

(3/24/26)

(Do not use Matlab, Maple, Mathematica, etc. You may use Claude or ChatGPT, but say so if you do.)

ENG ME 740:

Exercises (Set 4) (Due 3/31/26)

1. Write down the inverse of the matrix

$$A = \begin{pmatrix} \cos \theta & -\sin \theta \cos \alpha & \sin \theta \sin \alpha & a \cos \theta \\ \sin \theta & \cos \theta \cos \alpha & -\cos \theta \sin \alpha & a \sin \theta \\ 0 & \sin \alpha & \cos \alpha & d \\ 0 & 0 & 0 & 1 \end{pmatrix}.$$

2. Given a prescribed position and orientation of the planar 3-bar manipulator of the second Exercise Set, there are two possible solutions to the inverse kinematics problem. If we add one more link (in such a way that the manipulator is still planar), how many solutions are there?

3. The figure shows a 2-bar planar manipulator with rotary joints. The second link is half as long as the first ($r_1 = 2r_2$). The joint limits are:

$$0 < \theta_1 < 180^\circ$$

$$-90^\circ < \theta_2 < 180^\circ.$$

Sketch the approximate workspace (= the set of points which can be reached by the tip of the second link).

