Cam and followers.

Single slider Mech (only L.P).

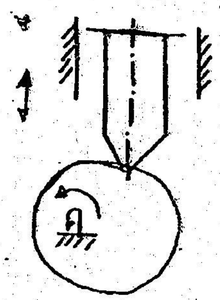
CAM

It is the Mechanical Element which drives another Element known as follower in a Specified Way through ~~Specified Way~~ the direct Contact

classification of Cams

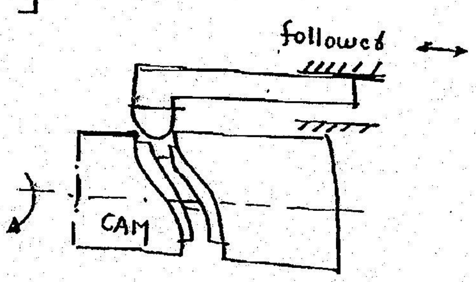
1. plate/Radial/Disc CAM.

line of Motion of follower] ⊥r
Axis of Rotation of CAM]



2. Cylindrical CAM

Line of Motion of follower] Parallel
Axis of Rotation of CAM]



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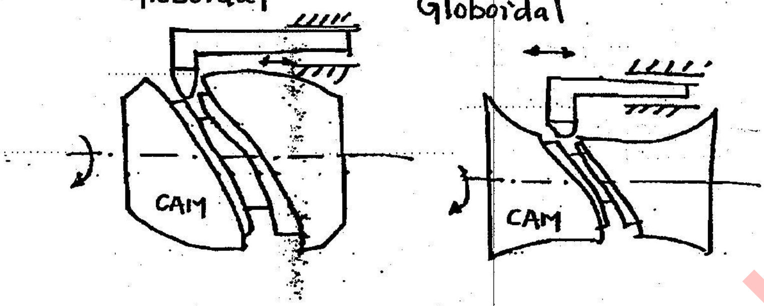
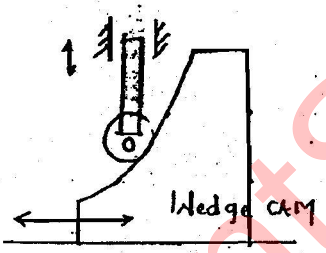
Globoidal CAM

Convex Globoidal

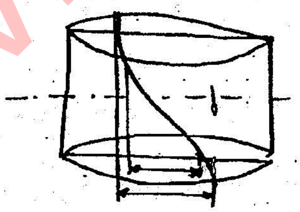
Concave Globoidal



Wedge CAM



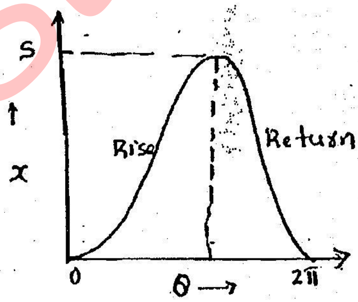
Note



to decrease Stroke length

IInd Way

1. Rise - Return CAM



x - follower displacement

θ - CAM Rotation.

S - stroke Length.

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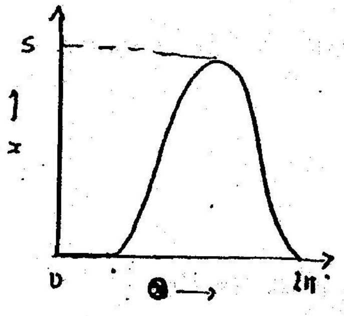
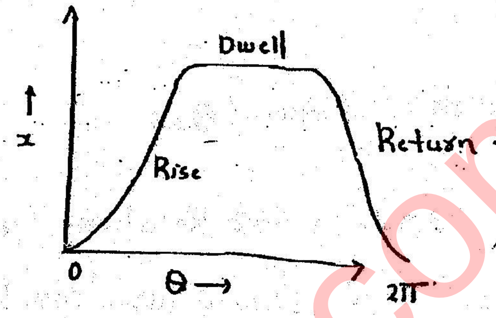
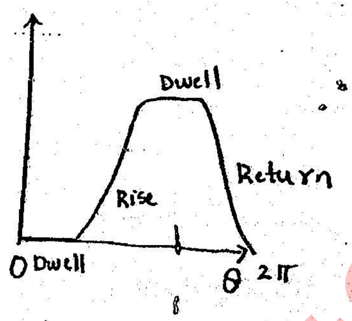
2. Dwell - Rise - Return CAM



3. Rise - dwell - Return CAM



4. Dwell - Rise - dwell - Return CAM



Angles of CAM

i) Out stroke angle (θ_o) (Angle of Ascend).

It is an angle of CAM Rotation in which follower Rises.

ii) Return stroke angle (Angle of decend) (R) [instroke angle]

It is an angle of CAM Rotation in which follower Returns.

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Angle of Dwell (S).

It is angle of CAM Rotation in which follower is stationary.

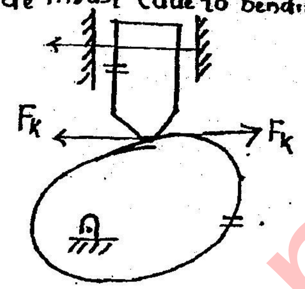
Angle of Action (θ_a)

Angle of CAM Rotation from beginning of rise to the end of the return stroke of the follower. $\theta_a \leq 2\pi$

follower classificat.

1. Knife Edge follower

Side Thrust (due to bending)



Contact Area of follower with CAM.

$\Downarrow$

ZERO (Sharp Edge)

Excessive Wear and Side Thrust

Totally failed follower

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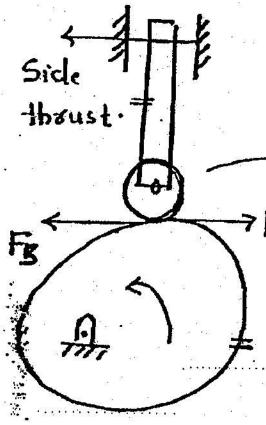
Roller follower



Side Thrust is there

But

THE BEST

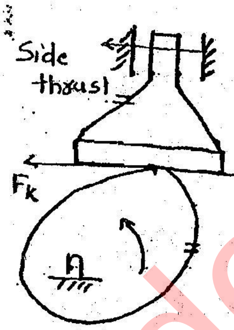
bcoz Wear is Absent.

Disadv

Space Requirement is very high.

