1. (c)

$$E_0=\frac{3}{5}\times\frac{8\times7}{R}\times\frac{e^2}{4\pi\varepsilon_0}=\frac{3}{5}\times\frac{8\times7}{R}\times1.44MeV$$

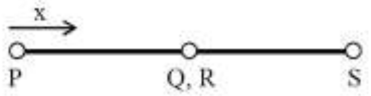
$$E_N=\frac{3}{5}\times\frac{7\times6}{R}\times\frac{e^2}{4\pi\varepsilon_0}=\frac{3}{5}\times\frac{7\times6}{R}\times1.44MeV$$

so $|E_0-E_N|=\frac{3}{5}\times\frac{1.44}{R}\times7(2)\ldots$ (i)

Now mass defect of N atom = 8 x 1.008665 + 7 x 1.007825 - 15.000109
= 0.1239864 u
So binding energy = 0.1239864 x 931.5 MeV
and mass defect of O atom = 7 x 1.008665 + 8 x 1.007825 - 15.003065
= 0.12019044 u
So binding energy =0.12019044 x 931.5 MeV
So $|B_0 - B_N|$ = 0.0037960 x 931.5 MeV .. .. (ii)
from (i) and (ii) we get
R= 3.42 fin.

2. (a)

From given data;



so, $T-10=\frac{400-T}{2}$

$\Rightarrow$ T = 140 °C
As a function of x,
T(x)=10+130x
$\Rightarrow$ AT(x) = T(x)-10=130x
Extension in a small element of length dx is

$dl=\alpha\Delta T(x)dx=130\alpha xdx$

$\Rightarrow$ Net extension

$$\Delta l=130\alpha\int_0^1 xdx=\frac{130}{2}\times1.2\times10^{-5}\times1$$

or, Δl = 0.78mm.

3. (c)

Initial activity $\frac{\text{Initial activity}}{64}=\frac{\text{Required activity}}{2^6}$

Time required = 6 half lives
= 6 x 18 days
= 108 days.

4. (c)

In first; main scale reading = 2.8 cm.

Vernier scale reading = 7 x $\frac{1}{10}$ =0.07 cm

So reading = 2.87 cm ;
In second; main scale reading = 2.8 cm

Vernier scale reading = $7\times\frac{-0.1}{10}=\frac{-0.7}{10}$ = -0.07 cm

so reading = (2.80 + 0.10 - 0.07) cm = 2.83 cm

5. (c)

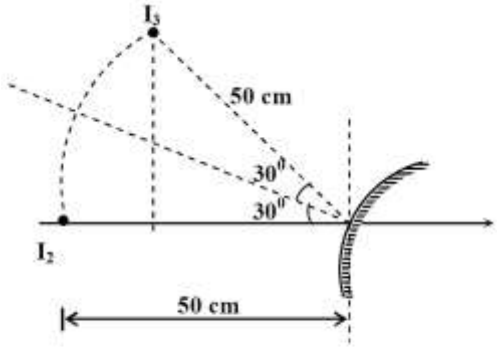
$\gamma=\frac{5}{3}\Rightarrow$ monoatomic gas

From first law of thermodynamics

H = W + ΔU
W = P_i ΔV
= 700J
ΔU = nC_v ΔT
$= \frac{3}{2}\left[P_f V_f - P_i V_i\right] = -\frac{900}{8} J$
So, H = W + ΔU =588 J

6. (a)

First Image I_1 from the lens will be formed at 75 cm to the right of the lens.



Taking the mirror to be straight, the image I_2 after reflection will be formed at 50 cm to the left of the mirror.
On rotation of mirror by 30 the final image is I_3.
So x = 50-50 cos 60° = 25 cm.
And y= 50 sin 60° =$25\sqrt{3}$ cm

7. (b, c)

Since S_1S_2 line is perpendicular to screen shape of pattern is concentric semicircle

At $O, \frac{2\pi}{\lambda}(S_1O - S_2O) = \frac{2\pi 0.6003\times10^{-3}}{600\times10^{-9}} = 2001\pi$

$\therefore$ darkness close to O.

