac{10a}{n}\text{ mm}$$

6. Option (4) is correct.

Given,

$$\vec{B} = 8 \times 10^{-8}\hat{z}\ T \text{ and } c = 3 \times 10^{8} \text{m/s}$$



Using the relation

$$E = Bc = (8 \times 10^{-8})\ (3 \times 10^{8}) = 24$$

Given: Electromagnetic wave travels in a direction along y-axis.

Since, E x B = c;

Magnetic Field B is along z axis and wave travels along y axis.

So, $(-\hat{x}) \times (\hat{z}) = \hat{y}$

The electric field, E will be along negative x direction.

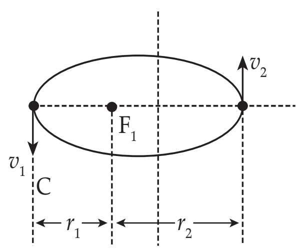
Hence, $\vec{E} = -24\,\hat{x}$ V/m

7. Option (3) is correct.

$r_2 = 1.6 \times 10^{12} m$

$r_1 = 8 \times 10^{10} m$

$v_1 = 6 \times 10^{4}$ m/s



Apply conservation of angular momentum

$$mv_1r_1 = mv_2r_2$$

$$\Rightarrow \quad (6 \times 10^{4})\ (8 \times 10^{10}) = v_2\,(1.6 \times 10^{12})$$

$$v_2 = 3 \times 10^{3} \text{ m/s}$$

8. Option (4) is correct.

Given,

$m = 200$ g, $r = 20$ cm, T = 40 s

Using the expression

$$T = \frac{2\pi}{\omega}$$

$$\omega = \frac{2\pi}{40} = \frac{\pi}{20} = \frac{3.14}{20} \text{ radian/second}$$

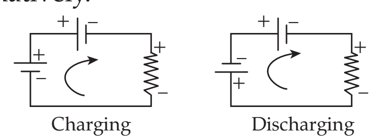
Normal force will provide the necessary centripetal force.

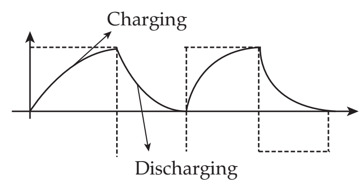
$$N = mr\omega^2 = \left(\frac{200}{1000}\right)\left(\frac{20}{100}\right)\left[\frac{3.14}{20}\right]^2$$

$$= 9.859 \times 10^{-4}\text{N}$$

9. Option (2) is correct.

The capacitor starts charging when initially (+) voltage across input than the capacitor will reach upto saturation level, where (-) voltage of AC appears across output the capacitor starts discharge and this process keeps on going alternatively.





10. Option (3) is correct.

Heat and work are not state variables, therefore, it is neither extensive nor intensive. It is dependent on path. Heat and work are path functions.

11. Option (4) is correct.

Given,

length of wire = l

Area of cross section = A

Resistivity of wire = ρ

Therefore, resistance of wire

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

Now, new length of the wire is

$$l' = 2l$$

New cross- section of wire is

$$A' = \frac{A}{2}$$

New resistance

$$R' = \frac{\rho(2l)}{\frac{A}{2}} = 4\frac{\rho l}{A}$$

Resultant current,

$$I' = \frac{V}{R'} = \frac{V}{4\frac{\rho l}{A}}$$

$$= \frac{1}{4}\frac{VA}{\rho l}$$

12. Option (1) is correct.

According to Hydrostatic's Law

$$P = P_0 + h\rho g$$

Given

$$P_1 = 3 \times 10^5 \text{Pa}$$

So, $P_1 = P_0 + h\rho g$

$$h\rho g = [3 \times 10^5 - 10^5] \text{ Pa} = 2 \times 10^5 \text{Pa}$$

If depth is doubled

$$2h\rho g = 2 \times 2 \times 10^5 \quad \Rightarrow 4 \times 10^5 \text{ Pa}$$

So, $P_2 = P_0 + 4 \times 10^5 \Rightarrow 5 \times 10^5 \text{Pa}$

% increase in pressure

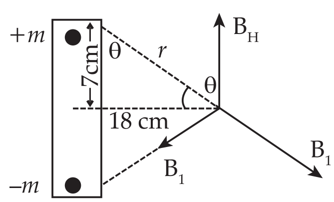
$$= \frac{P_2 - P_1}{P_1} \times 100 = \left(\frac{2 \times 10^5}{3 \times 10^5}\right) \times 100$$

$$= \frac{200}{3} \ \%$$

13. Option (2) is correct.

Given

Length of bar Magnet = 14 cm



$$B_H = 0.4\text{G}$$

From the diagram we observe

$$B_H = 2B_1 \sin\theta$$

$$0.4 \times 10^{-4} = 2\left[\frac{\mu_0 m}{4\pi r^2}\right]\left[\frac{7}{r}\right]$$

$$0.4 \times 10^{-4} = 2\left[\frac{7 \times 10^{-7} m}{\left[7^2 + 18^2\right]^{\frac{3}{2}}} \times 10^4\right]$$

$$m = \frac{4 \times 10^{-2} \times (373)^{\frac{3}{2}}}{14}$$

Magnetic Moment, $M = m \times \frac{14}{100}$

$$\Rightarrow \qquad \frac{4 \times 10^{-2} \times (373)^{\frac{3}{2}}}{14}\left[\frac{14}{100}\right]$$

$$M = 2.880 \text{ J/T}$$

14. Option (3) is correct.

Here we are using ideal gas equation

$$PV = nRT$$

$n \rightarrow$ total number of moles of the mixture of gases

Number of moles of O_2 'n_1' $= \frac{16}{32} = 0.5$ mole

Number of moles of N_2 'n_2' $= \frac{28}{28} = 1$ mole

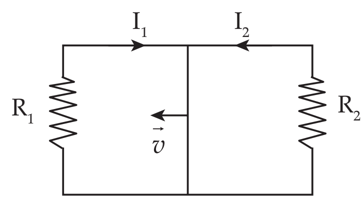
Number of moles of CO_2 'n_3' $= \frac{44}{44} = 1$ mole

$n = n_1 + n_2 + n_3 = \frac{5}{2}$ moles

Hence, $PV = \frac{5}{2}$ RT or $P = \frac{5RT}{2V}$

15. Option (1) is correct.

When bar slides towards left area of loop 1 decreases to increase the magnetic flux current flow in clockwise direction, and area of loop 2 increases so current flow in anticlockwise direction.



16. Option (1) is correct.

Using the relation

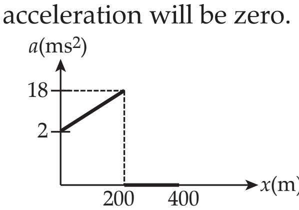
$$a = v\frac{dv}{dx}$$

From $x = 0$ to 200m, slope of velocity vs displacement graph is constant but velocity is increasing.

So, acceleration will increase.

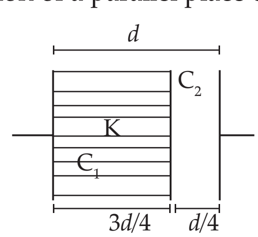
From $x = 200$ to 400m slope of velocity vs displacement graph is zero.

Hence, acceleration will be zero.



17. Option (1) is correct.

The expression of a parallel place capacitor



Here, $C_0 = \dfrac{A\varepsilon_0}{d}$

So, $C_1 = \dfrac{KA\varepsilon_0}{\frac{3d}{4}}$ ....at $d \rightarrow \dfrac{3d}{4}$

And $C_2 = \dfrac{A\varepsilon_0}{\frac{d}{4}}$ .... at $d \rightarrow \dfrac{d}{4}$

Now equivalent capacitance

$$C' = \frac{C_1C_2}{C_1+C_2}$$

$$\Rightarrow \frac{\left(4K\frac{A\varepsilon_0}{3d}\right)\left(4\frac{A\varepsilon_0}{d}\right)}{4K\frac{A\varepsilon_0}{3d}+4\frac{A\varepsilon_0}{d}}$$

$$\Rightarrow \frac{\frac{4KA^2\varepsilon_0^2}{3d^2}\times 4}{\frac{4A\varepsilon_0}{d}\left[\frac{K}{3}+1\right]} \Rightarrow \frac{4K}{(3+K)}C_0$$

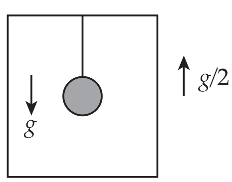
18. Option (2) is correct.

For an electromagnetic wave, average energy density due to electric field (U_e) and magnetic field (U_m) is same.

19. Option (3) is correct.

Using the expression

$$T = 2\pi\sqrt{\frac{l}{g}}$$



When the lift moves with an acceleration $\frac{g}{2}$ in upward direction, a pseudo force is acting downwards.

Effective acceleration

$$g_{eff} = g+\frac{g}{2}$$

$$= 3g/2$$

Therefore, new time period

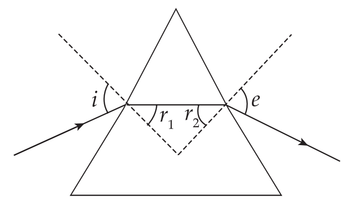
$$T' = 2\pi\sqrt{\frac{l}{g_{eff}}}$$

$$= 2\pi\sqrt{\frac{l}{3g/2}} = \sqrt{\frac{2}{3}}T$$

20. Option (2) is correct.

Condition for minimum angle of deviation

$i = e$ [angle of incidence = angle of emergence]



$r_1 = r_2$ [refracted ray is parallel to the base of prism]

Incident ray and emergent ray are symmetric to the prism. The refracted ray inside the prism becomes parallel to its base Angle of incidence is equal to that of the angle of emergence.

Section B

21. Correct answer is [600].

Given,

Fringe width (β) $= 6$ mm $= 6 \times 10^{-3}$ m

$d = 1$ mm $= 1 \times 10^{-3}$ m

$D = 10$ m

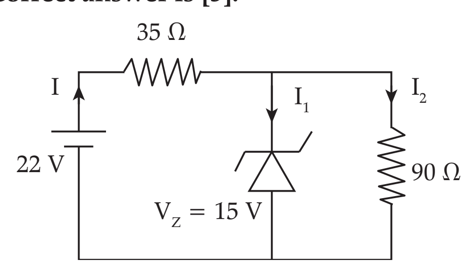
Using the expression

$$\beta = \frac{D\lambda}{d}$$

$$6 \times 10^{-3} = \frac{\lambda \times 10}{10^{-3}}$$

So, $\lambda = 600$ nm

22. Correct answer is [5].



Voltage across 35Ω = (22 − 15) = 7V

Current across R_S, $I = \dfrac{7}{35} = \dfrac{1}{5}$ A

Current across R_L, $I_2 = \dfrac{15}{90} = \dfrac{1}{6}$ A

So, $I_1 = I - I_2 = \frac{1}{5} - \frac{1}{6} = \frac{1}{30}$ A

Power dissipated across the zener diode = 15 × $\frac{1}{30}$ = 0.5W = 5×10^{-1} W

