CLASS XI

1. **(b)** Magnetic moment = Current × Area

2. **(c)** As C is added to t, therefore, C has the dimensions of T.

As $\frac{b}{t} = V$,

$b = V \times t = LT^{-1} \times T = (L)$

From $V = at$, $a = \frac{v}{t} = \frac{LT^{-1}}{T} = \left[LT^{-2}\right]$

3. **(b)** $P = \frac{a^3b^2}{cd} \Rightarrow \frac{\Delta P}{P} = \pm\left(3\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + \frac{\Delta c}{c} + \frac{\Delta d}{d}\right)$

$= \pm(3\times1 + 2\times2 + 3 + 4) \Rightarrow \pm14\%$

4. **(a)** Length, time and velocity can be deduced from one another. Therefore, they cannot enter into the list of fundamental quantities in any system.

5. **(c)** $P = \frac{F}{A} = \frac{MLT^{-2}}{L^2} = \left[ML^{-1}T^{-2}\right] = \frac{M}{LT^2}$

6. **(c)** $[X] = [F] \times [\rho]^{1/2}$

$= [MLT^{-2}] \times \left[\frac{M}{L^3}\right]^{1/2} = \left[M^{3/2}L^{-1/2}T^{-2}\right]$

7. **(a)** $W = \frac{1}{2}Kx^2 \Rightarrow [K] = \frac{[w]}{[x^2]} = \frac{[ML^2T^{-2}]}{[L^2]} = [MT^{-2}]$

8. **(d)** $V = at + bt^2$

$[V] = [bt^2]$

$LT^{-1} = bT^2 \quad \Rightarrow [b] = [LT^{-3}]$

9. **(c)** $F = M^1 L^1 T^{-2}$

$\therefore T^2 = \frac{M^1 L^1}{F}$

$T = M^{1/2} L^{1/2} F^{-1/2}$

10. **(c)** Let $G = C^x g^y P^z$

$[M^{-1}L^3T^{-2}] = [LT^{-1}]^x [LT^{-2}]^y [ML^{-1}T^{-2}]^z$

$= M^z L^{x+y-z} T^{-x-2y-2z}$

Applying principle of homogeneity of dimensions, we get

$z = -1$, $x + y - z = 3$

$-x - 2y - 2z = -2$

On solving, we get,

$y = 2$, $x = 0$

$\therefore G = C^0 g^2 P^{-1}$

11. **(d)** $L = [c]^a [G]^b \left[\frac{e^2}{4\pi\varepsilon_0}\right]^c$

$= [LT^{-1}]^a [M^{-1} L^3 T^{-2}]^b [ML^3 T^{-2}]^c$

$= L^{a+3b+3c} T^{-a-2b-2c} M^{-b-c}$

$a + 3b + 3c = 1$; $-a - 2b - 2c = 0$; $-b + c = 0$

$b = \frac{1}{2} \qquad c = \frac{1}{2} \qquad \downarrow$

$a = -2$

$L = c^{-2}G^{1/2}\left[\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

$L = \frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

12. **(b)** Relative density $= \frac{\text{Weight in air}}{\text{Loss of weight in water}}$

$P = \frac{5.00}{1.00} = 5.00$

$\frac{dP}{P} = \frac{0.05}{5.00} + \frac{0.1}{1.00} = 0.11 = 11\%$

$P = 5.00 \pm 11\%$

13. **(c)** Volume of sphere $= \frac{4}{3}\pi r^3$

$\Delta r = 2\% \Rightarrow \frac{\Delta v}{V} = \frac{3\Delta r}{r}$

$\Rightarrow \frac{\Delta v}{V} = 3 \times 2 = 6\%$

Error in determination of volume of sphere is equal to 6%.

14. **(c)** One main scale division, 1 M.S.D = x cm

One vernier scale division, 1 V.S.D = $\frac{(n-1)x}{n}$

Least count = 1 M.S.D – 1 V.S.D

$= \frac{nx - nx + x}{n} = \frac{x}{n}\text{cm}$

15. **(b)** If, $x = a^n$

then; $\frac{\Delta x}{x} = \pm n\left(\frac{\Delta a}{a}\right)$

16. **(b)** Here, maximum fraction error is:

$\frac{\Delta Q}{Q} = \pm\left(n\frac{\Delta x}{x} + \frac{m\Delta y}{y}\right)$

$\therefore$ Absolute error in Q, i.e.,

$\Delta Q = \pm\left(n\frac{\Delta x}{x} + \frac{m\Delta y}{y}\right)Q$

17. **(b)** Impulse = Force × Time

Therefore dimensional formula of impulse = Dimensional formula of force × Dimensional formula of time = $[MLT^{-2}]$ $[T]$ $\Rightarrow$ $[MLT^{-1}]$ and dimensional formula of linear momentum $[p] = MLT^{-1}$.

18. **(a)** L/R is known as the time constant of the LR series circuit, as its dimension is [T]

19. **(c)** Induced $emf\,|\varepsilon| = L\frac{dI}{dt}$

where L is the self inductance and $\frac{dI}{dt}$ is the rate of change of current.

$\therefore$ Dimensional formula of $L = \frac{|\varepsilon|}{\frac{dI}{dt}}$

$$= \frac{w}{q} \cdot \frac{dt}{di} = \frac{[ML^2T^{-2}][T]}{[AT][A]} = [ML^2T^{-2}A^{-2}]$$

20. (a) Capacitance $C = \frac{\text{Charge}}{\text{Potential difference}}$

$$[C] = \frac{[q]}{[V]}$$

Resistance $R = \frac{\text{Potential difference}}{\text{Current}}$

$$[R] = \frac{[V]}{[I]}$$

[CR] = [C][R]

$$= \frac{[q]}{[I]} = \frac{AT}{A} = T$$

Ch - 2 Motion in a Straight Line

1. (a) $\sqrt{x} = 3t + 5$

Squaring both side

$$\left(\sqrt{x}\right)^2 = (3t+5)^2$$

$$x = 9t^2 + 25 + 30t$$

Differentiate both side

$$\frac{dx}{dt} = \frac{d\left(9t^2 + 30t + 25\right)}{dt}$$

$V = 18t + 30$

Velocity will increase with time.

2. (b) Distance covered in nth second is given by

$$s_n = u + \frac{a}{2}(2n-1)$$

Given : u = 0, a = g

$$\therefore \quad s_4 = \frac{g}{2}(2\times 4 - 1) = \frac{7g}{2}$$

$$s_5 = \frac{g}{2}(2\times 5 - 1) = \frac{9g}{2}$$

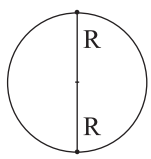
$$\therefore \quad \frac{s_4}{s_5} = \frac{7}{9}$$

3. (b) Displacement is zero

4. (a) Displacement = 2R

Time = 20 sec.

$$\text{Average velocity} = \frac{2R}{20} = \frac{2\times 80}{20} = 8\,\text{m/s}$$



5. (d) $x = a + bt^2$

Differentiating both side

$$\frac{dx}{dt} = \frac{d\left(a + bt^2\right)}{dt} \Rightarrow V = 0 + 2bt$$

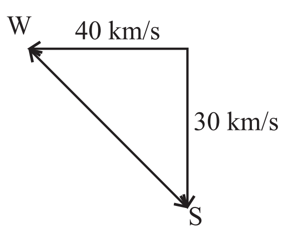
$V = 0 + 2 \times 15 \times 3$

$V = 90\ \text{cms}^{-1}$

6. (b) $V_{avg} = \dfrac{2xy}{x+y}$

$$48 = \frac{2\times 40\times V}{40 + V} \quad \Rightarrow \quad V = 60\ \text{km/h}$$

7. (a)



$$\Delta v = -40\hat{i} + 30\hat{j}$$

$|\Delta v|$ Magnitude of change in velocity $= \sqrt{(30)^2 + (40)^2}$

$$= \sqrt{900 + 1600}$$

$$|\Delta v| = \sqrt{2500} = 50\,\text{km/s}$$

$$|a| = \frac{50}{10}\,\text{km/s}^2$$

$$= 5\ \text{km/s}^2$$

8. (b) $u = -19.6\ \text{ms}^{-1}$ $\quad a = 9.8\ \text{ms}^{-2}$ $\quad t = 6\text{s}$

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

$$S = -19.6\times 6 + \frac{1}{2}\times 9.8 \times 6^2$$

$$= -19.6\times 6 + 4.9\times 36$$

$S = 58.8$ m

9. (b) Velocity when ball strikes the ground $V = \sqrt{2gh_1}$

$$V = \sqrt{2\times 10\times 10} = \sqrt{200}$$

Velocity of ball after rebound $V = \sqrt{2gh_2}$

$$V = \sqrt{2\times 10\times 2.5} = \sqrt{50}$$

Change in velocity / time

$$= \frac{\sqrt{50} - \left(-\sqrt{200}\right)}{0.01} = \frac{7.07 + 14.114}{0.01} = 2121.2\,\text{m/s}^2$$

10. (b) $x = \dfrac{1}{t+5} \Rightarrow v = \dfrac{dx}{dt} = -\dfrac{1}{(t+5)^2}$

Acceleration,

$$a = \frac{dv}{dt} = \frac{2}{(t+5)^3} \Rightarrow a \propto (\text{velocity})^{3/2}$$

11. (c) Velocity of descent or ascent always equal.

$$V = \sqrt{2\times g\times h} = \sqrt{2\times 10\times 40} = \sqrt{800} = 20\sqrt{2}\ \text{m/s}$$

Time of ascent and descent always equal.

T = time of ascent + time of descent

$T = t_1 + t_2$

Let t_1 is the time of ascent and t_2 be that of descent

$v = u - gt$

$0 = u - gt_1$	$v = u + gt_2$
$u = gt_1$	$u = 0 + gt_2$
$t_1 = \dfrac{u}{g}$	$\dfrac{u}{g} = t_2$

$T = t_1 + t_2$

$$T = \frac{u}{g} + \frac{u}{g} = \frac{2u}{g} = \frac{2\times\sqrt{800}}{10}$$

$T = 4\times\sqrt{2}$ sec

$T = 4 \times 1.41 = 5.64$ seconds

12. (b) In one dimensional motion, the body can have only one value of velocity at a time.

13. **(c)** $v^2 = u^2 - 2gs \Rightarrow 0 = u^2 - 2gs$

$u^2 = 2gs \Rightarrow u^2 \propto S$

Motion under gravity is independent of mass

$$\frac{u^2}{16u^2} = \frac{50}{h}$$

$h = 16 \times 50$

$h = 800$ m

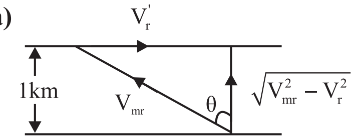
14. **(d)** $v = (150 - 10x)^{1/2} \Rightarrow \frac{dv}{dt} = \frac{d(150-10x)^{1/2}}{dt} \times \frac{dx}{dx}$

$$\frac{dv}{dt} = \frac{d(150-10x)^{1/2}}{dx} \times \frac{dx}{dt} \Rightarrow a = \frac{d(150-10x)^{1/2}}{dx} v$$

$$a = \frac{1}{2} \times (150-10x)^{-1/2} (-10) \times (150-10x)^{1/2}$$

$a = -5$ m/s^2

15. **(a)**



$V_{mr} = 5$ km/hr $t = 15$ min

$$t = \frac{d}{\sqrt{V_{mr}^2 - V_r^2}} \Rightarrow \frac{15}{60} = \frac{1}{\sqrt{25 - V_r^2}}$$

$$\Rightarrow 4 = \sqrt{25 - V_r^2} \Rightarrow V_r^2 = 25 - 16 \Rightarrow V_r^2 = 9$$

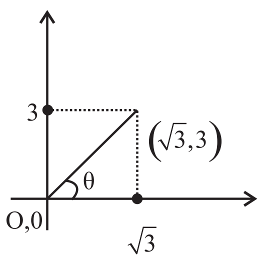
$\Rightarrow V_r = 3$ km/hr

16. **(a)** Velocity = area under acceleration time graph

Velocity = (5 × 1) – (5 × 1) + (5 × 1)

Velocity = 5 – 5 + 5 = 5 m/s^2

17. **(b)**



Let the particle moving in a straight line makes an angle θ with x-axis.

$$\text{slope} = \tan\theta = \frac{y}{x} = \frac{3}{\sqrt{3}}$$

$$\text{Since}, \tan\theta = \sqrt{3},\ \theta = 60°$$

18. **(c)** In this question, we have to find net velocity with respect to the earth that will be equal to velocity of the girl plus velocity of escalator.

Let displacement is L, then

Velocity of girl, $v_g = \frac{L}{t_1}$

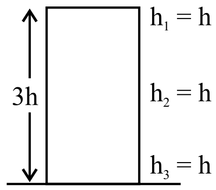
Velocity of escalator, $v_e = \frac{L}{t_2}$

Net velocity of the girl $= v_g + v_e = \frac{L}{t_1} + \frac{L}{t_2}$

If t is total time taken in covering distance L, then

$$\frac{L}{t} = \frac{L}{t_1} = \frac{L}{t_2} \quad \Rightarrow \quad t = \frac{t_1 t_2}{t_1 + t_2}$$

19. **(d)** t_1 – Cover h_1 distance



t_2 – Cover h_2 distance

t_3 – Cover h_3 distance

Now for S = 2h g = g u = O ...(i)

$$t_1 = \sqrt{\frac{2h}{g}}$$

$$\therefore 2h = \frac{1}{2} g (t'_2)^2$$

$$t'_2 = 2\sqrt{\frac{h}{g}}$$

$$\therefore\ t_2 = t_2 - t_1$$

$$= 2\sqrt{\frac{h}{g}} - \sqrt{\frac{2h}{g}} = \sqrt{\frac{2h}{g}} \left(\sqrt{2} - 1\right)$$

$$t_2 = \sqrt{\frac{2h}{g}} \left(\sqrt{2} - 1\right) \quad .....(ii)$$

For S = 3h, u = 0 g = g

$$t_3' = \sqrt{\frac{6h}{g}},\ t_3 = t_3' - t_2 - t_1$$

$$= \sqrt{\frac{2h}{g}} \left(\sqrt{3} - \sqrt{2} + 1 - 1\right)$$

$$t_3 = \sqrt{\frac{2h}{g}} \left(\sqrt{3} - \sqrt{2}\right)$$

$$t_1 : t_2 : t_3 = 1 : \left(\sqrt{2} - 1\right) : \left(\sqrt{3} - \sqrt{2}\right)$$

20. **(b)** $X_p(t) = at + bt^2$ $X_Q(t) = ft - t^2$

$V_p = a + 2bt$ $V_Q = f - 2t$

as $V_p = V_Q$

$a + 2bt = f - 2t$

$$\Rightarrow t = \frac{f - a}{2(1 + b)}$$

Ch - 3 Motion in a Plane

1. **(*)** Resultant of vectors $\vec{A}$ and $\vec{B}$

So, $\vec{R} = \vec{A} + \vec{B}$

$\vec{R} = 4\hat{i} + 3\hat{j} + 6\hat{k} - \hat{i} + 8\hat{j} - 8\hat{k}$

$\vec{R} = 3\hat{i} + 11\hat{j} - 2\hat{k}$

$$\hat{R} = \frac{3\hat{i} + 11\hat{j} - 2\hat{k}}{\sqrt{(3)^2 + (11)^2 + (-2)^2}}$$

$$\vec{R} = \frac{3\hat{i} + 11\hat{j} - 2\hat{k}}{\sqrt{9 + 121 + 4}} = \frac{3\hat{i} + 11\hat{j} - 2\hat{k}}{\sqrt{134}}$$

None of them are correct.

2. **(a)** Angle $(45° - \theta)$, Range = R1

$(45° + \theta)$, Range = R_2

$$\frac{R_1}{R_2} = \frac{\left[\dfrac{u^2 \sin 2(45^0 - \theta)}{g}\right]}{\left[\dfrac{u^2 \sin 2(45^0 + \theta)}{g}\right]} = \frac{u^2 \sin(90 - 2\theta)}{u^2 \sin(90 + 2\theta)}$$

$$= \frac{\cos 2\theta}{\cos 2\theta} = 1$$

$\therefore R_1 = R_2$

Hence, for complementary angles, ranges will be same.

3. **(c)** According to the question

$$\left|\vec{A} + \vec{B}\right| = n\left|\vec{A} - \vec{B}\right|$$

$$\left|\vec{A} + \vec{B}\right| = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

$$\left|\vec{A} - \vec{B}\right| = \sqrt{A^2B^2 - 2AB\cos\theta}$$

$$\left|\vec{A}\right| = \left|\vec{B}\right|$$

Squaring both side

$A^2 + B^2 + 2AB\cos\theta = n^2 (A^2 + B^2 - 2AB\cos\theta)$

$A^2 + B^2 + 2AB\cos\theta = n^2A^2 + n^2B^2 - n^2 \times 2AB\cos\theta$

$2A^2 + 2A^2\cos\theta = 2n^2A^2 - 2n^2A^2\cos\theta$

$2A^2 (1 + \cos\theta) = 2n^2A^2 (1 - \cos\theta)$

$1 + \cos\theta = n^2 - n^2\cos\theta$

$1 + \cos\theta + n^2\cos\theta = n^2$

$$\cos\theta = \frac{n^2 - 1}{n^2 + 1}$$

$$\theta = \cos^{-1}\left(\frac{n^2 - 1}{n^2 + 1}\right)$$

4. **(c)** For perpendicular condition, $\vec{A}.\vec{B} = 0$

$\vec{A}.\vec{B} = (\hat{i}A\cos\theta + \hat{j}A\sin\theta)(\hat{i}B\sin\theta - \hat{j}B\cos\theta)$

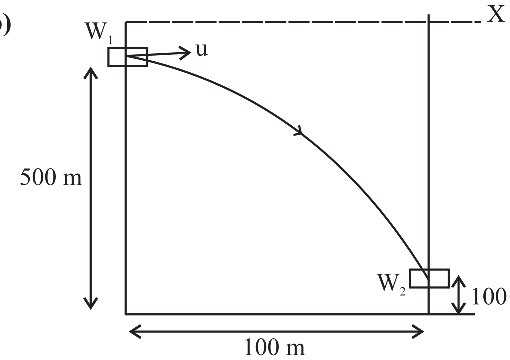
$= A\cos\theta\, B\sin\theta - A\sin\theta\, B\cos\theta$

$= AB\sin\theta\cos\theta - AB\sin\theta\cos\theta$

$= 0$

$\vec{A}.\vec{B} = 0$ (condition satisfied)

5. **(b)**



Height of W_1 = 500 m

Height of W_2 = 100

Net vertical height which attains by ball = 500 – 100 = 400 m

Time taken by the ball to enter W_2 is

$$S = ut + \frac{1}{2}gt^2 \Rightarrow 400 = 0 + \frac{1}{2} \times 10t^2$$

$$\frac{400}{5} = t^2 \Rightarrow t = \sqrt{80} = 8.9\,\text{sec}.$$

Motion of the ball from W_1 to W_2

$$S = u_x t + \frac{1}{2}a_x t^2$$

$$100 = u \times 8.9 + \frac{1}{2} \times (0) \times (8.9)^2$$

u = 11.2 m/s

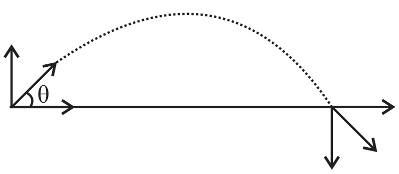
Short trick: Horizontal Range = 100 m

Vertical height = 500 – 100 = 400 m

$$R = u\sqrt{\frac{2h}{g}} \Rightarrow u = R\sqrt{\frac{g}{2h}}$$

$$u = 100 \times \sqrt{\frac{10}{2 \times 400}} = \frac{100}{8.9} = 11.2\,\text{m/s}$$

6. **(a)**



The horizontal momentum does not change. The change in vertical momentum is

$$mv\sin\theta - (-mv\sin\theta) = 2mv\frac{1}{\sqrt{2}} = \sqrt{2}mv$$

7. **(a)** Maximum range $= \dfrac{u^2}{g}$

$10 \times 15000 = u^2$

$150000 = u^2$

$100\sqrt{15} = 387.2\,\text{m/s}$

8. (b) According to the relations $R = \dfrac{u^2 \sin 2\theta}{g}$, $H = \dfrac{u^2 \sin^2 \theta}{2g}$

$$H_{max} = \frac{u^2 \sin^2 30^0}{2g} = \frac{u^2}{8g}$$

$$R = \frac{u^2 \sin 60°}{g} = \frac{u^2\sqrt{3}}{2g}$$

$$\therefore \frac{H}{R} = \frac{u^2}{8g} \times \frac{2g}{u^2\sqrt{3}} \Rightarrow R = 4\sqrt{3}H$$

9. (b) $x = a \sin\omega t, \quad y = a \cos\omega t$

Square and adding both sides

$x^2 + y^2 = a^2 \sin^2\omega t + a^2\cos^2\omega t = a^2$

$\Rightarrow x^2 + y^2 = a^2 \Rightarrow$ circle

10. (a) For projectile A,

Max. Height $H_A = \dfrac{u_A{}^2 \sin^2 60°}{2g}$

For projectile B

$$H_B = \frac{u_B{}^2 \sin^2 \theta}{2g}$$

According to question

$$\frac{u_A{}^2 \sin^2 60°}{2g} = \frac{u_B{}^2 \sin^2 \theta}{2g}$$

$$\frac{u_A{}^2}{u_B{}^2} = \frac{\sin^2\theta}{\sin^2 60°} \Rightarrow \left(\frac{1}{\sqrt{2}}\right)^2 = \frac{\sin^2\theta}{\left(\frac{\sqrt{3}}{2}\right)^2}$$

$$\Rightarrow \frac{3}{4} \times \frac{1}{2} = \sin^2\theta$$

$$\Rightarrow \sin\theta = \frac{\sqrt{3}}{2\sqrt{2}}$$

$$\theta = \sin^{-1}\left(\frac{\sqrt{3}}{2\sqrt{2}}\right)$$

11. (c) Let width of the river be d speed of stream be v and the speed of the boat relative to water be u and the angle with the verticle at which the boat must move for minimum drifting is θ.

Time taken to cross the river $= \dfrac{d}{u\cos\theta}$

Drift of the boat is $(v - u\sin\theta)\,(d/u\cos\theta)$

Differentiating this w.r.t time and equating to zero we get the angle θ for minimum drifting as $\sin^{-1}\left(\dfrac{u}{v}\right)$

Angle with the direction of the stream is

$$90° + \sin^{-1}\left(\frac{u}{v}\right)$$

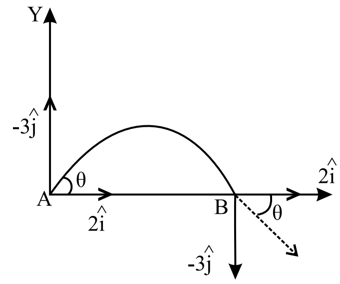
Here $u = \dfrac{v}{n}$

$$\therefore \text{ Angle} = \frac{\pi}{2} + \sin^{-1}\left(\frac{1}{n}\right)$$

12. (a) Since relative acceleration is zero, therefore relative velocity will be constant.

