01/02/2023
Evening

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Answers & Solutions

Time : 3 hrs. for M.M. : 300

JEE (Main)-2023 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) The Test Booklet consists of 90 questions. The maximum marks are 300.

(3) There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.

(i) **Section-A:** This section contains 20 multiple choice questions which have only one correct answer. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer.

(ii) **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10.** The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

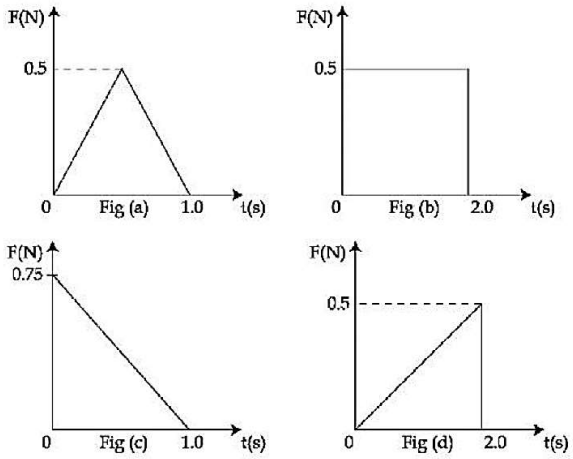
PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Figures (a), (b), (c) and (d) show variation of force with time.



The impulse is highest in

(1) Fig. (d) (2) Fig. (c)

(3) Fig. (b) (4) Fig. (a)

Answer (3)

Sol. Impulse $\propto$ area under (F-t) graph.

Impulse for graph (b) is maximum.

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

Assertion A : Two metallic spheres are charged to the same potential. One of them is hollow and another is solid, and both have the same radii. Solid sphere will have lower charge than the hollow one.

Reason R: Capacitance of metallic spheres depend on the radii of spheres.

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

(1) Both **A** and **R** are true but **R** is **not** the correct explanation of **A**

(2) **A** is false but **R** is true

(3) Both **A** and **R** are true but **R** is the correct explanation of **A**

(4) **A** is true but **R** is false

Answer (2)

Sol. Assertion (A) is incorrect

Both spheres will have same charge.

Reason (R) is correct.

3. A coil is placed in magnetic field such that plane of coil is perpendicular to the direction of magnetic field. The magnetic flux through a coil can be changed:

A. By changing the magnitude of the magnetic field within the coil.

B. By changing the area of coil within the magnetic field.

C. By changing the angle between the direction of magnetic field and the plane of the coil.

D. By reversing the magnetic field direction abruptly without changing its magnitude.

Choose the most appropriate answer from the options given below:

(1) A and B only (2) A, B and D only

(3) A and C only (4) A, B and C only

Answer (4)

Sol. Flux can be changed by changing magnetic field, area of coil, change the angle between B and A.

4. An electron of a hydrogen like atom, having Z = 4, jumps from 4^{th} energy state to 2^{nd} energy state. The energy released in this process, will be:

(Given Rch = 13.6 eV)

Where R = Rydberg constant, c = Speed of light in vacuum, h = Planck's constant)

(1) 3.4 eV (2) 10.5 eV

(3) 40.8 eV (4) 13.6 eV

Answer (3)

Sol. $E = 13.6Z^2\left[\frac{1}{2^2}-\frac{1}{4^2}\right]$

$= 13.6 \times 16 \times \left[\frac{1}{4}-\frac{1}{16}\right]$

$= 40.8$ eV

5. Given below are two statements: One is labelled as **Assertion A** and the other is labelled as **Reason R.**

Assertion A: For measuring the potential difference across a resistance of 600 Ω, the voltmeter with resistance 1000 Ω will be preferred over voltmeter with resistance 4000 Ω.

Reason R: Voltmeter with higher resistance will draw smaller current than voltmeter with lower resistance.

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

(1) Both **A** and **R** are correct but **R** is **not** the correct explanation of **A**

(2) Both **A** and **R** are correct but **R** is the correct explanation of **A**

(3) **A** is not correct but **R** is correct

(4) **A** is correct but **R** is not correct

Answer (3)

Sol. (A) is not correct because we need higher voltmeter resistance.

(R) is correct based on reason given above.

6. Choose the correct statement about Zener diode

(1) It works as a voltage regulator only in forward bias

(2) It works as a voltage regulator in forward bias and behaves like simple pn junction diode in reverse bias.

