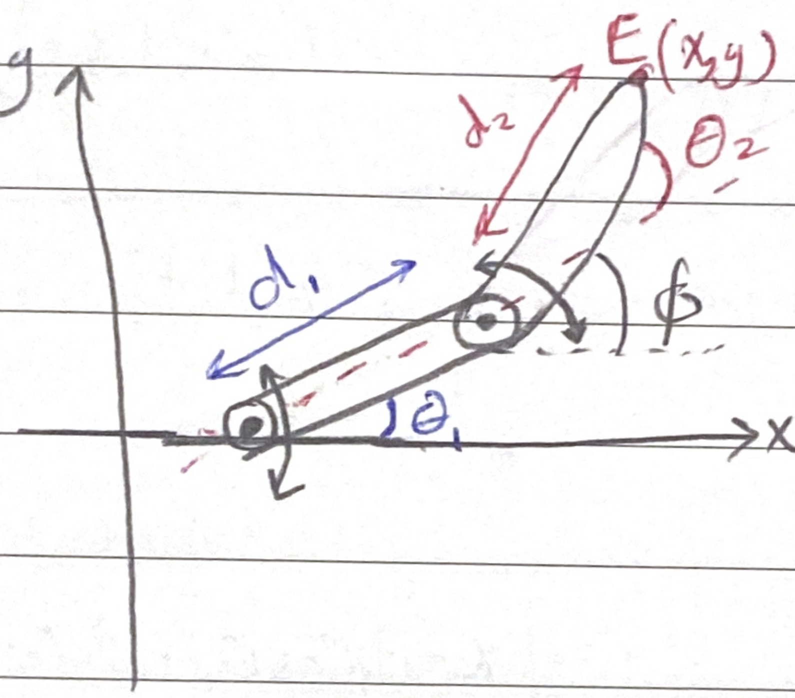
Forward Kinematics degree of freedom (DOF)

↳ Given joint angles ⟶ $\theta_1, \theta_2, d_1, d_2$

↳ We want to find a location of a point in different frame.

* What is forward kinematics?

It is a system can be 2D or 3D consist of two rodes with a joint that can move in a specific motion specified by an angle.



NOTE:

θ: Anti clock ⟶ +ve

θ: clockwise ⟶ −ve

Joint Space	World Space
* θ_1, θ_2 ⟹ it represents the coordinates attached to the joints.	* ϕ, E(x,y) ⟹ it represents the absolute coordinates of position of endifector. * ϕ ⟶ represents the overall position of rode "d_2"

Forward kinematics ⟹ It is a system that goes from joint space to world space in order to find the unknowns.

Summery:

Forward / Direct Kinematiss :

Joint Space $\Longrightarrow$ World Space

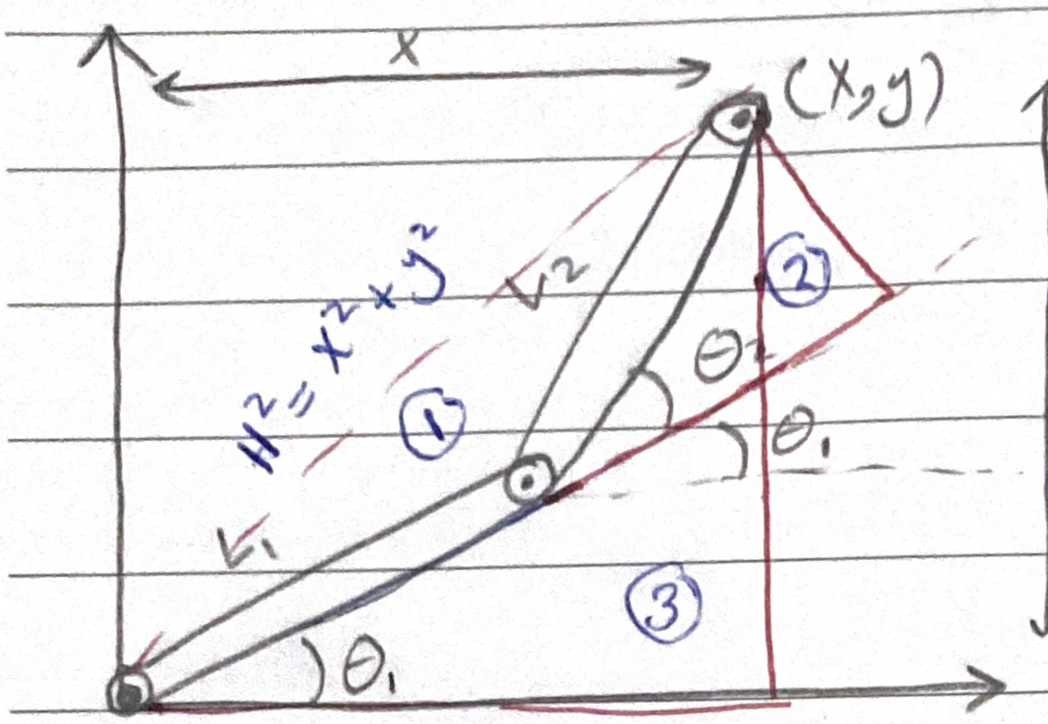
$\theta_1, \theta_2, \rightarrow$ Known $\qquad \phi, E(x, y) \rightarrow$??

