Mechanism

① Kutzbach criterion

$$F = 3(n-1) - 2j - h$$

If $F = 1$ (constrained mechanism)

$$3n - 2j - h = 4$$

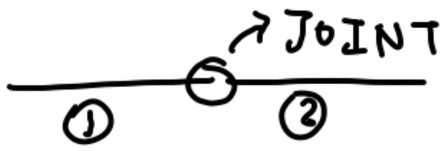
Grubler criterion

② Let $n_2, n_3, \dots, n_k$ be binary, tertiary, --- links

$$n = n_2 + n_3 + \dots + n_k \quad \hookrightarrow (1)$$

Let "j" be the no. of joints.

We are limiting to the case of simple hinge



So total no. of elements $= 2j$

Total no. of elements is also equal to $(2n_2 + 3n_3 + \dots + kn_k)$

$$2j = 2n_2 + 3n_3 + \dots + kn_k \quad \hookrightarrow (2)$$

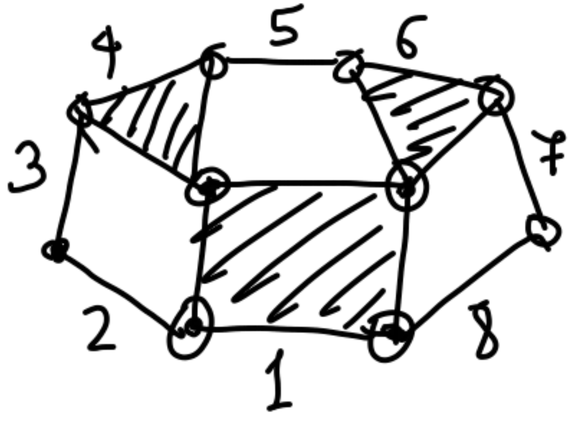
$$\therefore F = 3(n_2 + \dots + n_k - 1) - (2n_2 + 3n_3 + \dots + kn_k)$$

$$\therefore n_2 = (F+3) + n_4 + 2n_5 + \dots + (k-3)n_k$$

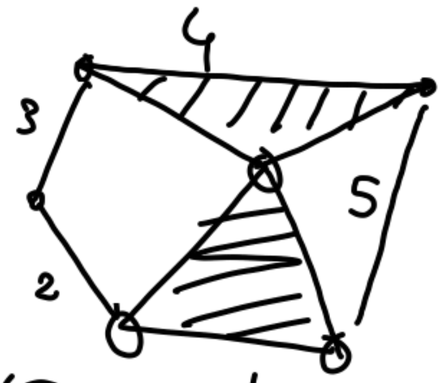
So minimum no. of binary links $= 4$

Given "n" no. of links.

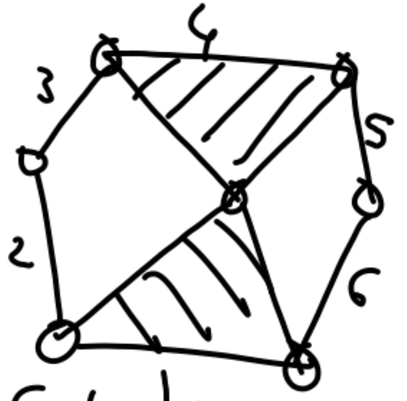
We want to find out what is the maximum no. of hinges, a link can have?



