Acceleration analysis using Polygons

same as velocity

$\vec{a}_B = \vec{a}_A + \vec{a}_{B/A}$

translation at A

rotation about A

But here $\vec{a}_{B/A}$ has two components : Tangential and Normal

So $\vec{a}_B = \vec{a}_A + (a_{B/A})_n + (a_{B/A})_t$

$= \vec{a}_A + -\omega^2 \times r_{B/A} + \alpha \times \vec{r}_{B/A}$

Direction: Pointing to A

Direction $\perp \vec{r}_{B/A}$ in the direction of α

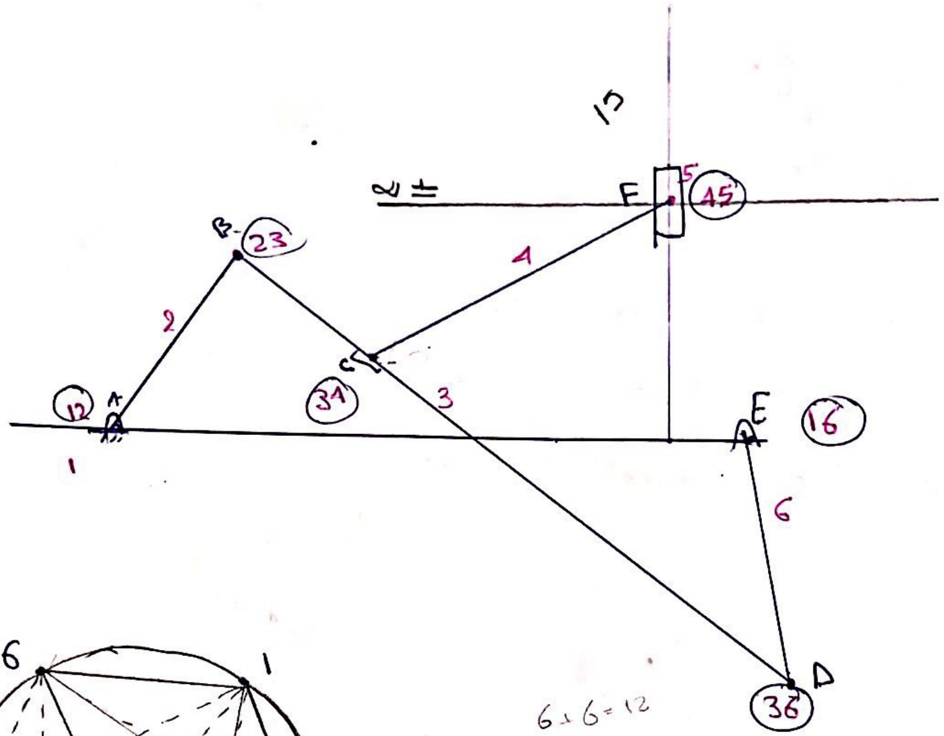
* Contact point

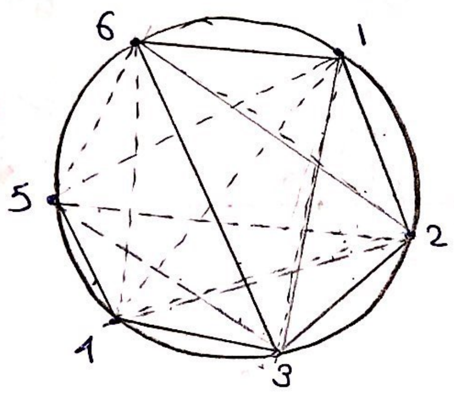
Without slipping

Component of the acceleration along the common tangent direction is equal on both bodies.

Examples:-

Question on IC:





- We need to find All instant-Centers :-

1- find Number of ICs:

$$N = \frac{n(n-1)}{2} = \frac{6(5)}{2} = 15$$

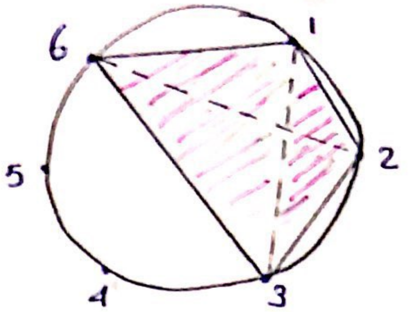
2- we have 6 Known ICs:-

3- search for triangles that has two Known and one unknown that is between the triangle and Another triangle.

