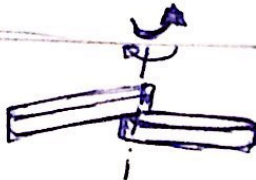
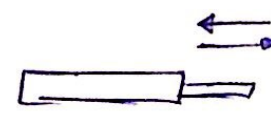
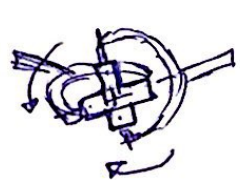



* Kinematic Analysis * 2 D.O.F [1]

[1] How to calculate degrees of freedom?
[Joints]

		Dof
[A] Revolute		1
[B] Prismatic		1
[C] Universal		2
[D] Spherical		3

$$d.o.f = m(N - 1 - J) + J$$

$$d.o.f = m(L - 1) - 2J$$

[Dimensions]

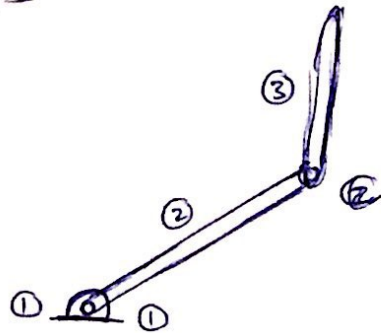
[Links]

[Joints]

+ H_p

* Kinematic Analysis * 2 DOF [2]

Example :-

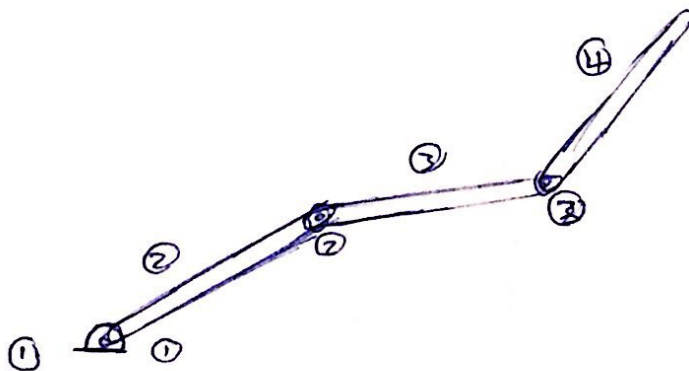


$$\text{Formula } D.O.F = m(L - 1) - 2J$$

$$m = 3, \quad L = 3, \quad J = 2$$

$$D.O.F = 3(3 - 1) - 2 \times (2) = \boxed{2 \text{ D.O.F}}$$

Example :-



$$m = 4, \quad L = 4, \quad J = 3$$

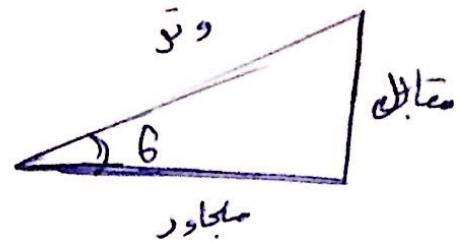
$$D.O.F = 4(4 - 1) - 2(3) = \boxed{3 \text{ D.O.F}}$$

* Kinematic Analysis * 2 D.O.F [3]

