Grashof criterion

$$S = \min(l_1, l_2, l_3, l_4)$$

$$l = \max(l_1, l_2, l_3, l_4)$$

(*) If $(l+s) < (p+q)$ Inversion

↳ Grashoff chain.

Atleast 1 chain will complete full revolution.

(a) If link adjacent to "s" is fixed, we get crank-rocker mechanism

(b) If link opposite to "s" is fixed, we get Double Rocker mechanism

(c) If link "s" is fixed, we get double crank or drag mechanism

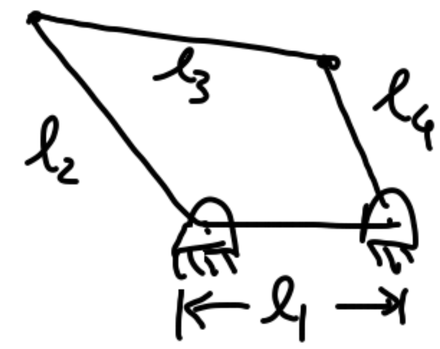
(*) If $(l+s) > (p+q)$,

we have non-Grashoff chain.

None of the link completes full revolution.

Triple rocker mechanism

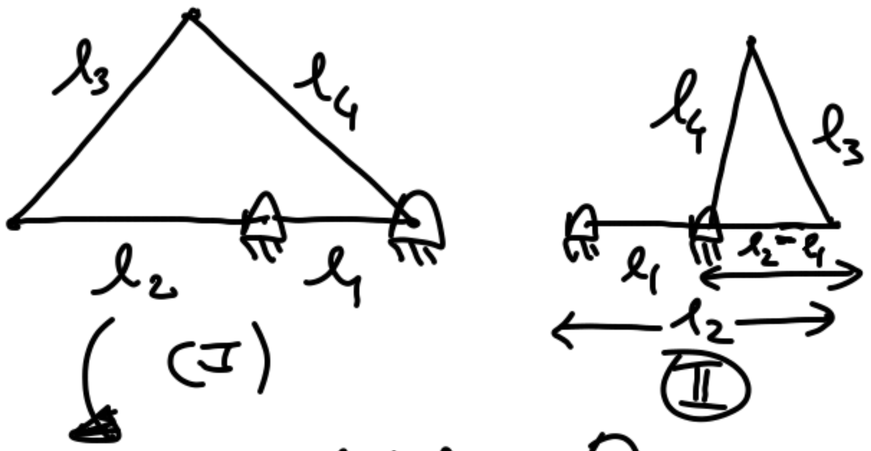
Proof:



We assume $l_2 > l_1$

We want to find conditions for l_2 to complete full revolutions.

l_2 should attain two extreme positions



$l_1+l_2 < l_3+l_4$ — ①

From (II) →

$l_4 < l_3+(l_2-l_1)$

$l_3 < l_4+(l_2-l_1)$

$l_2-l_1 < l_3+l_4$

$l_4+l_1 < l_3+l_2$ → ②

$l_3+l_1 < l_4+l_2$ → ③

① + ② →

$2l_1+\cancel{l_2}+\cancel{l_4} < 2l_3+\cancel{l_2}+\cancel{l_4}$

$l_1 < l_3$ — ④

① + ③ → $l_1 < l_4$ — ⑤

② + ③ ⇒ $l_1 < l_2$ — ⑥

l_1 is the shortest link

Based on the notation for Grashof criterion

$S = l_1$

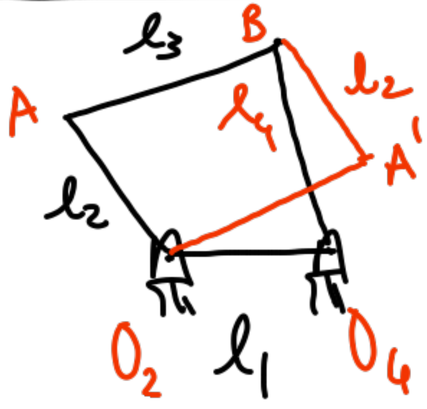
$l = \max(l_2, l_3, l_4)$

$s+l = \max(l_1+l_2,\ l_1+l_3,\ l_1+l_4)$

$p+q = \min(l_3+l_4,\ l_2+l_4,\ l_2+l_3)$

So inequalities ①, ② and ③ Can be combined to get

$(s+l) < (p+q)$



$O_2A'BA$ is a parallelogram.

