# JEE (Main) PHYSICS SOLVED PAPER

# 2023

**08th April Shift 1**

**General Instructions :**

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

## Section A

**Q. 1.** A cylindrical wire of mass (0.4 ± 0.01)g has length (8 ± 0.04) cm and radius (6 ± 0.03) mm. The maximum error in its density will be:
**(A)** 4% **(B)** 1%
**(C)** 3.5% **(D)** 5%

**Q. 2.** The engine of a train moving with speed 10 $ms^{-1}$ towards a platform sounds a whistle at frequency 400 Hz. The frequency heard by a passenger inside the train is : (neglect air speed. Speed of sound in air = 330 $ms^{-1}$)
**(A)** 400 Hz **(B)** 388 Hz
**(C)** 200 Hz **(D)** 412 Hz

**Q. 3.** The weight of a body on the earth is 400 N. Then weight of the body when taken to a depth half of the radius of the earth will be:
**(A)** 300 N **(B)** Zero
**(C)** 100 N **(D)** 200 N

**Q. 4.** A TV transmitting antenna is 98 m high and the receiving antenna is at the ground level. If the radius of the earth is 6400 km, the surface area covered by the transmitting antenna is approximately:
**(A)** 120 $km^2$ **(B)** 1549 $km^2$
**(C)** 4868 $km^2$ **(D)** 3942 $km^2$

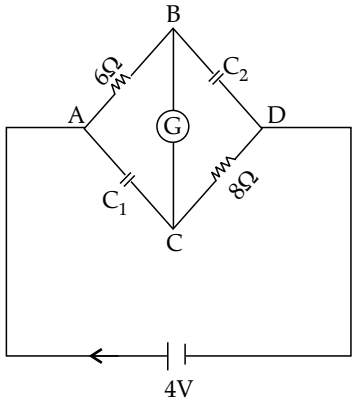
**Q. 5.** Certain galvanometers have a fixed core made of non magnetic metallic material. The function of this metallic material is
**(A)** To produce large deflecting torque on the coil
**(B)** To bring the coil to rest quickly
**(C)** To oscillate the coil in magnetic field for longer period of time
**(D)** To make the magnetic field radial

**Q. 6.** Dimension of $\frac{1}{\mu_0\varepsilon_0}$ should be equal to

**(A)** $\frac{T}{L}$ **(B)** $\frac{T^2}{L^2}$
**(C)** $\frac{L}{T}$ **(D)** $\frac{L^2}{T^2}$

**Q. 7.** Two projectiles A and B are thrown with initial velocities of 40 m/s and 60 m/s at angles 30° and 60° with the horizontal respectively. The ratio of their ranges respectively is ($g$ = 10 $m/s^2$)
**(A)** $2:\sqrt{3}$ **(B)** $\sqrt{3}:2$
**(C)** 4 : 9 **(D)** 1 : 1

**Q. 8.** In this figure the resistance of the coil of galvanometer G is 2 Ω. The emf of the cell is 4 V. The ratio of potential difference across $C_1$ and $C_2$ is:

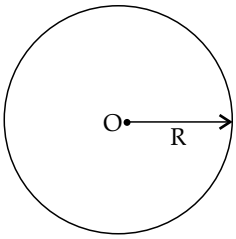


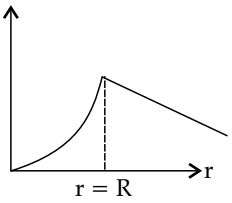

**(A)** $\frac{5}{4}$ **(B)** 1
**(C)** $\frac{4}{5}$ **(D)** $\frac{3}{4}$

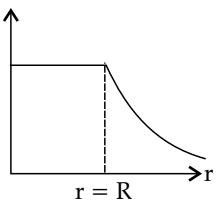
**Q. 9.** A charge particle moving in magnetic field B, has the components of velocity along B as well as perpendicular to B. The path of the charge particle will be
**(A)** Helical path with the axis along magnetic field B
**(B)** Straight along the direction of magnetic field B
**(C)** Helical path with the axis perpendicular to the direction of magnetic field B
**(D)** Circular path

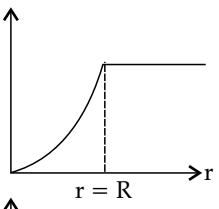
**Q. 10.** Proton (P) and electron (e) will have same de-Broglie wavelength when the ratio of their momentum is (assume, $m_p = 1849\ m_e$):
**(A)** 1 : 43 **(B)** 43 : 1
**(C)** 1 : 1849 **(D)** 1 : 1

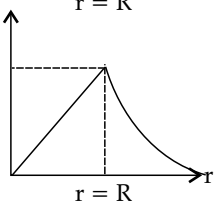
**Q. 11.** Graphical variation of electric field due to a uniformly charged insulating solid sphere of radius R, with distance r from the centre O is represented by:




**(A)**



**(B)**



**(C)**



**(D)**



**Q. 12.** For a nucleus ${}^{A}_{Z}X$ having mass number A and atomic number Z

A. The surface energy per nucleon $(b_s) = -a_1 A^{2/3}$.

B. The Coulomb contribution to the binding energy $b_c = -a_2 \dfrac{Z(Z-1)}{A^{4/3}}$

C. The volume energy $bv = a_3A$

D. Decrease in the binding energy is proportional to surface area.

E. While estimating the surface energy, it is assumed that each nucleon interacts with 12 nucleons. ($a_1$, $a_2$ and $a_3$ are constants)

Choose the most appropriate answer from the options given below:

**(A)** B, C only **(B)** A, B, C, D only
**(C)** B, C, E only **(D)** C, D only

**Q. 13.** At any instant the velocity of a particle of mass 500 g is $(2t\hat{i} + 3t^2\hat{j})$ ms$^{-1}$. If the force acting on the particle at $t$ = 1s is $(\hat{i} + x\hat{j})$ N . Then the value of $x$ will be:

**(A)** 2 **(B)** 6
**(C)** 3 **(D)** 4

**Q. 14.** Given below are two statements:

**Statement I:** If E be the total energy of a satellite moving around the earth, then its potential energy will be $\dfrac{E}{2}$.

**Statement II:** The kinetic energy of a satellite revolving in an orbit is equal to the half the magnitude of total energy E.

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 incorrect

**(B)** Statement I is incorrect but Statement II is correct

**(C)** Statement I is correct but Statement II is incorrect

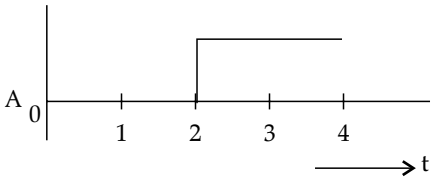
**(D)** Both Statement I and Statement II are correct

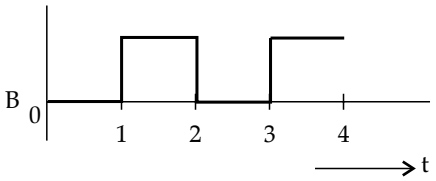
**Q. 15.** Two forces having magnitude A and $\dfrac{A}{2}$ are perpendicular to each other. The magnitude of their resultant is:

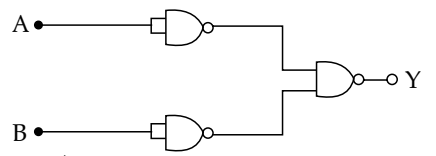
**(A)** $\dfrac{5A}{2}$ **(B)** $\dfrac{\sqrt{5}A^2}{2}$

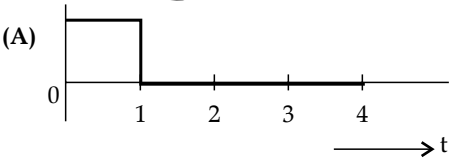
**(C)** $\dfrac{\sqrt{5}A}{4}$ **(D)** $\dfrac{\sqrt{5}A}{2}$

