MeEn 537 Homework #3

1. Work the following problems from your textbook:
   (a) 4-2
   (b) 4-10
   (c) 4-13
   (d) 4-15
   (e) 4-16 (do this by hand)
   (f) 4-17 (do this by hand, except for the determinant)
2. Do the following:
   (a) Write the Jacobian for the 2 link manipulator that we looked at in class in the end effector frame using the following two methods (which should agree in terms of the result):
      i. by direct calculation
      ii. by transforming the original Geometric Jacobian that we found in class
   (b) Using the Jacobian for the 2 link manipulator from class, find the required torques to apply a force in the following directions at the following joint configurations (make note of anything that you think is interesting or increases your understanding). How do your answers change if the force given is a reaction force instead of a force applied by the end-effector?:
      i. $q = [0, \pi/4]$, $F = [-1, 0, 0]$ Newtons
      ii. $q = [0, \pi/2]$, $F = [-1, 0, 0]$ Newtons
      iii. $q = [\pi/4, \pi/4]$, $F = [-1, -1, 0]$ Newtons
      iv. $q = [0, 0]$, $F = [0, 0, 1]$ Newtons
      v. $q = [0, 0]$, $F = [1, 0, 0]$ Newtons
   (c) Sketch the configurations where the following manipulators are in a singular configuration (i.e. the columns of the Jacobian are no longer linearly independent):
      i. Figure 3.6 in the book.
      ii. Figure 3.8 in the book.
      iii. Figure 3.29 in the book.
   (d) For each of the cases in problem c, please sketch the reciprocal wrenches as well (directions in which the structre of the robot can apply "infinite" force).