EC4.401- Robotics: Dynamics and Control
Mid Semester Examination

Date: 24/09/2025

Maximum Marks: 20

Instructions:

1. This is an open book exam. You can bring either your own written notes, a photocopy of notes, or a textbook—any one of these is fine.
2. Read the questions and associated figures carefully; information is conveyed through both text and figures.

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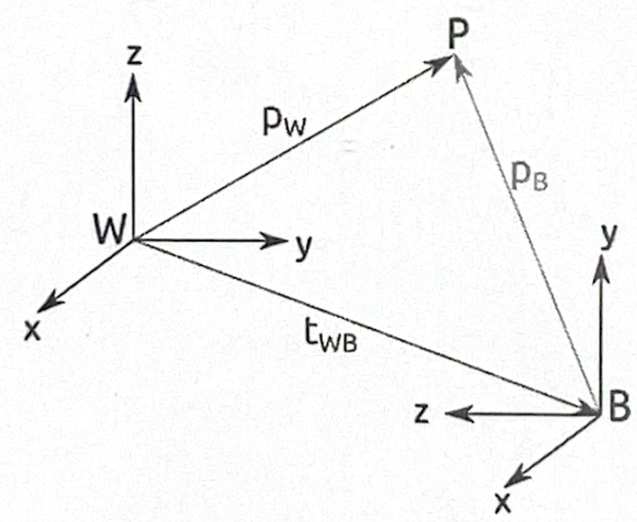
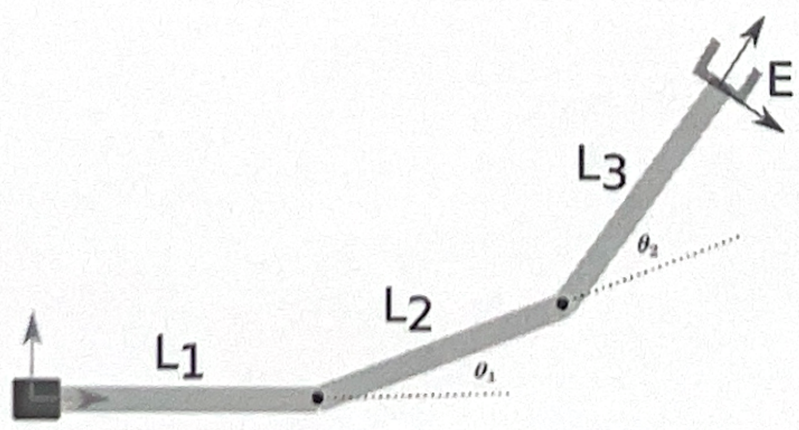
1. In the figure below, two frames, W and B, are shown. The position of frame B with respect to frame W is given by $t_{WB} = [3\ 1\ 1]^T$. For a point P, its position in frame B is $p_B = [1\ 1\ 1]^T$. Find the homogeneous transformation matrix T_{WB} and the position vector p_W.

   [*5 marks*]



2. Find the forward kinematics of the planar robot arm shown below. Link L_1 is fixed and cannot move, while the remaining two links are attached by revolute joints.

   [*5 marks*]

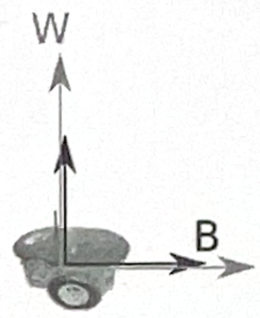


virtual 3 axis

local axis

3. The world frame ($\{W\}$) and the body frame ($\{B\}$) of a mobile robot are initially coincident. The robot first rotates by $\pi/6$ and then moves forward by 3 m. It then rotates about its body frame by π and again moves forward by 3 m. Using homogeneous transformation matrices, determine the final location of the robot in $\{W\}$.

[*5 marks*]



4. Consider the Jacobian matrices of a planar 2-link manipulator in two configurations:

$$J_1 = \begin{bmatrix} -1 & -0.5 \\ \sqrt{3} & \frac{\sqrt{3}}{2} \end{bmatrix}, \qquad J_2 = \begin{bmatrix} -0.5 & -0.5 \\ 1.866 & 0.866 \end{bmatrix}$$

For each Jacobian, analyze whether it is possible for the end-effector to generate a tip velocity in an arbitrary direction in the plane. Justify your answer.

[*5 marks*]