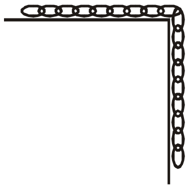
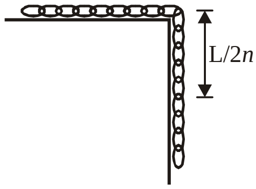
CBSE Mains- 2008

PHYSICS

1. $1/n^{th}$ part of a uniform chain of length L is hanging on a table, find the work done in pulling up the chain.

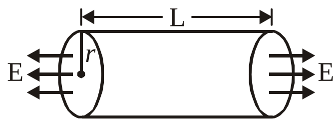


Sol: $$W = \left(\frac{m}{n}\right) g \left(\frac{L}{2n}\right) = \frac{mg\,L}{2n^2}$$



Here $\frac{m}{n}$ is mass of the hanging part which is displaced by a distance $\frac{L}{2n}$ in vertical direction.

2. Electric field in a region is given by as shown in the figure. Find the flux passing through flat part and curved part and the charge enclosed by the cylinder.



Sol: Flux passing through flat part $= \pi r^2 E + \pi r^2 E$

$= 2\pi r^2 E$

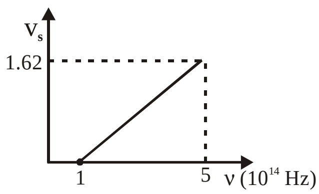
Flux passing through curved part = 0

(E and surface area is perpendicular)

$$\phi_{net} = \frac{q_{en}}{\varepsilon_0}$$

$\therefore \quad q_{en} = 2\pi r^2 E\,\varepsilon_0$

3. Find the work function from the given graph.

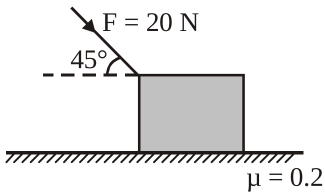


Sol: Slope of the curve $= \frac{h}{e}$

$$\therefore \quad \frac{1.62}{4 \times 10^{14}} = \frac{h}{e}$$

$$h = \frac{1.62 \times 1.9 \times 10^{-19}}{4 \times 10^{14}} = 7.7 \times 10^{-34} \text{ J-s}$$

4. A force of 20 N is acting on a block of mass 5 kg as shown in the figure. Determine the velocity of block at t = 5 sec.



Sol: $F_X = 20\cos 45° = \frac{20}{\sqrt{2}}\text{ N} = 14.2\text{ N}$

$F_Y = 20\sin 45° = \frac{20}{\sqrt{2}}\text{ N}$

$f_{s,\max} = \mu N$

$= 0.2\,(mg + F_Y)$

$= 0.2\left(50 + \frac{20}{\sqrt{2}}\right)$

$= 12.82\text{ N}$

$\therefore\quad a = \frac{F_X - f_{s,\max}}{m}$

$= \frac{14.2 - 12.8}{5}$

$= 0.28\text{ m/s}^2$

5. Determine the dimensions of a in the following equation $\left(P + \frac{a}{V^2}\right)(V - b) = RT$.

Sol: $P \equiv \frac{a}{V^2}$

$a \equiv PV^2$

$= \frac{MLT^{-2}}{L^2} \times L^6$

$= [ML^5T^{-2}]$

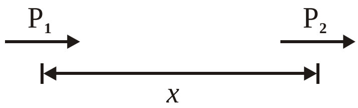
6. A charge q is distributed on a ring of radius R. What is potential on the axis at distance a from the centre. Determine the electric field by using expression of potential at that point.

Sol: $V = \frac{Kq}{(R^2 + a^2)^{1/2}}$

$$E = -\left(\frac{dV}{da}\right) = -Kq \times (-1/2)\,(R^2 + a^2)^{-3/2} \times 2a$$

$$= \frac{Kqa}{(R^2 + a^2)^{3/2}}$$

7. Two dipoles having dipole moments P_1 and P_2 are separated by distance x as shown in the figure. Determine torque on P_2 due to P_1.



Sol: At axial point E is along axis so torque of forces acting on P_2 is zero

8. A transistor with $\beta = 69$ has collector current $i_C = 7$ mA. Find

(a) Emitter current

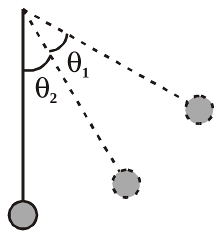
(b) Base current

Sol: Given $\beta = 69 = \frac{I_c}{i_b}$

$\Rightarrow$ $i_b = 7/69 = 0.101$ mA

$i_e = i_b + i_c = 7 + 0.101 = 7.101$ mA

9. A block of mass m is tied to a string of length l. Block is left when string makes an angle θ_1 with vertical. What is velocity at lowest position and tension in string when it makes an angle θ_2 with vertical ($\theta_2 < \theta_1$).



