AME 339 - Kinematics and Dynamics of Machinery

Limit Configurations, Dead Configurations and Transmission Angles

Figure 1 shows a four bar linkage. If one of the two levers is selected as the input, the other lever is then considered the output. There are two possibilities, as shown.

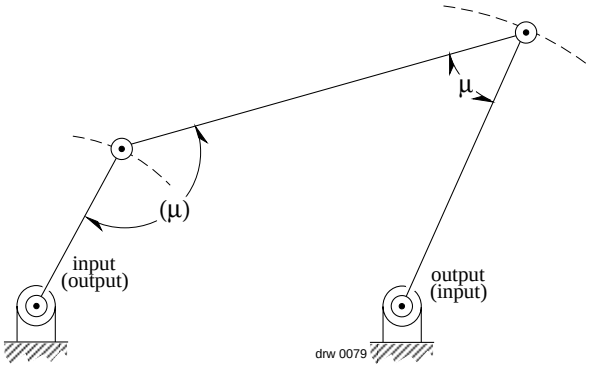

Figure 1: A Four Bar Linkage

Limit and Dead Configurations

Figure 2 shows the four bar in its limit and dead configurations. As is seen, whether the configuration is a limit or dead configuration, depends on which of the two levers is the input.

Neglecting inertia and gravity effects, the coupler acts as a two force member, hence the direction of the force transmitted by the coupler is along the line connecting the centers of the two moving hinges. If you do not understand this, see me in my office, not next week, but today. (By next week you should consider dropping the course of you don't understand this!)

Recognizing this fact explains the limit configurations, where the four bar has an infinite mechanical advantage. In the limit configurations, zero driving torque applied to the input lever can equilibrate an infinite load torque applied to the output lever. Draw a free-body of each moving link in the system to see this, and see me asap if you need help doing that.

Likewise, knowledge of the coupler as a two force member explains the dead configurations, where the four bar has zero mechanical advantage. In the dead configurations, an infinite driving torque must be applied to the input lever in order to equilibrate any finite load torque applied to the output lever. Again, draw a free-body of each moving link in the system to see this, and see me asap if you need help doing that.

So, we see that in fact limit and dead configurations are the same, and which of the two is occurring depends solely on which lever is the input. In a more general way both the limit and dead configurations can be referred to as "dwell configurations", since one of the levers in the four bar (the one on the left in Figure 1) is momentarily dwelling (not rotating) with respect to the other lever.

