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Exercise 8

This is about the degree of freedom problem. We will make a "toy" version of that. Consider an arm that only moves within a plane. Assume the arm has two joints (a "shoulder" and an "elbow"). You want to control the tip of the arm (the "hand"), but only along the horizontal axis, x. You do not care about the axis, y, that points away from the body.

1. Make a drawing of the arm with coordinate axes and make the joint angles. Introduce two parameters, l_i, for the length of the upper and the lower arm, respectively.

2. Write down the equation that determines where the horizontal position position of the hand is as a function of the two joint angles (you can adapt the 3 joint equations from the lecture, but you can also figure this out yourself).

3. Compute the "uncontrolled manifold" (UCM) by solving for one of the two joint angles in that equation. For very value of x, you have a different UCM.

4. Make a drawing of that manifold (approximate) as a line in the space of the two joint angles.

5. Draw two examples of arm configurations that have the same x value (this is trivial). Connect in your mind the drawing of the UCM to that variation of arm configurations: How does the arm change when you move along the UCM?