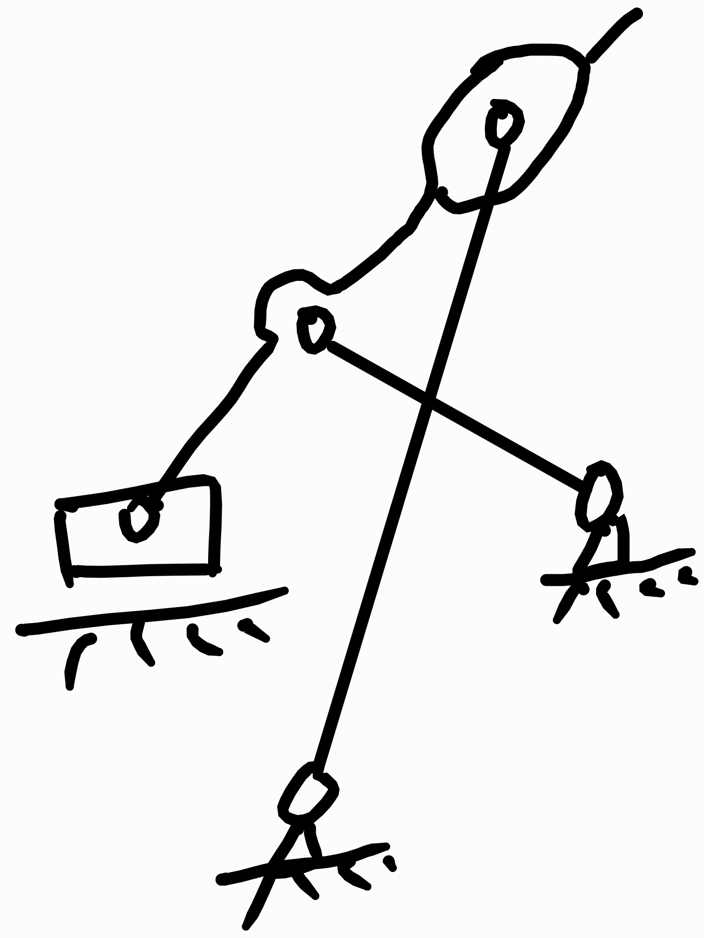
1.1)



Types of links:

- 2 ternary links
- 3 binary links

Types of joints:

- 4 revolute joints
- 1 prismatic joint
- 1 pin-in-slot joint

$$DoF = 3(n_L - 1) - 2n_J' - n_J''$$

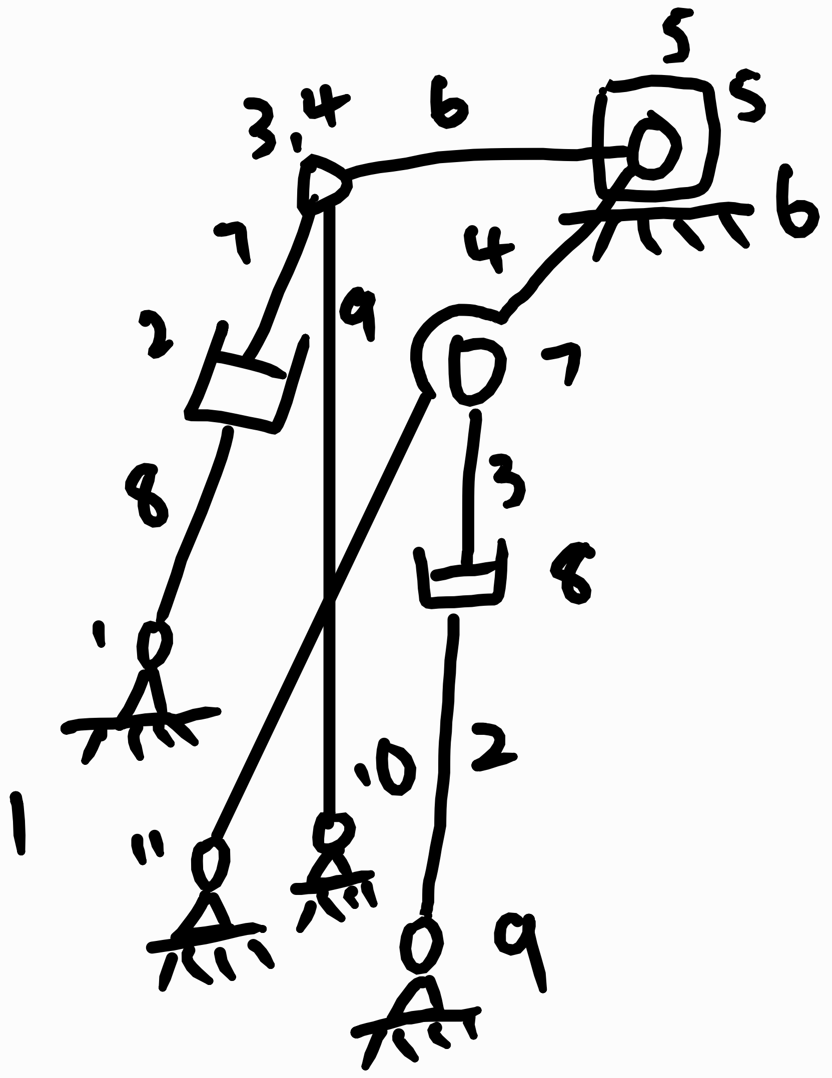
$$n_L = 5, \quad n_J' = 5, \quad n_J'' = 1$$

