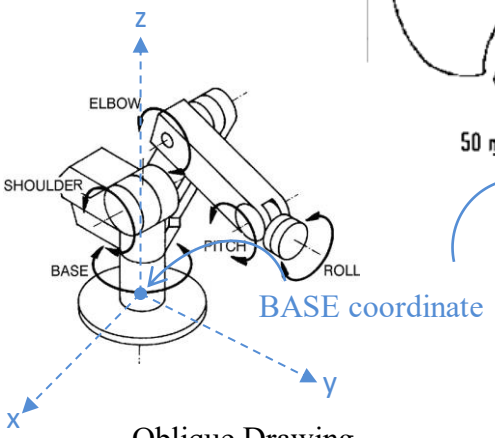
Robotics: Assignment II

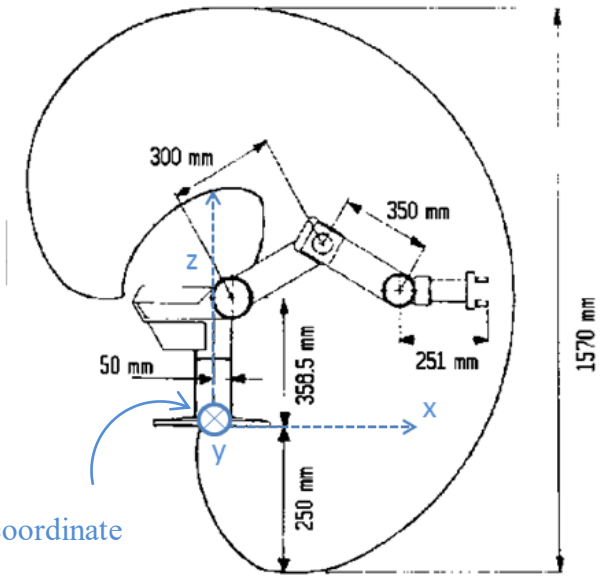
Forward Kinematics and Inverse Kinematics

Due: 2021/11/15 13:00 pm(GMT+8)

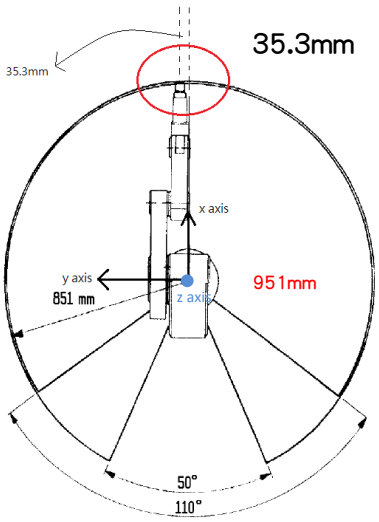
Consider the ER-7 robot arm shown in the following figures:



Oblique Drawing



Lateral View



Top View

PART A (25%)

(1) According to ER-7 arm, draw the link coordinate diagram using D-H convention in Craig version from lecture slides page 34. **(10%)**

(2) Find the kinematics parameters of ER-7 and fill the table below: **(15%)**

Joint	$\boldsymbol{\alpha_{i-1}}$ (°)	$\boldsymbol{a_{i-1}}$ (mm)	$\boldsymbol{d_i}$ (mm)	$\boldsymbol{\theta_i}$
1				θ_1
2				θ_2
3				θ_3
4				θ_4
5				θ_5

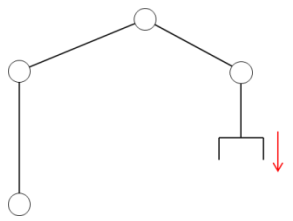
PART B (30%)

Derive transformation matrices for each consecutive link, and also the transformation matrices T_0^5 (from frame 5 to frame 0).

Note: This should be revised to list all the transformation matrix, i.e. $T_{BASE}^1, T_1^2, T_2^3, T_3^4, T_4^5, T_{BASE}^5$ or ${}^{BASE}_{1}T, {}^{1}_{2}T, {}^{2}_{3}T, {}^{3}_{4}T, {}^{4}_{5}T, {}^{BASE}_{5}T$.

PART C (45%)

(1) Derive the inverse kinematics for ER-7. Given the target pose of the gripper tip $(x, y, z, \phi, \theta, \psi)$ with respect to the base coordinate, calculate $(\theta_1, \theta_2, \theta_3, \theta_4, \theta_5)$. For the transformation from the base to the gripper tip, please refer to Inverse Kinematic slides. Let's assume the target is reachable in elbow-up configuration, and that the gripper tip pose is always vertically downward. **(30%)**



(2) Based on the previous question, please calculate $(\theta_1, \theta_2, \theta_3, \theta_4, \theta_5)$ with the

following target poses. The translation parameters (x, y, z) are in millimeter, and the rotation parameters (ϕ, θ, ψ) are in radian. **(15%)**

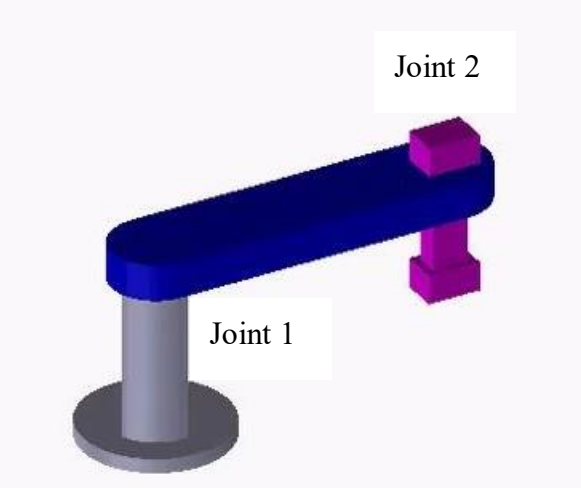
(a) $(x, y, z, \phi, \theta, \psi) = (600,100,0, \pi/4, 0, \pi)$

(b) $(x, y, z, \phi, \theta, \psi) = (600,100,100, \pi/4, 0, \pi)$

(c) $(x, y, z, \phi, \theta, \psi) = (600, -100,100, -\pi/4, 0, \pi)$

PART D (10%) bonus

Consider the following robot arm which is consist of a revolute joint and prismatic joint:



(1) Find the DH representation the same as Part A (1) **(6%)**

(2) For all DH parameters $(\boldsymbol{\alpha_{i-1}, a_{i-1}, d_i, \theta_i})$, which two parameters are actuator joint (varying parameters)? **(4%)**

Submission

Please convert your report into a PDF file, **submit to the NTU COOL**.

Name your PDF file as <STUDENT_ID>_HW2.pdf. For example, R10345678_HW2.pdf

Please make your work follow this format:

- Use A4 paper.
- Staple the pages together and put your name and student ID on the top of the first page.
- If you use a scanned copy, please write legibly. (Maybe more than usual. TAs are not very good at reading cursive writing.)