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JEE (Main)

PAPER-1 (B.E./B. TECH.)

2023

COMPUTER BASED TEST (CBT)

Questions & Solutions

Date: 01 February, 2023 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

Resonance Eduventures Ltd.

Reg. Office & Corp. Office : CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Raj.) - 324005

Ph. No.: +91-744-2777777, 2777700 | **FAX No. :** +91-022-39167222

To Know more : sms **RESO** at **56677** | **Website :** www.resonance.ac.in | **E-mail :** contact@resonance.ac.in | **CIN :** U80302RJ2007PLC024029

Toll Free : 1800 258 5555 7340010333 facebook.com/ResonanceEdu twitter.com/ResonanceEdu www.youtube.com/resowatch blog.resonance.ac.in

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PART : PHYSICS

1. A steel wire with mass per unit length 7.0×10^{-3} kg m^{-1} is under tension of 70 N. The speed of transverse waves in the wire will be

(1) 10 m/s (2) 100 m/s (3) 200π m/s (4) 50 m/s

Ans. **(2)**

Sol. $V=\sqrt{\frac{T}{\mu}}$

$V=\sqrt{\frac{70}{7\times10^{-3}}}$

$V = 100$ m/s

2. $\left(P+\frac{a}{V^2}\right)(V-b)=RT$ represents the equation of state of some gases. Where P is the pressure, V is the volume, T is the temperature and a, b, R are the constants. The physical quantity, which has dimensional formula as that of $\frac{b^2}{a}$, will be

(1) Bulk modulus (2) Compressibility (3) Modulus of rigidity (4) Energy density

Ans. **(2)**

Sol. $\left(p+\frac{an^2}{V^2}\right), a=\frac{PV^2}{n^2}$

$\frac{a=M^1L^{-1}\times L^6}{(mol)^2} = M^1L^5T^{-2}\,mol^{-2}$

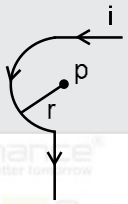
$nb = V$

$b = V/n = L^3/mol$

then $\frac{b^2}{a}=\frac{L^6}{mol^2}\frac{mol^2}{M^1L^5T^{-2}}$

$= M^{-1}L^1T^2$ is the dimension of compressibility.

3. Find the magnetic field at the point P in figure. The curved portion is a semicircle connected to two long straight wires.



(1) $\frac{\mu_0 i}{2r}\left(1+\frac{1}{\pi}\right)$ (2) $\frac{\mu_0 i}{2r}\left(1+\frac{2}{\pi}\right)$ (3) $\frac{\mu_0 i}{2r}\left(\frac{1}{2}+\frac{1}{\pi}\right)$ (4) $\frac{\mu_0 i}{2r}\left(\frac{1}{2}+\frac{1}{2\pi}\right)$

Ans. **(4)**

Sol. $B_0 = B_1 + B_2 + B_3$

$= \frac{\mu_0 i}{4\pi R}+\frac{\mu_0 i}{4R}+0=\frac{\mu_0 i}{4R}\left(\frac{\pi+1}{\pi}\right)=\frac{\mu_0 i}{2R}\left(\frac{1}{2}+\frac{1}{2\pi}\right)$

4. The mass of proton, neutron and helium nucleus are respectively 1.0073 u, 1.0087 u and 4.0015 u. The binding energy of helium nucleus is :

(1) 14.2 MeV (2) 7.1 MeV (3) 56.8 MeV (4) 28.4 MeV

Ans. **(4)**

Sol. Δm = mass defect = $(2\ m_p + 2\ m_n) - m_{He}$

$\Delta m = (2 \times 1.0073) + 2\ (1.0087) - 4.0015 = 4.032 - 4.0015$

$\Delta m = 0.0305$ amu

$E = (\Delta m \times 931.5)$ MeV

$E = 0.0305 \times 931.5$ MeV

$E = 28.41$ MeV

5. Match List I with List II:

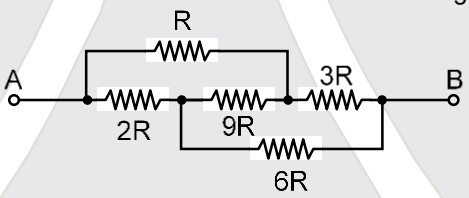
List I	List II
A. AC generator	I. Presence of both L and C
B. Transformer	II. Electromagnetic Induction
C. Resonance phenomenon to occur	III. Quality factor
D. Sharpness of resonance	IV. Mutual induction

