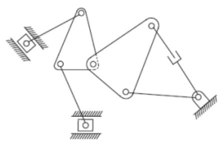
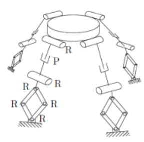
Mechatronics System Design-1
Assignment 2

Name : Shaik Affan Adeeb
Roll No : 2022102054

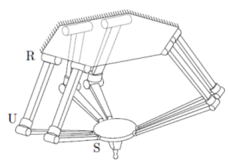
Question 2 :
Determine DoF for the following mechanisms.



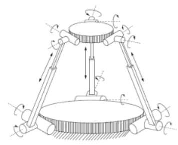
(a)



(b)



(c)



(d)

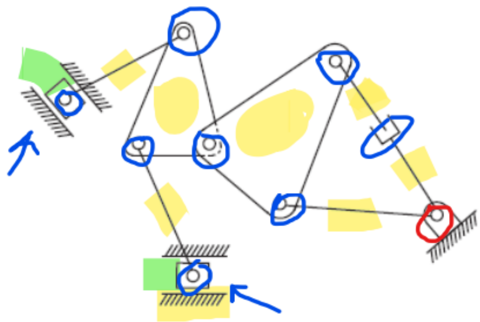
Solution :

(a) I have highlighted the links in below figure. There are two tertiary links, 2 sliding links, one ground link and remaining are binary links.So therefore total number of links are 10. Now for joints i have rounded up with ink, there are total 12 joints including two sliding joints.The red colour joint is connected to 3 links , so we count it as 2 effective joints. Therefore

$$N = 10, j_1 = 12$$

As it is a 2D figure, so we use:

$$DOF = 3(N - 1) - 2(j_1) - (j_2)$$



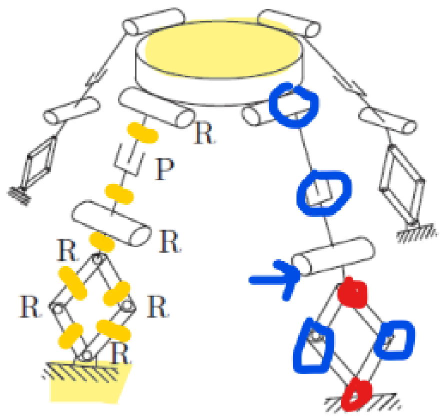
(a)

$$\implies \text{DOF} = 3(10-1) - 2(12) - 0 = 27 - 24 = 3.$$

$$\boxed{\implies DOF = 3}$$

. . . .

(b) In the below figure i have marked links in yellow colour. As it is sym-



(b)

metrical so we calculate links and joints of one side and multiply by 4. Now we have 7 binary links marked in yellow so totally 7*4 = 28 binary links and then one link is on top(shaded in yellow) and one is ground link. So therefore there are totally 28+2 = 30 links.
Now for joints i have rounded in blue and red ones rounded are connected with 3 links so they are effectively 2 links. So therefore there are 9*4 = 36 joints in total. Therefore :

$$N = 30, j_1 = 36$$

Now this is a 3D model so we use

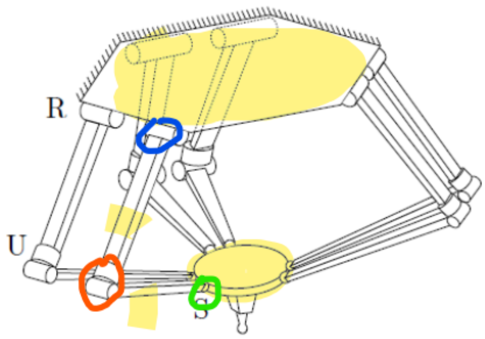
$$DOF = 6(N-1) - 5(j_1) - 4(j_2) - 3(j_3) - 2(j_4) - j_5$$

$$\implies 6(30-1) - 5(36) - 0 \implies 6(29) - 180 = 174 - 180 = -6$$

$$\boxed{\implies DOF = -6}$$

Another way considering spacial 3D: No of links =5, joints= 6 =¿ DOF=15-12=3 =¿DOD of one part =3
Now for whole 3D diagram :
links=3*4+1+1=14, joints = 4*4=16
Therefore DOF= 78-60-12= $\boxed{6}$

(c) Here as this 3D figure is symmetrical and on one bar we have two links so



(c)

6*2 = 12 links and one is top link and one is bottom link so therefore there are totally 14 links. And there are 6 joints at bottom(green marked) which have 3 DOF and 6 joints at middle(red marked) of 2 DOF and 6 joints at top(blue marked) of 1 DOF. So there are in total 18 joints.
Therefore

$$N = 14, j_1 = 6, j_2 = 6, j_3 = 6$$

Now this is a 3D model so we use

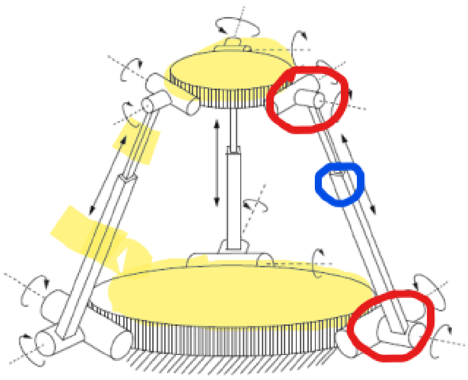
$$DOF = 6(N-1) - 5(j_1) - 4(j_2) - 3(j_3) - 2(j_4) - j_5$$

$$\implies DOF = 6(14-1) - 5(6) - 4(6) - 3(6) - 0 \implies 78 - 30 - 24 - 18 \implies 78 - 72 = 6$$

$$\boxed{\implies DOF = 6}$$

....