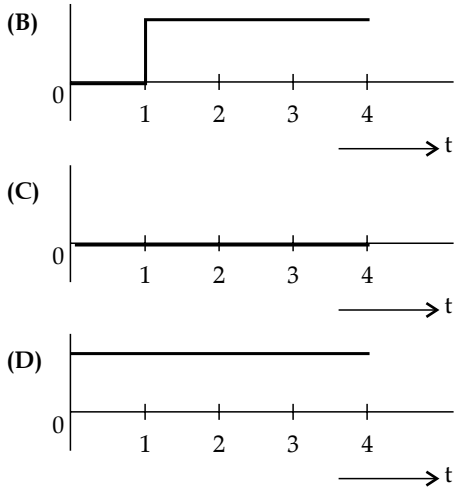
**Q. 16.** For the logic circuit shown, the output waveform at Y is:




**(A)**





**Q. 17.** An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10}$ N/m$^2$ undergoes elastic strain of 0.04%. The energy per unit volume stored in the rod in SI unit is:
**(A)** 5600 **(B)** 2800
**(C)** 11200 **(D)** 8400

**Q. 18.** Given below are two statements:
**Statement I:** If heat is added to a system, its temperature must increase.
**Statement II:** If positive work is done by a system in a thermodynamic process, its volume must increase.
In the light of the above statements, choose the correct answer from the options given below
**(A)** Both Statement I and Statement II are true
**(B)** Both Statement I and Statement II are false
**(C)** Statement I is true but Statement II is false
**(D)** Statement I is false but Statement II is true

**Q. 19.** An air bubble of volume 1 cm$^3$ rises from the bottom of a lake 40 m deep to the surface at a temperature of 12°C. The atmospheric pressure is $1 \times 10^5$ Pa, the density of water is 1000 kg/m$^3$ and $g = 10$ m/s$^2$. There is no difference of the temperature of water at the depth of 40 m and on the surface. The volume of air bubble when it reaches the surface will be:
**(A)** 3 cm$^3$ **(B)** 4 cm$^3$
**(C)** 2 cm$^3$ **(D)** 5 cm$^3$

**Q. 20.** In a reflecting telescope, a secondary mirror is used to:
**(A)** Make chromatic aberration zero
**(B)** Reduce the problem of mechanical support
**(C)** Move the eyepiece outside the telescopic tube
**(D)** Remove spherical aberration

## Section B

**Q. 21.** The momentum of a body is increased by 50%. The percentage increase in the kinetic energy of the body is _____ %

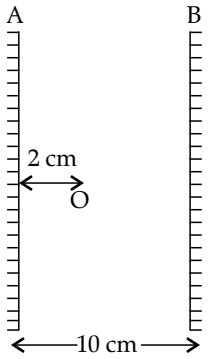
**Q. 22.** A nucleus with mass number 242 and binding energy per nucleon as 7.6 MeV breaks into two fragment each with mass number 121. If each fragment nucleus has binding energy per nucleon as 8.1 MeV, the total gain in binding energy is _____ MeV.

**Q. 23.** An electric dipole of dipole moment $6.0 \times 10^{-6}$ Cm placed in a uniform electric field of $1.5 \times 10^3$ NC$^{-1}$ in such a way that dipole moment is along electric field. The work done in rotating dipole by 180° in this field will be _____ mJ.

**Q. 24.** An organ pipe 40 cm long is open at both ends. The speed of sound in air is 360 ms$^{-1}$. The frequency of the second harmonic is _____ Hz.

**Q. 25.** The moment of inertia of a semicircular ring about an axis, passing through the center and perpendicular to the plane of ring, is $\frac{1}{x}$ MR$^2$, where R is the radius and M is the mass of the semicircular ring. The value of $x$ will be _____.

**Q. 26.** Two vertical parallel mirrors A and B are separated by 10 cm. A point object O is placed at a distance of 2 cm from mirror A. The distance of the second nearest image behind mirror A from the mirror A is _____ cm




**Q. 27.** The magnetic intensity at the center of a long current carrying solenoid is found to be $1.6 \times 10^3$ Am$^{-1}$. If the number of turns is 8 per cm, then the current flowing through the solenoid is _____ A.

**Q. 28.** A current of 2 A through a wire of cross-sectional area 25.0 mm$^2$. The number of free electrons in a cubic meter are $2.0 \times 10^{28}$. The drift velocity of the electrons is _____ $\times 10^{-6}$ ms$^{-1}$

(given, charge on electron = $1.6 \times 10^{-19}$ C).

**Q. 29.** An oscillating LC circuit consists of a 75 mH inductor and a 1.2 μF capacitor. If the maximum charge to the capacitor is 2.7 μC. The maximum current in the circuit will be _____ mA.

**Q. 30.** An air bubble of diameter 6 mm rises steadily through a solution of density 1750 kg/m$^3$ at the rate of 0.35 cm/s. TGe co-efficient of viscosity of the solution (neglect density of air) is _____ poise (given, $g = 10$ ms$^{-2}$).

# Answer Key

| Q. No. | Answer | Topic Name | Chapter Name |
|---|---|---|---|
| 1 | A | Error | Unit and dimension |
| 2 | A | Doppler's effect | Sound wave |
| 3 | D | Variation of $g$ | Gravitation |
| 4 | D | Range | Communication system |
| 5 | B | Galvanometer | Magnetism |
| 6 | D | Dimensional equation | Units & Dimension |
| 7 | C | Range of projectile | Motion in 2D |
| 8 | C | RC circuit | Electric current |
| 9 | A | Force on moving charge in magnetic field | Moving charge and magnetism |
| 10 | D | Debroglie wavelength | Dual nature of matter |
| 11 | D | electric field due to charged sphere | Electrostatics |
| 12 | D | Binding energy | Nuclear physics |
| 13 | C | Momentum | Newton's second law |
| 14 | A | Energy of satellite | Gravitation |
| 15 | D | Resultant vector | Vectors |
| 16 | B | Logic gates | Semiconductors |
| 17 | A | Energy stored in stretched rod | Elasticity |
| 18 | D | Thermodynamic process | Thermodynamics |
| 19 | D | Isothermal process | Thermodynamics |
| 20 | C | Telescope | Ray optics |
| 21 | [125] | Kinetic energy | Work, Energy and Power |
| 22 | [121] | Binding energy | Nuclear physics |
| 23 | [18] | Dipole in uniform electric field | Electric dipole |
| 24 | [900] | Organ pipe | Sound wave |
| 25 | [1] | MI of semicircular ring | Rotational motion |
| 26 | [18] | Plane mirror | Ray optics |
| 27 | [2] | Solenoid | Electromagnetism |
| 28 | [25] | Drift velocity | Electric current |
| 29 | [9] | LC circuit | Electromagnetic induction |
| 30 | [10] | Terminal velocity | Fluid mechanics |

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**08th April Shift 1**

## ANSWERS WITH EXPLANATIONS

### Section A

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

$$\rho = \frac{m}{V} = \frac{m}{\pi r^2 l}$$

Now the relative error is given by

$$\left(\frac{\Delta\rho}{\rho}\right)_{max} = \left(\frac{\Delta m}{m}\right) + 2\left(\frac{\Delta r}{r}\right) + \left(\frac{\Delta l}{l}\right)$$

$$\Rightarrow \left(\frac{\Delta\rho}{\rho}\right)_{max} = \left(\frac{0.01}{0.4}\right) + 2\left(\frac{0.03}{6}\right) + \left(\frac{0.04}{8}\right)$$

$$\Rightarrow \left(\frac{\Delta\rho}{\rho}\right)_{max} = 0.04$$

Now % error in density $= \left(\frac{\Delta\rho}{\rho}\right) \times 100\%$

$= 0.04 \times 100\% = 4\%$

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

The relative velocity between the train and passanger is zero. Therefore there would not be Doppler's effect. And hence frequency heard by the passanger would be same 400 Hz.