8. (a, b, d)

Error in T

$T_{mean} = \frac{0.52+0.56+0.57+0.54+0.59}{5} = 0.556 \approx 0.56s$

$\Delta T_{mean} = 0.02$

$\therefore$ error in T is given by $\frac{0.02}{0.56}\times100$ = 3.57%

Error in r= $\frac{1}{10}$x 100=10%

Error in g

$\because T = 2\pi\sqrt{\frac{7(R-r)}{5g}}$

$T^2 = 4\pi^2 \frac{7}{5}\left(\frac{R-r}{g}\right)$

$g = \frac{28\pi^2}{5}\left(\frac{R-r}{T^2}\right)$

$\frac{\Delta g}{g} = \left(\frac{\Delta R+\Delta r}{R-r}\right) + 2\frac{\Delta T}{T} = \frac{2}{50} + 2\times0.0357$

$\therefore \frac{\Delta g}{g}\times100 \approx 11\%$

9. (c, d)

For right edge of loop from x = 0 to x = L

$$i = +\frac{vBL}{R}$$

$$F = iLB = \frac{vB^2L^2}{R} \text{ (leftwards)}$$

$$-mv\frac{dv}{dx} = \frac{vB^2L^2}{R}$$

$$\therefore v(x) = v_0 - \frac{B^2L^2}{mR}x$$

$$i(x) = \frac{v_0Bl}{R} - \frac{B^3L^3}{mR^2}x$$

$$F(x) = \frac{v_0B^2L^2}{R} - \frac{B^4L^4}{mR^2}\times \text{ (leftwards)}$$

10. (a)

Equation Becomes

$$\frac{hC}{\lambda_{ph}} + eV - \phi = \frac{P_{\max}^2}{2m}$$

$$\frac{hC}{\lambda_{Ph}} + eV - \phi = \frac{h^2}{2m\lambda_e^2}$$

For $V >> \frac{\phi}{e}$

$$\Rightarrow \phi << eV \text{ and } \frac{hC}{\lambda_{ph}} << eV \Rightarrow eV = \frac{h^2}{2m\lambda_e^2}$$

$$\lambda_e \propto \frac{1}{\sqrt{V}}$$

when V is made four times λ_e is halved.

11. (d) OR (a, d)

$$\omega_z = \frac{\omega a}{l}\cos\theta = \omega / 5$$

12. (a, c)

For maximum voltage range across a galvanometer, all the elements must be connected in series. For maximum current range through a galvanometer, all the elements should be connected in parallel.

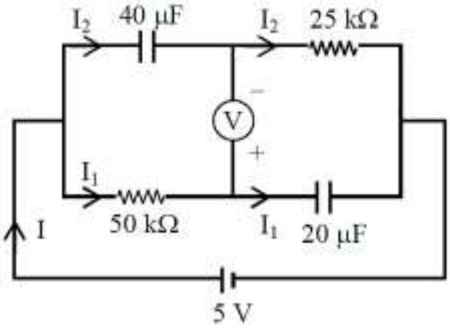
13. (a, b, c, d)

at t = 0, voltage across each capacitor is zero, so reading of voltmeter is -5 Volt.

at $t = \infty$, capacitors are fully charged. So for ideal voltmeter, reading is 5Volt.

at transient state, $I_1 = \frac{5}{50}e^{-\frac{t}{\tau}}mA, I_2 = \frac{5}{25}e^{-\frac{1}{\tau}}$ and $I = I_1 + I_2$

Where $\tau = 1\sec$



where τ = 1 sec

So I becomes 1/e times of the initial current after 1 sec.

The reading of voltmeter at any instant = $= \Delta V_{40\mu F} - \Delta V_{50k\Omega} = 5\left(1-e^{-\frac{1}{\tau}}\right) - 5e^{-\frac{1}{\tau}}$

So at t = ln2 sec, reading of voltmeter is zero.