$$\sin \theta = \frac{\text{مقابل}}{\text{وتر}}$$

$$\cos \theta = \frac{\text{مجاور}}{\text{وتر}}$$

$$\tan \theta = \frac{\text{مقابل}}{\text{مجاور}}$$

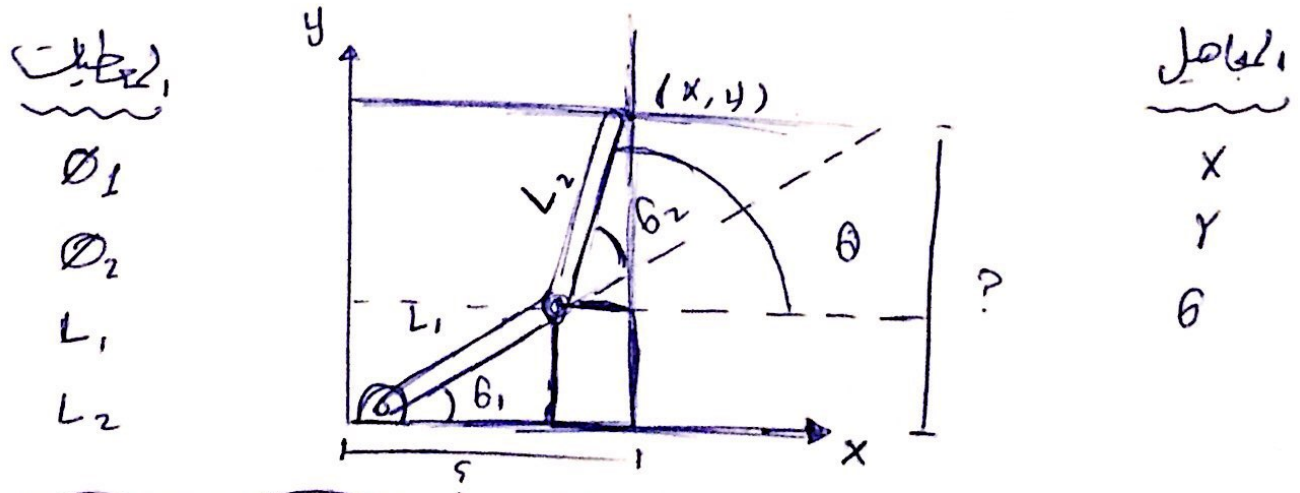


$$a^2 + b^2 = h^2 \quad \text{فیتاغورس}$$

$$(a \pm b)^2 = a^2 + b^2 + 2ab$$

قانون الجمع الكمال :-

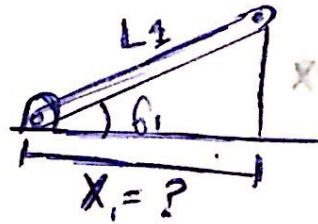
* Forward Kinematic *



$$\theta = \theta_1 + \theta_2$$

* Kinematic Analysis * 2 D.O.F [4]

* [1]

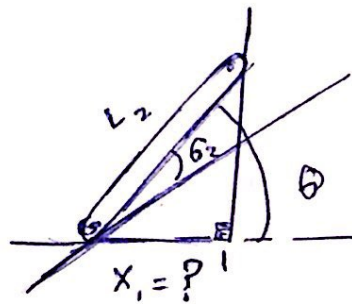


$$\cos \theta = \frac{\text{مجاور}}{\text{وتر}}$$

$$\cos \theta_1 = \frac{X_1}{L_1}$$

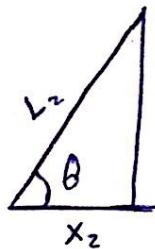
$$X_1 = L_1 \cos \theta_1$$

* [2]



$$\theta = \theta_1 + \theta_2$$

$$\cos \theta = \frac{\text{مجاور}}{\text{وتر}}$$



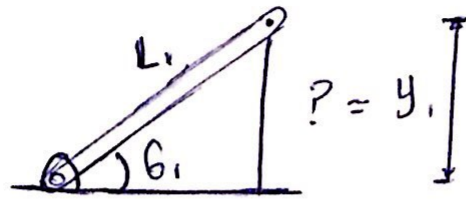
$$\cos \theta = \frac{X_2}{L_2}$$

$$X_2 = L_2 \cos \theta = L_2 \cos (\theta_1 + \theta_2)$$

$$X = X_1 + X_2 = L_1 \cos \theta_1 + L_2 \cos (\theta_1 + \theta_2)$$

※ Kinematic Analysis ※ 2 D.O.F [5]

※ [3]

