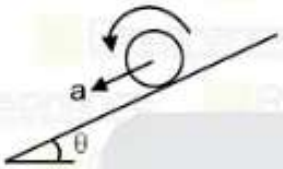
PART : PHYSICS

1. A solid sphere and a hollow sphere are roll down purely equal distances on same inclined plane (starting from rest) in time t_1 and t_2 then

(1) $t_1 > t_2$ (2) $t_1 < t_2$ (3) $t_1 = 2t_2$ (4) $t_1 = t_2$

Ans. **(2)**

Sol.



$$a = \frac{g\sin\theta}{1+\frac{I_{cm}}{mr^2}}$$

$(I_{cm})_{solid} < (I_{cm})_{hollow}$

$a_{solid} > a_{hollow}$

$t_1 < t_2$

2. A solid sphere rolls without slipping on a horizontal plane. What is ratio of translation kinetic energy to the rotation kinetic energy of the sphere?

(1) 4/3 (2) 3/4 (3) 2/5 (4) 5/2

Ans. **(4)**

Sol. $V = R\omega$

$$\frac{Kt}{Krot} = \frac{\frac{1}{2}mv^2}{\frac{1}{2}\times I\omega^2} = \frac{\frac{1}{2}mv^2}{\frac{1}{2}\times\frac{2}{5}mv^2} = \frac{5}{2}$$

3. Acceleration due to gravity on the surface of earth is g and acceleration due to gravity on a planet whose diameter is $\frac{1}{3}$ of that of earth and same mass as that of earth is g'. If g' = ng then n is.

(1) 9 (2) 2 (3) $\frac{1}{2}$ (4) 6

Ans. **(1)**

Sol. $g = \frac{GM}{R^2}$

$$g' = \frac{GM}{\left(\frac{R}{3}\right)^2} = \frac{9GM}{R^2}$$

$g' = 9\,g$

4. If an object of rest mass M_0 has momentum p and total energy E then which the of the following will be correct ? (where C is the velocity of light) -

(1) $E^2 = M_0^2C^2 + P^2C^2$ (2) $E^2 = M_0^2C^4 + P^2C^2$

(3) $E = M_0C^2 + PC^2$ (4) $E^2 = M_0C + PC$

Ans. **(2)**

Sol. In relativistic case $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$

$$P^2 = \frac{m0^2v^2}{\left(1-\frac{v^2}{c^2}\right)} = \frac{m_0^2\frac{v^2}{c^2}c^2}{\left(1-\frac{v^2}{c^2}\right)}$$

$$P^2 = \frac{m_0^2c^2\left(\frac{v^2}{c^2}-1+1\right)}{\left(1-\frac{v^2}{c^2}\right)}$$

$$P^2 = m_0^2c^2 + \frac{m_0^2c^2}{\left(1-\frac{v^2}{c^2}\right)}$$

$$p^2c^2 = m_0^2c^2 + \left(\frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}\right)c^4$$

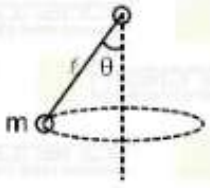
$p^2c^2 = -(m^0c^2)^2 + (mc^2)^2$

$(mc^2)^2 = p^2c^2 + (m_0c^2)^2$

$E^2 = p^2c^2 + m_0^2c^4$

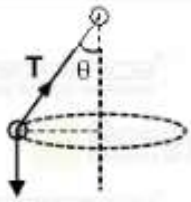
$E = \sqrt{(pc)^2 + (m_0c^2)^2}$

5. A bob of mass m is attached to a string of length 'ℓ'. If it is rotating in a horizontal circle of radius r with angular velocity $\omega = \frac{3}{\pi}\frac{\text{rev}}{\text{sec}}$ and tension in the string is x(mℓ) then value of x is _____



Ans. **36.00**

Sol.



$$\omega = \frac{3\ \text{rev}}{\pi\ \text{sec}}$$

$$\omega = \frac{3}{\pi} \times 2\pi \frac{\text{rev}}{\text{sec}}$$

$\omega = 6$

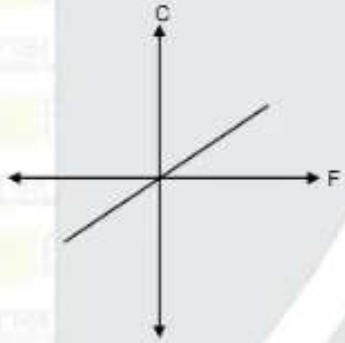
$T\sin\theta = m(\ell\sin\theta)\omega^2$

