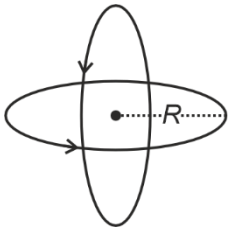
PHYSICS

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. Two rings of equal radius R arranged perpendicular to each other with common centre at C, carrying equal current I. Find magnetic field at C.

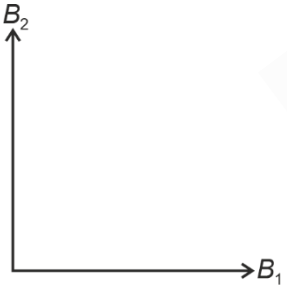


(1) $\frac{\mu_0 I}{2R}$ (2) $\frac{\mu_0 I}{R}$

(3) $\sqrt{2}\frac{\mu_0 I}{R}$ (4) $\frac{\mu_0 I}{\sqrt{2}R}$

Answer (4)

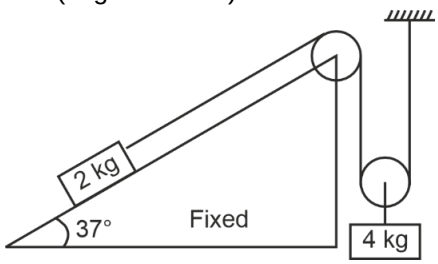
Sol.



$\vec{B}_1 = \frac{\mu_0 I}{2R}\hat{i}, \vec{B}_2 = \frac{\mu_0 I}{2R}\hat{j}$

$B_C = \frac{\mu_0 I}{\sqrt{2}R}$

2. Find the acceleration of 2 kg block shown in the diagram. (neglect friction)



(1) $\frac{4g}{15}$ (2) $\frac{2g}{15}$

(3) $\frac{g}{15}$ (4) $\frac{2g}{3}$

Answer (1)

Sol. For 2 kg block

$T - 2g\sin 37 = 2a$ ...(i)

For 4 kg block

$4g - 2T = \frac{4a}{2}$

$2g - T = a$ ...(ii)

$T = (2g - a)$

$2g - a - 2g \times \frac{3}{5} = 2a$

$3a = 2g \times \frac{2}{5}$

$\boxed{a = \frac{4g}{15}}$

3. A particle of mass m is projected with speed v at an angle of 30° with the horizontal, find its angular momentum about point of projection when it reaches its maximum height.

(1) $\frac{mv^3}{16g}$ (2) $\sqrt{3}\frac{mv^3}{16g}$

(3) $\frac{mv^3}{3g}$ (4) $\sqrt{3}\frac{mv^3}{8g}$

Answer (2)

Sol. Velocity at maximum height = $v\cos 30°$

$\therefore \quad L = m(v\cos 30)\,H$

$= mv\left(\frac{\sqrt{3}}{2}\right) \times \frac{v^2 \sin^2 30}{2g}$

$= \sqrt{3}\frac{mv^3}{16\,g}$

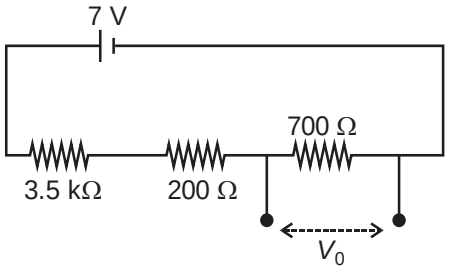
4. The ratio of kinetic energy & potential energy in 5^{th} excited state of Hydrogen atom is

(1) –2 (2) 2

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

Answer (3)

Sol. Kinetic energy: Potential energy = 1 : –2

5. 

In given circuit find potential difference across 700 Ω resistance (i.e. V_0).