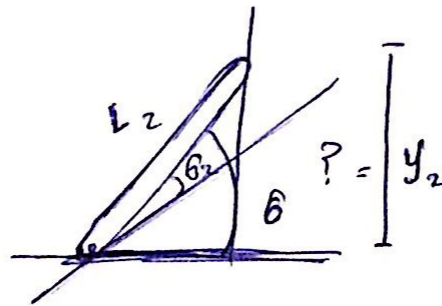


$$\sin \theta = \frac{y \cdot L}{\bar{y}}$$

$$\sin \theta_1 = \frac{y_1}{L_1}$$

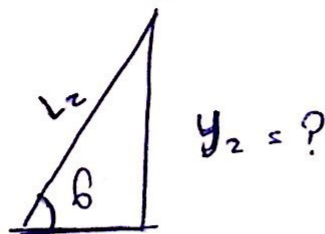
$$y_1 = L_1 \sin \theta_1$$

※ [4]



$$\theta = \theta_1 + \theta_2$$

$$\sin \theta = \frac{y \cdot L}{\bar{y}}$$



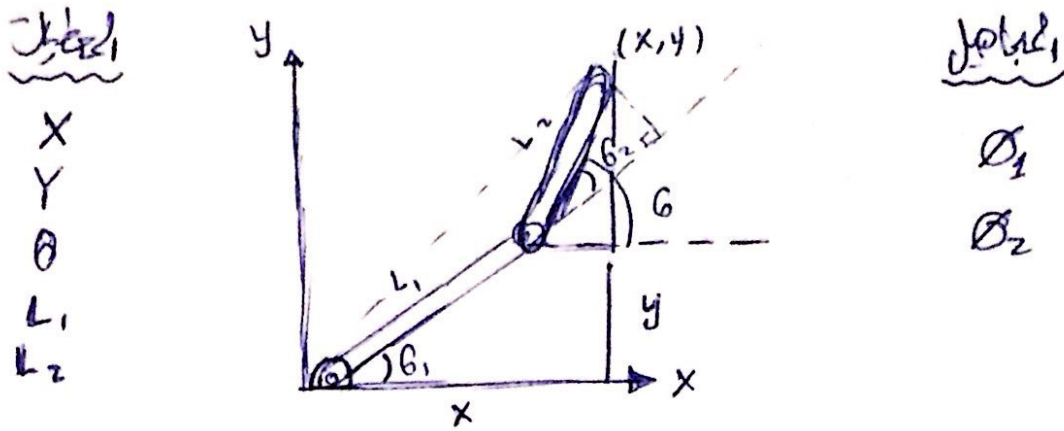
$$\sin \theta = \frac{y_2}{L_2}$$

$$y_2 = L_2 \sin \theta = L_2 \sin (\theta_1 + \theta_2)$$

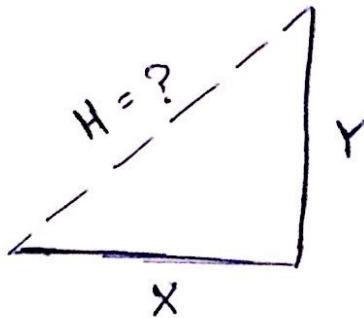
$$Y = y_1 + y_2 = L_1 \sin \theta_1 + L_2 \sin (\theta_1 + \theta_2)$$

* Kinematic Analysis * 2 D.O.F [6]

* Inverse kinematic *



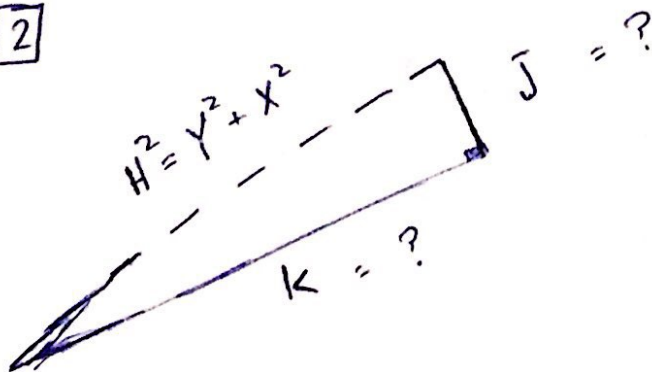
* [1]