(3) It works as a voltage regulator in both forward and reverse bias.

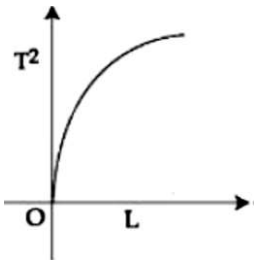
(4) It works as a voltage regulator in reverse bias and behaves like simple pn junction diode in forward bias.

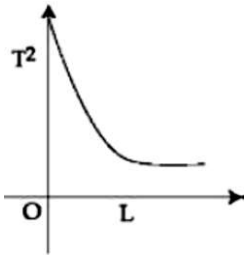
Answer (4)

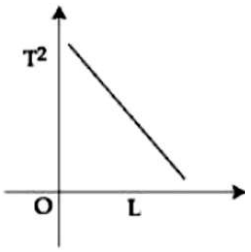
Sol. Theoretical.

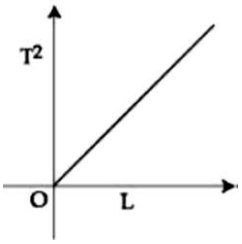
$\because$ Zener diode is a voltage regulator in reverse bias and behaves as simple pn junction diode in forward bias.

7. Choose the correct length (L) versus square of time period (T^2) graph for a simple pendulum executing simple harmonic motion.

(1) 

(2) 

(3) 

(4) 

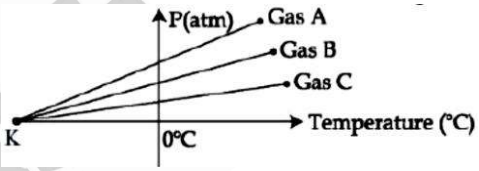
Answer (4)

Sol. $T^2 = \dfrac{(2\pi)^2 L}{g}$

$y = \dfrac{(2\pi)^2 x}{g}$ (y axis has T^2 & x axis has L)

$\therefore$ Straight line

8. For three low density gases A, B, C pressure versus temperature graphs are plotted while keeping them at constant volume, as shown in the figure.



The temperature corresponding to the point 'K' is

(1) –373°C (2) –273°C

(3) –40°C (4) –100°C

Answer (2)

Sol. $PV = nRT$

At constant volume

$P \propto T \Rightarrow$ straight line and absolute zero is the common intercept, T = –273°C

9. A Carnot engine operating between two reservoirs has efficiency $\frac{1}{3}$. When the temperature of cold reservoir raised by x, its efficiency decreases to $\frac{1}{6}$. The value of x, if the temperature of hot reservoir is 99°C, will be

(1) 66 K (2) 33 K

(3) 62 K (4) 16.5 K

Answer (3)

Sol. $\eta = 1 - \frac{T_C}{T_H}$

Initially $\frac{T_C}{T_H} = \frac{2}{3}$ .....(1)

Finally $\frac{T_{C+x}}{T_H} = \frac{5}{6}$ .....(2)

$T_H = 99^\circ C = 372$ K

$\therefore x = 62$ K

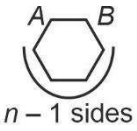
10. Equivalent resistance between the adjacent corners of a regular n-sided polygon of uniform wire of resistance R would be

(1) $\frac{(n-1)R}{(2n-1)}$ (2) $\frac{(n-1)R}{n^2}$

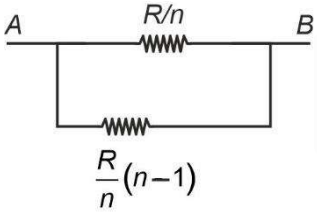
(3) $\frac{(n-1)R}{n}$ (4) $\frac{n^2R}{n-1}$

Answer (2)

Sol.



$n-1$ sides



$\frac{R}{n}(n-1)$

$\frac{1}{R_{eq}} = \frac{n}{R} + \frac{n}{R(n-1)} = \frac{n}{R}\left[1 + \frac{1}{n-1}\right]$

$R_{eq} = \frac{R(n-1)}{n^2}$

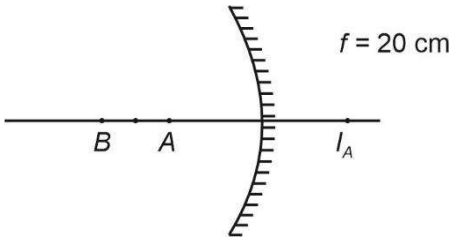
11. Two objects A and B are placed at 15 cm and 25 cm from the pole in front of a concave mirror having radius of curvature 40 cm. The distance between images formed by the mirror is

(1) 100 cm (2) 40 cm

(3) 160 cm (4) 60 cm

Answer (3)

Sol.



