

## 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"> <li>- L02. Use mathematical and software tools to model basic systems relevant to robotics;</li> <li>- L03. Analyse simple control feedback systems;</li> <li>- L04. Implement and code simple control systems using a high-level development platform;</li> </ul>
Handed Out:	December 2025
Due Date	5/1/2026 13:00
Expected deliverables	1. Matlab Simulink files for modelling and control (*.slx 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  <b>All marks will remain provisional until formally agreed by an Assessment Board.</b>

### 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>

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# 5ELEN018W Robotic Principles - Assignment

## *Deadline 5/1/2026, 13:00*

Dr Dimitris C. Dracopoulos  
*Email:* d.dracopoulos@westminster.ac.uk

### Description

Your task for this coursework is to model and control two robots which participate in a pulling/pushing heavy objects competition. 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 the two robots.
2. Control the system (PID control) using Simulink.
3. Write a short report (no more than 5 pages) discussing your results with the inclusion of appropriate diagrams.

### The Problem

Two mobile robots  $R1$  and  $R2$  participate in a robot competition. The objective of the competition is for teams consisting of 2 robots to pull/push two heavy train coaches in such a way, that each of the two coaches achieve a specific displacement  $y$  over time. The two train coaches are connected with an elastic band and both of them are connected to fixed points with additional elastic bands.

The dynamic system can be seen in Figure 1.

The application of the second law of Newton derives the following equations for the dynamic system, describing the motion of the two coaches:

$$\begin{aligned} G_1(t) &= M_{c_1} \cdot \ddot{y}_1 + \tau_1 \dot{y}_1 + (z_1 + z_2)y_1 - z_2 y_2 \\ G_2(t) &= M_{c_2} \cdot \ddot{y}_2 + \tau_2 \dot{y}_2 + (z_2 + z_3)y_2 - z_2 y_1 \end{aligned} \tag{1}$$

where  $\cdot$  denotes multiplication.  $z_1, z_2, z_3$  are the stiffness coefficients of the three elastic bands and  $\tau_1, \tau_2$  are the rolling friction coefficients for the different types of wheels of the two coaches.  $M_{c_1}, M_{c_2}$  are the masses for coach 1 and coach 2 respectively.  $G_1(t)$  is the force that robot  $R1$  applies to train coach 1 at time  $t$  and  $G_2(t)$  is the force that robot  $R2$  applies to train coach 2 at time  $t$ .

For the purposes of all simulations in this problem, the following values should be used:

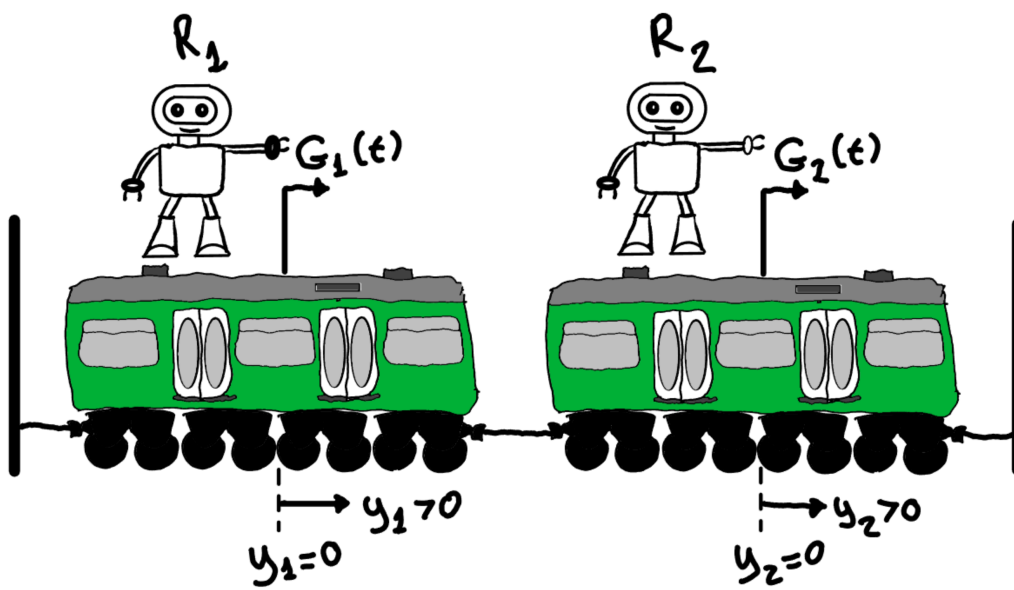


Figure 1: The 2 train coaches system controlled by the robots.

