INF3480 - Spring 2015
Compulsory Assignment 1
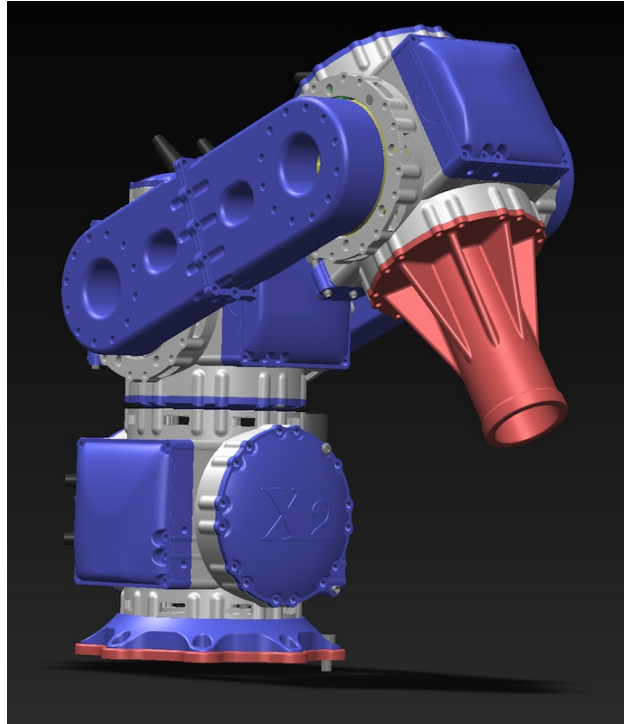*Deadline: Tuesday, March 17th 2015 (before midnight)*

Figure 1: The X2 Robot

Introduction

Figure 1 displays the X2 robot which we will work with in the compulsory assignments in INF3480. The robot consists of three identical parts, the first one is attached to the surface beneath the robot, and does not rotate. The next part is attached on top of the first part, and rotates alround the vertical axis. The second and third parts are connected with a link (the long blue one in figure 1). In each end of this link, there is a revolute joint. A pen will be attached to the tip of the robt.
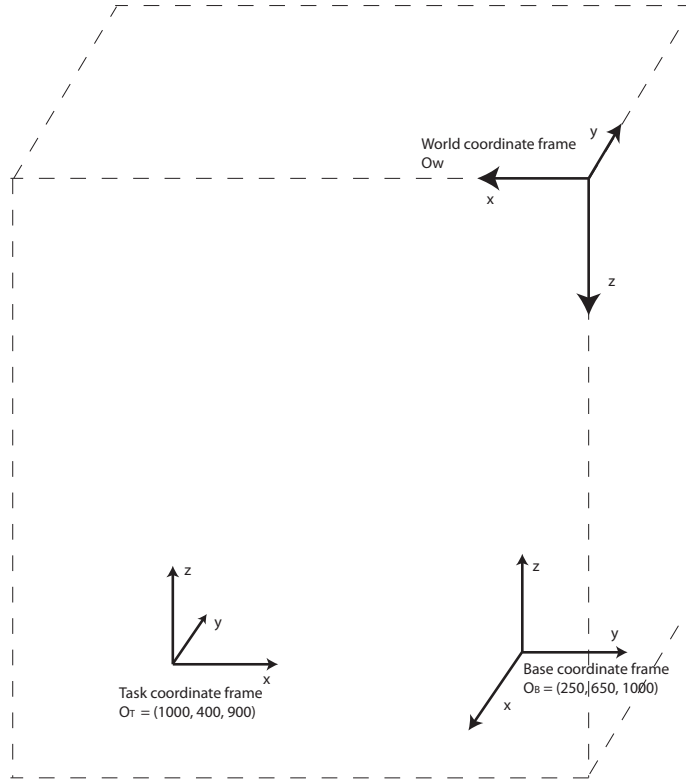
Figure 2: Coordinate frames (see also figure 4)

1

Figure 2 shows three coordinate frames. We name them *World coordinate frame* {W}, *Base coordinate frame* {B} and *Task coordinate frame* {T}.

Origin of coordinate frame {B} is located at position X = 250, Y = 650, Z = 1000 in {W}.

Origin of coordinate frame {T} is located at position X = 1000, Y = 400, Z = 900 in {W}.