Hence, $x = 5$

23. Correct answer is [5].

We can find % error in R by using expression,

$$R = \frac{V}{I}$$

$$\frac{\Delta R}{R} \times 100 = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$$

$$= \frac{2}{50} \times 100 + \frac{0.2}{20} \times 100$$

$$= (4 + 1) = 5\%$$

24. Correct answer is [4].

Peak voltage $[V_0]$ = 250 V

So, $V_{RMS} = \frac{V_0}{\sqrt{2}} = \frac{250}{\sqrt{2}}$ V

Resistance [R] = 8 Ω

Inductor [L] = 24 mH

Capacitor [C] = 60 μF

The dissipated power at resonant condition

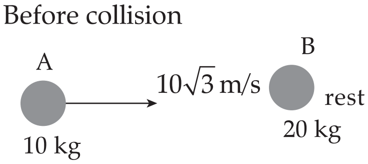
$$P = \frac{[V_{RMS}]^2}{R} \Rightarrow \frac{\left(\frac{250}{\sqrt{2}}\right)^2}{8}$$

$$\Rightarrow 3906.25 \text{ W}$$

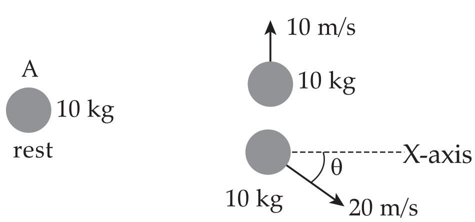
Approx. P = 4 kW

25. Correct answer is [30].

Before collision



After collision



Apply conservation of momentum along X-axis

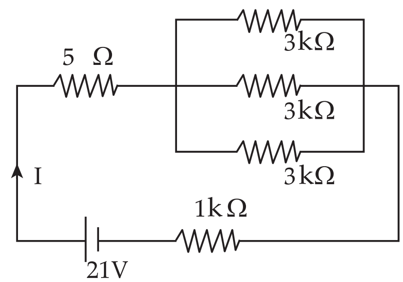
$$10 \times 10\sqrt{3} = 20 \cos\theta \times 10$$

$$\cos\theta = \frac{\sqrt{3}}{2}$$

$$\theta = 30°$$

26. Correct answer is [3].

All 3 k Ω are in parallel so,



$$\frac{1}{R_1} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{3}{3} \text{ k}\Omega$$

$$R_1 = 1 \text{ k}\Omega$$

$$R_{eq} = 1 \text{ k}\Omega + 5 \text{ k}\Omega + 1 \text{ k}\Omega \Rightarrow 7 \text{ k}\Omega$$

So, $I = \frac{21}{7000} \Rightarrow 3$ mA

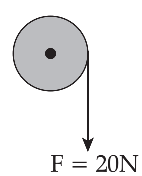
$x = 3$

27. Correct answer is [20].

Mass of a disk = 20 kg

Radius of a disk = 0.2 m

Torque due to force, F = 20 N is τ



Since, $\tau = I\alpha$

$$F = \frac{mr^2}{2}\alpha$$

$$\alpha = \frac{2F}{mr} = \frac{2 \times 20}{20 \times 0.2}$$

$$\Rightarrow 10 \text{ rad/s}^2$$

Using kinematic equation for rotational motion

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$(50)^2 = 0 + 2(10)\theta$$

$$\theta = \frac{2500}{20} = 125 \text{ radian}$$

No. of revolution = $\frac{125}{6.28} \approx 20$ revolution

28. Correct answer is [15].

Using the expression for Balmer series for 1st line

$$\frac{1}{\lambda_1} = Rz^2\left[\frac{1}{4}-\frac{1}{9}\right] = \frac{5}{36}Rz^2$$

For 3rd line

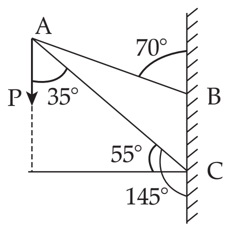
$$\frac{1}{\lambda_3} = Rz^2\left[\frac{1}{4}-\frac{1}{25}\right] = \frac{21}{100}Rz^2$$

$$\frac{\lambda_1}{\lambda_3} = \frac{21}{100}\times\frac{36}{5} \Rightarrow 15.12\times 10^{-1}$$

So, $x = 15$

29. Correct answer is [82].

Component of P along AC is P cos 35°

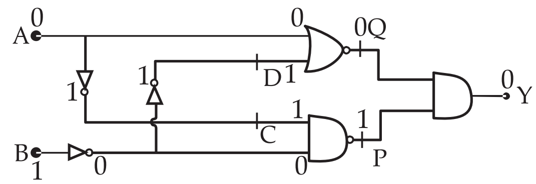


Given : P = 100 N and cos 35° = 0.819

The magnitue of force along the arm AC

$$F_{AC} = P\cos 35°$$
$$= 100 \times 0.819\text{ N}$$
$$= 81.9\text{ N}$$
$$\approx 82\text{ N}$$

30. Correct answer is [0].



TRUTH TABLE

A	B	C	D	P	Q	Y
0	1	1	1	1	0	0

Final answer is 0

❐❐❐

JEE (Main) PHYSICS SOLVED PAPER

2021
20^{th} 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 :

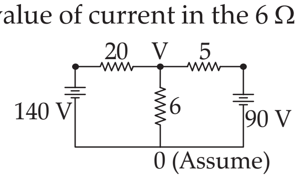
(1) $\sqrt{A^2 + B^2 - \sqrt{2}AB}$

(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

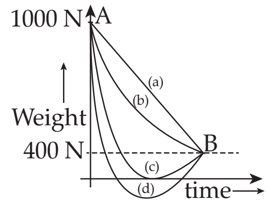
Q. 4. A deuteron and an alpha particle having equal kinetic energy enter perpendicular into a magnetic field. Let r_d and r_α be their respective radii of circular path. The value of $\frac{r_d}{r_\alpha}$ is equal to

(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 :

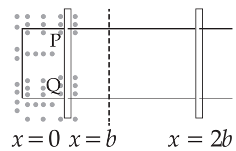
(1) S, β, k and μR have the same dimensions.

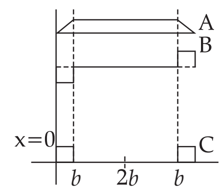
(2) α and J have the same dimensions.

(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

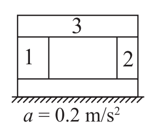
(2) A-Power dissipated, B-Flux, C-EMF

(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 __________

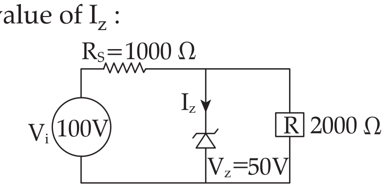
[take $g = 10$ m/s^2 and $\mu_s = 0.2$]



(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

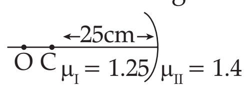
(3) 0.1 A **(4)** 25m A

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

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

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

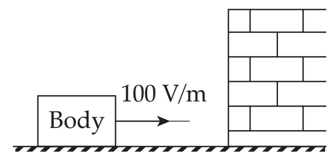
Q. 20. Consider a mixture of gas molecule of types A, B and C having masses $m_A < m_B < m_C$ ratio of their root mean square speeds at normal temperature and pressure is :

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

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

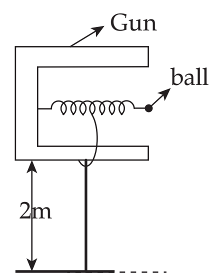
Section B

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 $\left(\dfrac{m}{M}\right)$ is $\dfrac{1}{x}$. 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^o is $\frac{1}{x} \times 10^{-3}$ F. Then the value of x is_____________.

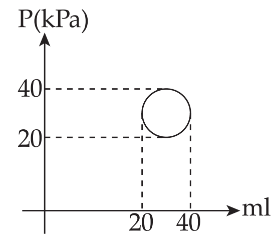
Q. 26. The frequency of a car horn encountered a change from 400 Hz to 500 Hz, when the car approaches a vertical wall. If the speed of sound is 330 m/s. Then the speed of car is ______ km/h.

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

JEE (Main) PHYSICS SOLVED PAPER

2021
20^{th} July Shift 1

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.

$$\vec{A}.\vec{B} = \vec{A}\times\vec{B} \qquad \text{[given]}$$

$$|\vec{A}||\vec{B}|\cos\theta = |\vec{A}||\vec{B}|\sin\theta\,\hat{n}$$

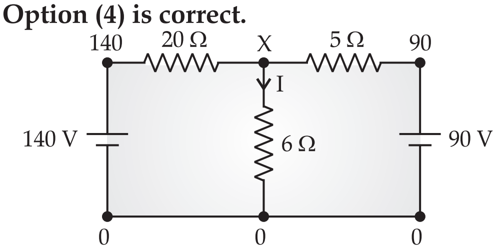
This is possible only when $\theta = 45°$

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

$$= \sqrt{A^2+B^2-2AB\cos45°}$$

$$= \sqrt{A^2+B^2-\sqrt{2}AB}$$

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

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

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

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

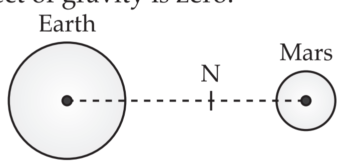
$$\log_e 3 = \lambda_{net}\, t$$

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

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

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

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

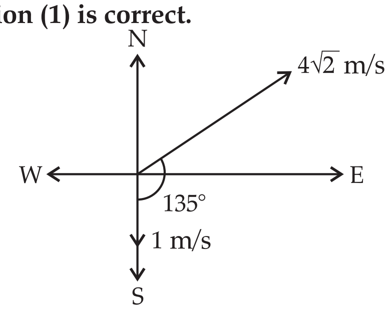
Now, $$T_1 = \frac{k[l_1 - l]}{l} \quad \text{...(i)}$$

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.



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

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

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

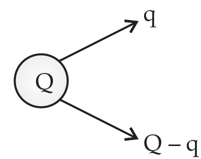
$$= \sqrt{(4\sqrt{2})^2 + (1)^2 + 2(4\sqrt{2})(1)\left(\frac{-1}{\sqrt{2}}\right)}$$

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

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.

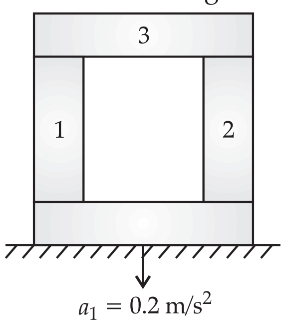
So, A $\rightarrow$ flux

B $\rightarrow$ emf

C $\rightarrow$ power dissipated

13. Option (4) is correct.

Mass of a steel block is 10 kg.

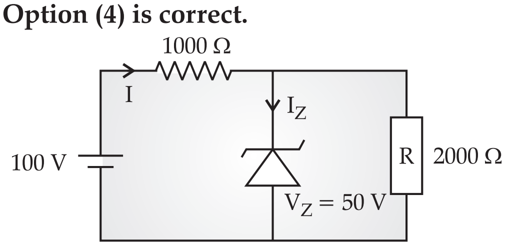


Mass of all cylinder M = 20 × 3 + 10 = 70 kg

The force equation in vertical direction

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

14. Option (4) is correct.



Voltage across load resistance is 50V

$$(\text{I} - \text{I}_z) = \frac{\text{V}_\text{Z}}{\text{R}} = \frac{50}{2000} = 25 \text{ mA}$$

And, $$\text{I} = \frac{\text{V}_\text{Z}}{\text{R}_\text{S}} = \frac{50}{1000} = 50 \text{ mA}$$

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

15. Option (2) is correct.

Apply conservation of momentum;

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

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

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

Energy of γ ray $= h\nu$

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

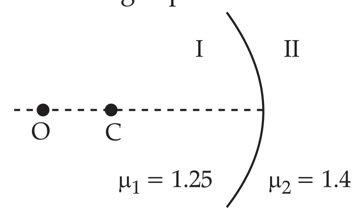
Loss in internal energy $= \text{E}_\gamma + \text{K.E}_{\text{Nu}}$

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

16. Option (3) is correct.

Radius (R) = 25 cm

Refraction through spherical surface

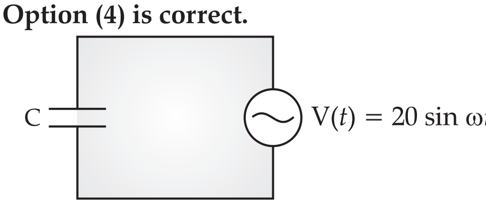


$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{\text{R}}$$

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

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

17. Option (4) is correct.



Frequency = 50 Hz

d = 2 mm, A = 1 m^2

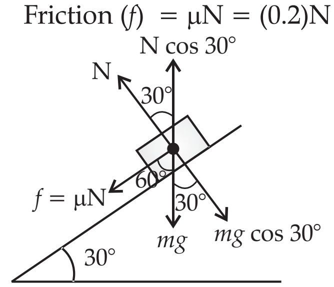
$$\text{C} = \frac{\text{A}\varepsilon_0}{d} = \frac{1 \times 8.85 \times 10^{-12}}{2 \times 10^{-3}}$$
$$= 4.425 \times 10^{-9} \text{ F}$$

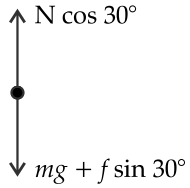
$$\text{X}_\text{C} = \frac{1}{\omega\text{C}} = \frac{1}{2\pi(50)(4.425 \times 10^{-9})}$$
$$= 0.7193 \times 10^6 \ \Omega$$

$$\text{displacement current } (\text{I}_d) = \frac{\text{V}_0}{\text{X}_\text{C}} = \frac{20}{0.7193 \times 10^6}$$
$$= 27.81 \ \mu\text{A}$$
$$\simeq 27.79 \ \mu\text{A}$$

18. Option (4) is correct.

Friction $(f) = \mu\text{N} = (0.2)\text{N}$





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

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

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

20. Option (4) is correct.

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

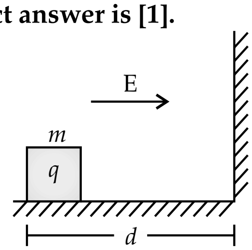
$$M_A < M_B < M_C$$

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.

