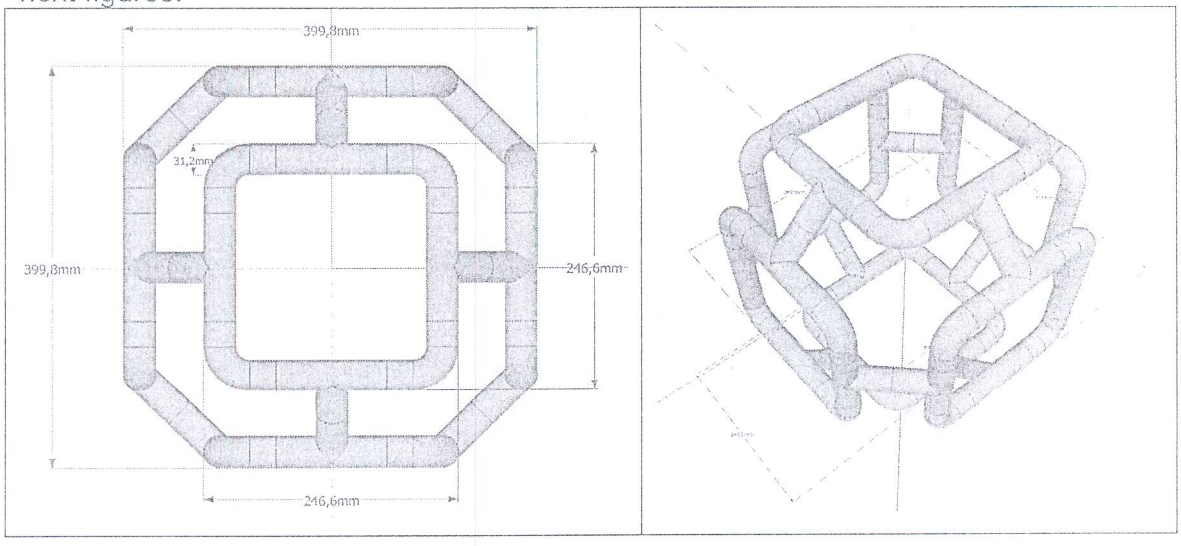
Departament d'Enginyeria de Sistemes, Automàtica i Informàtica Industrial
UNIVERSITAT POLITÈCNICA DE CATALUNYA

ETSEIB – January, 20th, 2016 Name:_____

Problem #1 – Kinematics

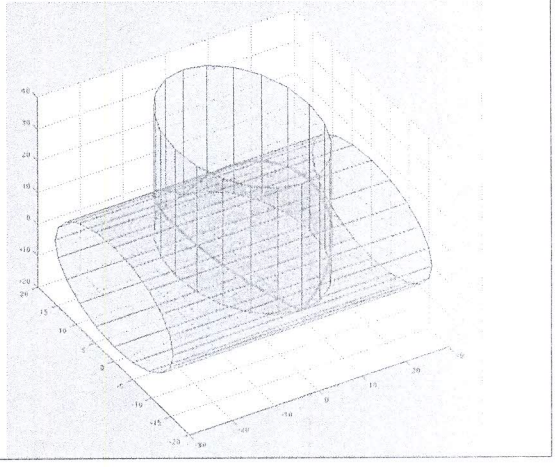
A Unimation Puma 560 robot is used to weld a folded tubes frame as it is shown in the next figures.



The task for the Puma 560 consists in welding the six folded squared tube among them. The welding trajectory can be assumed as two orthogonal and intersecting cylinders with radius 15.6mm. The trajectory to be followed by the welder can be parameterized as follows and it can be shown below:

$$p(t)=\begin{pmatrix} x(t) \\ y(t) \\ z(t) \end{pmatrix}=\begin{pmatrix} r\cos(t) \\ r\sin(t) \\ r\cos(t) \end{pmatrix};t\in[0,2\pi]$$

?



1. Write a pseudo code1 to obtain 32 welding points of two intersecting tubes.
2. Make a draft of the necessary reference frames to perform the welding of the 24 locations.
3. Write a pseudo code1 to obtain the welding points for any of the four welds of a squared

[1] Use the Robotics Tool Box functions

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Problem #2 – Path generation

The robot shown in the following figure is set in a production line, in which the task to do is to pick pieces at point Pi and place them at the Pf.
Due to production planning, the robot has to move 3500 pieces per day. The line works 24 hours / day, and takes up 10% downtime for maintenance issues, which means that they have approximately 77700 sec. as productive time.