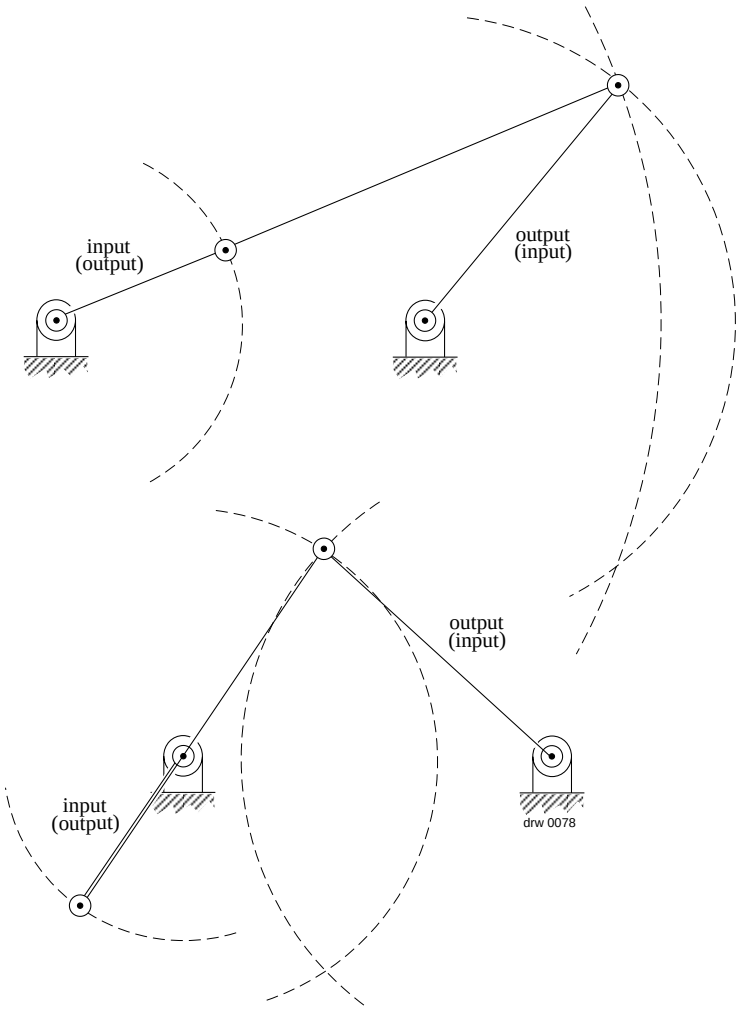

Figure 2: Limit and Dead Configurations of the Four Bar Linkage

A four bar mechanism is referred to in a manner that describes the type of input and output motion as (input type)-(output type). For example, a crank-rocker four bar has a crank input and a rocker output. We can now make some general statements.

- A four bar with a crank input has no dead configurations.
- A four bar with a rocker input has dead configurations.
- A four bar with a crank output has no limit configurations.
- A four bar with a rocker output has limit configurations.

The Transmission Angle
Associated with a four bar in any particular configuration is an angle referred to as the transmission angle. The transmission angle (μ) is defined as the internal angle between the coupler and the output lever, as shown in Figure 1.

The transmission angle is an indicator of the effectiveness of the four bar's ability to transmit torque from the input lever to the output lever. A general "design rule of thumb" is that the tranmission angle should never be less than 30° or greater than 150°. In other words, the coupler and output lever never approach closer than 30° to forming a straight line (which would be a dead configuration). The value of 30° here is nominal, and would actually depend on the quality of the bearings. For poor bearings a larger number could be used, and for very low friction bearings, a smaller number may be accepted.

In four bars with crank inputs (i.e. no dead configurations) it is useful to determine how near a dead configuration the four bar approaches. We may also see how well the mechanism is doing in following the above design rule. Figure 3 shows the configurations of a crank input four bar where the transmission angle will have its maximum and minimum values, i.e. the configurations where it most closely approaches a dead configuration. According to the design rule, the minimum transmission angle in Figure 3 should not be less 30° and the maximum transmission angle should not exceed 150°.

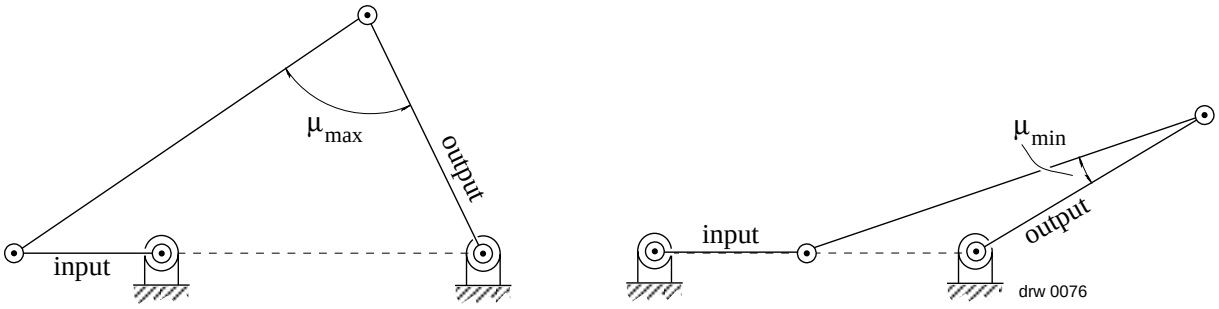

Figure 3: Max. and Min. Transmission Angles of the Four Bar

We can also apply these results to the crank-slider mechanism, such as that shown in Figure 4. Note that the crank-slider has an equivalent four bar mechanism where one of the levers is infinitely long.

Figure 5 shows the limit configurations of a crank-slider.
Figure 6 shows the dead configurations.
Figure 7 shows the configurations that correspond to the maximum and minmum transmission angles.