Used in Aircrafts

Flat Face Follower



Mushroom follower
⇓
flat face follower

in which flat face [circular disc] form.

* Contact Area is little high (point contact).

dA (differential Area)

Wear is highly Reduced Compared to knife Edge.

But

Surface stresses are stored

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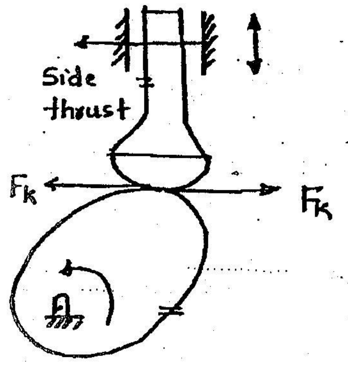
4. Spherical - Faced follower



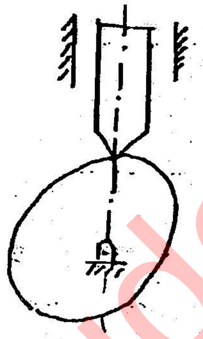
Used in IC-Engine.

Wear is less Compared to kenife Edge.

Radial follower

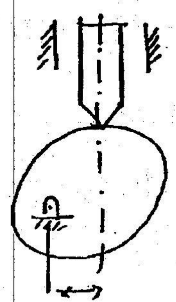
When the line of Motion of follower is passing through CAM Centre of Rotation, Then Such a follower is known as

1. Radial follower



2. offset follower

When the line of Motion of follower having a little offset from cam Centre of Rotation Then Such a follower is known as offset follower



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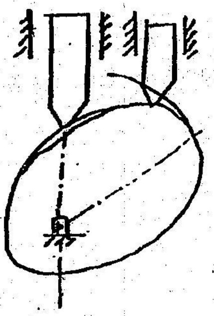
Note:-



The purpose of Giving little bit offset was just to decrease a little bit Wear, As a result, The Side thrust is also decreased a little bit.

Cam Terminology

1. Base Circle

It is the Min. radius circle of CAM from CAM centre of Rotatn which touches the CAM profile.

* The Size of any Cam is Specified by the Size of the base Circle.

2. Trace point (or) pitch curve-

The pt. on the follower Which is req. to trace the CAM Profile is known as trace pt. and the curve traced by the trace pt. by keeping the CAM Stationary and Revolving the follower around it is known as pitch curve.

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3) prime circle

Min. Radius Circle of pitch curve from CAM Centre of Rotat^n is known as prime circle.

4). Pressure Angle

It is an angle b/w the line of Action and Line of Motion of follower.

5) Pitch point and pitch circle

That point on the pitch curve, where the pr. Angle is Maximum is known as pitch point and the circle drawn from Centre of Rotat^n of CAM having a Radius equal to the dist from pitch pt. from Centre of Rotat^n of CAM is known as pitch circle.

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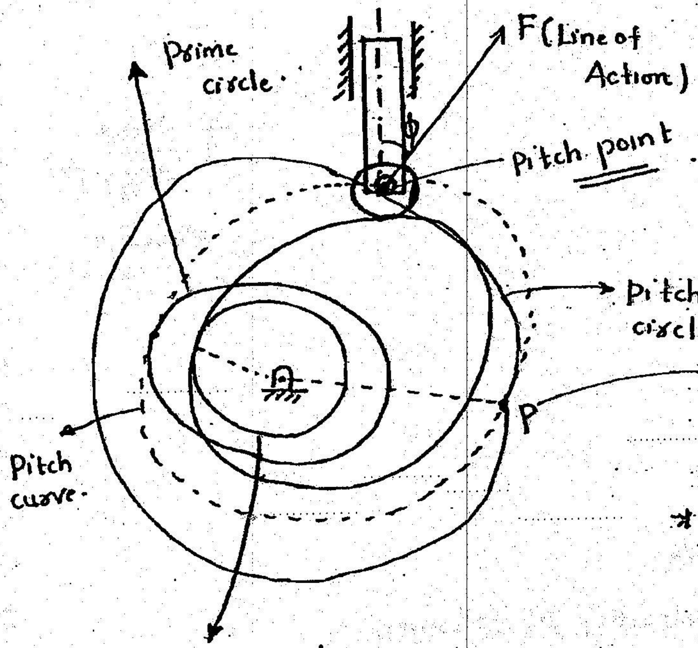

* Pitch point Can be More than one, But pitch circle is only one.

* Pressure Angle exists When one body Rotates other.

* Pitch Curve of other type followers discussed will coincide With it's Base circle.

* Trace point of the Roller follower ~~which~~ is the point at ~~that~~ which follows the CAM in full Rotatn. [centre of Roller]

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follower Derivatives

θ - CAM Rotation

$x \to$ Follower displacement.

$\omega \to$ CAM Angular Velocity.

$s \to$ Stroke Length.

$$\frac{1}{R} = \frac{d^2y/dx^2}{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{3/2}}$$

- Radius of curvature

Ist derivative

$\frac{dx}{d\theta} \to$ Slope of $(x-\theta)$ curve

$\to$ "Represents" the velocity of follower.

$$\frac{dx}{d\theta}\left(\frac{d\theta}{dt}\right) \to \text{const (CAM Rotation)}$$

IInd derivative

$$\frac{d^2x}{d\theta^2}$$

$\frac{d^2x}{d\theta^2} \to$ "Represents" the Radius of curvature

$$R \propto \frac{1}{(d^2x/d\theta^2)}$$

$\to$ Represents the accn. of follower.

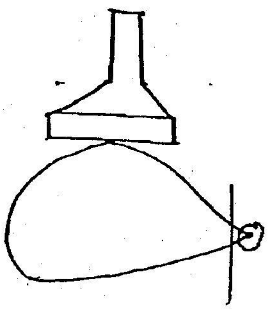
if any point the CAM profile is sharp pointed

$\Rightarrow$ At that point

$R \to 0$.

$\frac{d^2x}{d\theta^2} \to \infty$

$\Rightarrow a \to \infty$ (undefined).



under cutting (interference)

$R \to 0$

$a \to \infty$.

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III^{rd} derivative

$\frac{d^3x}{d\theta^3}$ → Represents the Rate of change of Radius of curvature.
→ Represent the Jerks.

Follower Motion and it's characteristics

x → Follower displacement.

θ = CAM Rotation.