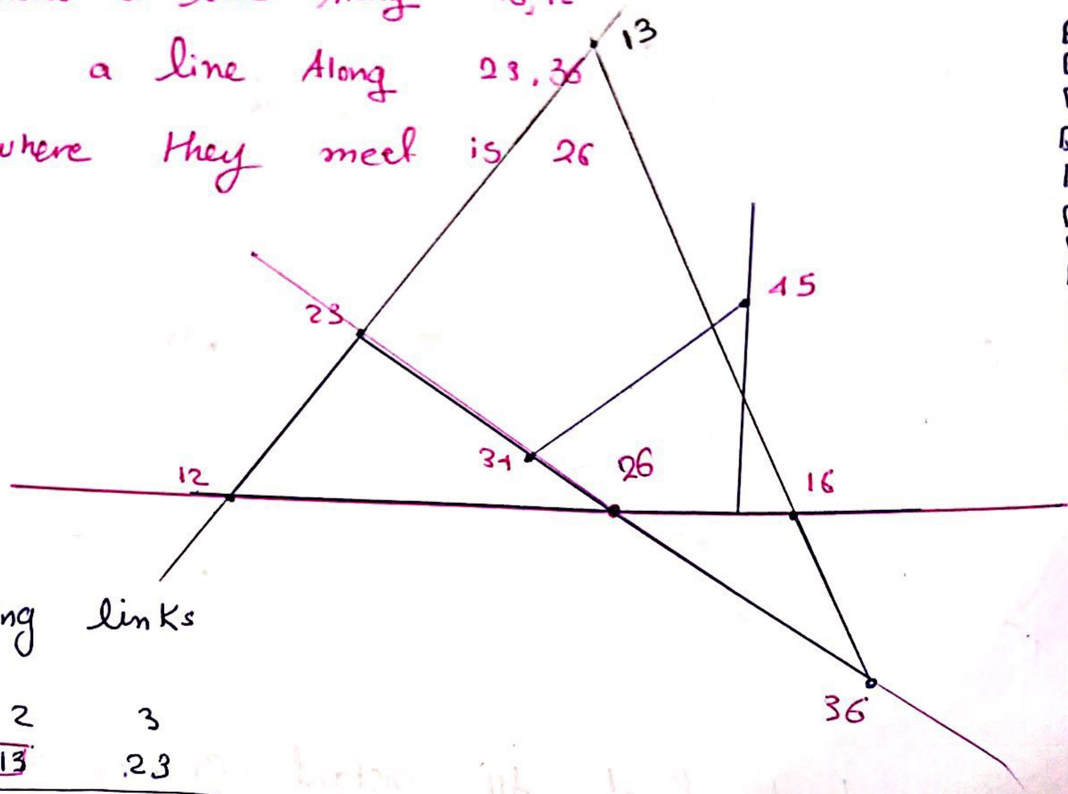
a) we can find 26 , 13

Taking links :-

6	1	2
16	12	$\boxed{26}$
2	3	6
23	36	$\boxed{26}$



- Draw a line Along 16, 12
and a line Along 23, 36
where They meet is 26



- ☑ 12
- ☑ 13
- ☑ 14
- ☑ 15
- ☑ 16
- ☑ 23
- ☑ 24
- ☑ 25
- ☑ 26
- ☑ 34
- ☑ 35
- ☑ 36
- ☑ 45
- ☐ 46
- ☑ 56