(1) 2 V (2) 0.5 V

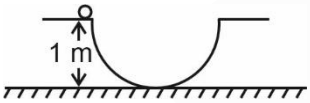
(3) 1.1 V (4) Zero

Answer (3)

Sol. $i = \frac{7}{3.5\,k + 0.9\ \text{k}\Omega} = \frac{7}{4.4\,k}$

$V_0 = i \times 700\ \Omega = \frac{7}{4.4\,k} \times .7\,k = \frac{4.9}{4.4} = 1.1\ \text{V}$

6. A ball is released from a height of 1 m on a smooth hemispherical surface as shown. Find its velocity when it is at a height of 0.5 m. (Take g = 10 m/s^2)



(1) 20 m/s (2) 10 m/s

(3) $\sqrt{10}$ m/s (4) 5 m/s

Answer (3)

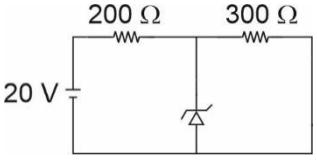
Sol. By conservation of mechanical energy

$mg(1) = \frac{1}{2}mv^2 + mg(0.5)$

$v^2 = 10$

$v = \sqrt{10}$ m/s

7. Find current through zener diode if its breakdown voltage is 5V.



(1) 58.33 mA (2) 25 mA

(3) 28.33 mA (4) 20.23 mA

Answer (1)

Sol. $i_{\text{battery}} = \frac{(20-5)}{200} = \frac{15}{200}$ A

$i_{300\Omega} = \frac{5}{300}$ A

$\therefore\ i_{\text{zener}} = \frac{15}{200} - \frac{5}{300}$

= 58.33 mA

8. Ball released from height 10 m strikes ground and rebounds height 5 m. Find impulse imparted by ground while collision, given mass of ball is 100 g. (Take g = 10 m/s^2)

(1) $(\sqrt{2}-1)$ Ns (2) $(\sqrt{2}+2)$ Ns

(3) $(2\sqrt{2}-1)$ Ns (4) $(\sqrt{2}+1)$ Ns

Answer (4)

Sol. $v_1 = \sqrt{2g10}$

$v_2 = \sqrt{2g5}$

$\vec{I} = \Delta\vec{p}$

$I = 0.1\{\sqrt{2g10} + \sqrt{2g5}\}$

$= 0.1\{10\sqrt{2}+10\}$

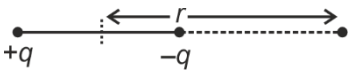
$= (\sqrt{2}+1)$ Ns

9. Potential due to electric dipole on axial position at distance r from dipole is proportional to (assume r >> length of dipole)

(1) $\frac{1}{r}$ (2) $\frac{1}{r^3}$

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

Answer (3)

Sol. 

$|E| = \frac{2kP}{r^3}$

$E = -\frac{dv}{dr},\ v \propto \frac{1}{r^2}$

10. Maximum wavelength of light source such that photoelectron can be ejected from material of work function 3 eV is

(1) 2133.3 Å (2) 3133.3 Å

(3) 4133.3 Å (4) 313.3 Å

Answer (3)

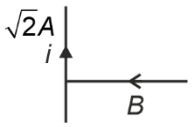
Sol. $\lambda = \frac{12400}{3} = 4133.3\,\text{Å}$

11. A long wire carrying current $\sqrt{2}A$ is placed in uniform magnetic field of 3×10^{-5} T. If magnetic field is perpendicular to wire, find the magnetic force on unit length of wire.

(1) 3×10^{-4} N (2) $3\sqrt{2} \times 10^{-5}$ N

(3) 3×10^{3} N (4) Zero

Answer (2)

Sol. 

$F = i$ L B $\sin\theta$

$= \sqrt{2} \times 1 \times 3 \times 10^{-5} \times \sin 90$

$F = 3\sqrt{2} \times 10^{-5}$ N

12. If the area of cross-section is halved and length of wire having young's modulus Y is doubled, then its young's modulus will become

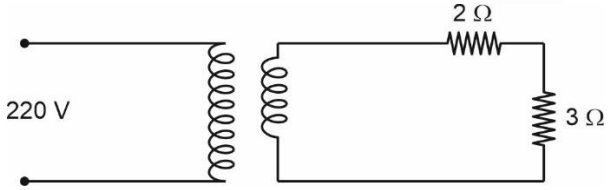
(1) Y (2) $4Y$

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

Answer (1)

Sol. Young's modulus is property of material of wire and it is independent of geometrical factors.