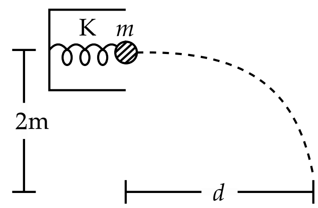
$$\text{Time period (T)} = 2\left(\frac{1}{2}\right) = 1 \text{ s.}$$

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



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

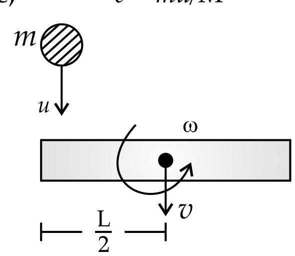
Now, $d = vt = [0.5\sqrt{10}]\left[\frac{2}{\sqrt{10}}\right] = 1 \text{ m}$

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, $e = 1$.

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

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

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

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

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

$$X_C - X_L = R$$

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

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

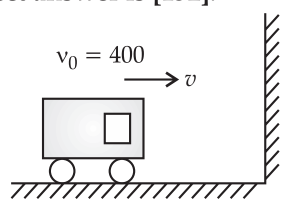
$$\Rightarrow \quad \frac{1}{\omega C} = 1 + 300(30 \times 10^{-3}) = 10\ \Omega$$

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].

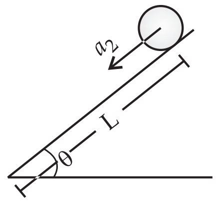
Using the relation

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

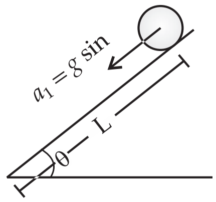
$$200 = V_M + 160$$

$$A_m = V_M = 40$$

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

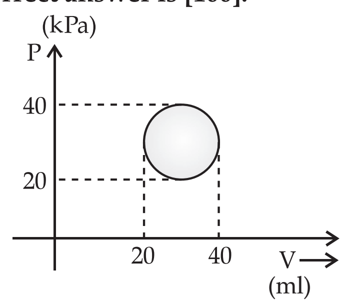
at $t = 1$, $$y = \frac{1}{1+(x-v)^2} \quad \text{...(i)}$$

Compare (i) with given equation

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

So, $$v = 2 \text{ m/s}$$

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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JEE (Main) PHYSICS SOLVED PAPER

2021

26^{th} August 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

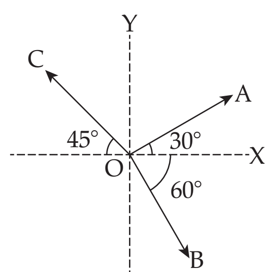
Section A

Q. 1 An inductor coil stores 64 J of magnetic field energy and dissipates energy at the rate of 640 W when a current of 8 A is passed through it. If this coil is joined across an ideal battery, find the time constant of the circuit in seconds:

(1) 0.4 **(2)** 0.8

(3) 0.125 **(4)** 0.2

Q. 2 The magnitude of vectors $\overrightarrow{OA}$, $\overrightarrow{OB}$ and $\overrightarrow{OC}$ in the given figure are equal. The direction of $\overrightarrow{OA}+\overrightarrow{OB}-\overrightarrow{OC}$ with x-axis will be :



(1) $\tan^{-1}\frac{(1+\sqrt{3}-\sqrt{2})}{(1-\sqrt{3}-\sqrt{2})}$ **(2)** $\tan^{-1}\frac{(\sqrt{3}-1+\sqrt{2})}{(1-\sqrt{3}+\sqrt{2})}$

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

Q. 3 A series LCR circuit deriven by 300 V at a frequency of 50 Hz contains a resistance $R = 3\ k\Omega$, an inductor of inductive reactance $X_L = 250\ \pi\Omega$ and an unknown capacitor. The value of capacitance to maximize the average power should be:

(1) 4 μF **(2)** 25 μF

(3) 40 μF **(4)** 400 μF

Q. 4 In a Screw Gauge, fifth division of the circular scale coincides with the reference line when the ratchet is closed. There are 50 divisions on the circular scale, and the main scale moves by 0.5 mm on a complete rotation. For a particular observation, the reading on the main scale is 5 mm and the 20^{th} division of the circular scale coincides with reference line. Calculate the true reading.

(1) 5.00 mm **(2)** 5.20 mm

(3) 5.15 mm **(4)** 5.25 mm

Q. 5 If E, L, M and G denote the quantities as energy, angular momentum, mass and constant of gravitation respectively, then the dimensions of P in the formula $P = EL^2M^{-5}G^{-2}$ are:

(1) $[M^0 L^1 T^0]$ **(2)** $[M^{-1} L^{-1} T^2]$

(3) $[M^0 L^0 T^0]$ **(4)** $[M^1 L^1 T^{-2}]$

Q. 6 Statement I:

By doping silicon semiconductor with pentavalent material, the electrons density increases.

Statement II:

The *n*-type semiconductor has net negative charge.

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

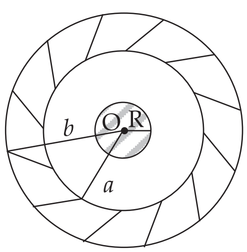
(1) Both Statement I and Statement II are true.

(2) Statement I is true but Statement II is false.

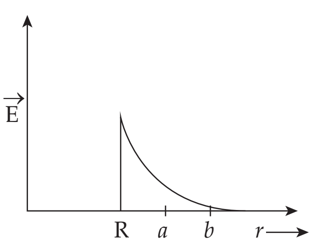
(3) Both Statement I and Statement II are false.

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

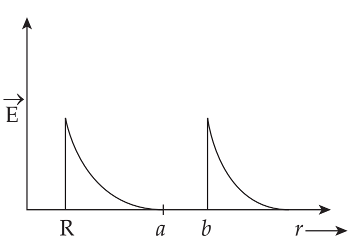
Q. 7 A solid metal sphere of radius R having charge q is enclosed inside the concentric spherical shell of inner radius a and outer radius b as shown in figure. The approximate variation of electric field $\vec{E}$ as a function of distance r from centre O is given by:



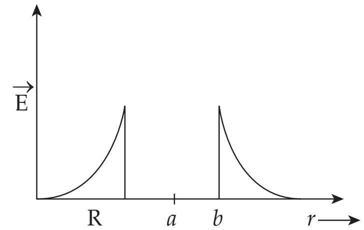
(1)



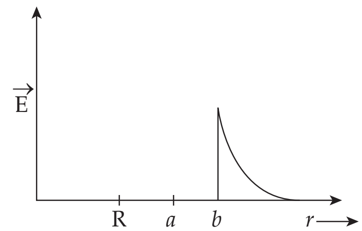
(2)



(3)



(4)



Q. 8 Two narrow bores of diameter 5.0 mm and 8.0 mm are joined together to form a U-shaped tube open at both ends. If this U-tube contains water, what is the difference in the level of two limbs of the tube.

[Take surface tension of water $T = 7.3\times10^{-2}\,Nm^{-1}$, angle of contact $= 0$, $g = 10\ ms^{-2}$ and density of water $= 1.0\times10^{3}\,kgm^{-3}$]

(1) 5.34 mm **(2)** 4.97 mm

(3) 2.19 mm **(4)** 3.62 mm

Q. 9 What equal length of an iron wire and a copper-nickel alloy wire, each of 2 mm diameter connected parallel to give an equivalent resistance of 3 Ω?

(Given resistivities of iron and copper-nickel alloy wire are 12 μΩ cm and 51 μΩ cm respectively)

(1) 82 m **(2)** 110 m

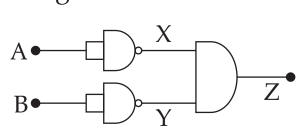
(3) 97 m **(4)** 90 m

Q. 10 The rms speeds of the molecules of Hydrogen, Oxygen and Carbon dioxide at the same temperature are V_H, V_O and V_{CO_2} respectively then:

(1) $V_H = V_O > V_{CO_2}$ **(2)** $V_{CO_2} > V_O > V_H$

(3) $V_H > V_O > V_{CO_2}$ **(4)** $V_H = V_O = V_{CO_2}$

Q. 11 Identify the logic operation carried out by the given circuit:



(1) NOR **(2)** OR

(3) NAND **(4)** AND

Q. 12 Car B overtakes another car A at a relative speed of 40 ms^{-1}. How fast will the image of car B appear to move in the mirror of focal length 10 cm fitted in car A, when the car B is 1.9 m away from the car A?

(1) 0.1 ms^{-1} **(2)** 0.2 ms^{-1}
(3) 4 ms^{-1} **(4)** 40 ms^{-1}

Q. 13 Inside a uniform spherical shell:

(a) the gravitational field is zero.
(b) the gravitational potential is zero.
(c) the gravitational field is same everywhere.
(d) the gravitational potential is same everywhere.
(e) all of the above.

Choose the most appropriate answer from the options given below:

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

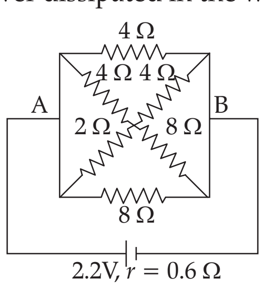
Q. 14 In a photoelectric experiment ultraviolet light of wavelength 280 nm is used with lithium cathode having work function $\phi = 2.5$ eV. If the wavelength of incident light is switched to 400 nm, find out the change in the stopping potential. $\left(h = 6.63\times10^{-34}\,\text{Js}, c = 3\times10^{8}\,\text{ms}^{-1}\right)$

(1) 1.9 V **(2)** 1.1 V
(3) 1.3 V **(4)** 0.6 V

Q. 15 A particular hydrogen like ion emits radiation of frequency 2.92×10^{15} Hz when it makes transition from $n = 3$ to $n = 1$. The frequency in Hz of radiation emitted in transition from $n = 2$ to $n = 1$ will be:

(1) 0.44×10^{15} **(2)** 4.38×10^{15}
(3) 6.57×10^{15} **(4)** 2.46×10^{15}

Q. 16 In the given figure, the emf of the cell is 2.2 V and if internal resistance is 0.6 Ω Calculate the power dissipated in the whole circuit:



(1) 2.2 W **(2)** 1.32 W
(3) 0.65 W **(4)** 4.4 W

Q. 17 The initial mass of a rocket is 1000 kg. Calculate at what rate the fuel should be burnt so that the rocket is given an acceleration of 20 ms^{-2}. The gases comes out at a relative speed of 500 ms^{-1} with respect to the rocket:

(1) 60 kg s^{-1} **(2)** 10 kg s^{-1}
(3) 6.0×10^2 kg s^{-1} **(4)** 500 kg s^{-1}

Q. 18 The fractional change in the magnetic field intensity at a distance 'r' from centre on the axis of current carrying coil of radius 'a' to the magnetic field intensity at the centre of the same coil is : (Take $r < a$).