- Taking links

1	2	3
12	$\boxed{13}$	23
1	6	3
16	$\boxed{13}$	36

- Draw a line Along 12 , 23
and " " " 16 , 36
where They meet is 13

We can find: 14, 35

1 3 5

13 15 $\boxed{35}$

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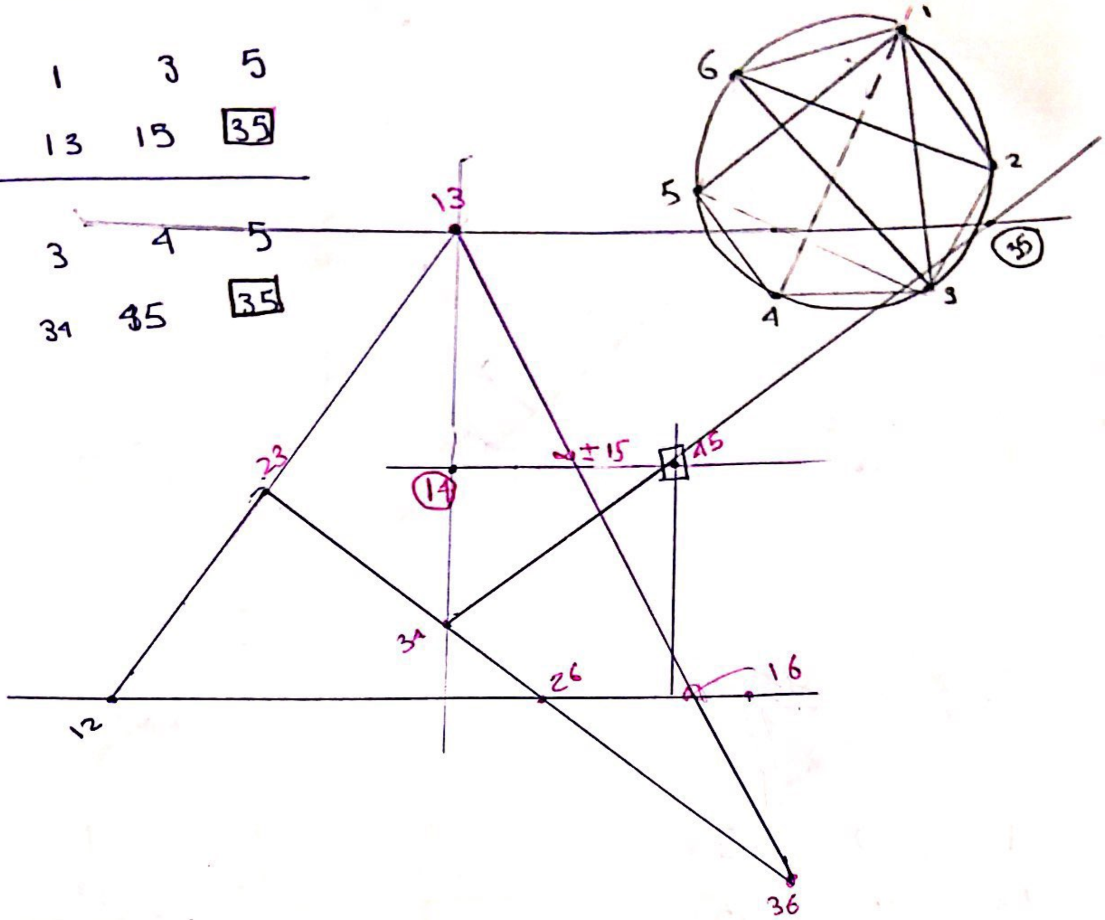
3 4 5

34 45 $\boxed{35}$



To find 14:

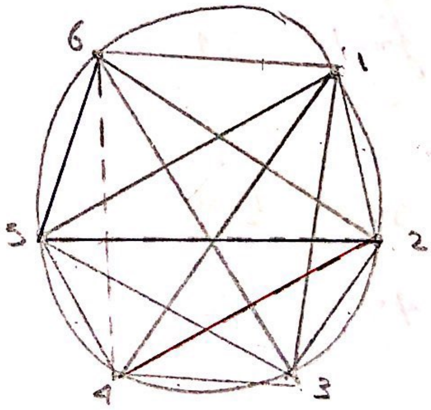
1 5 4

15 45 $\boxed{14}$

---

1 3 4

13 34 $\boxed{14}$



we can find: $\underset{①}{65}$ - $\underset{②}{46}$, $\underset{③}{25}$, $\underset{④}{24}$