(d) In this symmetrical 3D on one bar there 2 binary links(highlighted with



(d)

yellow) and there 3 such bars so 2*3 = 6 and top and bottom links , so therefore there are totally 6+2 = 8 links.
Now red coloured rounded joints have 2 DOF and blue rounded one's have 1 DOF.This implies joints = 3 + 6 = 9, Therefore :

$$N = 8, j_1 = 3, j_2 = 6$$

Now this is a 3D model so we use

$$DOF = 6(N-1) - 5(j_1) - 4(j_2) - 3(j_3) - 2(j_4) - j_5$$

$$\implies DOF = 6(8-1) - 5(3) - 4(6) \implies 42 - 15 - 24 \implies 42 - 39 = 3$$

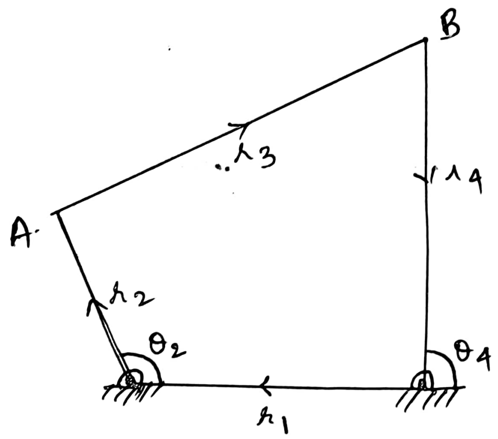
$$\boxed{\implies DOF = 3}$$

Question 4(a):

Determination of the link length dimensions to generate a particular coupler curve is beyond the scope of this assignment. If the link lengths are given, one can easily determine the coupler curve graphically or analytically using the methods discussed in the class. Assume suitable link lengths for a Grashof mechanism with crank-rocker inversion (a representative picture is shown below), and utilize Matlab to generate different algebraic curves by selecting five different points on the Coupler.

Solution :

Let's take Grashof mechanism with crank-rocker inversion as given:-



$$\theta_1 = 0^\circ \quad \text{(angle made by} \overrightarrow{r_1} \text{and ground)}$$

Method 1:
Assuming $\overrightarrow{R_1}, \overrightarrow{R_2}$ $\overrightarrow{R_3}, \overrightarrow{R_4}$ in clockwise direction and of lengths r_1, r_2, r_3, r_4 respectively.

Now writing loop closure equations:-

$$\overrightarrow{R_1} + \overrightarrow{R_2} + \overrightarrow{R_3} + \overrightarrow{R_4} = 0$$

Now assuming the given plane as complex plane :

$$\Rightarrow r_1 e^{i\theta_1} + r_2 e^{i\theta_2} + r_3 e^{i\theta_3} + r_4 e^{i\theta_4} = 0$$

$$As \quad \theta_1 = 0^\circ$$

$$\Rightarrow r_1 + r_2 e^{i\theta_2} + r_3 e^{i\theta_3} + r_4 e^{i\theta_4} = 0$$

$$\Rightarrow r_1 + r_2 \cos\theta_2 + r_3 \cos\theta_3 + r_4 \cos\theta_4 + i\left[r_2 \sin\theta_2 + r_3 \sin\theta_3 + r_4 \sin\theta_4\right] = 0$$

Now equating real part and imaginary part to zero, we get :

$$\begin{aligned} \Rightarrow \quad & r_1 + r_2 \cos\theta_2 + r_3 \cos\theta_3 + r_4 \cos\theta_4 = 0 \\ & r_2 \sin\theta_2 + \lambda_3 \sin\theta_3 + r_4 \sin\theta_4 = 0 \end{aligned}$$

Now all lengths are known and θ_2 is also known, as we are taking it as input. so Now let's try to eliminate θ_3 :- from above two equations:

$$\begin{aligned} r_3 \cos\theta_3 &= -r_1 - r_2 \cos\theta_2 - r_4 \cos\theta_4 \\ r_3 \sin\theta_3 &= -r_2 \sin\theta_2 - r_4 \cos\theta_4 \end{aligned}$$

Now squaring and adding above two equations:-

$$\begin{aligned} \Longrightarrow r_3^2 \cos^2\theta_3 &= r_1^2 + r_2^2 \cos_2^2 + r_4^2 \cos\theta_4^2 + 2r_1 r_2 \cos\theta_2 + 2r_2 r_4 \cos\theta_2 \cos\theta_4 + 2r_1 r_4 \cos\theta_4 \\ r_3^2 \sin^2\theta_3 &= 0 + r_2^2 \sin^2\theta_2 + r_4^2 \sin_4^2 + 2r_2 r_4 \sin\theta_2 \sin\theta_4 \end{aligned}$$

Now adding above equations:-

$$r_3^2 = r_1^2 + r_2^2 + r_4^2 + 2r_1 r_2 \cos\theta_2 + 2r_2 r_4 \left(\cos\theta_2 \cos\theta_4 + \sin\theta_2 \sin\theta_4\right) + 2r_1 r_4 \cos\theta_4$$

$$\Rightarrow r_3^2 = r_1^2 + r_2^2 + r_4^2 + 2r_1 r_2 \cos\theta_2 + 2r_2 r_4 \cos\left(\theta_2 - \theta_4\right) + 2r_1 r_4 \cos\theta_4$$

$$\Rightarrow \cos\left(\theta_2 - \theta_4\right) = \frac{r_3^2 - r_1^2 - r_2^2 - r_4^2 - 2r_1 r_2 \cos\theta_2 - 2r_1 r_4 \cos\theta_4}{2r_2 r_4}$$

$$\Rightarrow \cos\left(\theta_2 - \theta_4\right) = \frac{r_3^2 - r_1^2 - r_2^2 - r_4^2}{2r_2 r_4} - \frac{r_1}{r_4}\cos\theta_2 - \frac{r_1}{r_2}\cos\theta_4$$