$T = m\omega^2\ell = m(36)\ell = x(m\ell)$

$x = 36$

6. Which of the following graph is correct. Hence F = Fahrenheit. & C = Celsius

(1)



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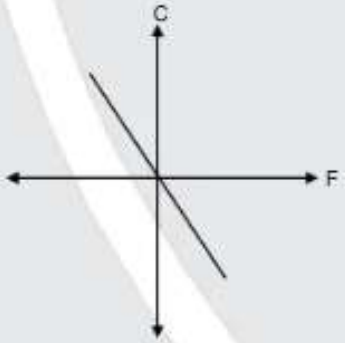

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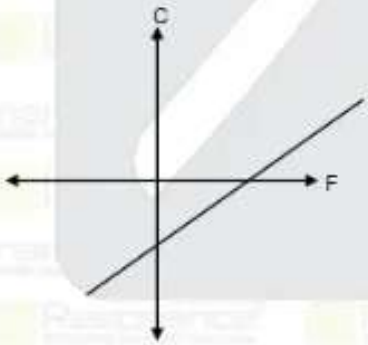

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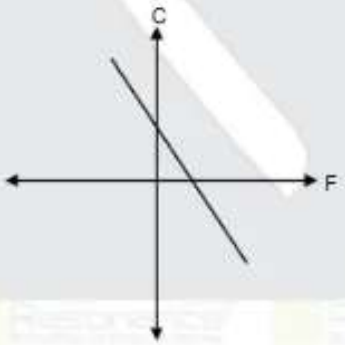


Ans. **(3)**

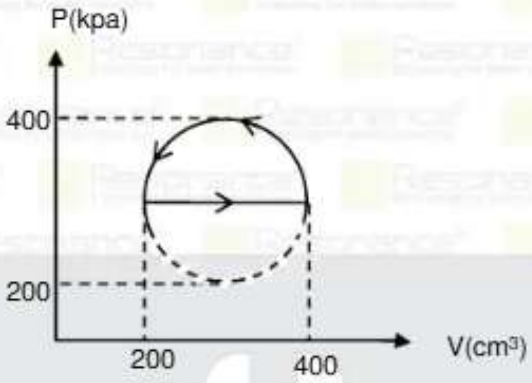
Sol. $\frac{C-0}{100} = \frac{F-32}{180} \Rightarrow C = \frac{5}{5}(F-32)$

$C = \frac{5F}{9} - \frac{160}{9}$

$\text{Slope} = \frac{5}{9} = +\text{Ve}$

$\text{Intercept} = \frac{-160}{9}$

7. An ideal gas is undergone through a cyclic process as shown in the graph. The net heat ejected by the gas during one cycle will be : -



(1) 5 πJ (2) 10 πJ (3) 15 πJ (4) 2.5 πJ

Ans. **(1)**

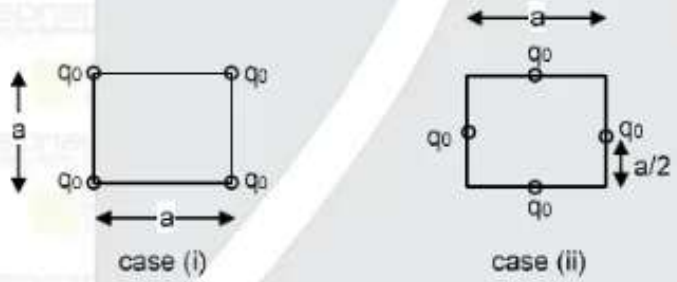
Sol. W_{cycle} = Area enclosed by P -V cycle = $\frac{\pi ab}{2}$

$W_{cycle} = -\frac{1}{2}\pi(100 \times (10^{-2})^3)(100 \times 10^3)$

$Q_{cycle} = W_{cycle} = -5\pi$

Heat rejected by the gas = 5πJ

8.