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

Q. 19 An electric appliance supplies 6000 J/min heat to the system. If the system delivers a power of 90 W. How long it would take to increase the internal energy by 2.5×10^3 J?

(1) 4.1×10^1s **(2)** 2.4×10^3s
(3) 2.5×10^2s **(4)** 2.5×10^1s

Q. 20 The material filled between the plates of a parallel plate capacitor has resistivity 200Ωm The value of capacitance of the capacitor is 2 pF. If a potential difference of 40V is applied across the plates of the capacitor, then the value of leakage current flowing out of the capacitor is: (given the value of relative permitivity of material is 50)

(1) 9.0 μA **(2)** 0.9 μA
(3) 9.0 mA **(4)** 0.9 mA

Section B

Q. 21 Two spherical balls having equal masses with radius of 5 cm each are thrown upwards along the same vertical direction at an interval of 3 s with the same initial velocity of 35 m/s, then these balls collide at a height of ________m.

(take g = 10 m/s^2)

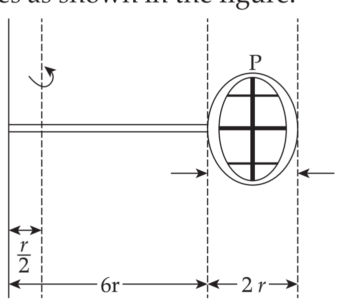
Q. 22 A source and a detector move away from each other in absence of wind with a speed of 20 m/s with respect to the ground. If the detector detects a frequency of 1800 Hz of the sound coming from the source, then the original frequency of source considering speed of sound in air 340 m/s will be ________ Hz.

Q. 23 White light is passed through a double slit and interference observed on a screen 1.5 m away. The separation between the slits is 0.3 mm. The first violet and red fringes are formed 2.0 mm and 3.5 mm away from the central white fringes. The difference in wavelengths of red and voilet light is ________ nm.

Q. 24 An amplitude modulated wave is represented by $C_m(t) = 10\,(1 + 0.2\cos 12560t) \times \sin\,(111\times10^4 t)$ volts. The modulating frequency in kHz will be ________.

Q. 25 Two travelling waves produces a standing wave represented by equation. $y = 1.0$ mm $\cos\,(1.57\text{ cm}^{-1})\,x\,\sin\,(78.5\text{ s}^{-1})\,t$. The node closest to the orgin in the region $x > 0$ will be at $x =$ ________ cm.

Q. 26 Consider a badminton racket with length scales as shown in the figure.



If the mass of the linear and circular portions of the badminton racket are same (M) and the mass of the threads are negligible, the moment of inertia of the racket about an axis perpendicular to the handle and in the plane of the ring at, $\frac{r}{2}$ distance from the end A of the handle will be ________ Mr^2.

Q. 27 A uniform chain of length 3 metre and mass 3 kg overhangs a smooth table with 2 metre laying on the table. If k is the kinetic energy of the chain in joule as it completely slips off the table, then value of k is ________. (Take $g = 10\text{ m/s}^2$)

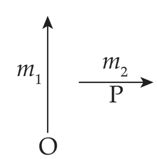
Q. 28 A soap bubble of radius 3 cm is formed inside the another soap bubble of radius 6 cm. The radius of an equivalent soap bubble which has the same excess pressure as inside the smaller bubble with respect to the atmospheric pressure is ________ cm.

Q. 29 The electric field in a plane electromagnetic wave is given by

$$\vec{E} = 200\cos\left[\left(\frac{0.5\times10^3}{\text{m}}\right)x - \left(1.5\times10^{11}\,\frac{\text{rad}}{\text{s}}\times t\right)\right]\frac{\text{V}}{\text{m}}\hat{j}$$

If the wave falls normally on a perfectly reflecting surface having an area of 100 cm^2. If the radiation pressure exerted by the E.M. wave on the surface during a 10 minute exposure is $\frac{x}{10^9}\,\frac{\text{N}}{\text{m}^2}$. Find the value of x.

Q. 30 Two short magnetic dipoles m_1 and m_2 each having magnetic moment of 1 Am^2 are placed at point O and P respectively. The distance between OP is 1 metre. The torque experienced by the magnetic dipole m_2 due to the presence of m_1 is ________ $\times 10^{-7}$ Nm.



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Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	4	RC Circuit	Alternating Current
2	4	Vectors	Vectors
3	1	Electrical Resonance	Alternating Current
4	3	Least Count and Zero Error	Errors and Measurement
5	3	Dimensions	Mesurement and Dimensions
6	2	N Type Semi Conductor	Semiconductors
7	2	Electric Field Inside The Shell	Charges and Fields
8	3	Surface Tension	Mechanical Properties of Fluids
9	3	Resistance	Current and Electricity
10	3	Rms Speed	Kinetic Theory of Gases
11	1	Logic Gates	Digital Circuits
12	1	Ray Optics	Ray Optics
13	1	Gravitational Potential	Gravitation
14	3	Photoelectric effect Effect	Photoelectric Effect
15	4	Transition	Atoms and Nuclei
16	1	Power	Current and Electricity
17	1	Rocket Propulsion	Laws of Motion
18	1	Magnetic Field on The Axis of The Coil	Moving Charges and Magnetic Field
19	3	First Law of Thermodynamics	Heat and Thermodynamics
20	4	Current Leakage	Capacitance
21	50	Motion Under Gravity	Kinematics 1D
22	2025	Doppler's Effect	Waves
23	300	Interference	Waves
24	2	Communication	Communication
25	1	Waves In A String	Waves
26	52	Moment of Inertia	Rigid Body
27	40	Friction	Laws of Motion
28	2	Surface Tension	Surface Tension
29	354	Em Waves	EM Waves
30	1	Magnetic Moment	Magnetism

JEE (Main) PHYSICS SOLVED PAPER

2021
26th August Shift 1

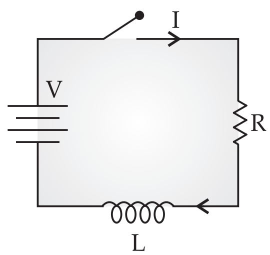
ANSWERS WITH EXPLANATIONS

Physics

Section A

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

Time constant, $\tau = \frac{L}{R}$?



Here, energy stored in inductor, $E = \frac{1}{2} LI^2$

Power, $P = I^2R$

So, $$\frac{E}{P} = \frac{\frac{1}{2}I^2L}{I^2R}$$

$$= \frac{1}{2}\frac{L}{R} = \frac{\tau}{2}$$

$$\Rightarrow \quad \tau = \frac{2 \times E}{P}$$

$$= \frac{2 \times 64}{640}$$ (Here, E = 64J and P = 540W)

$$= \frac{2}{10}$$

$$= 0.2 \text{ s}$$

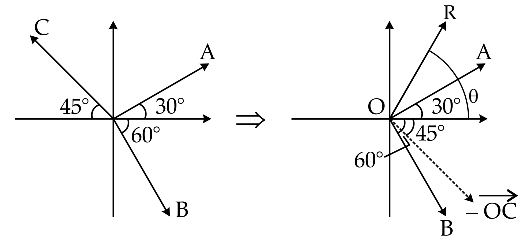
2. **Option (4) is correct.**

We need to find direction of

$$\vec{R} = \vec{OA} + \vec{OB} - \vec{OC}$$

$$= \vec{OA} + \vec{OB} + (-\vec{OC})$$

So to get $-\vec{OC}$ reverse direction of $\overline{OC}$



Now find ΣA_x and ΣA_y

$$\vec{R} = \Sigma R_x \hat{i} + \Sigma R_y \hat{j}$$

Direction, $\theta = \tan^{-1} \frac{\Sigma R_y}{\Sigma R_x}$

Summation of x-component of each

$$\Sigma R_x = (1.\cos 30° + 1.\cos 45° + 1.\cos 60°)\hat{i}$$

$$\Sigma R_y = (1.\sin 30° - 1.\sin 45° - 1.\sin 60°)\hat{j}$$

Here, we have considered unit length of each value

$$\Sigma R_x = \left(\frac{\sqrt{3}}{2} + \frac{1}{\sqrt{2}} + \frac{1}{2}\right)\hat{i}$$

$$\Sigma R_y = \left(\frac{1}{2} - \frac{1}{\sqrt{2}} - \frac{\sqrt{3}}{2}\right)\hat{j}$$

$$\tan\theta = \frac{\Sigma R_y}{\Sigma R_x} = \frac{\left(\frac{\sqrt{2} - 2 - \sqrt{6}}{2\sqrt{2}}\right)}{\left(\frac{\sqrt{6} + 2 + \sqrt{2}}{2\sqrt{2}}\right)}$$

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

$$= \tan^{-1}\left(\frac{1 - \sqrt{3} - \sqrt{2}}{1 + \sqrt{3} + \sqrt{2}}\right)$$

3. Option (1) is correct.

Given V = 300 V, f = 50 Hz

$R = 3k\,\Omega \quad X_L = 250\pi\,\Omega$

Here, average power in circuit is to be maximized.

In Series Resonance Circuit, the impedence is minimum, this way we can maximize power

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = Z_{min} \qquad \text{if } X_L = X_C$$

$$X_L = X_C = \frac{1}{\omega C}$$

$$\Rightarrow \qquad C = \frac{1}{\omega X_L}$$

$$= \frac{1}{2\pi \times 50 \times 250\pi}$$

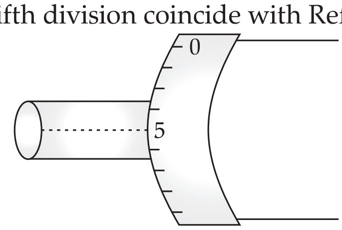
$$C = 0.04 \times 10^{-4}$$

$$= 4\,\mu F$$

4. Option (3) is correct.

$$\text{Least count} = \frac{0.5}{50}$$

Here fifth division coincide with Refrence line



This is the case of positive zero error, as zero error always subtracted from observed reading to get actual reading

True Reading = Observed – Zero Error

Observed Reading = 5 + L.C. × 20 – L.C × 5

$$= 5 + \frac{0.5}{50} \times 20 - \frac{0.5}{50} \times 5$$

$$= 5.15 \text{ mm}$$

5. Option (3) is correct.

Since,

The dimensions of energy

$$[E] = [ML^2T^{-2}]$$

The dimensions of angular momemtum

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

The dimensions of mass

$$[M] = [M]$$

The dimensions of gravitational constant

$$[G] = [M^{-1}L^3T^{-2}]$$

Given,

$$P = EL^2M^{-5}G^{-2}$$

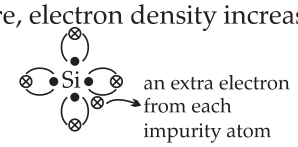
Thus, dimensions of P will be

$$[P] = [ML^2T^{-2}][ML^2T^{-1}]^2[M]^{-5}[M^{-1}L^3T^{-2}]^{-2}$$
$$= [ML^2T^{-2}][M^2L^4T^{-2}][M^{-5}][M^2L^{-6}T^4]$$
$$= [M^0L^0T^0]$$

6. Option (2) is correct.

Statement-I is true.

By doping silicon with pentavalent impurity, it gives an extra electron so called donor impurity. Therefore, electron density increases.

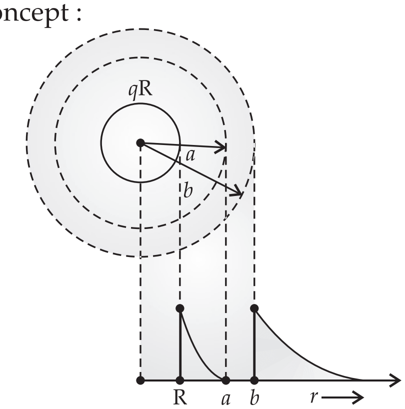


Statement-II is false.

Net charge on semiconductor on either of the type is zero.

7. Option (2) is correct.

Concept :



As we know there is no charge inside the conductor.