14. (a, b, d)

Case (i): $\omega' = \sqrt{\dfrac{k}{M+m}}$

$MA\sqrt{\dfrac{k}{M}} = (M+m)A'\sqrt{\dfrac{k}{M+m}}$, so $A' = A\sqrt{\dfrac{M}{M+m}}$

$E' = \dfrac{1}{2}(M+m)\dfrac{k}{M+m}A^2\dfrac{M}{M+m} = \dfrac{1}{2}\dfrac{kA^2M}{M+m}$

$v' = \dfrac{Mv}{M+m}$

Case(ii): $\omega' = \sqrt{\dfrac{k}{M+m}}$

A remains same

$E' = \dfrac{1}{2}(M+m)\dfrac{k}{M+m}A^2$ (Remains Same)

$v' = A\sqrt{\dfrac{k}{M+m}}$

15. (i) (d)

$v\dfrac{dv}{dr} = \omega^2 r$, where v is the velocity of the block radially outward.

$\int_0^v v\,dv = \omega^2\int_{R/2}^{r} r\,dr$

$\Rightarrow v = \omega\sqrt{r^2 - \dfrac{R^2}{4}}$

$\int_{R/2}^{r}\dfrac{dr}{\sqrt{r^2-\dfrac{R^2}{4}}} = \omega\int_0^t dt$

$r = \dfrac{R}{4}\left(e^{\omega t} + e^{-\omega t}\right)$

(ii) (c)

$\vec{F}_{rot} = \vec{F}_{in} + 2m\left(\vec{v}_{rot}\times\vec{\omega}\right) + m\left(\vec{\omega}\times\vec{r}\right)\times\vec{\omega}$

$= -m\omega^2 r\hat{i} + 2mv_{rot}\omega\left(-j\right) + m\omega^2 r\hat{i}$

$= -2mv_{rot}\omega j$

$v_{rot} = \dfrac{dr}{dt} = \dfrac{\omega R}{4}\left(e^{\omega t} - e^{-\omega t}\right)$

16. (i) (a)

After hitting the top plate, the balls will get negatively charged and will now get attracted to the bottom plate which is positively charged. The motion of the balls will be periodic but not SHM.

(ii) (b)

If Q is charge on balls, then Q $\propto$ V_0 ...(i)

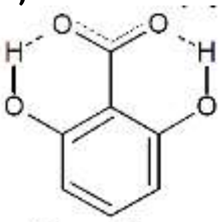
Also $h = \dfrac{1}{2}at^2 = \dfrac{1}{2}\left(\dfrac{QV_0}{mh}\right)t^2$

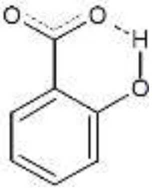
$\Rightarrow t \propto \frac{1}{V_0}$

Now, $I_{av} \propto \frac{Q}{t}$

$\Rightarrow I_{av} \propto V_0^2$

17. **(a)** Stabler the conjugate base stronger the acid.


Conjugate base stabilized by intramolecular H-bond from both the sides.


Conjugate base stabilized by intramolecular H-bond from one side

18. **(a)**

$[Ni(NH_3)_6]^{2+}$; $[Pt(NH_3)_4]^{2+}$; $[Zn(NH_3)_4]^{2+}$
octahedral square planar tetrahedral