The axes Z_W, Z_B and Z_T are parallel to each other
The axes X_W, Y_B and X_T are parallel to each other
The axes Y_W, X_B and Y_T are parallel to each other

Figure 2 displays the direction of the axes.

Find T_T^B ,
(the transformation matrix expressing the position and orientation of {T} with respect to {B})

Show your solution by setting up the necessary expressions and calculations.
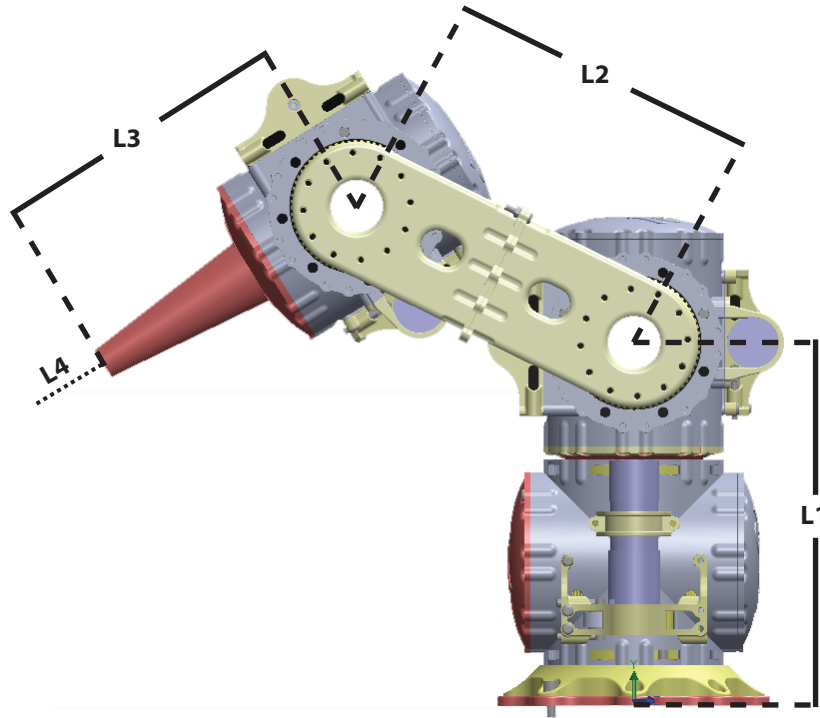
Figure 3: Robot

2

Figure 3 shows the necessary measures to work with the robot. The dotted line at the end of the robot denotes the pen that will be attached at the end of the robot.

a) Sketch the workspace of the robot.

b) Draw a simple illustration of the robot, showing the coordinate frames and the Denavit-Hartenberg parameters. Explain briefly your choice of origo and rotation axis. Show the DH-parameters in a table.

