Problems

Course Title: Introduction to Robotics **Course Code:** IE410 **Semester:** Winter, 2021

1. Find out 3×3 matrices which describe the following motion of robot in 2D
   (a) A $\pi/2$ rotation about the origin
   (b) A translation of one unit in the x-direction followed by a $\pi/2$ rotation about the origin

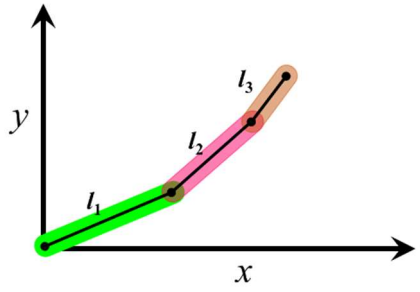
2. A robot is rotated by $\pi/3$ radians about x-axis, and then $\pi/3$ radians about y-axis. Find the axis of resulting composite rotation.

3. Find the 4×4 matrices for a robot corresponding to the following 3-D rigid transformation:
   (a) A rotation of $\pi/3$ radians about x-axis, followed by a translation of 3 units in the z-direction.
   (b) A translation of 3 units in the z-direction, followed by a rotation of $\pi/3$ radians about x-axis.

4. Consider a three joint planar manipulator with $l_1 = 2$, $l_2 = 3$ and $l_3 = 1$ in some units. Find the x, y coordinates of the point with home position, and the angle the last link makes with the x-axis when the joint angle are:
   (a) $\theta_1 = \pi/6, \quad \theta_2 = \pi/6, \quad \theta_3 = \pi/6$
   (b) $\theta_1 = \pi/2, \quad \theta_2 = 4\pi/3, \quad \theta_3 = \pi/3$
   (c) $\theta_1 = -\pi/6, \quad \theta_2 = 2\pi/3, \quad \theta_3 = -\pi/3$

5. A planar robot has link lengths $l_1 = 2$ and $l_2 = 1$ in some unit. Use the inverse kinematics equations to find the joint angles which will place the end effector at $x = \sqrt{3} + ½$ and $y = 1 + \sqrt{3}/2$

6. A robot manipulator has the kinematic structure illustrated in the following Figure



   (a) By setting up a suitable co-ordinate system and reference position, find the kinematics equation for the co-ordinates of the end effector
   (b) Calculate the Jacobian of this manipulator.