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

Given $w = mg = 400$ N

$$d = \frac{R}{2}$$

At depth $d$,

$$g' = g\left(1 - \frac{d}{R}\right)$$

$$\Rightarrow g' = g\left(1 - \frac{R}{2R}\right) \Rightarrow g' = g\left(\frac{1}{2}\right) = \frac{g}{2}$$

So,

$$w' = mg' = \frac{mg}{2}$$

$$w' = \frac{400}{2} = 200 \text{ N}$$

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

Given values

$h_T = 98$ m

$h_R = 0$

R = 6400 km

Now

$$d = \sqrt{2Rh_T} + \sqrt{2Rh_r}$$

$$= \sqrt{2 \times 6400 \times 10^3 \times 98} + 0$$

$$d = \frac{112}{\sqrt{2}} \text{km}$$

Now area $= \pi d^2$

$$= \frac{22}{7} \times \left(\frac{112}{\sqrt{2}}\right)^2 = 3942 \text{ km}^2$$

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

By making fixed core with non magnetic material, the coil is brought quickly at rest because due to motion of the coil eddy current develops.

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

Since,

$$c^2 = \frac{1}{\mu_0 \varepsilon_0} \quad \text{(where } c = \text{speed of light)}$$

$$\Rightarrow \left[\frac{1}{\mu_0 \varepsilon_0}\right] = [c^2]$$

$$\Rightarrow \left[\frac{1}{\mu_0 \varepsilon_0}\right] = [L^2 T^{-2}] = \left[\frac{L^2}{T^2}\right]$$

**7. Option (C) is correct.**

Range of a projectile is given by

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

Now $R_A = \frac{(40)^2 \sin(2 \times 30)}{g}$ ...(i)

$$R_B = \frac{(60)^2 \sin(2 \times 60)}{g}$$ ...(ii)

From (i) & (ii)

$$\frac{R_A}{R_B} = \frac{(40)^2 \sin(2 \times 30)}{(60)^2 \sin(2 \times 60)} = \frac{4}{9}$$

**8. Option (C) is correct.**

At a steady state, no current would be flowing in capacitor circuit.

Required $= 6 + 2 + 8 = 16\ \Omega$

From Ohm's law

$$i = \frac{V}{R} = \frac{4}{16} = \frac{1}{4} \text{A}$$

Voltage across AC

$$V_{AC} = i(6 + 2) = \frac{1}{4} \times 8 = 2 \text{ V}$$

Voltage across BD

$$V_{BD} = i(2 + 8) = \frac{1}{4} \times 10 = 2.5 \text{ V}$$

Now $\frac{V_{AC}}{V_{BD}} = \frac{2}{2.5} = \frac{4}{5}$

**9. Option (A) is correct.**

As the velocity vector has two components. One is along magnetic field and other is perpendicular to it. Due to perpendicular component of velocity, the charge particle moves in circular path.

And the component of velocity is along the magnetic field remains unchanged.
Therefore the particle will move in helical path along magnetic field.

**10. Option (D) is correct.**
Debroglie wavelength (λ) is given by :

$$\lambda = \frac{h}{mv} \qquad (h = \text{plank's const.})$$

According to the question,

$$\lambda_e = \lambda p$$

$$\Rightarrow \frac{h}{m_e v_e} = \frac{h}{m_p v_p}$$

$$\Rightarrow \frac{h}{p_e} = \frac{h}{p_p} \qquad (\because P = mv)$$

$$\Rightarrow P_e = P_p \Rightarrow \frac{P_P}{P_e} = \frac{1}{1}$$

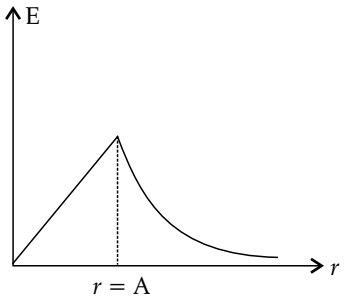
**11. Option (D) is correct.**
Electric field due to uniformly charged solid sphere is given by

$$E = \frac{Q}{4\pi\varepsilon_0 r^2} \qquad r \geq R$$

&

$$E = \frac{Qr}{4\pi\varepsilon_0 R^3} \qquad r \leq R$$

Therefore
$E \propto r$ when $r \leq R$
and $E \propto \frac{1}{r^2}$ when $r \geq R$
So




**12. Option (D) is correct.**

Mass number $A \propto r^3 \Rightarrow r \propto A^{\frac{1}{3}}$

Now, surface energy per nucleon $\propto \frac{r^2}{A} \propto \frac{A^{\frac{2}{3}}}{A} \propto \frac{1}{A^{\frac{1}{3}}}$
is

$$= -\frac{a_2 Z(Z-1)}{(A)^{\frac{1}{3}}}$$

And volume energy $\propto A$
Based on above statement, the correct option is (D).

**13. Option (C) is correct.**
Given value,
$m = 500\ g = 0.5\ kg$

$$\vec{v} = (2t\hat{i} + 3t^2\hat{j})$$

$$\vec{a} = \frac{d\vec{v}}{dt} = 2\hat{i} + 6t\hat{j}$$

acceleration at $t = 1$ sec.

$$\vec{a} = 2\hat{i} + 6\hat{j}$$

Now,

$$\vec{F} = m\vec{a} = 0.5(2\hat{i} + 6\hat{j}) \quad = \hat{i} + 3\hat{j}$$

$$\vec{F} = \hat{i} + x\hat{j}$$

Therefore, $x = 3$

**14. Option (A) is correct.**
Kinetic energy of satellite $= \frac{1}{2}mv^2 = \frac{GMm}{2r}$
Now, potential energy of the satellite

$$U = -\frac{GMm}{2r}$$

Total energy = K.E + U

$$= \frac{GMm}{2r} - \frac{GMm}{r} = -\frac{6Mm}{2r}$$

Therefore, potential energy = 2 × total energy
and, kinetic energy = |Total energy|

**15. Option (D) is correct.**

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

$$\Rightarrow |\vec{F}_{net}| = \sqrt{A^2 + \left(\frac{A}{2}\right)^2 + 2A + \frac{A}{2} \times \cos 90^\circ} \quad (\because \theta = 90^\circ)$$

$$\Rightarrow |\vec{F}_{net}| = \sqrt{A^2 + \frac{A^2}{4}}$$

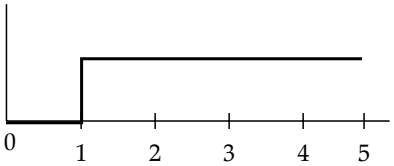
$$\Rightarrow |\vec{F}_{net}| = \sqrt{\frac{5A^2}{4}}$$

$$\Rightarrow |\vec{F}_{net}| = \sqrt{5}\frac{A}{2}$$

**16. Option (B) is correct.**
For the given circuit the truth table would be :

| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

The truth table shows that the output graph is given by :




**17. Option (A) is correct.**
Given values,
$y = 7 \times 10^{10}\ N/m^2$

strain (E) = 0.04% = $\frac{0.04}{100}$

Now

Energy $= \frac{1}{2}\left(\frac{YA}{l}\right)(\Delta l)^2$

$\Rightarrow$ Energy $= \frac{1}{2}\left(\frac{\Delta l}{l}\right)^2 YAl$

$\Rightarrow \frac{\text{Energy}}{Al} = \frac{1}{2}Y(E)^2$

$\Rightarrow \frac{E}{V} = \frac{1}{2}\times 7\times 10^{10}\times\frac{0.04\times 0.04}{100\times 100} = 56\times 10^2$

(where volume = A × $l$)

**18. Option (D) is correct.**

**Statement-I:** From I$^{st}$ law of thermodynamics

$$\Delta Q = \Delta u + w$$

If heat is supplied ot the system and converted into work done.