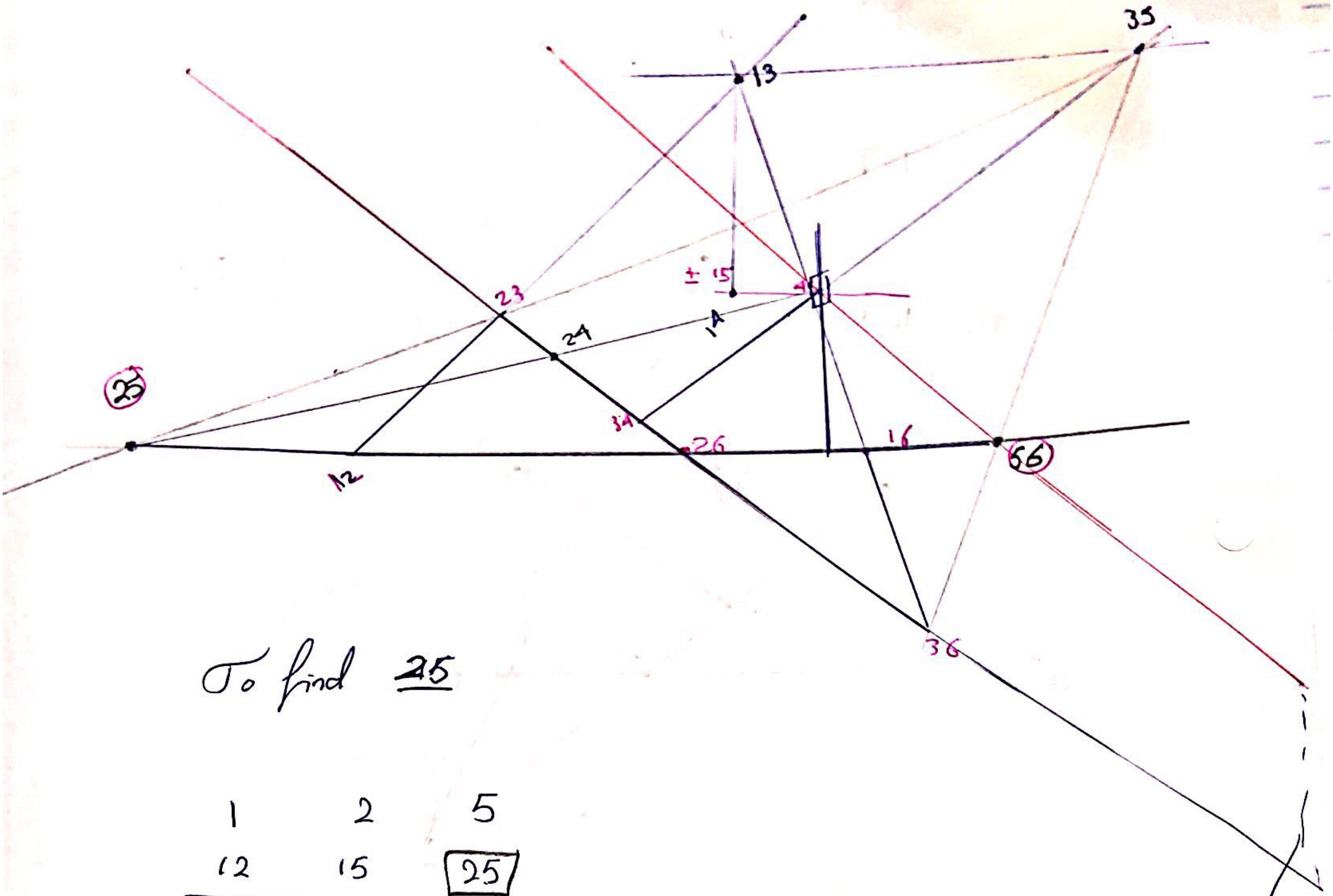
6 1 5

16 15 $\boxed{56}$

---

6 3 5

36 35 $\boxed{56}$



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To find $\underline{25}$

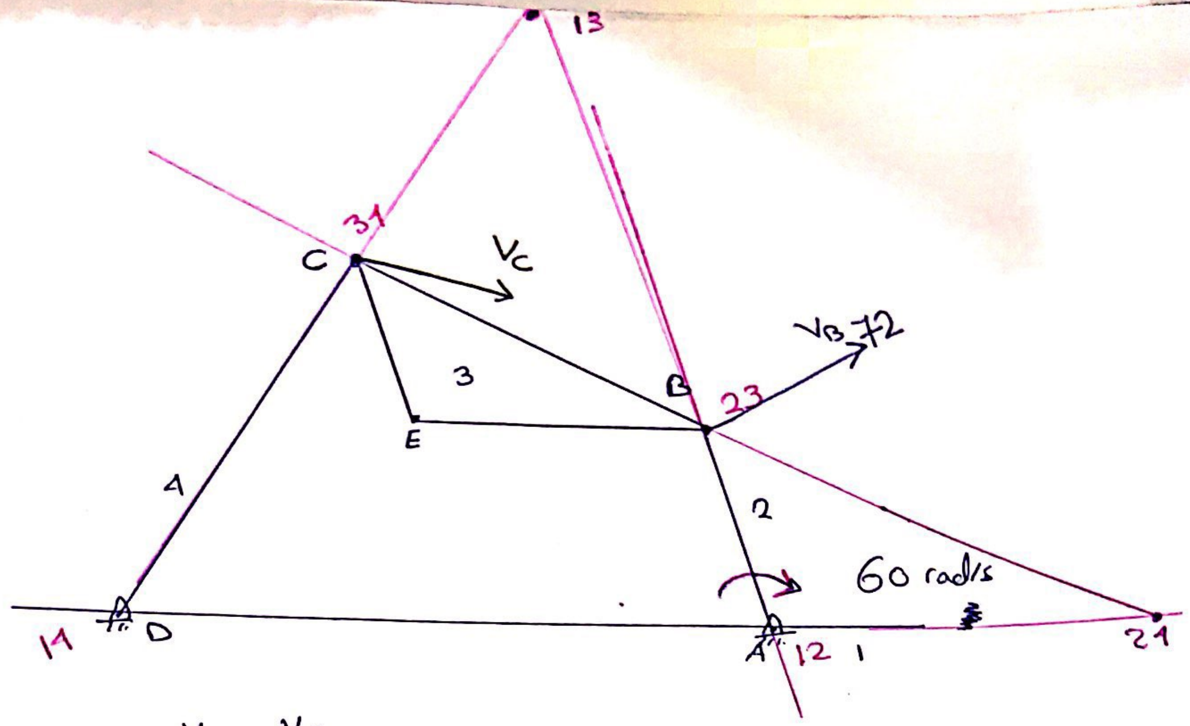
1	2	5
12	15	$\boxed{25}$
2	3	5
23	35	$\boxed{25}$

To find $\underline{24}$

2	3	4
23	34	$\boxed{24}$
2	4	5
25	45	$\boxed{24}$

To find $\underline{46}$

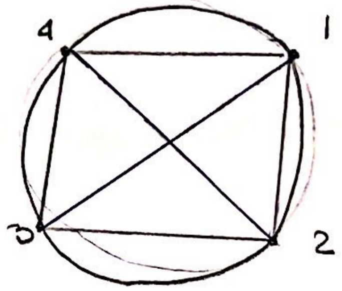
2	4	6
24	26	$\boxed{46}$
4	5	6
45	56	$\boxed{46}$



V_C , V_E

find 13

1	2	3
12	23	$\boxed{13}$
1	3	4
14	34	$\boxed{13}$



$V_B = (60)(1.2) = 72$