When we consider innermost sphere

For region or $0 < r < R$, $E = 0$

$$R < r < a, \; E \propto \frac{1}{r^2}$$

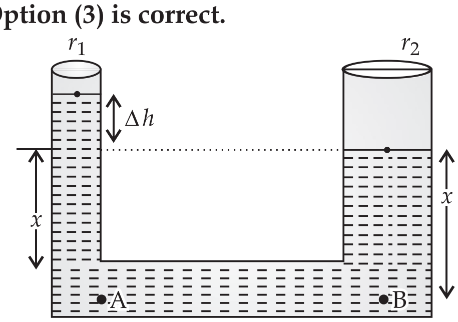
The shell is hollow. So, no charge is there inside the shell.

$$a < r < b \Rightarrow E = 0$$

For region, $\quad r > b,$

$$E \propto \frac{1}{r^2}$$

8. Option (3) is correct.



The bore which is more fine (less radius) make the water to rise to greater height. So let Δh height of column is more than the other bore as shown in figure.

Consider two points A and B on the same level. So, the pressure will also be same

$$P_A = P_B$$

$$P_{atm} - \frac{2T}{r_1} + \rho g(\Delta h) + \rho g x = P_{atm} - \frac{2T}{r_2} + \rho g x$$

$$\Rightarrow \quad \rho g \Delta h = 2T\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

$$\Rightarrow \quad \Delta h = \frac{2T}{\rho g}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\Rightarrow \Delta h = \frac{2 \times 7.3 \times 10^{-2}}{1 \times 10^3 \times 10}\left(\frac{1}{(2.5 \times 10^{-3})} - \frac{1}{(4 \times 10^{-3})}\right)$$

$$\Rightarrow \Delta h = 2.19 \times 10^{-3}\, m = 2.19 \text{ mm}$$

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

Given that both the wires are of same dimensions

i.e., $l_{Cu-Ni} = l_{Fe} = l$ and $A_{Fe} = A_{Cu-Ni} = \pi r^2$

From the relation, $R = \rho \frac{l}{A}$, ρ-Resistivity.

Given $\rho_{Fe} = 12\, \mu\Omega$ cm, $\rho_{Cu-Ni} = 15\, \mu\Omega$ cm, $R_{eq.} = 3\Omega$

$$\frac{1}{R_{eq}} = \frac{1}{R_{Fe}} + \frac{1}{R_{Cu\text{-}Ni}}$$

$$\Rightarrow \quad \frac{1}{3} = \frac{A}{\rho_{Fe} l} + \frac{A}{\rho_{CuNi} l}$$

$$l = 3A\left(\frac{1}{\rho_{Fe}} + \frac{1}{\rho_{Cu\text{-}Ni}}\right)$$

$$= 3\pi r^2 \left(\frac{\rho_{Fe} + \rho_{Cu\text{-}Ni}}{\rho_{Fe} \times \rho_{Cu\text{-}Ni}}\right)$$

$$l = 3\pi \times (1 \times 10^{-3})^2 \left[\frac{12 \quad 51}{12 \times 51}\right]$$

$$= 97 \text{ m}$$

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

Root mean square velocity,

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

Temperature is same for all. So, $V_{rms} \propto \frac{1}{\sqrt{M}}$

So, the lighter gas has greater r.m.s. speed.

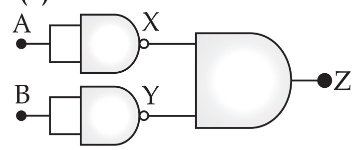
$$V_H : V_O : V_{CO_2} = \frac{1}{\sqrt{M_H}} : \frac{1}{\sqrt{M_O}} : \frac{1}{\sqrt{M_{CO_2}}}$$

$$= \frac{1}{1} : \frac{1}{\sqrt{16}} : \frac{1}{\sqrt{44}}$$

$$= \frac{1}{1} : \frac{1}{4} : \frac{1}{2\sqrt{11}}$$

$$V_H > V_O > V_{CO_2}.$$

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



From above diagram

$$X = \overline{A}$$

$$Y = \overline{B}$$

As X and Y are input of AND Gate

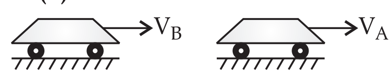
Thus, $\quad Z = \overline{A}.\overline{B}$

From Demorgan's theorem

$$\overline{A}.\overline{B} = \overline{A + B}$$

So, NOR Gate

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



As,

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

On differentiating w.r.t. time 't', we get

$$-\frac{du}{dt}.\frac{1}{u^2} - \frac{dv}{dt}.\frac{1}{v^2} = 0$$

$$\Rightarrow \quad \frac{du}{dt} = \text{object speed, } (V_0)$$

$$\frac{dv}{dt} = \text{image speed, } (V_I)$$

$$V_I = -m^2 V_0 \text{ ...(i)} \quad \left\{\begin{array}{ll} \because & u = -1.9 \text{ cm} \\ \because & f = 10 \text{ cm} \end{array}\right\}$$

$$\text{Magnification, } m = \frac{v}{u} = \frac{f}{f - u}$$

$$m = \frac{10}{10 - (-190)}$$

$$\Rightarrow \quad m = \frac{10}{200} = \frac{1}{20}$$

Putting values in equation (i)

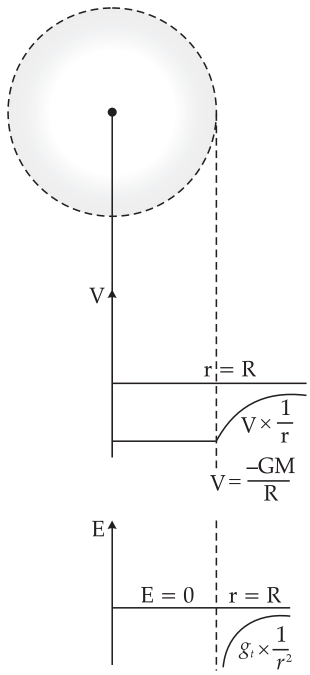
$$V_I = -\left(\frac{1}{20}\right)^2 \times 40$$

$$V_I = -0.1 \text{ m/s}$$

Hence, the can will appear to move with speed 0.1 m/s

13. Option (1) is correct.

Concept : Inside spherical shell



There is no effective mass so, intensity of gravitational field is zero.

And inside at all points gravitational field is zero so we can say intensity of gravitational field is zero.

Gravitational potential from surface to center of the shell is constant and same.

14. Option (3) is correct.

From Einstein equation

$$(eV_0)_1 = \frac{hc}{\lambda_1} - W \quad \text{...(i)}$$

and $$(eV_0)_2 = \frac{hc}{\lambda_2} - W \quad \text{...(ii)}$$

Substracting eqn (ii) from eqn (i)

$$e(V_{01} - V_{02}) = hc\left\{\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right\}$$

$$(V_{01} - V_{02}) = \frac{hc}{e}\left\{\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right\}$$

We are given $\lambda_1 = 280$ nm, $\lambda_2 = 400$ nm

Change in stopping potential in V

$$\left(\frac{6.63\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}}\right)\left[\frac{1}{280} - \frac{1}{400}\right]\times10^{9}$$

$$\Rightarrow \frac{12.43\times10^{2}\times120}{280\times400}$$

$$\Rightarrow (V_{01} - V_{02}) = 1.33 \text{ V}$$

15. Option (4) is correct.

Let the atomic no. of hydrogen like atom be z, and the transition taken place from n_1 to n_2

So, the wavelength in transition

$$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

For first transition, $n_1 = 3$, $n_2 = 1$

$$\frac{1}{\lambda} = Rz^2\left(\frac{1}{1} - \frac{1}{9}\right)$$

$$= \frac{8}{9}Rz^2$$

$$\because \quad c = f\lambda$$

$$\Rightarrow \quad f = \frac{8}{9}Rz^2.c \quad \text{...(i)}$$

Similarly for $n_1 = 2$ to $n = 1$

$$f' = Rz^2c\left(\frac{1}{1} - \frac{1}{4}\right)$$

$$= Rz^2c\times\frac{3}{4} \quad \text{...(ii)}$$

Dividing eqn (ii) by eqn (i), we get

$$\frac{f'}{f} = \frac{27}{32}$$

$$\Rightarrow \quad f' = \left(\frac{27}{32}\right)f$$

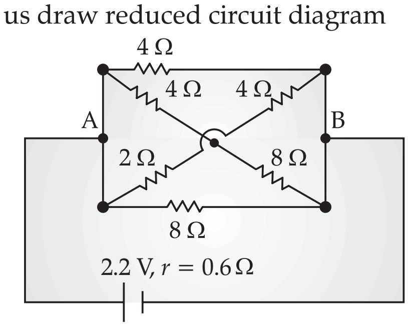
$$f' = \frac{27}{32}\times2.92\times10^{15} \text{ Hz}$$

$$= 2.46 \times 10^{15} \text{ Hz}$$

16. Option (1) is correct.

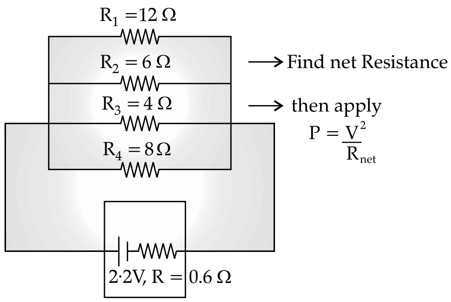
Concept :

Let us draw reduced circuit diagram



If we notice in this diagram that first end of each arm is connected to A, and second end is connected to end B. So, all arms are connected in parallel.

We can redraw as



Equivalent resistance for external resistance, R_{eq}

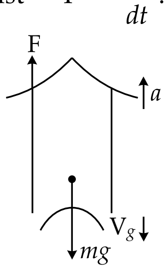
So,
$$\frac{1}{R_{eq}} = \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4}$$
$$= \frac{1}{12}+\frac{1}{6}+\frac{1}{4}+\frac{1}{8}$$
$$R_{eq} = \frac{8}{5} = 1.6\Omega$$
$$R_{Net} = R_{eq} + 0.6$$
$$= 1.6 + 0.6$$
$$= 2.2\,\Omega$$

Now, dissipated power $= \frac{V^2}{R}$
$$= \frac{(2.2)^2}{2.2}$$
$$= 2.2 \text{ W}$$

17. Option (1) is correct.

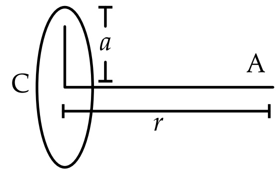
Rocket is example of variable mass system. If rate of loss of mass be $\frac{dm}{dt}$ and the gas leaves rocket relative speed of V_g then

$$\text{Upthrust} = F = \frac{dm}{dt}.V_g$$



From free body diagram
$$F - mg = ma$$
$$\Rightarrow \frac{dm}{dt}.V_g - mg = ma$$
$$\frac{dm}{dt} = \frac{m(g+a)}{V_g}$$
$$= \frac{1000(10+20)}{500}$$
$$\frac{dm}{dt} = 2 \times 30 = 60 \text{ kg/s}$$

18. Option (1) is correct.



Let the intensity of magnetic field at centre be B_C and at axis by B_A

then the fraction change $= \frac{\Delta B}{B_C} = \frac{B_C - B_A}{B_A}$ ...(i)

at center $\quad B_C = \frac{\mu_0 I}{2a}$

at axis $\quad B_A = \frac{\mu_0 I a^2}{2(a^2+x^2)^{3/2}}$

Put in equation (i), we get
$$\frac{\Delta B}{B_C} = \frac{\frac{\mu_0 i}{2a} - \frac{\mu_0 i a^2}{2(1^2+x^2)^{3/2}}}{\frac{\mu_0 i}{2a}}$$
$$= 1 - \frac{1}{\left(1+\frac{x^2}{a^2}\right)^{3/2}}$$
$$\frac{\Delta B}{B_C} = 1 - \left(1+\frac{x^2}{a^2}\right)^{-\frac{3}{2}}$$

Using binomial $(1 + x)^n = 1 + nx + ...$ Neglecting higher degree terms as $r < a$

$$\frac{\Delta B}{B_C} = 1 - \left(1 - \frac{3}{2}\frac{x^2}{a^2}\right)$$
$$\frac{\Delta B}{B_C} = \frac{3x^2}{2a^2} \qquad \text{put } x = r$$
$$\frac{\Delta B}{B_C} = \frac{3r^2}{2a^2}$$

19. Option (3) is correct.

Given $\frac{\Delta Q}{\Delta t} = 6000\frac{J}{\text{min}} = \frac{6000}{60}\frac{J}{s}$

$$\frac{dW}{dt} = 90 \text{ W},$$

let in time Δt internal energy increase by ΔU

So, $\quad \Delta U = 2.5 \times 10^3$ J

From first law of thermodynamics

$$\Delta U = Q - W$$

$$\frac{\Delta U}{\Delta t} = \frac{\Delta Q}{\Delta t} - \frac{\Delta W}{\Delta t}$$

Now putting the given values

$$\frac{2.5 \times 10^3}{\Delta t} = 100 - 90 = 10$$

$$\Delta t = 250 \text{ s} = 2.5 \times 10^1 \text{ s}$$

20. Option (4) is correct.

Current leakage is small current that flows through capacitor when voltage is applied.

