



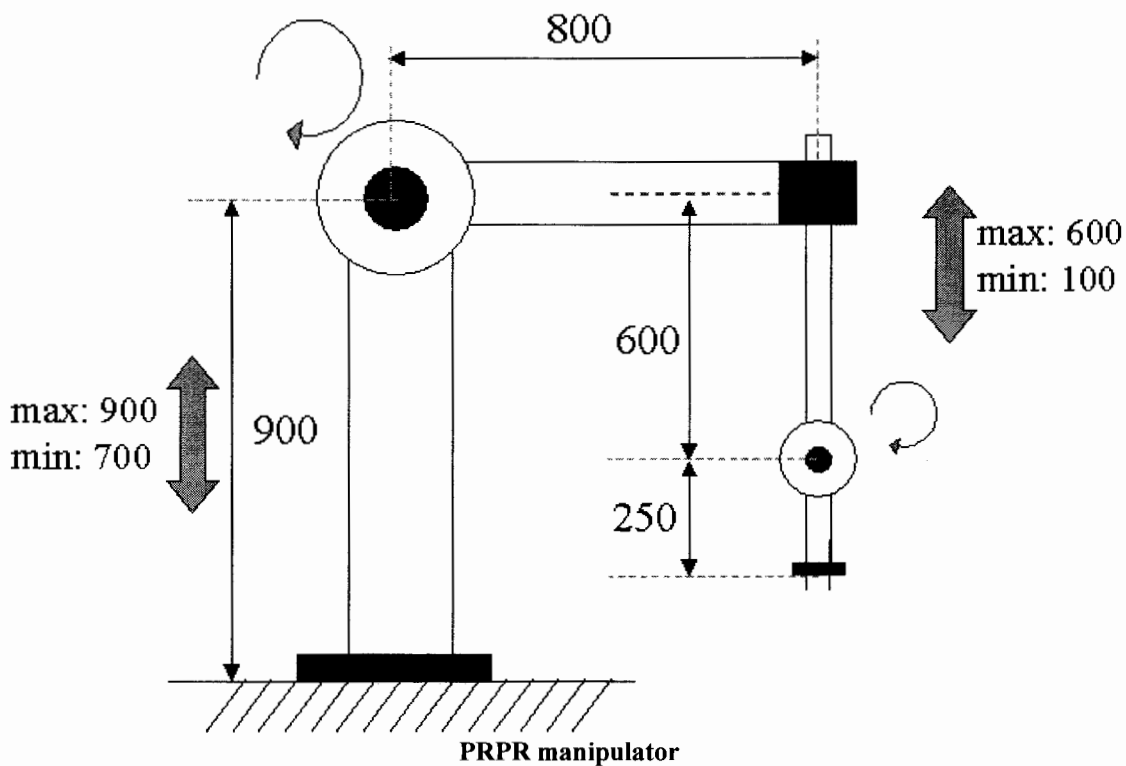
Exam – 11/Apr/2005 (4 Questions)

Student Name:

Student Number:

*Please include student name and student number in all pages you hand in.*

Question 1



For a given manipulator do the following tasks:

- 1.1 Select either **standard** or **modified** DH notation to use. Mark your choice.
- 1.2 Assign coordinate frames to the manipulator according to selected notation.
- 1.3 Build a DH table for the manipulator.

Question 2

Trajectory planning. This question has been split in two in order to help you to analyze it.

- 2.1 First take a look at each of the graphics shown below, explain each of them, the meaning of the peaks and valleys.
- 2.2 Compare both graphics, and give a brief description of the comparison.