19. **(d)**

Anode: $H_2 - 2e \rightleftharpoons 2H^+$

Cathode: $M^{4+} + 2e \rightleftharpoons M^{2+}$

Net cell reaction: $H_2 + M^{4+} \rightleftharpoons 2H^+ + M^{2+}$

$$E_{cell} = E^0_{cell} - \frac{0.059}{2}\log\frac{\left[H^+\right]^2\left[M^{2+}\right]}{\left[M^{4+}\right]\times P_{H_2}}$$

$$0.092 = 0.151 - \frac{0.059}{2}\log 10^x$$

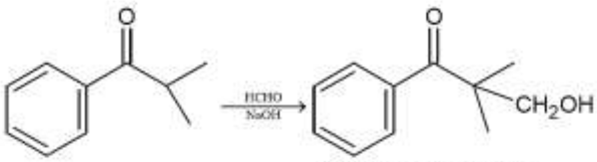
$$0.092 = 0.151 - \frac{0.059}{2}x$$

$$\frac{0.059x}{2} = 0.151 - 0.092$$

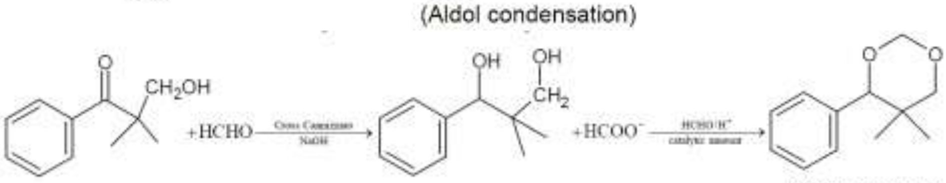
$$0.059x = 0.059 \times 2$$

$$x = 2$$

20. **(a)**



(Aldol condensation)



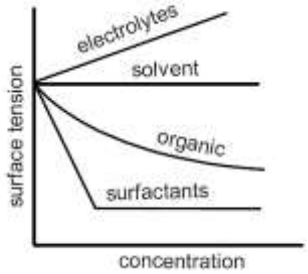
(acetal formation)

21. **(a)**

$$Ag^+ + 2S_2O_3^{2-} \rightarrow \underset{\substack{X \\ (clear\ solution)}}{\left[Ag\left(S_2O_3\right)_2\right]^{3-}} \xrightarrow{Ag^+} \underset{\substack{Y \\ (white)}}{Ag_2S_2O_3} \xrightarrow{with\ time} \underset{\substack{Z \\ (black)}}{Ag_2S}$$

$Ag_2S_2O_3 + H_2O \rightarrow Ag_2S + H_2SO_4$

22. **(d)** Strong electrolytes like KC1 increase the surface tension slightly. Low molar mass organic compounds usually decrease the surface tension. Surface active organic compounds like detergents sharply decrease surface tension



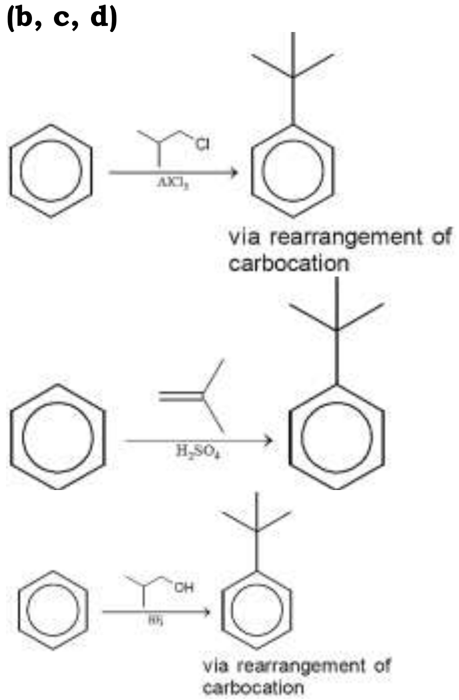
23. **(b, c)**

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} \underset{\substack{D-(+)-glu\cos e \\ +52^0}}{C_6H_{12}O_6} + \underset{\substack{D-(-)-fructose \\ -92^0}}{C_6H_{12}O_6}$$

$$\alpha_{invert\,sugar} = \frac{+52^0 - 92^0}{2} = -20^0$$

$$\alpha_{invert\,sugar} = \frac{+52^0 - 92^0}{2} = -20^0$$ (average is taken as both monomers are one mole each)

24. **(b, c, d)**



25. **(a, b, c)** Refining of blister copper is done by poling technique.