ثابتة غورس :-

$$H^2 = X^2 + Y^2$$

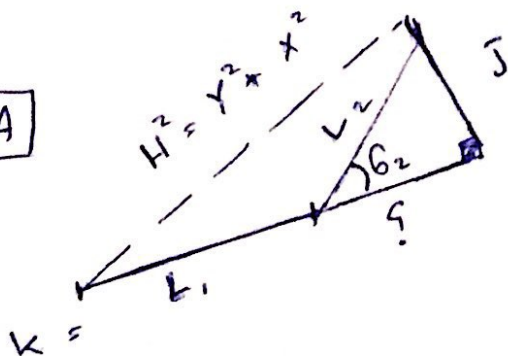
* [2]



$$\sin \theta = \frac{Y}{H}$$

$$\sin \theta_2 = \frac{Y}{L_2}$$

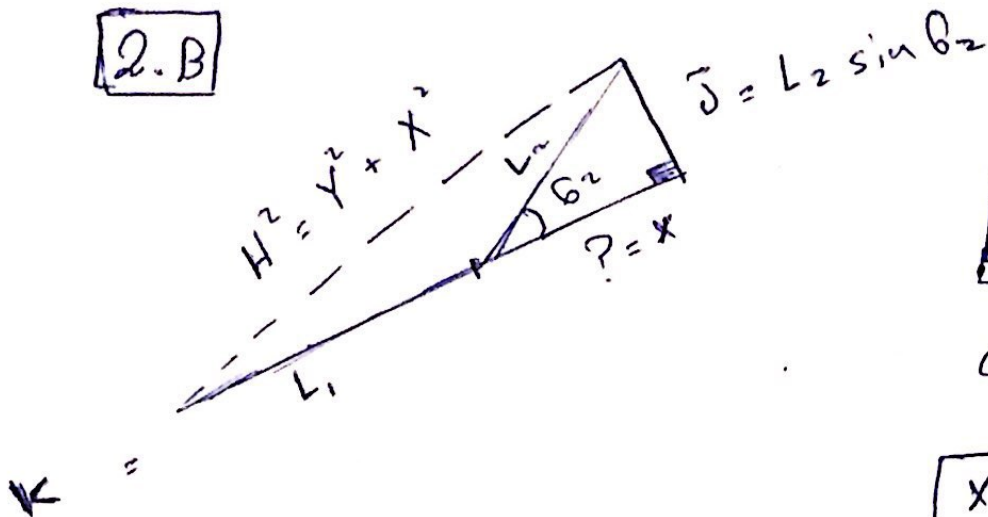
[2. A]



$$* \quad Y = L_2 \sin \theta_2$$

* Kinematic Analysis * 2 D.O.F [7]

