

ASSUMPTION UNIVERSITY
SCHOOL OF ENGINEERING
MIDTERM EXAMINATION 1 / 2021 (SET2: ID end with 2,4)

SUBJECT : MCE4101-Introduction to Robotics
LECTURER : Asst. Prof. Dr. Narong Aphiratsakun
DATE : 29 June 2021
TIME : 18.00-20.00 (2 Hr)

NAME	SURNAME	ID.NO.	SEC.....
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Make sure you have all the questions.

- Total examination paper: 3 questions, 4 pages (not including cover page).

Instructions:

1. This examination is worth a total of 100 points. This examination will contribute to 25% of your final grade.
2. **Open books Examination.**
3. Any calculator can be used.
4. The University's examination regulations are on the reverse page. Students are expected to read and strictly observe them while the examination is in progress. Failure to do so would subject students to the terms of punishments.

This is to inform that

- Students are NOT allowed to use Smart Watches in examinations. Should they be brought into examination rooms, they are required to be placed on the floor under students' desk or chair.
- Violators will be subjected to the terms of punishment for violating examination regulations and/or cheating in the examination.

Other pertinent University's examination regulations are on the reverse page.

**Students are expected to read and strictly observe them while the examination is in progress.
Failure to do so would subject students to the terms of punishments for violating examination regulations and/or cheating in the examination.**

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1. (30 Minute). Consider the VME robot shown in Figure 1.1 below.

a) (20 Marks) Evaluate the homogenous transformation matrices **values** for T_{drill}^0 by using **CURRENT FRAME** method of defining reference frames, where reference frames starting from the base $[x_0, y_0, z_0]$ to the end point $[x_{end}, y_{end}, z_{end}]$ are given. Where $L_4^* = 10$ and $L_1 = 50, L_2 = 25, L_3 = 10, L_5 = 5$.

Show your working steps from base to end points.

b) (5 Marks) Compute the driller location (P_{drill}) with reference to base where $L_4^* = 10$ and $L_1 = 50, L_2 = 25, L_3 = 10, L_5 = 5$.