Assuming

$$k_1 = \frac{r_3^2 - r_1^2 - l_2^2 - r_4^2}{2r_2 r_4}$$

$$k_2 = \frac{r_1}{r_4}$$
$$k_3 = \frac{r_1}{r_2}$$

Therefore, our equation now becomes:

$$\cos(\theta_2 - \theta_4) = k_1 - k_2 \cos\theta_2 - k_3 \cos\theta_4 \longrightarrow (1)$$

Now using half using angle formula:

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

Let us take $\tan(\theta_4/2) = t$:

$$\implies \cos\theta_4 = \frac{1-t^2}{1+t^2} \quad \sin\theta_4 = \frac{2t}{1+t^2}$$

Now from equation (1):

$$\begin{aligned}
&\cos(\theta_2 - \theta_4) = k_1 - k_2\cos\theta_2 - k_3\cos\theta_4 \\
\Rightarrow &\cos\theta_2\cos\theta_4 + \sin\theta_2\sin\theta_4 = k_1 - k_2\cos\theta_2 - k_3\cos\theta_4 \\
\Rightarrow &\cos\theta_2\left(\frac{1-t^2}{1+t^2}\right) + \sin\theta_2\left(\frac{2t}{1+t^2}\right) = k_1 - k_2\cos\theta_2 - k_3\left(\frac{1-t^2}{1+t^2}\right) \\
\Rightarrow &\left(1-t^2\right)\cos\theta_2 + 2t\left(\sin\theta_2\right) = k_1\left(1+t^2\right) - k_2\cos\theta_2\left(1+t^2\right) - k_3\left(1-t^2\right)
\end{aligned}$$

Now making it a quadratic in t :-

$$\begin{aligned}
&\cos\theta_2 - t^2\cos\theta_2 + 2t\sin\theta_2 = k_1 + k_1t^2 - k_2\cos\theta_2 - t^2k_2\cos\theta_2 - k_3 + k_3t^2 \\
\Rightarrow &t^2k_2\cos\theta_2 - t^2\cos\theta_2 - k_3t^2 - k_1t^2 + 2t\sin\theta_2 + \cos\theta_2 + k_3 - k_1 + k_2\cos\theta_2 \\
\Rightarrow &t^2\left(k_2\cos\theta_2 - \cos\theta_2 - k_3 - k_1\right) + 2t\sin\theta_2 + \left(\cos\theta_2 - k_1 + k_3 + k_2\cos\theta_2\right) = 0
\end{aligned}$$

Assuming:

$$A = k_2\cos\theta_2 - \cos\theta_2 - k_3 - k_1$$
$$B = 2\sin\theta_2, C = \cos\theta_2 - k_1 + k_3 + k_2\cos\theta_2$$

$\Rightarrow$ we can write:

$$At^2 + Bt + C = 0$$

Now using quadratic formula:-

$$t = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$$Ast = \tan\left(\frac{\theta_4}{2}\right) \Rightarrow \tan\left(\frac{\theta_4}{2}\right) = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$$\boxed{\Rightarrow \theta_4 = 2\tan^{-1}\left(\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}\right)}$$

Now using equations which we have used at first we can find θ_3:

$$r_3 \cos\theta_3 = -r_1 - r_2 \cos\theta_2 - r_4 \cos\theta_4$$
$$r_3 \sin\theta_3 = -r_2 \sin\theta_2 - r_4 \sin\theta_4$$

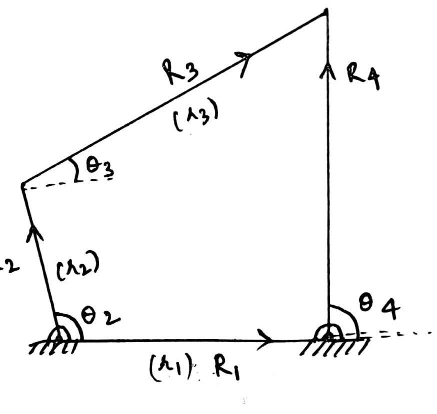
Dividing both equations:

$$\tan\theta_3 = \frac{-r_2 \sin\theta_2 - r_4 \sin\theta_4}{-r_1 - r_2 \cos\theta_2 - r_4 \cos\theta_4}$$

$$\boxed{\Rightarrow \theta_3 = \tan^{-1}\left(\frac{r_2 \sin\theta_2 + r_4 \sin\theta_4}{r_1 + r_2 \cos\theta_2 + r_4 \cos\theta_4}\right)}$$

Method 2:

Taking $\overrightarrow{R_1}, \overrightarrow{R_2}\ \overrightarrow{R_3}, \overrightarrow{R_4}$ directions as shown in figure below(which was discussed in class) :



Loop closer equation:-

$$-\overrightarrow{R_1} + \overrightarrow{R_2} + \overrightarrow{R_3} - \vec{R_4} = 0$$

assuming complex plane:-

$$\Rightarrow -r_1 e^{i\theta_1} + r_2 e^{i\theta_2} + r_3 e^{i\theta_3} - r_4 e^{i\theta_4} = 0$$

As $\theta_1 = 0^\circ$

$$\Rightarrow -r_1 + r_2 e^{i\theta_2} + r_3 e^{i\theta_3} - r_4 e^{i\theta_4} = 0$$

Now comparing real and imaginary parts :-

$$-r_1 + r_2 \cos\theta_2 + r_3 \cos\theta_3 - r_4 \cos\theta_4 = 0$$
$$r_2 \sin\theta_2 + r_3 \sin\theta_3 - r_4 \sin\theta_4 = 0$$

Now eleminating θ_3 :..