Then, $\Delta u < 0$. Hence, $\Delta T < 0$

Statement I is false

**Statement-II:** Work done in thermodynamics system is given by

$$w = \int PdV$$

Therefore, to get the positive work done volume of the system must increase

Statement-II is true

**19. Option (D) is correct.**

$P = P_0 + \rho gh$

$= 10^5\,Pa + 10^3 \times 10 \times 40 = 5 \times 10^5\,Pa$

In isothermal process

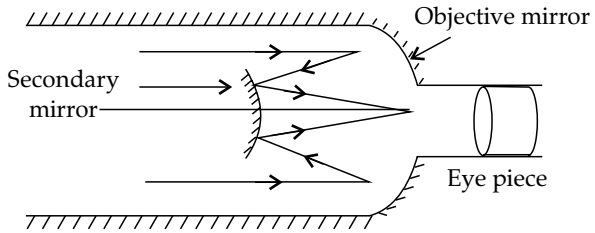
$PV = P_0V_0$

$\Rightarrow 5 \times 10^5\,Pa \times 1\,cm^3 = 10^5\,Pa \times V_0$

$\Rightarrow V_0 = \frac{5\times 10^5\,Pa\times 1cm^3}{5\times 10^5\,Pa}$

$\Rightarrow V_0 = 5\,cm^3$

**20. Option (C) is correct.**




Here the secondary mirror is used to move the eyepiece outside the telescope & it has advantage of a large focal length in a short telescope.

## Section B

**21. The correct answer is (125).**

K.E. = $\frac{P^2}{2m}$

K.E.$_{initial} = \frac{P^2}{2m}$

K.E.$_{final} = \frac{(1.5P)^2}{2m} = 2.25\frac{P^2}{2m}$

% increase in K.E. = $\frac{2.25\frac{P^2}{2m} - \frac{P^2}{2m}}{\frac{P^2}{2m}} \times 100$

% increase in K.E. = 1.25 × 100 = 125%

**22. The correct answer is (121).**

Binding energy (Initial) = 242 × 7.6 MeV

Binding energy (final)

= 121 × 8.1 MeV + 121 × 8.1 MeV

= 242 × 8.1 MeV

Gain in binding energy.

= Binding energy final – Binding energy initial

= 242 × 8.1 – 242 × 7.6

= 242 (8.1 – 7.6)

= 242 × 0.5 = 121 MeV

**23. The correct answer is (18).**

Work done in rotating the dipole = $V_f - V_i$

Now, $V_f = -PE\cos(180°)$

$V_i = -PE\cos 0°$

Therefore, $W = V_f - V_i$

$= (-PE\cos 180°) - (-PE\cos 0°)$

$= 2PE$

$= 2 \times 6 \times 10^{-6} \times 1.5 \times 10^3 = 18$ mJ

**24. The correct answer is (900).**

In an open organ pipe, the condition for second hormonies is :

The length of organ pipe = wavelength

$$h = \lambda$$

Now frequency = $f = \frac{v}{\lambda}$

$\Rightarrow f = \frac{360}{L} = \frac{360}{\frac{40}{100}} = \frac{360\times 100}{40}$

$\Rightarrow f = 900$ Hz

**25. The correct answer is (1).**

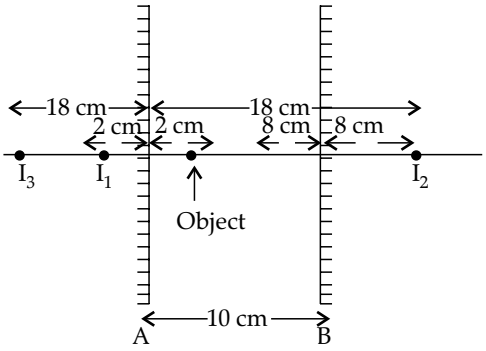
Moment of inertia of a semicircular ring about its centre and perpendicular to the plane of ring is given by $MR^2$

Therefore, $MR^2 = \frac{1}{x}MR^2$

$\therefore x = 1$

**26. The correct answer is (18).**

Therefore the second nearest image behind mirror A is at 18 cm




**27. The correct answer is (2).**

$B = \mu_0 ni$

and $H = \dfrac{B}{\mu_0}$

$\Rightarrow H = \dfrac{\mu_0 ni}{\mu_0} = ni$

Now, $i = \dfrac{H}{h} = \dfrac{1.6\times10^3\times10^{-2}}{8} = 2\,A$

**28. The correct answer is (25).**

$V_d = \dfrac{I}{neA}$

$\Rightarrow V_d = \dfrac{2}{2\times10^{28}\times1.6\times10^{-19}\times25\times10^{-6}}$

$\Rightarrow V_d = 25\times10^{-6}$ m/s

**29. The correct answer is (9).**

Maximum energy stored in capacitor

= Maximum energy stored in inductor which is given by :

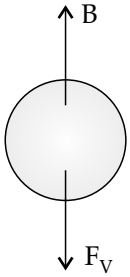
$\dfrac{1}{2}Li_{max}^2 = \dfrac{1}{2}\dfrac{Q_{max}^2}{C}$

$\Rightarrow i_{max}^2 = \dfrac{Q_{max}^2}{LC}$

$\Rightarrow i_{max} = \sqrt{\dfrac{Q_{max}^2}{LC}} = \dfrac{Q_{max}}{\sqrt{LC}}$

$= \dfrac{2.7\times10^{-6}}{\sqrt{75\times10^{-3}\times1.2\times10^{-6}}} = 9$ mA

**30. The correct answer is (10).**




From Newton's 1st law

$F_{net} = 0$

V = Constant

As the bubble moves with constant velocity, so net force must be zero.

$\therefore B = F_V$

$\Rightarrow \dfrac{4}{3}\pi R^3\rho g = 6\pi\eta RV$

$\Rightarrow \eta = \dfrac{4\pi R^3\rho g}{3\times6\pi RV}$

$\Rightarrow \eta = \dfrac{2R^2\rho g}{9V}$

$\Rightarrow \eta = \dfrac{2\times(3\times10^{-3})^2\times1750\times10}{9\times0.35\times10^{-2}}$

$\Rightarrow \eta = 10$ Poise

# JEE (Main) PHYSICS SOLVED PAPER

# 2023

**08th April Shift 2**

**General Instructions :**

*(i) There are 30 questions in this section.*

*(ii) Section A consists of 20 Multiple choice questions and Section B consists of 10 Numerical value type questions. In Section B, candidates have to attempt any five questions out of 10.*

*(iii) There will be only one correct choice in the given four choices in Section A. For each question for Section A, 4 marks will be awarded for correct choice, 1 mark will be deducted for incorrect choice questions and zero mark will be awarded for not attempted questions.*

*(iv) For Section B questions, 4 marks will be awarded for correct answer and zero for unattempted and incorrect answer.*

*(v) Any textual, printed or written material, mobile phones, calculator etc. is not allowed for the students appearing for the test.*

*(vi) All calculations/ written work should be done in the rough sheet which is provided with Question Paper.*

## Section A

**Q. 1.** A hydraulic automobile lift is designed to lift vehicles of mass 5000 kg. The area of cross section of the cylinder carrying the load is 250 $cm^2$. The maximum pressure the smaller piston would have to bear is [Assume $g = 10\ m/s^2$] :

**(A)** $2 \times 10^{+5}$ Pa **(B)** $20 \times 10^{+6}$ Pa

**(C)** $200 \times 10^{+6}$ Pa **(D)** $2 \times 10^{+6}$ Pa

**Q. 2.** The orbital angular momentum of a satellite is L, when it is revolving in a circular orbit at height $h$ from earth surface. If the distance of satellite from the earth center is increased by eight times to its initial value, then the new angular momentum will be-