Given,

$\rho = 200\ \Omega\text{m}$, $C = 2 \times 10^{-12}$ F, $V = 40$ V, $k = 50$

Leakage current as function of time

$$i(f) = i_0\, e^{\frac{-t}{\tau}} \quad \text{...(i)}$$

Here, $i_0 = \dfrac{q_0}{\rho\, k\varepsilon_0}$ for maximum current.

Put in equation (i)

$$i = \frac{CV_0}{\rho k\varepsilon_0} e^{-t/k\varepsilon_0\rho}$$

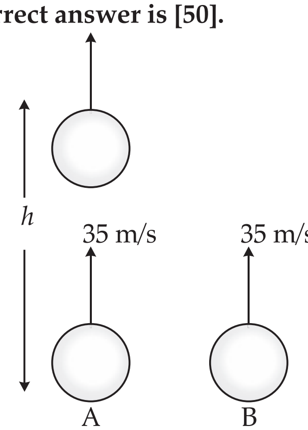
$$i_{\text{leakage}} = \frac{CV_0}{\rho\, k\varepsilon_0} \text{ as } t \to \infty$$

$$= \frac{2 \times 10^{-12} \times 40}{200 \times 50 \times 8.85 \times 10^{-12}}$$

$$= 903\ \mu\text{A} = 0.9 \text{ mA}$$

Section B

21. The correct answer is [50].



Displacement of two balls are

$$S_1 = 35t - \frac{1}{2} g t^2$$

And $$S_2 = 35(t-3) - \frac{1}{2} g (t-3)^2$$

$$\Rightarrow \quad S_1 = S_2 = h$$

$$\Rightarrow \quad 35t - \frac{gt^2}{2} = 35(t-3) - \frac{g(t-3)^2}{2}$$

$$\Rightarrow \quad \frac{g}{2}\left[t^2 - (t-3)^2\right] = 105$$

$$\Rightarrow \quad (2t-3)(3) = \frac{210}{10}$$

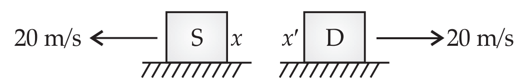
$$\Rightarrow \quad 2t = 10 \Rightarrow t = 5 \text{ s}$$

$$\Rightarrow \quad h = 35 \times 5 - \frac{10}{2} \times 25$$

$$= 175 - 125$$

$$= 50 \text{ m}$$

22. The correct answer is [2025].



By applying Doppler formula

$$f_{app} = f_0\left(\frac{V - V_D}{V - V_S}\right)$$

Here using sign convention

$V_S = -20$ m/s (moving opposite to sound direction)

$V_D = 20$ m/s (moving in direction of sound)

$$f_{app} = f\left(\frac{340 - 20}{340 + 20}\right)$$

$$\Rightarrow \quad 1800 = f\left(\frac{320}{360}\right)$$

$$f = 2025 \text{ Hz}$$

23. The correct answer is [300].

Position of first bright fringe $= \dfrac{\lambda D}{d}$

So position of first red fringe $= Y_R = \dfrac{\lambda_R D}{d}$ ...(i)

Position of first violet fringe $= Y_V = \dfrac{\lambda_V D}{d}$ ...(ii)

From eqn (i) and eqn (ii)

$$Y_R - Y_V = (\lambda_R - \lambda_V)\frac{D}{d}$$

$$(Y_R - Y_V)\frac{d}{D} = \lambda_R - \lambda_V$$

$$\lambda_R - \lambda_V = \frac{(3.5-2)}{1.5} \times 0.3 \times 10^{-3} \text{mm}$$

$$\lambda_R - \lambda_V = 0.3 \times 10^{-3} \text{ mm}$$

$$\Delta\lambda = \lambda_R - \lambda_V = 300 \text{ nm}$$

24. The correct answer is [2].

Concept : Comparing given equation of amplitude modulated wave by standard equation, we can get;

$$C_m = Ac\left(1 + \frac{A_m}{A_c}\cos 2xf_m t\right)\sin 2\pi f_c t$$

Given : $C_m = 10(1 + 0.2 \cos 12560t) \sin(111 \times 10^4 t)$

So, $\cos 2\pi f_m t = \cos 12560 t$

$\Rightarrow$ $2\pi f_m = 12560$

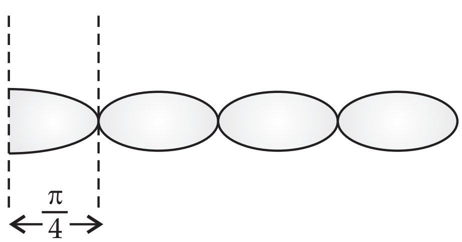
$\Rightarrow$ $f_m = \dfrac{12560}{2 \times 3.14} = 2000 = 2\text{kHz}$

25. The correct answer is [1].

Concept : By comparing given equation with equation of standing wave $y = 2A \cos kx \sin \omega t$

Amplitude $R = 2A \cos kx$

Given equation, $y = 1.0 \text{ mm} \cos(1.5 \text{ cm}^{-1})\, x \sin (78.5)\text{s}^{-1})\, t$



Comparing cos term

$$k = 1.57 = \frac{2\pi}{\lambda}$$

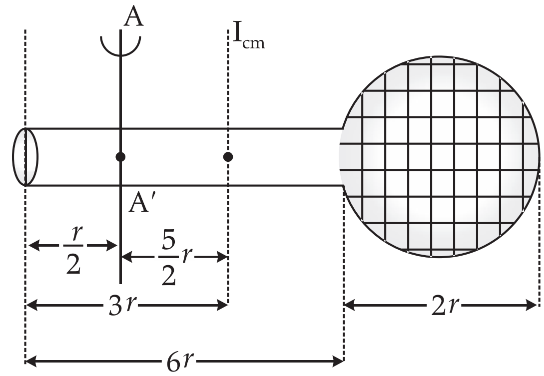
$$\lambda = \frac{2\pi}{1.57} \text{cm}$$

Closest Node Position from origin $= \dfrac{\lambda}{4}$

$$= \frac{2\pi}{4 \times 1.57} = 1 \text{ cm}$$

26. The correct answer is [52].

Concept : In this



Problem we have to use parallel axis theorem twice in order to get moment of inertia of linear and circular part.

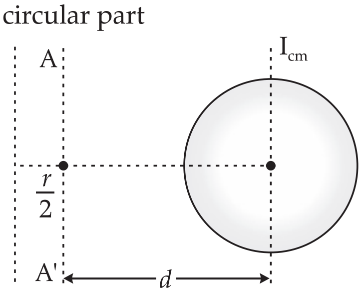
MI of linear part

$$I'_{AA} = I_{cm} + Md^2$$

$$= \frac{M(6r)^2}{12} + M\left(\frac{5}{2}r\right)^2$$

$$I'_{AA} = \frac{36Mr^2}{12} + \frac{25Mr^2}{4}$$

MI of circular part



$$I'_{AA} = I_{cm} + Md^2$$

$$= \frac{Mr^2}{2} + M\left(\frac{13}{2}r\right)^2$$

$$I'_{AA} = \frac{Mr^2}{2} + \frac{169}{4}Mr^2$$

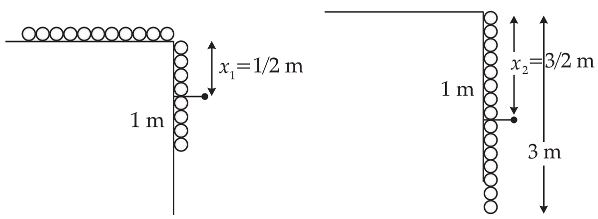
$$\text{Net M.I} = \underbrace{I_{AA}}_{\text{Linear Part}} + \underbrace{I_{AA'}}_{\text{Circular Part}}$$

$$\text{Net MI} = \left(\frac{36Mr^2}{12} + \frac{25}{4}Mr^2\right) + \left(\frac{Mr^2}{2} + \frac{169}{4}Mr^2\right)$$

$$\text{Net MI} = 52\, Mr^2$$

27. The correct answer is [40].

When the chain falls its center of mass goes down from $x_1 = \frac{1}{2}$ m to $x_2 = \frac{3}{2}$ m.



From conservation of Mechanical energy

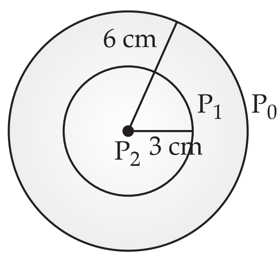
$$\Delta k = U_f - U_i$$

$$= \left(3 \times g \times \frac{3}{2}\right) - \left(1 \times g \times \frac{1}{2}\right)$$

$$= 45 - 5 = 40 \text{ J}$$

28. The correct answer is [2].

Concept : The formula for excess pressure for soap bubble, $\Delta P = \frac{4T}{R}$



So, applying this formula for interior, middle and exterior, surface, we can get result.

$$P_1 - P_0 = \frac{4T}{6}$$

and, $$P_2 - P_1 = \frac{4T}{3}$$

So, $$P_2 - P_0 = (P_1 - P_0) + (P_2 - P_1)$$

$$P_2 - P_0 = \frac{4T}{6} + \frac{4T}{3}$$

$$\Rightarrow \quad \frac{4T}{R} = \frac{4T}{6} + \frac{4T}{3}$$

$$\Rightarrow \quad \frac{1}{R} = \frac{1}{6} + \frac{1}{3}$$

$$R = 2 \text{ cm}$$

29. The correct answer is [354].

Concept : By comparing given equation with $E = E_0 \cos(kx - wt)$ we can find required parameter then use formula

$$\text{Radiation pressure} = \frac{2I}{c}$$

and $$I = \frac{1}{2} \varepsilon_0 E_0^2 c$$

$$\text{Radiation Pressure} = \frac{2I}{c} = \left(\frac{2}{c}\right)\left(\frac{1}{2}\varepsilon_0 E_0^2 c\right)$$

$$= \varepsilon_0 E^2$$

Here, $E = 200 \frac{V}{m}$ and $\varepsilon_0 = 8.85 \times 10^{-12}$

$$\text{Radiation Pressure} = 8.85 \times 10^{-12} \times (200)^2$$

$$= 354.0 \times 10^{-9} \text{ N/m}^2$$

30. The correct answer is [1].

Concept : Magnetic dipole (2) is laying in magnetic field of (1) so it will experience a torque

$$\tau = (m_2 \times B_1) \sin 90°$$

$$\tau = m_2 B_1$$

Magnetic Dipole (2) is lying in equatorial position of dipole (1)

So, $$B_1 = \frac{\mu_0}{4\pi} \times \frac{m_1}{r^3}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{1}{1^3}$$

The torque $$\tau = 1 \times \frac{\mu_0}{4\pi} . \times 1$$

$$= 1 \times 10^{-7} \text{ N.m}$$

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JEE (Main) PHYSICS SAMPLE PRACTICE PAPER 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 position of a particle is x–y plane is described by the variables $x = at^3$ and $y = 2at$. Then the acceleration of the particle.......

