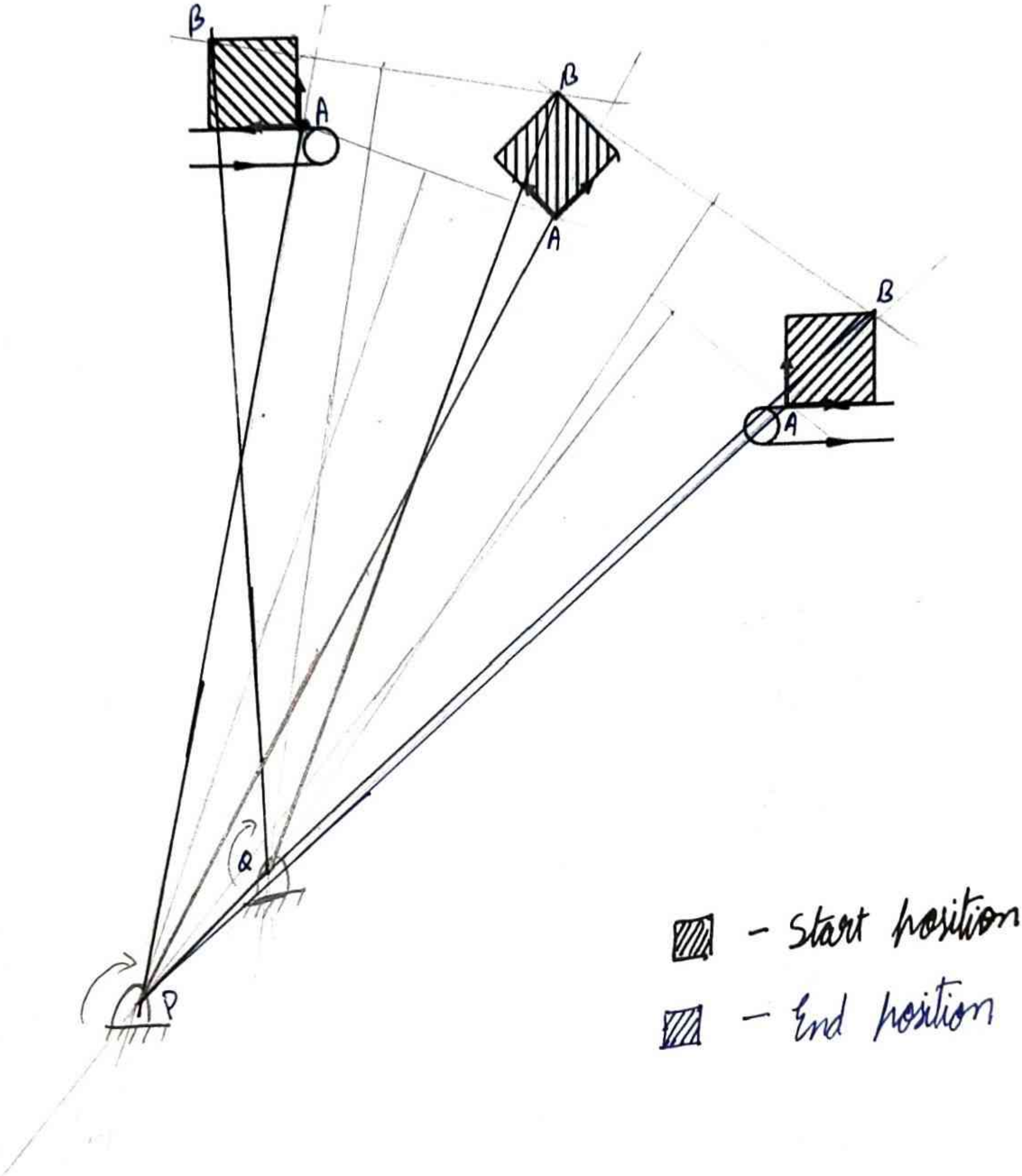
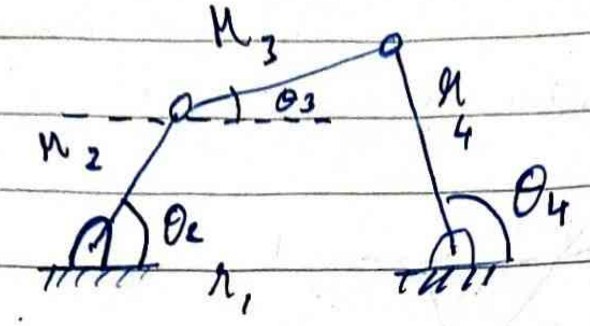
1. *Take a print of the below figure and use the geometry tools to graphically synthesize a mechanism to transport an object through the given poses* **(15)**



2. a)



$$\vec{r_2} + \vec{r_3} = \vec{r_4} + \vec{r_1}$$

$$r_2 e^{i\theta_2} + r_3 e^{i\theta_3} = r_4 e^{i\theta_4} + r_1 e^{i\theta_1}$$

$\theta_1 = 0$,

$$r_2\cos\theta_2 + r_3\cos\theta_3 = r_4\cos\theta_4 + r_1$$

① — $r_3\cos\theta_3 = r_4\cos\theta_4 + r_1 - r_2\cos\theta_2$

② — $r_3\sin\theta_3 = r_4\sin\theta_4 - r_2\sin\theta_2$

①² + ②²,

$$r_3^2 = \cancel{r_4^2\cos^2\theta_4} + r_1^2 + \cancel{r_2^2\cos^2\theta_2}$$
$$+ 2r_4r_1c\theta_4 - \cancel{2r_4c\theta_4r_2c\theta_2}$$
$$- 2r_1r_2c\theta_2$$
$$+ \cancel{r_4^2s^2\theta_4} + \cancel{r_2^2s^2\theta_2} - \cancel{2r_4r_2s\theta_2}\,s\theta_4$$
$$= r_4^2 + r_1^2 + r_2^2 - 2r_4r_2c(\theta_2-\theta_4)$$
$$+ 2r_4r_1c\theta_4 - 2r_1r_2c\theta_2$$

$$2r_4r_2c(\theta_2-\theta_4) = r_4^2 + r_1^2 + r_2^2 - r_3^2 + 2r_4r_1c\theta_4 - 2r_1r_2c\theta_2$$

$$c(\theta_2-\theta_4) = \underbrace{\frac{r_4^2+r_1^2+r_2^2-r_3^2}{2r_4r_2}}_{K_3} + \underbrace{\frac{r_1}{r_2}}_{K_1}c\theta_4 - \underbrace{\frac{r_1}{r_4}}_{K_2}c\theta_2$$

Let

$$\therefore c(\theta_2 - \theta_4) = K_1 c\theta_4 + K_2 c\theta_2 + K_3$$

$$s\theta_2\, s\theta_4 + c\theta_2\, c\theta_4 = K_1 c\theta_4 + K_2 c\theta_2 + K_3$$

Using $\sin\theta = \frac{2\tan(\theta/2)}{1+\tan^2(\theta/2)}$, $\cos\theta = \frac{1-\tan^2(\theta/2)}{1+\tan^2(\theta/2)}$

and let $t = \tan(\theta/2)$,

$$t^2\overbrace{(K_2 c\theta_2 + K_3 + c\theta_2 - K_1)}^{a} + t\underbrace{(-2 s\theta_2)}_{b} + \underbrace{(K_2 c\theta_2 + K_3 - c\theta_2 + K_1)}_{c} = 0$$

we can calculate t using

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

and consequently we get θ_4, θ_3 from 1 and 2