13. (d) In a projectile vertical component of velocity keeps on changing with time.

While horizontal velocity component remains constant



$\therefore$ Velocity is $2\hat{i} - 3\hat{j}$

14. (c) As we know that, $v = r\omega$

$$\therefore \omega = \frac{v}{r}$$

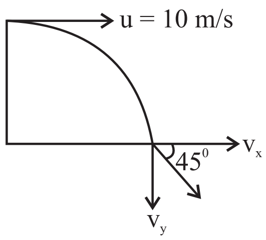
15. (c) Tangential acceleration $= a_t = a$

radial acceleration $= a_r = \dfrac{v^2}{R}$

net acceleration $= \sqrt{a_t^2 + a_r^2} = \sqrt{a^2 + \left(\dfrac{v^2}{R}\right)^2}$

16. (d) $\tan 45^o = \dfrac{V_y}{V_x}$

$$1 = \frac{V_y}{V_x}$$



17. (a) Range of projectile is given by,

$$R = \frac{2u^2 \sin\theta\cos\theta}{g} \quad ...(i)$$

$$\text{Height } H = \frac{u^2 \sin^2\theta}{2g} \quad ...(ii)$$

$$\text{And,} \quad H_1 = \frac{u^2 \sin^2(90° - \theta)}{2g} \quad ...(iii)$$

$$= \frac{u^2\cos^2\theta}{2g}$$

$$\text{Then, } HH_1 = \frac{u^2\sin^2\theta u^2\cos^2\theta}{2g \times 2g} \quad ...(iv)$$

From Eq. (i), we get

$$R^2 = \frac{4u^2\sin^2\theta u^2\cos^2\theta \times 4}{2g \times 2g}$$

$R = \sqrt{16HH_1}$ [from Eq. (iv)]

$$= 4\sqrt{HH_1}$$

18. (c) $\vec{r} = \cos\omega t\hat{x} + \sin\omega t\hat{y}$

$$\hat{v} = -\omega\sin\omega t\hat{x} + \omega\cos\omega t\hat{y}$$

$$\vec{a} = -\omega^2\cos\omega t\hat{x} + \omega^2(-\sin\omega t)\hat{y}$$

$$= -\omega^2\vec{r}$$

$$\vec{r}.\vec{v} = 0 \quad \text{hence } \vec{r} \perp \vec{v}$$

19. (d) $\vec{v}_{av} = \dfrac{\Delta\vec{r}}{\Delta t} = \dfrac{(13-2)\hat{i} + (14-3)\hat{j}}{5-0} = \dfrac{11}{5}(\hat{i}+\hat{j})$

20. (a) $K.E = \dfrac{1}{2}mv^2 = \dfrac{1}{2}m \times (2\pi\nu R)^2$

$$= \frac{1}{2}m \times 4 \times \pi^2 \times \nu^2 \times R^2$$

$K.E = m \times 2 \times \pi^2 \times \nu^2 \times R^2 \qquad (3.14)^2 = 9.85 \approx 10$

$$= 4 \times 2 \times 10 \times \frac{120}{60} \times \frac{120}{60} \times 4 \times 4$$

$K.E = 4 \times 2 \times 10 \times 2 \times 2 \times 16 = 5120$ J

1. **(d)** Particle will move with uniform velocity due to inertia.

2. **(c)** Newtons first law of motion also known as the law of inertia.

3. **(c)** Magnitude of force $\left(6\hat{i}-8\hat{j}+10\hat{k}\right)$N

$$=\sqrt{(6)^2+(8)^2+(10)^2}=10\sqrt{2}\,\text{N}$$

Acceleration = 1 ms^{-2}. So, mass $=10\sqrt{2}$ kg

4. **(c)** According to the third law of motion.

5. **(c)** $T=\dfrac{F(L-x)}{L}\Rightarrow T=\dfrac{5(20-5)}{20}=\dfrac{75}{20}=3.75\text{N}$

6. **(b)** Linear momentum will remain conserved

$$m_g v_g = m_b\, v_b$$

$$v_g=\frac{m_b v_b}{m_g}=\frac{20\times10^{-3}\times100}{2}=1\,\text{m/s}$$

7. **(d)** $\text{Impulse}=\dfrac{\text{momentum}}{\text{time}}=\dfrac{150\times10^{-3}\times20}{0.1}=30\text{N}$

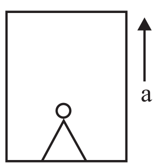
8. **(b)** Tension is given by

$$T=\frac{2m_1m_3}{m_1+m_2+m_3}\times g=\frac{2\times6\times6\times10}{6+6+6}=\frac{720}{18}=40$$

9. **(c)** Here, Mass of a person, m = 60 kg

Mass of lift, M = 940 kg, a = 1 m/s^2, g = 10 m/s^2

Let T be the tension in the supporting cable.



$\therefore$ T – (M + m)g = (M + m)a

T = (M + m)(a + g)

= (940 + 60)(1 + 10) = 11000 N

10. **(a)** Acceleration of the system

$$a=\frac{(m_2-m_1)}{(m_1+m_2)}g=\left(\frac{7-5}{7+5}\right)\times9.8=\frac{2}{12}\times9.8$$

$$=\frac{19.6}{2}=1.63\ \text{m/s}^2$$

11. **(c)** Equations of motions are

for 2 kg block, $F-T_1=2a$ ....(i)

for 3 kg block, $T_1-T_2=3a$ ...... (ii)

For 5 kg block

$T_2=5a$ (iii)

putting the value of T_2 in eq (ii)

$\therefore$ $T_1-5a=3a \Rightarrow T_1=8a$ [Putting in eq (i)]

$F-8a=2a \Rightarrow$

F = 10 N (a = 1 m/s^2)

12. **(d)** Take 6 kg and 10 kg blocks as a single block of mass 16 kg

$\therefore$ F = ma

15 = 19 a

$$a=\frac{15}{19}\,\text{m/s}^2$$

T_1 = 16 a

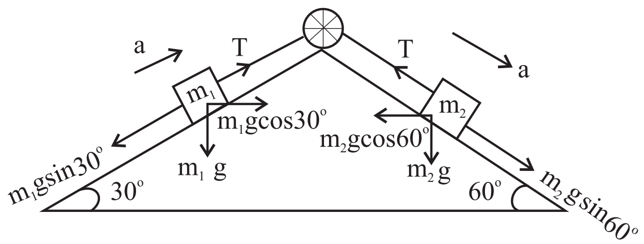
$$\Rightarrow T_1=16\times\frac{15}{19}=12.63\ \text{N}$$

13. **(a)** $m_2 g\sin60°-T=m_2a$ --- (i)

$T-m_1\,g\sin30°=m_1a$ ---- (ii)

Adding both equations.

$$\frac{m_2g\sin60^\circ-m_1g\sin30^\circ}{(m_1+m_2)}=a$$



$$\frac{(m_2\sin60^\circ-m_1\sin30^\circ)}{(m_1+m_2)}=\frac{9.8\left(5\times\frac{\sqrt3}{2}-3\times\frac12\right)}{8}$$

$$a=\frac{9.8(2.5\times1.71-1.5)}{8}$$

a = 3.39 m/s^2

14. **(a)** Initial velocity of a ball = v

When ball strikes the wall normally it referees back, then final velocity = – v

Change in velocity ΔV = v – (– v) = 2v

Force exerted by the ball on the wall is given by Newton's second law,

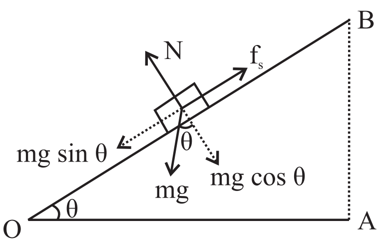
i.e., $F=ma=\dfrac{m\Delta v}{\Delta t}=\dfrac{(m2v)}{t}=\dfrac{2mv}{t}$

15. **(d)** fs = μsR = μs mg = 0.4 × 2 × 9.8 = 7.8N

= 7.8 N

Applying force smaller than the friction force, then the block will not move, because static friction is self adjusting so, it will be equal to 2.5 N

16. **(b)**



The forces acting on a block of mass m at rest on an inclined plane are (i) the weight mg acting vertically downwards (ii) the normal force N of the plane on the block, and (iii) the static frictional force f_s opposing the impending motion. In equilibrium, the resultant of these forces must be zero. Resolving the weight mg along the two directions shown.

We have $mg\sin\theta = f_s, \quad mg\cos\theta = N \Rightarrow \tan\theta = \frac{f_s}{N}$

As θ increases, the self-adjusting frictional force f_s increases until at $\theta = \theta_{max}$, f_s achieves its maximum value, $(f_s)_{max} = \mu_s N \Rightarrow (f_s)_{max} / N = \mu_s$.

Therefore, $\tan\theta_{max} = \mu_s$ or $\theta_{max} = \tan^{-1}\mu_s$

When θ becomes just a little more than θ_{max}, there is a small net force on the block and it begins to slide. Note that θ_{max} depends only on μ_s and is independent of the mass of the block.

For $\theta_{max} = 15^o \Rightarrow \mu_s = \tan 15^o = 0.27$

17. **(a)** Centripetal force $= \frac{mv^2}{r}$

$$\therefore \frac{F_1}{F_2} = \frac{3r_1}{r_1} \Rightarrow F_2 = \frac{F}{3}$$

18. **(c)** Let θ, be the angle made by the rod with the track, i.e. angle of taking

$$\tan\theta = \frac{mv^2/r}{mg} \Rightarrow \tan\theta = \frac{v^2}{rg}$$

$$\Rightarrow \qquad \tan\theta = \frac{(10)^2}{10\times10} = 1$$

$$\therefore \qquad \theta = 45°$$

19. **(c)** Change in momentum,

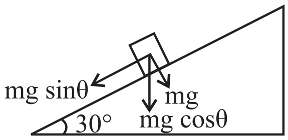
$$\int\Delta p = \int F dt = \text{Area of } F - t \text{ graph}$$

$$= \frac{1}{2}\times2\times6 - 3\times2 + 4\times3 = 12 \text{ Ns}$$

20. **(a)** $v = \sqrt{\mu rg} = \sqrt{1.5\times180\times9.8} = \sqrt{2646} = 51.4 m/s$

Ch - 5 Work, Energy and Power

1. (c)



$w = mg\sin\theta \times s$ = mg sin 30° × s

$$w = 200\times10\times\frac{1}{2}\times10$$

$$w = 10^4 J = 10KJ$$

2. (d) Work done in stretching a string to obtain an extension l is

$$W_1 = \frac{1}{2}K\ell^2$$

Similarly, work done in stretching a string to obtain extension ℓ_1 is

$$W_2 = \frac{1}{2}K\ell_1^2$$

∴ Work done in second stretching will be.

$$W = W_2 - W_1$$

$$= \frac{1}{2}K(\ell_1^2 - \ell^2)$$

3. (b) $u = \frac{1}{2}kx^2 \Rightarrow u \propto x^2 \Rightarrow \frac{u_1}{u_2} = \left(\frac{2}{6}\right)^2$

$$\therefore\ u_2 = u_1 \times \frac{36}{4} = 4\times9 = 36\,J$$

4. (d) $\vec{A}.\vec{B} = 0$

$$\cos\omega t\cos\frac{\omega t}{2} + \sin\omega t\sin\frac{\omega t}{2} = 0$$

$$\cos\left(\omega t - \frac{\omega t}{2}\right) = 0 \Rightarrow \cos\frac{\omega t}{2} = 0$$

$$\Rightarrow \frac{\omega t}{2} = \frac{\pi}{2} \Rightarrow t = \frac{\pi}{\omega}$$

5. (b) As we know that $E = \frac{P^2}{2m} \Rightarrow E \propto \frac{1}{m}$

$$\therefore\ \frac{E_1}{E_2} = \frac{m_2}{m_1} = \frac{6m}{3m} = \frac{2}{1}$$

6. (a) $P = \sqrt{2m\,K.E}$

$$\therefore\ \frac{P_1}{P_2} = \sqrt{\frac{2m_1\,K.E_1}{2m_2 K.E_2}} = \sqrt{\frac{2\times3m\times27}{2\times m\times1}} = \sqrt{\frac{81}{1}} = \frac{9}{1}$$

7. (d) $E = \frac{P^2}{2m} = \frac{(Ft)^2}{2m} \qquad \left\{F = \frac{P}{t}\right\}$

$$E = \frac{F^2t^2}{2m}$$

8. (d) F = –0.1 x J/m

According to Work Energy theorem

Work done by all force = $K_f - K_i$

$$\Rightarrow \int F.dx = K_f - K_i$$

$$\Rightarrow \int_{20}^{30} -0.1x\ dx = K_f - \frac{1}{2}\times mu^2$$

$$(-)0.1\left[\frac{x^2}{2}\right]_{20}^{30} = K_f - \frac{1}{2}\times10\times10^2$$

$$\frac{1}{10\times2}\left[x^2\right]_{30}^{20} = K_f - 500$$

Limit inverse to make –ve to positive

$$\frac{1}{20}\times\left[400 - 900\right] = K_f - 500$$

$$-\frac{500}{20} = K_f - 500$$

$$K_f = 500 - 25 = 475\ J$$

9. (b) Work done in stretching the spring initially by 5cm,

$$W_1 = \frac{1}{2}k\times x_1^2$$

$$= \frac{1}{2}\times5\times10^3\times(5\times10^{-2})^2 = 6.25\,J$$

Now, work done in stretching the spring by 10 cm, i.e. 5 cm + 5 cm

$$W_2 = \frac{1}{2}k(x_1 + x_2)^2$$

$$= \frac{1}{2}\times5\times10^3(5\times10^{-2} + 5\times10^{-2})^2 = 25\,J$$

Net work done = $W_2 - W_1$ = 25 – 6.25

= 18.75 J = 18.75 N m

10. (c) At maximum height, kinetic energy converts into potential energy, i.e.

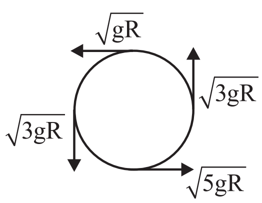
U_{max} = 490 J

suppose at height h', potential energy becomes half.

$$\Rightarrow mgh' = \frac{U_{max}}{2}$$

$$\text{Or } h' = \frac{490}{2\times2\times9.8} = 12.5\text{m}$$

11. (d) Minimum velocity required at different points to complete full vertical circle



12. (b) $P = \frac{w}{t} = \frac{\vec{F}\cdot\vec{S}}{t}$

$= \frac{(3\hat{i}+4\hat{j}+5\hat{k}).(2\hat{i}+3\hat{j}+4\hat{k})}{5} = \frac{6+12+20}{5}$

$P = \frac{38}{5}$ Watt

$P = 7.6$ Watt

13. (c) Output power $= \frac{mgh}{t} = \frac{200\times9.8\times20}{10} = 3920$ watt

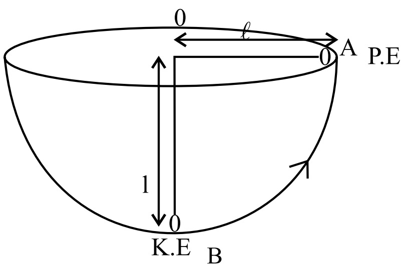
$\therefore \ \eta = \frac{P_o}{P_i} \Rightarrow P_i = \frac{P_o}{\eta} = \frac{3920\times100}{80} = 4900$ watt

14. (d) $P = \frac{mgh}{t} = \frac{(\rho\times V)gh}{t} \Rightarrow \frac{P\times t}{\rho\times gh} = V$

$V = \frac{5\times10^3\times5\times60}{10^{-3}\times10\times50}$

$V = \frac{1500\times10^6}{500} = 3\times10^6 L$

15. (d)



At point A all of the K.E transformed into the potential energy

$\frac{1}{2}mv^2 = mg\ell$

$v = \sqrt{2g\ell}$

16. (b) To climb a height h, the boy utilizes potential energy = mgh

In order to climb, he will use the efficient energy.

Energy of one bread = 21 KJ = 21 × 10³ J

Efficiency of boy = 28%

Hence, energy consumed by boy

$= \frac{28}{100}\times21000 = 5880\text{J}$ .....(i)

From law of conservation of energy, this energy is utilized in giving potential energy mgh, where g is acceleration due to gravity.

$\therefore$ mgh = 40 × 9.8 × h ...(ii)

From equation Eqs. (i) and (ii), we have

$\Rightarrow 40\times9.8\times h = 5880$

$\Rightarrow \quad h = \frac{5880}{40\times9.8} = 15\text{m}$

17. (a) $\Rightarrow f = \frac{P}{V}$

At the time of maximum velocity f = r, i.e.,

$\Rightarrow$ net force onload = 0

$\Rightarrow r = \frac{P}{V_{max}} \Rightarrow V_{max} = \frac{P}{r}$

$F = \frac{P}{v}$

$m.\frac{dv}{dt} = \frac{P}{v}$

$\int_0^{P/2r} v.dv = \left(\frac{P}{m}\int_0^t dt\right)$

$\frac{1}{2}\left(\frac{P}{2r}\right)^2 = \frac{Pt}{m}$

$t = \frac{Pm}{8r^2}$

18. (c) $\frac{dv}{dt} = k^2rt^2$

$\Rightarrow v = \frac{k^2rt^3}{3}$

Centripetal force will not supply the power and power by the tangential force

$= m\frac{dv}{dt}v \ (P = FV)$

$= mk^2rt^2\frac{k^2rt^3}{3} = \frac{mk^4r^2t^5}{3}$

19. (d) $m\frac{dv}{dt} = Kv^{-2}$

$\int m\left(v^2dv\right) = \int Kdt$

$m\left(\frac{v^3}{3}\right) = Kt$

$\frac{1}{2}mv^2 = \frac{3}{2}\frac{Kt}{v}$

20. (d) $P \leftarrow (2M) \quad (3M) \rightarrow P$

$F_{ext} = 0$

$\vec{P}$ = constant

$K.E. = \frac{P^2}{2m} \Rightarrow K.E. \propto \frac{1}{m}$

$\therefore K.E_{2M} = \frac{3E}{5}$

1. (c) x = 0 because there is no x-coordinate and mass also lies in z axis.

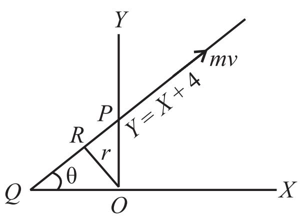
$$z = \frac{m_1 z_1 + m_2 z_2}{m_1 + m_2} = \frac{9\times 5 + 11\times 9}{9+11}$$

$$\frac{45+99}{20} = \frac{144}{20}$$

$z = 7.2$ m

2. (a) $\vec{L} = \vec{r}\times\vec{p}$

Y = X + 4 line has been shown in the figure.



When X = 0, Y = 4, so OP = 4.

The slope of the line can be obtained by comparing with the equation of line
y = mx + c

m = tan θ = 1 $\Rightarrow \theta = 45°$

$\angle OQP = \angle OPQ = 45°$

If we draw a line perpendicular to this line.

Length of the $\perp$ar

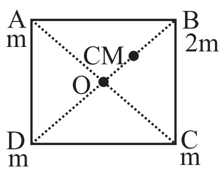
= OR = OP sin 45°

$$= \frac{4}{\sqrt{2}} = 2\sqrt{2}$$

Angular momentum of particle along this line

$$= r\times mv = 2\sqrt{2}\times 5\times 3\sqrt{2} = 60 \text{ units}$$

3. (c)



If all the masses were same, the CM was at O but as the mass at B is 2 m, so the CM of the system will shift towards B. So, CM will be on line OB.

4. (d) Total kinetic energy $= E_{\text{trans}} + E_{\text{rot}} = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$$= \frac{1}{2}mv^2 + \frac{1}{2}\times\left(\frac{2}{5}mr^2\right)\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{5}mv^2 = \frac{7}{10}mv^2$$

$$\therefore \frac{E_{\text{trans}}}{E_{\text{total}}} = \frac{\frac{1}{2}mv^2}{\frac{7}{10}mv^2} = \frac{5}{7}$$

5. (*) As we know that, $\alpha = \frac{2\pi n}{t} = \frac{2\times\pi\times\frac{680}{60}}{9} = \frac{2\pi\times 680}{60\times 9}$

$$\alpha = \frac{1360\pi}{540} = 2.51\pi$$

α = 2.51 π rad/s

None of the given option are correct.

6. (a) As we know that $\tau = \frac{dL}{dt} = \frac{7L-3L}{4} = \frac{4L}{4} = L$

7. (b) Centripetal force, $F = \frac{mv^2}{r}$

$$\therefore F = \frac{m}{r}\times\left(\frac{L}{mr}\right)^2 = \frac{mL^2}{rm^2r^2} = \frac{L^2}{r^3 m} \quad \left(\text{L} = \text{mvr}, \frac{L}{mr} = v\right)$$

8. (a) As we know

$$I = Mk^2 \Rightarrow k = \sqrt{\frac{I}{M}} = \sqrt{\frac{200}{15}} = \sqrt{\frac{40}{3}} = \sqrt{13.33} = 3.65\,\text{m}$$

9. (d) Wire is bent into circular ring, then radius of wire

$$l = 2\pi R \Rightarrow R = \frac{l}{2\pi}$$

∴ Moment of inertia of ring about its own axis

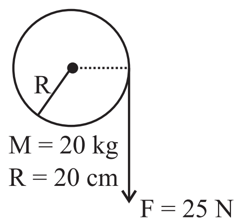
$$\therefore I = MR^2 = M\left(\frac{l}{2\pi}\right)^2 = \frac{Ml^2}{4\pi^2}$$

10. (a) P.E. = total K.E

$$mgh = \frac{7}{10}mv^2, v = \sqrt{\frac{10gh}{7}}$$

11. (c) Paragraph of this question is missing it is as given below:

A cord of negligible mass is wound round the rim of a fly wheel (disc) of mass 20 kg and radius 20 cm. A steady pull of 25 N is applied on the cord as shown in figure. The flywheel is mounted on a horizontal axle with frictionless bearings.



Explanation: Let ω be the final angular velocity.

Since, the wheel starts from rest, Now,

$$\omega^2 = \omega_0^2 + 2\alpha\theta, \omega_0 = 0, \alpha = 12.50\text{s}^{-2}$$

The angular displacement θ = Length of unwound string/ radius of wheel.

$\Rightarrow$ θ = 2 m/0.2 m = 10 rad

ω^2 = 2 × 12.5 × 10.0 = 250 (rad/s)2

$\therefore$ KE gained $= \frac{1}{2} \times 0.4 \times 250 = 50\,J \qquad (\because I = 0.4\,kg\,m^2)$

12. (a) $\vec{v} = \vec{\omega} \times \vec{r} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & -2 & 3 \\ 1 & 1 & 1 \end{vmatrix}$

$\hat{i}(-2-3) - \hat{j}(1-3) + \hat{k}(1+2)$

$= -5\hat{i} + 2\hat{j} + 3\hat{k}$

13. (a) Question is not clear it should be like-

what will be the K.E of the rolling motion, if K is the rotational K.E ofthe system about centre of man and M is the man and V_{CM} is the velocity about COM?