If we focus on the 4-bar $O_2A'BO_4$

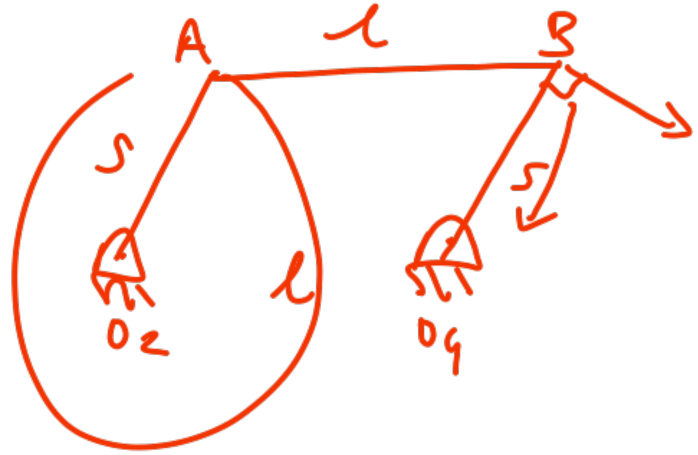
If $l_3 < l_1$

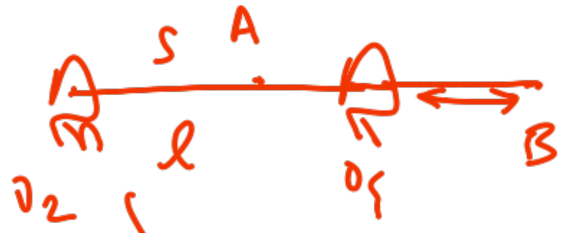
then we can show O_2A' will complete full revolution.

$O_2A' \parallel AB$.

AB will also complete full revolution.

Parallelogram Linkage





All the links being inline is the transition point.

Tutorial #3

① Application of Kutzbach criterion

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

n: No. of Links

j: No. of lower pairs

h: No. of higher pairs

(a) $n = 9$

$h = 0$

$j = 11$

$F = 2$

(b) $n = 8$

$h = 0$

$j = 11$

$F = -1$

(c) $n = 10$

$j = 13$

$h = 0$

$F = 27 - 26$

$F = 1$

(d) $n = 9$

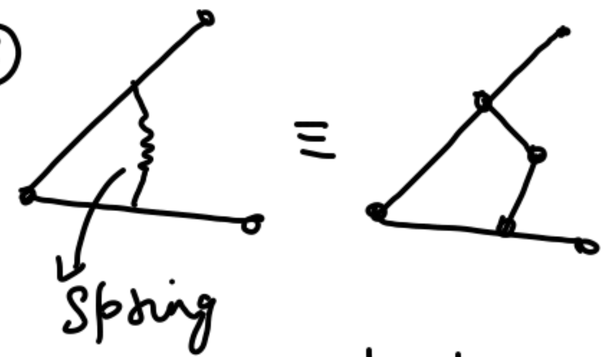
$j = 11$

$h = 0$

$F = 2$

At B, we have a revolute joint between 4 and 5

(e)



Equivalent mechanism

At A: two) B pairs

At 4 } Slider joint

Roller pin is a higher pair

Q1. (c) $n = 9$

$h = 1$

$j = 10$

$F = 3 \times 8 - 2 \times 10 - 1$

$= 24 - 20 - 1$

$= 3$

Q2: $s = 4, l = 18$

$p = 9, q = 14$

$s + l = 22$

$p + q = 23$

So Grashof chain