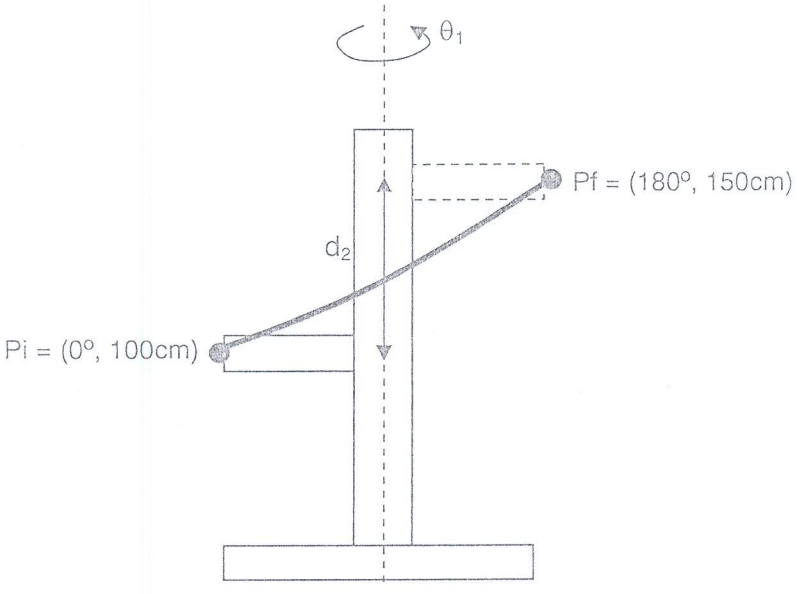
Another system feature is that the time of opening and closing the gripper (including settling time) are 1.1 sec. each one.

It wants to make an isochronous movement with parabolic speed profile. Knowing that the actuators have a maximum speed of:

6 rpm for rotational joint θ_1
$6x10^3$ mm/min. ror translational joint d_2

and joints are directly linked to the motor shaft,

a) It is required to find and justify the interpolating polynomials, which will run inside the robot controller, to carry out the above mentioned specifications.



b) Will be it possible to accomplish the given production specifications?. Justify your answer.

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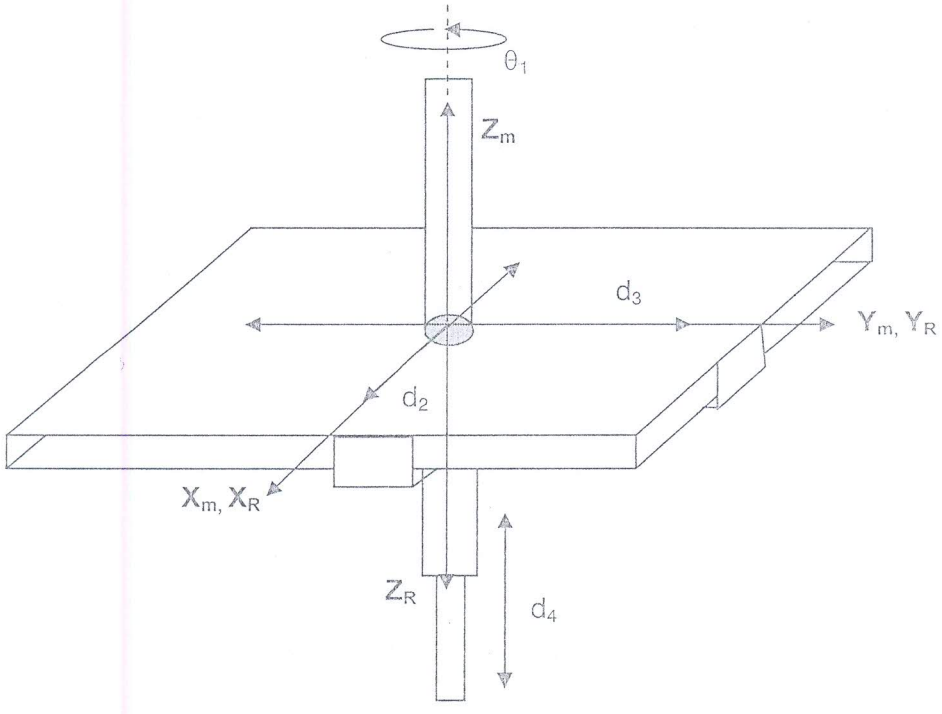
Problem #3 - Dynamics

There is a modified cartesian robot including a rotational joint which is able to hang the whole structure from ceiling. The following figure shows the robot described.



In the figure we can identify the World coordinate system { X_m, Y_m i Z_m} and the Robot coordinate system { X_R, Y_R i Z_R }

1. You are asked to find and justify the Jacobian matrix for this robot.

2. Assuming that:

$\theta_1 = 45°$,	$\dot{\theta}_1 = 10°/sec$,
$d_2 = 30$ cm,	$\dot{d}_2 = 10$ cm/ sec,
$d_3 = 50$ cm,	$\dot{d}_3 = 10$ cm/ sec,
$d_4 = 120$ cm,	$\dot{d}_4 = 10$ cm/ sec,

   Which will be the robot position referenced to the world coordinate system?

   Find and justify the concrete value of the Jacobian at this particular point?

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Question #4 – Robot Control

As we know, in the robotics context the gravity disturbance is not unknown... so How can we take advantage about this knowledge in order to improve the robot control system?

Question #5 – Robot Programming

Explains the functionality of the following RAPID code lines, making emphasis on the parameters and its reference with the different parts of Robot Kinematics, Dynamics, Trajectory Generation and Control

```
CONST robtarget home:=[[13.33,-511.92,718.02],[0.493626,0.461682,0.517774,-
    0.524494],[-1,-1,-1,1],[9E+09,9E+09,9E+09,9E+09,9E+09,9E+09]];

MOVEJ home,v50,z10,tool0, wframe0;
```