find 24

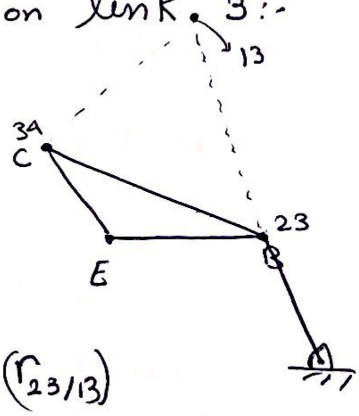
4	3	2
23	34	$\boxed{24}$
4	1	2
12	14	$\boxed{24}$

$V_E = (\omega_3) \times r_{E/B}$

$=$

found from this

Working on link 3:-



$V_B = V_{23} = \omega_3 (r_{23/13})$

$V_B = V_{23} = \omega_2 (r_{23/12})$

$\omega_3 = \dfrac{(60)\ r_{23/12}}{r_{23/13}}$

Given

$= (60) \times 1.2$ Given

measured by ruler

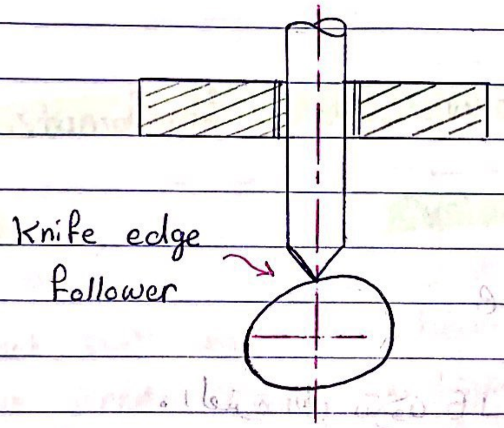
CAM Analysis :-

cam and follower

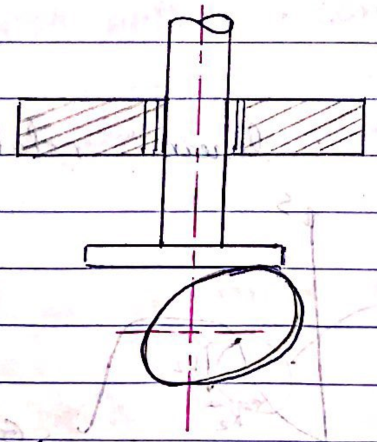
The force must be continuous so the position, Velocity and acceleration needs to be continuous.