$$r_3^2 \cos_3^2 \theta_3 = \left[(r_4 \cos\theta_4 + r_1 - r_2 \cos_2\theta_2\right]^2$$
$$r_3^2 \sin^2\theta_3 = r_4^2 \sin^2\theta_4 + r_2^2 \sin^2\theta_2 - 2r_2 r_4 \sin\theta_2 \sin\theta_4$$
$$\Rightarrow r_3^2 \cos^2\theta_3 = r_4^2 \cos^2\theta_4 + r_1^2 + r_2^2 \cos^2\theta_2 + 2r_1 r_4 \cos\theta_4 - 2r_1 r_2 r_2 \cos\theta_2 - 2r_2 r_4 \cos\theta_2 \cos\theta_4$$
$$r_3^2 \sin^2\theta_3 = r_4^2 \sin^2\theta_4 + r_2^2 \sin^2\theta_2 - 2r_2 r_4 \sin\theta_2 \sin\theta_4$$

On adding above equations we get:-

$$r_3^2 = r_4^2 + r_1^2 + r_2^2 + 2r_1 r_4 \cos\theta_4 - 2r_1 r_2 \cos\theta_2 - 2r_2 r_4 (\cos\theta_2 \cos\theta_4 + \sin\theta_2 \sin\theta_4)$$

$$\Rightarrow r_3^2 = r_4^2 + r_1^2 + r_2^2 + 2r_1 r_4 \cos\theta_4 - 2r_1 r_2 \cos\theta_2 - 2r_2 r_4 \cos(\theta_2 - \theta_4)$$
$$\Rightarrow 2r_2 r_4 \cos(\theta_2 - \theta_4) = -r_3^2 + r_4^2 + r_1^2 + r_2^2 + 2r_1 r_4 \cos\theta_4 - 2r_1 r_2 \cos\theta_2$$
$$\Rightarrow \cos(\theta_2 - \theta_4) = \frac{r_1^2 + r_2^2 + r_4^2 - r_3^2}{2r_2 r_4} + \frac{r_1}{r_2}\cos\theta_4 - \frac{r_1}{r_4}\cos\theta_2$$

Assuming:

$$k_3 = \frac{r_1^2 + r_2^2 + r_4^2 - r_3^2}{2r_2 r_4}$$
$$k_1 = \frac{r_1}{r_2}$$
$$k_2 = \frac{r_1}{r_4}$$

$\Rightarrow$ Our above equation becomes:-

$$\cos(\theta_2 - \theta_4) = k_3 + k_1 \cos\theta_4 - k_2 \cos\theta_2 \text{..........(1)}$$

Now using the same half angle formulas os mention in method -1:-

$$t = \tan\left(\frac{\theta_4}{2}\right) \Rightarrow \cos\theta_4 = \frac{1-t^2}{1+t^2}, \sin\theta_4 = \frac{2t}{1+t^2}$$

On expanding (1) we get:-

$$\cos\theta_2\left(\frac{1-t^2}{1+t^2}\right) + \sin\theta_2\left(\frac{2t}{1+t^2}\right) = k_3 + k_1\left(\frac{1-t^2}{1+t^2}\right) - k_2\cos\theta_2$$
$$\Rightarrow \cos\theta_2\left(1-t^2\right) + \sin\theta_2(2t) = k_3\left(1+t^2\right) + k_1\left(1-t^2\right) - k_2\cos\theta_2\left(1+t^2\right)$$

Now making Quadratic in t:-

$$\Rightarrow (\cos\theta_2 - k_1 - k_2\cos\theta_2 + k_3)\,t^2 - 2\sin\theta_2 t + (k_1 + k_3 - k_2\cos\theta_2 - \cos\theta_2)$$

Now assuming

$$A = \cos\theta_2 - k_1 - k_2\cos\theta_2 + k_3$$
$$B = -2\sin\theta_2$$
$$C = k_1 + k_3 - k_2\cos\theta_2 - \cos\theta_2$$

$\Rightarrow$ Quadratic Equation becomes:-

$$At^2 + Bt + C = 0$$

$\Rightarrow$ from Quadratic formula:

$$t = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$
$$\Rightarrow t = \tan\left(\frac{\theta_4}{2}\right) = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$
$$\Rightarrow \theta_4 = 2\tan^{-1}\left(\frac{-B \pm \sqrt{B^2 - 4AC}}{2A}\right)$$

We will get two values of θ_4 for one value of θ_2. These are referred to as the crossed and open configurations of the linkage and also two circuits of linkage.

Now finding θ_3 :- Using our starting equations:

$$r_4\cos\theta_4 = r_2\cos\theta_2 + r_3\cos\theta_3 - r_1$$
$$r_4\sin\theta_4 = r_2\sin\theta_2 + r_3\sin\theta_3$$

on squaring and adding we get: -

$$r_4^2\cos^2\theta_4 = r_2^2\cos^2\theta_2 + r_3^2\cos^2\theta_3 + r_1^2 - 2r_1r_2\cos\theta_2 + 2r_2r_3\cos\theta_2\cos\theta_3 - 2r_1r_3\cos\theta_3$$

$$r_4^2 \sin^2\theta_4 = r_2^2 \sin^2\theta_2 + r_3^2 \sin^2\theta_3 + 2r_2r_3 \sin\theta_2 \sin\theta_3$$

$\Rightarrow$ Now adding above equations: -

$$r_4^2 = r_2^2 + r_3^2 + r_1^2 - 2r_1r_2\cos\theta_2 - 2r_1r_3\cos\theta_3 + 2r_2r_3\left(\cos\left(\theta_2+\theta_3\right)\right)$$

$$\Rightarrow \cos\left(\theta_2+\theta_3\right) = \frac{r_4^2 - r_2^2 - r_3^2 - r_1^2}{2r_2r_3} + \frac{r_1}{r_3}\cos\theta_2 - \frac{r_1}{r_2}\cos\theta_3$$

$$taking \quad k_5 = \frac{r_4^2 - r_2^2 - r_3^2 - r_1^2}{2r_2r_3}, k_4 = \frac{r_1}{r_3}, k_1 = \frac{r_1}{r_2}$$