- $z_1 = 10$
- $z_2 = 8$
- $z_3 = 15$
- $\tau_1 = 2$
- $\tau_2 = 3$
- $M_{c_1} = 3.1$
- $M_{c_2} = 2.8$
- $y_1(0) = 0$ : initial position (at time  $t = 0$ ) of coach 1
- $\dot{y}_1(0) = 0$ : initial speed (at time  $t = 0$ ) of coach 1
- $y_2(0) = 1$ : initial position (at time  $t = 0$ ) of coach 2
- $\dot{y}_2(0) = 0$ : initial speed (at time  $t = 0$ ) of coach 2

*For the purposes of this coursework units are omitted, but the values given assume that all the implied units are compatible for all the calculations.*

## 1 Simulink Model

Implement a Simulink block diagram model of the dynamic system of the two robots pulling/pushing the train coaches, as described by Equation (1).

## 2 Control of the Simulink Model

Extend the Simulink model you developed in Section 1 with two PID controllers, which the two robots use to control the displacements of the two coaches.

Robot  $R1$  attempts to control the displacement  $y_1$  of coach 1 so that it follows the desired signal shown in Figure 2. Robot  $R2$  attempts to control the displacement  $y_2$  of coach 2 so that it follows the desired signal shown in Figure 3.

The total simulation time is 1000 secs. Coach 1 starts at  $y_1 = 0$  with speed  $\dot{y}_1 = 0$ . Coach 2 starts at  $y_2 = 1$  with speed  $\dot{y}_2 = 0$ .

To generate the signal shown in Figure 2 which is the desired displacement  $y_1$  of coach 1, 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.

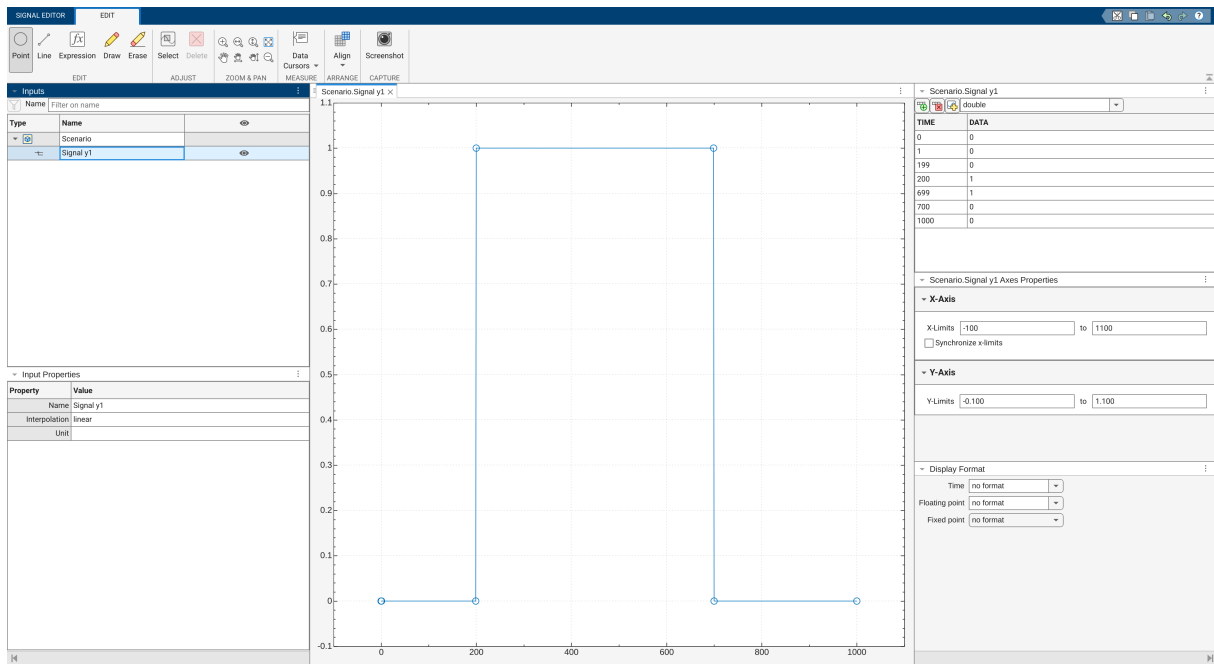


Figure 2: The desired displacement  $y_1$  for train coach 1. The robot controller  $R1$  should try to drive the system to this response.

4. Double click on “View or hide the signal icon to visualise the signal.
5. Enter the data [0 1 199 200 699 700 1000] as the times values on the top right pane.
6. Enter the data [0 0 0 1 1 0 0] as the corresponding data values on the top tight pane.
7. On the left pane “Inputs” disable and then enable the view the signal to see the constructed signal in the appropriate range.
8. 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).

To generate the signal shown in Figure 3 which is the desired displacement  $y_2$  of coach 2, 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. Enter the data [0 1 49 50 149 150 299 300 650 650 900] as the times values on the top right pane.
6. Enter the data [0 0 0 0.7 0.7 1 1 0.5 0.5 1 1] as the corresponding data values on the top tight pane.

