

5ELEN018W - Robotic Principles Coursework (Semester 1)

Module leader	Dr D. Dracopoulos
Unit	Coursework
Weighting:	50%
Qualifying mark	30%
Description	
Learning Outcomes Covered in this Assignment:	<ul style="list-style-type: none">- L02. Use mathematical and software tools to model basic systems relevant to robotics;- L03. Analyse simple control feedback systems;- L04. Implement and code simple control systems using a high-level development platform;
Handed Out:	December 2023
Due Date	8/1/2024 13:00
Expected deliverables	<ol style="list-style-type: none">1. Matlab Simulink files for modelling and control (*.six files)2. Report in PDF format
Method of Submission:	Online via Blackboard
Type of Feedback and Due Date:	Individual feedback via Blackboard within 3 weeks of submission All marks will remain provisional until formally agreed by an Assessment Board.

Assessment regulations

Refer to section 4 of the "How you study" guide for undergraduate students for a clarification of how you are assessed, penalties and late submissions, what constitutes plagiarism etc.

Penalty for Late Submission

If you submit your coursework late but within 24 hours or one working day of the specified deadline, 10 marks will be deducted from the final mark, as a penalty for late submission, except for work which obtains a mark in the range 40 – 49%, in which case the mark will be capped at the pass mark (40%). If you submit your coursework more than 24 hours or more than one working day after the specified deadline you will be given a mark of zero for the work in question unless a claim of Mitigating Circumstances has been submitted and accepted as valid.

It is recognised that on occasion, illness or a personal crisis can mean that you fail to submit a piece of work on time. In such cases you must inform the Campus Office in writing on a mitigating circumstances form, giving the reason for your late or non-submission. You must provide relevant documentary evidence with the form. This information will be reported to the relevant Assessment Board that will decide whether the mark of zero shall stand. For more detailed information regarding University Assessment Regulations, please refer to the following website

[:http://www.westminster.ac.uk/study/current-students/resources/academic-regulations](http://www.westminster.ac.uk/study/current-students/resources/academic-regulations)

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5ELEN018W Robotic Principles - Assignment

Deadline 8/1/2024, 13:00

Dr Dimitris C. Dracopoulos
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Description

Your task for this coursework is to model and control a mobile robot doing shopping for its human owner using Simulink.

You will be assessed for 3 parts (the details of which are described in the following sections of this specification):

1. Model the dynamic system of a robot pushing a shopping trolley to the house of its human owner using Simulink.
2. Control the system (PID control) using Simulink.
3. Write a short report (no more than 3 pages) discussing your results with the inclusion of appropriate diagrams.

The Problem

A mobile robot (equipped with wheels) is pushing a shopping trolley in order to arrive to the house of its human the owner. The robot travels along in one dimension x and pushes the trolley towards the same dimension.

The robot applies a force F_R to the shopping trolley to make it to move ahead. It is assumed that due to the mechanics of the robot and the trolley, the connection of the hand of the robot and the trolley acts as a spring with stiffness z . The mass of the robot is m_R and the mass of the shopping trolley is m_{tr} . The rolling friction coefficient is τ .

The application of the second law of Newton derives the following equations for the dynamic system, describing the motion of the robot pushing the shopping trolley:

$$\begin{aligned} F_R - z(x_R - x_{tr}) &= m_R \cdot \ddot{x}_R + \tau \cdot m_R \cdot g \cdot \dot{x}_R \\ z \cdot (x_R - x_{tr}) &= m_{tr} \cdot \ddot{x}_{tr} + \tau \cdot m_{tr} \cdot g \cdot \dot{x}_{tr} \end{aligned} \quad (1)$$

where \cdot denotes multiplication. x_R is the displacement of the robot and x_{tr} is the displacement of the shopping trolley. $g = 9.81m/s^2$ is the gravity. For the purposes of the simulation of the system here, use $F_R = 2, \tau = 0.05, z = 1, m_R = 2, m_{tr} = 1$.

1 Simulink Model

Implement a Simulink block diagram model of the robot pushing the shopping trolley dynamic system described in equations (1).