26. **(b, c, d)**

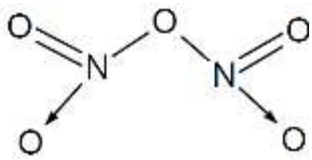
The middle layers will have 12 nearest neighbours. The top-most layer will have 9 nearest neighbours. $4r = a\sqrt{2}$, where 'a' is edge length of unit cell and 'r' is radius of atom.

27. **(c, d)** $NaBH_4$ and Raney Ni/H_2 do not react with acid, ester or epoxide entities of an organic compound.

28. **(a, b)** Benzene + toluene will form ideal solution. Phenol + aniline will show negative deviation.

29. **(b, d)**

$$2HNO_3 \xrightarrow[(dehydration, -H_2O)]{P_4O_{10}} N_2O_5$$



$$Na + N_2O_5 \rightarrow NaNO_3 + \underset{(brown)}{NO_2} \uparrow$$

30. (a, c)

31. (i) (b)

$$\underset{1}{X_2(g)} \rightleftharpoons 2X(g)$$

$$1-\frac{\beta_e}{2} \qquad \beta_e$$

$$\Rightarrow 1-\frac{\beta_e}{2}+\beta_e$$

$$\Rightarrow 1+\frac{\beta_e}{2}$$

$$K_p = \frac{(p_x)^2}{p_{x_2}}$$

$$= \frac{\left(\dfrac{\beta_e \times 2}{1+\dfrac{\beta_e}{2}}\right)^2}{\dfrac{\left(1-\dfrac{\beta_e}{2}\right)\times 2}{1+\dfrac{\beta_e}{2}}}$$

$$= \frac{2\beta_e^2}{1-\dfrac{\beta_e^2}{4}}$$

$$K_p = \frac{8\beta_e^2}{4-\beta_e^2}$$

(ii) (c)

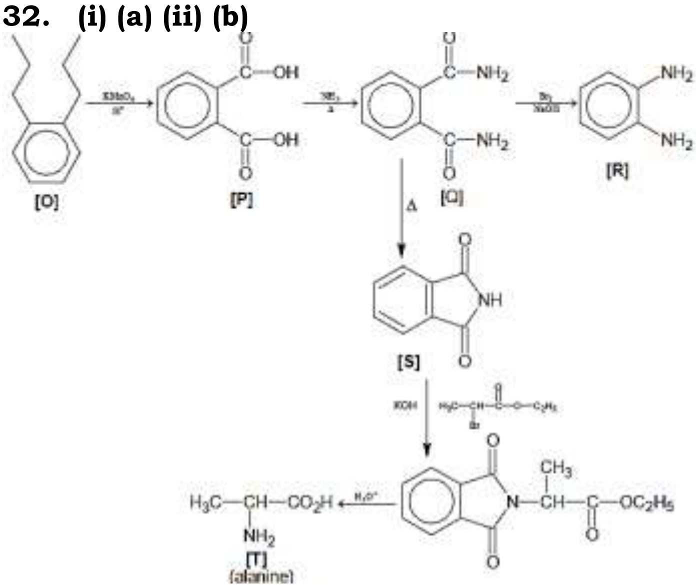
There is no data given to find the β equiiibrium exact value.

ΔG_c^0=-2.303RTlogK$_c$

logK$_c$ = -1

K$_c$<1

32. (i) (a) (ii) (b)



33. (b)

$$P=\begin{bmatrix}1&0&0\\4&1&0\\16&4&1\end{bmatrix}=\begin{bmatrix}0&0&0\\4&0&0\\16&4&0\end{bmatrix}+\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\end{bmatrix}$$

let $A=\begin{bmatrix}0&0&0\\4&0&0\\16&4&0\end{bmatrix}\Rightarrow A^2=\begin{bmatrix}0&0&0\\0&0&0\\16&0&0\end{bmatrix}$ and $A^3=\begin{bmatrix}0&0&0\\0&0&0\\0&0&0\end{bmatrix}$