**(A)** 8 L **(B)** 3 L

**(C)** 4 L **(D)** 9 L

**Q. 3.** The waves emitted when a metal target is bombarded with high energy electrons are

**(A)** Microwaves **(B)** X-rays

**(C)** Radio Waves **(D)** Infrared rays

**Q. 4.** Match List I with List II:

| LIST-I | | LIST-II | |
|---|---|---|---|
| **A.** | Torque | **I.** | $ML^{-2}T^{-2}$ |
| **B.** | Stress | **II.** | $ML^{2}T^{-2}$ |
| **C.** | Pressure gradient | **III.** | $ML^{-1}T^{-1}$ |
| **D.** | Coefficient of viscosity | **IV.** | $ML^{-1}T^{-2}$ |

Choose the correct answer from the options given below:

**(A)** A-III, B-IV, C-I, D-II

**(B)** A-II, B-I, C-IV, D-III

**(C)** A-IV, B-II, C-III, D-I

**(D)** A-II, B-IV, C-I, D-III

**Q. 5.** Give below are two statements

**Statement I :** Area under velocity- time graph gives the distance travelled by the body in a given time.

**Statement II :** Area under acceleration- time graph is equal to the change in velocity- in the given time.

In the light of given statement, choose the correct answer from the options given below

**(A)** Both Statement I and Statement II are true.

**(B)** Statement I is correct but Statement II is false.

**(C)** Both Statement I and and Statement II are false

**(D)** Statement I is incorrect but Statement II is true.

**Q. 6.** The power radiated from a linear antenna of length $l$ is proportional to (Given, $\lambda$ = Wavelength of wave):

**(A)** $\frac{l}{\lambda}$ **(B)** $\frac{l^2}{\lambda}$

**(C)** $\frac{l}{\lambda^2}$ **(D)** $\left(\frac{l}{\lambda}\right)^2$

Q. 7. Electric potential at a point 'P' due to a point charge of $5 \times 10^{-9}$C is 50 V. The distance of 'P' from the point charge is:

(Assume, $\frac{1}{4\pi\varepsilon_0} = 9\times10^{+9}\ Nm^2C^{-2}$)

**(A)** 3 cm **(B)** 9 cm

**(C)** 0.9 cm **(D)** 90 cm

**Q. 8.** The acceleration due to gravity at height h above the earth if $h << R$ (Radius of earth) is given by

**(A)** $g' = g\left(1-\frac{h^2}{2R^2}\right)$ **(B)** $g' = g\left(1-\frac{h}{2R}\right)$

**(C)** $g' = g\left(1-\frac{2h^2}{R^2}\right)$ **(D)** $g' = g\left(1-\frac{2h}{R}\right)$

**Q. 9.** An emf of 0.08 V is induced in a metal rod of length 10 cm held normal to a uniform magnetic field of 0.4 T, when moves with a velocity of:
**(A)** 2 $ms^{-1}$ **(B)** 20 $ms^{-1}$
**(C)** 3.2 $ms^{-1}$ **(D)** 0.5 $ms^{-1}$

**Q. 10.** Work done by a Carnot engine operating between temperatures 127°C and 27°C is 2 kJ. The amount of heat transferred to the engine by the reservoir is:
**(A)** 2 kJ **(B)** 4 kJ
**(C)** 2.67 kJ **(D)** 8 kJ

**Q. 11.** The width of fringe is 2 mm on the screen in a double slits experiment for the light of wavelength of 400 nm. The width of the fringe for the light of wavelength 600 nm will be:
**(A)** 1.33 mm **(B)** 3 mm
**(C)** 2 mm **(D)** 4 mm

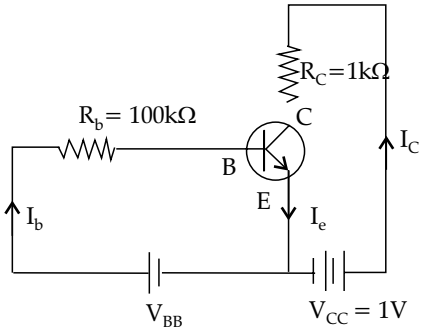
**Q. 12.** The temperature at which the kinetic energy of oxygen molecules becomes double than its value at 27°C is
**(A)** 1227°C **(B)** 627°C
**(C)** 327°C **(D)** 927°C

**Q. 13.** Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R
**Assertion A :** Electromagnets are made of soft iron.
**Reason R :** Soft iron has high permeability and low retentivity.
In the light of above, statements, chose the most appropriate answer from the options given below
**(A)** A is correct but R is not correct
**(B)** Both A and R are correct and R is the correct explanation of A
**(C)** Both A and R are correct but R is NOT the correct explanation of A
**(D)** A is not correct but R is correct

**Q. 14.** The trajectory of projectile, projected from the ground is given by $y = x-\frac{x^2}{20}$. Where $x$ and $y$ are measured in meter. The maximum height attained by the projectile will be.
**(A)** 10 m **(B)** 200 m
**(C)** $10\sqrt{2}$ m **(D)** 5 m

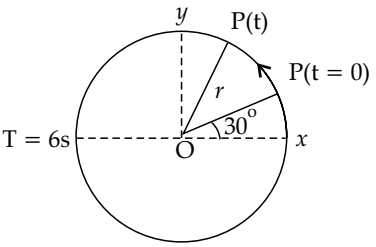
**Q. 15.** A bullet of mass 0.1 kg moving horizontally with speed 400 $ms^{-1}$ hits a wooden block of mass 3.9 kg kept on a horizontal rough surface. The bullet gets embedded into the block and moves 20 m before coming to rest. The coefficient of friction between the block and the surface is _____.
(Given $g$ = 10 $m/s^2$)
**(A)** 0.90 **(B)** 0.65
**(C)** 0.25 **(D)** 0.50

**Q. 16.** For a given transistor amplifier circuit in CE configuration $V_{CC}$ = 1 V, $R_C$ = 1 kΩ, $R_b$ = 100 kΩ and β = 100. Value of base current $I_b$ is




**(A)** $I_b$ = 100 μA **(B)** $I_b$ = 10 μA
**(C)** $I_b$ = 0.1 μA **(D)** $I_b$ = 1.0 μA

**Q. 17.** For particle P revolving round the centre O with radius of circular path $r$ and angular velocity ω, as shown in below figure, the projection of OP on the $x$-axis at time $t$ is




**(A)** $x(t) = r\cos\left(\omega t+\frac{\pi}{6}\right)$

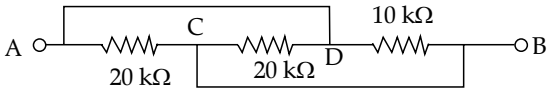
**(B)** $x(t) = r\cos\left(\omega t-\frac{\pi}{6}\omega\right)$

**(C)** $x(t) = r\cos(\omega t)$

**(D)** $x(t) = r\sin\left(\omega t+\frac{\pi}{6}\right)$

**Q. 18.** A radio active material is reduced to 1/8 of its original amount in 3 days. If $8\times10^{-3}$ kg of the material is left after 5 days the initial amount of the material is
**(A)** 64 g **(B)** 40 g
**(C)** 32 g **(D)** 256 g

**Q. 19.** The equivalent resistance between A and B as shown in figure is:




**(A)** 20 kΩ **(B)** 30 kΩ
**(C)** 5 kΩ **(D)** 10 kΩ

**Q. 20.** In photo electric effect
A. The photocurrent is proportional to the intensity of the incident radiation.
B. Maximum Kinetic energy with which photoelectrons are emitted depends on the intensity of incident light.