$I_A \Rightarrow \frac{1}{v} - \frac{1}{15} = -\frac{1}{20}$

$v = 60$ (+ ve, virtual)

$I_B \Rightarrow \frac{1}{v} - \frac{1}{25} = -\frac{1}{20}$

$v = -100$ (– ve, real)

distance b/w images $I_A - I_B = 60 - (-100)$

$= 160$ cm

12. For a body projected at an angle with the horizontal from the ground, choose the correct statement.

(1) The horizontal component of velocity is zero at the highest point.

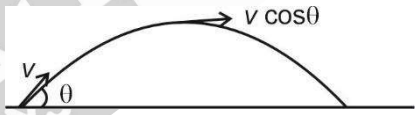
(2) The vertical component of momentum is maximum at the highest point.

(3) Gravitational potential energy is maximum at the highest point

(4) The Kinetic Energy (K.E.) is zero at the highest point of projectile motion.

Answer (3)

Sol.



At highest point $KE = \frac{1}{2}mv^2\cos^2\theta \neq 0$

horizontal momentum = $mv\cos\theta \neq 0$

vertical momentum = 0

PE = mgh (Max at maximum height)

13. The threshold frequency of a metal is f_0. When the light of frequency $2f_0$ is incident on the metal plate, the maximum velocity of photoelectrons is v_1. When the frequency of incident radiation is increases to $5f_0$, the maximum velocity of photoelectrons emitted is v_2. The ratio of v_1 to v_2 is:

(1) $\frac{v_1}{v_2} = \frac{1}{2}$ (2) $\frac{v_1}{v_2} = \frac{1}{4}$

(3) $\frac{v_1}{v_2} = \frac{1}{8}$ (4) $\frac{v_1}{v_2} = \frac{1}{16}$

Answer (1)

Sol. $\frac{1}{2}mv^2 = hf - hf_0$

$\Rightarrow \frac{1}{2}mv_1^2 = 2hf_0 - hf_0 = hf_0$ ...(1)

also, $\frac{1}{2}mv_2^2 = 5hf_0 - hf_0 = 4hf_0$ ...(2)

taking ratio,

$\frac{v_1^2}{v_2^2} = \frac{1}{4} \Rightarrow \frac{v_1}{v_2} = \frac{1}{2}$

14. The escape velocities of two planets *A* and *B* are in the ratio 1 : 2. If the ratio of their radii respectively is 1 : 3, then the ratio of acceleration due to gravity of planet *A* to the acceleration of gravity of planet *B* will be:

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

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

Answer (4)

Sol. $V_e = \sqrt{2gR}$

$\frac{(V_e)_A}{(V_e)_B} = \sqrt{\frac{g_A R_A}{g_B R_B}}$

$\Rightarrow \frac{1}{4} = \left(\frac{g_A}{g_B}\right) \times \frac{1}{3}$

$\frac{g_A}{g_B} = \left(\frac{3}{4}\right)$

15. The ratio of average electric energy density and total average energy density of electromagnetic wave is

(1) 3 (2) 2

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

Answer (4)

Sol. Average electric energy density = $\frac{1}{4}\varepsilon_0 E_0^2$

Average energy density = $\frac{1}{2}\varepsilon_0 E_0^2$

Ratio of electric average energy density to the average energy density = $\left(\frac{1}{2}\right)$.