$\Rightarrow$ A^n is a null matrix $\forall n\ge 3$

$$P^{50}=(I+A)^{50}=I+50A+\frac{50\times 49}{2}A^2$$

$$Q+I=\begin{bmatrix}1&0&0\\0&1&0\\0&0&1\end{bmatrix}+50\begin{bmatrix}0&0&0\\4&0&0\\16&4&0\end{bmatrix}+25\times 49\begin{bmatrix}0&0&0\\0&0&0\\16&0&0\end{bmatrix}$$

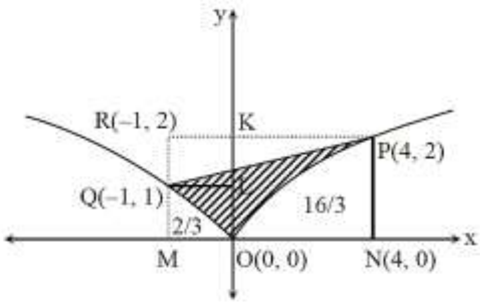
$$\Rightarrow\left(\frac{q_{31}+q_{32}}{q_{21}}\right)=\frac{16(50+25\times 49)+50\times 4}{50\times 4}$$

$$=\frac{16\times 51+8}{8}=102+1=103$$

34. (c)

Shifting origin to (-3, 0)

Area $\left\{(x,y)\in R^2: y\ge\sqrt{|x|}, 5y\le x+6\le 15\right\}$



Area = Region (OPK) + Region (QLKR) + Region (OLQ) – Triangle (PQR)

Area = $=\frac{8}{3}+1+\frac{1}{3}-\frac{5}{2}=\frac{3}{2}$

35. (c)

$$T_k=2\left(\cot\left(\frac{\pi}{4}+(k-1)\frac{\pi}{6}\right)-\cot\left(\frac{\pi}{4}+\frac{k\pi}{6}\right)\right)$$

$$T_k=V_{k-1}-V_k$$

$$S_{13}=V_0-V_{13}$$

$$=2\left(\cot\left(\frac{\pi}{4}\right)-\cot\left(\frac{\pi}{4}+\frac{13\pi}{6}\right)\right)$$

$$=2\left(1-\cot\frac{5\pi}{12}\right)$$

$$=2\left(1-\left(2-\sqrt{3}\right)\right)=2\left(\sqrt{3}-1\right)$$

36. (b)

$a_2, a_3,\ldots, a_{50}$ are Arithmetic Means and $b_2, b_3,\ldots, b_{50}$ are Geometric Means between $a_1(=b_1)$ and $a_{51}(=b_{51})$

Hence $b_2 < a_2$, $b_3 < a_3\ldots$

$\Rightarrow t<S$

Also, a_1, a_{51}, a_{101} is an Arithmetic Progression and b_1, b_{51}, b_{101} is a Geometric Progression

Since $a_1 = b_1$ and $a_{51} = b_{51}$

$\Rightarrow b_{101} > a_{101}$

37. (a)

$$= \int_0^{\frac{\pi}{2}} \left(\frac{x^2 \cos x}{1+e^x} + \frac{x^2 \cos x}{1+e^{-x}} \right) dx$$

$$= \int_0^{\frac{\pi}{2}} \frac{x^2 \cos x + x^2 e^x \cos x}{1+e^x} dx$$

$$= \int_0^{\frac{\pi}{2}} x^2 \cos x dx$$

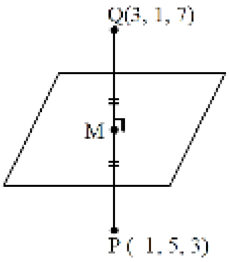
$$= \left(x^2 \sin x\right)_0^{\pi/2} - \int_0^{\pi/2} 2x \sin x dx$$

$$= \frac{\pi^2}{4} - 2\left[\left[\left(x(-\cos x)\right)\right]_0^{\pi/2} - \int_0^{\pi/2} -\cos x dx\right]$$

$$= \frac{\pi^2}{4} - 2\left[-(0-0) + (\sin x)\right]_0^{\pi/2}$$

$$= \frac{\pi^2}{4} - 2$$

38. (c)