$$\therefore DoF = 3(5-1) - 2(5) - 1$$

$$= 1$$

The degree of freedom of the mechanism is 1.

1.2a)



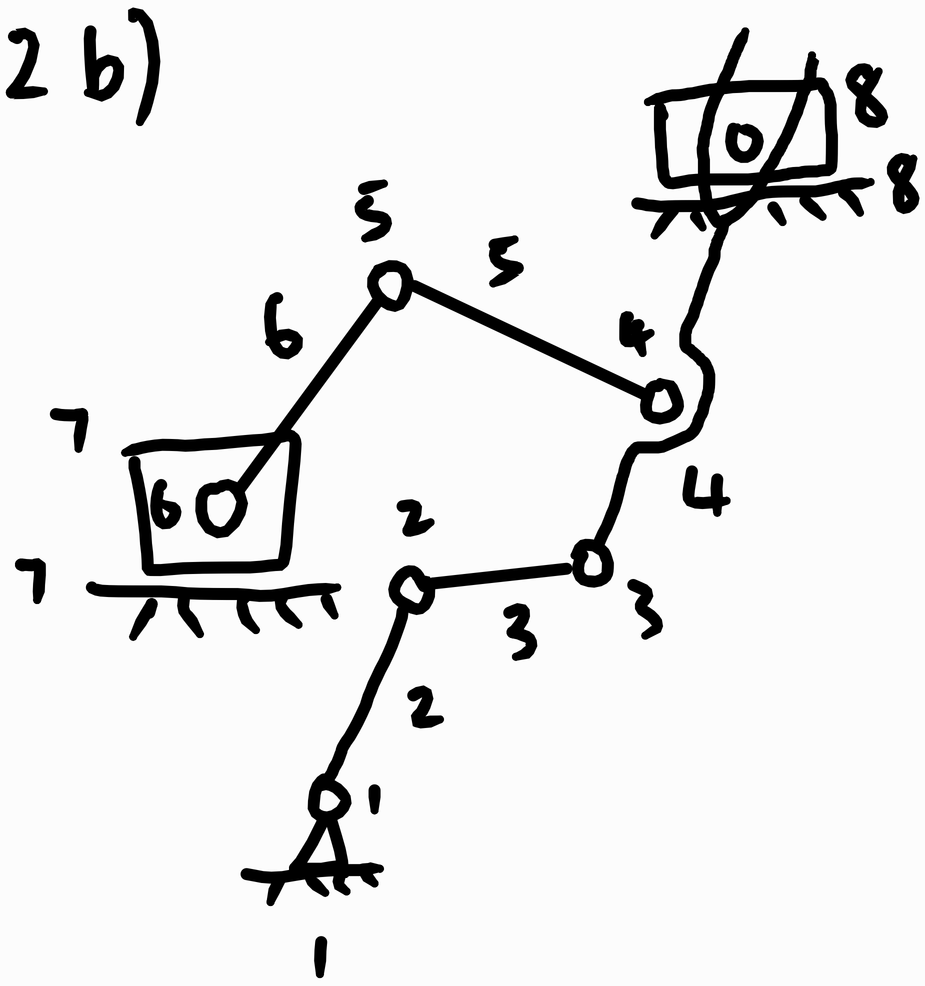
$$DoF = 3(n_L - 1) - 2n_J' - n_J''$$

$$n_L = 9, \quad n_J' = 11, \quad n_J'' = 0$$

$$DoF = 3(9-1) - 2(11) - 0$$

$$= 2$$

1.2 b)