ω → CAM Ang. Velocity

$\omega = \frac{d\theta}{dt}$

$t = 2sec$

$S = 0 + \frac{1}{2} g \times 2 \times 2$
$= 2g$.

$V = 0 + 2g$

θ_0 → outstroke angle.

t_0 → outstroke time.

$\boxed{t_0 = \frac{\theta_0}{\omega}}$

θ_R → Return stroke angle.

$\boxed{t_R = \frac{\theta_R}{\omega}}$

S → stroke length.

V → Velocity of ~~flo~~ follower.

$[V_0]_{mean} = \frac{S}{t_0} = \frac{S}{\frac{\theta_0}{\omega}} = \frac{\omega S}{\theta_0}$

$\boxed{(V_R)_{mean} = \frac{\omega \cdot S}{\theta_R}}$

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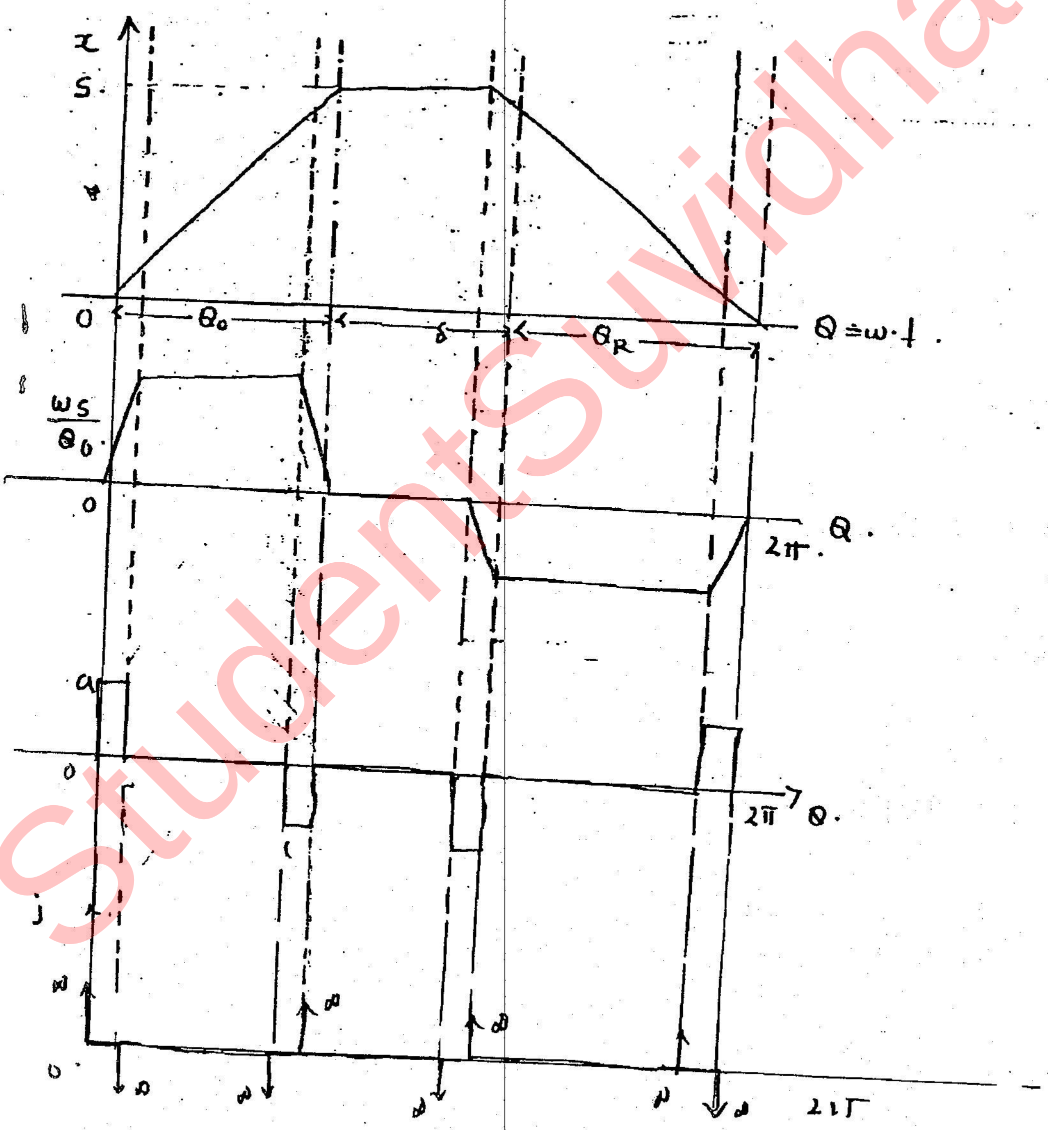
1. Uniform Velocity Motion

Displacement Linear

$V_0 = (V_0)_{max} = (V_0)_{mean} = (V_0)_{min} = \frac{\omega \cdot s}{\theta_0}$

$V_R = (V_R)_{max} = (V_R)_{mean} = (V_R)_{min} = \frac{\omega \cdot s}{\theta_R}$

Used in Very-Very slow speed



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2. Uniform Accelaration and Retardation Motion

Displacement $\longrightarrow$ parabolic.