Mirror image of (3, 1, 7) Q(3, 1, 7)

$$\frac{x-3}{1} = \frac{y-1}{-1} = \frac{z-7}{1} = \frac{-2(3-1+7-3)}{3}$$

Equation of plane passing through line and (-1, 5, 3)

$$\vec{n} = \begin{vmatrix} x & y & z \\ -1 & 5 & 3 \\ 1 & 2 & 1 \end{vmatrix}$$

39. (a, b)

$f(x) = a\cos(x^3 - x) + bx\sin(x(x^2+1))$

It is a differentiable function $\forall x \in R$

40. (b, c)

$$f(x) = \lim_{n\to\infty} \left(\frac{\prod_{r=1}^{n} \left(1 + \frac{rx}{n}\right)}{\prod_{r=1}^{n} \left(1 + \left(\frac{rx}{n}\right)^2\right)} \right)^{\frac{x}{n}}$$

$$= e^{x\int_0^1 \ln(1+xy)dy - \ln\left(1+(xy)^2\right)dy} = e^{\int_0^x \ln(1+t)dt - \ln\left(1+t^2\right)dt}$$

$$f'(x) = f(x)\ln\left(\frac{1+x}{1+x^2}\right)$$

For x $\in$ (0, 1) it is increasing function

$f'(2) = f(2)\ \ln\left(\frac{3}{5}\right) < 0$

$$\frac{f'(3)}{f(3)} = \ln\left(\frac{2}{5}\right), \frac{f'(2)}{f(2)} = \ln\left(\frac{3}{5}\right)$$

41. (a, d)

$$\lim_{x\to 2}\frac{f(x)g(x)}{f'(x)g'(x)} = 1$$

$$\Rightarrow \lim_{x\to 2}\frac{f'(2)g(x)+g'(x)f(x)}{f''(x)g'(x)+f'(x)g''(x)}$$

$$\Rightarrow \frac{g'(2)f(2)}{f''(2)g'(2)} = 1$$

$$\Rightarrow f(2) = f''(2)$$

Since f(2) > 0, f''(2) > 0

$\Rightarrow$ f has a local minimum at x = 2.

42. (b, c)

$$w.\left(u\times\vec{v}\right) = 1$$

$$\Rightarrow |w||u\times\hat{v}|\cos\alpha = 1$$

$$\cos\alpha = 1$$

$\Rightarrow w \perp u$ and $w \perp \vec{v}$

as it is given there exist a vector $\vec{v}$

$\Rightarrow w$ must be $\perp$ to u

hence infinite many such $\vec{v}$ exists.

if $u = u_1\hat{i} + u_2 j$

$$\vec{u}.\vec{w} = 0 \Rightarrow (u_1 + u_2) = 0$$

$$\Rightarrow |u_1| = |u_2|$$

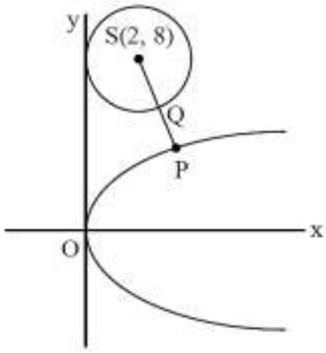
if $u = u_1\hat{i} + u_3 k$

$$\vec{u}.\vec{w} = 0$$

$$u_1 + 2u_3 = 0$$

$$\Rightarrow |u_1| = 2|u_3|$$

43. (a, c, d)



Equation of normal of parabola is

y + tx = 2t + t^3

Normal passes through S(2, 8)