Four charges each of value q_0 are placed as shown. If potential energy of system is k_1 in case (i) and PE of system is k_2 in case (ii) then what is value of $k_2 - k_1$

(1) $\frac{kq_0^2}{a}\left[3\sqrt{2}-2\right]$ (2) $\frac{kq_0^2}{a}\left[5\sqrt{2}-2\right]$ (3) $\frac{kq_0^2}{a}\left[3\sqrt{2}+2\right]$ (4) Zero

Ans. **(1)**

Sol. $k_1 = 2\left[\frac{kq_0^2}{a}+\frac{kq_0^2}{a}+\frac{kq_0^2}{\sqrt{2}a}\right] = \frac{2kq_0^2}{a}\left[2+\frac{1}{\sqrt{2}}\right]$

$k_2 = 2\left[\frac{kq_0^2}{a/\sqrt{2}}\times 2+\frac{kq_0^2}{a}\right] = \frac{2kq_0^2}{a}\left[2\sqrt{2}+1\right]$

$k_2 - k_1 = \frac{kq_0^2}{a}\left(3\sqrt{2}-2\right)$

9. **Statement-1:** If in adiabatic process volume is decrease from V to V/2 then temperature also decreases
Statement-2: Free expansion is irreversible as well as adiabatic
(1) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(2) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True

Ans. **(4)**

Sol. $T.V^{\gamma-1}$ = constant
when volume decreases then temperature increases

10. Which of the following option is correct for increasing order of wave length
(i) Infrared ray
(ii) x-ray
(iii) UV-ray
(iv) Microwave-ray
(1) (i), (ii), (iii), (iv) (2) (iv), (i), (iii), (ii) (3) (ii), (iii), (i), (iv) (4) (ii), (iii), (i), (iv)

Ans. **(3)**

Sol. $\lambda_x < \lambda_{UV} < \lambda_{Ir} < \lambda_{Micro}$

11. Find the fringe width, if complete YDSE is immersed in a medium of refractive index $\mu = 1.44$.
Given $\lambda_{air} = 690$ nm , D = 0.72 meter d = 1.5mm
(1) 0.23 mm (2) 1.23 mm (3) 2.28 mm (4) 0.40 mm

Ans. **(1)**

Sol. $\beta_{red} = \frac{\lambda_{air}}{\mu}\frac{D}{d}$

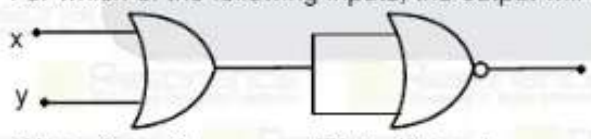
$= \frac{690\times10^{-9}\times72\times10^{-2}}{144\times10}$

$= \frac{690}{2\times3\times10^{-3}}$

$= 230 \times 1^{-6}$

0.23 mm

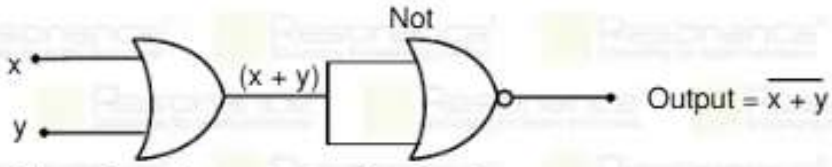
12. For which of the following inputs, the output will be zero (0) : -



(A) x = 0, y = 0 (B) x = 0, y = 1
(C) x = 1, y = 0 (D) x = 1, y = 1
(1) A,B,C (2) B, C, D (3) Only A (4) Only D

Ans. **(2)**

Sol.



(A) $x = 0, y = 0 \Rightarrow$ output $= 0 + 0 = 1$

(B) $x = 0, y = 1 \Rightarrow$ output $0 + 1 = 0$

(C) $x = 1, y = 0 \Rightarrow$ output $1 + 0 = 0$

(D) $x = 1, y = 1 \Rightarrow$ output $1 + 1 = 0$

13. Power of two sources S_1 and S_2 are in ratio 2 : 1 and 2×10^{15} photons per sec of wavelength 600 nm from S_1 are emitted then find the number of photons per second emitted from source S_2 of wavelength 300 nm ?

(1) 5×10^{15} (2) 2×10^{15} (3) 5×10^{14} (4) 2×10^{14}

Ans. **(3)**

Sol. $P_1 = P = \frac{N_1 hc}{\lambda_1}$ $P = \frac{Nhc}{\lambda}$ $N \rightarrow$ No. of photon/sec

$$P_2 = \frac{P}{2} = \frac{N_2 hc}{\lambda_2}$$

$$\frac{P_1}{P_2} = \frac{N_1}{\lambda_1} \cdot \frac{\lambda_2}{N_2}$$

$$N_2 = \frac{N_1 \lambda_2}{\lambda_1 2} = \frac{2 \times 10^{15} \times 300}{600 \times 2}$$

$n_2 = 5 \times 10^{14}$ per second

14. **Statement (1) :** An electron in a uniform magnetic field, can move without changing its velocity vector.
Statement (2) : In the above case, the magnetic field should be along the direction of its velocity.