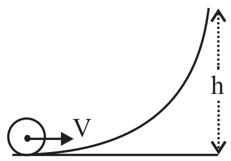
Explanation: The kinetic energy of a rolling body is the sum of kinetic energy of translation $\left(\frac{1}{2}Mv_{cm}^2\right)$ and kinetic energy of rotation $\left(k = \frac{1}{2}I\omega^2\right)$

So, total KE of rolling motion

$= \frac{1}{2}I\omega^2 + \frac{1}{2}M\,v_{CM}^2 \Rightarrow \; = K + \frac{1}{2}Mv_{CM}^2$

14. (b) $\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$

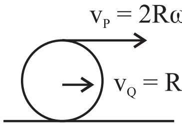
$\frac{1}{2}mv^2 + \frac{1}{2}\frac{MR^2}{2}\frac{v^2}{R^2} = mgh$



$\frac{3}{4}mv^2 = mgh$

$h = \frac{3v^2}{4g}$

15. (b)



For pure rolling $v_Q = R\omega$ $v_P = v_Q + R\omega$

$v_P = 2v_Q$

16. (c) NCERT (XI) Ch - 7, Pg. 164, 165

For circular disc, for circular ring,

$MK_1^2 = \frac{MR^2}{2} \qquad MK_2^2 = MR^2$

$\Rightarrow K_1 = \frac{R}{\sqrt{2}} \qquad \Rightarrow K_2 = R$

So, $\frac{K_1}{K_2} = \frac{R/\sqrt{2}}{R} = \frac{1}{\sqrt{2}}$

17. (d) Moment of inertia of a uniform circular disc about an axis through its centre and perpendicular to its plane is

$I_C = \frac{1}{2}MR^2$

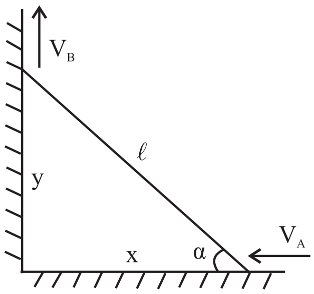
By the theorem of parallel axes,

$I = I_C + Mh^2 = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$

Moment of inertia of a uniform circular disc about an axis touching the disc at its diameter and normal to the disc is $\frac{3}{2}MR^2$

18. (a) For pure rolling of sphere relative motion of point of contact of sphere and plank should be zero. For this the point of contact has a velocity equal to the velocity of plank.

19. (b) $x^2 + y^2 = \ell^2 =$ constant



$2x\frac{dx}{dt} + 2y\frac{dy}{dt} = 0 \quad \Rightarrow \quad \frac{dx}{dt} = -V_A = -10$

$\frac{dy}{dt} = V_B \quad \& \quad \frac{y}{x} = \tan\alpha = \tan 60° = \sqrt{3}$

$10 = \sqrt{3}V_B \Rightarrow \boxed{V_B = \frac{10}{\sqrt{3}}}$

20. (c) According to the conservation of angular momentum

$I\omega =$ constant

When second disc is dropped on it and forms a unit.

$I_1\omega_1 = (I_1 + I_2)\omega_2$

(angular momentum always constant)

$\frac{I_1\omega_1}{I_1 + I_2} = \omega_2$

1. **(d)** Only Archimedes uplift will change as it is dependent on acceleration due to gravity

2. **(d)** $F = \frac{Gm_1m_2}{r^2}$ and $F' = \frac{Gm_1m_2}{(3r)^2} = \frac{F}{9}$

$$\% \text{ decrease} = \frac{\left(F - \frac{F}{9}\right)\times 100}{F}$$

$$= \frac{8}{9}\times 100 = 89\%$$

3. **(a)** Weight of body of mass "m" at pole = mg

$g'' = g - \omega^2 R \cos\lambda$

$\omega = 0$ at pole

hence, $g'' = g$ will not be changed

4. **(b)** Inside spherical shell, E = 0

Outside shell $E \propto \frac{1}{r}$

5. **(c)** $\frac{g}{g'} = \left[\frac{R+h}{R}\right]^2$

$\frac{16}{1} = \left[\frac{R+h}{R}\right]^2$

$\frac{R+h}{R} = 4$

$h = 3R$

6. **(b)** $g \propto \frac{1}{R^2}$

$$g' = \frac{1}{100}\times g = \frac{g}{100} \propto \frac{1}{(R+h)^2} \Rightarrow g' = \frac{g}{100}$$

$$\Rightarrow \frac{1}{(R+h)^2} = \frac{1}{R^2.100}$$

$$\Rightarrow \frac{(R+h)^2}{R^2} = 100$$

$\Rightarrow R + h = 10\,R$

$\Rightarrow h = 9\,R$

7. **(a)** $g = \frac{GM}{r^2} = \frac{G}{r^2}\times\frac{4}{3}\pi r^3 d = \frac{4}{3}\pi r d G$

$\Rightarrow g \propto dr$

$\frac{g_1}{g_2} = \frac{d_1r_1}{d_2r_2}$

8. **(b)** g″ = g – w2Re

If the rotational speed is increased then acceleration due to gravity (g″) decrease this will cause weight of body to decrease

9. **(b)** $DU = \frac{-GMm}{R+2R} - \left[\frac{-GMm}{R}\right]$

$= \frac{GMm}{R} - \frac{GMm}{3R}$

$= \frac{2}{3}mgR$

10. **(b)** $Ve = \sqrt{\frac{2\,GM_e}{R_e}}$

$M_p = \frac{M_e}{2}, R_p = \frac{R_e}{4}$

$V_e' = \sqrt{\frac{2G\,M_e\times 4}{2\,R_e}} = \sqrt{2}\,V_e$

11. **(b)** $BE = -E = \frac{GMm}{2r}$

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

$BE = \frac{gmR^2}{2r}$

12. **(a)** In earth's atmosphere the average thermal velocity of even the highest molecules at the maximum possible temperature is small compared to escape velocity which in turn depends upon gravity

13. **(d)** $V^2 = u^2 + 2gh$

$u' = 0, v = \sqrt{2gh}$

If $V'' = \frac{V_e}{3}$

$\sqrt{2gh} = \frac{1}{3}\sqrt{2gR}$ we get $h = \frac{R}{9}$

14. **(b)** $mV_A\times OA = mV_B\times OB, \frac{V_B}{V_A} = \frac{OA}{OB} = x$

15. **(c)** By Keplar's third law

16. **(c)** Angular momentum is conserved

$v_1d_1 = v_2d_2$

17. **(d)** Applying law of conservation of energy for asteroid at a distance 10 Re and at earth's surface, ...(i)

$K_i + U_i = K_f + U_i$

Now, $K_i = \frac{1}{2}mv_i^2$ and $U_i = -\frac{GM_em}{10R_e}$

$K_f = \frac{1}{2}mv_f^2$

and $U_f = -\frac{GM_em}{R_e}$

$$\frac{1}{2}mv_i^2 - \frac{GM_em}{10R_e} = \frac{1}{2}mv_f^2 - \frac{GM_em}{R_e}$$

$$\frac{1}{2}mv_i^2 + \frac{GM_e m}{R_e}\left[-\frac{1}{10}+1\right] = \frac{1}{2}mv_f^2$$

$$\Rightarrow v_i^2 + \frac{2GM_e}{R_e}\left[\frac{-1}{10}+1\right] = v_f^2$$

18. (c) $U_i + K_i = U_f + K_f$

$$-\frac{GMm}{R} + \frac{1}{2}m(2v_e)^2 = 0 + \frac{1}{2}mv^2$$

Or $-\frac{GM}{R} + 2v_e^2 = \frac{1}{2}v^2$

Or $-\frac{2GM}{R} + \frac{8GM}{R} = v^2$

Or $v = \sqrt{\frac{6GM}{R}} = \sqrt{3\left(\frac{2GM}{R}\right)}$

$$= \sqrt{3(2gR)} = \sqrt{3}v_e$$

19. (c) $g = \frac{GM}{R^2}$ $\quad M = \left(\frac{4}{3}\pi R^3\right)J$

$$\Rightarrow g = \frac{4G\pi R^3}{3R^2} \times J \quad J = \left(\frac{3}{4\pi GR}\right)g$$

$\therefore\ J \propto g$

20. (a) Area Velocity $= \frac{dA}{dt} = \frac{L}{2m} = \frac{mvr}{2m}$

$$= \frac{vr}{2} = \frac{r}{2}\sqrt{\frac{GM}{r}} = \frac{1}{2}\sqrt{GMr}$$

$$\frac{dA}{dt} \propto r^{1/2}$$

1. (c) $U = \frac{1}{2} \times \text{Stress} \times \text{Strain} \times \text{Volume}$

$$\frac{U}{V} = \frac{1}{2}(\text{Stress}) \times \frac{\text{Stress}}{Y} = \frac{1}{2} \times \frac{(\text{Stress})^2}{Y} = \frac{1}{2}\frac{S^2}{Y}$$

2. (a) $Y = \frac{F \times L}{A \times \Delta L}$ $\quad Y \propto \frac{L}{A} \Rightarrow Y \propto \frac{L}{r^2}$

$$\therefore \frac{Y_1}{Y_2} = \frac{L}{r_2} \times \frac{3}{L} \times \frac{r^2}{4} = \frac{3}{4} \Rightarrow Y_2 = \frac{4}{3}Y$$

3. (b) Energy stored per unit volume $= \frac{1}{2} \times \text{Strain} \times \text{Stress}$

$$= \frac{1}{2} \times \text{Young's Modulus} \times (\text{Strain})^2$$

$$= \frac{1}{2} Y \times A^2$$

4. (d) $\text{Stress} = \frac{\text{force}}{\text{Area}}$ $\quad \text{Stress} \propto \frac{1}{\eth r^2}$

$$\frac{S_B}{S_A} = \frac{r_A^{\ 2}}{r_B^{\ 2}} = (3)^2 = 9S_A$$

5. (c) $Y = \frac{\text{Stress}}{\text{Strain}}$, which is constant.

6. (d) $Y = \frac{F \times L}{A \times \Delta L} \Rightarrow F = \frac{Y \times A \times \Delta L}{L}$

$$= \frac{2 \times 10^{11} \times 100 \times (3L - L)}{L}$$

$$\therefore F = 2 \times 10^{11} \times 100 \times 2 = 4 \times 10^{13}\,\text{N}$$

7. (b) Poisson's ratio $\sigma = \frac{-\Delta r}{r} \times \frac{l}{\Delta l}$

$$\frac{\Delta r}{r} = -\sigma\frac{\Delta l}{l} \quad ....(1)$$

Volume = Area × length

$V = \pi r^2 l$

$\therefore$ $\log V = \log \pi + 2 \log r + \log l$

$$\frac{\Delta V}{V} = 2\frac{\Delta r}{r} + \frac{\Delta l}{l}$$

$$\frac{\Delta V}{V} = 2\left(\frac{-\sigma \Delta l}{l}\right) + \frac{\Delta l}{l} \quad \text{(from equation 1)}$$

$$\Rightarrow \frac{\Delta V}{V} = \frac{\Delta l}{l}(1 - 2\sigma)$$

(poisson's ratio is constant for metal or material) fraction neglected poisson's ratio because we can't calculate fraction of constant.

8. (d) $\frac{\Delta V}{V} = \frac{0.08}{100} = 8 \times 10^{-4}$, $P = 500\ aTm$

$$\therefore B = \frac{P}{\frac{\Delta V}{V}} = \frac{500 \times 0.76 \times 13.6 \times 10^3 \times 9.8}{8 \times 10^{-4}}$$

$$B = 6330.8 \times 10^7$$

$$B = 6.3 \times 10^{10}\ \text{N/m}^2$$

9. (c) Side of cube = 8 cm = 8×10^{-2} m

Force on upper face = 10×10^3 N

Displacement = 0.5×10^{-3} N

Area of upper face = $(8 \times 10^{-2})^2 = 16 \times 10^{-4}\,\text{m}^2$

Displacement = 0.5×10^{-3} m

$$\therefore G = \frac{F \times L}{A \times \Delta L} = \frac{10^4 \times 8 \times 10^{-2}}{16 \times 10^{-4} \times 0.5 \times 10^{-3}}$$

$$= 1 \times 10^9\ \text{N/m}^2$$

10. (b) $\frac{9}{Y} = \frac{3}{G} + \frac{1}{B}$ $\quad (\because\ \gamma = 3B)$

$$\therefore G = \frac{3}{2}B = 1.5\ \text{B}$$

11. (d) $\text{h} = \frac{2\text{T}\cos\theta}{\rho g r}$

As r, h, T are same, $\frac{\cos\theta}{\rho}$ = constant

$$\Rightarrow \frac{\cos\theta_1}{\rho_1} = \frac{\cos\theta_2}{\rho_2} = \frac{\cos\theta_3}{\rho_3}$$

As $\rho_1 > \rho_2 > \rho_3$

$\Rightarrow \cos\theta_1 > \cos\theta_2 > \cos\theta_3 \Rightarrow \theta_1 < \theta_2 < \theta_3$

As water rises so θ must be acute

So, $0 \le \theta_1 < \theta_2 < \theta_3 < \pi/2$

12. (b) w = $(\text{T} \times \Delta\text{A}) \times 2 = (0.05 \times 80 \times 10^{-4}) \times 2$

$\therefore$ w = 8×10^{-4} J

13. (b) Given angle of contact is 0°.

$$\text{h} = \frac{2\text{S}\cos\theta}{\rho r g} = \frac{2 \times 7.4 \times 10^{-3} \times \cos 0^\circ}{10^3 \times 10^{-3} \times 9.8} = 1.51 \times 10^{-3} = 1.51\text{mm}$$

14. (a) $\text{h} = \frac{2\text{S}\cos\theta}{\rho r g}$ $\Rightarrow$ liquid will rise in a tube if angle is acute.

15. (b) $\text{h} = \frac{2\text{S}\cos\theta}{r\rho g} \Rightarrow 0 = \frac{2\text{s}\cos\theta}{r\rho g}$

$\therefore \cos\theta = 0^\circ \Rightarrow \theta = 90^\circ$

16. (d) Excess pressure inside soap bubble $\text{P} = \frac{2\text{S}}{\text{R}}$

$$\text{P}_1 = \frac{2\text{S}}{\text{R}_1},\ \text{P}_2 = \frac{2\text{S}}{\text{R}_2}$$

$$\therefore \frac{2T}{R_1} = 4\times\frac{2T}{R_2} \Rightarrow R_2 = 4R_1$$

$$\frac{m_1}{m_2} = \frac{V_1\rho}{V_2\rho} = \frac{4/3\pi R_1^3\rho}{4/3\pi R_2^3\rho} = \frac{R_1^3}{64R_1^3} = \frac{1}{64}$$

17. (d) According to the relation, $P_1V_1 = P_2V_2$

$$(H+h)\rho g\times\frac{4}{3}\pi r^3 = H\rho g\times\frac{4}{3}\pi(3r)^3$$

$$(H+h)r^3 = 27Hr^3$$

$$\Rightarrow h = 26H$$

18. (c) Refers to NCERT Page No. 264 (Class-XI, Part - 2).

19. (c) Refers to NCERT Page No. 256 (Class-XI, Part - 2).

20. (d) $W = T(2\Delta A) \qquad \{\Delta A = (20-8)\ cm^2\}$

$$\Rightarrow T = \frac{W}{2\Delta A} = \frac{3\times10^{-4}}{2\times12\times10^{-4}} = 0.125\ Nm^{-1}$$

1. (a) $\alpha = \dfrac{\Delta L}{L_o \Delta T} \Rightarrow \Delta T = \dfrac{\Delta L}{L_o \times \alpha} = \dfrac{3}{100 \times 2 \times 10^{-5}}$

$\Delta T = 1.5 \times 10^3 = 1500°C$

2. (a) $\alpha = \dfrac{\gamma}{3} = \dfrac{5\times10^{-5}}{3} = 1.6\times10^{-5}\ /°C$

3. (c) $Q = mc\Delta T \Rightarrow \dfrac{Q}{mc} = \Delta T$

$c = \infty,\ \Delta T = 0$

4. (a) According to Stefan's law

Rate of energy radiated $E \propto T^4$
where T is the absolute temperature of a black body.

$\therefore\ E \propto (727 + 273)^4$ or $E \propto [1000]^4$

5. (b) The amount of heat per unit mass absorbed or rejected by the substance to change its temperature by one unit is called specific heat capacity. But if mass is not there then it will be thermal capacity.

6. (b) At the time of Boiling $c = \infty$ because $\Delta T = 0$

7. (c) According to the relation $T = \dfrac{K_1T_1\ell_2 + K_2T_2\ell_1}{K_1\ell_2 + K_2\ell_1}$

$$T = \frac{9K\times80\times10 + K\times0+20}{9K\times10+K\times20} = \frac{9K\times800}{90K+20K}$$

$$= \frac{9K\times800}{110K}$$

$T = 65.4\ °C$

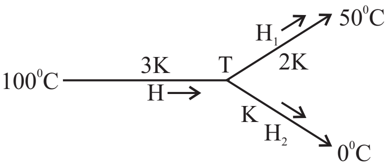
8. (a) Wien's displacement law expresses relation between wavelength corresponding to maximum energy and temperature. It states that the product of absolute temperature and the wavelength at which the emissive power is maximum is constant, i.e. $\lambda_{max}\,T$ = constant.

9. (d) According to the relations.

In series combination $K_S = \dfrac{2K_1K_2}{K_1+K_2}$

In parallel combination $K_P = \dfrac{K_1+K_2}{2}$

$$\frac{K_S}{K_P} = \frac{\dfrac{2K_1K_2}{K_1+K_2}}{\dfrac{K_1+K_2}{2}} = \frac{4K_1K_2}{(K_1+K_2)^2}$$

10. (a) 

Rate of flow of heat,

$H = H + H_2$

Using $H = \dfrac{KA(T_1 - T_2)}{L}$

$$\frac{3K(T-100)A}{L} = \frac{2K(50-T)A}{L} + \frac{K(0-T)A}{L}$$

$3(T - 100) = 2(50 - T) + (0 - T)$

$6T = 400$

$T = \dfrac{400}{6} = \dfrac{200}{3}°C$

11. (a) Every colour has their particular wavelength or wavelength range and among the given option only wiens displacement law give the relation between wavelength and temperature as λT = constant

12. (a) According to Newton's law of colling

$$\frac{\theta_1 - \theta_2}{t} = k\left[\frac{\theta_1+\theta_2}{2} - \theta_0\right]$$

$$\Rightarrow \frac{70-60}{5} = k\left[\frac{70+60}{2} - \theta_0\right]$$

$2 = k[65 - \theta_0]$ ....(i)

and

$$\frac{60-54}{5} = k\left[\frac{60+54}{2} - \theta_0\right]$$

$\Rightarrow \dfrac{6}{5} = k[57 - \theta_0]$.................(ii)

By dividing Eqs. (i) by (ii) we have

$\dfrac{10}{5} = \dfrac{65-\theta_0}{37-\theta_0} \Rightarrow \theta_0 = 45°C$

13. (d) $I \propto \dfrac{1}{\lambda} \Rightarrow \lambda \propto \dfrac{1}{I}$

$\lambda_3 < \lambda_2 < \lambda_1 \Rightarrow \lambda \propto \dfrac{1}{T}$

$\therefore T_3 > T_2 > T_1$ $\therefore$ Short trick $I \propto T$

14. (c) Wien's law states that $\lambda \propto \dfrac{1}{t}$

$$\frac{\lambda_1}{\lambda_2} = \frac{T_2}{T_1} \Rightarrow T_2 = \frac{\lambda_1}{\lambda_2} \times T_1 = \frac{2.2\times10^{-6}}{4.4\times10^{-5}} \times 1000$$

$\therefore\ T_2 = 50$ K

$\therefore$ 49 K is nearest to 50.

15. (d) Thermal resistance $(R) = \dfrac{kA}{\ell}$

$R_{eq} = \dfrac{R_1R_2}{R_1+R_2}$ ($\because$ for parallel)

$$\frac{\ell}{2k_{eq}A} = \frac{\ell}{k_1A} + \frac{\ell}{k_2A}$$

Thermal resistance $(R) = \dfrac{\ell}{kA}$

Rods are in parallel combination

$$R_{eq} = \frac{R_1R_2}{R_1 + R_2}$$

$$\frac{\ell}{K_{eq}(2A)} = \frac{\frac{\ell}{K_1A} \cdot \frac{\ell}{K_2A}}{\frac{\ell}{K_1A} + \frac{\ell}{K_2A}} = \frac{\frac{1}{K_1K_2}\frac{\ell}{A}}{\frac{1}{K_1} + \frac{1}{K_2}}$$

$$= \frac{\frac{1}{K_1K_2}\frac{\ell}{A}}{\frac{K_1 + K_2}{K_1K_2}} = \frac{1}{(K_1 + K_2)}\frac{\ell}{A}$$

$$\Rightarrow K_{eq} = \frac{K_1 + K_2}{2}$$

16. (b) In satellite weightlessness condition exist, no gravitational pull present which pull heavy/dense cold liquid towards bottom, no boiling effect.

17. (c) $\frac{\Delta Q}{\Delta t} = \frac{KA\Delta T}{\ell}$

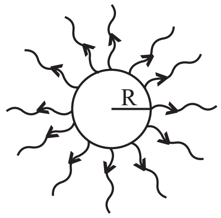
$$4 \text{ J/s} = \frac{KA[110 - 100]}{\ell} \qquad \Delta T = 110 - 100 = 10°C$$

Similarly for

$\Delta T = 210 – 200 = 10°C$

$$\frac{\Delta Q}{\Delta t} = \frac{kA[210 - 200]}{\ell} \Rightarrow \frac{\Delta Q}{\Delta t} = 4 \text{ J/s}$$

18. (d) Heat radiated by star of radius R



$Q = A\sigma\varepsilon T^4$

$\varepsilon = 1$ $\quad\therefore$ acts as black body

$Q = 4\pi R^2\sigma T^4$ $\quad$ Area of star $= 4\pi R^2$

$$T = \left[\frac{Q}{4\pi R^2\sigma}\right]^{1/4}$$

19. (a) $L_2 = \ell_2(1 + \alpha_2\Delta\theta)$ ....(1)

$L_1 = \ell_1(1 + \alpha_1\Delta\theta)$ ....(2)

Subtract eq (2) by (1), we get

$$(L_2 - L_1) = (\ell_2 - \ell_1) + \Delta\theta(\ell_2\alpha_2 - \ell_1\alpha_1)$$

$$\Delta\theta(\ell_2\alpha_2 - \ell_1\alpha_1) = 0$$

$$\alpha_2\ell_2 = \alpha_1\ell_1$$

20. (d) Heat required to melt 1 kg ice at 0°C to water at 0°C

$Q = M_{ice}\,L_{ice} = (1 \text{ kg})\,(80 \text{ cal/g})$

$= 8 \times 10^4$ cal

$$\Delta S = \frac{Q}{T} = \frac{8 \times 10^4 \text{ cal}}{273 \text{ K}} = 293 \text{ cal/K}$$

1. (b) In a cyclic and isothermal processes, energy supplied to a system does not change temperature of the system

If gas expands ΔW = +ve, then volume of gas system increases

2. (c) Ist law of thermodynamics

$\Delta Q = \Delta U + \Delta W$

ΔQ is a state function, so ΔQ – ΔW is not a path function

3. (c) $dU = \mu C_V dT = \frac{\mu R dT}{\gamma - 1} = \frac{P(2V - V)}{\gamma - 1} = \frac{PV}{\gamma - 1}$

4. (c) Efficiency of Carnot engine (η1) = 40% = 0.4;

Heat intake = 500 K and

New efficiency (η_2) = 50% = 0.5.