Choose the **correct** answer from the options given below:

(1) A-IV, B- III, C-I, D-II (2) A-II, B- IV, C-I, D-III (3) A-II, B- I, C-III, D-IV (4) A-IV, B- II, C-I, D-III

Ans. **(4)**

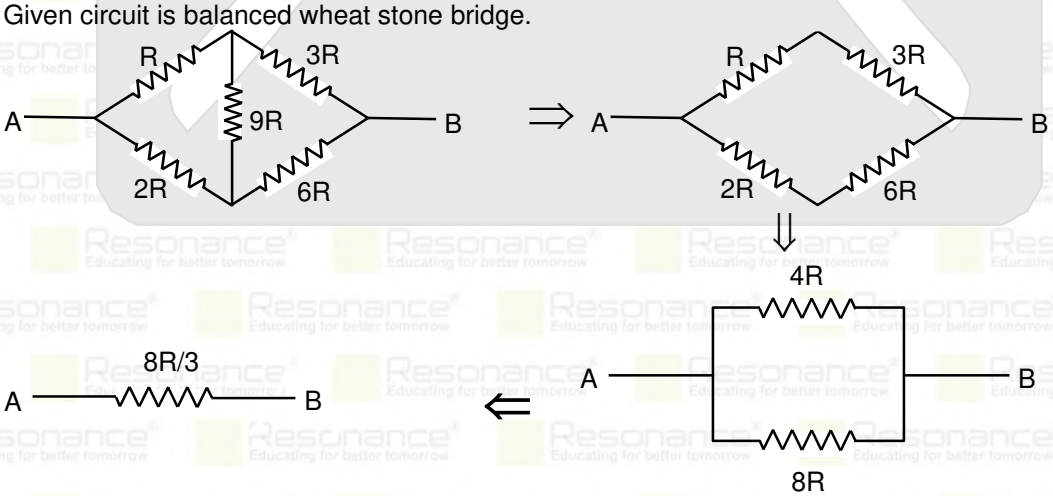
6. The equivalent resistance between A and B of the network shown in figure:



(1) $11\frac{2}{3}$ R (2) 14 R (3) $\frac{8}{3}$R (4) 21 R

Ans. **(3)**

Sol. Given circuit is balanced wheat stone bridge.



$$R_{eq} = \frac{R_1R_2}{R_1+R_2} = \frac{8R \times 4R}{12R} = \frac{8R}{3}$$

7. The average kinetic energy of a molecule of the gas is

(1) proportional to absolute temperature (2) proportional to volume

(3) dependent on the nature of the gas (4) proportional to pressure

Ans. **(1)**

Sol. $<\Delta KE> = \frac{f}{2}KT$

$\Delta KE \propto T$

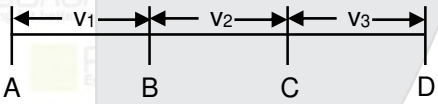
8. An object moves with speed $v_1, v_2,$ and v_3 along a line segment AB, BC and CD respectively as shown in figure. Where AB=BC and AD= 3AB, then average speed of the object will be:

(1) $\frac{(v_1+v_2+v_3)}{3}$ (2) $\frac{v_1v_2v_3}{(v_1v_2+v_2v_3+v_3v_1)}$

(3) $\frac{(v_1v_2v_3)}{3v_1v_2v_3}$ (4) $\frac{v_1v_2v_3}{3(v_1v_2+v_2v_3+v_3v_1)}$

Ans. **(2)**

Sol.