(1) Both statement 1 and statement 2 is correct, and statement 2 is the correct explanation of statement 1

(2) Both statement 1 and Statement 2 is correct but statement 2 is not the correct explanation of statement 1

(3) Statement 1 is correct, but statement 2 is incorrect

(4) Statement 1 is incorrect, but statement 2 is correct.

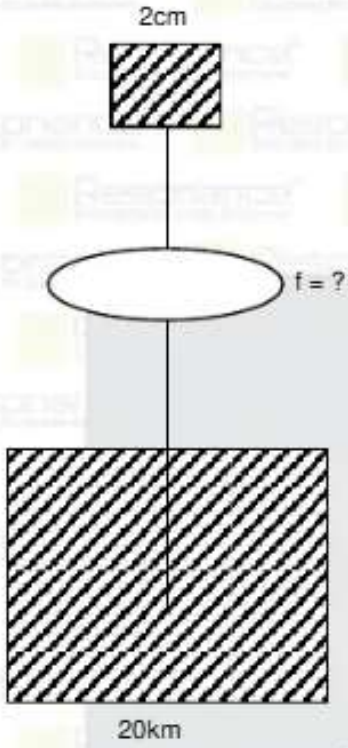
Ans. **(1)**

15. A drone camera situated at a height of 18 km, capture an image of area 400km^2, on a camera film of size 2cm × 2 cm. find the focal length of the lens used in camera in mm.

(1) 6 (2) 14 (3) 18 (4) 27

Ans. **(3)**

Sol.



$$|m| = \frac{h_i}{h_0} = \frac{2cm}{20km} = \frac{2\times10^{-2}}{20\times10^{3}} = 10^{-6}$$

Since the image is real, so it will be inverted

$$m = -10^{-6} = \frac{-1}{10^{6}}$$

$$m = \frac{f}{f+u}$$

$$-\frac{10}{10^{6}} = \frac{f}{f+(-18km)}]$$

$10^6 f = -f + 18\ km$

$10^6 f = 18\ km$

$$f = \frac{18km}{10^{6}} = \frac{18\times10^{3}\times10^{3}mm}{10^{6}}$$

$f = 18\ mm$

16. A spherical conductor carries a charge of 4×10^{-8}C brought in contact with an uncharged spherical conductor and they are separated by a distance r. Now force between them is 9×10^{-3} N. Determine the separation between the charges.

(1) 7 (2) 4 (3) 9 (4) 2

Ans. **(4)**

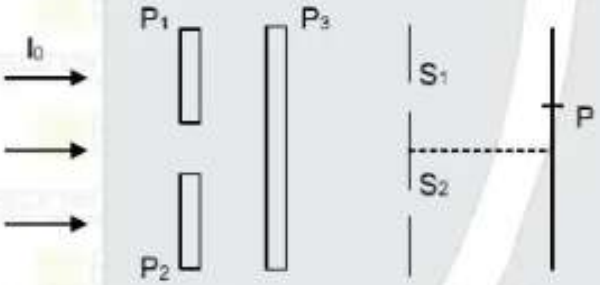
Sol.

$$\frac{Kq^2}{R^2} = 9 \times 10^{-3}$$

$$\frac{9\times10^{9}\times2\times10^{-8}\times2\times10^{-8}}{9\times10^{-3}} = R^2$$

$R = 2$ cm

17.



In the following diagram polarizer P_1 & P_2 are orthogonal and P_3 is aligned at 45° w.r.t. P_1 and P_2. If unpolarised light of intensity I_0 is incident on P_1 and P_2 and light after passing through P_3 is used in YDSE. at some point P where path difference is $\frac{\lambda}{3}$, What is resultant intensity?

