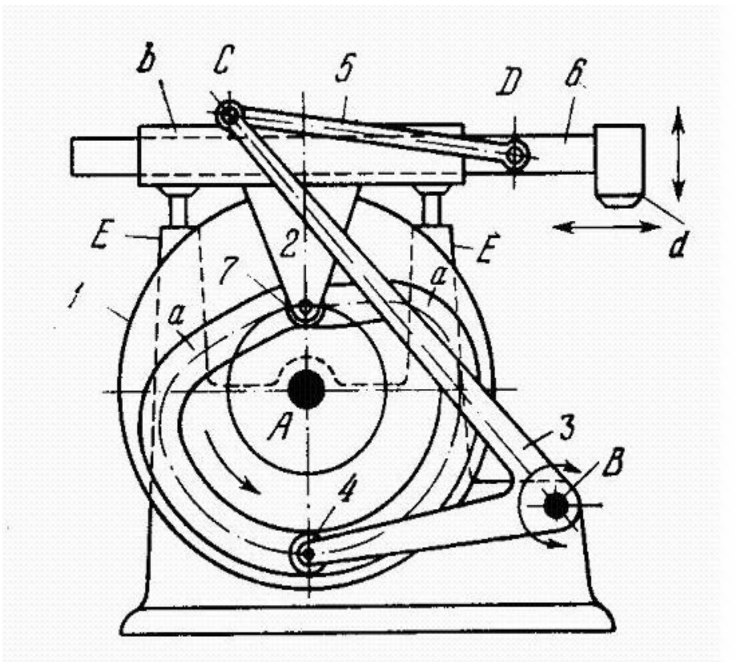
Kinematics of Machinery (ME325)

(S4-07) ----- Cam Lever mechanism for motion in two Perpendicular directions



I. **Degrees of freedom**

No. of links n = 8

Assumption: No slip between rollers ‘4 & 7’ and groove ‘a’

$j_1 = 10$

$j_2 = 0$

Dof $= 3(n-1) - 2j_1 - j_2$

$= 3(8-1) - 2 \times 10 - 0$

$= 1$

II. **Description and Working of mechanism**

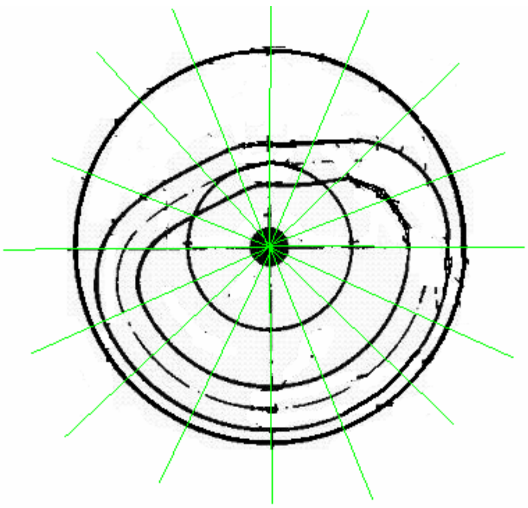
Face cam **1** rotates about fixed axis A and has profiled groove a.

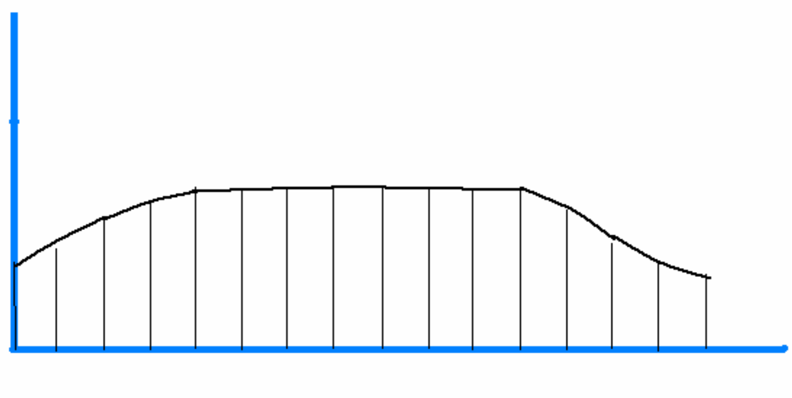
Follower **2** reciprocates in fixed guides E-E and carries roller **7** which rolls and slides along groove **‘a’**.