c) Calculate the forward kinematics for this robot. Your answer should be a transformation matrix T_t^B denoting the transformation of the tool coordinate frame {t} located at the tip of the pen, with respect to the base coordinate frame {B}. This transformation matrix is a function of the angles of the three joints.
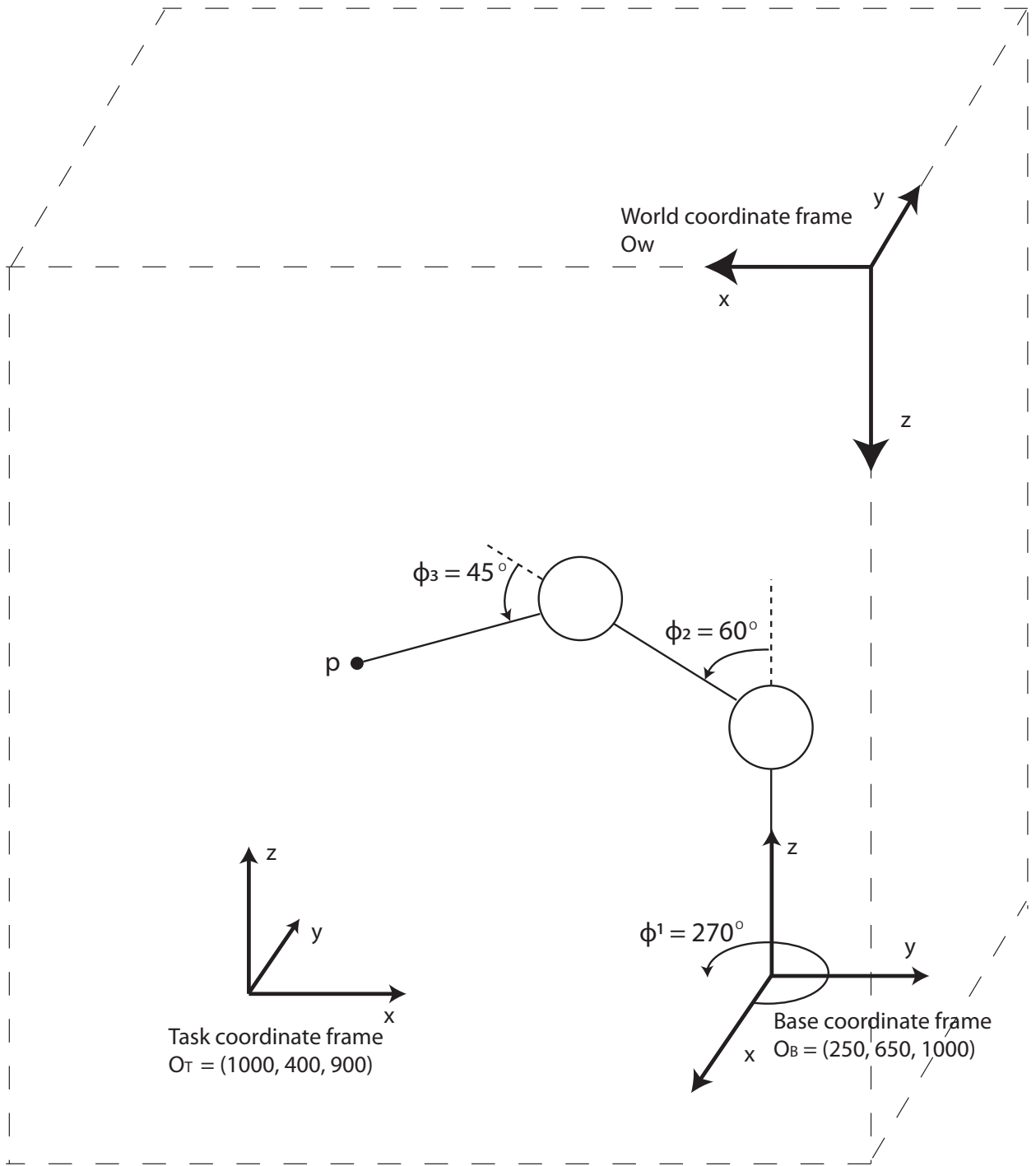
World coordinate frame
Ow

$\phi_3 = 45°$

$\phi_2 = 60°$

p

z

z

$\phi^1 = 270°$

y

y

x

Task coordinate frame
OT = (1000, 400, 900)

Base coordinate frame
OB = (250, 650, 1000)

x

Figure 4: Robot

3

Point p is located at the tip of the robot (where the tip of the pen is). We adjust the robot as displayed in figure 4, where $\phi_1 = 270°, \phi_2 = 60°, \phi_3 = 45°$. (These angles are of course not to be used directly, you have to figure out the correct θ-angles for the DH-convention yourself.)

Use the following dimensions in your calculation:

- L1 = 281 mm

- L2 = 238.93 mm

- L3 = 231 mm

- L4 = 50 mm

Find p^T, the coordinates of point p given in the task coordinate frame {T}.

Hint: Use your calculations from question 1 and 2c to find the answer to this question

4

Derive the inverse kinematic equations for the X2 robot, and show the different steps. How many solutions exist for the joint angles given an arbitrary position of the tip of the pen?

Requirements:

Each student must hand in their own assignment, and you are required to have read the following requirements to student submissions at the department of informatics: http://www.mn.uio.no/ifi/english/studies/admin/mandatory-assignments/assignments-guidelines.html

Submit your assignment on https://devilry.ifi.uio.no/.
Your submission must include:

- A pdf-document with answers to the questions.

- The two illustrations asked for in questions 2a and 2b

Remember to name all your files.

Deadline: Tuesday, March 17th 2015