C. Max K.E with which photoelectrons are emitted depends on the frequency of incident light.
D. The emission of photoelectrons require a minimum threshold intensity of incident radiation.
E. Max. K.E of the photoelectrons is independent of the frequency of the incident light.
Choose the correct answer from the options given below:
**(A)** B and C only **(B)** A and C only
**(C)** A and E only **(D)** A and B only

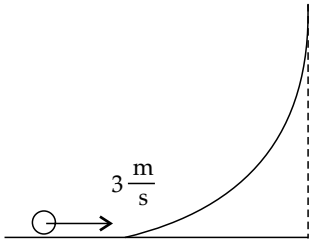
## Section B

**Q. 21.** A 600 pF capacitor is charged by 200 V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. Electrostatic energy lost in the process is _____ μJ

**Q. 22.** A series combination of resistor of resistance 100 Ω, inductor of inductance 1 H and capacitor of capacitance 6.25 μF is connected to an ac source. The quality factor of the circuit will be _____

**Q. 23.** The number density of free electrons in copper is nearly $8 \times 10^{28}$ $m^{-3}$. A copper wire has its area of cross section $= 2 \times 10^{-6}$ $m^2$ and is carrying a current of 3.2 A. The drift speed of the electrons is _____ $\times 10^{-6}$ $ms^{-1}$

**Q. 24.** A hollow spherical ball of uniform density rolls up a curved surface with an initial velocity 3 m/s (as shown in figure). Maximum height with respect to the initial position covered by it will be _____ cm (take, $g = 10$ m/s$^2$)




**Q. 25.** A steel rod of length 1 m and cross sectional area $10^{-4}$ $m^2$ is heated from 0°C to 200°C without being allowed to extend or bend. The compressive tension produced in the rod is _____ $\times 10^4$N. (Given Young's modulus of steel $= 2 \times 10^{11}$ $Nm^{-2}$, coefficient of linear expansion $= 10^{-5}K^{-1}$)

**Q. 26.** The ratio of magnetic field at the centre of a current carrying coil of radius r to the magnetic field at distance from the centre of coil on its axis is $\sqrt{x}:1$ . The value of $x$ is _____

**Q. 27.** The ratio of wavelength of spectral lines $H_\alpha$ and $H_\beta$ in the Balmer series is $\frac{x}{20}$. The value of $x$ is _____.

**Q. 28.** Two transparent media having refractive indices 1.0 and 1.5 are separated by a spherical refracting surface of radius of curvature 30 cm. The centre of curvature of surface is towards denser medium and a point object is placed on the principle axis in rarer medium at a distance of 15 cm from the pole of the surface. The distance of image from the pole of the surface is _____ cm.

**Q. 29.** A guitar string of length 90 cm vibrates with a fundamental frequency of 120 Hz. The length of the string producing a fundamental frequency of 180 Hz will be _____ cm.

**Q. 30.** A body of mass 5 kg is moving with a momentum of 10 kg $ms^{-1}$. Now a force of 2 N acts on the body in the direction of its motion for 5 s. The increase in the Kinetic energy of the body is _____ J.

# Answer Key

| Q. No. | Answer | Topic Name | Chapter Name |
|---|---|---|---|
| 1 | D | Pascal's law | Fluid mechanics |
| 2 | B | Satellight | Gravitation |
| 3 | B | X ray | EM waves |
| 4 | D | Dimension | Units & Dimensions |
| 5 | D | v-t and a-t graph | Motion in One Dimension |
| 6 | D | Power of antenna | Communication System |
| 7 | D | Electric potential | Electrostatics |
| 8 | D | Acceleration due to gravity | Gravitation |
| 9 | A | Induced EMF | Electromagnetic Induction |
| 10 | D | Carnot engine | Thermodynamics |
| 11 | B | YDSE | Wave optics |
| 12 | C | Kinetic energy of gas | Kinetic theory of gasses |
| 13 | B | Electromagnet | Electromagnetism |
| 14 | D | Projectile | Motion in 2D |
| 15 | C | Momentum conservation | Collision |
| 16 | B | Transistor | Semiconductors |
| 17 | A | Phasor | Circular Motion |
| 18 | D | Half life | Nuclear Physics |
| 19 | C | Resistance circuit | Electric Current |
| 20 | B | Kinetic Energy of photoelectron | Photoelectric Effect |
| 21 | [6] | Energy in capacotors | Capacitors |
| 22 | [4] | RLC circuit | Electromagnetic Induction |
| 23 | [125] | Drift velocity | Electric current |
| 24 | [75] | Rotational Kinetic Energy | Rotational Motion |
| 25 | [4] | Thermal stresses | Elasticity |
| 26 | [8] | Magnetic field due to current carrying loop | Magnetism |
| 27 | [27] | Hydrogen spectra | Atoms |
| 28 | [30] | Refraction through spherical surfaces | Ray optics |
| 29 | [60] | Fundamental Frequency | Sound waves |
| 30 | [30] | Change in Kinetic Energy | Work, Energy and Power |

# JEE (Main) PHYSICS SOLVED PAPER

# 2023

**08th April Shift 2**

## ANSWERS WITH EXPLANATIONS

### Section A

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

Given, $m = 5000$ kg

$A = 250\ cm^2 = 250 \times 10^{-4}\ m^2$

$F = mg = 5000 \times 10 = 50000$ N

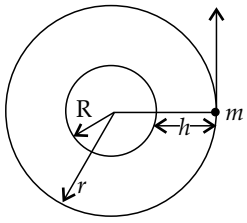
From Pascal's law pressure would be same at both ends of piston.

$$P = \frac{F}{A}$$

$$P = \frac{50000}{250 \times 10^{-4}} = 2 \times 10^6\ Pa$$

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

Angular momentum is given by




$L = mvr$

where $v = \sqrt{\frac{GM}{r}}$

$$L = m\sqrt{\frac{GM}{r}} \times r = m\sqrt{\frac{GMr^2}{r}} = \sqrt{GMr}$$

$$L \propto r^{\frac{1}{2}}$$

Now, the new distance from centre $= r + 8r = 9r$

New angular momentum

$$L' \propto (9r)^{\frac{1}{2}}$$

Therefore,

$$\frac{L'}{L} = \frac{(r)^{\frac{1}{2}}}{(9r)^{\frac{1}{2}}} = \frac{1}{3}$$

$\Rightarrow L' = 3L$

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

When target metal is bombarded with high energy electron then X-rays are emitted.

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

A. $\vec{\tau} = \vec{r} \times \vec{F}$

$[\tau] = [L]\,[MLT^{-2}] = ML^2T^{-2}$

B. $\sigma = \frac{F}{A} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$

C. $\frac{\Delta P}{\Delta x} = \frac{\left[\frac{F}{A}\right]}{L} = ML^{-2}T^{-2}$

D. $F = 6\pi\eta rV$

$\Rightarrow MLT^{-2} = [\eta]\,L^2T^{-1}$

$\Rightarrow [\eta] = ML^{-1}T^{-1}$

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

$\vec{S} = \int \vec{V} dt$

Therefore area under velocit time graph gives displacement.

Hence statement-I is false.

Area under acceleration time graph gives change in velocity.

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

$\Rightarrow dV = a\,dt$

$\Rightarrow \int dV = \int a\,dt$

Hence statement-II is correct.