16. In an amplitude modulation, a modulating signal having amplitude of X V is superimposed with a carrier signal of amplitude Y V in first case. Then, in second case, the same modulating signal is superimposed with different carrier signal of amplitude 2Y V. The ratio of modulation index in the two cases respectively will be:

(1) 2 : 1 (2) 1 : 2

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

Answer (1)

Sol. μ = modulation index

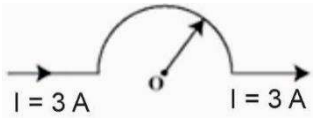
$\mu_1 = \frac{A_m}{A_{c_1}} = \left(\frac{X}{Y}\right)$

$\mu_2 = \frac{A_m}{A_{c_2}} = \left(\frac{X}{2Y}\right)$

$\Rightarrow \frac{\mu_1}{\mu_2} = \frac{\left(\frac{X}{Y}\right)}{\left(\frac{X}{2Y}\right)} = 2:1$

17. As shown in the figure, a long straight conductor with semicircular arc of radius $\frac{\pi}{10}$ m is carrying current I = 3 A. The magnitude of the magnetic field at the center O of the arc is:

(The permeability of the vacuum = $4\pi \times 10^{-7}$ NA^{-2})

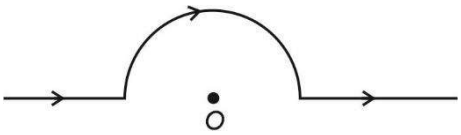


(1) 6μT (2) 1μT

(3) 4μT (4) 3μT

Answer (4)

Sol.



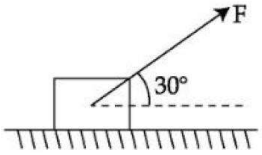
Magnetic field at *B* will be only due to the semi-circular arc.

So, $B = \left(\frac{\mu_0 i}{4r}\right) = \frac{\left(4\pi \times 10^{-7}\right) \times 3}{4 \times \left(\frac{\pi}{10}\right)}$

$= 3 \times 10^{-6}$ T

$= 3\ \mu$T

18. As shown in the figure a block of mass 10 kg lying on a horizontal surface is pulled by a force F acting at an angle 30°, with horizontal. For μ_s = 0.25, the block will just start to move for the value of F : [Given g = 10 ms^{-2}]

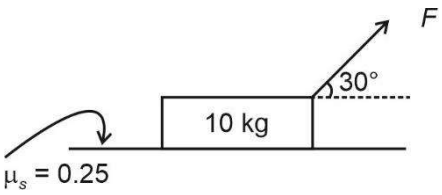


(1) 25.2 N (2) 33.3 N

(3) 20 N (4) 35.7 N

Answer (1)

Sol.



$F\cos30° = \mu N$ ...(i)

$$N = (10g - F\sin30°) = \left(100 - \frac{F}{2}\right) \quad ...(ii)$$

On solving (i) and (ii)

$$\Rightarrow \frac{\sqrt{3}}{2}F = 0.25\left(100 - \frac{F}{2}\right)$$

$$\Rightarrow \left(\frac{\sqrt{3}}{2} + \frac{1}{8}\right)F = 25$$

$$F = \frac{25\times 8}{\left(1+4\sqrt{3}\right)} = \frac{200}{\left(4\sqrt{3}+1\right)} \text{ N}$$

= 25.22 N

19. The Young's modulus of a steel wire of length 6 m and cross-sectional area 3 mm^2, is 2 × 10^{11} N/m^2. The wire is suspended from its support on a given planet. A block of mass 4 kg is attached to the free end of the wire. The acceleration due to gravity on the planet is $\frac{1}{4}$ of its value on the earth. The elongation of wire is (Take g on the earth = 10 m/s^2):

(1) 0.1 cm (2) 0.1 mm

(3) 1 mm (4) 1 cm

Answer (2)

Sol. $$\Delta l = \frac{FL}{AY} = \frac{\frac{Mg}{4}\times L}{AY}$$

$$= \frac{\frac{4\times 10}{4}\times 6}{3\times 10^{-6}\times 2\times 10^{11}}$$

$$= \frac{60}{6\times 10^5} = 10^{-4} \text{ m} = 0.1 \text{ mm}$$

20. If the velocity of light c, universal gravitational constant G and Planck's constant h are chosen as fundamental quantities. The dimensions of mass in the new system is:

(1) $\left[h^{1/2}c^{1/2}G^{-1/2}\right]$ (2) $\left[h^{1/2}c^{-1/2}G^{1}\right]$

(3) $\left[h^{-1/2}c^{1/2}G^{1/2}\right]$ (4) $\left[h^{1}c^{1}G^{-1}\right]$

Answer (1)