2 Control of the Simulink Model

Extend the Simulink model you developed in Section 1 with a PID controller, so that the speed of the robot follows the desired speed shown in Figure 1. The total simulation time is 1000 secs and the robot starts with a speed of 0, increasing its speed to 1 after 200 secs and keeping this speed for 500 secs before coming to a rest (speed equals to 0) at time $t = 700$ secs.

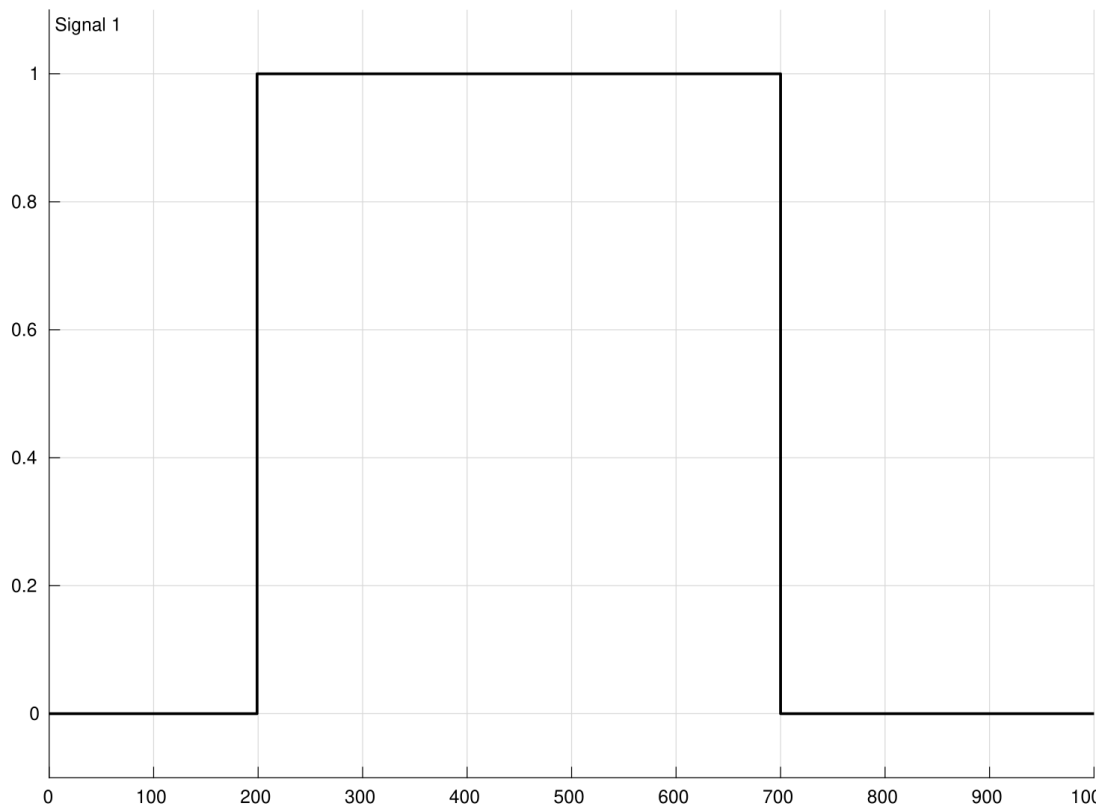


Figure 1: The desired speed x_R of the robot pushing a shopping trolley system. The controller should try to drive the system to this response.

To generate the signal shown in Figure 1 which is the desired speed (response) of the dynamic system, you should use the *Signal Editor* Simulink block found under the *Sources* library of blocks. Then:

1. Double click the block to open it.
2. Launch the Signal Editor user interface by pressing the icon next to the text “To create and edit scenarios, launch Signal Editor user interface.”
3. In the new window that appears, press the Inputs tab on the left.