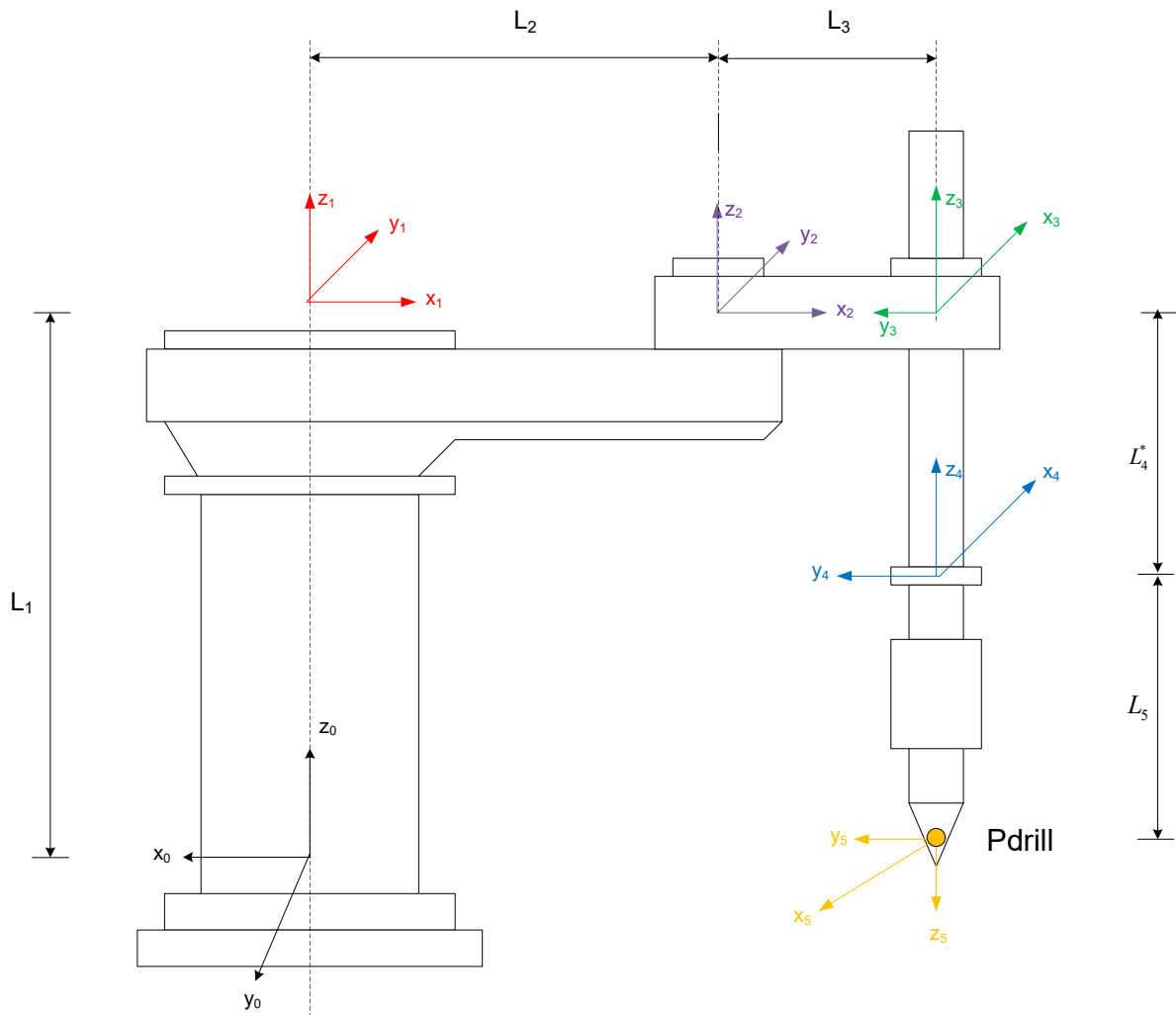


Figure 1.1: The VME robot.

Total 25 Marks

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2. (30 Minute). Consider the VME robot shown in Figure 2.1 below.

a) (20 Marks) Evaluate the homogenous transformation matrices **values** for T_{drill}^0 by using **FIXED FRAME** method of defining reference frames, where reference frames starting from the base $[x_0, y_0, z_0]$ to the end point $[x_{end}, y_{end}, z_{end}]$ are given. Where $L_4^* = 10$ and $L_1 = 50, L_2 = 25, L_3 = 10, L_5 = 5$.

Show your working steps from base to end points.

b) (5 Marks) Compute the driller location (P_{drill}) with reference to base where $L_4^* = 10$ and $L_1 = 50, L_2 = 25, L_3 = 10, L_5 = 5$.