Sol. $c = LT^{-1}$

$G \equiv M^{-1}L^3T^{-2}$

$h = ML^2T^{-1}$

Let $M = c^x G^y h^z$

$\Rightarrow M^1L^0T^0 = M^{z-y} L^{x+3y+2z} T^{-x-2y-z}$

$\Rightarrow x + 2y + z = 0$ ...(i)

$x + 3y + 2z = 0$ ...(ii)

$z - y = 1$ ...(iii)

$$\Rightarrow x = \frac{1}{2},\ y = \frac{-1}{2},\ z = \frac{1}{2}$$

$\Rightarrow M = c^{1/2} G^{-1/2} h^{1/2}$

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. A force F =(5 + 3y^2) acts on a particle in the y-direction, where F is in newton and y is in meter. The work done by the force during a displacement from y = 2m to y = 5m is _____ J.

Answer (132)

Sol. $W = \int F\,dy = \int_2^5 (5+3y^2)\,dy$

$= (5y + y^3)\Big|_2^5$

= (15 + 125 – 8) J

= 132 J

22. A block is fastened to a horizontal spring. The block is pulled to a distance x = 10 cm from its equilibrium position (at x = 0) on a frictionless surface from rest. The energy of the block at x = 5 cm is 0.25 J. The spring constant of the spring is _____ Nm^{-1}.

Answer (50)

Sol. $\frac{1}{2}kx^2 = 0.25$ J

$\Rightarrow \quad k = \frac{0.25\times 2}{(0.01)} = (50\ N/m)$

23. A square shaped coil of area 70 cm^2 having 600 turns rotates in magnetic field of 0.4 Wbm^{-2}, about an axis which is parallel to one of the side of the coil and perpendicular to the direction of field. If the coil completes 500 revolution in a minute, the instantaneous emf when the plane of the coil is inclined at 60° with the field, will be _____V.

(Take $\pi = \frac{22}{7}$)

Answer (44)

Sol. $\phi = BA\cos\omega t$

$\varepsilon = -\frac{d\phi}{dt} = +BA\omega\sin\omega t$

$= 0.4\times 600\times\frac{70}{10^4}\times\frac{500\times 2\pi}{60}\sin 30^\circ$

$= \frac{0.4\times 6\times 7}{600}\times 500\times\frac{44}{7}\times\frac{1}{2} = 44$ volts

24. For a train engine moving with speed of 20 ms^{-1}, the driver must apply brakes at a distance of 500 m before the station for the train to come to rest at the station. If the brakes were applied at half of this distance, the train engine would cross the station with speed $\sqrt{x}$ ms^{-1}. The value of x is _____.

(Assuming same retardation is produced by brakes)

Answer (200)

Sol. Distance up to the station = 250 m

Also $0^2 - 20^2 = 2(a)\,(500)$

$\Rightarrow \quad a = \frac{-400}{1000} = -0.4\ m/s^2$

$\Rightarrow \quad v^2 - 20^2 = 2(-0.4)\,(250)$

$\Rightarrow \quad v^2 - 400 - 200$

$\Rightarrow \quad v = \sqrt{200}$ m/s

$\Rightarrow \quad x = 200$

25. Nucleus A having Z = 17 and equal number of protons and neutrons has 1.2 MeV binding energy per nucleon.

Another nucleus B of Z = 12 has total 26 nucleons and 1.8 MeV binding energy per nucleons.

The difference of binding energy of B and A will be _____ MeV.

Answer (6)

Sol. BE_A = (17 + 17)1.2 MeV = 40.8 MeV

BE_B = 26 × 1.8 MeV = 46.8 MeV

$BE_B - BE_A$ = 6 MeV

26. A cubical volume is bounded by the surfaces x = 0, x = 0, x = a, y = 0, y = a, z = 0, z = a. The electric field in the region is given by $\vec{E} = E_0 x\,\hat{i}$. Where E_0 = 4×10^4 $NC^{-1}m^{-1}$. If a = 2 cm, the charge contained in the cubical volume is Q × 10^{-14}C. The value of Q is _____. (Take $\in_0$ = 9 × 10^{-12} C^2/Nm^2)

Answer (288)

Sol. $\phi_{net} = E_0 a a^3 - E_0\,(0)\,(a^2)$

$\frac{q_{encl.}}{\varepsilon_0} = E_0\,a^3$

$q_{encl.}$ = 4 × 10^4 × 8 × 10^{-6} × 9 × 10^{-12}

= 288 × 10^{-14}

∴ Q = 288

27. The surface of water in a water tank of cross-section area 750 cm^2 on the top of a house is h m above the tap level. The speed of water coming out through the tap of cross-section area 500 mm^2 is 30 cm/s. At that instant, $\frac{dh}{dt}$ is $x \times 10^{-3}$ m/s. The value of x will be _____.