By using half angle again:-

$$\cos\theta_2\left(\frac{1-t^2)}{1+t^2} - \sin\theta_2\left(\frac{2t}{1+t^2}\right) = k_5 + k_4\cos\theta_2 - k_1\cos\theta_3 \; where, t = \tan\left(\frac{\theta_3}{2}\right)$$

$$\Rightarrow \cos\theta_2\left(1-t^2\right) - \sin\theta_2(2t) = k_5\left(1+t^2\right) + k_4\cos\theta_2\left(1+t^2\right) - k_1\cos\theta_3\left(1+t^2\right)$$
$$\Rightarrow \cos\theta_2\left(1-t^2\right) - \sin\theta_2(2t) = k_5\left(1+t^2\right) + k_4\cos\theta_2\left(1+t^2\right) - k_1\left(1-t^2\right)$$

Now making quadratic in t: -

$$\left(\cos\theta_2 - k_1 + k_4\cos\theta_2 + k_5\right)t^2 - 2\sin\theta_2 t + k_1 + k_4\cos\theta_2 - \cos\theta_2 - k_5$$

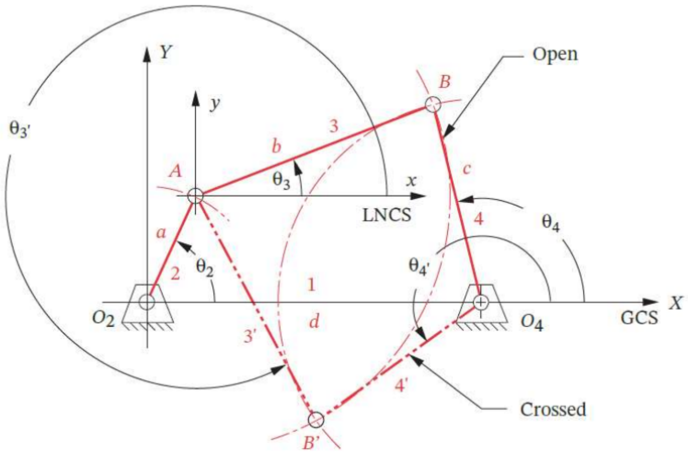
$\Rightarrow$ Solution to quadratic in t =

$$t = \tan\left(\frac{\theta_3}{2}\right) = 2\tan^{-1}\left(\frac{-E \pm \sqrt{E^2 - 4DF}}{2D}\right)$$

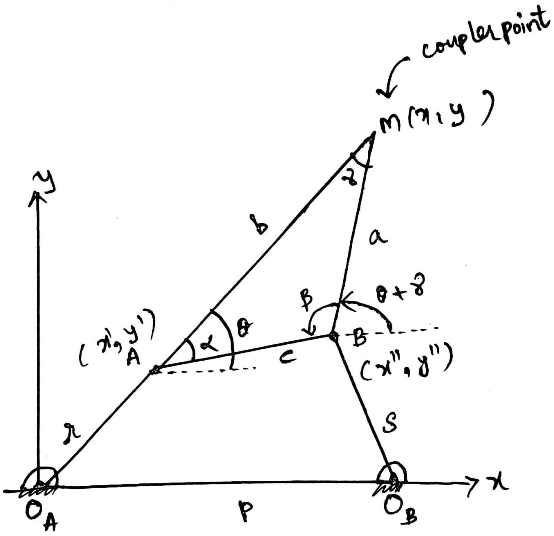
where: $-D = \cos\theta_2 - k_1 + k_4\cos\theta_2 + k_5$

$$E = -2\sin\theta_2$$
$$F = k_1 + k_4\cos\theta_2 - \cos\theta_2 + k_5$$

Therefore θ_3 also has 2 solutions for each value of θ_2, corresponding to closed and open circuits of linkage as shown in below figure:



Now in fourbar couples curves, the position of coupler points can be defined using either the length and angle, or any combination of three parameters within a triangle. The equation describing the coupler-point curve for a four-bar linkage can be derived using analytic geometry principles.



Let $(x'; y')$ and (x'', y'') , (x, y) be respectively the coordinates of A, B and coupler point M. Now,

$$x' = x - b\cos\theta$$
$$x'' = x - a\cos(\theta + y)$$

and

$$y' = y - b\sin\theta$$
$$y'' = y - a\sin(\theta + y)$$

Now as A and B describe circles about centre O_A and O_B respectively so on dropping a perpendicular from A and B to base and applying hypotenese theorem in that forming triangles we get:

$$x'^2 + y'^2 = r^2......(1) \quad \text{and} \quad (x'' - p)^2 + y'' = s^2.....(2)$$

Now putting x', y', we get:

$$(x - b\cos\theta)^2 + (y - b\sin\theta)^2 = r^2$$

$$x^2 + b^2\cos^2\theta - 2xb\cos\theta + y^2 + b^2\sin^2\theta - 2yb\sin\theta = x$$
$$\Rightarrow \quad x\cos\theta + y\sin\theta = \frac{x^2 + y^2 + b^2 - x^2}{2b} - 0$$

Now putting x'', y'' in eqn(2), we get:

$$(x - a\cos(\theta + \gamma) - p)^2 + (y - a\sin(\theta + \gamma))^2 = s^2$$
$$[(x - p)\cos\gamma + y\sin\gamma]\cos\theta - [(x - p)\sin\gamma - y\cos\gamma]\sin\theta$$
$$= \frac{(x - p)^2 + y^2 + a^2 - s^2}{2a}$$