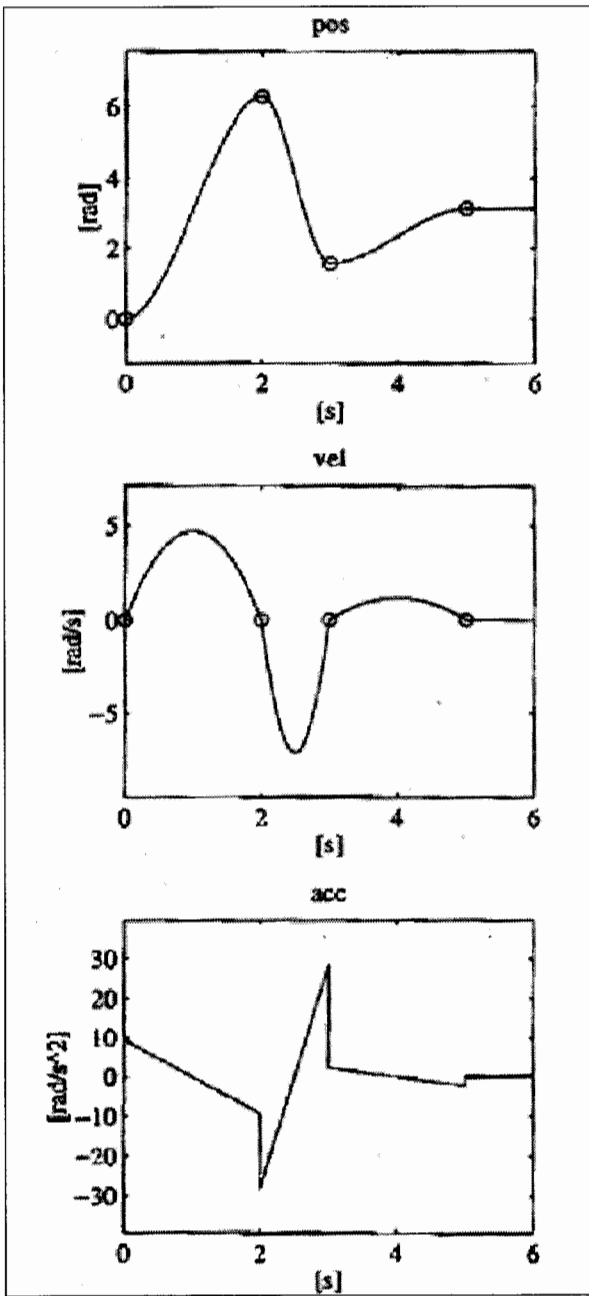


Fig. 1 Time history of position, velocity and acceleration with a time law of interpolating polynomials with computed velocities at path points.

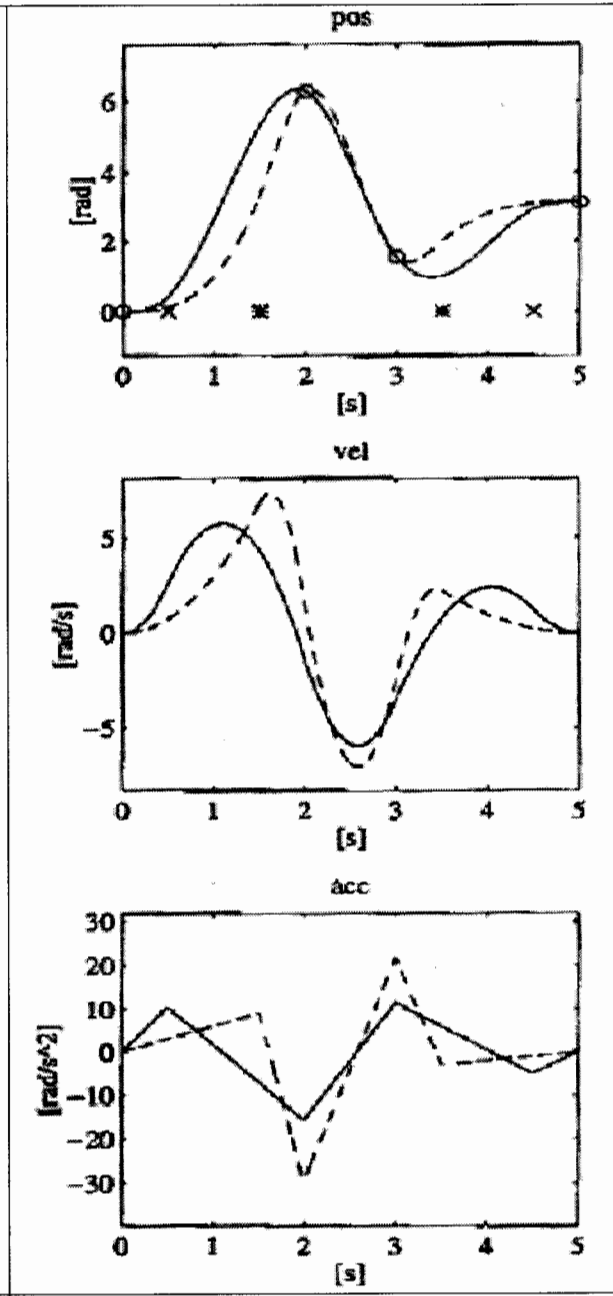
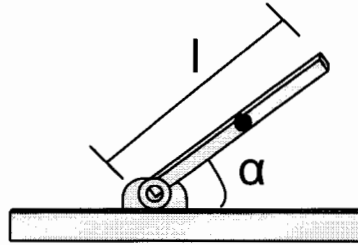