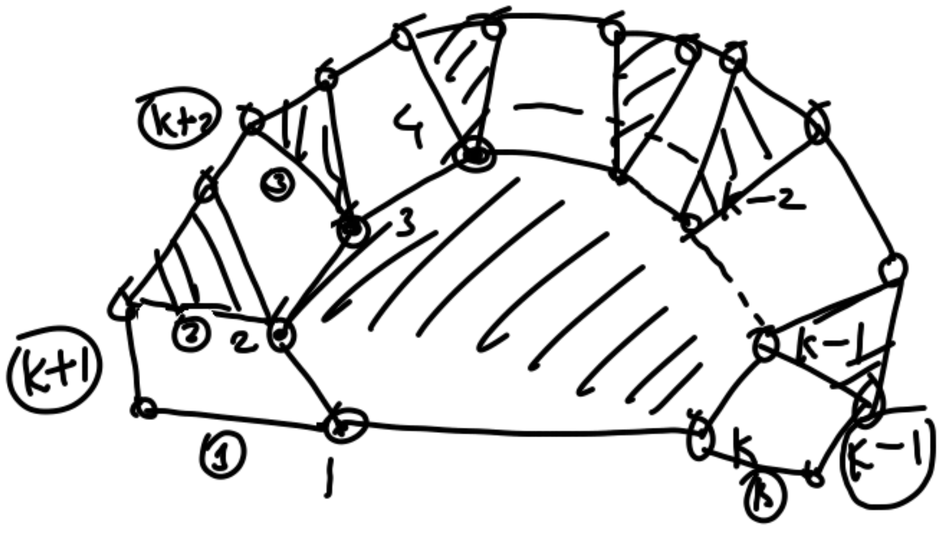
min. no. of elements = 8



(5 elem)



(6 elem)



No. of links : $k + k-1 + 1 = 2k$

Min. no. of elements = $2k$

Given "n" no. of links, we can have a link with maximum

$$\begin{cases} n/2 & (n = \text{EVEN}) \\ \frac{(n+1)}{2} & (n = \text{ODD}) \end{cases}$$

hinges

$F = 1$; $n = 6$

$1 = 3(n-1) - 2j$

$= 3(6-1) - 2j$

$j = 7$

$n/2 = 3$

So in this case we can binary and ternary links

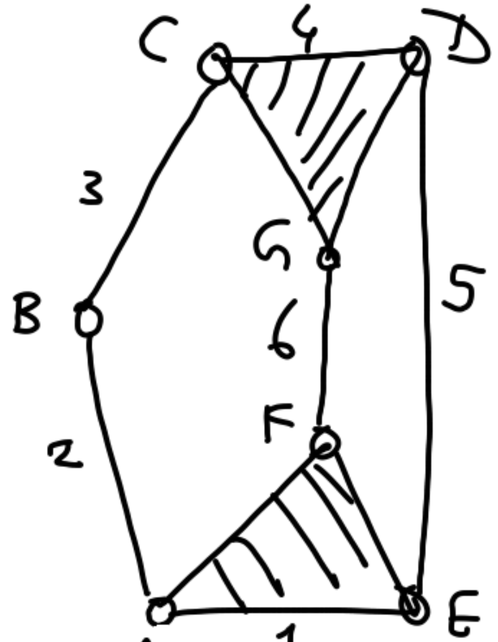
n_2 n_3

$n_2 + n_3 = 6$ — (1)

$2n_2 + 3n_3 = 2j = 14$ — (2)

$2n_2 + 2n_3 = 12$ — (3)