Now by eliminating θ between the last two equations we will get couples point curve: after solving for $\cos\theta$ and $\sin\theta$, and then substituting the value in $\cos^2\theta + \sin^2\theta = 1$ we will get,

$$\left[\begin{array}{l} \{\sin\alpha[(x - p)\sin\gamma - y\cos\gamma]\,(x^2 + y^2 + b^2 - r^2) + y\sin\beta\,[(x - p)^2 + \\ y^2 + a^2 - s^2]\}^2 + \{\sin\alpha\,[(x - p)\cos\gamma + y\sin\gamma\,(x^2 + y^2 + b^2 - r^2) \\ -x\sin\beta\,[(x - p)^2 + y^2 + a^2 - s^2]\}^2\Big] \\ \quad = 4k^2\sin^2\alpha\sin^2\beta\sin^2 y[x(x - p) - y - py\cot\gamma]^2 \end{array} \right.$$

$$where, k = \frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}$$

Which is constant of sine law applied in triangle ABM.
This equation is of sixth degree- tricircular sextic. And order of these type of equations can be found by using the below formula :

$\boxed{M = 2.3^{\left(\frac{n}{2} - 1\right)}}$ where n is number of bars, in 4 bar case we take n=4

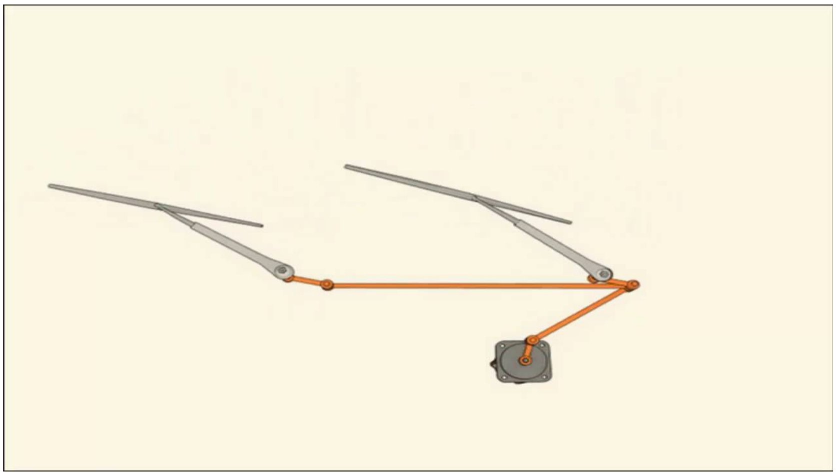
Question 5

Solution :

Firstly i have drwan a circle with radius 30m, then extrude this for 11m. then drawing second circle by taking previous base as palne with diameter of 37m. Then extruding it for 4.1m, then select it and do draft for 45 degrees downwards. Then extrude inner 11m extended circle to 8m still.Then make rectangles with centre as centre of circles and of width 10m and extrude it for 7.5m. Then select four faces of rectangle and do circular pattern. Then do fillet of four edges of rectangle for 1 degree. In this way our one half get's created. The I extruded our first crlce to 11m still now back side and done same thing as i have done for fornt sides.
All pictures related to this are there in zip

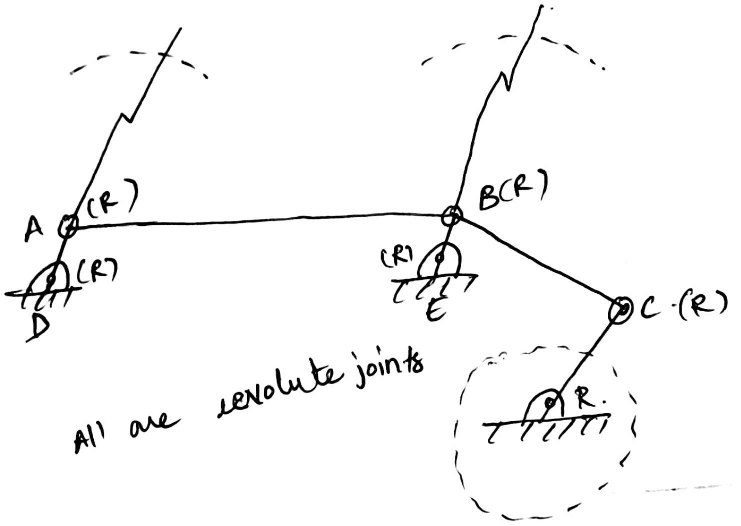
Question 1:

Solution :

