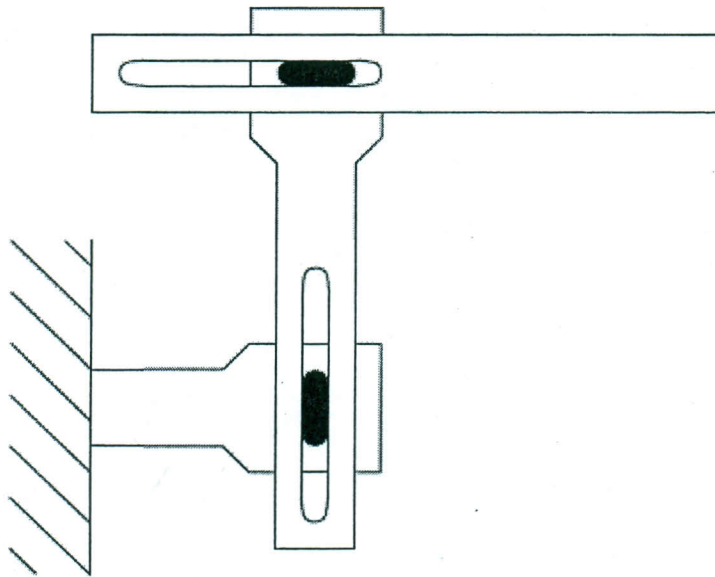


Open Notes Exam (only printed PowerPoint presentations are allowed)

1. Suppose \mathbf{R} represents a rotation of 45° about \mathbf{x}_0 followed by a rotation of 90° about \mathbf{z}_1 . Find the equivalent axis/angle to represent \mathbf{R} . Repeat the solution using **Robotics Toolbox for Matlab**.
2. Consider the two-link manipulator shown below which has two **prismatic** joints. Derive the **forward kinematic equations** using the **DH-convention**. How many solutions existed for the **inverse kinematic problem** of this manipulator?



3. Find the 6×2 **Jacobian** for the two-link manipulator of Problem 2. Are there **singular configurations** for this manipulator?
4. Derive the **Euler-Lagrange equations** for the two-link manipulator of Problem 2 if the mass of each link is **1 kg**. Calculate the actuators' forces required to move the end-effector with acceleration having horizontal component of **10 m/s²** to the right and vertical component of **5 m/s²** upward.