The efficiency $(\eta) = 1 - \frac{T_2}{T_1}$ *or* $\frac{T_2}{T_1} = 1 - \eta$.

For first case, $\frac{T_2}{500} = 1 - 0.4$ *or* $T_2 = 300\text{K}$.

For second case, $\frac{300}{T_1} = 1 - 0.5$ *or* $T_1 = 600\text{K}$.

5. (a) W = area under P – V graph

$= \frac{1}{2}[(3-1) + (2-1)] \times (2 \times 10^2 - 10^2)$

= 150 Joule

6. (c) In isothermal process curves between P and V is such that T_2 is farther from the origin than the isothermal at T_1

$T_2 > T_1$

7. (d) Heat delivered = Q_1

C.O.P $(\beta) = \frac{Q_2}{W} = \frac{Q_1 - W}{W} = \frac{Q_1}{W} - 1 = \frac{T_2}{T_1 - T_2}$

$\Rightarrow \frac{Q_1}{W} = 1 + \frac{t_2° + 273}{t_1° - t_2°} = \frac{t_1° + 273}{t_1° + t_2°}$

8. (d) $P_1^{1-\gamma} T_1^{\gamma} = P_2^{1-\gamma} T_2^{\gamma}$

$$\left[\frac{P_1}{P_2}\right]^{1-\gamma} = \left[\frac{T_2}{T_1}\right]^{\gamma}$$

$$\left[\frac{8P_1}{P_1}\right]^{1-\frac{5}{3}} = \left[\frac{T_2}{300}\right]^{5/3}$$

$$\left[\frac{1}{8}\right]^{2/3} = \left[\frac{T_2}{300}\right]^{5/3}$$

$T_2 = 131$ K

or $T_2 = -142°$C

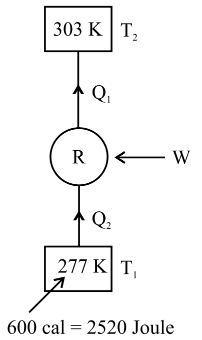
9. (a) $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{300}{600} = \frac{1}{2}$

$\frac{W}{Q} = \eta$

$\frac{800}{Q} = \eta$

$Q = \frac{800}{\eta} = 1600$ J

10. (c)



$\beta = \frac{Q_2}{W} = \frac{T_2}{T_1 - T_2}$

$\frac{2520}{W} = \frac{277}{303 - 277} \quad \Rightarrow \quad W = 236.5$ joule

Power $= \frac{W}{t} = \frac{236.5}{1\text{ sec}}$ joule $= 236.5$ watt

11. (a) M = 1kg, L = 80cal/°C

$\Delta S = \frac{ML}{T} = \frac{1000 \times 80}{273} = 293$ cal/k

12. (b) $\eta = 1 - \frac{T_1}{T_2}$

$= 1 - \frac{300}{900}$

$\eta = \frac{2}{3}$

13. (b) Rotating fan in closed room increases the kinetic energy of air molecules, which on subsequent collision produces heat, hence temperature of room increases.

14. (b) $\beta = \frac{Q_2}{W} = \frac{T_L}{T_H - T_L}$

$Q_2 = W \frac{T_L}{T_H - T_L}$

$Q_2 = \frac{1 \times 273}{303 - 273}$

$Q_2 = 9$ Joule

$Q_1 = Q_2 + W \Rightarrow 9 + 1$

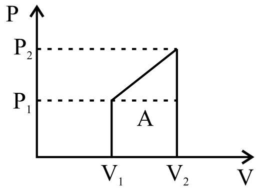
$Q_1 = 10$ Joule

15. (a) $\beta = \frac{Q_2}{W} = \frac{1 - \eta}{\eta}$

$$\frac{Q_2}{10} = \frac{1-0.1}{0.1} \quad \Rightarrow \quad Q_2 = 90 \text{ Joule}$$

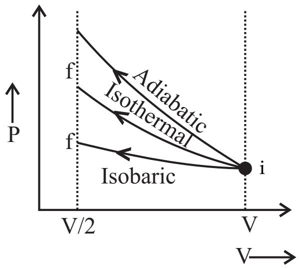
16. (c) Pressure, volume, temperature and mass are state functions

17. (b)



$$W = \frac{1}{2}[P_1 + P_2][V_2 - V_1]$$

18. (b) NCERT (XI) Ch - 12, Pg. 307



work done on the gas

$W_{isochoric} = 0$

and $W_{adiabatic} > W_{Isothermal} > W_{Isobaric}$

19. (c) $W = PdV \Rightarrow \frac{W}{n} = \int_{V_1}^{V_2} \frac{RT}{V} dV = RT \log_e \frac{V_2}{V_1}$

20. (b) Coefficient of performance of refrigerator

$$C.O.P = \frac{T_L}{T_H - T_L}$$

where $T_L \rightarrow$ lower Temperature

and $T_H \rightarrow$ Higher Temperature

So, $5 = \frac{T_L}{T_H - T_L}$

$$\Rightarrow T_H = \frac{6}{5} T_L = \frac{6}{5}(253) = 303.6 \text{ k}$$

$$= 303.6 - 273 = 30.6°C$$

$$= 31°C$$

1. **(a)** Gases cannot be liquified above critical temperature however large the pressure may be.

2. **(c)** $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$V_2 = \frac{P_1V_1T_2}{P_2T_1}$

$V_2 = \frac{1 \times 500 \times (273-3)}{0.5 \times (273+27)} = 900$

3. **(d)** PV = nRT Where $n = \frac{m}{\text{molecular mass}} = \frac{5}{32}\text{moles}$

4. **(d)** At constant temp.

PV= const $\left\{V_2 = V_1 - \frac{10V_1}{100} \Rightarrow 0.90V_1\right\}$

$P_1V_1 = P_2V_2$

$P_2 = \frac{P_1V_1}{V_2}$

$\frac{P_2}{P_1} = \frac{V_1}{V_2} = \frac{100}{90}$

$\%\left(\frac{P_2 - P_1}{P_1}\right) = \frac{1}{9} \times 100 \Rightarrow 11.1\%$

5. **(c)** $n = \frac{PV}{RT}$

n =1.98

$n = \frac{m}{M} = 1.98$

m = 1.98M ⇒ 1.98 × 28

m = 55.86g

6. **(d)** $\frac{PV}{T} = K$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\left\{V = \frac{m}{d}\right\}$

$\frac{P_1m}{T_1d_1} = \frac{P_2m}{T_2d_2}$

$\frac{P_1}{d_1T_1} = \frac{P_2}{d_2T_2}$

7. **(c)** Energy per degree of freedom = $\frac{1}{2}kT$ (law of equipartition of energy) For a polyatomic gas with n degrees of freedom, the mean energy per molecule $= \frac{1}{2}nkT$.

8. **(c)** Oxygen is diatomic. It has 5 degrees of freedom as heat is given to O_2, C_V increases from $\frac{5R}{2}$ to $\frac{7R}{2}$.Hence internal energy increases In such cases molecules have an additional degree of freedom due to their vibrational motion

9. **(b)** $C_P = \frac{5}{2}R$ $C_V = \frac{3}{2}R$ $\therefore \frac{C_P}{C_V} = \frac{5}{3}$

10. **(d)** Specific heat at constant volume (CV) and degree of freedom

$C_V = \frac{fR}{2} = \frac{6R}{2}$ $\therefore f = 6$

$C_V = 3R$

11. **(a)** $\frac{1}{3}Nmc^2 = \frac{2}{3}\left(\frac{1}{2}Nm\right)c^2 = \frac{2}{3}E$

12. **(d)** CP – CV = R

$\frac{C_P}{C_P} - \frac{C_V}{C_P} = \frac{R}{C_P}$

$1 - \frac{1}{\gamma} = \frac{R}{C_P}$

$C_P = \frac{\gamma R}{\gamma - 1}$

13. **(c)** $v_{rms} = \sqrt{\frac{3RT}{M}}$

Gas is compressed isothermally, so T remains constant and v_{rms} will remains same

14. **(d)** Root mean square velocity does not depend upon pressure. Hence, the rms velocity remains same

15. **(a)** Initial temperature (T_1) = 18°C.

= (273 + 18) = 291 K and $V_2 = V_1/8$.

For adiabatic compression, $TV^{\gamma-1}$ = constant

Or $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$.

Therefore $T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$

$= 291 \times (8)^{1.4-1} = 291 \times (8)^{0.4}$

= 291 × 2.297 = 668.4 K. = 395.4°C

16. **(d)** Kinetic energy (per mol) $= \frac{f}{2}RT$

$K = \frac{3}{2}RT$

Note; when nothing said about the atomicity of gas, goes for translational kinetic energy

$K = \frac{3}{2} \times 8.31 \times 273$

$= 3.4 \times 10^3$ Joule

17. **(b)** Mean free path $\lambda_m = \frac{1}{\sqrt{2}\pi d^2 n}$

Where d = diameter of molecule $\Rightarrow \lambda_m \propto \frac{1}{r^2}$

18. (b) Pressure exerted by the gas

$$P = \frac{1}{3}\rho v_2 \Rightarrow \frac{1}{3}\frac{m}{V}v^2 \quad \text{(multiply and divide RHS by 2.)}$$

$$= \frac{2}{3V} \times \left(\frac{1}{2}mv^2\right)$$

$$= \frac{2}{3}E, \quad \text{(For unit volume)}$$

19. (a) At a given temperature (T) all the ideal gas molecules no matter what their masses, have the same average translational kinetic energy

$$E = \frac{3}{2}KT$$

so E does not depend upon density

$$\frac{E_1}{E_2} = \frac{1}{1}$$

20. (b) $\gamma = 1 + \frac{2}{f}$

Here degree of freedom → n

$$\therefore \gamma = 1 + \frac{2}{n}$$

1. (d) For instantaneous displacement

put t = 1

$x = 5\cos[2\pi + \frac{\pi}{4}]$

$= 5\cos\frac{\pi}{4} = \frac{5}{\sqrt{2}}$

2. (c) $K\ell$ = constant $\Rightarrow K' = 4K$

& $T = 2\pi\sqrt{\frac{m}{K}} \qquad \Rightarrow T' = \frac{T}{2}$

3. (c) Phase difference $\Delta\phi = \frac{3\pi}{6} - \frac{\pi}{6} = \frac{\pi}{3}$

4. (c) y = A sin wt – B cos wt

let $A = a\cos\theta$, $B = a\sin\theta$

$a^2 = A^2 + B^2$

$a = \sqrt{A^2 + B^2}$

5. (b) $KE = \frac{1}{3}PE$

$\frac{1}{2}m\omega^2(A^2 - y^2) = \frac{1}{3}\times\frac{1}{2}m\omega^2 y^2$

$3A^2 = 4y$

$y = \frac{\sqrt{3}\,A}{2}$

y = 87% of A

6. (b) $\because\ T = 2\pi\sqrt{\frac{m}{K}} \Rightarrow K \propto \frac{1}{T^2}$

In this case $K = K_1 + K_2$

$\frac{1}{t_0^2} = \frac{1}{t_1^2} + \frac{1}{t_2^2} \quad \Rightarrow \quad t_0^{-2} = t_1^{-2} + t_2^{-2}$

7. (b) Acceleration of particle executing SHM at a displacement x from the mean position is given by, = – k(x + a).

8. (c) $x = A\cos\omega t$

$x = A/2$

we get $\omega t = 60°$

$\frac{KE}{PE} = \frac{\frac{1}{2}m\omega^2A^2\sin^2\omega t}{\frac{1}{2}m\omega^2A^2\cos\omega t} \Rightarrow \tan^2\omega t$

$= \tan^2 60°$

$= 3$

9. (b) Potential energy, $U = \frac{1}{2}Kx^2$

$2U = kx^2 \qquad \therefore F = -kx$

$2U = -Fx$

$\frac{2U}{F} = -x$

$\frac{2U}{F} + x = 0$

10. (a) $u \to u_{max}$ at mean position

so phase change $= \pi - \pi/3 = \frac{2\pi}{3}$

time $= \frac{T}{3}$

11. (a) For a motion to be S.H.M.

Force directly proportional to –y

i.e., F = –ky

12. (a) Effective acceleration in a lift desending with acceleration g/3 is

$g_{eff} = g - \frac{g}{3} \Rightarrow \frac{2g}{3}$

$T = 2\pi\sqrt{\frac{L}{g_{eff}}} \Rightarrow 2\pi\sqrt{\frac{3L}{2g}}$

13. (d) For given combination, the net spring constant, $k = k_1 + k_2$

Hence, $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m}{k_1 + k_2}}$

14. (c) $K.E = K_0\cos^2\omega t$

Since, the total energy is conserved in the motion, maximum value of kinetic energy is equal to the maximum value of potential energy which is also equal to Total Energy.

Total Energy = Max^m K.E. = Max^m P.E.

Since, Max^m K.E. = K_0

Total energy and Max^m P.E.= K_0

15. (a) $g_{eff} = g\cos\alpha \quad T = 2\pi\sqrt{\frac{l_{eff}}{g_{eff}}}$

so, $\omega = 6\ s^{-1}$

16. (d) General equation for particle displacement

$x = x_0\sin\omega t$

Velocity for particle

$V = \frac{dx}{dt} = \omega V_0\cos\omega t$

Acceleration of a particle

$a = \frac{dv}{dt} = -a_0\omega^2\sin\omega t$

$a = +\omega^2 a_0\cos\left[\frac{\pi}{2} + \omega t\right]$

Phase difference $(\Delta\phi) = \frac{\pi}{2}$

17. (d) A ω = 12 cm/s & 2A = 4cm

18. (c) (i) y = sin ωt – cosωt

$$=\sqrt{2}\left[\frac{1}{\sqrt{2}}\sin\omega t-\frac{1}{\sqrt{2}}\cos\omega t\right]$$

$$=\sqrt{2}\sin\left(\omega t-\frac{\pi}{4}\right)\text{ So, This is S.H.M.}$$

(ii) y = $\sin^3\omega t$

$$=\frac{1}{4}[3\sin\omega t-\sin 3\omega t]$$

This is periodic motion with 2 different frequency

$$(iii)\ y=5\cos\left(\frac{3\pi}{4}-3\omega t\right)$$

$$=5\cos\left(3\omega t-\frac{3\pi}{4}\right)\ (\because \cos(-\theta)=\cos\theta)$$

It is S.H.M. with time period $T=\frac{2\pi}{3\omega}$

(iv) y = 1 + ωt + ω^2t^2

It is non-periodic motion y will increase monotonously with time So, (i) and (iii) represents S.H.M.

19. (a) Value of g decreases on going below earth's surface $T\propto\frac{1}{\sqrt{g}}$. With depth g decreases according to relation $g' = g\left[1-\frac{d}{R}\right]$. If g decreases, Time period increases

20. (d) Acceleration = ω^2R and $\omega=\left(\frac{2\pi}{T}\right)$

$$=\left(\frac{2\pi}{T}\right)^2\times R$$

$$=\left(\frac{2\pi}{0.2\pi}\right)^2\times\frac{5}{100}=5\,m/s^2$$

1. (c) When a wave undergoes refraction, then its velocity changes

2. (b) $\omega = 100, K = 20$

velocity of waves $= \dfrac{\omega}{K} \Rightarrow \dfrac{100}{20} = 5$ m/s

3. (b) For a standard progressive wave

$$y = A\sin\left[2x\left(\frac{t}{T} - \frac{x}{\lambda}\right) + \phi\right]$$

The given equation can be written as

$$y = 4\sin\left[2x\left(\frac{t}{10} - \frac{x}{18}\right) + \frac{\pi}{6}\right]$$

On comparing, $\phi = \dfrac{\pi}{6}$

$\therefore A = 4$ cm, T = 10 s,

$\lambda = 18$ cm and $\phi = \pi/6$.

4. (c) $x = A \sin (ky - \omega t)$

5. (b) $v = \sqrt{\dfrac{T}{\mu}} = \sqrt{\dfrac{T}{\rho A}}$

where, ρ = density

A = Area of cross-section

$\mu = \mu A$ = mass of unit length

6. (a) $v = \sqrt{\dfrac{T}{\mu}}$

7. (b) With the propagation of a longitudinal wave, energy alone is propagated.

8. (b) $V = \sqrt{xg}$ where 'x' is the distance from lower end, so on moving up velocity also increases.

9. (a) $\mu = \dfrac{0.035}{5.5}$ kg/m, $T = 77$ N

where μ is mass per unit length.

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{77 \times 5.5}{0.035}} = 110 \text{ m/s}$$

10. (c) Density of medium increase with humidity, speed of sound directly proportional to the density.

11. (b) Velocity $\propto \sqrt{\text{Temperature}}$

$$\frac{2V}{V} = \sqrt{\frac{T_2}{T_1}}$$

$T_2 = 4T_1$

$T_2 = 4 \times 273 = 1092$ K

or $T_2 = 1092 - 273 \Rightarrow 819°C$

12. (a) Phase difference $\theta = 60° = \dfrac{\pi}{3}$ rad.

Phase difference $(\theta) = \dfrac{\pi}{3} = \dfrac{2\pi}{\lambda} \times$ Path difference.

Therefore path difference $= \dfrac{\pi}{3} \times \dfrac{\lambda}{2\pi} = \dfrac{\lambda}{6}$.

13. (c) General equation of waves

$y_0 = a \sin \omega t$

$\omega_1 = 2000\pi \quad \omega_2 = 2008\pi$

$2\pi f_1 = 2000\pi \quad 2\pi f_2 = 2008\pi$

$f_1 = 1000$ Hz $\quad f_2 = 1004$ Hz

beats $= f_2 - f_1$

$= 1004 - 1000 = 4$ Hz

14. (d) $f_0 = \dfrac{V_s}{4\ell_0} = \dfrac{340}{4 \times 85 \times 10^{-2}}$

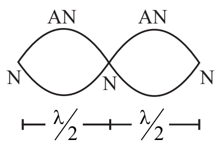
$f_0 = 100$ Hz

only odd harmonics are produced

100 Hz, 300 Hz, 500 Hz, 700 Hz, 900 Hz, 1100 Hz

15. (a) $\dfrac{\lambda}{2} + \dfrac{\lambda}{2} = 1.21$ Å

$\lambda = 1.21$Å



16. (d) $f' = f_0\left[\dfrac{V_{sound} - V_{observer}}{V_{sound} - V_{source}}\right]$

$V_0 = 0$ [observer stationary]

$$f' = f_0\left[\frac{V}{V - \dfrac{V}{10}}\right]$$

$$f' = f_0 \frac{10}{9}$$

$$\frac{f'}{f_0} = \frac{10}{9}$$

17. (d) If source moves perpendicular to observer's motion then change in freq. = 0 (No doppler's effect)

18. (a) $y = A \sin (100t) \cos (0.01x)$.

Comparing it with standard equation

$$y = A\sin\left(\frac{2\pi}{T}t\right)\cos\left(\frac{2x}{\lambda}x\right),$$

we get $T = \dfrac{\pi}{50}$ and $\lambda = 200\pi$.

Therefore velocity, $(v) = \dfrac{\lambda}{T} = \dfrac{200\pi}{\pi/50} = 200 \times 50$

$= 10000 = 10^4$ m/s.

19. (c) Frequency of waves $n = \dfrac{54}{60}$ per second

$\lambda = 10$ m

$\therefore$ v = nλ

$$= \frac{54}{60} \times 10 = 9 \text{ m / sec}.$$

20. (c) velocity of sound $v \propto \sqrt{T}$

$$\therefore \frac{v}{2v} = \frac{\sqrt{273+27}}{\sqrt{T}} \text{ or } T = 1200 \text{ K} = 927°\text{C}$$

CLASS XII

1. **(c)** Quantisation of charge q = ne

2. **(b)** To orient the dipole at any angle θ from its initial position, work has to be done on the dipole from $\theta = 0°$ to θ

$\therefore$ Potential energy = $pE(1 - \cos\theta)$

3. **(a)** $q_1 = q_2 = 2 \times 10^{-8}C$, $r = 1m$

Tension in the string will be equal to the force between the charge.

According to coulomb's law,

$$F = \frac{Kq_1q_2}{r^2}$$

$$= \frac{9\times10^9 \times \left(2\times10^{-8}\right)^2}{(1)^2}$$

$$= \frac{9\times10^9 \times 4\times10^{-16}}{1}$$

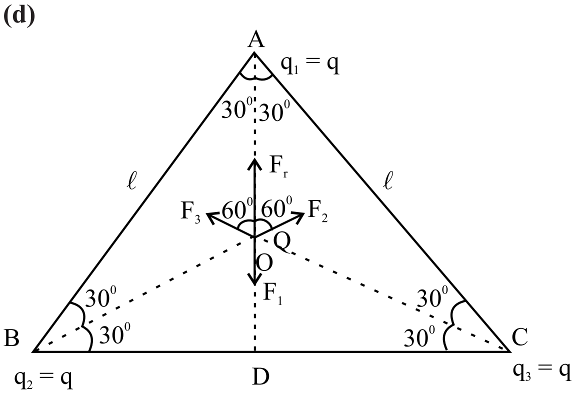
$$= 36 \times 10^{-7}N = 3.6 \times 10^{-6}N$$

4. **(c)** According to quantisation of charge, q = ne

q = ne

$$n = \frac{q}{e} = \frac{1\times10^{-7}}{1.6\times10^{-19}} = 6.25\times10^{11}$$

5. **(d)**



$$\frac{AD}{AB} = \cos 30°$$

AD = AB cos 30°

$$AD = \frac{\ell\sqrt{3}}{2}$$

Distance AO of centroid from A. is $\frac{2}{3}AD$

$$= \frac{2}{3}\times\frac{\ell\sqrt{3}}{2} = \frac{\ell}{\sqrt{3}}$$

Similarly BO and CO are equal to $\frac{\ell}{\sqrt{3}}$

Force on Q at O due to charge q placed at A

$$F_1 = \frac{kQq}{\left(\ell/\sqrt{3}\right)^2} = \frac{3KQq}{\ell^2} \text{ along AO}$$

Similarly $F_2 = \frac{3KQq}{\ell^2}$ along OB

$$F_3 = \frac{3KQq}{\ell^2} \text{ along CO}$$

Angle between F_2 and F_3 is 120°

According to parallelogram law

$$F_r = \sqrt{F_2^2 + F_3^2 + 2F_2F_3\cos120°} \quad F_1 = F_2 = F_3 = F$$

$$F_r = \sqrt{F^2 + F^2 + 2F^2\left(\frac{-1}{2}\right)}$$

$$F_r = \sqrt{F^2 + F^2 - F^2} = \sqrt{F^2} = F$$

Force due to charge q at A is equal and opposite to the resultant force F_1. So the force experienced is Zero.