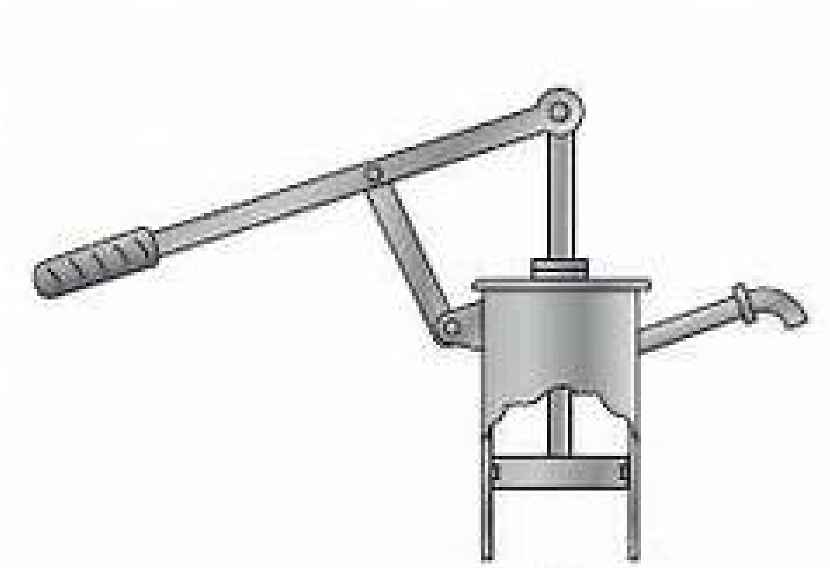


1) Wiper mechanism

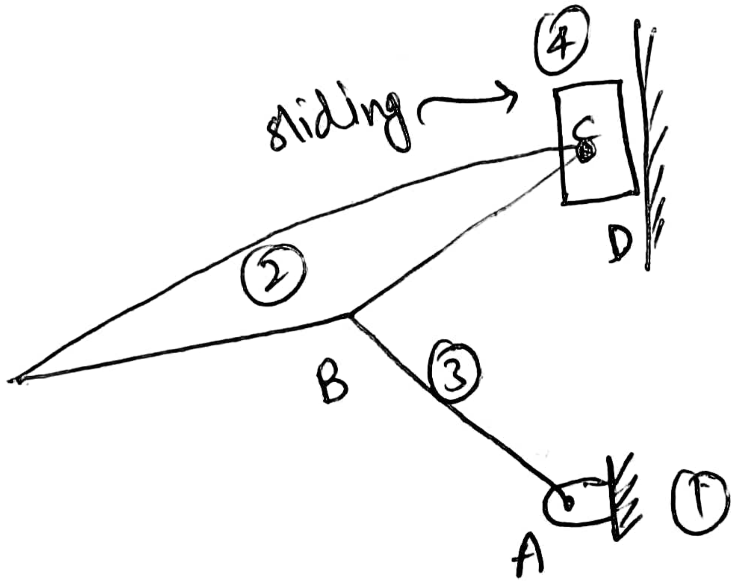
Below is kinematic digram of wiper mechanism