2.B

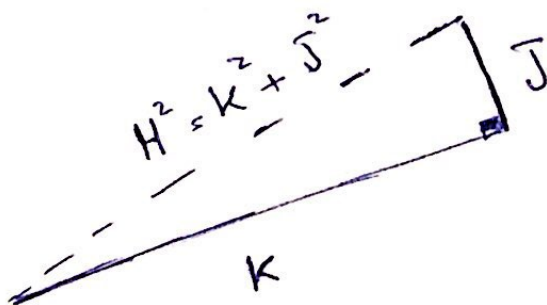


$$\cos \theta_1 = \frac{J}{H}$$

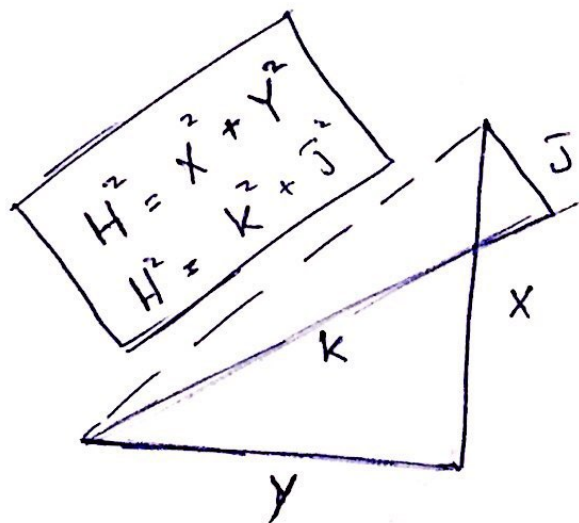
$$\cos \theta_2 = \frac{X}{L_2}$$

$$X = L_2 \cos \theta_2$$

$$K = L_1 + X = L_1 + L_2 \cos \theta_2$$

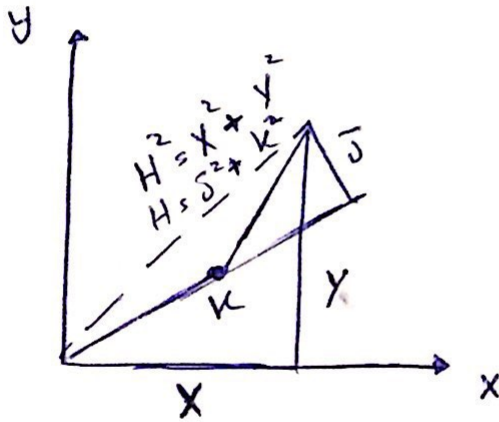


3.



* Kinematic Analysis * 2 D.O.F [8]

∴ عندنا متلبين لو تر واحد :-



$$* \bar{J} = L_2 \sin \theta_2$$

$$* k = L_1 + L_2 \cos \theta_2$$

قانون المجموع الكمال :-

$$[(a \pm b)^2 = a^2 + b^2 + 2ab]$$

$$H^2 = H^2$$

$$X^2 + Y^2 = \bar{J}^2 + k^2$$

$$X^2 + Y^2 = [L_2 \sin \theta_2]^2 + [L_1 + L_2 \cos \theta_2]^2$$

$$X^2 + Y^2 = [L_2^2 \sin^2 \theta_2] + [L_1^2 + L_2^2 \cos^2 \theta_2 + 2 L_1 L_2 \cos \theta_2]$$

$$X^2 + Y^2 = [L_2^2 \sin^2 \theta_2] + [L_1^2 + L_2^2 \cos^2 \theta_2 + 2 L_1 L_2 \cos \theta_2]$$

$$[\sin^2 \theta + \cos^2 \theta = 1] = \text{نقطة ١}$$

$$X^2 + Y^2 = L_1^2 + L_2^2 + 2 L_1 L_2 \cos \theta_2$$

$$\cos \theta_2 = \frac{X^2 + Y^2 - L_1^2 - L_2^2}{2 L_1 L_2}$$

~~★~~ Kinematic Analysis ~~★~~ 2 D.O.F 9

Final Answer : ~

Forward Kinematic :-

$$X = L_1 \cos \theta_1 + L_2 \cos (\theta_1 + \theta_2)$$

$$Y = L_1 \sin \theta_1 + L_2 \sin (\theta_1 + \theta_2)$$

Inverse Kinematic :-

$$\cos \theta_2 = \frac{X^2 + Y^2 - L_1^2 - L_2^2}{2 L_1 L_2}$$

$$\theta_2 = \cos^{-1} \left(\frac{X^2 + Y^2 - L_1^2 - L_2^2}{2 L_1 L_2} \right)$$

$\theta_1 = \theta - \theta_2$

پ. ل. عبدالقادر