Course: MECH 567: Robot Kinematics & Dynamics
Instructor: Daniel Bruder, PhD

Assigned Date: 02/01/2024
Due: 11:59 PM on Thursday, 02/15/2024
Submit by uploading on canvas

Homework 2

Problem 1

Verify that for $\omega \in R^3$, $\|\omega\| \neq 1$

$$e^{\widehat{\omega}\theta} = I + \frac{\widehat{\omega}}{\|\omega\|}\sin\left(\|\omega\|\,\theta\right) + \frac{\widehat{\omega}^2}{\|\omega\|^2}\left(1 - \cos\left(\|\omega\|\,\theta\right)\right)$$

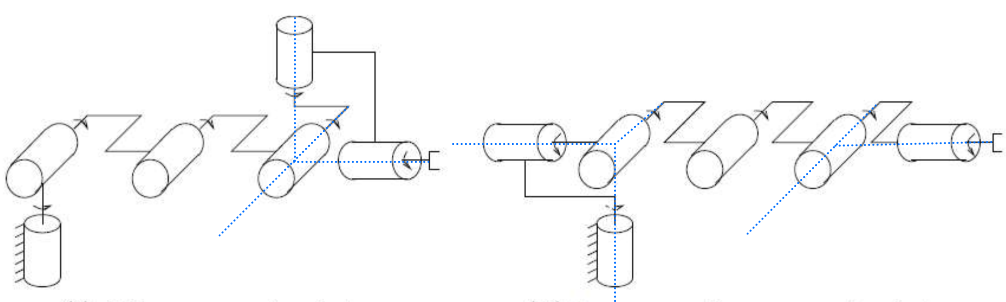
Problem 2

A robot threads a nut onto a bolt with a pitch of 10 threads per inch parallel to the z axis and intersecting the x−y plane at [1”, 1”, 0]. Find the twist coordinates ξ that describe the motion of the nut.

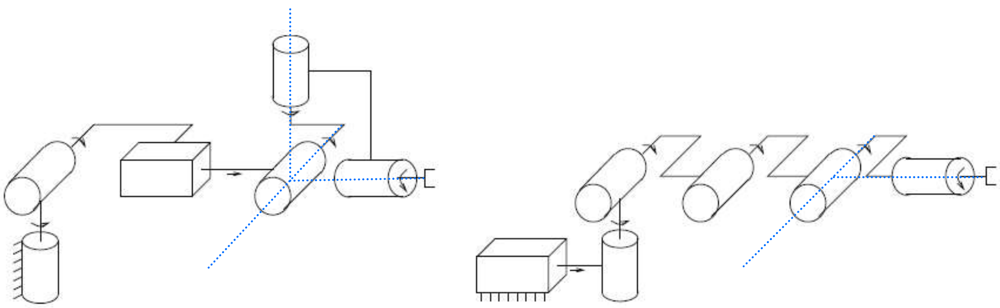
Problem 3

Find the twist coordinates ξ and $g_{st}(0)$ ($g_{st}(0)$ represents the Rigid Body Transformation between the frame attached to the last link of the manipulator and the base frame) for all 4 manipulators shown below (show your chosen base and tool frames, but please keep them parallel to those used in the book; i.e., z vertical, y to the right, x out of the page). **In this problem, we assume there are no offsets between joints in *x* and *z*.** Please label the offsets in y as $l_1, l_2, \ldots, l_n$ accordingly.

Note:- When the axes of rotation of two consecutive joints intersect, you can ignore the offsets.



(i) Elbow manipulator (ii) Inverse elbow manipulator



(iii) Stanford manipulator (iv) Rhino robot

Figure 3.24: Sample manipulators. Revolute joints are represented by cylinders; prismatic joints are represented by rectangular boxes.

Problem 4

Find the matrix exponential $e^{\hat{\xi}\theta}$ for each of the six twists for the Stanford manipulator (Figure 3.24 iii) that you found in problem 2. Please calculate these by hand; **do not use** Mathematica or equivalent.

Problem 5

Using **Mathematica**, derive the complete transform $g_{st}(\theta)$ via the product of exponential for all four manipulators in problem 3 (Figure 3.24). Copy and paste your code in the homework. The problem will be graded based on the setup of the twists and syntax of commands rather than the final output.

Hint: Read Appendix B in MLS for a brief description of Mathematica.
