CHAPTER 3 - HOMEWORK

3-1  Was worked w/ Inkscape - see Solution on 3

3-2

See 3.3-4°:

1) \( r_2 + r_3 + r_4 > r_1 \)  \( \text{Links (2), (3), & (4)} \) must together be long enough to span distance between pivots

2) \( r_2 + r_1 + r_4 > r_3 \)

3) \( r_2 + r_3 - r_4 < r_1 \)  If not true, \( r_2 \) could go 360°

4) \( r_3 - r_2 + r_4 > r_1 \)
Apply conditions:

1) \[ 31.8 + r_3 + 63.5 > 102 \]
   \[ r_3 > 6.7 \]

2) \[ r_3 < r_1 + r_2 + r_3 = 102 + 31.8 + 63.5 \]
   \[ r_3 < 197.3 \]

3) \[ r_3 < r_1 - r_2 + r_4 = 102 - 31.8 + 63.5 \]
   \[ r_3 < 133.7 \]

4) \[ r_3 > r_1 + r_2 - r_4 = 102 + 31.8 - 63.5 \]
   \[ r_3 > 70.3 \]

All conditions must be true. Most restrictive are 3) & 4), so

\[ 70.3 < r_3 < 133.7 \]
Motion analysis of mechanism in Martin, Problem 3-1

I used Inkscape to draw the mechanism. Then for all three movable links, I moved their rotation points from the centers of the links to the ends about which I wanted them to be rotated. This was done simply by clicking on the little cross that shows the center of rotation and dragging it to the desired rotation point. For links 2 and 4, the desired rotation point was the fixed pivot for those links. Then the rotation point of link 3 was point B.

Figure 1: Motion analysis of mechanism via Inkscape

Let link 2 (the driver) rotate through certain angles. For each angular displacement, I moved link 3’s point B to the end of link 2. Then I rotated link 3 and link 4 until the end of link 4 and point C on link 3 coincided. With the mechanism then together, I marked the location of points C and D and wrote beside each point, the angular displacement of link 2 that corresponded with that location of those two points. These displacements of link 2 are all measured counterclockwise from the positive horizontal direction; i.e. the position shown for link 2 is 90°.

The above figure shows the result of the procedure described above. Point D at the top of triangular link 3 moves in a counterclockwise, kidney-shaped circuit as link 2 traverses its circular path counterclockwise also. Link 4 does not rotate through a complete 360° revolution. Rather it rocks back and forth, reaching the ends of its swing at about 180° and 330°. Note that this swing is not uniformly swept. Link 4’s point C moves slowly, as link 2 is pointed away from it, at 300°-360°. But as link 2 traverses the angular displacements opposite of that, i.e. around 180°, link 4 moves very fast. Note, for instance, the distance between point C’s position with link 2 at 180° and 210°. Compare that with the difference between C’s position at 300° and 330°, which are very close to each other. If link 2 is moving at a constant angular velocity, then the further apart adjacent points for points C and D, the faster the velocity of the point between those two points. Thus, for example, point C is moving very slowly at the right-hand end of its stroke. It moves much more rapidly at the left-hand end of its stroke. Since point C is at the end of link 4, this means that the angular velocity of link 4 is much faster at the left-hand end of its stroke, and it is very slow at the right-hand end of its stroke.
Want time ratio of 1.75:1, working stroke = 660 mm.

\[ \theta_1 = 229.1^\circ \quad \theta_2 = 130.9^\circ \]

\[ \text{Calc } \theta_2, \theta_4, \theta_{5x0} \]

\[ \omega_2 = 40 \text{ rpm}, \text{ find } v_0\text{-avg for stroke } S \text{ return.} \]

\[ \text{Time ratio:} \]

\[ \frac{1.75}{1} \cdot 60 \cdot \frac{360}{2.75} = \frac{\theta_2}{1} = \frac{\theta_1}{1.75} \]
\[ 980 - 258 = 722 \]

\[ \frac{722}{\cos 24.55} = 794 \]

\[ 980 - 794 = 186 \]

\[ 680 - 381 = 299 \]
1) Draw link 2 at angles from 02 so have 1.75:1 time ratio. Don't know r2.

2) New link 4 must pass through these 2 lines from 02 at right angles, extremes of 4's swing.

3) Stroke of 6 is 660 mm, to move up 4 until swing is 660 mm. Light line shows this.

4) Midpoint vertically between ends of stroke a mid-stroke on 4 is pin point of 5 on 6, Point D.
5) Look @ stroke of (6). It is 660 mm or very close to it. We'd known the complex was 381 mm, so it was simply drawn as such.

Because 5 moves up and down a little, I was afraid stroke would not be 660 mm but would be a bit shorter. But, no. The configuration of 5 and 6 at the left extreme is identical to their configuration at the right extreme, so, indeed, the distance 6 travels from left to right is 660 mm. For instance, if somehow 6 were always directed above point C, it's stroke would still be 660 mm.
3-4 \( w_2 \) is constant & c.w. Time ratio = 2:1
Slew of 6 is to left
\( O_2O_4 \) is 76.2 mm
\( S = 343 \) mm
\( CD = 3 \) \((O_4C)\)

O_2 may be above or below O_4
Show mech @ extreme right
Compute \( O_2B, O_4C, CD \).

Now need \( \theta \) & \( 2 \theta \) will be used to set time ratio. Look @
Circle geometry of two circles
Fig 3-10 shows \( O_2B = O_4C \)
Seemingly, but this doesn't seem to be a requirement of mech.
Worksheet for SVG/Inkscape Solution

560 - 76.2 = 423.8

As this is, when B'' rotates CW to B', O moves to right on slow travel. Backwards

Put into SVG/Inkscape, what's known will help visualize.

If put O2 above O4, maybe slow strake to left.

\[ \sin 30 = \frac{76.2}{x} \]

\[ x = \frac{152.4}{30} \]

421.5 + 514.5 = 936
1) $O_4 C$ must be $s/2$
2) This angle must be $120^\circ$
3) This distance is given as $76.2$ mm
4) 1), 2), and 3) fix $r_2$ at $152.4$ mm
5) As 2) rotates CW in top drawing, C moves down. Since 2) must traverse $2/3$ of its rotation during this leftward movement, this is the slow part of cycle.

Note: It is difficult to see everything a priori at first. Start with facts you know, then things become clearer.