Follower **3** oscillates about fixed axis **B** and carries roller **4** which rolls and slides along grove a. Connecting rod **5** is connected by turning pairs **C** & **D** to follower **3** and to slide **6** which reciprocates in guide b of follower **2**.

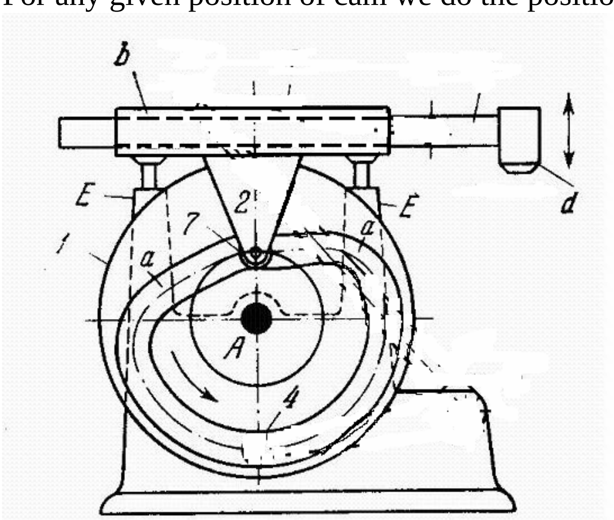
Groove **‘a’** is designed so that slide 6 with member d reciprocates in two perpendicular directions. During horizontal travel of slide **6**, follower **2** is stationary. On the other hand, during vertical travel of slide **6**, together with follower **2**, slide **6** has no horizontal motion in guide ‘**b**’.

III. **Position Analysis**





For any given position of cam we do the position analysis of other parts.



Position of roller **7** is exactly above axis **A** of the cam in the groove. Now we know the height of follower **2** so we can find out the height of link **6** from any reference base.

We also know the position of axis **B**. So taking **B4** as radius and **B** as center we cut an arc on groove **‘a’** to get the position of roller **4**. Now make angle **4BC** to get the position of **C**. From C take radius **CD** and mark off arc on link 6 to get position of **D**.

IV. **Velocity Analysis**

Consider cam is rotating at constant angular velocity w.
Then for follower 2 we have $\mathbf{V}_2$ =

$$\frac{dy}{dt} = \frac{dy}{d\theta} \cdot \frac{d\theta}{dt}$$

$$\frac{dy}{dt} = \frac{dy}{d\theta} \cdot w$$

Now axis B is fixed. So $\mathbf{w}_{4/B} = \mathbf{w}_{C/B}$.
V_D in X direction is = V_C in X direction.
So we get the velocity of d as = (Vc in X , V_2 in Y)

V. **Acceleration Analysis**

From the cam profile we find the accelerations of followers.
Now for follower 4 we obtain

$$a_4 = a_B + w_{4B} \times (w_{4B} \times R_{4B})$$

$$a_B = 0$$

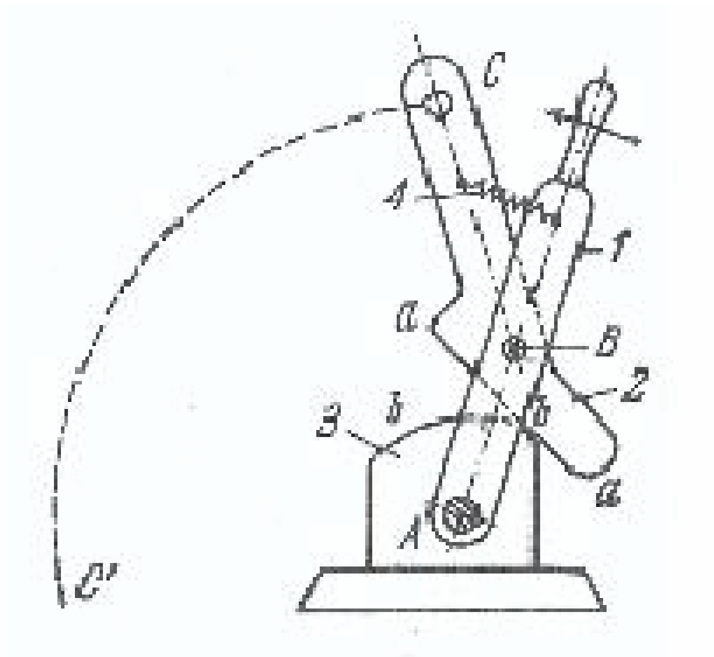
$$\text{So,} \quad a_4 = w_{4B} \times (w_{4B} \times R_{4B})$$