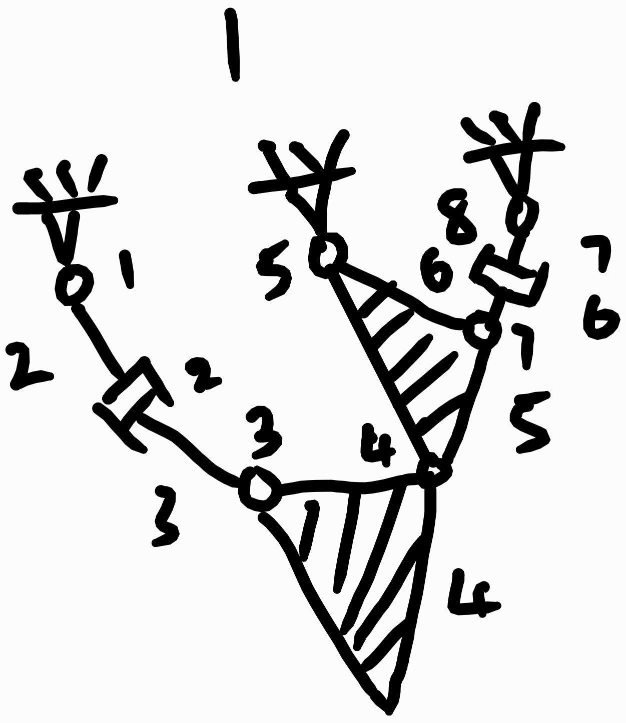
$$DoF = 3(n_L - 1) - 2n_J' - 2n_J''$$

$$n_L = 8, \; n_J' = 8, \; n_J'' = 1$$

$$DoF = 3(8-1) - 2(8) - 1$$

$$= 4$$

1.2 c)



$$DoF = 3(n_L - 1) - 2n_J' - n_J''$$

$$n_L = 7, \; n_J' = 8, \; n_J'' = 0$$

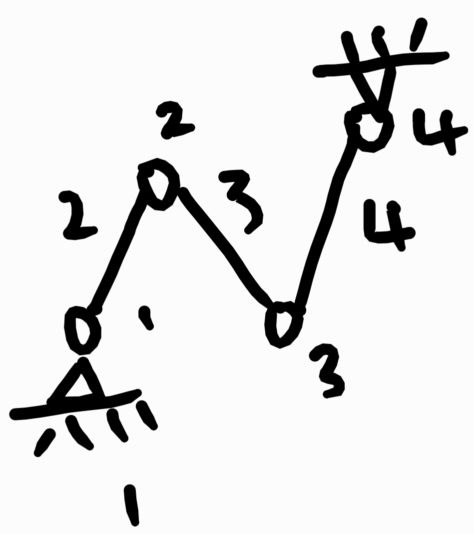
$$DoF = 3(7-1) - 2(8) - 0$$

$$= 2$$

1.3 a) There two reasons for this system to be a planar mechanism:

1. The axis of all revolute joints are parallel
2. The links are moving on parallel planes.

b)