Reverse/Indirect Kinematics:

Joint Space $\Longleftarrow$ World Space

$\theta_1, \theta_2 \rightarrow$?? $\qquad \phi, E(x, y) \rightarrow$ known

Inverse Kinematics : 2 DOF I need to find (θ_1, θ_2)



$T_1 \longrightarrow H^2 = x^2 + y^2$

$T_2 \longrightarrow J = L_2 \sin\theta_2$

$T_3 \longrightarrow K = L_1 + L_2 \cos\theta_2$

$T_4 \longrightarrow H^2 = J^2 + K^2$

$$x^2 + y^2 = J^2 + K^2$$

$$x^2 + y^2 = (L_2 \sin\theta_2)^2 + (L_1 + L_2 \cos\theta_2)^2$$

$$x^2 + y^2 = L_2^2 \sin^2\theta_2 + L_1^2 + 2L_1L_2\cos\theta_2 + L_2^2\cos^2\theta_2$$

$$x^2 + y^2 = L_2^2 + L_1^2 + 2L_1L_2\cos\theta_2$$

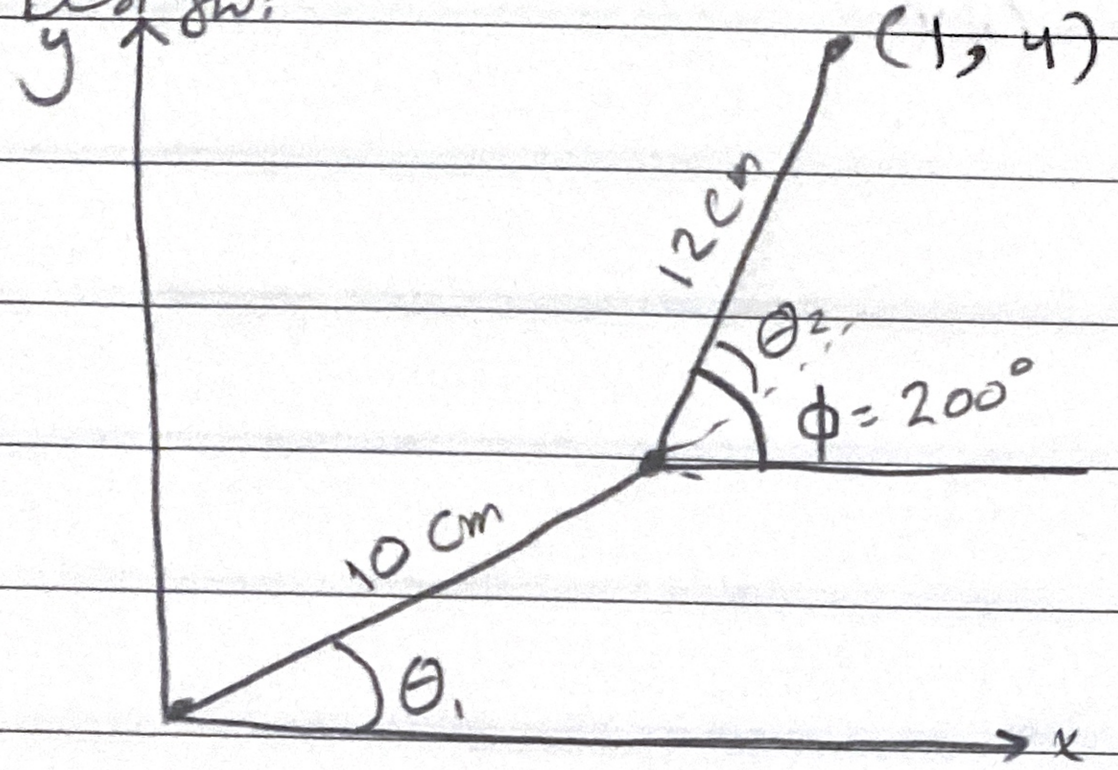
$$\cos\theta_2 = (x^2 + y^2 - L_1^2 - L_2^2)/2L_1L_2$$

$$\phi = \theta_1 + \theta_2 \longrightarrow \theta_1 = \phi - \theta_2$$

Calculation of 2DOF inverse Kinematics assuming:

$X = 1cm, y = 4cm, L_1 = 10cm, L_2 = 12cm, \phi = 200^\circ$

① Design:



② Calculation:

↳ find θ_2:

$$\cos\theta_2 = (x^2 + y^2 - L_1^2 - L_2^2) / 2L_1L_2$$

$$= (1^2 + 4^2 - 10^2 - 12^2) / 2(10)(12)$$

$$\cos\theta_2 = -0.8625 \longrightarrow \theta_2 = \cos^{-1}(-0.8625)$$

$$\theta_2 = 149.5 \simeq 150^\circ$$

↳ find θ_1:

$$\theta_1 = \phi - \theta_2$$

$$= 200 - 150 = 50^\circ$$