(1) is $6a$ at $t = 0$ **(2)** is $6a$ at $t = 1$

(3) is $3a$ at $t = 0$ **(4)** is $3a$ at $t = 1$

Q. 2. Which of the following options may be the correct estimate of the mean free path of gas particles ? [n : Number of gas particle per unit volume, d : diameter]

(1) $\lambda = \frac{1}{d^2n^2}$ **(2)** $\lambda = \frac{n^2d}{\sqrt{2}}$

(3) $\lambda = \frac{nd^2}{\sqrt{2}}$ **(4)** $\lambda = \frac{1}{\sqrt{2}nd^2}$

Q. 3. A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 steps backward, and so on. Each step is 1 m long and required 1 s to cover. How long the drunkard takes to fall in a pit 13 m away from the start ?

(1) 9 s **(2)** 21 s

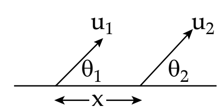
(3) 32 s **(4)** 37 s

Q. 4. If T be the total time of flight of a current of water and H be the maximum height attained by it from the point of projection, then H/T will be : (u = projection velocity, θ = projection angle)

(1) $\left(\frac{1}{2}\right)u \sin\theta$ **(2)** $\left(\frac{1}{4}\right)u \sin\theta$

(3) $u \sin\theta$ **(4)** $2u \sin\theta$

Q. 5. Two particles are projected simultaneously from the level ground as shown in figure. They may collide after a time :



(1) $\frac{x\sin\theta_2}{u_1}$ **(2)** $\frac{x\sin\theta_2}{u_2}$

(3) $\frac{x\sin\theta_2}{u_1\sin(\theta_2-\theta_1)}$ **(4)** $\frac{x\sin\theta_2}{u_2\sin(\theta_2-\theta_1)}$

Q. 6. If a body of mass m is moving on a rough horizontal surface of coefficient of kinetic friction μ, the net resultant force exerted by surface on the body is :

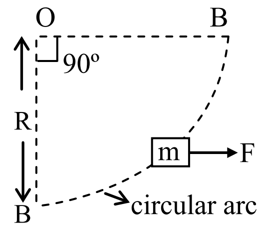
(1) $mg\sqrt{1+\mu^2}$ **(2)** μmg

(3) mg **(4)** $mg\sqrt{1-\mu^2}$

Q. 7. An electric fan has blades of length 30 cm as measured from the axis of rotation. If the fan is rotating at 1200 r.p.m. The acceleration of a point on the tip of the blade is about :

(1) 1600 m/s^2 **(2)** 4740 m/s^2
(3) 2370 m/s^2 **(4)** 5055 m/s^2

Q. 8. A block of mass *m* is taken from A to B slowly under the action of a constant force F. Work done by this force is :



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

Q. 9. A monkey of mass 20 kg rides on a 40 kg trolley moving with constant speed of 8 m/s along a horizontal track. If the monkey jumps vertically to grab the overhanging branch of a tree, the speed of the trolley after the monkey has jumped off is :

(1) 8 m/s **(2)** 1 m/s
(3) 4 m/s **(4)** 12 m/s

Q. 10. A rod of mass 'm' hinged at one end is free to rotate in a horizontal plane. A small bullet of mass m/4 travelling with speed '*u*' hits the rod and attaches to it at its centre. Find the angular speed of rotation of rod just after the bullet hits the rod 3.

[take length of the rod as '*l*']

(1) $\frac{6}{19}\frac{u}{l}$ **(2)** $\frac{6}{13}\frac{u}{l}$
(3) $\frac{3}{19}\frac{u}{l}$ **(4)** $\frac{3}{13}\frac{u}{l}$

Q. 11. If R is the radius of the earth and *g* is the acceleration due to gravity on the earth's surface, the mean density of the earth is :

(1) $\frac{4}{3}\frac{G}{R}$ **(2)** $\frac{3\pi R}{4gG}$
(3) $\frac{3g}{4\pi RG}$ **(4)** $\frac{\pi Rg}{ü}$

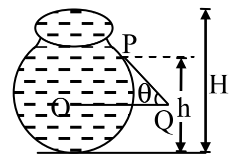
Q. 12. A particle is oscillating according to the equation X = 7 cos 0.5 πt, where '*t*' is in second. The point moves from the position of equilibrium to maximum displacement in time :

(1) 4.0 second **(2)** 2.0 second
(3) 1.0 second **(4)** 0.5 second

Q. 13. A metal wire of length L, area of cross section A and Young's modulus Y behaves as a spring of spring constant *k* given by:

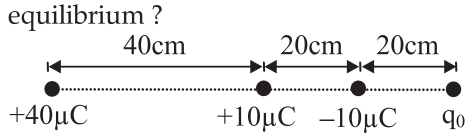
(1) k = YA/L **(2)** k = 2YA/L
(3) k = YA/2L **(4)** k = YL/A

Q. 14. Figure shows the vertical cross-section of a vessel filled with liquid of density ρ. The normal thrust per unit area on the walls of the vessel at point P, as shown will be :



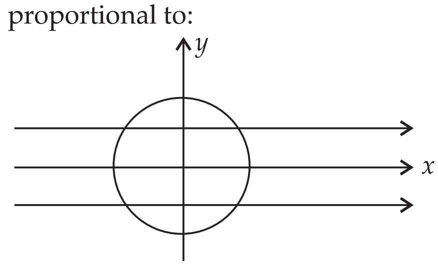
(1) $h \rho g$ **(2)** $(H - h) \rho g$
(3) $(H - h) \rho g \cos \theta$ **(4)** $H \rho g$

Q. 15. Four point charges are placed in a straight line with magnitude and separation as shown in the diagram. What should be the value of q_0 such that + 10μ*C* charge is in equilibrium ?



(1) – 80 μ*C* **(2)** + 40 μ*C*
(3) + 80 μ*C* **(4)** – 20 μ*C*

Q. 16. A conducting loop of resistance *R* and radius *r* has its centre at the origin of the coordinate system in a magnetic field of induction *B*. When it is rotated about *y*-axis through 90°, the net charge flown in the loop is directly proportional to:

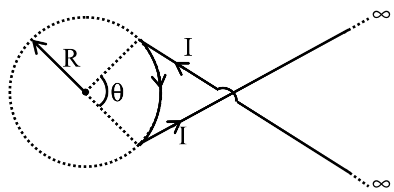


(1) R^{-1} **(2)** R
(3) r^2 **(4)** r

Q. 17. In copper, each copper atom releases one electron. If a current of 1.1 A is flowing in the copper wire of uniform cross-sectional area of diameter 1 mm, then drift velocity of electrons will approximately be : (Density of copper = 9 × 10^3 kg /m^3, Atomic weight of copper = 63)

(1) 10.3 mm/s (2) 0.1 mm/s
(3) 0.2 mm/s (4) 0.2 cm/s

Q. 18. A wire carrying current i has the configuration shown in figure. For the magnetic field to be zero at the centre of the circle, θ must be :



(1) 1 radian (2) 2 radian
(3) π radian (4) 2π radian

Q. 19. When a clock is viewed in a mirror, the needles exhibit a time which appears to be 8:20. Then the actual time will be :

(1) 4:40 (2) 3:40
(3) 8:20 (4) 3:20

Q. 20. The value of angular momentum for He^+ ion in the first Bohr orbit is :

(1) $\frac{h}{2\pi}$ (2) $4 \times \frac{h}{2\pi}$
(3) $2 \times \frac{h}{2\pi}$ (4) nothing can be said

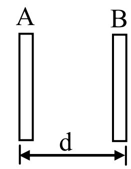
Section B

Q. 21. ^{23}Ne decays to ^{23}Na by negative beta emission. Mass of ^{23}Ne is 22.994465 amu mass of ^{23}Na is 22.989768 amu. The maximum kinetic energy of emitted electrons neglecting the kinetic energy of recoiling product nucleus is ....MeV

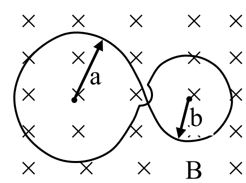
Q. 22. If photons of ultraviolet light of energy 12 eV are incident on a metal surface of work function of 4 eV, then the stopping potential (in eV) will be :

Q. 23. A light is entering from one medium refractive index $\left(RI = \frac{5}{3}\right)$ to another medium at an angle 30°. The angle of refraction for other medium is $\sin^{-1}\left(\frac{5}{6}\right)$. then the increase in angle of incidence is ...., such that the ray of light reflected back into the same medium.

Q. 24. Two plates A and B of a parallel plate capacitor are arranged in such a way, that the area of each plate is $S = 5 \times 10^{-3}$ m^2 and distance between them is d = 8.85 mm. Plate A has a positive charge $q_1 = 10^{-10}$ C and Plate B has charge $q_2 = +2 \times 10^{-10}$ C. Then the charge induced on the plate B due to the plate A be – (....... $\times 10^{-11}$)C



Q. 25. A plane loop is shaped in the form as shown in figure with radii a = 20 cm and b = 10 cm and is placed in a uniform time varying magnetic field $B = B_0 \sin \omega t$, where $B_0 = 10\ m$T and ω = 100 rad/s. The amplitude of the current induced in the loop if its resistance per unit length is equal to 50×10^{-3} Ω/m. The inductance of the loop is negligible is .... A.

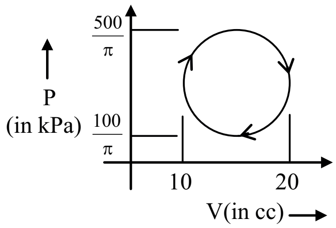


Q. 26. A series LCR circuit containing a resistance of 120 Ω has angular resonance frequency 4×10^5rad s^{-1}. At resonance the voltage across resistance and inductance are 60 V and 40 V respectively. At what frequency the current in the circuit lags the voltage by 45°. Give answer in ....$\times 10^5$rad s^{-1}.

Q. 27. On an X temperature scale, water freezes at –125°X and boils at 375°X. On a Y temperature scale, water freezes at –70°Y and boils at –30°Y. The value of temperature on X scale is....... on which value of temperature on y Scale becomes 50° Y

Q. 28. A diatomic molecule can be modelled as two rigid balls connected with spring such that the balls can vibrate with respect to centre of mass of the system (spring + balls). Consider a diatomic gas made of such diatomic molecule. If the gas performs 20 Joule of work under isobaric condition, then heat given to the gas is .... J.

Q. 29. Work done by gas in cyclic process is .... J.



Q. 30. In a quink tube experiment, a tuning fork of frequency 300 Hz is vibrated at one end. It is observed that intensity decreases from maximum to 50 % of its maximum value, as tube is moved by 6.25 cm. Velocity of sound is .... m/s.