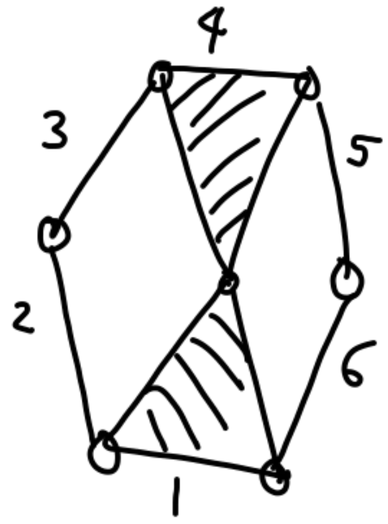
$n_3 = 2$; $n_2 = 4$



STEPHENSON MECHANISM

$2 + 2 + 2 + 2 + 2 + 2 + 2 = 14$

$2j$



WATT MECHANISM

$2 + 2 + 2 + 2 + 3 + 3 = 14$

$2n_2 + 3n_3$

$n = 7$; $F = 2$

$F = 3(n-1) - 2j$

$2 = 3(7-1) - 2j$

$j = 8$

Link with maximum no of hinges : $\frac{(n+1)}{2}$

$= 4$

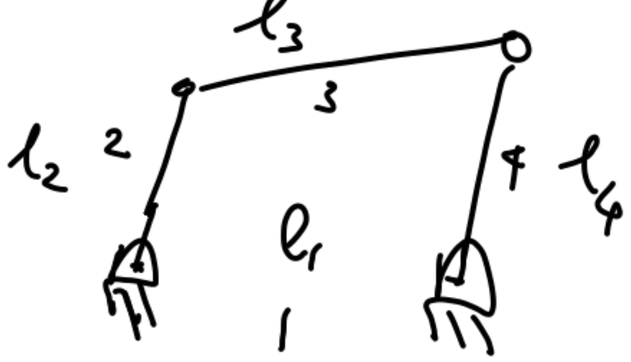
n_2, n_3, n_4

$n_2 + n_3 + n_4 = 7$ — (1)

$2n_2 + 3n_3 + 4n_4 = 16$ — (2)

$n_3 + 2n_4 = 2$

4 bar mechanism



What is the consequence of lengths of links

Grashoff Criterion

l_1, l_2, l_3, l_4
ascending order

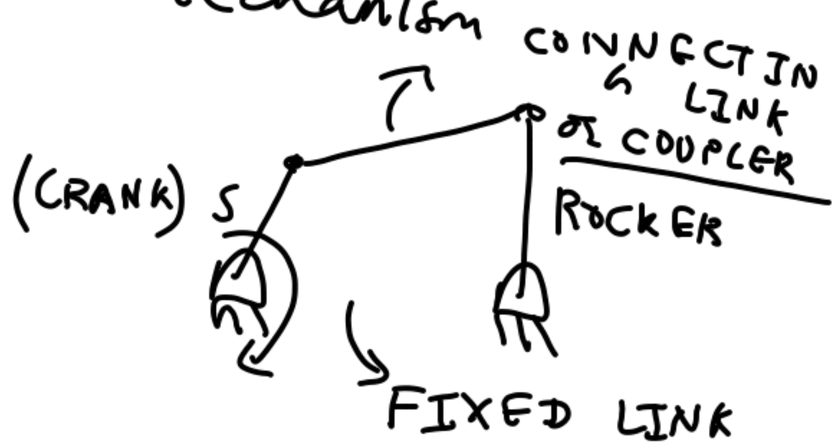
s, p, q, l
- s → shortest
- p, q → Intermediate
- l → Longest

If $l + s < p + q$

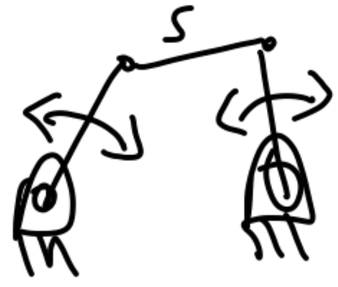
Then one of link will undergo full rotation

If $l + s > p + q$ then we have triple rocker mechanism

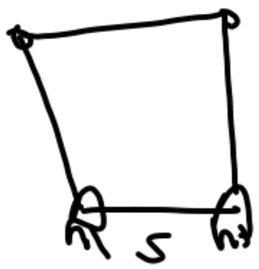
(a) link adjacent to "s" is fixed, then "s" will complete full rotation and we will have crank-rocker mechanism



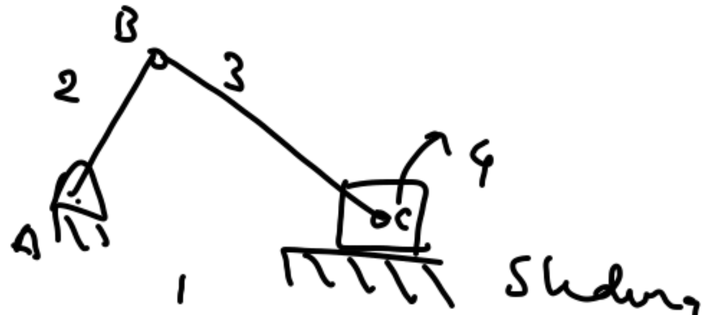
(b) If link opposite to "s" is fixed then we have double rocker mechanism



(c) If "s" is fixed, we will have a double crank mechanism / Drag link



Inversions of a mechanism are obtained by changing the fixed link.



$F = 3(4-1) - 2 \times 4 = 1$