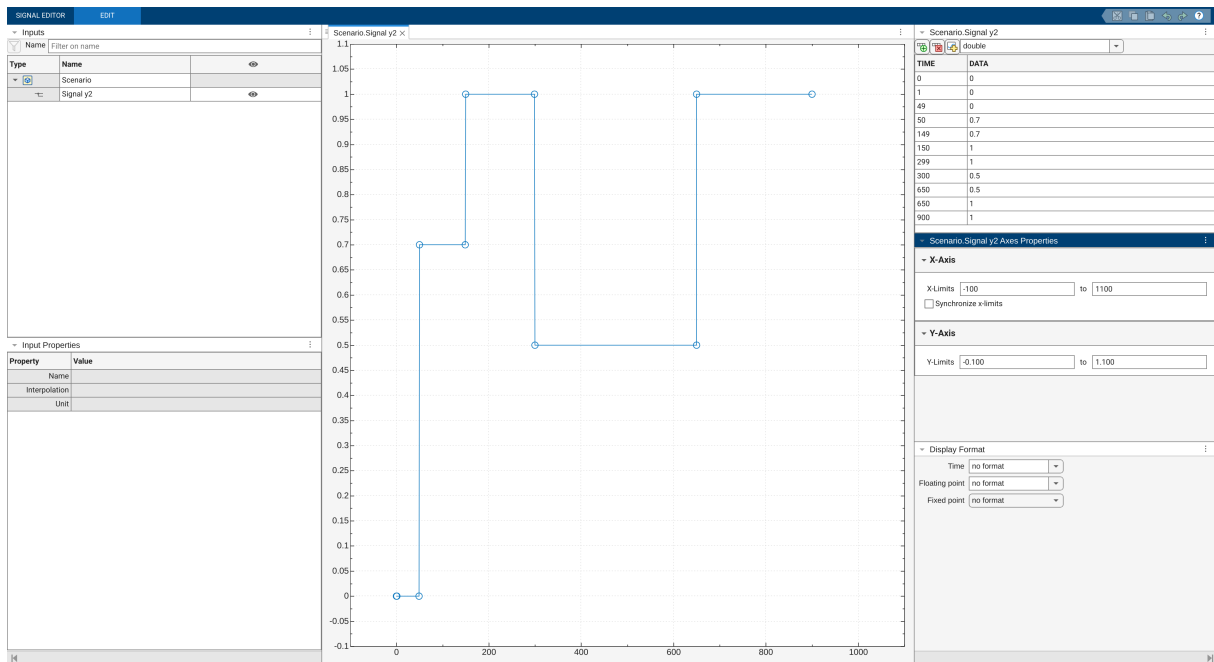


Figure 3: The desired displacement  $y_2$  for train coach 2. The robot controller  $R2$  should try to drive the system to this response.

- On the left pane “Inputs” disable and then enable the view the signal to see the constructed signal in the appropriate range.
- 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).

### 3 Report with Analysis of your Solution

You are expected to write a short report **in PDF format (no more than 5 pages)** which you discuss both your modelling and your controllers implementation of the plant. You should discuss how you chose the PID controller parameters and how these choices affect the performance of your controllers. 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*
  - 20 marks for a totally correct diagram

- 15–19 marks for minor omissions
- 10–14 marks for some major blocks missing
- 5–9 marks for a very incomplete diagram.
- 0–4 marks for a diagram not corresponding to the actual dynamic system.
- 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 controllers: *10 marks*
  - 4 marks for correct input connectivity
  - 4 marks for correct output connectivity
  - 2 marks for a correct block of the controllers and relative placement within the diagram.
- Initialisation of the PID controller parameters and appropriate reference signal: *10 marks*
  - 2 marks for the initialisation of the parameters
  - 8 marks for a totally correct reference signal
  - 5–7 marks for minor omissions in the reference signal
  - 0–4 marks for major omissions or a totally incorrect reference signal.
- Fine tuning of the controllers: *10 marks*
  - precise tuning: 10 marks
  - good but no precise tuning 5–9 marks
  - 0–4 marks for a poor or no tuning at all.

*All the above are for 2 controllers therefore half marks for each one of them.*

## 3. Analysis Report

- Response diagrams (step, Bode, etc.): *15 marks*
  - Bode diagrams: 5 marks
  - step response diagrams: 5 marks
  - additional diagrams: 5 marks.
  - For each of the above, higher marks will be given depending on the correctness and accuracy of the diagrams as well as their clarity.
- Analysis of response diagrams: *15 marks*
  - Excellent description of the diagrams: 12–15 marks
  - Sufficient description of the diagrams with some omissions: 8–11 marks
  - rather incomplete description or with some mistakes: 5–7 marks
  - poor or very incomplete or incorrect description: 0–4 marks.
- Analysis of stability and suitability of the choices made for the controllers: *10 marks*
  - 5 marks for the description of system stability
  - 5 marks for the justification of the suitability of the choices made.
  - For each of the above:
    - \* Excellent description/analysis/justification: 4–5 marks

- \* Sufficient but with some minor omissions discussion: 2–3 marks
- \* Poor or incorrect description: 0–1 mark

**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 5th of January 2026, 13:00.

## Submission Instructions

*Files to submit:* The Simulink model of the system (**slx** file), the controlled system (**slx** 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 you 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.2025 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](mailto: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.