Types of cams and followers :-

1) Disk cam with knife edge follower

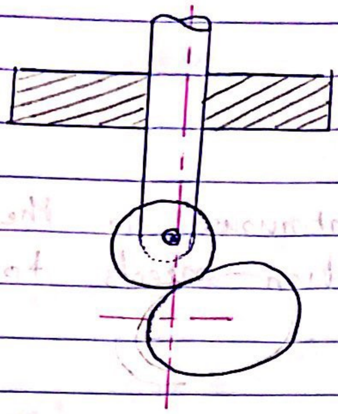


2) Disk cam with flate face follower



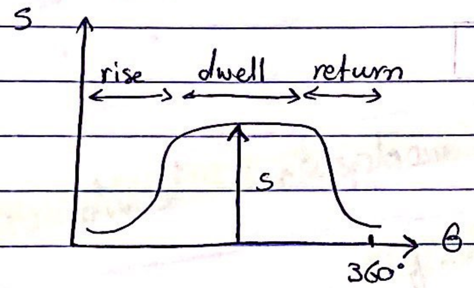
3) Disk cam with Roller follower

• حالة خاصة
من knife لتقليل الاحتكاك



• Displacement curve :-

motion of the follower as a function of the angle of the cam



dwell : • الفترة اللي بتكون θ لـ cam بتغير بس
حركة الـ follower ثابتة

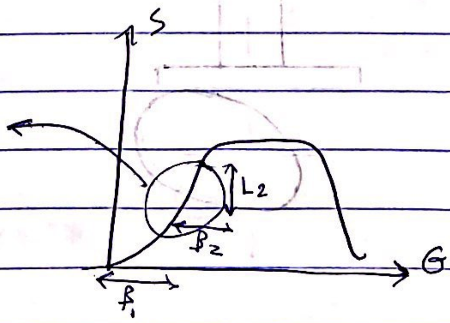
→ at dwell $V=0$, $a=0$

Common displacement curves:

1- constant velocity curves : linear relation

$y = y_0 + \text{slope}(x - x_0)$

$S = S_0 + \frac{L_2}{\beta_2}(\theta \quad)$



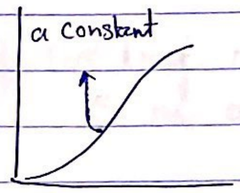
(S_0, β) اول نقطة في الخط

2. Constant acceleration

تستعمل معدلات الحركة

$$y = y_0 + V_0 t + \frac{1}{2} a_c t^2$$

$$S = S_0 + V_0 \theta + \frac{1}{2} a_c \theta^2$$



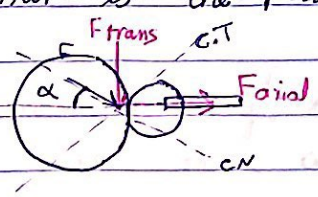
Note:

- If the curve was concaved up then a is pos
- " " " " " Down " a is neg

Standard displacement curve:

SHM Motion	Cycloidal Motion	Eight-power polynomial Motion
. lowest peak acc	. highest peak acc	
. lowest pressure Angle	. highest pressure Angle	
. used for high speed Cams	. used for low speed cams	
. can't match with dwell	. can match with dwell	
V=0 LL a=0 تستمر .	حتى بس تكون LL a=0 V=0 .	

→ What is the pressure Angle?



$F_{trans} = F \sin \alpha$

$\alpha \leq 30$. α should be small

• Cams curves drawing and analysis:-

Velocity and acceleration:

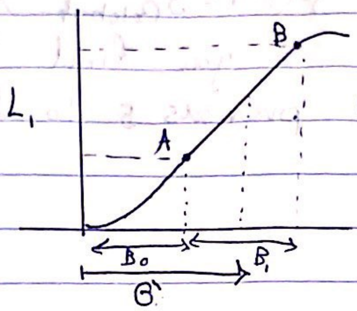
Cases.