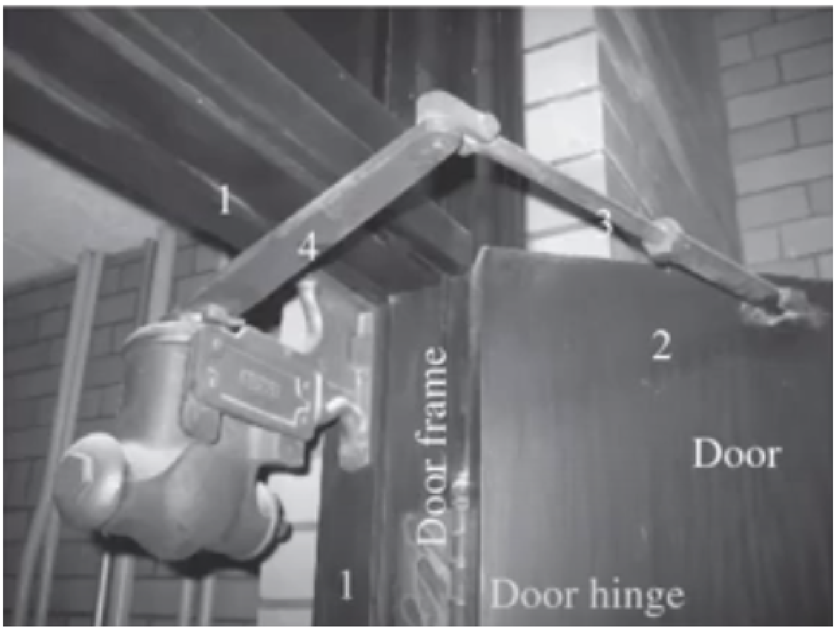
Wiper mechanism kinematic



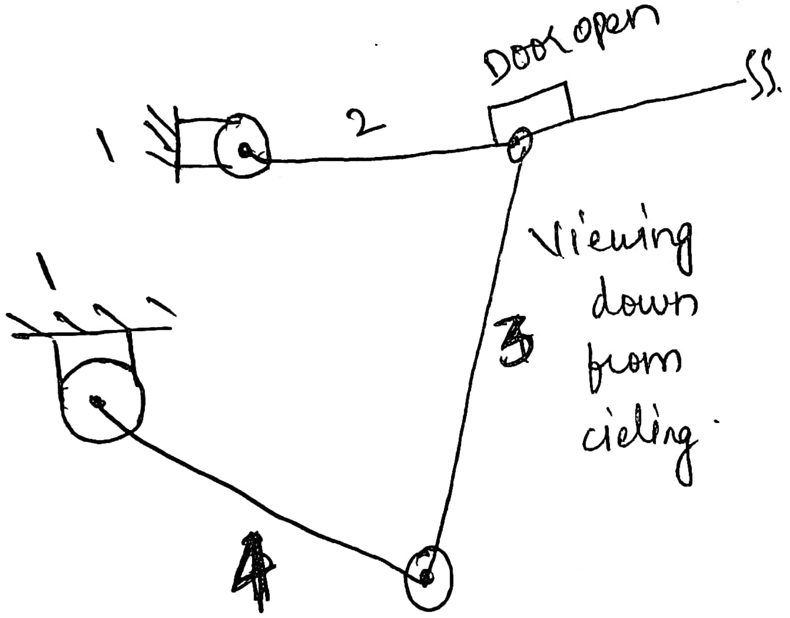
2) water pump



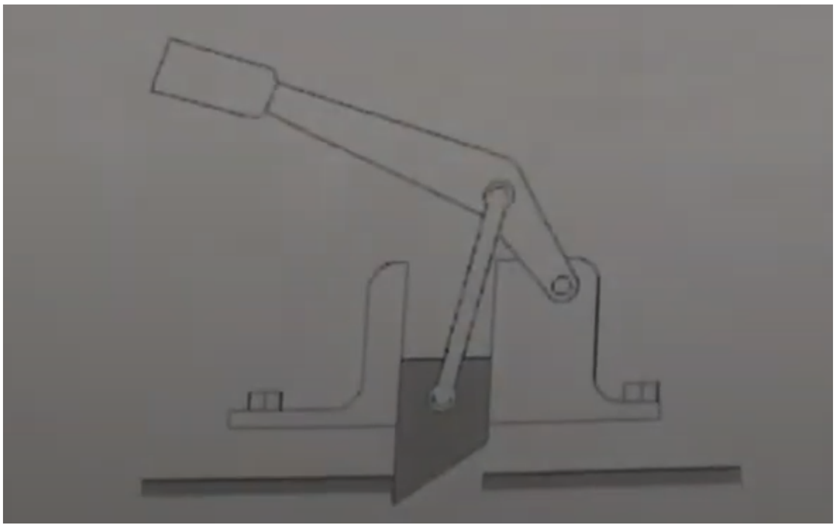
hand water pump kinematic



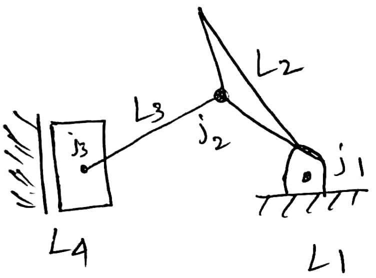
3)Door damper mechanism



Door damper mechanism kinematic

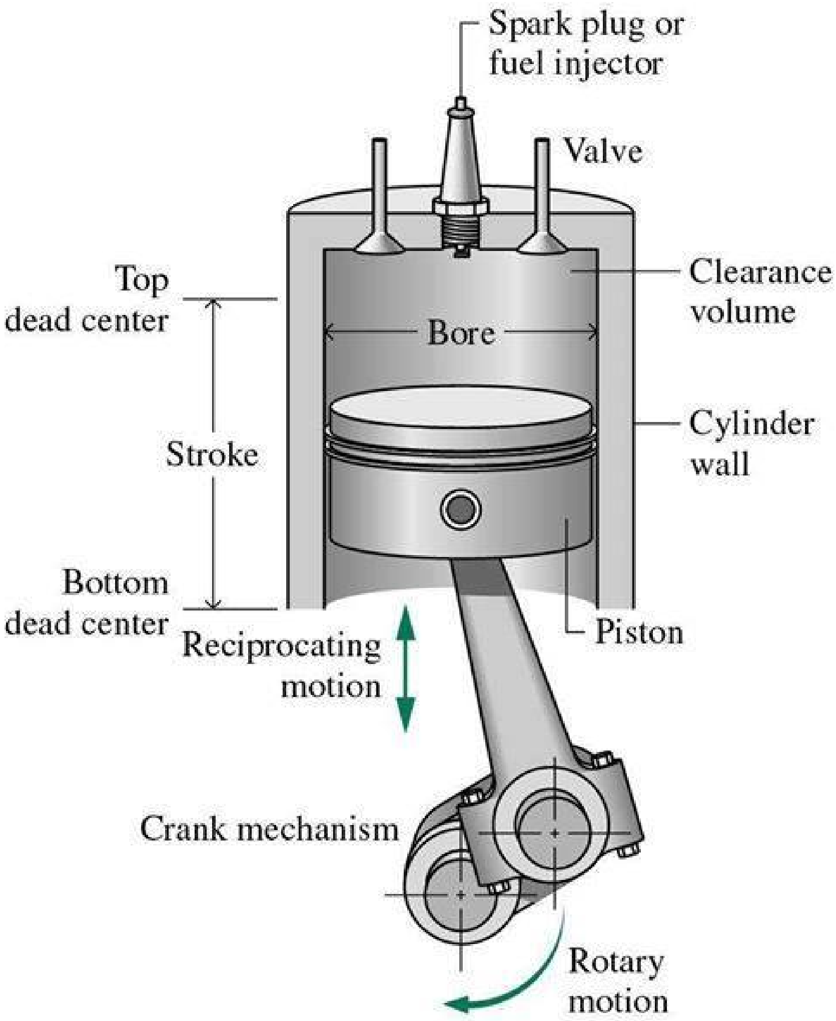


4)swear-press mechanism

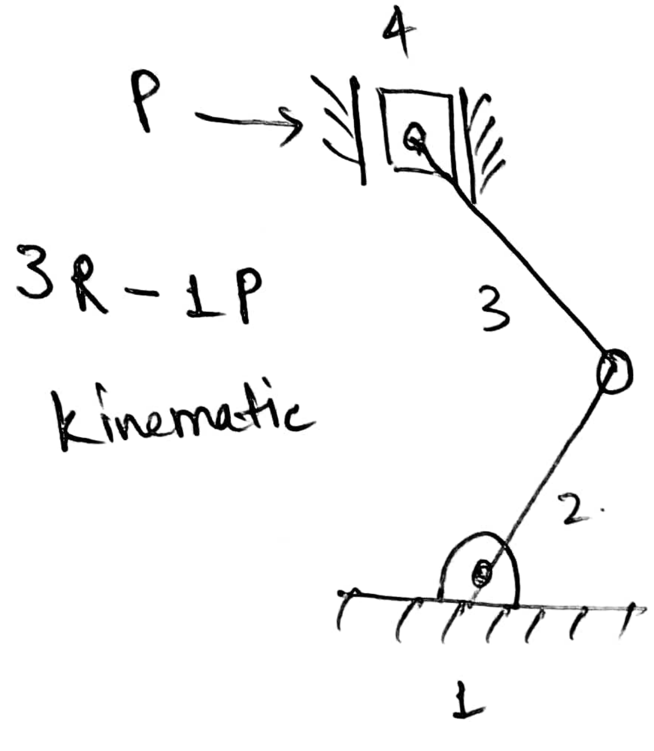


4links, 3joints
1joint = sliding.

swear-press mechanism kinematic



5) combustion Engine mechanism



combustion Engine mechanism kinematic