(1) $\frac{I_0}{2}$ (2) $\frac{I_0}{3}$ (3) $\frac{I_0}{4}$ (4) I_0

Ans. (3)

Sol. Intensity after P_1 & P_2 is $\frac{I_0}{2}$ and after P_3 ÞP $\frac{I_0}{2}\cos^2 45 = \frac{I_0}{2}\left(\frac{1}{2}\right) = \frac{I_0}{4}$

Now, $I_P = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\Delta\theta$

$$= \frac{I_0}{4} + \frac{I_0}{4} + 2\frac{I_0}{4}\cos\left[\frac{2\pi}{\lambda}\left(\frac{\lambda}{3}\right)\right]$$

$$= \frac{I_0}{2} + \frac{I_0}{2}\left[-\frac{1}{2}\right]$$

$$I_P = \frac{I_0}{4}$$

18. A hot body is placed in the surrounding of temperature 16°C. During first 4 minutes, its temperature falls from 40°C to 24°C, then find its temperature after 4 minutes.

(1) 12°C (2) 22°C (3) 10°C (4) 18.7°C

Ans. (4)

Sol. $\left(\frac{dT}{dt}\right) = k(T - T_0)$

$\left(\frac{40-24}{4\,min}\right) = k\left(\frac{24+40}{2} - 16\right)$ ...(i)

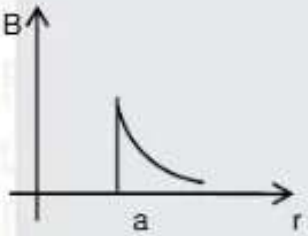
$\left(\frac{24-T}{4\,min}\right) = k\left(\frac{T+24}{2} - 16\right)$ ...(ii)

Solving the equations we get

$T = \frac{56}{3} = 18.7°C$

19. An infinitely long wire has current 'i' and its radius is 'a'. Choose the correct graph for 'B' v/s 'r' where 'r' is distance from centre of wire

(1)



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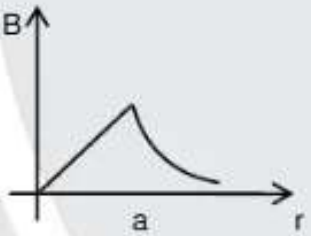

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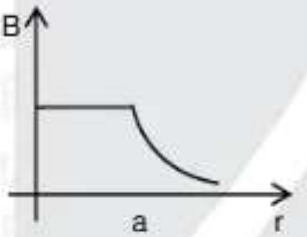

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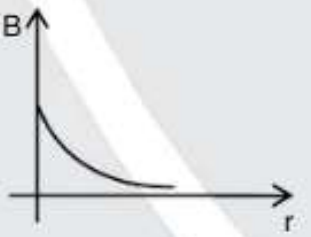


Ans. **(2)**

20. The position vector of a particle varies with time as $\vec{r} = \left(5t^2\hat{i} - 5t\hat{j}\right)$ m. The magnitude and direction of velocity at t = 2 will be ;

(1) $5\sqrt{15}$

(2) $5\sqrt{17}$ m/sec. at an angle of $\tan^{-1}(4)$ with –y axis

(3) $5\sqrt{17}$ m/sec. at an angle of $\tan^{-1}(4)$ with x axis

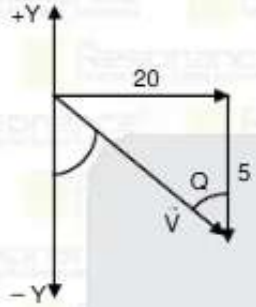
(4) $5\sqrt{17}$ m/sec. at an angle of $\tan^{-1}(4)$ with – x axis

Ans. **(2)**

Sol. $\vec{v} = \frac{d\vec{r}}{dt} = 10t\hat{i} - 5\hat{j}$

$\vec{v}_{t=2} = 20\hat{i} - 5\hat{j} \Rightarrow |V| = \sqrt{(20)^2 + (5)^2} = \sqrt{425}$

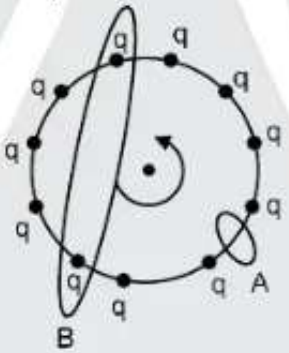
$= 5\sqrt{17}$ m/sec



$\tan\theta = \frac{20}{5} = 4$

$\theta = \tan^{-1}(4)$ with – y axis

21. Find the difference of the current ($I_A - I_B$). If n charge particles move in a circular path with ω angular velocity and there are two ampere's loop are given



where I_A is net current passing through the amperian loop A and I_B is the net current passing through loop B.