1- Constant velocity : Slope = $\frac{L}{B}$ (of that region) = V

Now, if you want to find S at a specific point then :-

→ $S = f(\theta)$ = slope × (Theta from the begining of the line : local θ)

Explanation:



Given from A→B : V is constant

you want S at θ'

you use : $S(\theta') = \frac{L_1}{B_1} (\theta' - B_0)$

local θ

2- Constant Acceleration / deacceleration :-

You can use The three equations of Motion with constant Acc:

- $V = V_0 + a\theta$ at this velocity

- $S - S_0 = V_0\theta + \frac{1}{2} a \theta^2$

- $V^2 = V_0^2 + 2a (S - S_0)$

Remember: if the acceleration is constant then V has a linear curve /

• finding (x,y) coordinates of a contact point at $\theta = \theta'$

You need to find R, L

L = V at that θ

Constant
and so L = slope

Unknown relation
But a is Cons
use : 3 eqs
of motion in Const Acc

C-N or H<N
Harmonic or Cycloidal
use given relations
putting θ_{Local} Not θ'

$R = C + f(\theta)$

given

$f(\theta') = S_{Global}$ Not local
So you find S_L and add previous S to it

Note:
We always want to increase N of H-curves

Note:
$S_G = S_L + \beta_0 + \beta_1$ ——
$V_G = V_L$
$a_G = a_L$

Note:
When finding T.F.W:-
we put β in radians

Note:
When using relations of C, H put β in radians

But in case
$V^- = V^+$
put in Degree

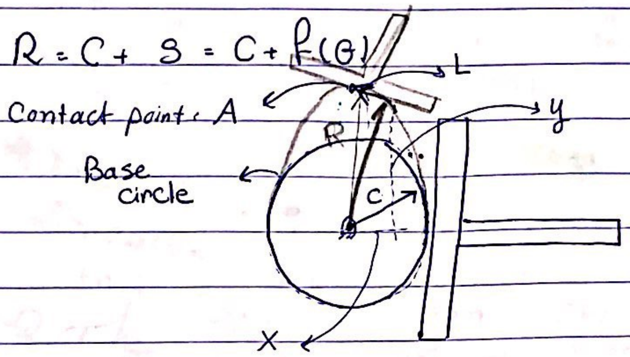
* Design of Cam profile :-

1- Flat face follower :-

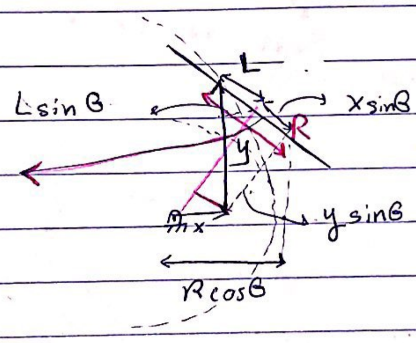
- C: radius of base circle
  : minimum distance between the face of the follower and the center of rotation of the cam.

- R: minimum 〃 〃 〃 〃
  〃 〃 〃 〃 〃 〃 〃 〃.

$R = C + S = C + f(\theta)$



Zooming in:-



- L : perp distance between the contact point and the axis of the follower

$L = y\cos\theta - x\sin\theta$

$L = \frac{dR}{d\theta} = \frac{dS}{d\theta} = V$

$R = x\cos\theta + y\sin\theta$

$x = R\cos\theta - L\sin\theta$

$y = R\sin\theta + L\cos\theta$

Cusp:

Remember: $X = R\cos\theta - L\sin\theta$

$y = R\sin\theta + L\cos\theta$

- **Cusp occurs when** : $c + f(\theta) + f''(\theta) = 0$
  so we need to make $c + \underbrace{f(\theta) + f''(\theta)}_{\text{find negative of these}} > 0$ to avoid cusp.

$$C > \left| \left[f(\theta) + f''(\theta) \right]_{min} \right|$$

ازا كان مجموع $f(\theta)$ و $f''(\theta)$ دايماً اكبر من
صفر دايماً مفيش Cusp

* How to Solve :

→ ① Search for a min $(f''(\theta))$. and obtain the θ that a min accurs at it

→ ② Then find $f(\theta)$ at that accelration (at that angle)