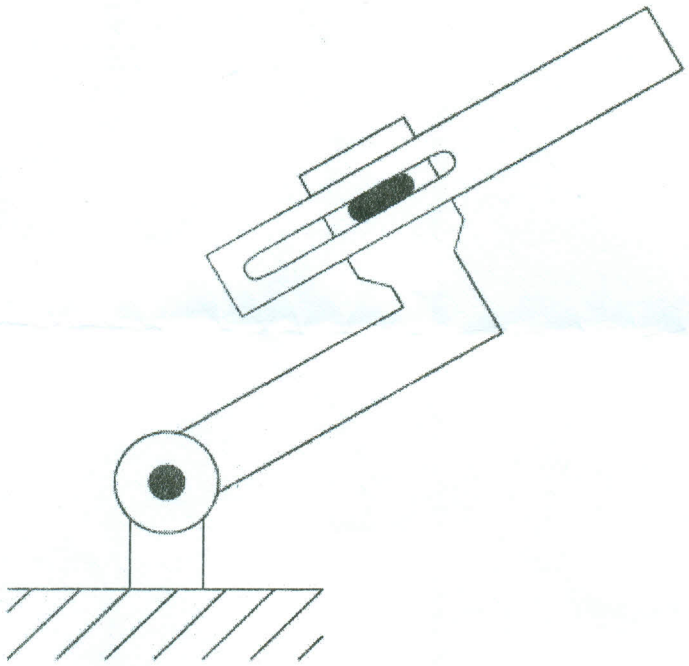
Mansoura University	**Robotics**
Faculty of Engineering	**Final Exam Fall 2011**
Prod. Eng. & Mech. Design Dept.	**Time: 3 Hours**

Open Notes Exam (only printed PowerPoint presentations are allowed)

1. Find the **rotation matrix** corresponding to the set of Euler angles $\{\pi/3, 0, \pi/6\}$. What is the direction of the resulted **x-axis** relative to the base frame? Repeat the solution using **Robotics Toolbox for Matlab**.

2. Consider the two-link manipulator shown below which has one **revolute** joint and one **prismatic** joint. 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. Let the **centers of masses** of links **1** and **2** coincide with the origins ($\mathbf{O_1}$ and $\mathbf{O_2}$) of their attached axes.