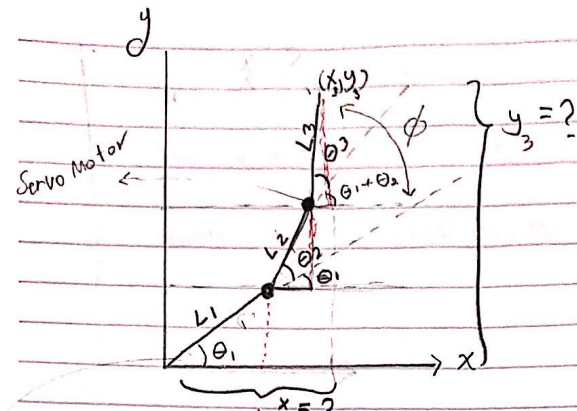


Forward kinematic

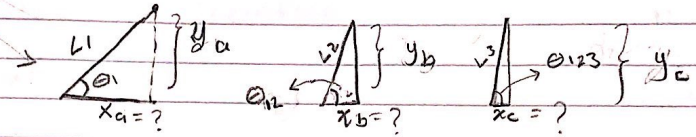


$\sin \theta = \frac{\text{مقابل / وتر}}{\text{وتر}}$
 $\cos \theta = \frac{\text{مجاور / وتر}}{\text{وتر}}$
 $\tan \theta = \frac{\text{مقابل / مجاور}}{\text{مجاور}}$

let's say that \Rightarrow

المعطيات	المجهول
$\theta_1, \theta_2, \theta_3, L_1, L_2, L_3$	x_3, y_3, ϕ

$$\phi = \theta_1 + \theta_2 + \theta_3$$



①

$$x_3 = x_a + x_b + x_c$$

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

$$x_3 = [L_1 \cos(\theta_1) + L_2 \cos(\theta_1 + \theta_2) + L_3 \cos(\theta_1 + \theta_2 + \theta_3)]$$