4. Double click on “View or hide the signal icon to visualise the signal.
5. Press the button on the top “Author Signal”.
6. Enter the data [0 1 199 200 699 700 1000] on the top textbox.
7. Enter the data [0 0 0 1 1 0 0] on the bottom textbox.
8. On the left pane “Inputs” disable and then enable the view the signal to see the constructed signal in the appropriate range.
9. Save the signal as a `mat` file and connect a Scope to the signal editor to see if it is displayed OK (you should change the simulation time in Simulink to 1000 steps and re-run your model).
10. Alternatively to the steps above, you could use the superposition of 2 step signals with the appropriate values added together (using the Add block) to construct the signal given to you in the Figure 1.

3 Report with Analysis of your Solution

You are expected to write a short report **in PDF format (no more than 3 pages)** which you discuss both your modelling and your controller implementation of the plant. You should discuss how you chose the PID controller parameters and how these choices affect the performance of your controller. You should include and discuss step response and Bode diagrams among others. A description of the stability of the overall system should also be included.

Marking Scheme:

In addition to the marks below, higher marks will be awarded for a better organised block diagram, a controller which is precisely tuned and an analysis that considers more than just the suggested plots.

1. Simulink Model

- Clear and consistent labelling of signals and blocks: *5 marks*
- Modelling of the dynamic system: *20 marks*
- Appropriate inputs and outputs and correct values of parameters for the modelling as given by the specification: *5 marks*

2. Controller

- Implementation of the PID controller: *10 marks*
- Initialisation of the PID controller parameters and appropriate reference signal: *10 marks*
- Fine tuning of the controller: *10 marks*

3. Analysis Report

- Response diagrams (step, Bode, etc.): *15 marks*
- Analysis of response diagrams: *15 marks*

- Analysis of stability and suitability of the choices made for the controller: *10 marks*

Submission of assignments using a different method other than Blackboard will not be accepted and zero (0) marks will be awarded in such cases.

Deadline: Monday 8th of January 2024, 13:00.

Submission Instructions

Files to submit: The Simulink model of the system (s1x file), the controlled system (s1x file) and the report in PDF format. All 3 files should be submitted in a single zip file.

You should submit via BlackBoard's Assignment functionality (do NOT use email, as email submissions will be ignored.), all the files described above. A single zip file with the name wNNNNNNNN (where wNNNNNNNN is your university ID login name) containing all the above files should be submitted.

Note that Blackboard will allow to make a submission multiple times. Make sure before submitting (i.e. before pressing the Submit button), that all the files you want to submit are contained there (or in the zip file you submit).

In the case of more than one submissions, only your last submission before the deadline given to you will be marked, so make sure that all the files are included in the last submission attempt and the last attempt is before the coursework deadline.

Request to mark submissions which are earlier than the last submission before the given deadline will be ignored as it is your responsibility to make sure everything is included in your last submission.

The following describes how to submit your work via BlackBoard:

1. Access <https://learning.westminster.ac.uk> and login using your username and password (if either of those is not known to you, contact the Service Desk, tel: +44 (0) 207 915 5488 or log a call via <https://servicedesk.westminster.ac.uk>).
2. Click on the module's name, MODULE: 5ELEN018W.2023 ROBOTIC PRINCIPLES found under My Modules & Courses.
3. Click on the Assessment->Submit Coursework->Coursework.
4. Click on View Assignment.
5. Attach your zip file containing all of the required files, by using the Browse button.
6. Create a Word or PDF file with the following information:
 - *Comments:* Type your full name and your registration number, followed by:
"I confirm that I understand what plagiarism is and have read and understood the section on Assessment Offences in the Essential Information for Students. The work that I have submitted is entirely my own. Any work from other authors is duly referenced and acknowledged."
7. Attach the file with the statement above.

8. Check that you have attached both the zip and the statement file.
9. Click the **Submit** button.

If Blackboard is unavailable before the deadline you must email the Registry at studentcentre@westminster.ac.uk with **cc:** to myself and your personal tutor before the deadline with a copy of the assignment, following the naming, title and comments conventions as given above and stating the time that you tried to access Blackboard. You are still expected to submit your assignment via Blackboard. Please keep checking Blackboard's availability at regular intervals up to and after the deadline for submission. You must submit your coursework through Blackboard as soon as you can after Blackboard becomes available again even if you have also emailed the coursework to the above recipients.