6. **(b)** Field line start from positive and ends at negative charge.

7. **(c)** $q = 4 \times 10^{-9}C$

r = 0.3 m, d = 0.4 m

E = ?

As we know:

$$E = \frac{qd}{4\pi\varepsilon_o\left(d^2 + r^2\right)^{3/2}}$$

$$E = \frac{9\times10^9\times4\times10^{-9}\times0.4}{\left(0.4^2 + 0.3^2\right)^{3/2}}$$

$$E = \frac{14.4}{(0.5)^3} = 115.2 N/C$$

At the center d = 0, E = 0

8. **(c)** $E = \frac{kp}{r^3} \Rightarrow E \propto \frac{p}{r^3} \Rightarrow \frac{E_1}{E} = \frac{2}{8} \Rightarrow E_1 = \frac{E}{4}$

9. **(a)** $u = 0, a = \frac{qE}{m}, \quad s = \ell \quad v = ?$

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

$$v^2 = 0 + \frac{2qE\ell}{m} \Rightarrow v = \sqrt{\frac{2qE\ell}{m}}$$

10. **(c)** When two spheres are joined charge flows till it equalizes. Hence, electric potential is same

$V_1 = V_2$

$$\frac{kq_1}{R_1} = \frac{kq_2}{R_2} \Rightarrow \frac{q_1}{q_2} = \frac{R_1}{R_2}$$

$$\therefore \frac{E_1}{E_2} = \frac{kq_1}{R_1^2}\times\frac{R_2^2}{kq_2} \text{ put value of } \frac{q_1}{q_2}$$

$$= \frac{R_1}{R_2}\times\frac{R_2^2}{R_1^2} = \frac{R_2}{R_1}$$

$$\frac{E_1}{E_2} = \frac{R_2}{R_1}$$

11. (a) Because all charge are present on the outer surface of the shell. Hence, no electric lines are present inside the shell so electric field is absent there.

12. (c) A cube have 6 faces so flux through one face is given by gauss law

$$\phi = \frac{q}{\varepsilon_o} \text{ (for the cube)}$$

$$\Rightarrow \phi = \frac{q}{6\varepsilon_o} \text{ (for each faces)}$$

13. (c) Total charge into the shell is zero because a dipole composed of negative and positive charge.

So, $q_{net} = 5(-q + q) = 0$

$$\phi = \frac{q}{\varepsilon_o} = \text{zero}$$

14. (b) $\phi = \vec{E}.\vec{A}$

$$\phi = \left(8\hat{i} + 8\hat{j} + \hat{k}\right) \cdot \left(10\hat{i}\right)$$

$$\phi = 80 \text{ Nm}^2\text{C}^{-1}$$

15. (d) From gauss law $\phi = \frac{q}{\varepsilon_o}$

This is the net flux coming out of the cube.

Since a cube has 6 sides. So electric flux through any face is

$$\phi = \frac{\phi}{6} = \frac{q}{6\varepsilon_o} \Rightarrow \frac{4\pi q}{6(4\pi\varepsilon_o)}$$

For two faces flux = $2\phi = \frac{4\pi q}{3(4\pi\varepsilon_o)}$

16. (c) Inside the conductor E = 0 so potential remains same.

17. (d) Any closed surface is equal to the net charge inside the surface divided by ε_o

Therefore $\phi = \frac{q}{\varepsilon_o}$

Let q_1 be the charge, due to which flux ϕ is entering the surface (this charge will be -ve)

$q_1 = -\phi_1 \varepsilon_o$

Let $+q_2$ be the charge due to which flux ϕ_2 is leaving the surface

$$\phi_2 = \frac{q_2}{\varepsilon_o}$$

$q_2 = \phi_2 \varepsilon_o$

So, electric charge inside the surface

$= q_2 + q_1 = \varepsilon_o \phi_2 - \varepsilon_o\phi_1$

$= \varepsilon_o (\phi_2 - \phi_1)$

18. (c) $E = -\frac{dv}{dx} = -\frac{d}{dx}\left(-x^3y - x^2z + 4\right)$

$E_x = 3x^2y + 2xz$

$$\therefore E_y = \frac{-d\left(-x^3y\right)}{dy} = -\left(-x^3\right) = x^3$$

$$E_z = \frac{-d\left(-x^2z^1\right)}{dz} = -\left(-x^2\right)$$

$E_z = x^2$

$$\vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k} = \left(2xz + 3x^2y\right)\hat{i} + \left(x^3\right)\hat{j} + \left(x^2\right)\hat{k}$$

19. (a) Work done = ΔKE

ΔKE = Force . Displacement

= q E. y

20. (c) Volume of 8 drops = volume of big drop

$$\frac{4}{3}\pi r^3 \times 8 = \frac{4}{3}\pi r^3 \Rightarrow 2r = R$$

According to the charge conservation 8q = Q

Potential of one small drop $V' = \frac{q}{4\pi\varepsilon_o r}$

Similarly potential of big drop $= \frac{Q}{4\pi\varepsilon_o R}$

$$\frac{V'}{V} = \frac{q}{Q} \times \frac{R}{r}$$

$$\frac{V'}{20} = \frac{q}{8q} \times \frac{2r}{r}$$

$$V = \frac{20}{4} = 5V$$

Short trick :

$V = n^{2/3}V$

$20 = (8)^{2/3}V$

20 = 4V

V = 5 volt

1. (d) $Q = CV \Rightarrow Q = 500 \times 10^{-6} \times 10 = 5000 \times 10^{-6}C$

The time interval required to charge the capacitor to $5000 \times 10^{-6}C$ will be equal to the one required for producing potential difference of 10V.

$$T = \frac{5000 \times 10^{-6}}{125 \times 10^{-6}} = 40\,\text{sec}$$

2. (d) $v = -x^2y - xz^3 + 4$

$$\vec{E} = \frac{-\partial v}{dx}\hat{i} - \frac{-\partial v}{dy}\hat{j} - \frac{-\partial v}{dz}\hat{k}$$

$$\vec{E}_x = \frac{-\partial v}{dx}\hat{i} = -\left[\frac{\partial}{\partial x}\left(-x^2y - xz^3 + 4\right)\right]\hat{i}$$

$$= \left(2xy + z^3\right)\hat{i}$$

$$\vec{E}_y = \frac{-\partial v}{dx}\hat{j} = \frac{-\partial}{dy}\left(x^2y - xz^3 + 4\right)\hat{j}$$

$$= x^2\hat{j}$$

$$\vec{E}_z = +3xz^2\hat{k}$$

So, $\vec{E} = \left(2xy + z^3\right)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$

3. (b) Capacity of an isolated sphere is $4\pi\varepsilon_o R$

capacity $\propto R$

4. (c) It will act as an isolated sphere of radius 'b'.

5. (c)

Air	Mica
$C_a = C_o$	$C_m = KC_o$
$X_{C_a} = \frac{1}{\omega C_o}$	$X_{C_b} = \frac{1}{K\omega C_o}$
$V_a = IX_{c_a}$	$V_b = I\,X_{c_b}$

$$V_b = I \times \frac{1}{K\omega C_o}$$

$$V_b = \frac{IX_{C_a}}{K}$$

$$V_b = \frac{V_a}{K}$$

$$V_a = KV_b$$

$$V_a > V_b$$

6. (d) When a dielectric slab is introduced between the plates the new capacitance will be

$$C_1 = \frac{\varepsilon_o A}{d - t\left(1 - \frac{1}{K}\right)}$$

$$\therefore \frac{C_1}{C} = \frac{\varepsilon_o A}{d - t\left(1 - \frac{1}{K}\right)} \times \frac{d}{\varepsilon_o A}$$

$$\therefore \frac{C_1}{C} = \frac{d}{d - t\left(1 - \frac{1}{K}\right)}$$

$$\frac{C_1}{C} = \frac{5 \times 10^{-3}}{5 \times 10^{-3} - 2 \times 10^{-3}\left(1 - \frac{1}{3}\right)}$$

$$\frac{C_1}{C} = \frac{5 \times 10^{-3}}{5 \times 10^{-3} - 2 \times 10^{-3}\left(\frac{2}{3}\right)}$$

$$\frac{C_1}{C} = \frac{5 \times 10^{-3}}{5 \times 10^{-3} - 1.33 \times 10^{-3}}$$

$$C_1 = \frac{5 \times 20}{3.67} = 27.2\mu F$$

7. (a) $W = q\Delta V$

For all cases potential difference remains same hence work done is same for all cases.

8. (c) $C_1 = \frac{K_1\varepsilon_o A}{d/2},\ C_2 = \frac{K_2\varepsilon_o A}{d/2}$

$$C_1 = \frac{2K_1\varepsilon_o A}{d},\ C_2 = \frac{2K_2\varepsilon_o A}{d}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_{eq}} = \frac{1}{\frac{2K_1\varepsilon_o A}{d}} + \frac{1}{\frac{2K_2\varepsilon_o A}{d}}$$

$$\frac{1}{C_{eq}} = \frac{d}{2K_1\varepsilon_o A} + \frac{d}{2K_2\varepsilon_o A}$$

$$\therefore \frac{1}{C_{eq}} = \frac{d}{2\varepsilon_o A}\left(\frac{K_1 + K_2}{K_1K_2}\right)$$

$$C_{eq} = \frac{2\varepsilon_o A}{d}\left(\frac{K_1K_2}{K_1 + K_2}\right)$$

9. (b) Heat produced in a wire is equal to the energy stored in capacitor.

$$H = \frac{1}{2}CV^2 = \frac{1}{2} \times (2 \times 10^{-6}) \times (200)^2 = 4 \times 10^{-2}\,J$$

10. (b) Net charge on spheres $= q_1 + q_2$

$$= -1 \times 10^{-2} + 5 \times 10^{-2}$$

$$= 4 \times 10^{-2}C$$

Charge carried by sphere $\propto$ Radius of sphere

$$\frac{q_1}{q_2} = \frac{r_2}{r_1}$$

$$\frac{q_1}{q_2} = \frac{3}{1} \Rightarrow q_1 = 3q_2$$

$q_1 + q_2 = 4 \times 10^{-2}C \Rightarrow 4q_2 = 4 \times 10^{-2}C$

$$q_2 = 10^{-2}C$$

Charge stored by bigger sphere

$q_1 = 3 \times 10^{-2} C$

11. (a) Equivalent capacitance $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}$

$$\frac{1}{C_{eq}} = \frac{1}{4} + \frac{1}{6} + \frac{1}{5} + \frac{1}{3}$$

$$\frac{1}{C_{eq}} = \frac{15+10+12+20}{60} = \frac{57}{60}$$

$C_{eq} = 1.05\ \mu F$

$q = C_{eq} V$

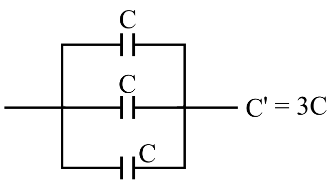
$\therefore\ q = 1.05 \times 10^{-6} \times 150 = 157.5 \times 10^{-6}$

$q = 1.5 \times 10^{-4} C$

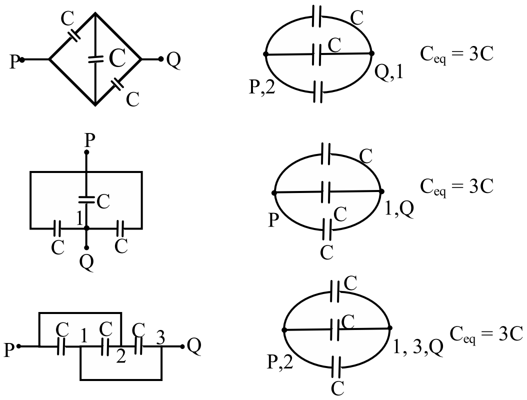
$$\therefore V = \frac{q}{C} = \frac{1.5 \times 10^{-4}}{5 \times 10^{-6}} = 0.3 \times 10^2$$

$V = 30$ volt

12. (b) The given circuit is as follows



13. (c)



14. (b) C_2 capacitor is uncharged capacitor that means potential difference across it is zero because capacity can't be zero.

$$C = \frac{\varepsilon_o A}{d},\ q = CV$$

then potential difference will be

$$V' = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$$

$V_2 = 0,\ V_1 = V$

$$\text{then, } V' = \frac{C_1 V + C_2(0)}{C_1 + C_2}$$

$$V' = \left(\frac{C_1}{C_1 + C_2}\right) V$$

15. (c) $\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$

$$\vec{E} = -(6y)\hat{i} - (6x - 1 + 2z)\hat{j} - (2y)\hat{k}$$

at point (1,1,0)

$$\vec{E} = -6\hat{i} - 5\hat{j} - 2\hat{k} = -(6\hat{i} + 5\hat{j} + 2\hat{k})$$

16. (b) As we know that the potential of the big drop

$V = n^{2/3} V_o$

$V_1 = (8)^{2/3} V_o$

$V_1 = 4V_o$

Potential of the smaller drops is V

$$\frac{V_1}{V_o} = \frac{4V_o}{V_o} = \frac{4}{1} = 4:1$$

17. (a) Given, $C_1 = 10\ pF = 10 \times 10^{-12} F$

$C_2 = 20\ pF = 20 \times 10^{-12}\ F$

$V_1 = 200\ V,\ V_2 = 100\ V$

Using $\Rightarrow q_1 = V_1 C_1$

$q_2 = V_2 C_2$

Common potential of capacitors

$$V = \frac{q_1 + q_2}{C_1 + C_2} = \frac{V_1 C_1 + V_2 C_2}{C_1 + C_2}$$

$$= \frac{200 \times 10 \times 10^{-12} + 100 \times 20 \times 10^{-12}}{10 \times 10^{-12} + 20 \times 10^{-12}} = \frac{4000}{30} = 133.3V$$

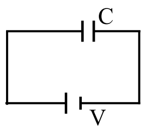
18. (c) $I = \frac{E}{r + R_2}$; P.D across $R_2 = IR_2 = \frac{ER_2}{r + R_2}$

$$Q = \frac{CER_2}{r + R_2}$$

19. (c) At time t = 0 capacitors acts as short circuit and hence current in both branch $I = \frac{V}{R}$.

20. (a) Energy stored in capacitor by charging

$$U_1 = \frac{1}{2} CV^2$$

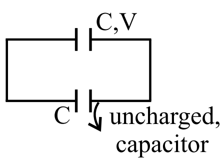


When it is connected parallel to uncharged capacitor

$V_1 = \frac{V}{2}$ [potential equal]

$C_{eff} = C + C = 2C$

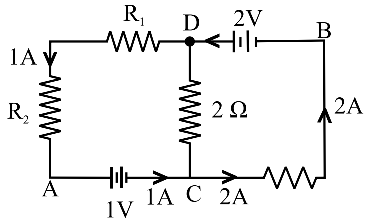
$$U_2 = \frac{1}{2} \times (2C)\left(\frac{V}{2}\right)^2 = \frac{U}{2}$$



Energy decreases by a factor of 2

1. (a) Due to the rise in temperature, resistance of conductor increases so graph between V and I becomes non linear.

2. (a) Applying Kirchoff voltage law in given path From A to B



Given, $V_A = 0$

$V_A - 1 + 2 - 2 = V_B$

$\Rightarrow V_B = -1$ V

3. (d) $R \propto \dfrac{\ell^2}{m} \Rightarrow R_1 : R_2 : R_3 = \dfrac{\ell_1^2}{m_1} : \dfrac{\ell_2^2}{m_2} : \dfrac{\ell_3^2}{m_3}$

$$= \frac{25}{1} : \frac{9}{3} : \frac{1}{5} = 25 : 3 : \frac{1}{5}$$

$R_1 : R_2 : R_3 = 125 : 15 : 1$

4. (b) $R = \rho \dfrac{\ell}{A}$

$V = A\ell$

By differentiation, $0 = \ell dA + A d\ell$ .....(1)

By differentiation, $dR = \dfrac{\rho(A d\ell - \ell dA)}{A^2}$ .....(2)

By putting value of $-\ell dA$ in equation (2), we get

$$dR = \frac{\rho 2 A d\ell}{A^2}$$

$$dR = \frac{2\rho dl}{A} \quad \text{or} \quad \frac{dR}{R} = \frac{2dl}{\ell} \quad \left(\because \rho = \frac{RA}{\ell}\right)$$

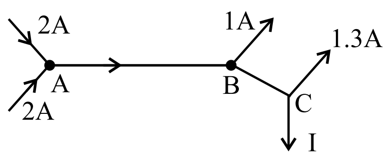
So, $\dfrac{dR}{R}\% = 2 \times \dfrac{dl}{\ell}\%$

$\dfrac{dR}{R}\% = 2 \times 0.1\%$

Hence, $\dfrac{dR}{R}\% = 0.2\%$

5. (c) $V_P - V_Q = \left[\dfrac{6}{3} + \dfrac{12 \times 6}{12 + 6}\right] \times \dfrac{1}{2} = (2 + 4)\dfrac{1}{2} = 3V$

6. (a) According to Kirchhoff's first law,



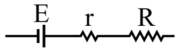
At junction A, $i_{AB} = 2 + 2 = 4A$

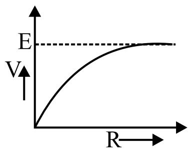
Now current $I = 4 - 1 - 1.3$

$= 1.7$ A

7. (c) $I = \dfrac{E}{R + r}$

$V = IR = \dfrac{ER}{R + r}$





For R = 0 V becomes zero

as $R = \infty$ V becomes E

8. (a) Power dissipated $= I^2R$

as we know $I = \dfrac{E}{R + r}$

$$P = \left(\frac{E}{R + r}\right)^2 R$$

$$\therefore \left(\frac{E}{R_1 + r}\right)^2 R_1 = \left(\frac{E}{R_2 + r}\right)^2 R_2$$

$$\Rightarrow R_1(R_2^2 + r^2 + 2R_2 r) = R_2(R_1^2 + r^2 + 2R_1 r)$$

$$\Rightarrow R_2^2 R_1 + R_1 r^2 + 2R_1 R_2 r = R_1^2 R_2 + R_2 r^2 + 2R_1 R_2 r$$

$$\Rightarrow (R_1 - R_2) r^2 = (R_1 - R_2) R_1 R_2$$

$$r = \sqrt{R_1 R_2}$$

9. (b) $\dfrac{5}{R} = \dfrac{\ell_1}{100 - \ell_1}$ and $\dfrac{5}{R/2} = \dfrac{1.6\ell_1}{100 - 1.6\ell_1}$

$\Rightarrow R = 15\ \Omega,\ \ell_1 = 25\ \text{cm}^2$

10. (c) power: $P = \dfrac{V^2}{R}$

For small variation in the value of power after differentiation:

$$\frac{\Delta P}{P} \times 100 = \frac{2 \times \Delta V}{V} \times 100\%$$

$$= 2 \times 2.5 = 5\%$$

$\therefore$ Power decreased by 5%

11. (b) Resistance of 25W bulb

$$R_1 = \frac{V^2}{P} = \frac{(220)^2}{25} = 1936\Omega$$

Resistance of 100W bulb

$$R_2 = \frac{V^2}{P} = \frac{(220)^2}{100} = 484\Omega$$

Series resistance $= R_1 + R_2$

$= 1936 + 484 = 2420\Omega$

Current through series combination will be $I = \dfrac{440}{2420} = \dfrac{2}{11}A$

$$V_2 = R_2 \times I = 484 \times \frac{2}{11} = 88V$$

$$V_1 = I \times R_1 = 1936 \times \frac{2}{11} = 352V$$

Thus the bulb of 25W will be fused because it can tolerate only 220V while the voltage across it is 352V

12. (b) Current in galvanometer $I_g = \frac{5}{100} I$

$$S = \frac{I_g G}{I - I_g}$$

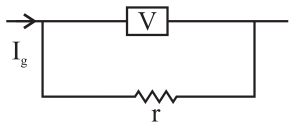
$$S = \frac{(5I/100)G}{I - \frac{5I}{100}} = \frac{5IG}{95I} = \frac{G}{19}$$

13. (d) As we know

R = 1000 ohm

$C = I_g R = 100 \times 10^{-3} \times 10^3 = 100$ V ....(i)

Voltameter is used as ammeter by providing a shunt resistance parallel to it



$\therefore$ voltage $V = I_g\left(\frac{Rr}{R+r}\right)$ ....(ii)

from (i) & (ii) we get

$$100 = I_g\left(\frac{Rr}{R+r}\right)$$

$$100 = 1 \times \left(\frac{1000r}{1000+r}\right)$$

$10^5 + 100r = 1000r$

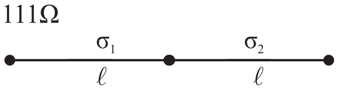
$10^5 = (1000 - 100)r$

$10^5 = 900r$

$$\frac{100000}{900} = r$$

$r \approx 111\Omega$

14. (b)



$R_{eq} = R_1 + R_2$

$$\Rightarrow \frac{2\ell}{\sigma_{eq} A} = \frac{\ell}{\sigma_1 A} + \frac{\ell}{\sigma_2 A} \Rightarrow \sigma_{eq} = \frac{2\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$$

15. (c) For the balance point of meterbridge.