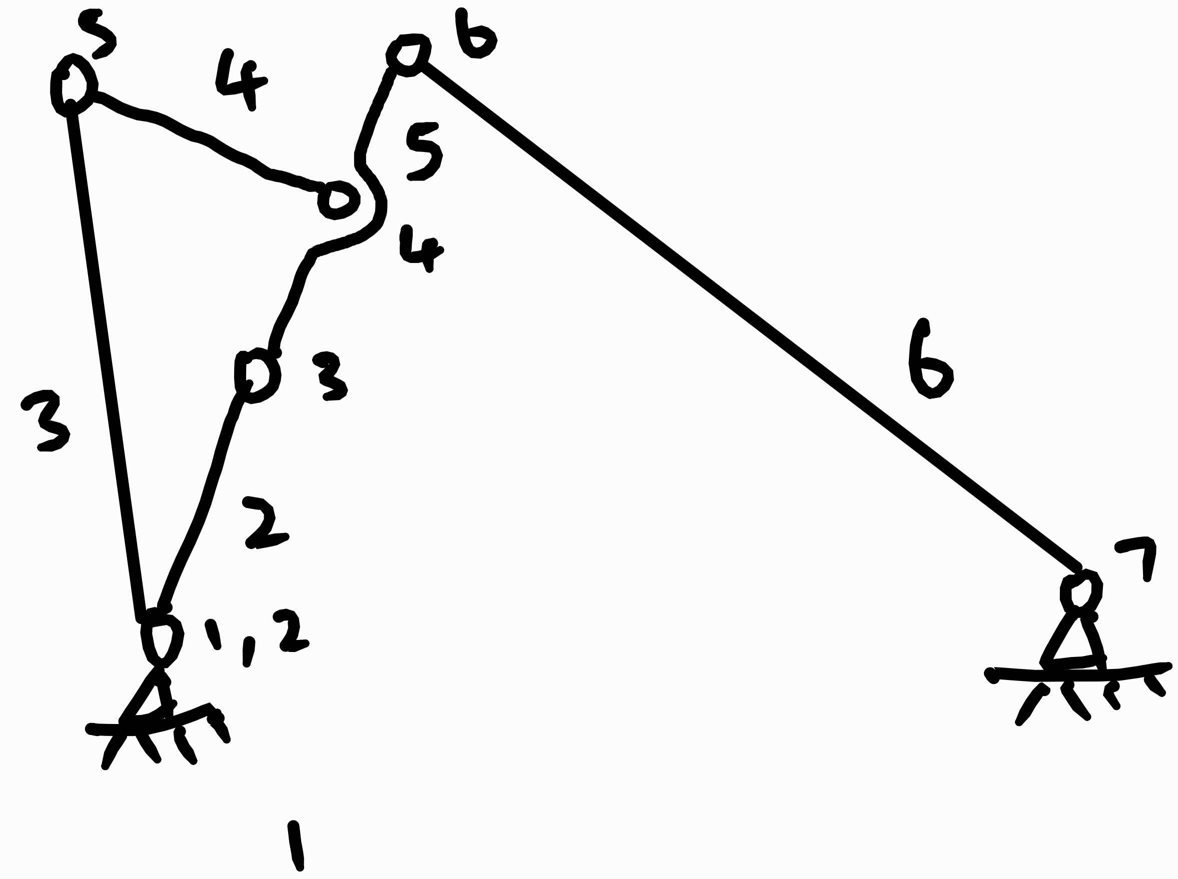
$$DoF = 3(n_L - 1) - 2(n_J') - n_J''$$

$$n_L = 4, \quad n_J' = 4, \quad n_J'' = 0$$

$$DoF = 3(4-1) - 2(4)$$
$$= 1$$

c) It will make the workout easier, because of the shorter leverage.

1.4)



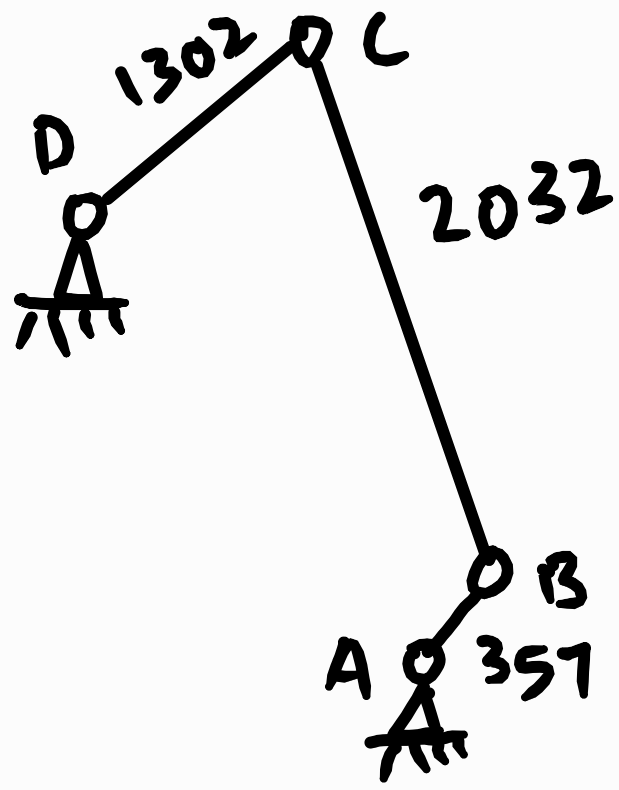
$$DoF = 3(n_L - 1) - 2n_J' - n_J''$$

$$n_L = 6, \quad n_J' = 7, \quad n_J'' = 0$$

$$DoF = 3(6-1) - 2(14) - 0$$

$$= 1$$

1.5a)