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

Radiating power of linear antenna is given by,

$$P = \frac{\pi}{12} I_{02} Z_0 \left(\frac{l}{\lambda}\right)^2$$

Hence,

$$P \propto \left(\frac{l}{\lambda}\right)^2$$

**7. Option (D) is correct.**

Given, $q = 5 \times 10^{-9}$ C

$V = 50$V

$$V = k\frac{q}{r} \qquad \left(k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \frac{Nm^2}{C^2}\right)$$

$$\Rightarrow 50 = \frac{9 \times 10^9 \times 5 \times 10^{-9}}{r}$$

$$\Rightarrow r = \frac{9 \times 5}{10} = 0.9\,m = 90\ cm$$

**8. Option (D) is correct.**

$$g = \frac{GM}{R^2} \qquad ...(i)$$

Now acceleration due to gravity at height $h$ is given by

$$g' = \frac{GM}{(R+h)^2} = \frac{GM}{R^2\left(1+\frac{h}{R}\right)^2}$$

$$\Rightarrow g' = \frac{g}{\left(1+\frac{h}{R}\right)^2} \qquad \left(\because \text{from(i)}\ g = \frac{GM}{R^2}\right)$$

$$\Rightarrow g' = g\left(1+\frac{h}{R}\right)^{-2}$$

$$\Rightarrow g' = g\left(1-\frac{2h}{R}\right)$$ from binomial expansion.

**9. Option (A) is correct.**

When a metal rod is held normal moving in uniform magnetic field then the induced emf is given by

Induced E = B$lv$

$$\Rightarrow \upsilon = \frac{E}{Bl} = \frac{0.08}{0.4 \times \frac{10}{100}}$$

$\upsilon = 0.08 \times 100/0.4 \times 10 = 2$ m/s

**10. Option (D) is correct.**

Efficiency of a carnot engine is given by

$$\eta = 1 - \frac{T_2}{T_1} = \frac{W}{Q_1}$$

where $T_1 = 127 + 273 = 400$K

$T_2 = 27 + 273 = 300$K

Therefore,

$$\frac{W}{Q_1} = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{400}$$

$$\Rightarrow \frac{2 \times 10^3 J}{Q_1} = \frac{1}{4}$$

$\Rightarrow Q_1 = 8 \times 10^3$ J $= 8$ kJ

**11. Option (B) is correct.**

Given, $\beta_1 = 2$mm, $\lambda_1 = 400$ nm

$\beta_2 = ?$, $\lambda_2 = 600$ nm

Fringe width ($\beta$) = $\frac{D\lambda}{d}$

$$\beta_1 = \frac{D\lambda_1}{d}$$

$$\beta_2 = \frac{D\lambda_2}{d}$$

$$\Rightarrow \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$$

$$\Rightarrow \frac{2mm}{\beta_2} = \frac{400 \text{ nm}}{600 \text{ nm}} = \frac{2}{3}$$

$$\Rightarrow \beta_2 = \frac{2 \times 3}{2} \text{mm} = 3 \text{mm}$$

**12. Option (C) is correct.**

Kinetic energy is given by

$$K = \frac{f}{2} KT$$

$K \propto T$

Therefore,

$$\frac{K_1}{K_2} = \frac{T_1}{T_2}$$

$$\Rightarrow \frac{1}{2} = \frac{(27 + 273)}{T_2}$$

$\Rightarrow T_2 = 2 \times 300$K

$\Rightarrow T_2 = 600$ K $= 327$ C

**13. Option (B) is correct.**

Soft iron has high permeability and low retentivity. Therefore, iron is used to make electromagnet.

So, both A & R are correct and R is the correct explanation of A.

**14. Option (D) is correct.**

$$y = x - \frac{x^2}{20} \quad \text{...(i)}$$

$$\frac{dy}{dx} = 0 \quad \text{(For maximum height)}$$

$$\Rightarrow \frac{dy}{dx} = 1 - \frac{2x}{20} = 0$$

$\Rightarrow 20 - 2x = 0$

$\Rightarrow x = 10$

Putting the value of $x$ in (i) for $y_{max}$.

$$y = x - \frac{x^2}{20}$$

$$\Rightarrow y_{max} = 10 - \frac{100}{20}$$

$= 10 - 5 = 5$ m

**15. Option (C) is correct.**

Momentum of bullet before collision

$P_i = 0.1 \times 400 = 40$ N-s

Momentum after collision

$P_f = (0.1 + 3.9)v$

Applying conservation of momentum

$P_i = P_f$

$\Rightarrow 40 = (0.1 + 3.9)v$

$\Rightarrow \upsilon = 10$m/s

Now, $v^2 = u^2 + 2as$

$\Rightarrow 0 = (10)^2 - 2 \times a \times 20$ ($u = 10$ m/s after collision)

$\Rightarrow 40a = 100$

$$\Rightarrow a = \frac{10}{4} = 2.5 \text{ m/s}^2$$

So, F = $ma$

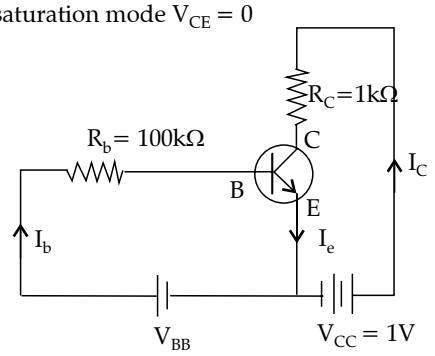
$\Rightarrow \mu mg = ma$

$\Rightarrow a = \mu g$

$$\Rightarrow \mu = \frac{a}{g} = \frac{2.5}{10} = 0.25$$

**16. Option (B) is correct.**

In saturation mode $V_{CE} = 0$




Now

$V_{CC} - I_c R_c = 0$ (from KVL)

$$\Rightarrow I_b = \frac{V_{CC}}{R_C} = \frac{1}{1 \times 10^3} = 10^{-3} \text{A}$$

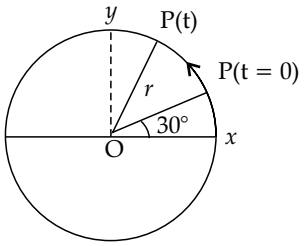
Given that

$$\beta = 100 = \frac{I_c}{I_b}$$

$\Rightarrow I_b = \frac{I_c}{100} = \frac{10^{-3}}{100} = 10^{-5}\,A$

$\Rightarrow I_b = 10\ \mu A$

**17. Option (A) is correct.**




After time $t$, the angular displacement will be

$\theta = \omega t$

Total angular displacement from $x$-axis.

$\theta_{total} = \omega t + \frac{\pi}{6} \qquad \left(\because 30° = \frac{\pi}{6}\right)$

Now, OP has two component

The horizontal component will be the projection along $x$-axis

$= r\cos(\theta_{Total}) = r\cos\left(\omega t + \frac{\pi}{6}\right)$

**18. Option (D) is correct.**

$m = m_0\left(\frac{1}{2}\right)^n$

$\Rightarrow \frac{m_0}{8} = m_0\left(\frac{1}{2}\right)^n$

$\Rightarrow \frac{1}{8} = \left(\frac{1}{2}\right)^3$

$\Rightarrow n = 3$

3 days = 3 half life

1 day = 1 half life

Now

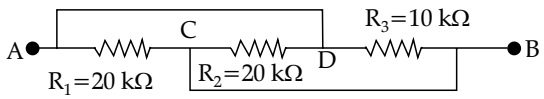
$m = m_0\left(\frac{1}{2}\right)^n$

$\Rightarrow 8 \times 10^{-3} = m_0\left(\frac{1}{2}\right)^5$

$\Rightarrow m_0 = 32 \times 8 \times 10^{-3}$

$\Rightarrow m_0 = 256\ g$

**19. Option (C) is correct.**




Potential across $R_1 = V_A - V_C \qquad (\because V_B = V_C)$

$= V_A - V_B$

Potential across $R_2 = V_D - V_C \qquad (\because V_D = V_A)$

$= V_A - V_B$

Potential across $R_3 = V_D - V_B \qquad (\because V_B = V_C)$

$= V_A - V_B$

It means all the resistance are in parallel

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\Rightarrow \frac{1}{R_{eq}} = \frac{1}{20} + \frac{1}{20} + \frac{1}{10}$

$\Rightarrow \frac{1}{R_{eq}} = \frac{1+1+2}{20}$

$\Rightarrow Req = \frac{20}{4} = 5\ k\Omega$

**20. Option (B) is correct.**

Intensity of incident light $\propto$ photo current

So, A statement is correct

Now, $K.E_{max} = h\nu - \phi$

$\therefore$ K.E. depends upon frequency

So, C statement is correct.