Fig. 2 Time history of position, velocity and acceleration with a time law of cubic splines for two different pairs of virtual points

### Question 3

Describe PID controller principles on the example of 1-joint manipulator.



**Single-joint manipulator**

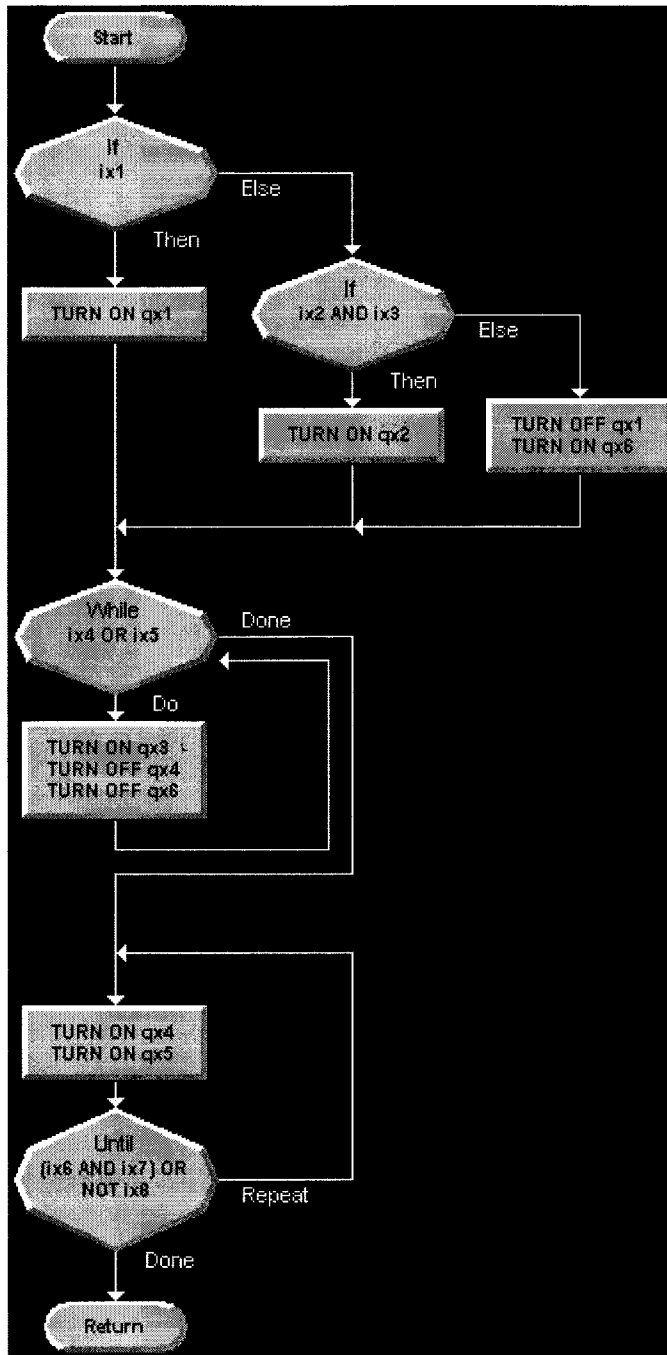
- 3.1 Which of the elements of the PID controller cancel the effect caused by gravity?
- 3.2 What functionality plays the Proportional control of a PID controller?
- 3.3 Which part of the PID examines the offset of *setpoint* and the *process variable* over time and corrects it when and if necessary?
- 3.4 Which one determines the magnitude of the difference between the *setpoint* and the *process variable* (known as *error*), and then applies appropriate changes to the *control variable* to eliminate *error*?