Case - I, when balancing length is 55 cm

$$\frac{P}{Q} = \frac{\ell_1}{100 - \ell_1} \Rightarrow \frac{3}{Q} = \frac{55}{45}$$

$$Q = \frac{45}{55} \times 3 \qquad .....(1)$$

case - II When an unknown resistance x is involved

$$\frac{P+x}{Q} = \frac{\ell_1}{100 - \ell_1}$$

$$\frac{3+x}{Q} = \frac{75}{25} \Rightarrow 3 + x = \frac{75}{25} \times Q \qquad .....(2)$$

By putting value of Q from equation (1) in equation (2)

$$3 + x = \frac{75}{25} \times \frac{45 \times 3}{55}$$

$$x = \frac{81}{11} - 3 = \frac{81 - 33}{11} = \frac{48}{11}\Omega$$

16. (a) $Q = at - bt^2$

$$i = a - 2bt \qquad \left\{\text{for } i = 0 \quad t = \frac{a}{2b}\right\}$$

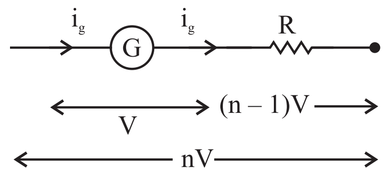
From Joules law of heating

$$dH = i^2 R dt; \ H = \int_0^{a/2b} (a - 2bt)^2 R dt$$

$$H = \left[\frac{(a-2bt)^3 R}{-3(2b)}\right]_0^{a/2b} = \frac{a^3 R}{6b}$$

17. (b) Suppose resistance R is connected in series with voltmeter as shown

By ohm's law



$i_g R = (n - 1)V$

$R = (n - 1)G$ [where $i_g = \frac{V}{G}$]

18. (b) $I_g = 1$ A, $I = 10$ A

$I_g G = (I - I_g) S$

$$\frac{G}{S} = \frac{I - I_g}{I_g} \Rightarrow \frac{10 - 1}{1} = \frac{9}{1}$$

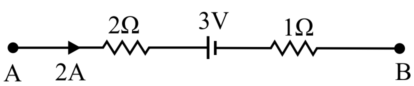
$$\frac{G}{S} = \frac{9}{1} \Rightarrow \frac{S}{G} = \frac{1}{9}$$

19. (c) $R = \frac{V}{I_g} - G$

$$R = \frac{1}{10 \times 10^{-3}} - 0.2$$

$R = 100 - 0.2 = 99.8\Omega$ in series

20. (b)



$V_B = V_A - (2 \times 2) - 3 - (2 \times 1)$

$\Rightarrow V_A - V_B = 9$ V

Ch - 4 Moving Charges and Magnetism

1. (d) Inner radius = 20 cm, outer radius = 22 cm

mean radius of the toroid $= \dfrac{r_1 + r_2}{2} = \dfrac{20+22}{2}$

r = 21 cm

r = 0.21 m

Total length of toroid = circumference

$L = 2\pi r = 2\pi \times 0.21$ m

$= 0.42\pi$ m

∴ No. of turns per unit length

$n = \dfrac{4200}{0.42\pi} = \dfrac{10000}{\pi} m^{-1}$

$B = \mu_o nI = 4\pi \times 10^{-7} \times \dfrac{10000}{\pi} \times 10$

B = 0.04T $\quad$ ($\because$ 1 T = 10^4 gauss)

= 0.04

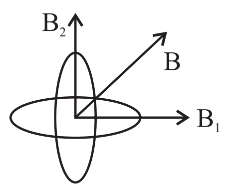
B = 400 gauss

2. (d) The plane of coil will orient itself so that area vector aligns itself along the magnetic field. The plane will orient perpendicular to the magnetic field.

3. (d) $B = \sqrt{B_1^2 + B_2^2}$

$B = \dfrac{\mu_o NI}{2R}\sqrt{1+3} = \dfrac{\mu_o NI \times 2}{2R}$

$B = \dfrac{\mu_o NI}{R}$

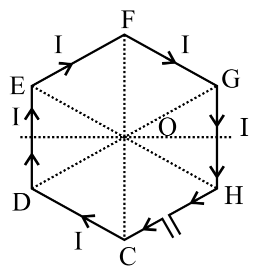


4. (b) Here ∠EOD = 60°

∠EON = 30° = ∠NOD

OE = OD = ED = a

$ON = OE\cos 30^o = a \times \dfrac{\sqrt{3}}{2}$



Total magnetic field induction at O due to current through all the six sides of hexagon is

$B = 6 \times \dfrac{\mu_o}{4\pi} \times \dfrac{I}{a\dfrac{\sqrt{3}}{2}}\left(\sin 30^o + \sin 30^o\right)$

$B = \dfrac{\sqrt{3}\mu_o I}{\pi a}$

5. (d) When current flows in a coil, its electric field is perpendicular to the magnetic field always. Hence a and b is the correct sentence.

6. (b) $B = \mu_o nI = 4\pi \times 10^{-7} \times \dfrac{200}{10^{-2}} \times 2.5$

7. (a) $B = \dfrac{\mu_0 i}{2\pi r}$ or $B \propto \dfrac{1}{r}$

When r is doubled, the magnetic field becomes halved.

∴ Here magnetic field will be

$\dfrac{0.4}{2} = 0.2$ T

8. (a) $B = \dfrac{Id\ell \sin\theta}{r^2} \times \dfrac{\mu_o}{4\pi}$

$B \propto I$

9. (a) Magnetic field at the ends of solenoid is half of the field present inside.

$B_{end} = \dfrac{B_{inside}}{2}$

$B' = \dfrac{\mu_o nI}{2}$

10. (a) Kinetic energy of electron $\left(\dfrac{1}{2} \times mv^2\right) = 10$ eV and magnetic induction B = 10^{-4} Wb/m^2.

Therefore $\dfrac{1}{2}(9.1 \times 10^{-31})v^2 = 10 \times (1.6 \times 10^{-19})$

Or, $v^2 = \dfrac{2 \times 10 \times \left(1.6 \times 10^{-19}\right)}{9.1 \times 10^{-31}} = 3.52 \times 10^{12}$

Or, v = 1.876 × 10^6 m

Centripetal force $= \dfrac{mv^2}{r} = Bev$

Therefore $r = \dfrac{mv}{Be} = \dfrac{(9.1 \times 10^{-31}) \times (1.876 \times 10^6)}{10^{-4} \times (1.6 \times 10^{-19})}$

= 11 × 10^{-2} m = 11 cm

11. (a) As we know that

F = ma

qvB sin 90° = ma

$a = \dfrac{qvB}{m}$

$a = \dfrac{1.6 \times 10^{-19} \times 2 \times 3.4 \times 10^7}{1.67 \times 10^{-27}}$

a = 6.5 × 10^{15} m/sec

12. (d) τ_{max} = NABI

$= I \times 1 \times \left(\pi r^2\right) B \quad \begin{bmatrix} 2\pi r = L \\ r = \dfrac{L}{2\pi} \end{bmatrix}$

$\tau_{max} = \pi I \left(\dfrac{L}{2\pi}\right)^2 B$

$T_{max} = \dfrac{L^2 IB}{4\pi}$

13. (b) F = qvBsinθ

F = 1.6 × 10^{-19} × 2 × 10^7 × 1.5 × sin 30°

$= 1.6 \times 10^{-12} \times 2 \times 1.5 \times \dfrac{1}{2}$

$F = 2.4 \times 10^{-12} N$

14. (a) $qvB = \frac{mv^2}{r}$

$r = \frac{mv}{Bq} = \sqrt{\frac{2mE}{q^2B^2}} \qquad \left(E = \frac{B^2q^2r^2}{2m}\right)$

$r_p = \sqrt{\frac{2mE}{e^2B^2}}, r_d = \sqrt{\frac{2(2m)E}{e^2B^2}}$

$r_\alpha = \sqrt{\frac{2 \times 4m \times E}{4e^2 \times B^2}}$

Hence. $r_p : r_d : r_\alpha = 1 : \sqrt{2} : 1$

15. (d) As we know

$\frac{F}{\ell} = \frac{\mu_o 2I_1I_2}{4\pi R}$

$\frac{F}{\ell} \propto \frac{1}{R}$

16. (a) Case (I) $A_1 = \frac{\pi D^2}{4} \quad ; \; n_1 = n, \; \theta_1 = \theta$

Case (II) $A_2 = \pi\left(\frac{D}{8}\right)^2$

$A_2 = \frac{\pi D^2}{64} \quad n_2 = 10n \quad \theta_2 = ?$

$I = \frac{K\theta_1}{n_1BA_1} = \frac{K\theta_2}{n_2BA_2}$

$\theta_2 = \theta_1 \times \frac{n_2A_2}{n_1A_1} = \frac{\theta \times 10n \times \frac{\pi D^2}{64}}{n \times \frac{\pi D^2}{4}}$

$= \theta \times 10 \times \frac{1}{16}$

$\theta_2 = \frac{5}{8}$ times the original

17. (d) $\tau = MB \sin\theta$

$\tau_{radial} = NIAB$

for radial magnetic field $\sin\theta = 90^o$

18. (d) Current sensitivity $\frac{\theta}{I} = \frac{NBA}{C}$

$= \frac{100 \times 5 \times 10^{-4}}{10^{-8}} = 5 rad / \mu \, amp$

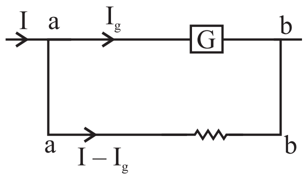
19. (b) The potential difference

$V_{ab} = (V_a - V_b)$ is the same for the path.

$I_gG = (I - I_g)S$

$I_g(G + S) = IS$

$\frac{I_g}{I} = \frac{S}{G+S}$



The fraction of current passing through shunt

$= \frac{I - I_g}{I}$

$= 1 - \frac{I_g}{I} = 1 - \frac{S}{S+G} = \frac{G}{S+G} = \frac{8}{2+8} = 0.8 \text{ A}$

20. (d) Let the current for one division of galvanometer be i

Current through the galvanometer $I_g = 10i$

Current through the ammeter $I = 50i$

$S = \frac{I_gG}{(I - I_g)}$

$G = S\left(\frac{I - I_g}{I_g}\right)$

$G = 12 \times \left[\frac{50i - 10i}{10i}\right]$

$= 12 \times \left(\frac{40i}{10i}\right) = 48 \, \Omega$

$G = 48 \, \Omega$

1. (d) As we know,

$$B = \frac{\mu_o 2M}{4\pi r^3}$$

$$= \frac{10^{-7} \times 2 \times 50}{(0.2)^3} = \frac{10^{-7} \times 100}{8 \times 10^{-3}}$$

$$B = 1.25 \times 10^{-3}\,T$$

2. (b) $M = NIA$

$M = NI(\pi R^2)$

$= 50 \times 12\pi(0.2)^2$

$= 50 \times 12 \times 3.14 \times 0.04 = 75.4\,Am^2$

3. (c) Work done in turning the magnet through 60°.

$(W_1) = MB(\cos 0° - \cos 60°) = MB\left(1 - \frac{1}{2}\right) = \frac{MB}{2}.$

Work done in turning the magnet through 90°.

$W_2 = MB(\cos 0° - \cos 90°)$

$= MB$

According to the question

$W_2 = nW_1$ ......(1)

$\therefore$ Here $\frac{W_2}{W_1} = \frac{MB}{\frac{MB}{2}} = 2$

$W_2 = 2W_1$ ......(2)

Comparing (1) and (2)

$n = 2$

4. (c) Torque $= MB \sin\theta$

$\tau_1 = MB_1 \sin 90^o = MB_1$

$\tau_2 = MB_2 \sin 90^o = MB_2$

$$\frac{\tau_1}{\tau_2} = \frac{MB_1}{MB_2} = \frac{B_1}{B_2} = \frac{\tau_1}{\tau_2}$$

5. (a) Permanent magnet is made up of material which have high coercivity, high retentivity and high permeability. Retentivity of steel is slightly smaller than soft iron but coercivity is much larger than soft iron which overcomes the retentivity effect.

6. (a) For protecting a magnetic needle it should be placed in iron box.

7. (a) $W = MB(\cos\theta_1 - \cos\theta_2)$

$= MB(\cos 0^o - \cos 60^o)$

$$= MB\left(1 - \frac{1}{2}\right) = \frac{MB}{2}$$

and $\tau = MB\sin\theta = MB.\sin 60 = MB\frac{\sqrt{3}}{2}$

$$\therefore \tau = \left(\frac{MB}{2}\right)\sqrt{3} \Rightarrow \tau = \sqrt{3}\,W$$

8. (b) According to the parallelogram law.

$$M = \sqrt{M_1^2 + M_2^2 + 2M_1M_2\cos 90^o} \quad (M_1 = M_2 = M)$$

$$M = \sqrt{M^2 + M^2} = \sqrt{2}M$$

9. (a) Here $V = \sqrt{3}H \quad \delta = ?$

$$\tan\delta = \frac{V}{H}$$

$$\therefore \tan\delta = \frac{\sqrt{3}H}{H}$$

$\delta = 60^o$

10. (c) $\tan\delta = \frac{V}{H}$

$$H = \frac{V}{\tan\delta} \Rightarrow \frac{0.16 \times \sqrt{3} \times 10^{-4}}{\frac{1}{\sqrt{3}}} = 0.16 \times 3 \times 10^{-4}$$

$H = 0.48 \times 10^{-4}$ Tesla

11. (d) $\tan\theta_1 = \frac{\tan\theta}{\cos\alpha} \Rightarrow \cos\alpha = \frac{\tan\theta}{\tan\theta_1}$

$$\tan\theta_2 = \frac{\tan\theta}{\cos(90 - \alpha)}$$

$$\tan\theta_2 = \frac{\tan\theta}{\sin\alpha} \Rightarrow \sin\alpha = \frac{\tan\theta}{\tan\theta_2}$$

$\sin^2\alpha + \cos^2\alpha = 1$ identity in trigonometry

$$\frac{\tan^2\theta}{\tan^2\theta_2} + \frac{\tan^2\theta}{\tan^2\theta_1} = 1$$

$$\tan^2\theta\left[\frac{1}{\tan^2\theta_2} + \frac{1}{\tan^2\theta_1}\right] = 1$$

$$\cot^2\theta_2 + \cot^2\theta_1 = \frac{1}{\tan^2\theta}$$

$$\cot^2\theta_2 + \cot^2\theta_1 = \cot^2\theta$$

12. (a) $T = 2\pi\sqrt{\frac{I}{MB}} \Rightarrow T \propto \frac{1}{\sqrt{M}}$

case I : $M_1 = 2M + M = 3M$

case II : $M_2 = 2M - M = M$

$$\frac{T_1}{T_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{M}{3M}} = \frac{1}{\sqrt{3}} \Rightarrow T_2 = \sqrt{3}\,T_1$$

$\therefore T_1 < T_2$

13. (d) $B = V_o$

total intensity

$$B = \sqrt{B_o^2 + V_o^2}$$

$$B = \sqrt{2}B_o$$

14. (b) In tangent galvanometer,

$I \propto \tan\theta$

$$\frac{I_1}{I_2} = \frac{\tan\theta_1}{\tan\theta_2} = \frac{I_1}{\frac{I_1}{\sqrt{3}}} = \frac{\tan 45^o}{\tan\theta_2}$$

$$\sqrt{3}\tan\theta_2 = 1$$

$$\tan\theta_2 = \frac{1}{\sqrt{3}}$$

$\theta_2 = 30^o$

$\therefore$ decrease in angle = $45^o - 30^o = 15^o$

15. (c) Net magnetic moment

$$m = \sqrt{m_1^2 + m_2^2 + 2m_1m_2\cos\theta}$$

$m_1 = m_2 = m$ will be maximum if $\cos\theta$ is maximum. Cos θ will be maximum when θ will be minimum.

$\therefore \theta = 30°$

16. (b) $T = 2\pi\sqrt{\frac{I}{MB}} = 4\,\text{sec}$

when magnet is cut into two equal parts, than new magnetic moments

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

New moment of inertia $I' = \frac{\left(\omega/2\right)\left(\ell/2\right)^2}{12} = \frac{1}{8}\times\frac{\omega\ell^2}{12}$

W = initial mass of the magnet.

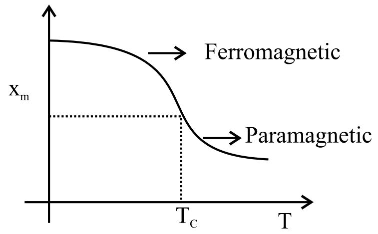
But $I = \frac{\omega\ell^2}{12}$: $\therefore I' = \frac{I}{8}$

$\therefore$ New time period $T' = 2\pi\sqrt{\frac{I'}{MB_H}}$

$$T' = 2\pi\sqrt{\frac{I/8}{\left(M/2\right)B_H}} \Rightarrow \frac{1}{2}\times 2\pi\sqrt{\frac{I}{MH}}$$

$$= \frac{1}{2}\times T = \frac{1}{2}\times 4 = 2\,\text{sec}$$

17. (a) Above Curie Temperature, ferromagnetic substance becomes paramagnetic



Ferromagnetic

$$\chi_m \propto \frac{1}{(T - T_C)}$$

$$\chi_m \propto \frac{1}{T}$$

18. (b) As we know $T = 2\pi\sqrt{\frac{I}{MB}}$

$$B = 4\pi^2\times\frac{I}{MT^2}$$

$$= 4\times\frac{22}{7}\times\frac{22}{7}\times\frac{7.5\times10^{-6}}{6.7\times10^{-2}\times(0.67)^2}$$

$$= 4\times\left(\frac{22}{7}\right)^2\times\frac{7.5\times10^{-6}}{6.7\times10^{-2}\times(0.67)^2}$$

$B = 9.852\times10^{-3}$T

19. (d) Soft iron has low retentivity and low coercive force.

20. (c) As $\chi_m = \frac{C}{T}$ $\therefore \frac{\chi_m}{\chi_{m'}} = \frac{T'}{T}$

$$T' = \frac{\chi_m}{\chi_{m'}}\times T = \frac{1.2\times10^{-5}}{1.44\times10^{-5}}\times300 = 250K$$

Ch - 6 Electromagnetic Induction

1. (a) According to the relation:

$$e = \frac{\phi_2 - \phi_1}{t} = \frac{(4B_0 - B_0)}{t} A_0$$

$$e = \frac{3B_0A_0}{t}$$

2. (d) $e = \frac{d\phi}{dt} = d\frac{(3t^2 + 4t + 9)}{dt} = 6t + 4$

$= (6 \times 2) + 4 \quad (t = 2s, \text{ given})$

$e = 16$ volt

3. (d) Flux linked with each turn of Solenoid

$= 4 \times 10^{-3}$ Wb

Total flux linked with Solenoid

$= 500 \times 4 \times 10^{-3} = 2$ Wb

As we know,

$\phi = Li$

$\Rightarrow 2 = 2 \times L$

$\Rightarrow L = 1$ H

4. (d) $e = BA\nu = B.A \times \frac{\omega}{2\pi} = B \times \pi R^2 \times \frac{\omega}{2\pi}$

$$e = \frac{1}{2}BR^2\omega = \frac{1}{2} \times 0.05 \times (2)^2 \times 60 = 6 \text{ volt}$$

5. (a) $e = \frac{-d\phi}{dt} = \frac{-BA\cos 180^0}{t}$

$$= \frac{-0.4 \times 10^{-4} \times 500 \times 10^{-4} \times (-1) \times 1000}{1/10}$$

$= 0.4 \times 500 \times 10 \times 10^{-8} \times 1000$

$= 2000 \times 10 \times 10^{-9} \times 1000$

$= 0.02$ V

6. (a) As we know,

$$e = L\frac{dI}{dt} \Rightarrow 0.20 = \frac{L(5-(-5))}{0.20}$$

$$\Rightarrow L = \frac{0.20 \times 0.20}{5+5} = 4 \times 10^{-3} H$$

7. (d) Number of turn = 1000

Net magnetic flux = $N\phi = 4 \times 10^{-3} \times 10^3$

$= 4$ Wb

$\phi = LI$

$4 = L \times 4$

$L = 1$ H

8. (b) Flux of the magnetic field through the loop is $\phi = B\pi r^2 \cos\omega t$

$E = \omega B\pi r^2 \sin\omega t$ (induced emf). $\sin\omega t$ changes direction in every half rotation.

9. (c) $\phi = (B)(\pi r^2) \Rightarrow e = \frac{d\phi}{dt} = (B)(2\pi r)\left(\frac{dr}{dt}\right)$

$= (0.025)(2\pi)(2 \times 10^{-2})(10^{-3}) = \pi\ \mu V$

10. (c) When flux completely linked with each other the coefficient of coupling becomes unity, $K = \frac{M}{\sqrt{L_1L_2}}$

11. (b) We knows that $L = \frac{\mu_0 N^2 A}{\ell} \Rightarrow \frac{\mu_0 N^2 \pi r^2}{\ell}$

$$\therefore\ L \propto N^2 \propto r^2 \propto \frac{1}{\ell}$$

$$\frac{L_2}{L_1} = \left(\frac{N_2}{N_1}\right)^2 \times \left(\frac{r_2}{r_1}\right)^2 \times \left(\frac{\ell_1}{\ell_2}\right)$$

$$= (1)^2 \times \left(\frac{2}{1}\right)^2 \times \frac{1}{2} = 2:1$$

$$\frac{L_2}{L_1} = \frac{2}{1}$$

12. (a) $I_p = ?\ E_p = 220V$

$E_s = 22$ V, $R_s = 220\Omega$

$$\therefore\ I_s = \frac{E_s}{R_s} = \frac{22}{220} = 0.1A$$

$$\text{As } \frac{I_p}{I_s} = \frac{E_s}{E_p}$$

$$\therefore\ I_p = \frac{E_s}{E_p} \times I_s = \frac{22 \times 0.1}{220} = 0.01A$$

13. (b) According to the transformation ratio.

$$\frac{N_s}{N_p} = \frac{I_p}{I_s} \Rightarrow \frac{2}{3} = \frac{3}{I_s} \Rightarrow I_s = \frac{9}{2}$$

$I_s = 4.5$

14. (a) As we know that, $\eta = \frac{\text{output}}{\text{Input}}$

$$\eta = \frac{E_sI_s}{I_pE_p} = \frac{80}{100} = \frac{200 \times I_s}{4 \times 10^3}$$

$$I_s = \frac{80}{100} \times \frac{4 \times 10^3}{200} = 16A$$

Also $E_p I_p = 4kW$

$$I_p = \frac{4 \times 10^3}{100} = 40$$

$I_p = 40A$, $I_s = 16A$

15. (a) $I = t^2 e^{-t}$ ....(1)

when $\frac{dI}{dt} = 0$, , emf = 0

Differentiating (1) w.r.t.

$$\frac{dI}{dt} = 2te^{-t} + (-1)e^{-t}t^2$$

$$\frac{dI}{dt} = 2te^{-t} - t^2e^{-t}$$

$0 = (2t - t^2)\, e^{-t}$

$t\,[2 - t] = 0 \Rightarrow t = 0, t = 2$ sec

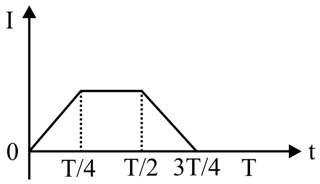
16. **(c)** As we know $\eta = \dfrac{\text{Output power}}{\text{Input power}}$

$\therefore$ Losses neglected in the case of 100% efficiency

$\eta = 1$

then, $P_o = P_i$

17. **(a)** Induced emf, $e = -L\dfrac{di}{dt}$



e will depend on $\dfrac{di}{dt}$

If slope of graph $\left(\dfrac{di}{dt}\right)$ is +ve, e will be negative

For $0 \le t \le \dfrac{T}{4}$

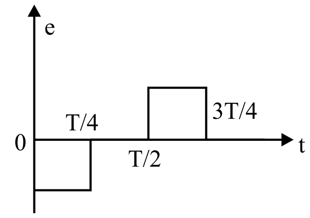
$\dfrac{di}{dt}$ = Constant and +ve, So e = –ve and constant

For $\dfrac{T}{4} \le t \le \dfrac{T}{2}$ (di/dt = 0 ; e = 0)

For $\dfrac{T}{2} \le t \le \dfrac{3T}{4}$

$\dfrac{di}{dt}$ = Constant and –ve, So, e = +ve and constant

Hence, graph of e–t is:



18. **(b)** $e = BNA\,\omega$

So, $E \propto \omega$

New speed $= \dfrac{120}{100} \times 1500 = 1800$ rpm

19. **(d)** Emf induced $\varepsilon = \dfrac{d\phi}{dt}$

$$= \frac{d}{dt}[BA\cos\theta] \quad \therefore \phi = BA\cos\theta$$

ε [for 'N' turns] = $NBA_{\Delta t}[\cos\theta_2 - \cos\theta_1]$

$\theta_1 = 180 \qquad \theta_2 = 0$

$$\varepsilon = 500 \times \frac{3\times10^{-5}}{0.25} \times \pi \times (10\times10^{-2})^2 \times [1-(-1)]$$

$\varepsilon = 3.8 \times 10^{-3}$ V

20. **(b)** As we know that

$e = NBA\omega$

$\therefore e \propto \omega$

Hence Induced e.m.f is doubled

1. **(d)** Power factor $\cos\phi = \frac{R}{Z}$

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (\omega L)^2}$$

$$Z = \sqrt{(30)^2 + (100 \times 400 \times 10^{-3})^2} = \sqrt{900 + 1600} = \sqrt{2500}$$

$Z = 50\ \Omega$

$$\therefore \cos\phi = \frac{R}{Z} = \frac{30}{50} = 0.6$$

2. **(c)** Resistance of both the bulbs are:

$$R_1 = \frac{V^2}{P_1} = \frac{(220)^2}{25}$$

$$R_2 = \frac{V^2}{P_2} = \frac{(220)^2}{100}$$

$$\frac{R_1}{R_2} = \frac{100}{25} \Rightarrow R_1 = 4R_2$$

$\therefore R_1 > R_2$

Hence 25W bulb will fuse.

