ME 3200 Mechatronics I Laboratory

Lab 4: Quick-Return Mechanism Design

Pre-lab Exercise

1. Crank-Slider

Design a crank-slider with a stroke of 1 inch and a time ratio of 1.40.

2. Crank-Rocker

Design a crank-rocker with an output angle of θ =30° and a time ratio of 1.40, where the rocker is 1.93" long (which corresponds to a distance of 1" between extreme positions).

NOTE: <u>Both these mechanisms (for all configurations) must fit within an 8"X8" area. Also, because of mechanical limitation of the hardware used in this lab, the minimum link length is approximately 1.5". If you derive a design that does not satisfy this minimum link length, you may scale the entire system appropriately as long as it fits within the 8"x8" area.</u>

Design of quick-return mechanisms using the graphical method:

You will need a pencil, ruler, compass, and protractor for this design. Refer to Figure 1 during this process.

1. Locate points B_1 and B_2 on your paper. These are the extreme points of the slider or the pin joint connecting the coupler and rocker, which will be termed *B* for this exercise.
2. Draw a line through B_1 at an angle $\gamma \neq 0$ from the line connecting B_1 and B_2.
3. Draw a line through B_2 at the construction angle d with respect to the first line as described in this step. The angle d will be determined using equation (2). The position of the crank when *B* is at the two extreme positions forms the obtuse angles α and β. Assume for this exercise that α > β and that the prescribed time ratio is determined by the ratio of a to b, where the sum of α and β is 360°. The following simultaneous equations are thus created:

$$\begin{aligned} \alpha - \beta \cdot TR &= 0 \\ \alpha + \beta &= 360° \end{aligned} \qquad (1)$$

where *TR* is the desired time ratio. The solution to these equations gives α and β. Once these are calculated, the construction angle d is determined from the supplement of either angle by the following:

$$\delta = |180° - \beta| = |180° - \alpha| \qquad (2)$$

The intersection of this line with the line drawn in step 2 gives the crank pivot O_2.

4. With your ruler, measure the distance between O_2 and B_1 the distance between O_2 and B_2. Keep in mind that the position B_2 is reached when the crank and coupler are collinear in the fully extended position, and B_1 is reached when they are collinear in the fully retracted position (the crank is right on top of the rocker). The following set of equations can then be used to find the lengths of the crank and the coupler:

$$\begin{aligned} \ell_{CPL} - \ell_{CR} &= \|O_2B_1\| \\ \ell_{CPL} + \ell_{CR} &= \|O_2B_2\| \end{aligned} \qquad (3)$$

where ℓ_{CPL} is the length of the coupler and ℓ_{CR} is the length of the crank.

5. For the crank-rocker, the rocker pivot O_4 is found by drawing a perpendicular bisector from the line connecting B_1 and B_2, and then finding the point on that line that creates the desired angle q. The length of the line that connects O_4 to either B_1 or B_2 is the length of the rocker. The distance between the pivots O_2 and O_4 is the link length of the ground.
6. Check the rotatability criteria in the case of the crank-slider, which is as follows:

$$\begin{aligned} \ell_{CR} &< \ell_{CPL} \\ \ell_{CPL} - \ell_{CR} &> d \end{aligned} \tag{4}$$

   where d is the perpendicular distance between O_2 and the line passing through B_1B_2, as indicated in Figure 1. Both of these criteria must be satisfied for the crank to rotate a full revolution.
7. Check the Grashof condition in the case of a crank-rocker, which is as follows:

$$s + l < p + q \tag{5}$$

   where s is the length of the shortest link (which must be the crank for crank-rocker inversion), l is the length of the longest link, and p and q are the lengths of the other two links.
8. The transmission angle m is the angle between coupler and the rocker. In the case of the crank-slider, the rocker can be viewed as having infinite length, thus the transmission angle is measured between the coupler and a line perpendicular to the slider path (not show on the Figure). When you have completed your design, it should look something like figure 1 below for the crank-rocker. The crank-slider will be similar with the exception of O_4.

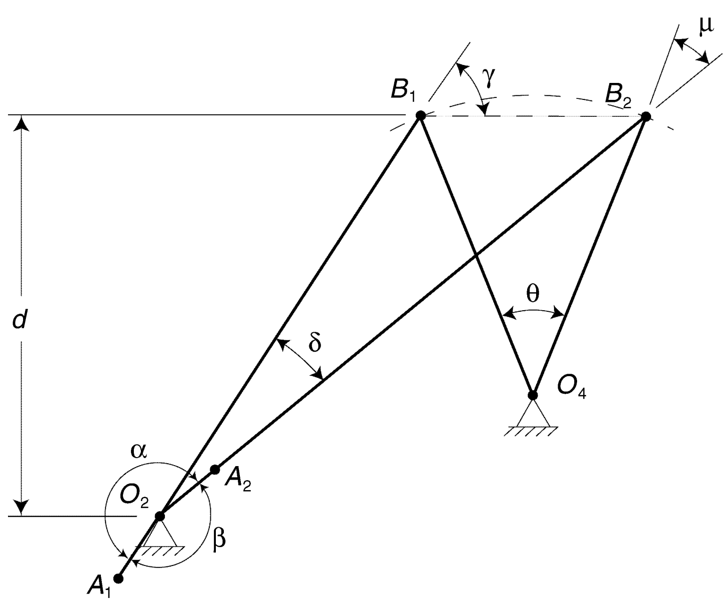

Figure 1. Graphical design of a crank-rocker type quick-return mechanism.

Laboratory Exercise

Equipment Needed: Mechanical breadboard, ruler, protractor, and linkage parts.

1. Crank-Slider

Build the mechanism and show the TA that it works. It may be necessary to scale the links if you have not designed the system to fit within the 8” x 8”

<u>What are the minimum and maximum transmission angles of your mechanism</u>?

2. Crank-Rocker

Build the mechanism and show that it works. It may be necessary to scale the links.

<u>What are the minimum and maximum transmission angles of your mechanism</u>?

Questions

Using a diagram, graphically show the components of Equation 3.

What are some applications of these mechanisms?

What does transmission angle indicate?

What would be the consequence of not satisfying either equations 4 or 5?