### Question 4

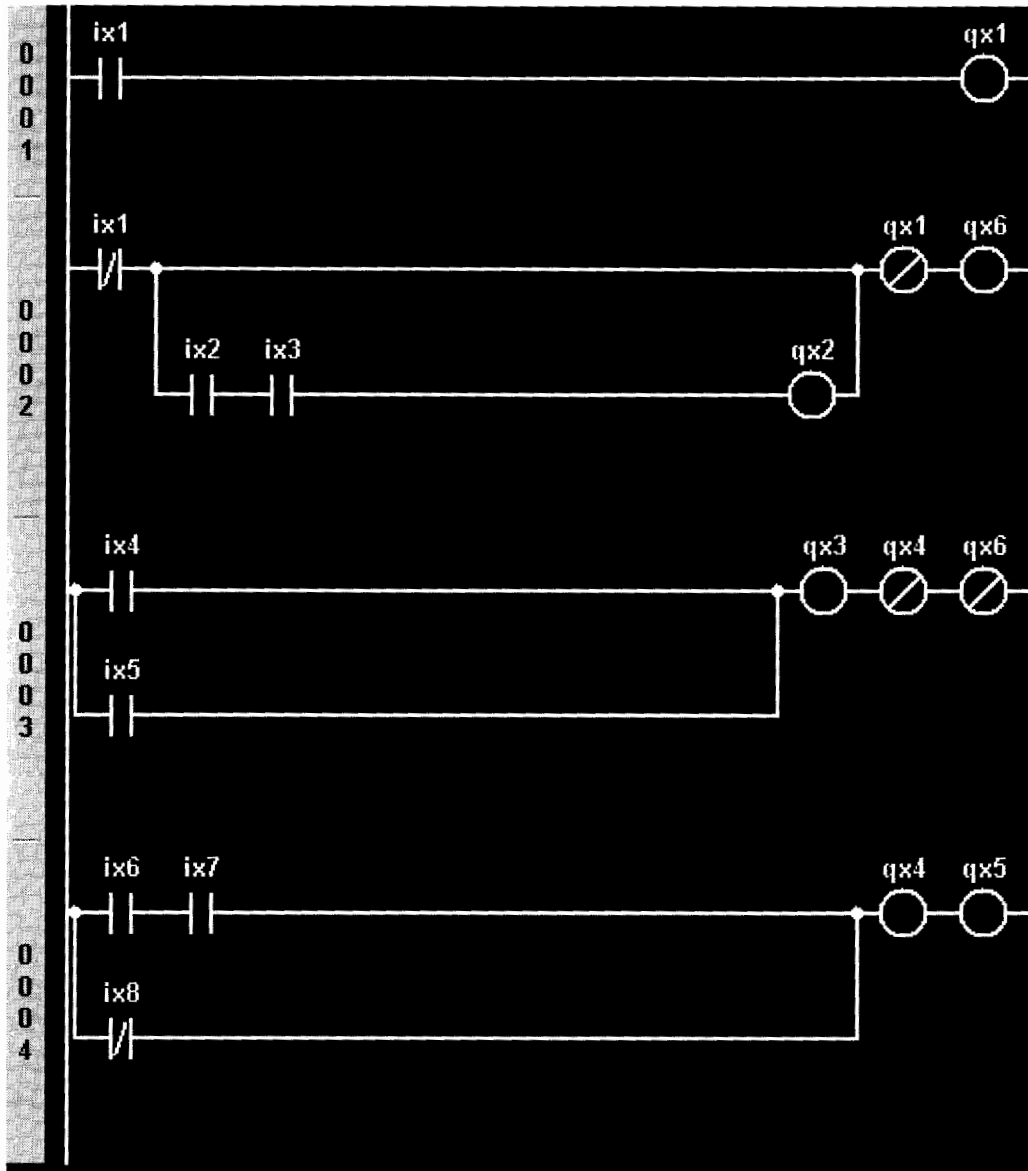
Consider two following programs in Visual Flowchart Language (VFL) and Ladder Diagrams (LD). Answer the following question for each of the two programs **VFL** and **LD**:

4.1 For the each output (qx1 – qx6) write the values of all inputs (ix1 – ix8) that would turn the given output ON.

*Example: qxN is ON if: ix1 = ON, ix2 = OFF; ix3 = ON, ix4 = OFF; ix5 = ON, ix6 = OFF; ix7 = --, ix8 = --*  
(-- means that the value of the input does not affect the value of output)



VFL Program



LD Program