13. In an electric transformer, 220 V is applied on primary coil having number of turn 100. Find output current through 3 Ω resistance if number of secondary turn is 10.



(1) 4 A (2) 4.4 A

(3) 2 A (4) 2.2 A

Answer (2)

Sol. $\frac{V_I}{V_0} = \frac{N_I}{N_0} \Rightarrow \frac{220}{V_0} = \frac{100}{10}$

$V_0 = 22$ V

$\therefore \quad I_0 = \frac{22}{5} = 4.4$ A

14. Find the temperature of H_2 gas at which its *rms* speed is equal to that of O_2 at 47°C.

(1) 20°C (2) –20°C

(3) –253°C (4) 17°C

Answer (3)

Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}$

$\frac{T}{2} = \frac{320}{32}$

$T = 20$ K

$\therefore T = -253$°C

15. In AC circuit with source voltage $\varepsilon = 20 \sin 1000t$ is connected to series L – R circuit whose power factor is $\frac{1}{\sqrt{2}}$. If $E = 25 \sin 2000t$, the new power factor is

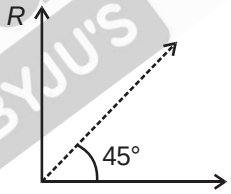
(1) $\frac{2}{\sqrt{5}}$ (2) $\frac{1}{\sqrt{5}}$

(3) $\frac{1}{\sqrt{3}}$ (4) $\sqrt{\frac{3}{5}}$

Answer (2)

Sol.

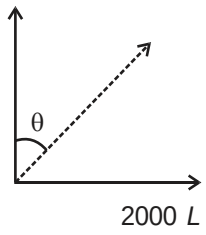
Old



$L\omega = 1000\,L \quad \Rightarrow \quad L\omega = R.$

New

$R = 1000\,L$



$\cos\theta = \frac{R}{Z}$

$= \frac{1000\,L}{\sqrt{(1000\,L)^2 + (2000\,L)^2}}$

$= \frac{1}{\sqrt{1+4}} = \frac{1}{\sqrt{5}}$

16. In an electromagnetic wave the electric field is given as $\vec{E} = E_0 \sin(\omega t - kz)\hat{i}$ the corresponding magnetic field will be

(1) $E_0 C \sin(\omega t - kz)\hat{j}$

(2) $\frac{E_0}{C}\sin(\omega t - kz)\hat{j}$

(3) $\frac{E_0}{C}\cos(\omega t - kz)\hat{i}$

(4) $\frac{E_0}{C}\sin(\omega t - kz)\hat{i}$

Answer (2)

Sol. $\vec{E} \times \vec{B}$ is along +z axis

$B_0 = \frac{E_0}{C}$

$\therefore \quad B = \frac{E_0}{C}\sin(\omega t - kz)\hat{j}$

17. At a point away from planet of radius 6400 km, the gravitational potential and field are -6.4×10^7 SI units and 6.4 SI units respectively. Find height of that point above surface of planet.

(1) 3000 km

(2) 6400 km

(3) 3600 km

(4) 9400 km

Answer (3)

Sol. $\frac{GM}{r} = 6.4 \times 10^7$ ...(i)

$\frac{GM}{r^2} = 6.4$ ...(ii)

$r = \frac{6.4 \times 10^7}{6.4}$

$= 10^7$ m

$= 10{,}000$ km

$R + h = 10{,}000$

$h = 10{,}000 - 6400 = 3600$ km

18. A wire has resistance of 60 Ω at temperature 27°C. When it is connected to a 220 V dc supply, a current 2.75 A flows through it at a certain temperature. Find the value of temperature, if coefficient of thermal resistance ($\propto$) is 2×10^{-4}/°C.