Similarly proceeding by repetitive use of this formula we can obtain acceleration of all links.

VI. **Kinematic requirements for designing the mechanism**

1. We observe that when roller **4** moves up and down in groove **'a'**, link **CB** oscillates. If we increase the length of **CB** then there will be more oscillations of point **C** and hence the horizontal travel of **D** increases.
2. By increasing the height of link **2** we can make the point D go higher.

(S1-16) ---- Lever with a Fixed Cam



I. Degrees of freedom

No. of links n = 3

$j_1 = 2$

$j_2 = 1$

Dof $= 3(n-1) - 2j_1 - j_2$

$= 3(3-1) - 2x2 - 1$

$= 1$

II. Description and Working of mechanism

Lever 1 turns about fixed axis A. Link 2 is hinged to link 1 by turning pair B. The lever 1 straight edge 'a-a' of link 2 is in contact with contour 'b-b' of fixed cam 3. When it is turned counterclockwise point C of link 2 travels to position C'. Various paths CC' of point C can be obtained by changing the contour 'b-b' of cam 3. Spring 4 holds link 2 against the cam.

III. Position Analysis

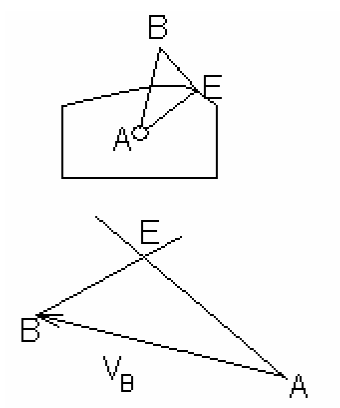
In the fig. on next slide : a-a is tangential to curve b-b. Hence BC always remains at a certain angle with the tangent to b-b. Hence if position of tangent is known, position of BC is also known.

We need to find point of contact E.
Given : All dimensions of mechanism and position of link-1 are known.
With B as centre and radius equal to height of B wrt line *a-a* , draw a circle.
Now the common tangent to the circle and cam will give the position of point of contact E.
As the position of E and B are known, we can determine position of every point on link-2 including point C.
NOTE : Position of tangent will depend on cam profile.

IV. Velocity Analysis

From Graphical method :

$$\vec{V}_C = \vec{\omega}_1 X \vec{R}_{AB} + \vec{\omega}_2 X \vec{R}_{BC}$$



V. Acceleration Analysis

Assuming that all dimensions are known, the equations for acceleration analysis are obtained as :

$$\vec{A}_E = \vec{A}_B + \vec{A}_{E/B}$$

$$\vec{A}_E = \vec{\omega}_1 X (\vec{\omega}_1 X \vec{R}_{AB}) + \vec{\alpha}_1 X \vec{R}_{AB} + \vec{\omega}_2 X (\vec{\omega}_2 X \vec{R}_{BE}) + \vec{\alpha}_2 X \vec{R}_{BE}$$

$$\& \vec{A}_E = \vec{\omega}_3 X (\vec{\omega}_3 X \vec{R}_{AE}) + \vec{\alpha}_3 X \vec{R}_{AE}$$

VI. Kinematic requirements for designing the mechanism

1. When link 1 moves point B is fixed on it and link 2 becomes tangential to profile on cam 3. To obtain a proportionate traverse of point C we simply need to increase the length of CB.
2. As seen in the position analysis, the position of point C depends on the position of tangent *a-a* which in turn depends on Cam profile.
Hence if the path traced by C is known, we can also construct the profile of cam.