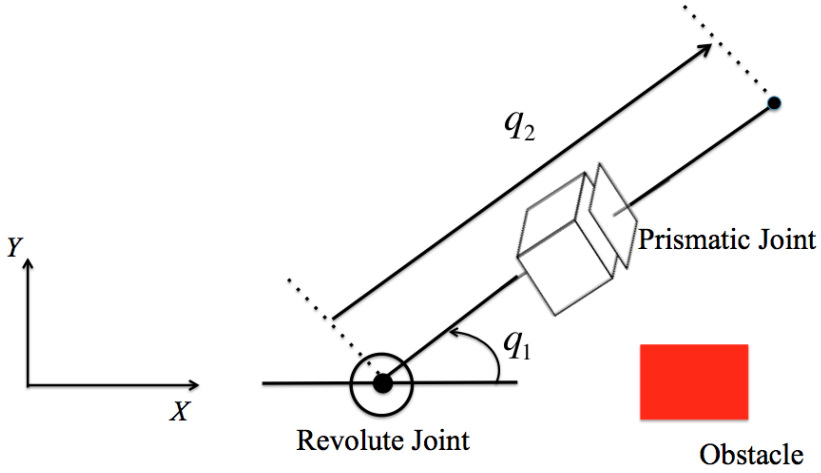
Homework 10

1. Consider the robot manipulator shown in the figure below.



The shaded region is an obstacle with (X, Y) coordinates of its vertices being $(2, -1)$, $(2, 1)$, $(3, -1)$, and $(3, 1)$. The origin of this coordinate frame is at the revolute joint of the robot manipulator. In the figure, the robot configuration is $q_1 = 30^o$ and $q_2 = 4$. We want to move the robot to configuration $q_1 = -30^o$ and $q_2 = 4$.

(a) Write the obstacle set in configuration space. Recall that the obstacle set in configuration space is the set of all joint variable values that will result in collision of any part of the robot with an obstacle in the environment.

(b) Note that while the straight-line trajectory (in configuration space) from the initial to desired final configuration will result in a collision, an intermediate configuration can be picked such that the robot can move from initial to the intermediate configuration and then from the intermediate configuration to the final configuration along straight lines. Find such an intermediate configuration.

2. Consider a mobile robot moving in an environment and equipped with sensors (e.g., RF receivers) that can measure distances to a set of points (e.g., RF beacons) in the environment. Let this set of points be given as the 2D coordinates $(0, 0)$, $(200, 200)$, $(150, 100)$, $(250, 200)$, and $(100, 250)$. Let the actual (but unknown) robot position (at some time instant) be $(100, 100)$. We want to estimate this position using the sensor measurements (i.e., localization). For this purpose, if the robot position is denoted as (x_r, y_r), the measurements of distances to the set of points as described above provide equations in terms of x_r and y_r. Write this set of equations.

We will get 5 equations (since there are five points in the set of points described above) with each equation being of the form $f_i(x_r, y_r) = d_i$ with d_i being the corresponding distance measurement. Then, we want to find an estimate of x_r and y_r to minimize the overall error, which could be defined as, for example, $e = \sqrt{\sum_{i=1}^{n}(f_i(x_r, y_r) - d_i)^2}$. Finding x_r and y_r to minimize this error is essentially a nonlinear optimization problem. With the coordinates of the set of points and the actual robot position as specified above, find the estimated robot position as described above. You can, for example, use the `fminsearch` function in Matlab to solve the nonlinear optimization problem described above.