Let say AB = d meter

then BC = d meter

AD = AB + BC + CD = 3AB

$\therefore$ AB = BC $\Rightarrow$ 2AB + CD = 3AB

$\Rightarrow$ CD = AB

Hence CD = d meter

$$\text{Average velocity} = \frac{3d}{\frac{d}{v_1}+\frac{d}{v_2}+\frac{d}{v_3}} = \frac{d}{d}\left(\frac{3}{\frac{1}{v_1}+\frac{1}{v_2}+\frac{1}{v_3}}\right)$$

$$\text{Average velocity} = \frac{3}{\frac{v_2v_3+v_1v_3+v_1v_2}{v_1v_2v_3}} = \frac{3v_1v_2v_3}{v_1v_2+v_2v_3+v_1v_3}$$

9. Match List I with List II:

List I	List II
A. Microwaves	I. Radio active decay of the nucleus
B. Gamma rays	II. Rapid acceleration and deceleration of electron in aerials
C. Radio waves	III. Inner shell electrons
D. X-rays	IV. Klystron valve

Choose the **correct** answer from the options given below:

(1) A-I, B- II, C-III, D-IV (2) A-I, B- III, C-IV, D-II

(3) A-IV, B- I, C-II, D-III (4) A-IV, B- III, C-II, D-I

Ans. **(2)**

Sol. (A) $\rightarrow$ (P), (B) $\rightarrow$ (S) , (C) $\rightarrow$ (R), (D) $\rightarrow$ Q

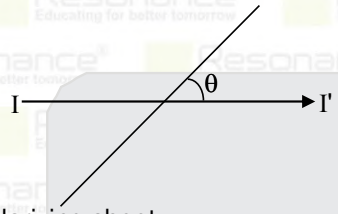
10. 'n' polarizing sheets are arranged such that each makes an angle 45° with the preceeding sheet. An unpolarized light of intensity I is incident into this arrangement. The output intensity is found to be $\frac{I}{64}$.

The value of n will be:

(1) 6 (2) 5 (3) 3 (4) 4

Ans. **(1)**

Sol.



Polarizing sheet

$I' = I\cos^2\theta$

$\theta = 45°$

$\Rightarrow \cos^2 45 = \frac{1}{2}$

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

output intensity = $\frac{I}{2^n}$ ($n \rightarrow$ number of polarizing sheets)

$\frac{I}{64} = \frac{I}{2^n}$

$\Rightarrow n = 6$

11. A mercury drop of radius 10^{-3} m is broken into 125 equal size droplets. Surface tension of mercury is 0.45 N m^{-1}. The gain in surface energy is:

(1) 5×10^{-5}J (2) 17.5×10^{-5}J (3) 2.26×10^{-5}J (4) 28×10^{-5}J

Ans. **(3)**

Sol. $V_i = V_f$

$\frac{4}{3}\pi R^3 = 125 \times \frac{4}{3}\pi r^3$

$R = 5r$

$r = \frac{10^{-3}}{5}$ m

$\Delta U = S\Delta A$

$= 0.45\,[125 \times 4\pi r^2 - 4\pi R^2] = 0.45\,[125 \times 4\,\pi r^2 - 4\pi(5r)^2] = 0.45 \times 25 \times \left(4\pi r^2\right)[5-1] = 2.26 \times 10^{-5}$ J

12. A proton moving with one tenth of velocity of light has a certain de Broglie wavelength of λ. An alpha particle having certain kinetic energy has the same De-Brogle wavelength λ. The ratio of kinetic energy of proton and that of alpha particle is:

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

Ans. **(2)**

Sol. $\lambda = \frac{h}{P} = \frac{h}{mv}$

$\lambda_\alpha = \lambda_P$

$\frac{h}{m_\alpha v_\alpha} = \frac{h}{m_P v_P}$ $[m_\alpha = 4m_P]$

$4m_P v_\alpha = m_P \frac{C}{10}$

$v_\alpha = \frac{C}{40}$; $\frac{(KE)_P}{(KE)_\alpha} = \frac{\frac{1}{2}m_P\left(\frac{C}{10}\right)^2}{\frac{1}{2}4m_P\left(\frac{C}{40}\right)^2} = \frac{1600}{4\times100} = \frac{4}{1} = 4:1$

13. Match List I with List II:

List I	List II
A. Intrinsic semiconductor	I. Fermi-level near the valence band
B. n-type semiconductor	II. Fermi-level in the middle of valence and conduction band
C. p-type semiconductor	III. Fermi-level near the conduction band
D. Metals	IV. Fermi-level inside the conduction band

Choose the **correct** answer from the options given below:

(1) A-I, B- II, C-III, D-IV (2) A-III, B-I, C-II, D-IV

(3) A-II, B- I, C-III, D-IV (4) A-II, B- III, C-I, D-IV

Ans. **(4)**

14. A sample of gas at temperature T is adiabatically expanded to double its volume. The work done by the gas in the process is (given $\gamma = \frac{3}{2}$):

(1) $W = TR\left[\sqrt{2}-2\right]$ (2) $W = \frac{R}{T}\left[2-\sqrt{2}\right]$

(3) $W = RT\left[2-\sqrt{2}\right]$ (4) $W = \frac{T}{R}\left[\sqrt{2}-2\right]$

Ans. **(3)**

Sol. $\omega = \frac{P_1V_1 - P_2V_2}{\gamma-1} = \frac{nR(T_1-T_2)}{\gamma-1}$

for an adiabatic process $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$

$T \times V^{\frac{3}{2}-1} = T_2 \times (2V)^{\frac{3}{2}-1}$

$\frac{T}{\sqrt{2}} = T_2$

$W = \frac{nR\left(T - \frac{T}{\sqrt{2}}\right)}{\frac{3}{2}-1}$; $W = \frac{nRT(\sqrt{2}-1)}{\sqrt{2}\times\frac{1}{2}}$

$W = nRT\,(2-\sqrt{2})$

we consider n = 1 as all options follow the same.

$W = RT\,(2-\sqrt{2})$

15. Which of the following frequencies does not belong to FM broadcast.
(1) 64 MHz (2) 106 MHz (3) 99 MHz (4) 89 MHz

Ans. **(1)**

Sol. Range of FM frequency = (88 – 108) MHz then 64 MHz is not the FM frequency.

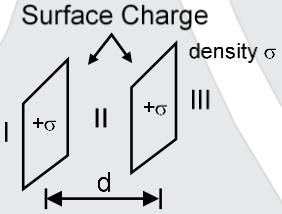
16. Given below are two statements :
Statement I : Acceleration due to gravity is different at different places on the surface of earth
Statement II : Acceleration due to gravity increases as we go down below the earth's surface.
In the light of the above statements, choose the **correct** answer from the options given below
(1) Both Statement I and Statement II are false
(2) Statement I is false but Statement II is true
(3) Statement I is true but Statement II is false
(4) Both Statement I and Statement II are true

Ans. **(3)**

Sol. gravity on surface of earth $g' = (g - R\omega^2\cos^2\theta)$, so as latitude changes, value of gravity also changes at each point on surface of earth.

As we go deep $g^1 = g1 - \left(1 - \frac{d}{R}\right) \Rightarrow$ gravity decreases so, statement 1 is correct and statement 2 is wrong

17. Let σ be the uniform surface charge density of two infinite thin plane sheets shown in figure. Then the electric fields in three different region E_I, E_{II} and E_{III} are:

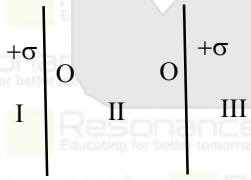


(1) $\vec{E}_I = 0, \vec{E}_{II} = \frac{\sigma}{\epsilon_0}\hat{n}, \vec{E}_{III} = 0$ (2) $\vec{E}_I = \frac{2\sigma}{\epsilon_0}\hat{n}, \vec{E}_{II} = 0, \vec{E}_{III} \frac{2\sigma}{\epsilon_0}\hat{n}$

(3) $\vec{E}_I = -\frac{\sigma}{\epsilon_0}\hat{n}, \vec{E}_{II} = 0, \vec{E}_{III} \frac{\sigma}{\epsilon_0}\hat{n}$ (4) $\vec{E}_I = -\frac{\sigma}{2\epsilon_0}\hat{n}, \vec{E}_{II} = 0, \vec{E}_{III} \frac{\sigma}{2\epsilon_0}\hat{n}$

Ans. **(3)**

Sol.