3. **(b)** For P = constant

$R \propto V^2$

$$\therefore\ R_1 = \frac{R \times (110)^2}{(220)^2} = \frac{R}{4}$$

4. **(c)** As we know,

The effective voltage is $V_{rms} = \frac{V_0}{\sqrt{2}}$

$$V_{rms} = \frac{423}{\sqrt{2}} = 300\,V$$

5. **(b)** Given equation is $e = 80 \sin 100\pi t$

$\therefore$ peak value of the voltage is 80V

Current amplitude $I_m = \frac{e_0}{Z}$

$$I_m = \frac{80}{20} = 4A$$

Effective current or root mean square current

$$I_{rms} = \frac{4}{\sqrt{2}} = \frac{4\sqrt{2}}{2} = 2\sqrt{2} = 2.828A$$

6. **(b)** Efficiency of transformer

$$(\eta) = \frac{V_S I_S}{V_P I_P} \times 100$$

$(V_S I_S)$ = Power in secondary coil = 100 W

$$\eta = \frac{100}{220 \times 0.5} \times 100 = 90.9 \approx 90\%$$

7. **(a)** Here, $L = 100\ mH = 10^{-1}\ H$

$C = 25\mu F = 25 \times 10^{-6}\ F$

$R = 15\Omega \quad E_V = 120\ V \quad \nu = 50\ Hz$

At resonance, $Z = R = 15\Omega$

$$I_V = \frac{E_V}{R} = \frac{120}{15} = 8A$$

$$\nu = \frac{1}{2 \times \pi\sqrt{LC}} = \frac{1 \times 7}{2 \times 22 \times \sqrt{10^{-1} \times 25 \times 10^{-6}}}$$

$$\nu = \frac{7 \times 10^3}{44 \times 1.58} = 100.7\,Hz$$

8. **(b)** As we know that,

$$\omega = \frac{1}{\sqrt{LC}}$$

$$\therefore \nu = \frac{1}{2\pi\sqrt{LC}}$$

$$(\nu) = (LC)^{-1/2}$$

9. **(c)** $I_o = 0.25A \qquad V = 60Hz \qquad L = 2H$

$$V_L = I_v X_L = \frac{I_o}{\sqrt{2}} X_L = \frac{I_o}{\sqrt{2}} \omega L$$

$$V_L = \frac{I_o 2\pi\nu L}{\sqrt{2}} = \frac{0.25}{\sqrt{2}} \times 2 \times \frac{22}{7} \times 60 \times 2$$

$V_L = 133.4V$

10. **(c)** $Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (2\pi\nu L)^2}$

$$Z = \sqrt{(40)^2 + 4\pi^2 \times (50)^2 \times (95.5 \times 10^{-3})^2} = 50\Omega$$

11. **(d)** $e = E_0 \sin \omega t$

$i = I_0 \sin(\omega t - \phi)$

Avg. power in circuit over one cycle of AC is

$$\langle P \rangle = \langle ei \rangle = \langle (E_0 \sin\omega t)[I_0 \sin(\omega t - \phi)] \rangle$$

$$= E_0 I_0 \langle (\sin^2 \omega t \cos\phi - \sin\omega t \cos\omega t \sin\phi) \rangle$$

$$= \frac{1}{2} E_0 I_0 \cos\phi$$

Avg. power can also be determined by

$$= \frac{E_0 I_0}{2} \cos\phi = \frac{E_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}} \times \cos\phi$$

where ϕ is phase difference between current and voltage.

12. **(c)** $X_L = 2 \times \pi \times \nu \times L$

$$= 2 \times \pi \times \frac{1}{\pi} \times 50 = 2 \times 50 = 100\Omega$$

13. (b) $\varepsilon = -L\dfrac{di}{dt}$

$$L = \frac{-\varepsilon}{\frac{di}{dt}} = \frac{-5\times10^{-3}}{(2-3)}\text{H} = 5\,\text{mH} \quad \begin{pmatrix}\because di = 2-3 \\ dt = 10^{-3}\end{pmatrix}$$

14. (b) Here, R = 3 Ω

$X_L = 3\ \Omega$

Phase difference between applied voltage and the current in the circuit

$$\tan\phi = \frac{X_L}{R} = 1 \Rightarrow \phi = \tan^{-1}(1) \Rightarrow \phi = \pi/4$$

15. (a) Here, Resistance, R = 3Ω

Inductive reflectance, $X_L = 10\Omega$

Capacitive reactance, $X_C = 14\Omega$

The impedence of the series LCR circuit is:

$$Z = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{(3)^2 + (14-10)^2}$$

$$Z = 5\Omega$$

16. (a) Short trick:

$$V_{rms} = \sqrt{\frac{(V_1)^2 + (V_2)^3 + (V_3)^2}{\text{Number of loops}}}$$

$$V_{rms} = \sqrt{\frac{(10)^2 + (10)^2 + (10)^2}{3}}$$

$$V_{rms} = \sqrt{\frac{300}{3}} = \sqrt{100} = 10\text{V}$$

For this type of waveform, $V_{rms} = V_{peak} = V_{avg}$

17. (b) The mechanical equivalent of spring constant in LC oscillating circuit is $K = \dfrac{1}{C}$

18. (b) Restoring force is provided by inductor.

19. (a) Power factor is cos ϕ, and cos ϕ varies in between cos0° to cos90° , which is ranges from 0 to 1.

20. (d) $P_{avg} = V_{rms} I_{rms} \cos\phi$

$$= \frac{1}{2}\times\frac{1}{2}\times\cos 60° = \frac{1}{2}\times\frac{1}{2}\times\frac{1}{2} = \frac{1}{8}\text{watt}$$

1. **(b)** $E = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{40}\,J$

$$E = \frac{6.6\times10^{-34}\times3\times10^{8}}{40\times1.6\times10^{-19}}\,eV \quad = \frac{19.8\times10^{-7}}{64}$$

$\Rightarrow E = 3.1 \times 10^{-8}$ eV

2. **(b)** X-rays emission: They are due to transitions in the inner energy levels of the atom.

Photoelectric emission: Emission of electrons from the metal surface on irradiation with radiation of suitable frequency.

Secondary emission: When an electron strikes the surface of a metallic plate, it emits other electrons from the surface.

Thermionic emission: When a metal is heated to a high temperature, the free electron gain kinetic energy and escape from the surface of the metal

3. **(d)** $B_0 = 5 \times 10^{-9}$ T

q = Charge on α-particle = 2 × e

$= 3.2 \times 10^{-19}$ C

Maximum electric field $E_0 = cB_O$

$E_o = (3 \times 10^8) \times (5 \times 10^{-9})$

$= 1.5\ Vm^{-1}$

Maximum force on α-particle due to electric field

$F_E = q \times E_0$

$= 3.2 \times 10^{-19} \times 1.5$

$F_E = 4.80 \times 10^{-19}$ N

Maximum force on α-particle due to magnetic field

$F_B = qvB$

$= 3.2 \times 10^{-19} \times 3 \times 10^8 \times 10^{-9} \times 5$

$F_B = 4.80 \times 10^{-19}$ N

4. **(a)** Pressure exerted by absorbed wave on the surface

$$P = \frac{I}{c} = \frac{2}{3\times10^{8}} = 0.667\times10^{-8}\,N/m^2$$

$= 6.67 \times 10^{-9}\ N/m^2$

5. **(b)** X-rays are used for the investigation of structure of solids because its wavelength is of the order of interatomic distances in the solid.

6. **(d)** $F = PA \quad : \quad P = \frac{I}{c}$

$$\therefore F = \frac{IA}{c} = \frac{6\times12}{3\times10^{8}} = 24\times10^{-8}\,N$$

7. **(c)** $E = 11\ KeV = 11 \times 10^3 \times 1.6 \times 10^{-19}$

$$11\times10^{-16}\times1.6 = \frac{hc}{\lambda}$$

$$\lambda = \frac{6.6\times10^{-34}\times3\times10^{8}}{1.6\times11\times10^{-16}} = 1.125\times10^{-10}\,m$$

$\lambda = 1.125$ Å

This wave lies in the region of X-ray

8. **(c)** Amplitude of oscillating magnetic field

$$B_0 = \frac{E_0}{c} = \frac{480}{3\times10^{8}} = 1.6\times10^{-6}\,Wb/m^2$$

9. **(c)** Refractive index of medium is:

$$\mu = \frac{c}{v} \qquad \text{where, } c = \frac{1}{\sqrt{\mu_0 k_0}}$$

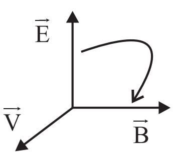
and $v = \frac{1}{\sqrt{\mu_0 k_0 \mu_r k_r}}$

$$\therefore \mu = \frac{1/\sqrt{\mu_0 k_0}}{1/\sqrt{\mu_0 k_0 \mu_r k_r}} = \sqrt{\mu_r k_r}$$

Given $\mu_r = \mu_0$ and $k_r = k_0$ then

$\mu = \sqrt{\mu_0 k_0}$

10. **(b)**



$\vec{E}\,\hat{j}\times\vec{B}\,\hat{i} = -\vec{V}\,\hat{k}$

velocity is in negative z - axis

$\downarrow$

$(-\hat{k})$

$\vec{E}\times\vec{B}$ parallel to $\vec{V}$

11. **(b)** $\mu = \frac{c}{v} = \frac{1/\sqrt{\mu_0\varepsilon_0}}{1/\sqrt{\mu\varepsilon}} = \sqrt{\frac{\mu\varepsilon}{\mu_o\varepsilon_o}}$

12. **(c)** $n = \frac{x}{\lambda} = \frac{10^{-3}}{4\times10^{-7}} = 0.25\times10^{4}$

13. **(c)** They are all electromagnetic waves so they are travel with same speed in vacuum.

14. **(a)** The frequency order of electromagnetic rays are γ-rays > X-rays > UV rays

A > B > C

$\therefore 5\times10^{22} - 3\times10^{18}\,Hz > 3\times10^{21} - 10^{16}\,Hz > 5\times10^{17} - 8\times10^{14}\,Hz$

15. **(b)** Here, $\omega = 2\pi \times 10^6$ and e.m. wave is moving in x direction as E.F. is varying with x

$$\text{Frequency} = \frac{\omega}{2\pi} = \frac{2\pi\times10^{6}}{2\pi} = 10^{6}\,Hz$$

$$\text{Wavelength} = \frac{2\pi}{\kappa} = \frac{2\pi}{\pi\times10^{-2}} = 200\ m$$

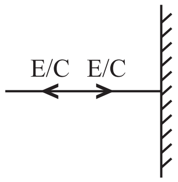
16. **(c)** α-rays is nothing but nucleus of helium moving at higher speed.

17. **(c)** Heat radiation is the another name of infrared radiation and it is a type of em wave which travels with the speed of light 3×10^8 m/s. Heat radiation is called because water molecules present in most materials readily absorb infra

waves. After absorbtion their thermal motion increases that is they heat up and heat their surrounding.

18. (c) $\lambda_m > \lambda_v > \lambda_x$ (go to critical point table)

19. (a)



Momentum of light $p = \frac{E}{C}$

So, momentum transferred to the surface

$$= p_f - p_i = \frac{2E}{C}$$

20. (d) $B_0 = \frac{E_0}{c} = \frac{60}{3 \times 10^8} = 2 \times 10^{-7}\,T$

1. (b) As we know

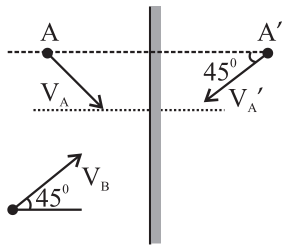
$$t = \frac{s}{v}$$

$$t = \frac{1.5\times10^8 \times 1000}{3\times10^8 \times 60}$$

$$t = \frac{500}{60} = 8.33\,min$$

2. (c) The boy will not be able to see his feet as in order to see his feet the mirror should be placed at the maximum of 0.7 m from the ground level. But as the mirror is placed at 0.8 m hence the boy will not be able to see his feet.

3. (a)



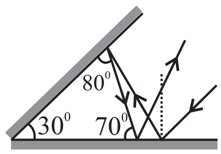
$$V_{A'B} = V_A + V_B$$

4. (a) $\delta_1 = 1000$ CW

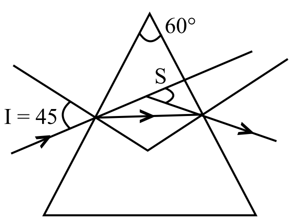
$\delta_2 = 180 - 20 = 160$ ACW

$\delta_3 = 180 - 40$ CW $= 140^0$

$\delta = 100^0 + 140^0 - 160^0 = 80^0$



5. (b)



$$\delta_{in} = 2i - A$$

$$= 2(45°) - 60° = 30°$$

$$\mu = \frac{\sin\left[\frac{A+\delta_{in}}{2}\right]}{\sin A/2} = \frac{\sin 45}{\sin 30} = \frac{1/\sqrt{2}}{1/2} = \sqrt{2}$$

6. (c) As we know,

$$\lambda \propto \frac{1}{\mu}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{\mu_2}{\mu_1} = \frac{\mu}{1}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{\mu}{1}$$

7. (c) $^2\mu_1 \times {}^3\mu_2 \times {}^4\mu_3 = \frac{\mu_1}{\mu_2} \times \frac{\mu_2}{\mu_3} \times \frac{\mu_3}{\mu_4}$

$$^2\mu_1 \times {}^3\mu_2 \times {}^4\mu_3 = \frac{\mu_1}{\mu_4}$$

$$^2\mu_1 \times {}^3\mu_2 \times {}^4\mu_3 = {}^4\mu_1 = \frac{1}{{}^1\mu_4}$$

8. (a) A → 2 and 3; B → 2 and 3; C → 2 and 4; D → 1 and 4.

9. (c) As we know,

$$\mu = \frac{1}{\sin C}$$

$$\sin C = \frac{1}{{}^w\mu_g}$$

$$C = \sin^{-1}\left(\frac{1}{{}^w\mu_g}\right)$$

$$C = \sin^{-1}\left(\frac{8}{9}\right)$$

Alternate method :

as by applying Snell's law

$$^g\mu_w = \frac{\sin i}{\sin r} \qquad i = C,\ r = 90^0$$

$$\frac{\mu_w}{\mu_g} = \frac{\sin C}{\sin 90^0}$$

$$\frac{4\times2}{3\times3} = \sin C$$

$$\sin^{-1}\left(\frac{8}{9}\right) = C$$

10. (b) Critical angle C is equal to incident angle if ray reflected normally ∴ $C = 90^0$ if-

i) $C > 90^0$ then TIR takes place

ii) $C \le 90^0$ then no TIR takes place.

11. (b) In vacuum $c = d/t$

In medium $v = \frac{5d}{T}$

$$\mu = \frac{c}{v} = \frac{T}{5t}$$

$$\text{Also, } \sin C = \frac{1}{\mu} \qquad \text{(C is critical angle)}$$

$$\therefore C = \sin^{-1}\left(\frac{5t}{T}\right)$$

12. (a) We know, $\mu = \dfrac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin A/2}$

$$\frac{c}{v} = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin A/2}$$

$$\Rightarrow v = \frac{c \times \sin A/2}{\sin\left(\frac{A+\delta m}{2}\right)}$$

$$v = \frac{3\times10^8 \sin 30^o}{\sin 45^o} \Rightarrow v = \frac{3\times10^8 \times 0.500}{0.707}$$

$v = 2.12 \times 10^8$ m/s

13. (a) $\frac{1}{f} = (\mu-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

$$\frac{1}{f} = \frac{1}{20}$$

f = 20 cm

14. (d) For real image m = –ve

$$m = -2$$

$\therefore$ As we know $M = \frac{f}{u+f}$

$$-2 = \frac{f}{u+f} \Rightarrow -2 = \frac{20}{u+20} \Rightarrow -2u + (-40) = 20$$

$$u = -30 \text{ cm}$$

15. (a) Power of lens, $P = \frac{100}{f}$

$$\therefore f = \frac{100}{10} = 10$$

According to the lens maker formula

$$\frac{1}{f} = (\mu-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{10} = (\mu-1)\left[\frac{2}{10}\right] \Rightarrow \mu = \frac{1}{2}+1$$

$$\mu = \frac{3}{2}$$

16. (a) $A_I = m^2 A_0$

$\therefore A_I = (4)^2 \times 100$

$\therefore A_I = 1600 \text{ cm}^2$

17. (a) $MP = \frac{f_0}{f_e} = \frac{200}{5} = 40$

18. (d) Magnification of compound microscope

$$m = \frac{-V_o}{u_o} \times \frac{D}{u_e}$$

$$m = m_o \times m_e$$

$$m = m_1 \times m_2$$

19. (d) Angular resolution $d\theta = \frac{1.22\lambda}{a}$

$$d\theta = \frac{1.22 \times 5000 \times 10^{-10}}{10 \times 10^{-2}}$$

$$d\theta = 6.1 \times 10^{-6} \text{ rad}$$

20. (b) At minimum deviation

$r_1 = r_2 = r$

$r_1 + r_2 = A$

$r + r = A$

$2r = A$

$$r = \frac{A}{2} = \frac{60}{2} = 30°$$

1. (d) Frequency = n; Wavelength = λ; Velocity of air = v and refractive index of glass slab = μ.

Frequency remains the same, when light changes the medium. Refractive index is the ratio of wavelengths in vacuum and in the given medium. Similarly refractive index is also the ratio of velocities in vacuum and in the given medium.

2. (a) Intensity $\propto$ width of slits

width $\propto$ (amplitude)^2

I $\propto$ (Amplitude)^2

$$\therefore \frac{I_1}{I_2} = \frac{a^2}{b^2} = \frac{1}{4} \Rightarrow \frac{1}{2} = \frac{a}{b}$$

So, width $\propto$ intensity

or b = 2a

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(a+b)^2}{(a-b)^2} = \left(\frac{a+2a}{a-2a}\right)^2$$

$$\left(\frac{3a}{-a}\right)^2 = \frac{9}{1}$$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{9}{1}$$

3. (c) $\beta = \dfrac{\lambda D}{d}$, $\beta' = \dfrac{\lambda' D}{d}$

$$\therefore \frac{\beta'}{\beta} = \frac{\lambda' D}{d} \times \frac{d}{\lambda D} = \frac{\lambda'}{\lambda} = \frac{1}{\mu}$$

$$\beta' = \frac{\beta}{\mu} = \frac{2}{1.33} = 1.5 \text{ mm}$$

4. (b) $A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$

$$A = \sqrt{16 + 9 + 2 \times 4 \times 3 \times \cos \pi/3}$$

$$\therefore A = \sqrt{25 + 24 \times \frac{1}{2}}$$

$$= \sqrt{25+12} = \sqrt{37} = 6.082$$

$A \approx 6$

5. (d) The phase difference between the light waves reaching the third bright fringe from the central bright fring will be $\Delta\phi = 2\, n\pi$

n = 3

$\Delta\phi = 2 \times 3 \times \pi = 6\pi$ (case of constructive interference)

6. (d) Let n_1 bright fringe of λ_1 coincides with n_2 bright fringe of λ_2. Then

$$\frac{n_1\lambda_1 D}{d} = \frac{n_2\lambda_2 D}{d}$$

or $n_1\lambda_1 = n_2\lambda_2$

$$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{10000}{12000} = \frac{5}{6}$$

Let x be given distance.

$$\therefore x = \frac{n_1\lambda_1 D}{d}$$

Here, $n_1 = 5$, D = 2 m, d = 2 mm = 2×10^{-3} m

$\lambda_1 = 12000\ \text{Å} = 12000 \times 10^{-10}$ m $= 12 \times 10^{-7}$ m

$$x = \frac{5 \times 12 \times 10^{-7} \text{ m} \times 2 \text{ m}}{2 \times 10^{-3} \text{ m}} = 6 \times 10^{-3} \text{ m} = 6 \text{ mm}$$

7. (a) If thin film appears dark

$2\,\mu t\cos r = n\lambda$ [for normal incidence r = 0°]

$$2\mu t = n\lambda \Rightarrow t = \frac{n\lambda}{2\mu}$$

$$t_{min} = \frac{5890 \times 10^{-10}}{2 \times 1} = 2.945 \times 10^{-7} \text{ m}$$

8. (d) $\beta = \dfrac{\lambda D}{d} \xrightarrow[\text{VIBGYOR}]{}, \lambda$ increases

$$\left.\begin{array}{l}\lambda_R > \lambda_G > \lambda_B \\ \text{so } \beta_R > \beta_G > \beta_B\end{array}\right. \Rightarrow \beta \propto \lambda$$

9. (a) Angular fringe width of first minima

$$\theta = \frac{2(2n-1)\lambda}{2d} = \frac{(2n-1)\lambda}{d}$$

$$\theta = \frac{(2\times1-1)\times 4.8\times10^{-7}}{0.6\times10^{-3}}$$

$= 8 \times 10^{-4}$ rad

Angular width = 8×10^{-4} rad

10. (d) a = 4cm = 4×10^{-2} m

λ = 2 cm = 2×10^{-2} m

Angular spread of central maximum (2θ) is

$a \sin\theta = \lambda n$

$$\sin\theta = \frac{2\times10^{-2}}{4\times10^{-2}} \Rightarrow \sin\theta = \frac{1}{2} \Rightarrow \theta = 30^\circ$$

Angular spread = $2\theta = 2 \times 30^\circ = 60^\circ$

11. (c) $\theta = \dfrac{1.22\lambda}{D} = \dfrac{1.22 \times 555 \times 10^{-9}}{25 \times 10^{-2}}$