Velocity = Linear

$$(V_o)_{max} = 2(V_o)_{mean} = \frac{2\omega s}{\theta_o}$$

$$(V_R)_{max} = \frac{2\omega s}{\theta_R}$$

$$(V_o)^2_{max} = 0 + 2a \times s/_2$$

$$= \frac{4\omega^2 s^2}{\theta_o^2} = \cancel{2} a \times s/_{\cancel{2}}$$

$$a = \frac{4\omega^2 s}{\theta_o^2}$$

Used up to Slow Speed

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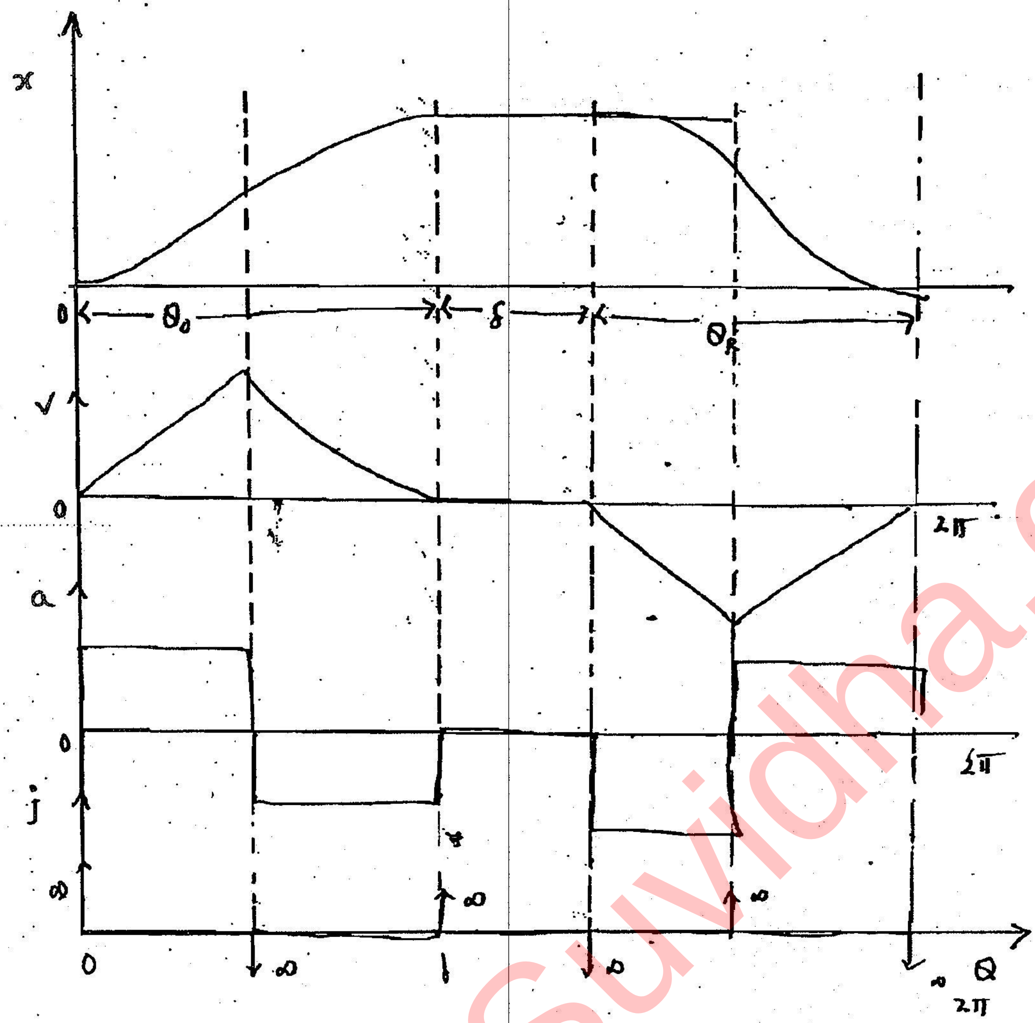
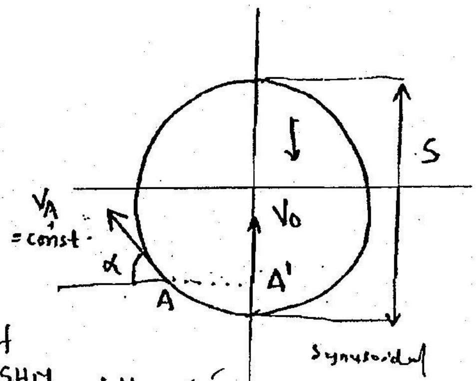


Simple Harmonic Motion

When a pt. Moves in a circular path with uniform Speed, then the Motion of it's Reflected pt on the diameter is known as SHM



motion of A' – SHM – follower

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$$V_A = \frac{(\pi S/2)}{t_0} = \frac{(\pi S/2)}{\left(\frac{\theta_0}{\omega}\right)} = \frac{\pi \cdot \omega \cdot S}{2\theta_0}$$

$$V_A' = V_0 = V_A \sin\alpha$$

$$V_0 = V_A' = \frac{\pi \omega \cdot S}{2\theta_0} \sin\alpha$$

**

$$\boxed{V_0 = \frac{\pi \omega S}{2\theta_0} \sin\left(\frac{\pi\theta}{\theta_0}\right)}$$

$$a_0 = \frac{dV_0}{dt} = \frac{dV_0}{d\theta} \frac{d\theta}{dt} \, \omega$$

$$= \frac{\pi \omega^2 S}{2\theta_0} \cos\left(\frac{\pi\theta}{\theta_0}\right) \cdot \frac{\pi}{\theta_0}$$

$$\boxed{a_0 = \frac{\pi^2 \omega^2 S}{2\theta_0^2} \cos\left(\frac{\pi\theta}{\theta_0}\right)}$$

Jerk $= \frac{da_0}{dt} = \frac{da_0}{d\theta} \cdot \frac{d\theta}{dt} \, \omega$

$$\frac{\pi^2 \omega^3 S}{2\theta_0^2} \left(-\sin\left(\frac{\pi\theta}{\theta_0}\right)\right) \cdot \frac{\pi}{\theta_0}$$

$$J = \frac{-\pi^3 \omega^3 S}{2\theta_0^3} \sin\left(\frac{\pi\theta}{\theta_0}\right)$$