$E_I = -\frac{\sigma}{\epsilon_0}$ $E_{II} = 0$ $E_{III} = \frac{\sigma}{\epsilon_0}$

18. If earth has a mass nine times and radius twice to that of a planet P. Then $\frac{v_e}{3}\sqrt{x}\ ms^{-1}$ will be the minimum velocity required by a rocket to pull out of gravitational force of P, where v_e is escape velocity on earth. The value of x is
(1) 1 (2) 18 (3) 3 (4) 2

Ans. **(4)**

Sol. We know that escape velocity $v = \sqrt{\frac{2GM}{R}}$

given $M_P = \frac{m_e}{9}$, $R_p = \frac{Re}{2}$ $\Rightarrow$ $V_P = \sqrt{\frac{2GM_P}{R_P}} = \sqrt{\frac{2\times G\times Me/9}{Re/2}}$

$V_P = \sqrt{\frac{2\times 2GMe}{9Re}}$ .....(1)

also $v_0 = \sqrt{\frac{2GMe}{Re}}$ .....(2)

from question (1) and (2)

$V_P = \frac{v_0}{3}\sqrt{2}$

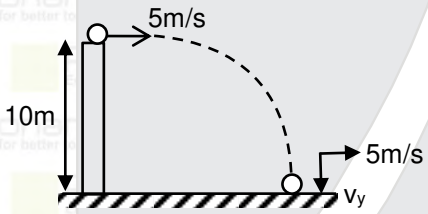
so, x = 2

19. A child stands on the edge of the cliff 10 m above the ground and throws a stone horizontally with an initial speed of 5 ms^{-1}. Neglecting the air resistance, the speed with which the stone hits the ground will be _____ms^{-1}.

(1) 15 (2) 20 (3) 30 (4) 25

Ans. **(1)**

Sol.



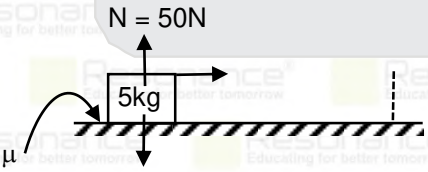
$V_y = \sqrt{2gh} = \sqrt{2\times 10\times 10} = 10\sqrt{2}$ m/s $\Rightarrow$ $v = \sqrt{V_x^2 + V_y^2} = \sqrt{200+25} = 15$ m/s

20. A block of mass 5 kg is placed at rest on a table of rough surface. Now, if a force of 30N is applied in the direction parallel to surface of the table, the block slides through a distance of 50 m in an interval of time 10s. Coefficient of kinetic friction is (given, g = 10 ms^{-2})

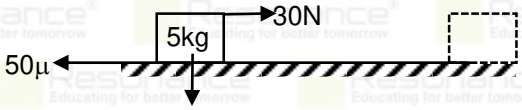
(1) 0.50 (2) 0.60 (3) 0.75 (4) 0.25

Ans. **(1)**

Sol.



$5(g) = 50N \Rightarrow$ Friction= 50μ



$5(g) = 50N \Rightarrow$ Friction= (50) (μ)

$F_{net} = (30 - 50\mu)N$

$a_{net} = \frac{30-50\mu}{5} = (6-10\mu)m/s^2$

Travelled displacement = 50 m

time taken = 10 sec

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

$50 = 0(t) + \frac{1}{2}(6-10\mu)(10)^2$

$50 = 1/2\ (6 - 10\mu)\ 100$

$\Rightarrow \quad \frac{50\times 2}{100} = (6 - 10\mu) \Rightarrow 6 - 10\mu = 1$

$10\mu = 6 - 1 = 5$

$\mu = 5/10 = 0.5$

$\mu = 0.5$

21. A light of energy 12.75 eV is incident on a hydrogen atom in its ground state. The atom absorbs the radiation and reaches to one of its excited states. The angular momentum of the atom in the excited state is $\frac{x}{\pi}\times 10^{-17}$eVs. The value of x is _____ (use h = 4.14×10^{-15} eVs, c = 3×10^{8} ms^{-1})

Ans. **828**

Sol. $12.75 = -13.6\left(\frac{1}{X^2} - \frac{1}{12}\right)$

$12.75 = -\frac{13.6}{X^2} + 13.6$

$X^2 = \frac{+13.6}{+0.85} = 16$

$X = 4$

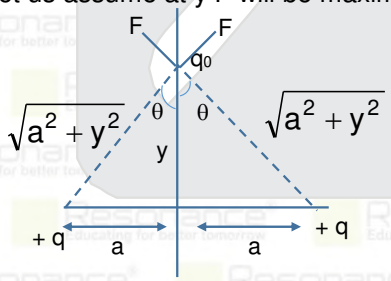
$mvr = \frac{Xh}{2\pi} \Rightarrow L = 4 \times \frac{h}{2\pi} \Rightarrow \quad L = \frac{2h}{\pi} = \frac{828\times10^{-17}}{\pi}$eVs