Answer (02)

Sol. AV= av

$$750\times10^{-4}\times\left(\frac{dh}{dt}\right)=(500\times10^{-6})(30\times10^{-2})$$

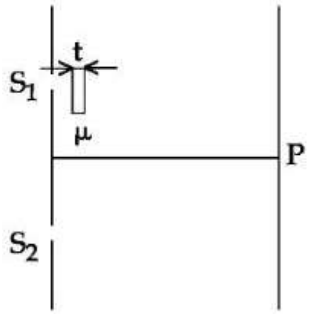
$$\frac{dh}{dt}=\frac{15\times10^{-5}}{75\times10^{-3}}$$

$$=\frac{1}{5}\times10^{-2}$$

$= 2 \times 10^{-3}$ m/s

$x = 2$

28. As shown in the figure, in Young's double slit experiment, a thin plate of thickness t = 10 μm and refractive index μ = 1.2 is inserted infront of slit S_1. The experiment is conducted in air (μ = 1) and uses a monochromatic light of wavelength λ = 500 nm. Due to the insertion of the plate, central maxima is shifted by a distance of $x\beta_0$. β_0 is the fringe-width before the insertion of the plate. The value of x is _____.



Answer (04)

Sol. shift due to slab $=\frac{(\mu-1)tD}{d}$

$$\frac{(\mu-1)tD}{d}=x\left(\frac{\lambda D}{d}\right)$$

$$x=\frac{(\mu-1)t}{\lambda}$$

$$=\frac{(1.2-1)\times10\times10^{-6}}{500\times10^{-9}}$$

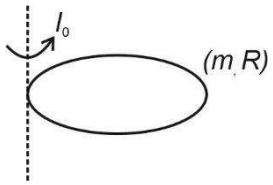
$$=\frac{0.2}{5}\times\frac{10^{-5}}{10^{-7}}$$

$$=\frac{1}{25}\times100$$

$= 4$

29. Moment of inertia of a disc of mass M and radius 'R' about any of its diameter is $\frac{MR^2}{4}$. The moment of inertia of this disc about an axis normal to the disc and passing through a point on its edge will be, $\frac{x}{2}MR^2$. The value of x is _____.

Answer (03)



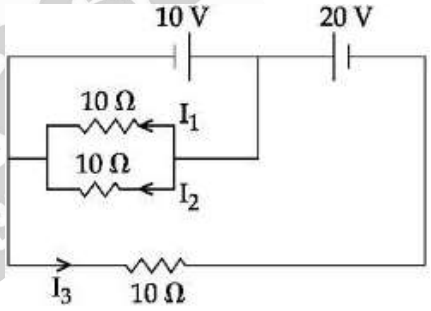
Sol.

$$\because I_D=\frac{mR^2}{4}$$

$$I_0=\frac{3}{2}mR^2$$

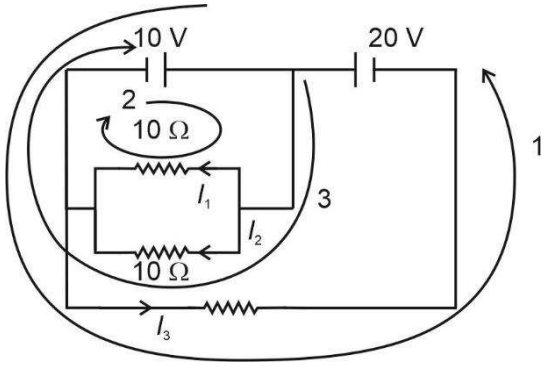
$\therefore x = 3$

30. In the given circuit, the value of $\left|\frac{I_1+I_3}{I_2}\right|$ is _____.



Answer (02)

Sol.



Using Kirchhoff's law in the indicated loop we get

$I_1 = I_2 = I_3 = 1$ A

So $\frac{I_1+I_3}{I_2}=2$