(1) 1694°C

(2) 1500°C

(3) 1000°C

(4) 1200°C

Answer (1)

Sol. Final resistance $(R) = \frac{V}{I} = 80\ \Omega$

then, $R = R_0(1 + \propto \Delta T)$

$80 = 60\left(1 + 2 \times 10^{-4}\Delta T\right)$

$\Delta T = 1666.67$

$T - 27$

$T = 1693.66$

$= 1694$°C

19. Match the two columns.

	Column 1		Column 2
P.	Surface tension	1.	$[ML^2T^{-2}]$
Q.	Viscosity	2.	$[ML^2T^{-1}]$
R.	Angular momentum	3.	$[ML^{-1}T^{-1}]$
S.	Rotational kinetic energy	4.	$[ML^0T^{-2}]$

(1) P–1, Q–2, R–3, S–4

(2) P–4, Q–3, R–2, S–1

(3) P–1, Q–3, R–4, S–2

(4) P–4, Q–2, R–1, S–3

Answer (2)

Sol. $S = \frac{F}{L}$

$\Rightarrow \quad [S] = [MT^{-2}]$

$F = nA\frac{dv}{dx}$

$\Rightarrow \quad \eta \equiv \frac{MLT^{-2} \cdot T}{L^2} = ML^{-1}T^{-1}$

$\vec{L} = \vec{r} \times \vec{p}$

$\Rightarrow L \equiv [ML^2T^{-1}]$

$KE = \frac{1}{2} I\omega^2$

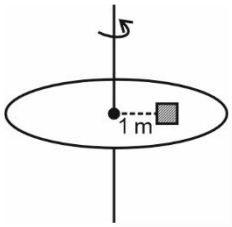
$\Rightarrow KE \equiv ML^2T^{-2}$

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 Numerical based questions. The answer to each question should be rounded-off to the nearest integer.

21. A block of mass 2 kg is placed on a disc which is rotating at constant angular velocity 4 rad/s. Find the friction force (in N) between block and disc if block is not sliding.



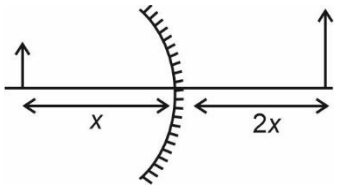
Answer (32)

Sol. Block is not slipping, so

$f = mr\omega^2 = 2 \times 1 \times 16 = 32$

22. Distance between virtual image, which is of twice of size of object placed in front of mirror and object is 45 cm. Magnitude of focal length of mirror is _____ cm.

Answer (30)



Sol.

$|m| = \left|\frac{v}{u}\right| = 2$

$|v| = |2u|$

$n + 2n = 45$

$n = 15$ cm

$u = -15$

$v = 30$

$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{30} + \frac{1}{-15} = \frac{1}{f}$

$\frac{1-2}{30} = \frac{-1}{30} = \frac{1}{f}$

$\Rightarrow f = 30$ cm

23. A particle is having uniform acceleration. If its displacement from t to $(t + 1)$ second is 120 m and change in velocity is 50 m/s. Find its displacement (in m) in $(t + 2)$ second.

Answer (170)

Sol. $\Delta v = a(t + 1 - t)$

$\therefore \quad a = 50$ m/s^2

$s = u + \frac{a}{2}(2(t+1) - 1)$

$120 = u + \frac{50}{2}(2t + 1)$

$\therefore \quad u = 120 - 25(2t + 1)$

In $(t + 2)^{th}$ second

$s' = u + \frac{a}{2}(2(t+2) - 1)$

$= u + 25(2t + 3)$

$= 120 - 25(2t) - 25 + 25(2t) + 75$

$s' = 170$ m

24. A uniform disc of mass 5 kg and radius 2 m is rotating with 10 rad/s. Now another identical disc is gently placed on first disc. Because of friction, both disc acquire common angular velocity. Loss of kinetic energy in process is _____ J.