Therefore x = 828

22. Two equal positive point charges are separated by a distance 2a. The distance of a point from the centre of the line joining two charges on the equatorial line (perpendicular bisector) at which force experienced by a test charge q_0 becomes maximum is $\frac{a}{\sqrt{x}}$. The value of x is _____.

Ans. **2**

Sol. Let us assume at y F will be maximum



$F_{net} = 2\ F\cos\theta \Rightarrow \quad F_{net} = \frac{2kqq_0y}{(a^2+y^2)^{3/2}}$

For F_{max} $\frac{dF_{net}}{dy} = 0$

then $y = \frac{a}{\sqrt{2}} \Rightarrow \frac{a}{\sqrt{2}} = \frac{a}{\sqrt{x}}$

Then the value of x is 2

23. In an experiment to find emf of a cell using potentiometer, the length of null point for a cell of emf 1.5 V is found to be 60 cm. If this cell is replaced by another cell of emf E, the length of null point increases by 40 cm. The value of E is $\frac{x}{10}$ V. The value of x is_____.

Ans. **25**

Sol. $E \propto l$

$$\frac{E_2}{E_1} = \frac{l_2}{l_1}$$

24. A certain pressure 'P' is applied to 1 litre of water and 2 litre of a liquid separately. Water gets compressed to 0.01% whereas the liquid gets compressed to 0.03%. The ratio of Bulk modulus of water to that of the liquid is $\frac{3}{x}$. The value of x is _____.

Ans. **1**

Sol. $\beta = \frac{-P}{\frac{\Delta v}{v}}$

$$\Rightarrow \quad P = \beta\frac{\Delta v}{v} \qquad \Rightarrow \qquad \frac{\beta_1}{\beta_2} = \frac{\beta_{water}}{\beta_{liquid}} = \frac{3}{1} \qquad \therefore \qquad x = 1$$

25. The amplitude of a particle executing SHM is 3cm. The displacement at which its kinetic energy will be 25% more than the potential energy is_____cm.

Ans. **2**

Sol. $TE = \frac{1}{2}KA^2 = \frac{1}{2}K\left(\frac{3}{100}\right)^2$

$TE = KE + PE$

Given $KE = \frac{125}{100}PE = \frac{5}{4}PE$

$$\therefore \frac{1}{2}K\left(\frac{3}{100}\right)^2 = \frac{9}{4}PE \quad \left[PE = \frac{1}{2}Kx^2\right]$$

$$\Rightarrow \frac{1}{2}K\left(\frac{3}{100}\right)^2 = \frac{9}{4}\times\frac{1}{2}Kx^2 \Rightarrow x = \frac{1}{50}m = 2\text{ cm}.$$

26. A charge particle of 2 μC accelerated by a potential difference of 100V enters a region of uniform magnetic field of magnitude 4 mT at right angle to the direction of field. The charge particle completes semicircle of radius 3 cm inside magnetic field. The mass of the charge particle is _____$\times 10^{-18}$kg.

Ans. **144**

Sol. $w = \Delta K.E.$

$9V = 1/2\ mV^2$

$2 \times 10^{-6} \times 100 = 1/2 \times m \times V^2$

$$\therefore \quad V = \sqrt{\frac{4\times10^{-4}}{m}}$$

Radius of moving charge in transverse magnetic field

$$R = \frac{mV}{qB}$$

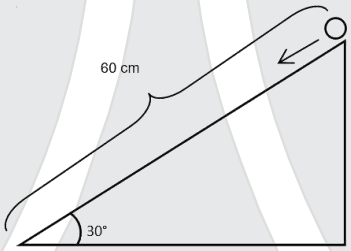
$$3 \times 10^{-2} = m \times \sqrt{\frac{4\times10^{-4}}{m}}$$

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

$$\sqrt{m} = \frac{24\times10^{-11}}{2\times10^{-2}} = 12.10^{-9}$$

$$m = 144 \times 10^{-18}\ kg$$

27. A solid cylinder is released from rest from the top of an inclined plane of inclination 30° and length 60 cm. If the cylinder rolls without slipping, its speed upon reaching the bottom of the inclined plane is _____ ms^{-1}.



