Exp 4: Path Generation Mechanism using Kinematic Inversion

In this experiment, you will graphically synthesize a 4-bar mechanism using kinematic inversion to follow a desired path (Fig. 1).
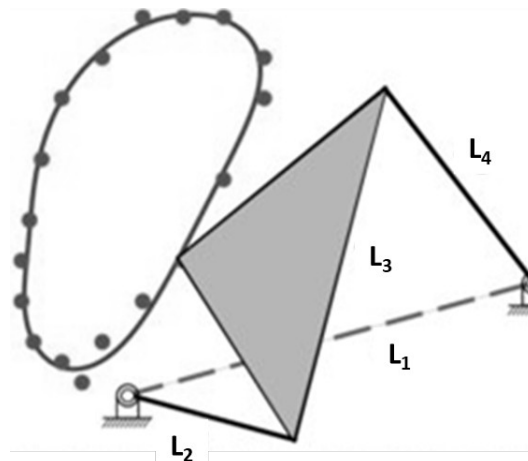

Fig. 1: The coupler (L_3) in a 4-bar linkage tracing a trajectory (solid blue line) based on desired points (red dots) [image adapted from Penunuri et al. (2011) Mech Mach Theory]

During the lab

You will be provided the required stationary like mount-boards, pins etc. with which you are supposed to construct a 4-bar mechanism, such that a point on the coupler passes through three desired points.

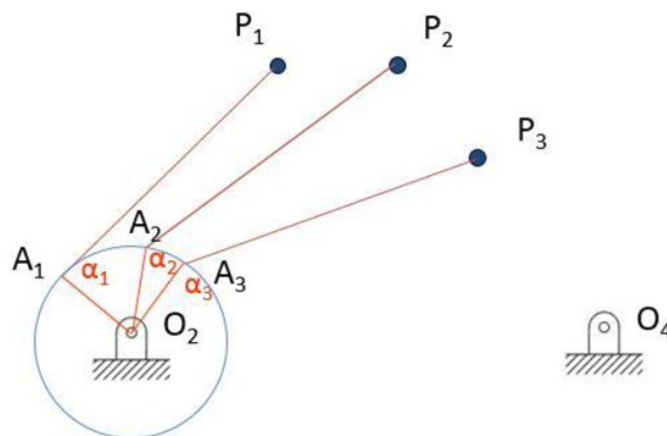Each group will be given a unique set of points (P_1, P_2 and P_3) (Fig. 2).

Fig. 2: Desired points on the coupler (P_1, P_2, P_3) and the corresponding crank positions

Choose points O_2 and O_4, the length of the crank O_2A_1, and one of the sides of the coupler A_1P_1. With A_1P_1 established, locate A_2 and A_3, such that $A_1P_1 = A_2P_2 = A_3P_3$, since the coupler is a rigid body. Measure α_1, α_2 and α_3 in a clockwise direction from the positive x-axis.

To locate the coupler pivot B, use the method of kinematic inversion to fix the coupler side A_1P_1 and rotate O_2O_4 (Fig. 3). Rotate the crank about A_1 by $(\alpha_2 - \alpha_1)$ to O'_2. Locate O'_4 as the intersection of the arc centred at O'_2 with radius O_2O_4 with the arc centred at P_1 with radius P_2O_4. Similarly, rotate the crank about A_1 by $(\alpha_3 - \alpha_1)$ to O''_2, and locate O''_4. Locate point B on the coupler as the intersection of the perpendicular bisectors of the lines $O_4O'_4$ and $O'_4O''_4$.
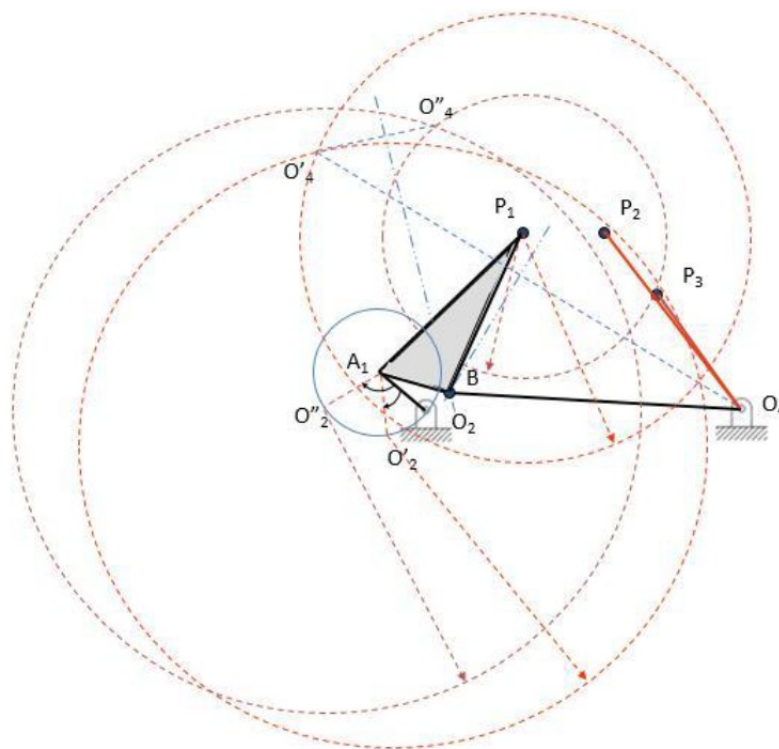

Fig. 3: Inverted joints O_2 and O_4 using the method of kinematic inversion

Using the mount board and pins, create the path generation mechanism. Trace the point P on the coupler over the range of the mechanism, and measure the experimental error between the actual trajectory and desired points.

Comment on whether the mechanism satisfies the Grashof criterion, and how variations in link lengths affect the analysis based on this law.