max

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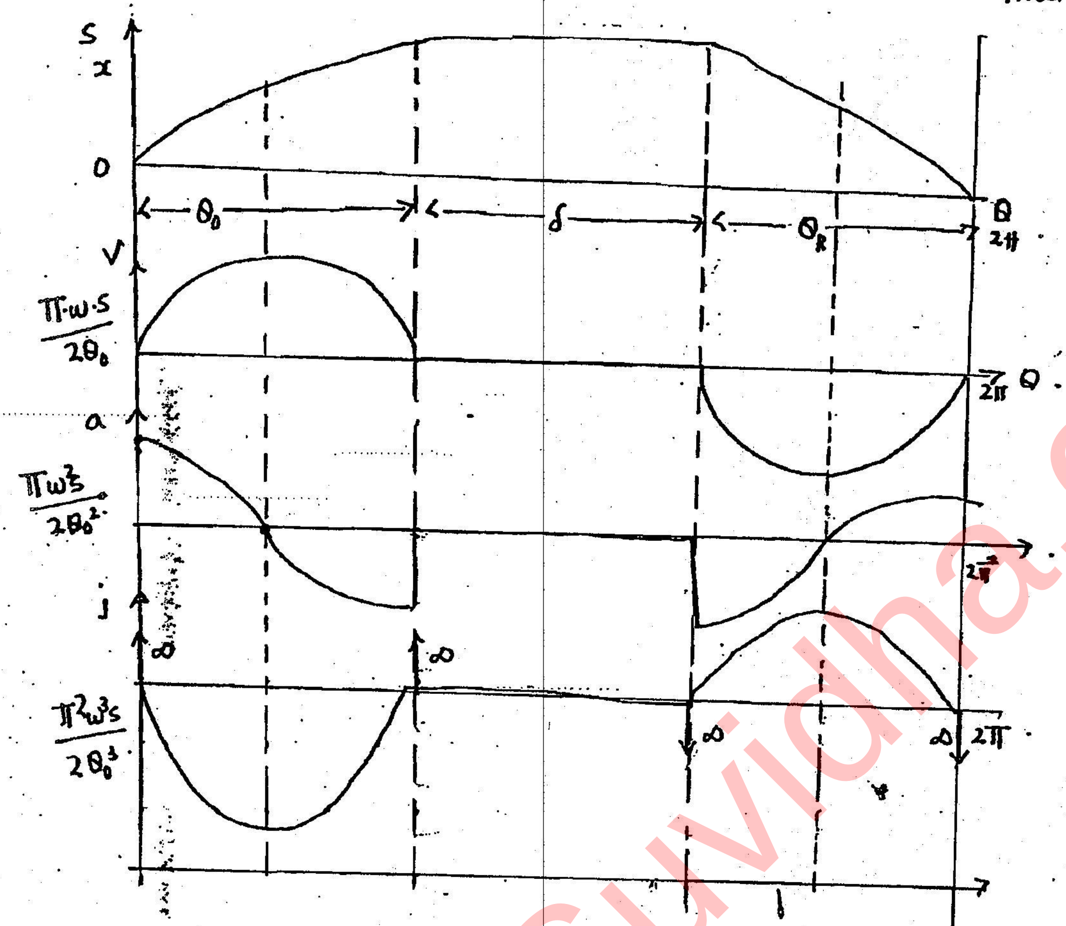
Used up to medium Speeds.



2. Cycloidal Motion (Linear $x - \sin x$ -ve sinusoidal mix)

The displacement of follower in outstroke

$$x_0 = S\left[\frac{\theta}{\theta_0} - \frac{1}{2\pi}\sin\left(\frac{2\pi\theta}{\theta_0}\right)\right]$$

$$V_0 = \frac{dx_0}{dt} = \frac{dx_0}{d\theta}\left(\frac{d\theta}{dt}\right) \rightarrow \omega$$

$$= \omega S\left[\frac{1}{\theta_0} - \frac{1}{2\pi}\cos\left(\frac{2\pi\theta}{\theta_0}\right)\cdot\frac{2\pi}{\theta_0}\right]$$

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$$V_0 = \frac{\omega \cdot s}{\theta_0}\left(1-\cos\left(\frac{2\pi\theta}{\theta_0}\right)\right) \Rightarrow fn.(\sin^2\theta)$$

At $\theta = \frac{\theta_0}{2} \rightarrow (V_0)_{max} = \frac{2\omega \cdot s}{\theta_0}$

$$a_0 = \frac{dv_0}{dt} = \frac{dv_0}{d\theta}\left(\frac{d\theta}{dt}\right) \rightarrow \omega$$

$$= \frac{\omega^2 \cdot s}{\theta_0}\left(\sin\left(\frac{2\pi\theta}{\theta_0}\right)\right) \cdot \frac{2\pi}{\theta_0}.$$

$$a_0 = \frac{2\pi\omega^2 \cdot s}{\theta_0^2} \sin\left(\frac{2\pi\theta}{\theta_0}\right)$$

Max. at $\theta = \frac{\theta_0}{4}$.

Min. at $\theta = 0^\circ$

$$J = \frac{da_0}{dt} = \frac{da_0}{d\theta}\left(\frac{d\theta}{dt}\right) \rightarrow \omega$$

$$= \frac{2\pi\omega^3 \cdot s}{\theta_0^2} \cdot \cos\left(\frac{2\pi\theta}{\theta_0}\right) \cdot (2\pi/\theta_0)$$

$$J = \frac{4\pi^2\omega^3 s}{\theta_0^3} \cos\left(\frac{2\pi\theta}{\theta_0}\right)$$

Max

Best

Used at High Speed

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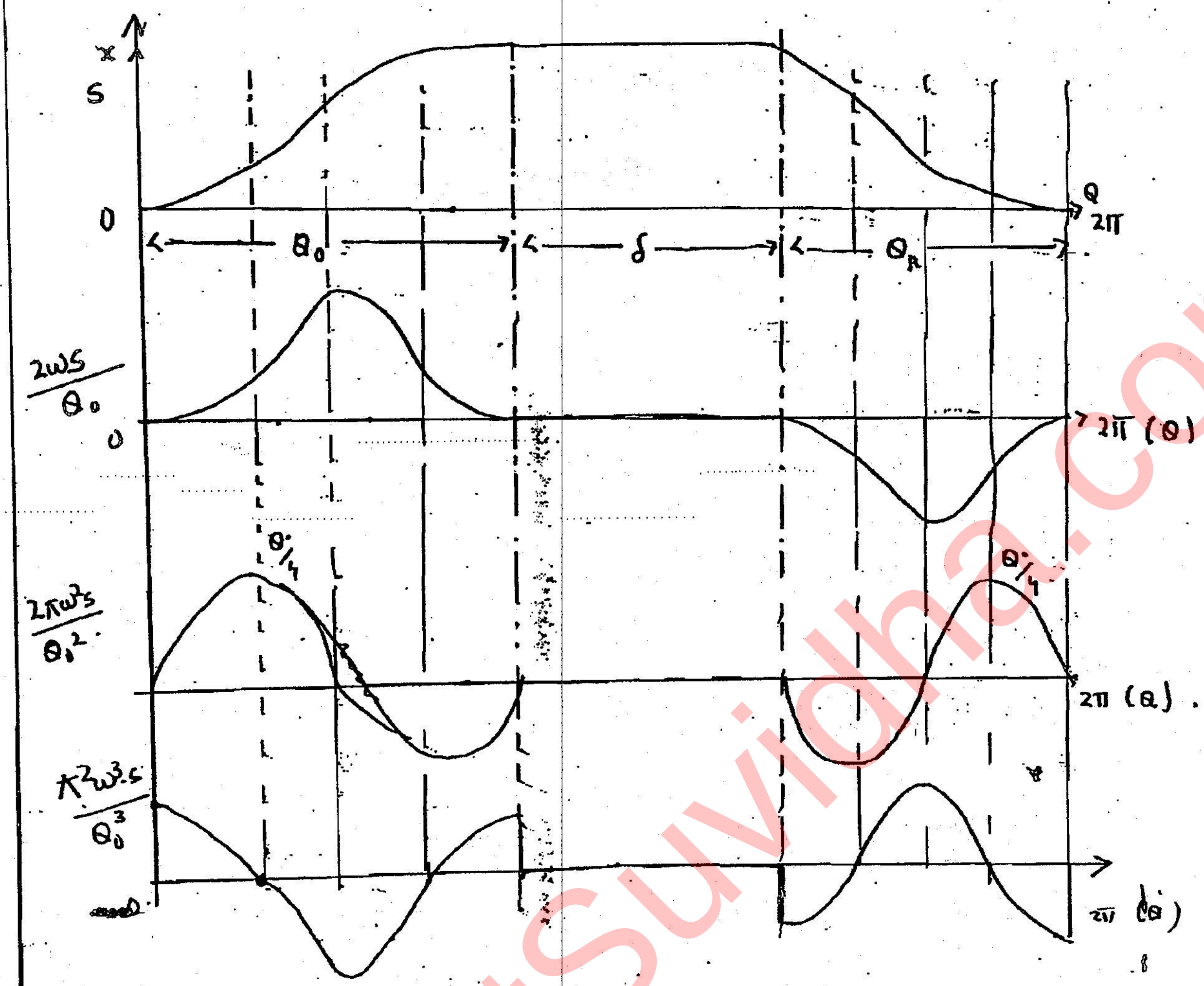

