CSE4421: Assignment 1

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1. Question 2.1 from the textbook.
2. Question 2.3 from the textbook.
3. One problem with representing a rotation as a product of three canonical rotations (RPY and Euler angle representations) is the phenomenon known as gimbal lock. When gimbal lock occurs, a column (and row) of the rotation matrix becomes fixed.
   (a) Write down the Z-X-Y Euler angle matrix representation as the product of three canonical rotations; do not multiply the matrices.
   (b) Set $\beta = 90$ degrees and multiply the matrices. Try to simplify the resulting rotation matrix as much as possible.
4. Question 2.5 from the textbook (recall that $A\mathbf{x} = \lambda\mathbf{x}$ for a matrix A, an eigenvector $\mathbf{x}$ and an eigenvalue λ).
5. **Graduate Students Only:** A 3D rotation can be represented by a line (the axis of rotation) and a scalar (the angle of rotation); the textbook describes this axis-angle representation on pages 46–48. Equations 2.81 and 2.82 give a way of computing the angle of rotation, but it is not clear how the formula for θ is derived. Compute the trace (the sum $r_{11} + r_{22} + r_{33}$ of the diagonal elements) of the matrix in Equation 2.80, and derive the formula for θ.
6. **Graduate Students Only:** Question 2.14 from the textbook.
7. Question 3.16 from the textbook.
8. Develop the forward kinematics for the A150. The figures from Lab 1 will be useful. The origin of frame 0 should be located on the table top with the positive x axis aligned with the arm when it is in the ready position and the positive z axis pointing up aligned with the waist rotational axis. The A150 has 5 revolute joints, so you will need 6 frames (frame 0 plus one for each joint). Show only the table of Denavit-Hartenberg parameters (and not the actual transformation matrices) and indicate the units you are using (inches or millimeters).