Answer Key

Q. No.	Answer	Topic Name	Q. No.	Answer	Topic Name
1	2	Kinematics	16	3	Equipotential surface
2	4	Kinetic theory of gases	17	2	Current Electricity
3	4	One Dimension	18	2	Magnetic Effect of Current
4	2	Projectile Motion	19	2	Ray Optics
5	3	Newton's Laws of Motion	20	1	Atomic Structure & Matter Wave
6	1	Friction	21	4.00	Nuclear Physics & Radioactivity
7	2	Circular Motion	22	8.00	Photoelectric Effect
8	1	Work Energy and Power	23	7.00	Refraction at Plane Surface
9	4	Newtons law of motion	24	5.00	Capacitance
10	1	Angular momentum	25	1.00	Electromagnetic Induction
11	3	Gravitation	26	8.00	Alternative Current
12	3	Simple harmonic motion	27	1375	Calorimetry
13	1	Properties of Matter	28	70.00	Thermodynamics
14	2	Fluid Mechanics	29	1.00	Thermodynamics
15	3	Electrostatics	30	150	Sound Wave

JEE (Main) PHYSICS SAMPLE PRACTICE PAPER 2

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 magnitude of vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ are respectively 12, 5 and 13 units and $\vec{A}+\vec{B}=\vec{C}$, then the angle between $\vec{A}$ and $\vec{B}$ is :

(1) 0 **(2)** π

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

Q. 2. A wave is represented by $y = a \sin (At - Bx + C)$ where A, B, C are constants and t is in seconds and x is in metre. The dimensions of A, B, C are :

(1) $[T^{-1}], [L], [M^0L^0T^0]$

(2) $[T^{-1}], [L^{-1}], [M^0L^0T^0]$

(3) $[T], [L], [M]$

(4) $[T^{-1}], [L^{-1}], [M^{-1}]$

Q. 3. A body moves in a straight line along, x-axis. Its distance x (in metre) from the origin is given by $x = 8t - 3t^2$. The average speed in the interval $t = 0$ to $t = 1$ second is :

(1) 5 ms^{-1} **(2)** – 4 ms^{-1}

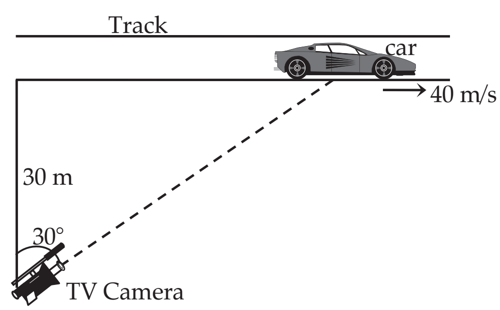
(3) 6 ms^{-1} **(4)** zero

Q. 4. In a legend the hero-kid kicked a toy pig so that it is projected with a speed greater than that of its cry. If the weight of the toy pig is assumed to be 5 kg and the time of contact 0.01 s, the force with which the hero-kid kicked him was (Speed of cry = 330 m/s) :

(1) 5×10^{-2} N **(2)** 2×10^5 N

(3) 1.65×10^5 N **(4)** 1.65×10^3 N

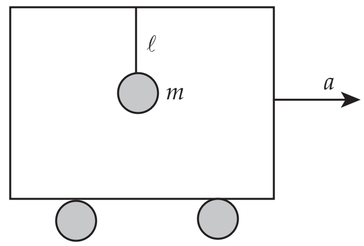
Q. 5. A racing car is travelling along a track at a constant speed of 40 m/s. A T.V. camera man is recording the event from a distance of 30 m directly away from the track as shown in figure. In order to keep the car under view in the position shown, the angular speed with which the camera should be rotated, is :



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

(3) $\frac{8}{3}\sqrt{3}$ rad/s **(4)** 1 rad/s

Q. 6. A pendulum of mass m and length ℓ is suspended from the ceiling of a trolley which has a constant acceleration a in the horizontal direction as shown in figure. Work done by the tension is (In the frame of trolley) :



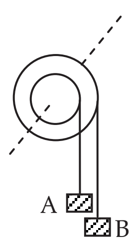
(1) $\frac{mg}{\tan\theta}[\cos(\tan^{-1}(a/g)-1]$

(2) $\frac{mg}{\tan\theta}[\sin(\tan^{-1}(a/g)-1]$

(3) $\frac{mg}{\cos\theta}[\sin(\tan^{-1}(a/g)-1]$

(4) $\frac{mg}{\cos\theta}[\cos(\tan^{-1}(a/g)-1]$

Q. 7. Figure shows a small wheel fixed coaxially on a bigger one of double the radius. The system rotates about the common axis. The strings supporting A and B do not slip on the wheels. If x and y be the distances travelled by A and B in the same time interval, then :



(1) $x = 2y$ **(2)** $x = y$

(3) $y = 2x$ **(4)** None of these

Q. 8. The velocities of a particle in SHM at positions x_1 and x_2 are v_1 and v_2, respectively, its time period will be

(1) $2\pi\sqrt{\frac{(v_1^2 - v_2^2)}{(x_2^2 - x_1^2)}}$ **(2)** $2\pi\sqrt{\frac{(x_1^2 + x_2^2)}{(v_2^2 - v_1^2)}}$

(3) $2\pi\sqrt{\frac{(x_1^2 - x_2^2)}{(v_2^2 - v_1^2)}}$ **(4)** $2\pi\sqrt{\frac{(x_1^2 + x_2^2)}{(v_2^2 + v_1^2)}}$

Q. 9. One cubic plate, having 15 cm side, floats on water surface. If surface tension of water is 60 dyne/cm. To lift this plate from water, Find the extra force required against weight.

(1) 3600 dyne **(2)** 1800 dyne

(3) 900 dyne **(4)** 7200 dyne

Q. 10. A train moving at 25 m/s makes a whistle of frequency 200 Hz. If the speed of sound in air is 340 m/s, find the frequency observed by a stationary observer.

(i) if observer is in front of the source

(ii) if observer is behind the train

(1) 186 Hz, 216 Hz **(2)** 216 Hz, 186 Hz

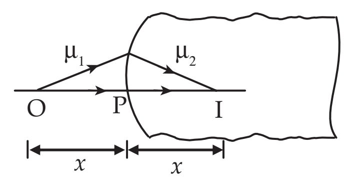
(3) 172 Hz, 220 Hz **(4)** 220 Hz, 172 Hz

Q. 11. Two coherent sources of different intensities send waves which interfere. The ratio of maximum intensity to the minimum intensity is 25. The intensities of the sources are in the ratio :

(1) 25 : 1 **(2)** 5 : 1

(3) 9 : 4 **(4)** 625 : 1

Q. 12. A spherical surface of radius R separates two medium of refractive indices μ_1 and μ_2, as shown in figure. Where should an object be placed in the medium 1 so that a real image formed in medium 2 is at the same distance ?



(1) $\left(\frac{\mu_2 - \mu_1}{\mu_2 + \mu_1}\right)R$ **(2)** $\left(\frac{\mu_2 + \mu_1}{\mu_2 - \mu_1}\right)R$

(3) $\left(\frac{\mu_2 + \mu_1}{\mu_2}\right)R$ **(4)** $\left(\frac{\mu_2}{\mu_2 + \mu_1}\right)R$

Q. 13. The dispersive powers of flint glass and crown glass are 0.053 and 0.034, respectively and their mean refractive indices are 1.68 and 1.53 for white light. Calculate the angle of the flint glass prism required to form an achromatic combination with a crown glass prism of refracting angle 4° :

(1) 2° **(2)** 4°

(3) 5° **(4)** 6°

Q. 14. In young's double slit experiment $\frac{d}{D} = 10^{-4}$ (d = distance between slits, D = distance of screen from the slits). At a point P on the screen resulting intensity is equal to the intensity due to individual slit I_0. Then the distance of point P from the central maximum is (λ = 6000 Å)

(1) 2 mm **(2)** 1 mm

(3) 0.5 mm **(4)** 4 mm

Q. 15. The mobility of electrons in a semiconductor chip of length 10 cm is observed to be 1000 cm^2/Vs. When a potential difference of 2V is applied across it. What is the drift speed of electrons.

(1) 2 m/s **(2)** 5 cm/s

(3) 2000 m/s **(4)** 1000 m/s

Q. 16. The energy levels of a certain atom for first, second and third levels are E, 4E/3 and 2E, respectively. A photon of wavelength λ is emitted for a transition $3 \rightarrow 1$. What will be the wavelength of emission for transition $2 \rightarrow 1$?

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

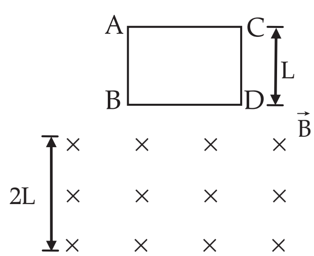
(3) $\frac{3\lambda}{4}$ **(4)** 3λ

Q. 17. The graph of $\ell n\left(\frac{R}{R_0}\right)$ versus ℓn A (R = radius of a nucleus and A = its mass number) is :

(1) a straight line **(2)** a parabola

(3) an ellipse **(4)** none of these

Q. 18. A square coil ABCD with its plane vertical is released from rest in a horizontal uniform magnetic field $\vec{B}$ of length 2L. The acceleration of the coil is :



(1) less than g for all the time till the loop crosses the magnetic field completely

(2) less than g when it enters the field and greater than g when it comes out of the field

(3) g all the time

(4) less than g when it enters and comes out of the field but equal to g when it is within the field

Q.19. We have three identical perfectly black plates. The temperatures of first and third plate is T and 3T. What is the temperature of second plate if system is in equilibrium ?

(1) $41^{1/4}$ T **(2)** $51^{1/4}$ T

(3) $2^{1/4}$ T **(4)** $37^{1/4}$ T

Q. 20. If a baseball player can throw a ball at maximum distance = d over a ground, the maximum vertical height to which he can throw it, will be (Ball has same initial speed in each case) :

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

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

Section B

Q. 21. A ball falls from a height of 1 m on a ground and it loses half its kinetic energy when it hits the ground. What would be the total distance covered by the ball after sufficiently long time ?

Q. 22. Consider a gravity-free hall in which an experimenter of mass 50 kg is resting on a 5 kg pillow, 8 ft above the floor of the hall. He pushes the pillow down so that it starts falling at a speed of 8 ft/s. The pillow makes a perfectly elastic collision with the floor, rebounds and reaches the experimenter's head. The time elapsed in the process is......s

Q. 23. A battery of EMF 10V sets up a current of 1A when connected across a resistor of 8Ω. If the resistor is shunted by another 8Ω resistor, what would be the current in the circuit ? (in A)

Q. 24. A liquid flows out drop by drop from a vessel through a vertical tube with an internal diameter of 2 mm, then the total number of drops that flows out during 10 grams of the liquid flow out..... [Assume that the diameter of the neck of a drop at the moment it breaks away is equal to the internal diameter of tube and surface tension is 0.02 N/m].

Q. 25. Combination of two identical capacitors, a resistor R and a DC voltage source of voltage 6 V is used in a experiment on C-R circuit. It is found that for a parallel combination of the capacitor the time in which the voltage of the fully charged combination reduces to half its original voltage is 10 s. For series combination the time (in sec) needed for reducing the voltage of the fully charged series combination by half is..........

Q. 26. A copper ball of density 8.6 g/cm^3, 1 cm in diameter is immersed in oil of density 0.8 g/cm^3. The charge in μC on the ball, if it remains just suspended in an electric field of intensity 3600 V/m acting in upward direction is..... μC.

Q. 27. Escape velocity for earth surface is 11 km/s. If the radius of any planet is two times the radius of the earth but average density is same as that of earth. Then the escape velocity (in km/s) at the planet will be.

Q. 28. A zener diode of voltage V_Z (= 6V) is used to maintain a constant voltage across a load resistance R_L (= 1000 Ω) by using a series resistance R_S (= 100 Ω). If the e.m.f. of source is E (= 9 V), what is the power (in watt) being dissipated in Zener diode?

Q. 29. At the centre of a circular coil of radius 5 cm carrying current, magnetic field due to earth is 0.5×10^{-5} W/m^2. What should be the current (in A) flowing through the coil so that it annuls the earth's magnetic field.

Q. 30. The temperature of reservoir of Carnot's engine operating with an efficency of 70% is 1000 kelvin. The temperature (in kelvin) of its sink is.

Answer Key

Q. No.	Answer	Topic's Name	Q. No.	Answer	Topic's Name
1	3	Vector	16	4	Atomic Structure
2	2	Unit & Dimension	17	1	Nuclear Physics
3	1	One Dimension	18	4	Electromagnetic Induction
4	2	Newton's Law of Motion	19	1	Stefan's Law
5	4	Circular Motion	20	1	Projectile Motion
6	4	Work Energy and Power	21	3.00	Coefficient of Restitution
7	3	Rotational	22	2.22	Conservation Law
8	3	Simple Harmonic Motion	23	1.67	Electricity
9	1	Fluid mechanics	24	780	Surface Tension
10	2	Doppler Effect	25	2.5	Capacitor
11	3	Wave Optics	26	34.00	Electrostatics
12	2	Refraction at Curved Surface	27	22	Gravitation
13	1	Prism	28	0.144	Zener diode
14	1	Wave optics	29	0.4	Magnetic field
15	1	Semiconductors	30	300	Thermodynamics