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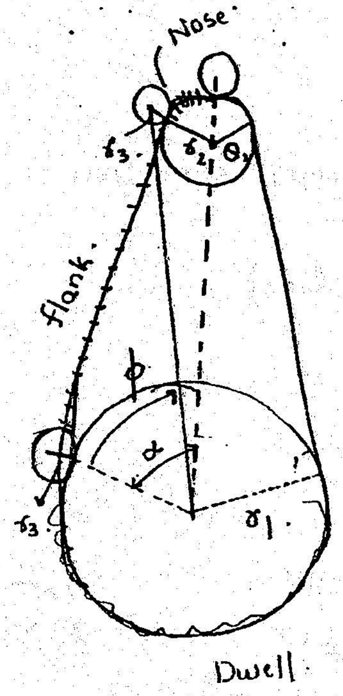
Special Contour CAMs

i) Tangent CAM with Roller follower

When flanks of CAM are straight and tangential to base circle and Nose circle, then the CAM is known as the same. It is a Symmetrical CAM, Works with Radial Roller follower.

$r_1 \rightarrow$ Rad. of Base circle
$r_2 \rightarrow$ Rad. of Nose circle.
$r_3 \rightarrow$ Rad. of Roller
$L \rightarrow$ Dist. b/w Centre of Base circle and Nose circle.
$\alpha \rightarrow$ Semi-Angle of action.
$\phi \rightarrow$ Semi-Angle of Action of flank.

$\theta \in [0, \phi] \rightarrow$ Flank.
$\theta \in [\phi, \alpha] \rightarrow$ Nose



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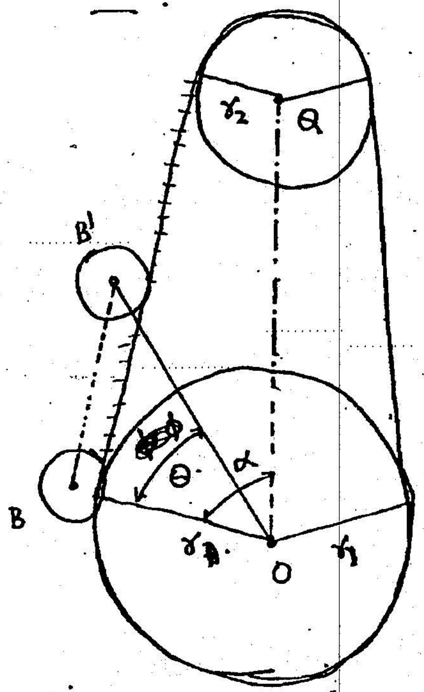
i) When follower is on flank.

$\theta \in (0, \phi)$.



Displacement

$x = OB' - OB$

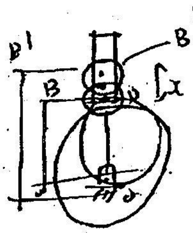
$= \left(\frac{OB}{\cos\theta} - OB\right)$

$= OB\left(\frac{1}{\cos\theta} - 1\right)$.

$= OB\left(\frac{1-\cos\theta}{\cos\theta}\right)$

$$\boxed{x = \frac{(r_1+r_3)(1-\cos\theta)}{\cos\theta}}$$

$V = \frac{dx}{d\theta}\left(\frac{d\theta}{dt}\right) \rightarrow \omega$.

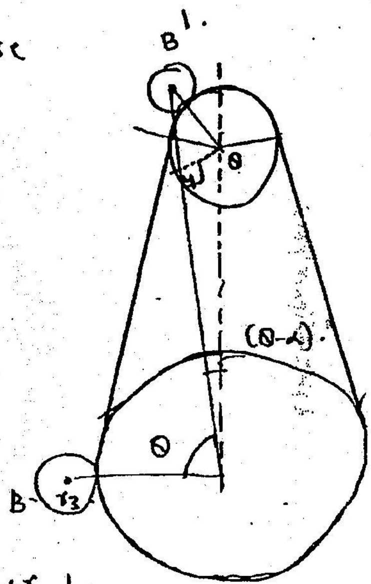


$V = (r_1+r_3)\cdot\omega\cdot\frac{\sin\theta}{\cos^2\theta}$.

$V_{max} = (r_1+r_3)\omega\cdot\frac{\sin\phi}{\cos^2\phi}$ | not $\pi/2$, $\theta \in (0,\phi)$

ii) When follower is on Nose

$\theta \in (\phi, \alpha)$.



Displacement

$x = (OB' - OB)$

$= (OM + MB') - OB$.