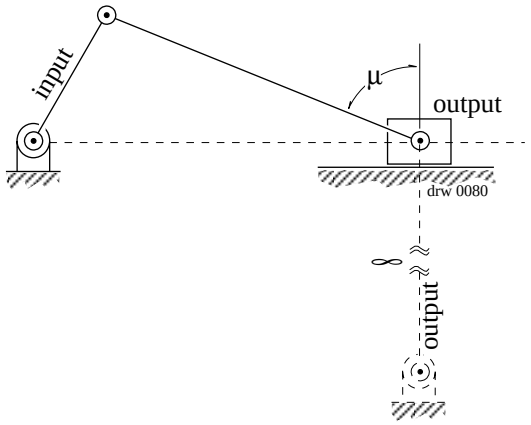

Figure 4: A Crank-Slider

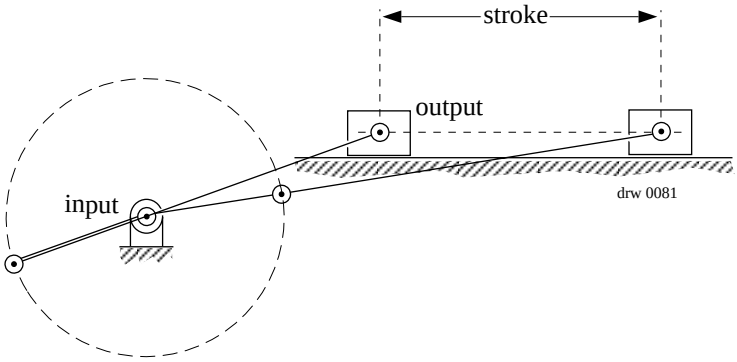

Figure 5: Limit Configurations of the Crank-Slider

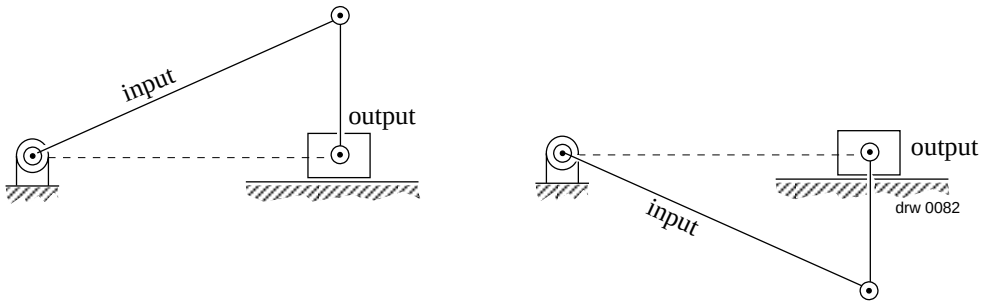

Figure 6: Dead Configurations of the Crank-Slider

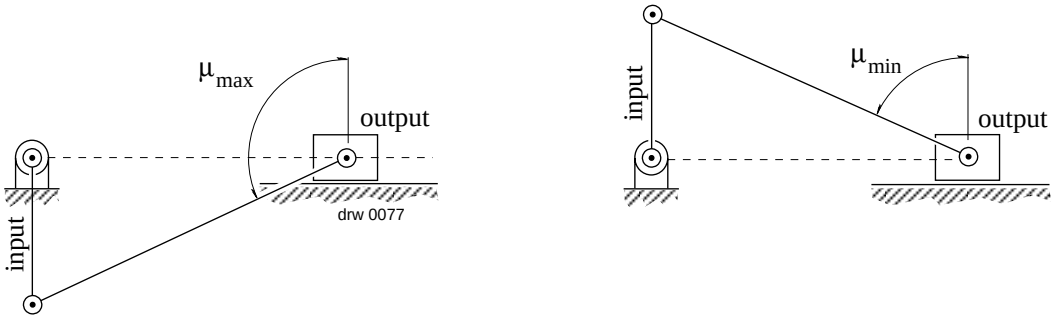

Figure 7: Max. and Min. Transmission Angles of the Crank-Slider