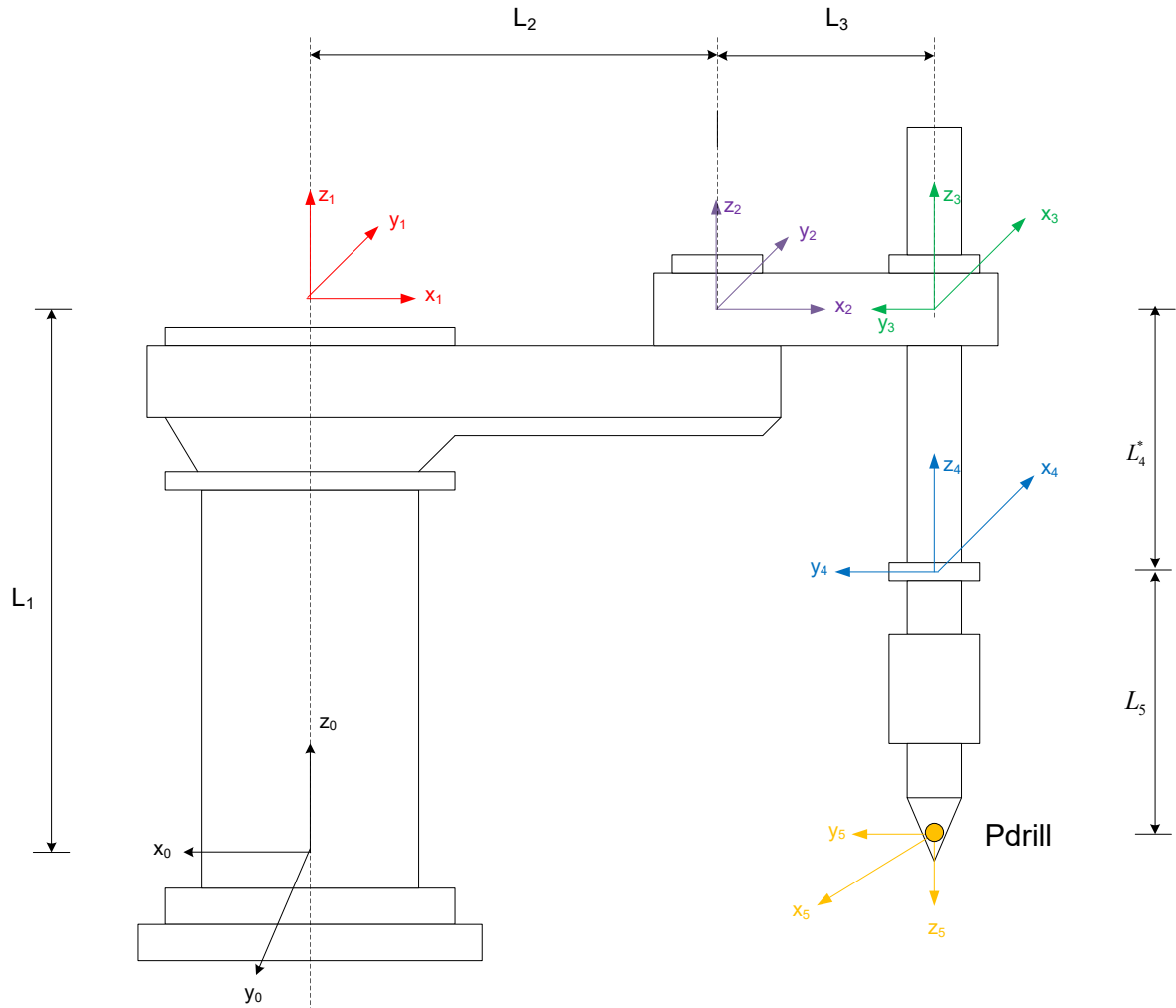


Figure 2.1: The VME robot.

Total 25 Marks

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3. (60 Minute). Consider the VME robot shown in Figure 3.1 below. VME robot is initially pointing towards x0 axis.

a) (30 Marks) Evaluate the homogenous transformation **matrices equations** (in term of variables $\theta_1^*, \theta_2^*, L_4, \theta_6^*$ and L_1, L_2, L_3, L_5) for $T_1^0, T_2^1, T_3^2, T_4^3$, and T_4^0 by **Denavit-Hartenberg** (DH) method of defining reference frames, where reference frames starting from the base $[x_0, y_0, z_0]$ to the driller are given. $\theta_1^*, \theta_2^*, L_4, \theta_6^*$ and L_1, L_2, L_3, L_5 are variables as shown in the Figure 3.1.

b) (5 Marks) Determine the matrix T_4^0 **values** when

$$\theta_1^* = 90^\circ, \theta_2^* = 0^\circ, L_4^* = 10, \theta_6^* = 0^\circ \text{ and } L_1 = 50, L_2 = 25, L_3 = 10, L_5 = 5.$$

c) (5 Marks) Compute the driller location (P_{drill}) with reference to base when

$$\theta_1^* = 90^\circ, \theta_2^* = 0^\circ, L_4^* = 10, \theta_6^* = 0^\circ \text{ and } L_1 = 50, L_2 = 25, L_3 = 10, L_5 = 5.$$

d) (5 Marks) Determine the matrix T_4^0 **values** when

$$\theta_1^* = 90^\circ, \theta_2^* = 90^\circ, L_4^* = 10, \theta_6^* = 0^\circ \text{ and } L_1 = 50, L_2 = 25, L_3 = 10, L_5 = 5.$$

e) (5 Marks) Compute the driller location (P_{drill}) with reference to base when

$$\theta_1^* = 90^\circ, \theta_2^* = 90^\circ, L_4^* = 10, \theta_6^* = 0^\circ \text{ and } L_1 = 50, L_2 = 25, L_3 = 10, L_5 = 5.$$

The diagram illustrates a 6-DOF robotic arm with the following components and labels:

- Base and Vertical Axis:** The base is shown with a vertical axis z_0 and a rotational joint θ_1^* . The vertical distance from the base to the first horizontal link is labeled L_1 .
- First Horizontal Link:** This link extends horizontally from the base. Its length is labeled L_2 . It has a coordinate frame with axes x_0 and y_0 .
- Second Horizontal Link:** This link extends horizontally from the first link. Its length is labeled L_3 . It has a coordinate frame with axes x_1 and y_1 . A rotational joint θ_2^* is indicated between the two horizontal links.
- Vertical Arm and End Effector:** The vertical arm has a length L_4^* and a coordinate frame with axes x_2 and y_2 . The end effector has a length L_5 and a coordinate frame with axes x_3 and y_3 . The end effector is labeled "Pdrill" and has a rotational joint θ_6^* and a coordinate frame with axes x_4 and y_4 .

Total 50 Marks

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