Ans. **2**

Sol. $$a = \frac{g\sin\theta}{1+\frac{k^2}{r^2}} = \frac{g\sin\theta}{1+\frac{1}{2}} = \frac{2}{3}gism\theta = \frac{2}{3}\times10\times\sin30° = \frac{10}{3}\ m/s$$

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

$$v^2 = 0 + 2 \times \frac{10}{3}\times0.60$$

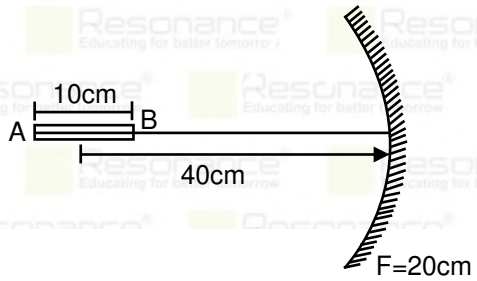
then $v^2 = 4$

$v = 2$ m/s

28. A thin cylindrical rod of length 10 cm is placed horizontally on the principle axis of a concave mirror of focal length 20 cm. The rod is placed in a such a way that midpoint of the rod is at 40cm from the pole of mirror. The length of the image formed by the mirror will be x/3 cm. The value of x is _____.

Ans. **32**

Sol.



$$\frac{1}{v_B}+\frac{1}{u_B}=\frac{1}{f}$$

$$\frac{1}{v}+\frac{1}{-35}=\frac{1}{-20}$$

$$\frac{1}{v}=\frac{1}{-20}+\frac{1}{35}=\frac{35-20}{35\times-20}=\frac{15}{-35\times20}=\frac{-140}{3}=v$$

$$\frac{1}{v_A}+\frac{1}{u_A}=\frac{1}{f}\quad;\quad\frac{1}{v_A}-\frac{1}{45}=\frac{1}{-20}$$

$$\frac{1}{v_A}=-\frac{1}{20}+\frac{1}{45}=\frac{45-20}{45\times-20}=\frac{25}{45\times-20}=-36$$

$$I=v_A-v_B=-36+\frac{140}{3}=\frac{-108+140}{3}$$

$$|I|=\frac{32}{3}\Rightarrow x=32$$

29. A series LCR circuit is connected to an ac source of 220V, 50Hz. The circuit contain a resistance R = 100Ω and an inductor of inductive reactance X_L = 79.6 Ω. The capacitance of the capacitor needed to maximize the average rate at which energy is supplied will be _____μF.

Ans. **40**

Sol. For max power

$$X_L=X_c=79.6\Omega$$

$$X_c=\frac{1}{W_c}$$

$$C=\frac{1}{2\pi\times50\times79.6}=39.98\mu F\approx40\mu F$$

30. A small particle moves to position $5\hat{i}-2\hat{j}+\hat{k}$ from its initial position $2\hat{i}+3\hat{j}-4\hat{k}$ under the action of force $5\hat{i}+2\hat{j}+7\hat{k}$N. The value of work done will be _____J.

Ans. **40**

Sol. Work done = Force · Displacement

$$W=\vec{F}.\vec{r}$$

Here $\vec{r}=\vec{r}_2-\vec{r}_1$

$$\vec{r}_2=5\hat{i}-2\hat{j}+\hat{k}$$

$$\vec{r}_1=2\hat{i}+3\hat{j}-4\hat{k}$$

$$\vec{r}=(5-2)\hat{i}+(-2-3)\hat{j}+(1-(-4))\hat{k}$$

$$\vec{r}=3\hat{i}-5\hat{j}+5\hat{k}$$

$$\text{Workdone}=\vec{F}.\vec{r}=(5\hat{i}+2\hat{j}+7\hat{k})\ .\ (3\hat{i}-5\hat{j}+5\hat{k})$$

$$=(15-10+35)\ J$$

Workdone = 40 Joule

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