## Section B

**21. The correct answer is (6)**

$U_i = \frac{1}{2}CV^2$

$U_i = \frac{1}{2} \times (600 \times 10^{-12}) \times (200)^2$

$U_i = 12\ \mu J$

Charge on capacitor $\Rightarrow Q = CV$

$Q = 600 \times 10^{-12} \times 200 = 12 \times 10^{-8}\ C$

When connected to another uncharged capacitor

$Q' = \frac{Q}{2} = \frac{12 \times 10^{-8}}{2} = 6 \times 10^{-8} C$

$U_f = 2 \times \frac{1}{2} \times \frac{Q'^2}{C} = \frac{Q'^2}{C}$

$\Rightarrow U_f = \frac{(6 \times 10^{-8})}{600 \times 10^{-12}} = 6\ \mu J$

$\Delta E = U_f - V_i = (12 - 6)\ \mu J = 6\ \mu J$

**22. The correct answer is (4).**

$R = 100\ \Omega$

$L = 1H$

$C = 6.25 \times 10^{-6}\ F$

$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1 \times 6.25 \times 10^{-6}}}$

$\Rightarrow \omega = 400/s$

Now

$Q_{factor} = \frac{\omega L}{R} = \frac{400 \times 1}{100} = 4$

**23. The correct answer is (125).**

$n = 8 \times 10^{28}\ m^{-3}$

$A = 2 \times 10^{-6}\ m^2$

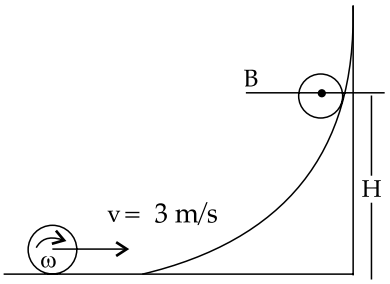
$I = 3.2A$

$V_d = \frac{i}{enA} = \frac{3.2}{1.6 \times 10^{-19} \times 8 \times 10^{28} \times 2 \times 10^{-6}}$

$\Rightarrow V_d = 125 \times 10^{-6}\ m/s$

**24. The correct answer is (75).**

Total initial kinetic energy




$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$v = R\omega$ (for pure rolling)

$K.EC = \frac{1}{2}mv^2 + \frac{1}{2}\times\frac{2}{3}mR^2\times\frac{v^2}{R^2} = \frac{5}{6}mv^2$

Energy remains conserve during whole journey.

$K.E._i + P.E._i = K.E._f + P.E._f$

$\Rightarrow \frac{5}{2}mv^2 = mgH \qquad (\because K.E._f = 0)$

$\Rightarrow H = \frac{5}{6}\times\frac{v^2}{g}$

$= \frac{5\times(3)^2}{6\times10}$

$= \frac{15}{20}\,m = 0.75\,m = 75\,cm$

**25. The correct answer is (4).**

$\frac{\sigma}{E} = Y$

$\Rightarrow \sigma = YE = Y\frac{\Delta l}{l}$

$\Rightarrow \sigma = Y = \frac{l\alpha\Delta T}{l}$

$\Rightarrow \sigma = Y\,\alpha\,\Delta T$

Now,

$\sigma = \frac{F}{A}$

$\Rightarrow F = \sigma A = YA\,\alpha\,\Delta T$

$\Rightarrow F = 2\times10^{11}\times10^{-4}\times10^{-5}\times200$

$= 4\times10^4$

$x = 4$

**26. The correct answer is (8).**

Magnetic field due to current carrying coil on axis at distance $d$.

$B_a = \frac{\mu_0 I r^2}{2(r^2+d^2)^{\frac{3}{2}}}$

Given that $d = r$

Now, $B_a = \frac{\mu_0 I r^2}{2(2r^2)^{\frac{3}{2}}} = \frac{\mu_0 I}{4\sqrt{2}r}$

Magnetic field at centre of current carrying coil

$B_c = \frac{\mu_0 I}{2r}$

$\frac{B_c}{B_a} = \frac{\mu_0 I}{2r}\times\frac{4\sqrt{2}r}{\mu_0 I} = \frac{2\sqrt{2}}{1} = \frac{\sqrt{8}}{1}$

$x = 8$

**27. The correct answer is (27).**

$\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$ for balmer series $n = 2$

Now, for $H_\alpha$, $m = 3$ and for $H_\beta$, $m = 4$

Here, $\frac{1}{\lambda_{H_\alpha}} = R\left(\frac{1}{4} - \frac{1}{9}\right) = \frac{5R}{36}$

& $\frac{1}{\lambda_{H_\beta}} = R\left(\frac{1}{4} - \frac{1}{16}\right) = \frac{3R}{16}$

So,

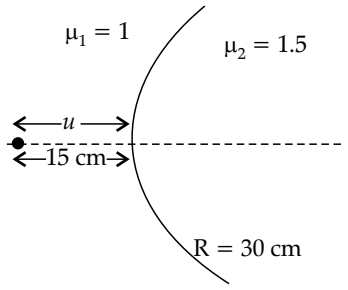
$\frac{\frac{1}{\lambda_{H_\alpha}}}{\frac{1}{\lambda_{H_\beta}}} = \frac{\frac{5R}{36}}{\frac{3R}{16}}$

$\Rightarrow \frac{\lambda_{H_\alpha}}{\lambda_{H_\beta}} = \frac{27}{20}$

$\therefore x = 27$

**28. The correct answer is (30).**

Refraction through spherical surface is given by:




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

$\Rightarrow \frac{1.5}{V} - \frac{1}{-15} = \frac{1.5-1}{30}$

$\Rightarrow \frac{1.5}{V} + \frac{1}{15} = \frac{1}{60}$

$\Rightarrow \frac{1.5}{V} + \frac{1}{60} - \frac{1}{15} = \frac{1-4}{60}$

$\Rightarrow \frac{1.5}{V} = -\frac{3}{60} = -\frac{1}{20}$

$\Rightarrow V = -20\times1.5 = -30$ cm

**29. The correct answer is (60).**

$l = \frac{\lambda}{2}$

$\Rightarrow \lambda = 2l$

Now, $\upsilon = f\lambda$

$\Rightarrow f_1 = \frac{\upsilon}{\lambda} = \frac{\upsilon}{2l_1}$

$\Rightarrow f_1 \propto \frac{1}{l_1}$

$\Rightarrow f_2 \propto \frac{1}{l_2}$

Here,

$\frac{f_1}{f_2} = \frac{l_2}{l_1}$

$\Rightarrow \frac{120}{180} = \frac{l_2}{90}$

$\Rightarrow l_2 = 60$ cm

**30. The correct answer is (30).**

Given, $P_i = 10$ kg ms$^{-1}$

Now from Newton's second law

$F = \frac{dP}{dt}$

$\Rightarrow F.dt = dP$

$\Rightarrow 2 \times 5 = P_f - P_i$

$\Rightarrow 10 = P_f - 10$

$\Rightarrow P_f = 20$ kg ms$^{-1}$

Now, $P_i = mV_i$

$10 = 5 \times V_i$

$\Rightarrow V_i = 2$ ms$^{-1}$

and $P_f = 20 = mV_f$

$\Rightarrow 20 = 5 \times V_f$

$\Rightarrow V_f = 4$ ms$^{-1}$

$\Delta$ K.E. $=$ K.E.$_f$ $-$ K.E.$_i$ $= \frac{1}{2} \times 5[(2)^2 - (4)^2]$

$= \frac{1}{2} \times 5 \times 12 = 30$ J