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

$$x_a = L_1 \cos \theta_1$$

②

$$y_3 = y_a + y_b + y_c$$

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

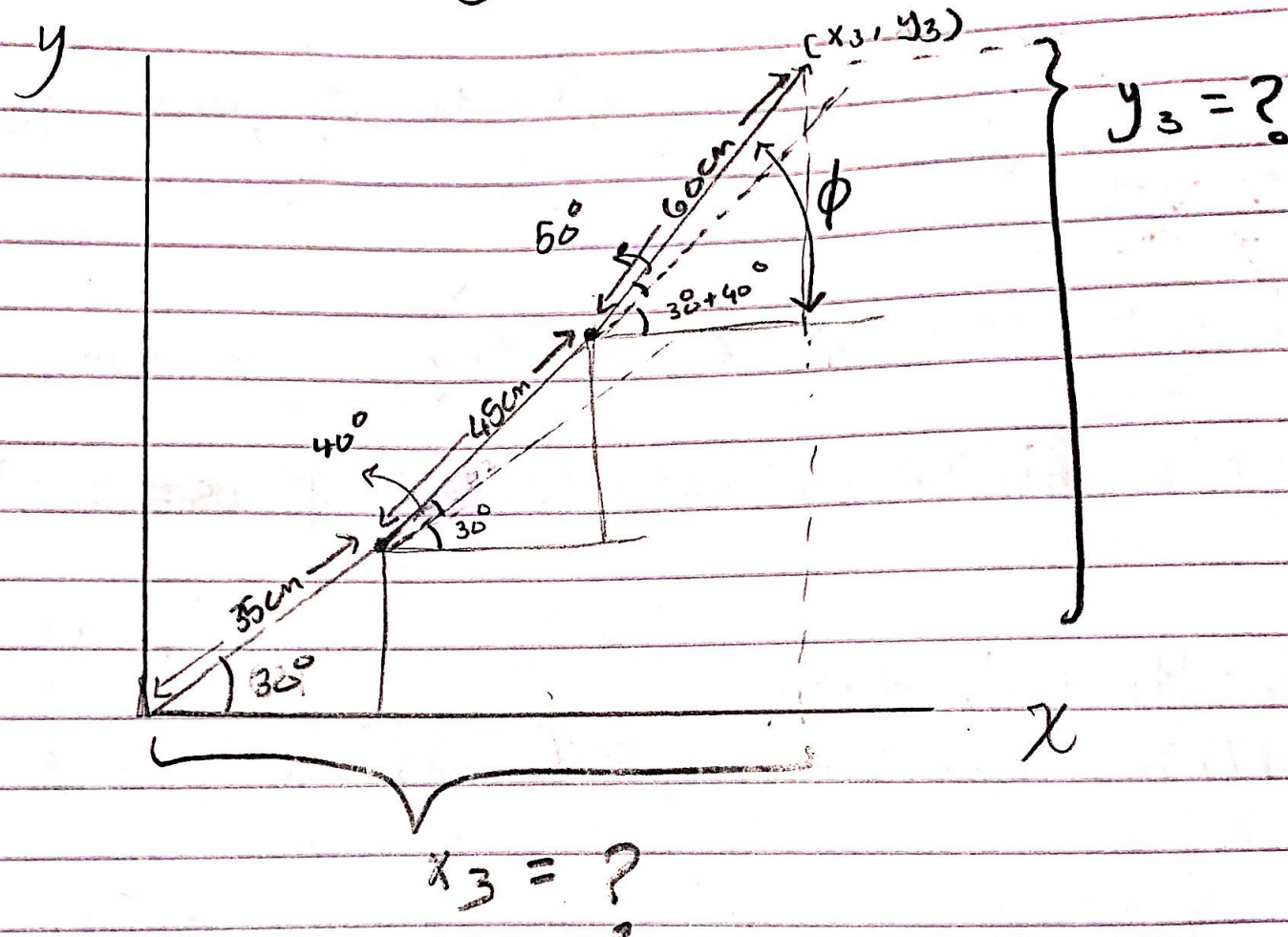
$$y_3 = [L_1 \sin \theta_1 + L_2 \sin(\theta_1 + \theta_2) + L_3 \sin(\theta_1 + \theta_2 + \theta_3)]$$

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

$$y_a = L_1 \sin \theta_1$$

$$\phi = \theta_1 + \theta_2 + \theta_3$$

Design



Now/ let's say that we have a robot that has 3 degrees of freedom;

$\theta_1 = 30^\circ$, $\theta_2 = 40^\circ$, $\theta_3 = 50^\circ$ and

the length of the arms are:

$L_1 = 35 \text{ cm}$, $L_2 = 45 \text{ cm}$, $L_3 = 60 \text{ cm}$, then

the end effector of the robot ~~arm~~ arm (x_3, y_3) will be? and the end effector angle of inclination ϕ will be?

$$x_3 = [L_1 \cos(\theta_1) + L_2 \cos(\theta_1 + \theta_2) + L_3 \cos(\theta_1 + \theta_2 + \theta_3)]$$

$$= [35 \cos(30) + 45 \cos(30 + 40) + 60 \cos(30 + 40 + 50)]$$

$$= 15.7 \text{ cm}$$

~~$y_3 = [L_1 \sin(\theta_1) + L_2 \sin(\theta_1 + \theta_2) + L_3 \sin(\theta_1 + \theta_2 + \theta_3)]$~~

$$y_3 = [L_1 \sin(\theta_1) + L_2 \sin(\theta_1 + \theta_2) + L_3 \sin(\theta_1 + \theta_2 + \theta_3)]$$

$$= [35 \sin(30) + 45 \sin(30 + 40) + 60 \sin(30 + 40 + 50)]$$

$$= 111.7 \text{ cm}$$

$\phi \rightarrow$ the end effector angle of inclination from zero.

$$\phi = \theta_1 + \theta_2 + \theta_3$$

$$\phi = 30 + 40 + 50 = 120^\circ$$