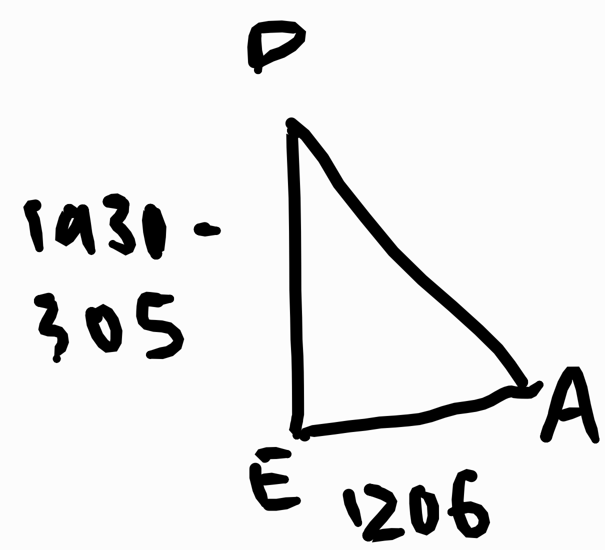


$$DoF = 3(n_L - 1) - 2n_J' - n_J''$$

$$n_L = 4, \quad n_J' = 4, \quad n_J'' = 0$$

$$DoF = 3(4-1) - 2(4) - 0$$

$$= 1$$



Grashof criterion

$$L_{max} + L_{min} \leq L_a + L_b$$

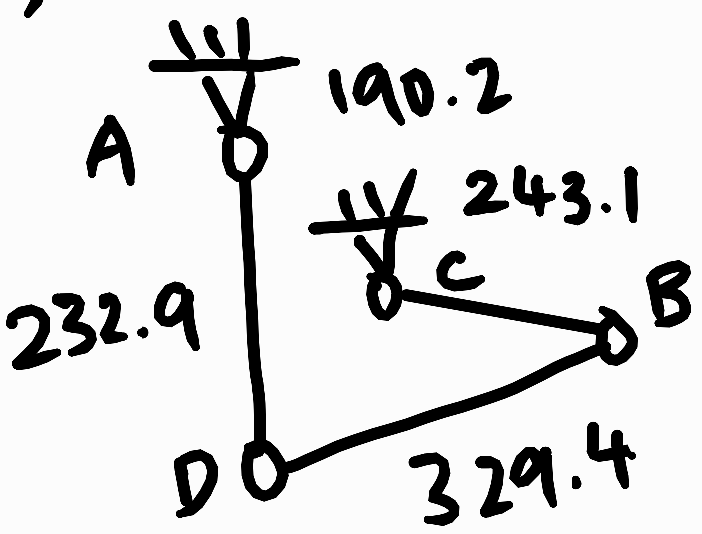
$$AD = \sqrt{1625^2 + 1206^2}$$
$$= 2023.626$$