$\theta = 2.7 \times 10^{-6}$ rad

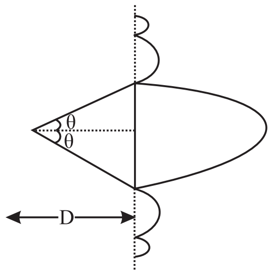
12. (d) Width of central bright fringe $= \dfrac{2\lambda D}{d}$

$$= \frac{2 \times 500 \times 10^{-9} \times 80 \times 10^{-2}}{0.2 \times 10^{-3}}$$

4×10^{-3} m

Width of central bright fringe = 4mm

13. (d) Linear width of central maxima = $2D\theta = 2D\frac{\lambda}{a}$



14. (a) Limit of resolution of telescope

$$d\theta = \frac{1.22\lambda}{D} = \frac{1.22\times 6\times 10^{-5}}{254}$$

[D = 100 inch
= 100 × 2.54
= 254 cm]

$d\theta = 2.9 \times 10^{-7}$ m

15. (b) Angular width = $\frac{2\lambda}{d}$

$$= \frac{2\times 12000\times 10^{-9}}{5\times 10^{-3}}$$

$$= \frac{24}{5}\times 10^{-3}$$

Angular width = 4.8×10^{-3} = 4.8mm

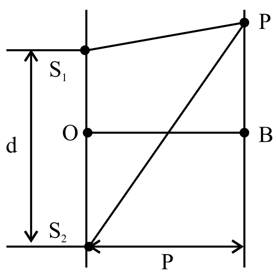
16. (b) According to Brewster law. $\mu = \tan i_p$

$1.732 = \tan i_p$

$\tan^{-1}(1.732) = i_p$

$60^o = i_p$

17. (d)



Path difference = $S_2P - S_1P$

$\sqrt{D^2+d^2} - D$

$$D\left\{1+\frac{1}{2}\frac{d^2}{D^2}\right\} - D$$

$$D\left\{1+\frac{1}{2}\frac{d^2}{D^2} - 1\right\} = \frac{d^2}{2D}$$

$$\Delta x = \frac{d^2}{2\times 10d} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$$

$$\Delta\phi = \frac{2\pi}{\lambda}\frac{\lambda}{4} = \frac{\pi}{2}$$

So intensity at desired point is

$$I = I_0\cos^2\frac{\phi}{2} = I_0\cos^2\frac{\pi}{4} = \frac{I_0}{2}$$

18. (d) By using $\mu = \tan i_p$

$\mu = \tan 60^o = \sqrt{3}$

$$C = \sin^{-1}\left(\frac{1}{\mu}\right) \Rightarrow C = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

19. (b) According to the Brewster $\mu = \tan i_p$

$\mu = \tan\ 53.74$

$\mu = \sqrt{2}$

$$\therefore \sqrt{2} = \frac{\sin i}{\sin r} \Rightarrow \sqrt{2} = \frac{\sin 45^o}{\sin r}$$

$$\sin r = \frac{1}{\sqrt{2}}\times\frac{1}{\sqrt{2}} = \frac{1}{2}$$

$$r = \sin^{-1}\left(\frac{1}{2}\right)$$

$r = 30^o$

20. (d) Let $\frac{I_1}{I_2} = \frac{n}{1}$

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2 - \left(\sqrt{I_1}-\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2 + \left(\sqrt{I_1}-\sqrt{I_2}\right)^2} = \frac{4\sqrt{I_1I_2}}{2\left(I_1+I_2\right)}$$

Dividing numerator and denominator by I_2,

$$\text{Required ratio will be } = \frac{2\sqrt{I_1/I_2}}{\left(\frac{I_1}{I_2}+1\right)} = \frac{2\sqrt{n}}{n+1}$$

1. (c) For an electron $\lambda = \dfrac{h}{\sqrt{2mk}}$

$$\therefore \lambda \propto \frac{1}{\sqrt{k}}$$

$$\therefore \frac{\lambda'}{\lambda} = \frac{\sqrt{k}}{\sqrt{3k}} \Rightarrow \lambda' = \frac{\lambda}{\sqrt{3}}$$

2. (d) Collision between the charged particles emitted from the cathode and the atoms of the gas cause the colored glow in the tube of electric discharge.

3. (c) Gain in K.E = charge × potential difference.

4. (a) Photons move with velocity of light and possess energy hν. Therefore it also exerts pressure.

5. (a) Energy of photon $E = h\nu = \dfrac{hc}{\lambda_p}$

$$\lambda_p = \frac{hc}{E}$$

Wave length of electron $\lambda_e = \dfrac{h}{\sqrt{2mE}}$

$$\therefore \frac{\lambda_p h}{\lambda_e} = \frac{hc}{E} \times \frac{\sqrt{2mE}}{h} = c\sqrt{\frac{2m}{E}}$$

6. (d) de Broglie wavelength, $\lambda = \dfrac{h}{p}$

For electron $\lambda = \dfrac{h}{p_e}$, for proton $\lambda_p = \dfrac{h}{P_p}$

As $\lambda_e = \lambda_p$ given

$\Rightarrow p_e = p_p$

7. (a) From the relation : K.E = $h\nu - \phi_o$

$$\therefore \text{K.E} = h\nu - h\nu_o$$

Thus $\phi = h\nu_o = \dfrac{hc}{\lambda_o}$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{6500 \times 10^{-10}} = 0.30 \times 10^{-16}$$

$$= \frac{0.30 \times 10^{-16}}{1.6 \times 10^{-19}} = 2\text{eV}$$

8. (b) The maximum kinetic energy of the emitted electron is given by.

$K_{max} = h\nu - \phi_o = h(4\nu - \nu) = h\,(3\nu)$

$K_{max} = 3h\nu$

9. (b) Stopping potential = $K_{max} = h\nu - \phi_0 = eV_s$

$= 1.8 - 0.5$

$= 1.3$ eV

10. (b) $\because \lambda = \dfrac{h}{mv} = \dfrac{h}{p}$

Since the wavelength of particle and electron are equal, momentum of electron should be equal to momentum of particle

$\Rightarrow m_1v_1 = m_2v_2$

$\Rightarrow 1\text{mg} \times v_1 = 3 \times 10^6 \times 9.1 \times 10^{-31}$

$\Rightarrow 10^{-6} \times v_1 = 3 \times 10^6 \times 9.1 \times 10^{-31}$

$v_1 = 2.7 \times 10^{-18}$ m/s

11. (a) As by the relation

$$eV_o = h\,(\nu - \nu_o)$$

$$V_o = \frac{h(\nu - \nu_o)}{e}$$

$$= \frac{6.6 \times 10^{-34} \times (8.2 - 3.3) \times 10^{14}}{1.6 \times 10^{-19}}$$

$$= \frac{6.6 \times (4.4) \times 10^{-1}}{1.6} = \frac{11 \times 6.6 \times 10^{-1}}{4}$$

$= 1.8 \approx 2$V

12. (a) $P = \dfrac{hc}{\lambda} \Rightarrow P \propto \dfrac{1}{\lambda}$ (Rectangular hyperbola)

13. (c) $W_o = \dfrac{6.6 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times \lambda_o} = \dfrac{12375}{\lambda_o}$

$$= \frac{12375}{4.2} = 2945\,\text{Å}$$

14. (c) $W_o = \dfrac{hc}{\lambda_o}$

$$\therefore W_o \propto \frac{1}{\lambda_o}$$

$$\frac{W_{o(T)}}{W_{o(No)}} = \frac{\lambda_{o(Na)}}{\lambda_{o(T)}} \Rightarrow \lambda_{o(T)} = \frac{\lambda_{o(Na)} \times W_{o(Na)}}{W_{o(T)}}$$

$$\lambda_{o(T)} = \frac{5460 \times 2.3}{4.5} = 2791\,\text{Å}$$

15. (c) $W_o = \dfrac{hc}{\lambda_o} = \dfrac{6.625 \times 10^{-34} \times 3 \times 10^8}{5000 \times 10^{-10}} = 4 \times 10^{-19}$ Joules

16. (a) $W_o = \dfrac{hc}{\lambda_o}$

Energy of the radiation of wavelength $2000\,\text{Å}$ is greater than the energy of 3000 Å hence we know

$$eV_o = \frac{hc}{\lambda} - \frac{hc}{\lambda_o}$$

$\therefore$ electron will be emitted.

17. (b) $\lambda_p = \dfrac{h}{p} = \dfrac{hc}{E}$ and $\lambda_e = \dfrac{h}{p} = \dfrac{h}{\sqrt{2mE}}$

$\Rightarrow \lambda_p \propto \lambda_e^2$

18. (c) From photoelectric equation

$$E = h\nu = \frac{hc}{\lambda}$$

$$E = \frac{6.6\times10^{-34}\times3\times10^{8}}{5000\times10^{-10}} = 3.96\times10^{-19}\,J$$

$$E = \frac{3.96\times10^{-19}}{1.6\times10^{-19}} = 2.48eV$$

Hence, $E_K = 2.48 - 1.90 = 0.58ev$

19. (b) According to the planck's quantum law

$$E = nh\nu = n\left(\frac{hc}{\lambda}\right)$$

$$\frac{E}{t} = \frac{n}{t}\left(\frac{hc}{\lambda}\right) \Rightarrow 10^{-7} = \left(\frac{n}{t}\right)\frac{6.6\times10^{-34}\times3\times10^{8}}{5000\times10^{-10}}$$

$$\frac{n}{t} = \frac{5000\times10^{-10}\times10^{-7}}{6.6\times10^{-34}\times3\times10^{8}} = 2.5\times10^{11}\text{ sec}$$

20. (c) $\lambda = \frac{0.286}{\sqrt{E(\text{in eV})}}\,\mathring{A}$

$$= \frac{0.286}{\sqrt{3}}\,\mathring{A}$$

$$= 1.65\times10^{-11}\,m$$

1. (b) $E = \frac{(Ze)(e)}{4\pi\varepsilon_o r} = \frac{9\times10^9 \times 79 \times (1.6\times10^{-19})^2}{5\times1.6\times10^{-13}}$

$r = 2.3 \times 10^{-14}$m

2. (a) In 1885, the first spectral series were observed by Johann Jakob Balmer, This series is called the Balmer series.

3. (d) H_δ line has smallest wavelength, Hence The frequency of this line will be maximum because $\nu \propto \frac{1}{\lambda}$.

4. (d) $\because$ K.E. $= \frac{1}{2}|\text{P.E.}|$

But Potential energy is negative.

So, total energy = K.E + P.E

$-3.4 = \frac{1}{2}\text{P.E.} - \text{P.E.}$

$\Rightarrow -3.4 = \frac{-\text{P.E.}}{2}$

$\Rightarrow$ K.E. = +3.4 eV

Basically, K.E. $= |\text{T.E.}| \Rightarrow$ K.E. $= \frac{1}{2}|\text{P.E.}|$

5. (a) For Lyman series

$\nu = Rc\left[\frac{1}{(1)^2} - \frac{1}{n^2}\right]$, n = 2,3,4....

For the series limit for lyman series $n = \infty$

$\therefore \nu_1 = Rc\left[\frac{1}{(1)^2} - \frac{1}{\infty^2}\right] = Rc$ (1)

For the first line of lyman series , n = 2

$\therefore \nu_2 = Rc\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right] = \frac{3}{4}Rc$ (1)

For Balmer series

$\therefore \nu = Rc\left[\frac{1}{(2)^2} - \frac{1}{n^2}\right]$ n = 3,4,5...

For the series limit of Balmer series, $n = \infty$

Similarly as eq. (1)

$\therefore \nu_3 = Rc\left[\frac{1}{(2)^2} - \frac{1}{(\infty)^2}\right] = \frac{Rc}{4}$ (3)

From eq (1), (2), & (3) we get

$v_1 = v_2 + v_3$

$\Rightarrow v_1 - v_2 = v_3$

6. (b) $eV_3 = \frac{1}{2}mv_{max}^2 = h\nu - \phi_0$

$2 = 5 - \phi_0 \Rightarrow \phi_0 = 3$ eV

In second case

$eV_s = 6 - 3 = 3eV \Rightarrow V_s = 3$ V

$\therefore V_{AC} = -3V$

7. (a) In the nth orbit, let rn = radius and vn = speed of electron.

Time period, $T_n = \frac{2\pi r_n}{V_n} \propto \frac{r_n}{V_n}$

Now, $r_n \propto n^2$ and $V_n \propto \frac{1}{n}$

$\therefore \frac{r_n}{V_n} \propto n^3$ or $T_n \propto n^3$

Here $8 = \left(\frac{n_1}{n_2}\right)^3 \Rightarrow \frac{n_1}{n_2} = 2 \Rightarrow n_1 = 2n_2$

8. (d) According to Einstein Mass-energy equivalence, For photon,

E = pC

Here, E = 1 MeV

$= 1 \times 10^6 \times 1.6 \times 10^{-19}$ J

$= 1.6 \times 10^{-13}$ J

$\therefore p = \frac{E}{C} = \frac{1.6\times10^{-13}}{3\times10^8} = 5\times10^{-22}$ kgm/s

9. (c) The radius of nth orbit

$r_n = \frac{n^2h^2 4\pi\varepsilon_o}{me^2}$

where $\frac{h^2 4\pi\varepsilon_o}{me^2} = a_o$ (Bohr radius)

Hence, $r_n = n^2a_o$

10. (b) Radius of nth orbit in hydrogen like atoms is

$r_n = \frac{a_o n^2}{z}$ (Where a_o is the Bohr's radius)

For hydrogen atom, Z = 1

$\therefore r_1 = a_0$ (n = 1 for ground state)

For Be^{3+}, Z = 4 $\therefore r_n = \frac{a_o n^2}{4}$

According to given problem

$r_1 = r_n$

$a_o = \frac{n^2 a_o}{4}$

n = 2

11. (c) Nuclear forces are short range forces

12. (c) $\frac{N}{N_o} = \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}} \Rightarrow \frac{1}{4} = \left(\frac{1}{2}\right)^{\frac{t}{10}}$

$$\Rightarrow \frac{t}{10} = 2 \Rightarrow t = 20$$

13. (c) Decay constant for the processes are

$$\lambda_1 = \frac{0.693}{t_1}, \ \lambda_2 = \frac{0.693}{t_2}$$

The probability that an active nucleus decays by the first process in small time dt is $\lambda_1 dt$.

Similarly for second decay. The probability that it decays either by first process or second process is $(\lambda_1 dt + \lambda_2 dt)$.

If effective decay constant is λ this probability is also equal to λdt

$$\therefore \lambda dt = \lambda_1 dt + \lambda_2 dt$$

$$\lambda = \lambda_1 + \lambda_2$$

$$\therefore \frac{0.693}{t} = \frac{0.693}{t_1} + \frac{0.693}{t_2}$$

$$\frac{1}{t} = \frac{1}{t_1} + \frac{1}{t_2}$$

14. (c) $^{A}_{Z}Y \xrightarrow[X_\alpha]{2X_\beta} A - 4x$

Here, mass no. change & Atomic no. remains same

z – 2x + 2x

Let no. of β particles emitted be 2x

And no. of α particles emitted be x

Emission of 1 β particle increases atomic no by 1

Emission of 1 α particle decreases atomic no by 2

So, Atomic number remains same

Hence, daughter is an isotope of parent.

15. (c) According to Einstein mass - energy equivalence,

$$E = mc^2 \Rightarrow m = \frac{E}{c^2} \Rightarrow \Delta m = \frac{\Delta E}{c^2}$$

Mass decay per second

$$= \frac{\Delta m}{\Delta t} = \frac{\Delta E}{c^2 \Delta t} = \frac{P}{c^2} = \frac{1000 \times 10^3}{(3 \times 10^8)^2}$$

$$= \frac{1}{9} \times 10^{-10}\,\text{kgs}^{-1}$$

Mass decay per hour

$$= \frac{1}{9} \times 10^{-10} \times 3600 = 4 \times 10^{-8}\,\text{kg}$$

= 40 μg

16. (d) As we know that radius $\propto [\text{Mass number}(A)]^{1/3}$

$$R = R_0 A^{1/3}$$

$$\text{Here}, R_{Ge} = 2R_{Be}$$

$$\frac{R_{Ge}}{R_{Be}} = \left[\frac{A_{Ge}}{A_{Be}}\right]^{1/3}$$

$$\Rightarrow \frac{2R_{Be}}{R_{Be}} = \left[\frac{A_{Ge}}{9}\right]^{1/3}$$

$$\Rightarrow (2)^3 = \frac{A_{Ge}}{9}$$

$\Rightarrow A_{Ge} = 72$ So, no. of nucleons in Ge = 72

17. (a) ${}_1H^2 + {}_1H^2 = {}_2He^4 + \Delta E$

$\Delta E = 4(7) - 2(1.1 + 1.1) = 23.6$ eV

18. (a) 180 – 4 – 0 – 4 – 0 = 172 Mass number

72 – 2 + 1 – 2 + 0 = 69 Atomic number

19. (b) It stops the high energy neutrons.

20. (a) $N = N_0 e^{-\lambda t}$ $\quad \lambda_1 = 8\lambda \quad \lambda_2 = \lambda$

$$N_1 = N_0 e^{-\lambda_1 t} \quad .....(1)$$

$$N_2 = N_0 e^{-\lambda_2 t} \quad .....(2)$$

Dividing Eq. (1) by Eq. (2), we get

$$\frac{N_1}{N_2} = e^{\lambda_2 t - \lambda_1 t}$$

$$\frac{1}{e} = e^{t(\lambda_2 - \lambda_1)}$$

$$e^{-1} = e^{t[\lambda - 8\lambda]} \Rightarrow e^{-1} = e^{-7\lambda t}$$

$$t = \frac{1}{7\lambda}$$

1. **(a)** Mean free path $d = 4 \times 10^{-8}$ m , $E = ?$

Energy of electron = 2 ev

$F = eE$

Work done on electron when it moves through distance d = eED. This work done is equal to the energy transfered to the electron, so

$\therefore$ eEd = 2 ev

Ed = 2v

$$E = \frac{2v}{d} = \frac{2 \times v}{4 \times 10^{-8}} = 5 \times 10^{7}\ v/m$$

2. **(c)** Because with rise in temperature, resistance of semiconductor decreases, hence overall resistance of the circuit decreases, which in turn increases the current in the circuit.

3. **(d)** Voltage drop across

$1\ k\Omega = V_z = 15$ V

$$I' = \frac{15\ V}{1\ k\Omega} = 15\ mA$$

Voltage drop across 250 Ω = 20 – 15 = 5 V

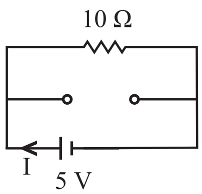
So, Current through $250\ \Omega = \frac{5}{250} = 20\ mA$

$\therefore$ Current through the Zener diode

= 20 – 15 = 5 mA

4. **(b)** Formation of energy bands in solids are due to Pauli's exclusion.

5. **(d)** $I = \frac{5}{10} = 0.5$ A



6. **(b)** Resistance will increase as Resistance $\propto \frac{1}{\text{Temperature}}$

7. **(b)** In an unbiased p-n junction the diffusion of charge carriers across the junction take from higher concentration to lower concentration.

8. **(b)** A=Voltage gain $A_V = \frac{\Delta V_C}{\Delta V_B} = \frac{R_L \Delta I_C}{\Delta V_B} = g_m R_L$

$$\frac{A_{V_1}}{A_{V_2}} = \frac{g_{m_1}}{g_{m_2}} \Rightarrow \frac{G}{A_{V_2}} = \frac{0.03}{0.02} \Rightarrow A_{V_2} = \frac{2}{3}G$$

9. **(c)** The depletion region created at the junction is devoid of free charge carriers.

10. **(c)** Diode is reversed biased, so only drift current due to minority carriers which is 20μA

Potential drop across Resistor

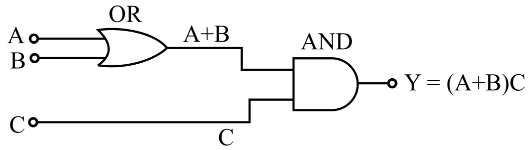
V = 15Ω × 20μA

= 300 μv = 0.0003V

Potential difference across the diode

= 4 – 0.0003 = 3.99 = 4V

11. **(b)**

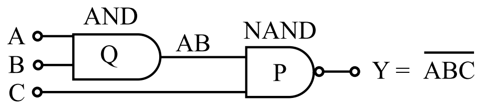


Option (b) satisfy, Y = 1

Y = (1 + 0)1

Y = 1

12. **(a)**



When A = B = C = 0 Y = 1

A = B = C = 1 Y = 0

13. **(c)** Input $V_{rms} = 20V$

Peak value of input voltage $V_o = \sqrt{2}\, V_{rms}$

$= \sqrt{2} \times 20 = 28.28V$

Since the transformer is a set up transformer having transformer ratio 1:2 the maximum value of output voltage of the transformer applied the diode will be

$V_o = 2 \times 28.28V$

$$\frac{2V_o}{\pi} \Rightarrow \frac{2 \times 2 \times 28.28}{\frac{22}{7}} = 36V$$

14. **(b)** Reverse resistance = $\frac{\Delta v}{\Delta I} = \frac{1}{0.5 \times 10^{-6}} = 2 \times 10^{+6}\Omega$

15. **(a)** Input signal $V_{in} = 2\cos\left(15t + \frac{\pi}{3}\right)$

Voltage gain = 150

CE amplifier gives phase difference of π between input and output signals

$$A_V = \frac{V_0}{V_{in}}$$

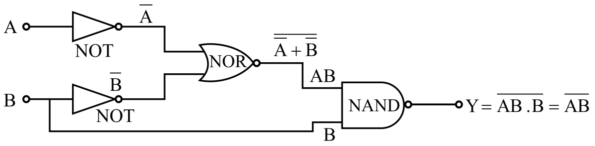
so $V_0 = A_V V_{in}$

So, $V_0 = 150 \times 2\cos\left(15t + \frac{\pi}{3} + \pi\right)$

$$V_0 = 300\cos\left(15t + \frac{4\pi}{3}\right)$$

16. **(b)** As the output voltage obtained in a half wave rectifier circuit has a single variation in one cycle of ac voltage, hence the fundamental frequency in the ripple of output voltage would be = 50Hz

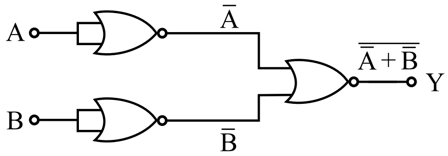
17. (a)



NAND gate

18. (a) $Y = \left(\overline{A+B}\right).\left(\overline{A+B}\right) = \overline{A+B} = \left(\bar{A}\cdot\bar{B}\right)$

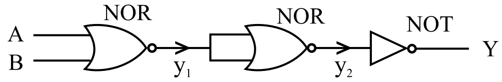
19. (b)



$$\overline{\bar{A}+\bar{B}} = \bar{\bar{A}}\cdot\bar{\bar{B}} = A\cdot B$$

AND gate

20. (b)



$y_1 = \overline{A+B}$

$y_2 = \overline{y_1+y_1} = \overline{y_1} = \overline{\overline{A+B}} = A+B$

$y = \overline{y_2} = \overline{A+B}$

NOR GATE