Answer (250)

Sol. COAM gives $I\omega_0 = 2I\omega$

$\omega = \frac{\omega_0}{2}$

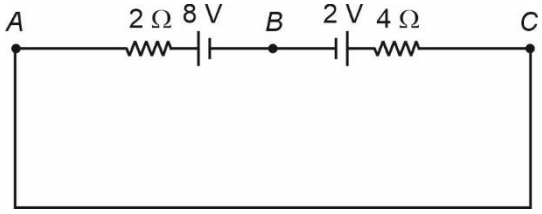
Loss in KE $= \frac{1}{2} I\omega_0^2 - \frac{1}{2}(2I)\left(\frac{\omega_0}{2}\right)^2$

$= \frac{1}{4} I\omega_0^2$

$= \frac{1}{4} \times 5 \times \frac{2}{2} \times 100 = 250$ J

25. Two cell one of emf 8 V, internal resistance 2 Ω and other of emf 2 V and internal resistance 4 Ω are connected as shown in figure.

Find potential difference (in V) across point *AC*.



Answer (0)

Sol. Current in circuit (I) = $\frac{8-2}{6}$ = 1 A.

So, $V_C - 4(1) - 2 + 8 - 2(1) = V_A$

$V_C - 6 - 2 + 8 = V_A$

$V_C - V_A = 0$ V

26. Electron in an hydrogen atom is excited to an energy level having energy –0.85 eV. Find the number of possible transitions it can make while de-excitation.

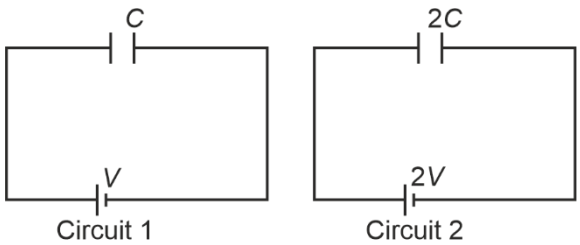
Answer (6)

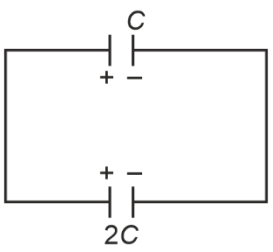
Sol. $-0.85 = \frac{-13.6}{n^2}$

$n = 4$

$\therefore$ Number of transitions = $\frac{4\times3}{2} = 6$

27. Energy stored in circuit 1 is E. If capacitors in circuit 1 and circuit 2 are connected in parallel as shown, the energy stored becomes $\frac{xE}{6}$, find x.





Answer (50)

Sol. Charge on $C_1 = CV$

Charge on $C_2 = 4CV$

When connected in parallel

$V_c = \frac{5V}{3}$

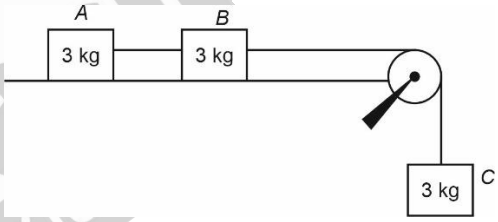
$\therefore \quad Q_1' = \frac{5}{3}CV, \quad Q_2' = \frac{10}{3}CV$

$\because \quad E = \frac{1}{2}CV^2$

$E' = \frac{25}{18}CV^2 + \frac{25}{9}CV^2$

$\frac{25}{6}CV^2 = \frac{50E}{6}$

$\therefore \quad x = 50$

28. 

If wire BC has Young's modulus of $Y = 2 \times 10^{11}$ N/m^2 and cross section area of 5×10^{-4} cm^2. Find strain in wire BC (in unit of 10^{-4})

Answer (20)

Sol. $a = \frac{3}{9}g$, For C, $3g - T = 3a = (3)\frac{3}{9}g$

$T = 2g = 20$ N

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

$\frac{\sigma}{Y} = \in \Rightarrow \frac{20}{5\times10^{-8}\times2\times10^{11}}$

$= 2 \times 10^{-3}$

$= 20 \times 10^{-4} \Rightarrow 20$

29.

30.