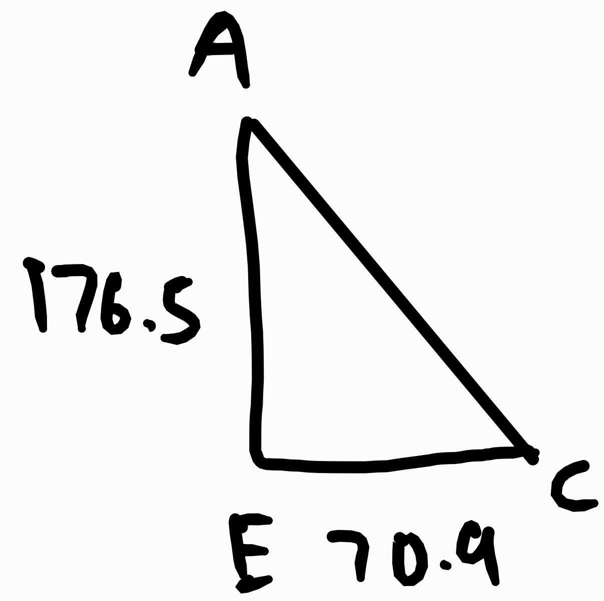
$$2032 + 357 \leq 2023.626 + 1302$$

$$2389 \leq 3325.626$$

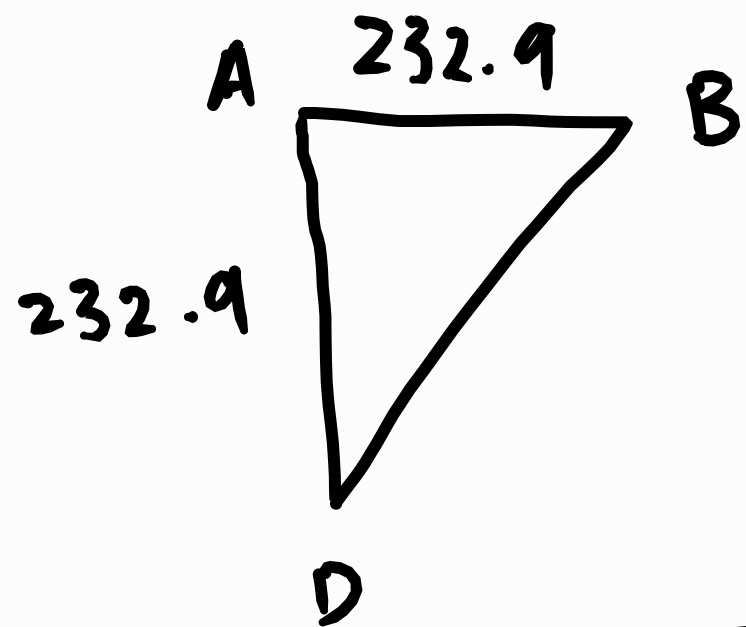
Since the shortest link AB is next to the fixed link AD, it is a crank-rocker Grashof linkage.

1.5b)





$AC = \sqrt{176.5^2 + 70.9^2}$
≈ 190.2



$BD = \sqrt{232.9^2 + 232.9^2}$
≈ 329.4

Grashof condition:

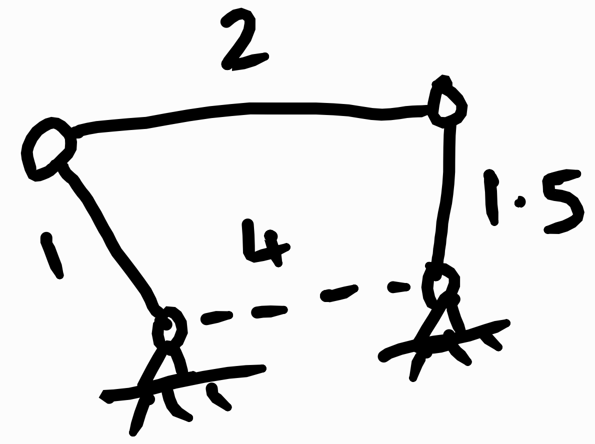
$L_{max} + L_{min} \leq L_a + L_B$

$329.4 + 190.2 \leq 232.9 + 243.1$

$519.6 \nleq 475.9$

$\therefore$ the linkage is a non-Grashof triple rocker linkage.

1.6 a)



i) Yes, a 4-bar linkage can be formed.

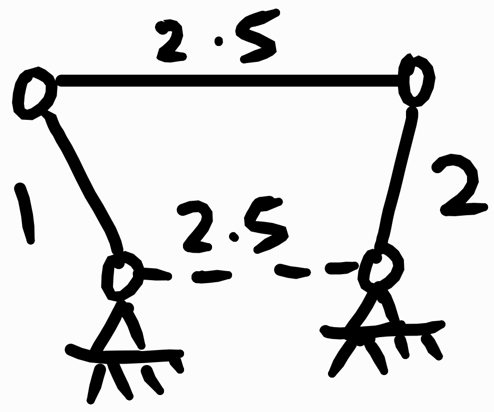
ii) Grashof condition:

$$L_{max} + L_{min} \leq L_a + L_b$$

$$4 + 1 \nleq 2 + 1.5$$

$$5 \nleq 3.5$$

$\therefore$ The linkage formed is a non-Grashof triple rocker linkage.