$= \cos(\alpha-\theta)$

$+ (r_2+r_3)\cos\beta - (r_1+r_3)$

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$L \sin(\alpha - \theta) = (r_2 + r_3) \sin\beta$.

$\sin\beta = 1$.

$\cos\beta = 1$.

$\text{Lift} = \text{stroke} - (L + r_2 + r_3) - (r_1 + r_3)$

$= L + (r_2 - r_1)$

Q). Base circle dia = 50mm. operates a Roller follower of 20mm dia. The line of Motion of follower passes thro' axis of cam. Angle b/w the tangential ~~plo~~ face of cam is 60°. Speed of CAM shaft is 200rpm. and lift of the follower 15mm. Calculate.

i) Main dimensions of CAM

ii) Accelaration of followers.

i) Beginning of lift

ii) When Roller touches the Nose.

iii) At the Apex of Nose.

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$r_1 = 25$ mm.

$r_3 = 10$ mm.

Lift = 15 mm

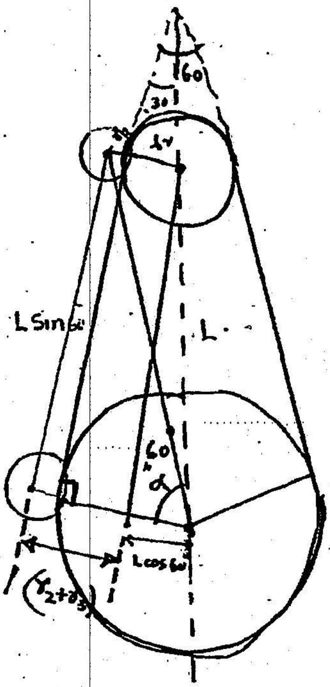
$= L + (r_2 - r_1)$.

$\alpha = ?$

$\phi = ?$

$L = ?$

$r_2 = ?$



$$\alpha = 180^\circ - [90^\circ + 30^\circ]$$

$$\alpha = 60^\circ$$

$$L\cos 60^\circ + r_2 + \cancel{r_3} = r_1 + \cancel{r_3}$$

$$L/2 + r_2 = 25 \quad \text{—(1)}$$

$$L + r_2 - 25 = 15$$

$$L + r_2 = 40 \quad \text{—(2)}$$

$$L/2 = 15$$

$$L = 30 \text{ mm}$$

$$r_2 = 10 \text{ mm}$$

$$\tan\phi = \frac{L\sin 60}{r_1 + r_3}$$

$$= \frac{30 \sin(60^\circ)}{25+10}$$

$$\phi = 36.58^\circ$$

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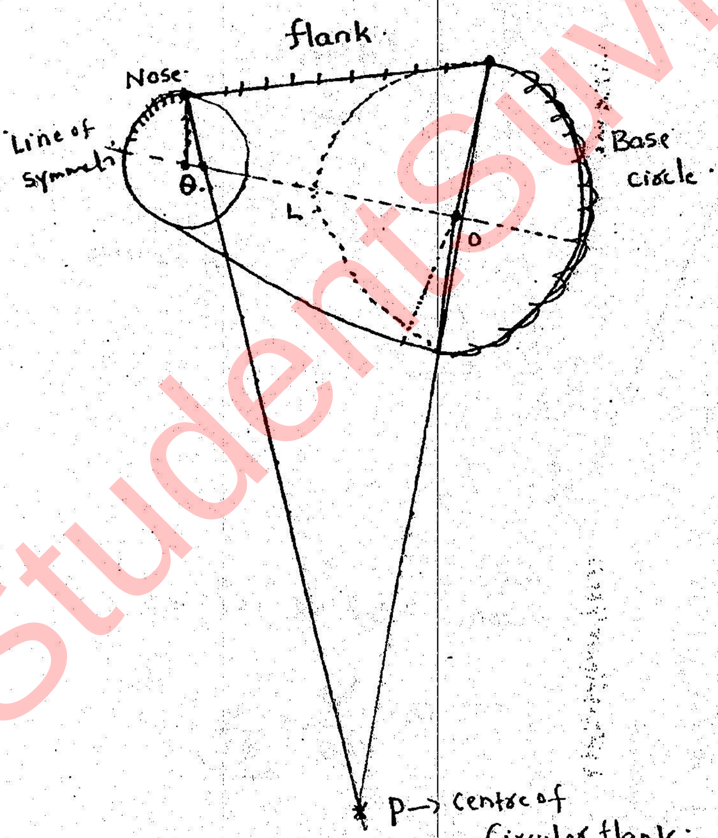
Circular Arc cam With flank face follower

When the flanks of CAM are off Convex circular arc and tangential to Base circle and Nose circle. The CAM is known as circular arc CAM. It is a Symmetrical CAM, Works with Radial flat face follower.

R → Radius of Circular flank.



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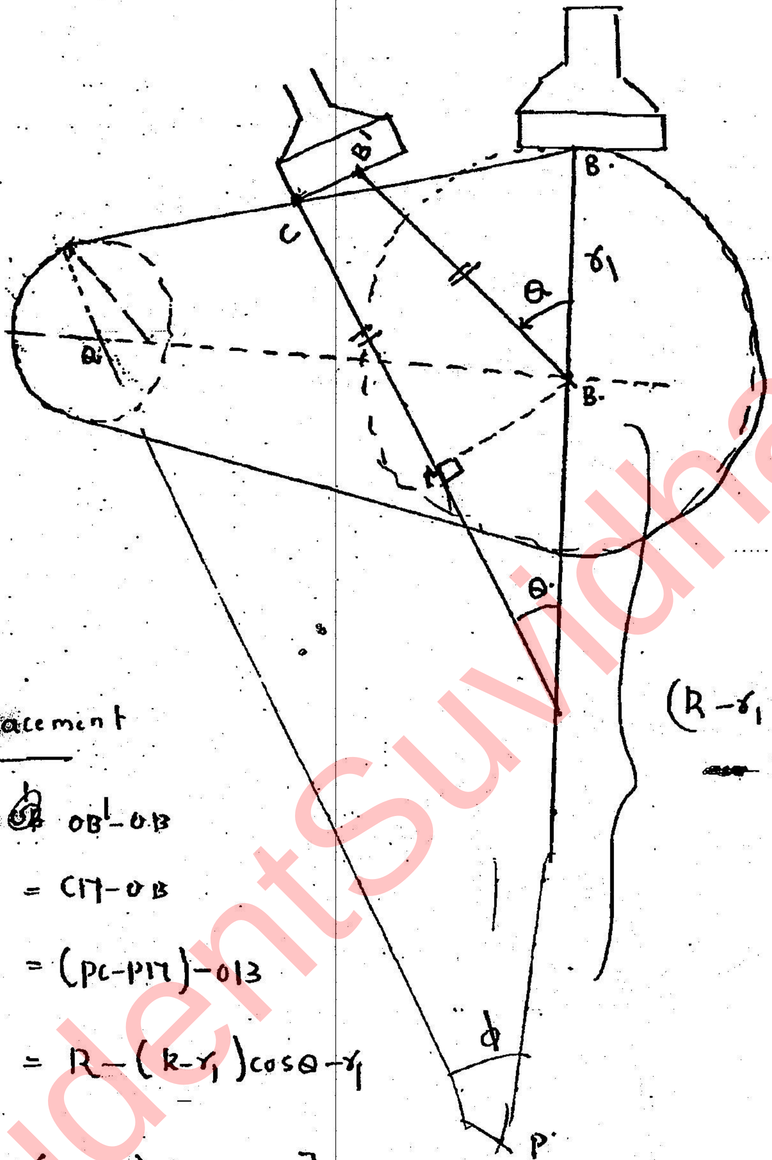
i) When the follower is flank.