8 + 2t = 2t + 1^3

$\Rightarrow t = 2$

Hence P = (4, 4) and SQ = radius = 2

44. (a, c, d)

$$x + iy = \frac{1}{a + ibt}$$

$$x^2 + y^2 - \frac{x}{a} = 0$$

(a) Centre $\left(\frac{1}{2a}, 0\right)$ $r = \frac{1}{2a}$ $a > 0$

(b) Centre $\left(\frac{1}{2a}, 0\right)$ $r = -\frac{1}{2a}$ $a < 0$

(c) x-axis $x = \frac{1}{a}, b = 0$

(d) y-axis y $= -\frac{1}{bt}$, a = 0

45. (b, c, d)

System has unique solution for $\frac{a}{3} \neq \frac{2}{-2}$

system has infinitely many solutions for $\frac{a}{3} = \frac{2}{-2} = \frac{\lambda}{\mu}$

and no solution for $\frac{a}{3} = \frac{2}{-2} \neq \frac{\lambda}{\mu}$

46. (b, c)

$f(x)=[x^2-3]$

Which is discontinuous at x = 1, $\sqrt{2}, \sqrt{3}$, 2

g(x) = f(x)[|x| + |4x-7|]

f(x) is non differentiable at

x=1, $\sqrt{2}, \sqrt{3}$

& |x| + |4x – 7| is non differentiable at x = 0, $\frac{7}{4}$

But f(x) = 0 $\forall x \in [\sqrt{3}, 2)$

Hence g(x) is non differentiable $x = 0, 1, \sqrt{2}, \sqrt{3}$

47. (b)

P(X > Y) = P(T_1 wins both) + P(T_1 wins either of the matches and other is draw)

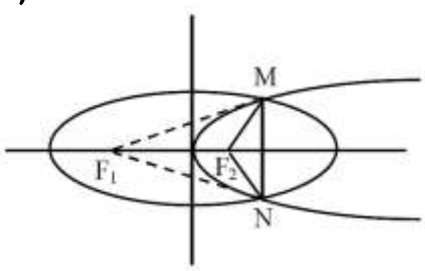
$$= \frac{1}{2} \times \frac{1}{2} + 2 \times \frac{1}{2} \times \frac{1}{6} = \frac{1}{4} + \frac{1}{6} = \frac{5}{12}$$

(ii) (c)

P(X = Y) = P(T_1 and T_2 win alternately) + P(Both matches are draws)

$$= 2 \times \frac{1}{2} \times \frac{1}{3} + \frac{1}{6} \times \frac{1}{6} = \frac{1}{3} + \frac{1}{36} = \frac{13}{36}$$

48. (a)



$e = \frac{1}{3}$

$F_1(-1,0)$

$F_2(1,0)$

Parabola: $y^2 = 4x$

M and N are $\left(\frac{3}{2},\sqrt{6}\right)$ & $\left(\frac{3}{2},-\sqrt{6}\right)$

For ortho center: one altitude is y = 0 (MN is perpendicular)

other altitude is : $\left(y-\sqrt{6}\right)=\frac{5}{2\sqrt{6}}\left(x-\frac{3}{2}\right)$

ortho center is $\left(-\frac{9}{10},0\right)$

(ii) (c)

Equation of tangent at M and N are $\frac{x}{6} \pm \frac{y\sqrt{6}}{8} = 1$

R(6, 0)

Equation of normal $\left(y-\sqrt{6}\right)=-\frac{\sqrt{6}}{2}\left(x-\frac{3}{2}\right)$

Area of Δ MQR= $\frac{1}{2}\times\sqrt{6}\times\frac{5}{2}=\frac{5\sqrt{6}}{4}$

Area of MF_1NF_2 $=\frac{\sqrt{6}}{2}+\frac{3\sqrt{6}}{2}=\frac{4\sqrt{6}}{2}$

Ratio : $\frac{5\sqrt{6}}{4}:\frac{4\sqrt{6}}{2}=\frac{5}{8}$