1.6b) 

i) Yes, a 4-bar linkage can be formed.

ii) Grashof condition:

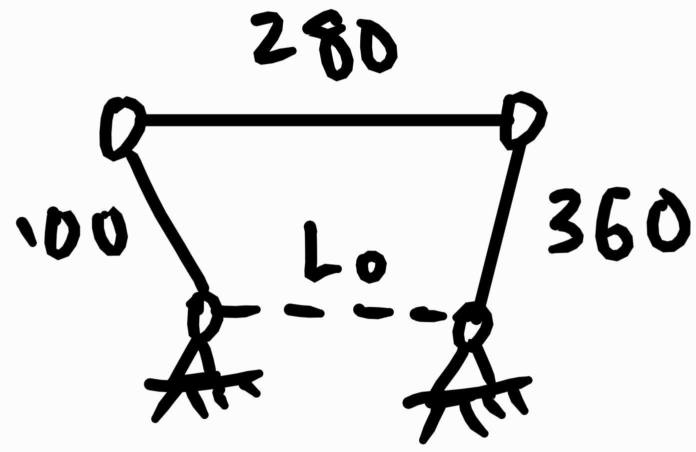
$$L_{max} + L_{min} \leq L_a + L_b$$

$$1 + 2.5 \leq 2.5 + 2$$

$$3.5 \leq 4.5$$

$\therefore$ The linkage is a Grashof crank-rocker linkage.

1.7)



For a Grashof linkage,

$$L_{max} + L_{min} \leq L_a + L_b$$

a) For a crank-rocker, the shortest link must be next to the fixed link, so

$$L_o > 100$$
$$L_o \neq L_{min}$$

$$\therefore \quad L_o = L_{max},\ L_a \text{ or } L_b$$

For $L = L_{max}$,

$$L_o + 100 \leq 360 + 280$$
$$L_o \leq 540$$

For $L = L_a$ or L_b

$$100 + 360 \leq L_o + 280$$
$$L_o \geq 180$$

$$\therefore \quad 180 \leq L_o \leq 540$$

1.7b) For a drag-link, the shortest link must be the fixed link, so

$$L_0 < 100$$
$$L_0 = L_{min}$$

$$\therefore L_0 + 360 \leq 100 + 280$$
$$0 < L_0 \leq 20$$

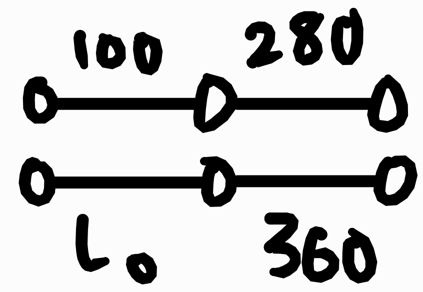
c) For a double-rocker, the shortest link must be opposite the fixed link. However, since the shortest link of the given links, L_1, is beside the fixed link, a double-rocker mechanism is impossible.

1.7d) For a change-point, all the links must be collinear, so by either

Collaspsing the links to the right,

$$L_0 + 360 = 100 + 280$$

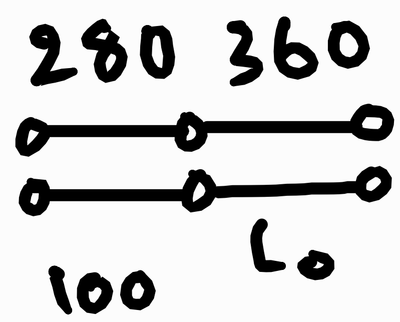
$$L_0 = 20$$



Collaspsing the links to the left,

$$100 + L_0 = 280 + 360$$

$$L_0 = 540$$



e) For Grashof linkages, we combine the solutions from part (a) to (d)

$$\therefore \quad 0 < L_0 \leq 20 \quad \text{or} \quad 180 \leq L_0 \leq 540$$

f) For a non-Grashof linkage, we take the range outside of part (e), so

$$20 < L_0 < 180 \quad \text{or} \quad L_0 > 540$$

Condition for forming a 4-bar linkage:

$$L_{max} \leq L_{min} + L_a + L_b$$

$$L_0 \leq 100 + 280 + 360$$

$$L_0 \leq 740$$

$$\therefore 20 < L_0 < 180 \quad \text{or} \quad 540 < L_0 \leq 740$$