$\theta \in [0, \phi]$.



Displacement

$x = OB' - OB$

$= CM - OB$

$= (PC - PM) - OB$

$= R - (R-\gamma_1)\cos\theta - \gamma_1$

$x = (R-\gamma_1)(1-\cos\theta)$

$v = \frac{dx}{d\theta}\left(\frac{d\theta}{dt}\right) \to \omega$

$\boxed{V = (R-\gamma_1)\cdot\omega\cdot\sin\theta}$

$V_{max} = (R-\gamma_1)\,\omega\sin\phi$

$a = \frac{dv}{d\theta}\left(\frac{d\theta}{dt}\right) \to \omega$

$a = (R-\gamma_1)\,\omega^2\cos\theta$

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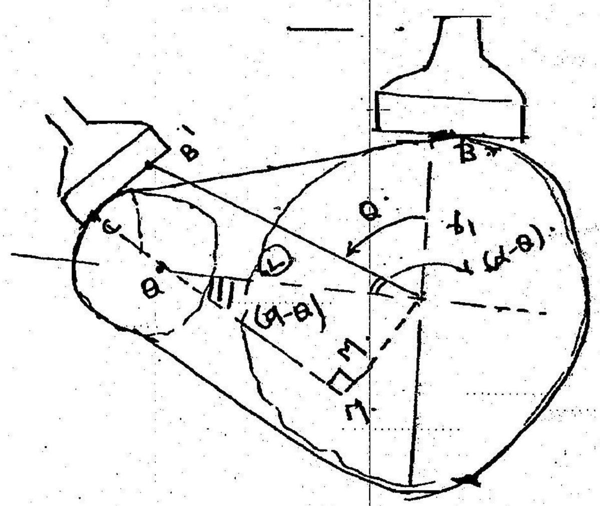
i) When the follower is on Nose



Displacement

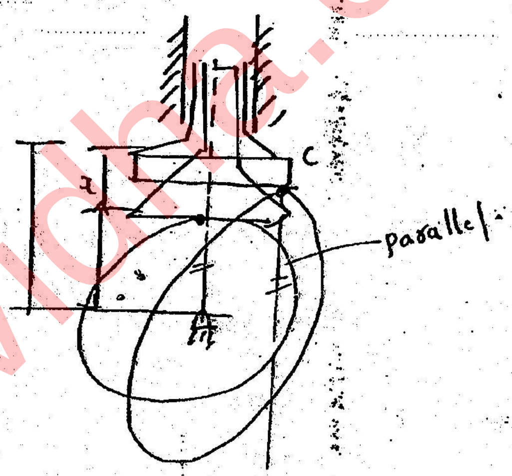
$x = OB' - OB$

$= CM - OB$

$= (CQ + QM) - OB$

$= r_2 + L\cos(\alpha - \theta) - r_1$

$x = (r_2 - r_1) + L\cos(\alpha - \theta)$



Lift

$L + (r_2 - r_1)$.

* The following data refers to a circular arc cam driving the flat face follower.

i) Min. radius of CAM = 40mm.

ii) Lift = 24 mm

iii) Angle of Lift = 75°

iv) Nose radius = 8mm.

rpm = 420 rpm

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i) Det. the Main dimension of CAM

ii) Velocity and acc. of the follower.

i) at. Beginning of Lift

ii). end of circular flank.

iii) Beginning of Nose.

iv) At the Apex of Nose.

$r_1 = 40mm$.

Lift $= 24mm = L + (r_2 - r_1)$.

~~$L + r_2 - 40$~~

$r_2 = 8mm$

$\alpha = 75°$

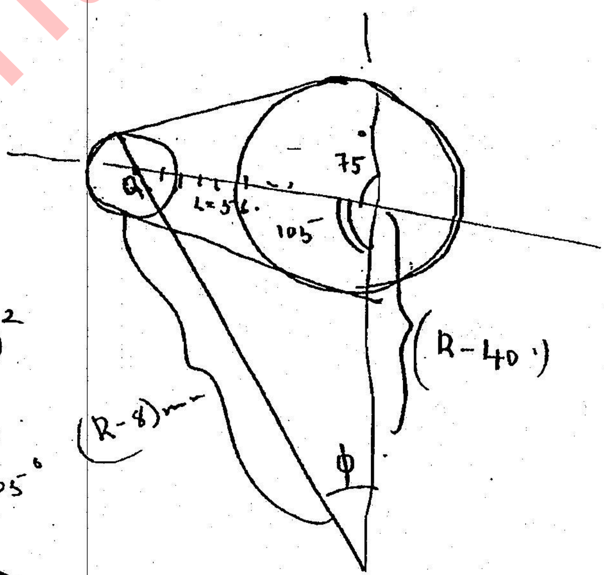
$\phi = ?$

$R = ?$

$L = ?$

$24 = L + (r_2 - r_1)$

$L = 56 m$.



Cos rule

$(R-8)^2 = (R-40)^2 + (56)^2$

$- 2(R-40)(56)\cos 105°$

$R = 73mm$

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