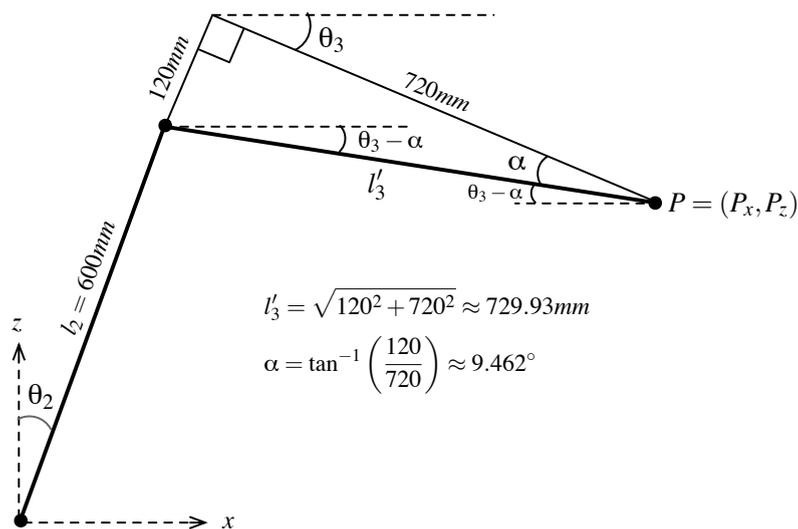


# MMS 319 Telerobot Remote Exercise

2nd Semester, 2004

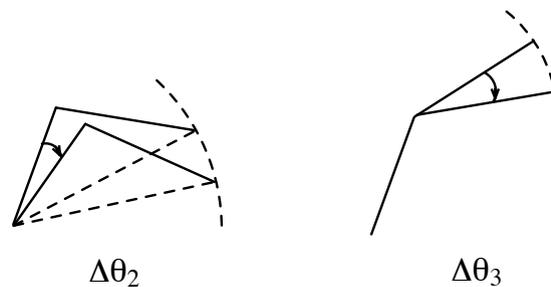
The aim of this task is to give you some practise at solving the kinematics of a simple two-bar linkage, and to test the remote control of the Telerobot. This will be good planer kinematics revision.

The Telerobot's links 2 & 3 can be represented as a two-bar mechanism:



**Figure 1:** Side view of the Telerobot links 2 & 3

A change in the value of a joint angle causes the end-effector to move in an arc about that joint.

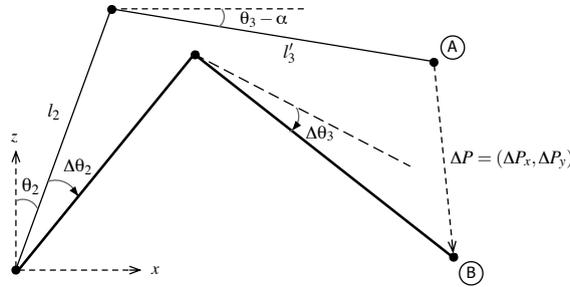


**Figure 2:** Changes in  $\theta_2$  and  $\theta_3$  cause the end-effector to move in an arc

For a small change, this arc can be approximated by a straight line. Thus, for small changes in the angles ( $\Delta\theta_2$  and  $\Delta\theta_3$ ) we can approximate the change in the end-effector position ( $\Delta P_x, \Delta P_y$ ). We can do this by solving:

$$\frac{\delta\Phi}{\delta q} \Delta q = 0$$

where  $\frac{\delta\Phi}{\delta q}$  is the Jacobian, and  $\Delta q$  is a small change in the inputs. For this two-bar mechanism,  $q = \begin{bmatrix} \theta_2 \\ \theta_3 \\ P_x \\ P_z \end{bmatrix}$ . (See your lecture notes for more information).



**Figure 3:** Small angle changes  $\Delta\theta_2$  and  $\Delta\theta_3$

## Procedure

1. Write down the vector closure equation for the linkage. Split this into equations for the  $x$  and  $z$  directions.
2. Write down  $\Phi$  and  $q$  for the mechanism.

$$\Phi = \begin{bmatrix} x\text{-direction components} \\ z\text{-direction components} \end{bmatrix} = \tilde{0}$$

3. Find  $\frac{\delta\Phi}{\delta q}$ , the derivative of  $\Phi$  with respect to  $q$  (in this case it should be a  $2 \times 4$  matrix).
4. Using  $\Delta q = [\Delta\theta_2 \ \Delta\theta_3 \ \Delta P_x \ \Delta P_z]$ , write out the matrix  $\frac{\delta\Phi}{\delta q} \Delta q = 0$  (in this case it is a  $2 \times 1$  matrix). Then write the two rows in  $\Delta P_x = \dots$  and  $\Delta P_y = \dots$  form.
5. Choose arbitrary values for  $\theta_2, \theta_3, \Delta\theta_2$  and  $\Delta\theta_3$  ( $\Delta\theta_2$  and  $\Delta\theta_3$  should be  $< 3^\circ$ ), and calculate  $\Delta P_x$  and  $\Delta P_y$ . (Make sure you convert  $\Delta\theta_2$  and  $\Delta\theta_3$  to radians)
6. Log into the Telerobot (see instructions below).
7. Set the angles to  $(0, \theta_2, \theta_3, 90, 90, 0)$ , move the robot and record the  $x$  and  $z$  coordinates.
8. Set the angles to  $(0, \theta_2 + \Delta\theta_2, \theta_3 + \Delta\theta_3, 90, 90, 0)$ , move the robot and compare the position to what you calculated before.
9. Choose some larger values for  $\Delta\theta_2$  and  $\Delta\theta_3$  and find out at what values the approximation starts to break down.

## Logging into the Telerobot

1. Go to Start menu > Programs > LabVIEW > LOL Login
2. Log in with your student number as your username and password.
3. Click the “Verify System tab”, and click the “Update My System” button to download the Telerobot client.
4. Go back to the “Choose Task” tab. From the Task list, choose “mms319 (Robot control)”. Click “Join queue”.
5. In the dialogue that comes up, select your time and click “OK”.
6. When the lab is ready, click “Enter lab”. You can now move the robot around and read the current position and joint angles. Remember to wait for the position and angle values to update after the robot moves!

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## What to submit

1. Your calculations
  2. A screenshot of the Telerobot remote client with your values
  3. How long it took you to do the calculations
  4. How long it took you to check your calculations with the Telerobot
  5. What you learnt from the exercise
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