(1) $\frac{nqw}{2\pi}$ (2) $\frac{nqw}{\pi}$ (3) $\frac{2\pi w}{nq}$ (4) $\frac{2\pi}{nqw}$

Ans. **(1)**

Sol. In loop B incoming and outgoing current is equal & opposite so $I_B = 0$

$T = \frac{2\pi}{\omega}$

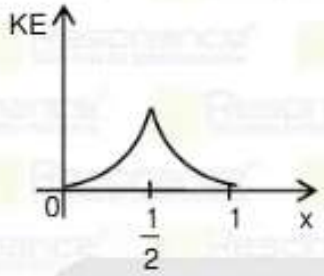
$I_A = \frac{nq}{T}$

$I_A = \frac{nq\omega}{2\pi}$

$I_A - I_B = \frac{nq\omega}{2\pi}$

22. $x(t) = x_0 \sin^2\left(\frac{t}{2}\right)$ (where $x_0 = 1$) find graph of Kinetic energy v/s x

(1)



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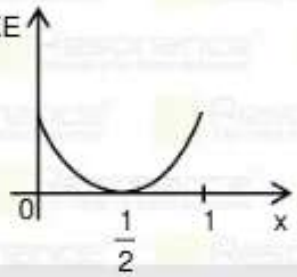

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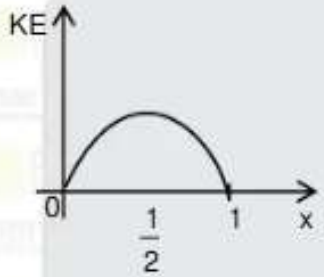

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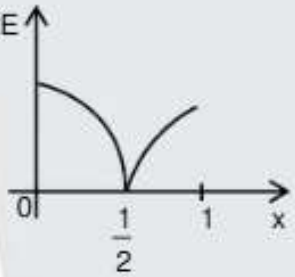


Ans. **(3)**

23. For the graph of stopping potential V_0 v/s frequency which statement is correct .

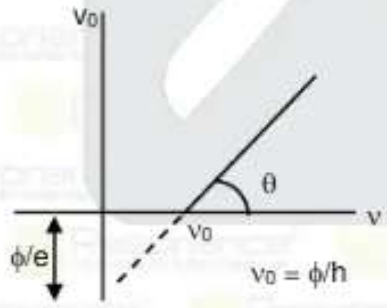
(1) graph is linear
(2) slope is d/h
(3) h is related to slope
(4) to find D, we don't require h.

Ans. **(1)**

Sol. $eV_0 = h\nu - h\nu_0$

$$v_0 = \frac{h\nu}{e} - \frac{h\nu_0}{e}$$

$$v_0 = \frac{h\nu}{e} - \frac{d}{e}$$



$$\tan\theta = \frac{h}{e} = \text{slope}$$

24. A electron is moving in a circular path inside a solenoid with a time period of 75 ns. The current through the solenoid is 1amp. Determine the number of turns per unit length of solenoid.

(1) 3.8×10^3 (2) 38×10^3 (3) 4.3×10^3 (4) 43×10^3

Ans. **(1)**

Sol. We know that

$$B = \frac{2\pi m}{qT} = \frac{2\times 3.14\times 9.1\times 10^{-31}}{1.6\times 10^{-16}\times 75\times 10^{-9}}$$

$$B = 4.78\times 10^{-3}\ T$$

$$\text{So, } n = \frac{B}{\mu_0 I} = \frac{B}{\mu_0 I}\ \frac{4.78\times 10^{-3}}{4\pi\times 10^{-2}\times 1}$$

$$n = 3.8\times 10^{3}$$

25. A material has a bulk modulus of 25×10^{11} N/m^2. If it undergoes a volumetric strain of 0.2%, what is the excess pressure applied ?

(1) 5×10^{8} N/m^2 (2) 5×10^{9} N/m^2 (3) 5×10^{10} N/m^2 (4) 5×10^{11} N/m^2

Ans. **(2)**

Sol. The bulk modulus K of a material is defined by the formula :

$$K = \frac{\text{ExcessPressure(P)}}{\text{VolumetricStrain}(\Delta V/V)}$$

Given data :

Bulk modulus, $K = 25 \times 10^{11}$ N/m^2

Volumetric strain, $\frac{\Delta V}{V} = 0.002$

Rearranging the formula to solve for excess pressure :

$$P = K\times\left(\frac{\Delta V}{V}\right)$$

Thus, the excess pressure is :

5×10^{9} N/m^2