Sol: $mgl(1 - \cos\theta_1) = \frac{1}{2}mv^2$

$\Rightarrow$ $v = \sqrt{2gl(1 - \cos\theta_1)}$

where v is velocity at lowest point

Velocity v_1 when string makes angle θ_2

$$\frac{1}{2}mv_1^2 + mgl(1 - \cos\theta_2) = mgl(1 - \cos\theta_1)$$

$\Rightarrow$ $v_1 = \sqrt{2gl(\cos\theta_2 - \cos\theta_1)}$

$$T - mg\cos\theta_2 = \frac{m v_1^2}{l}$$

$$T = mg\,(3\cos\theta_2 - 2\cos\theta_1)$$

10. The amplitude of a oscillator has amplitude A_0. After 80 oscillations its amplitudes becomes 0.8 A_0. What will be its amplitude after 150 oscillation.

Sol: Amplitude of damped oscillation at any time *t* is given by

$$A = A_0 e^{-bt}$$

Given

$$0.8\,A_0 = A_0\, e^{-b\times 80T} \qquad \text{(where T is time period)}$$

$$A = A_0\, e^{-b\times 150T}$$

$$\frac{\log_e 0.8}{\log_e \frac{A}{A_0}} = \frac{80}{150}$$

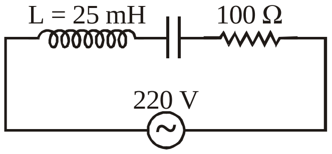
$$\Rightarrow \quad \log_e \frac{A}{A_0} = \frac{15}{8} \times \log_e \frac{4}{5}$$

Solving $A \cong 0.14\, A_0$

11. C_{11} looses β^+ emission complete the equation.

Sol: $^{11}_{6}C \rightarrow {}^{11}_{5}B + \beta^+ + \nu$ + energy

12. In L-C-R circuit potential across inductor is twice that of potential across R. Find the frequency of the source.



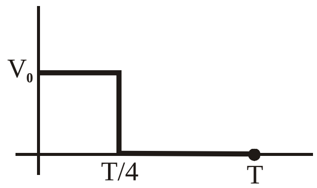
Sol: $V_L = 2V_R$

$I\omega L = 2IR$

$\Rightarrow \quad \omega = 2R/L$

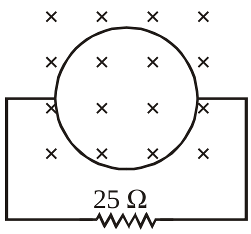
$$\therefore \quad f = \frac{1}{2\pi}\cdot\frac{2R}{L} = \frac{R}{\pi L} \simeq 1274 \text{ Hz}$$

13. Potential vs time graph of an a.c. source is shown in the figure. Find rms value.



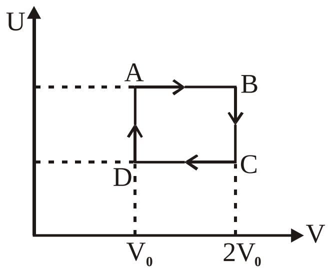
Sol:
$$V_{rms} = \left[\frac{\int_0^{T/4} V_0^2\, dt}{T}\right]^{1/2} = \frac{V_0}{2}$$

14. A coil having area 0.04 m^2 is rotated by 90° in 0.1 sec in a external magnetic field of 25 T. Find charge flown through resistance.



Sol: $q = \frac{\Delta\phi}{R} = \frac{25 \times 0.04 - 0}{25} = 0.04$ coulomb

15. One mole of an ideal gas undergoes thermodynamic process is shown on the U-V diagram. Determine heat exchange and the change in the internal energy in cyclic process given $T_A = 500$ K, $T_C = 300$ K and $\log_e 2 = 0.693$.



Sol: $W_{A \to B} = nRT \ln \frac{V_f}{V_i}$

$= 1 \times R \times 500 \ln\left(\frac{2\,V_0}{V_0}\right)$

$= 500$ R ln 2 = 319.5 RJ

$W_{C \to D} = nRT \ln\left(\frac{V_f}{V_i}\right)$

$= 1 \times R \times 300 \ln\left(\frac{V_0}{2\,V_0}\right)$

$= -300$ R ln 2 J

$= -191.7$ RJ

$\Delta Q = \Delta U + W$

$= 0 + (319.5R - 191.7\,R)$

$= 127.8R$ J

16. Two particles are moving with velocities 10 m/sec and 5 m/sec. Their acceleration are 2 m/sec^2 and 5 m/sec^2 respectively. They travel equal distances in given time. Determine that distance travelled by the particles.

Sol: $10t + \frac{1}{2} \times 2t^2 = 5t + \frac{1}{2} \times (5)t^2$

$\Rightarrow \quad 5t = \frac{3}{2}t^2$

$\Rightarrow \quad t = \frac{10}{3}$ sec

$\therefore \quad S = 10 \times \frac{10}{3} + \frac{1}{2} \times \frac{2 \times 100}{3} = \frac{200}{3} m$

17. A particle falls 20 m when dropped and acquires velocity of 5 m/sec. What is work done by air.

Sol: $W_{air} + W_g = K_f - K_i$

$W_{air} + mg \times 20 = \frac{1}{2} m \times 5^2 - 0$

$\Rightarrow \quad W_{air} = \frac{25}{2} m - 200 m = -187.5 m$

if $m = 1$ kg

$\therefore \quad W_{air} = -187.5$ J