MODULE DESCRIPTION FORM

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

ME528 CONTROL SYSTEMS DESIGN

Module Registrar: Prof M P. Cartmell matthew.cartmell@strath.ac.uk	**Taught To (Course): Cohorts for whom class is optional / elective**	
Other Lecturers Involved: None	**Credit Weighting: 10**	**Semester: 1**
Optional class	**Academic Level: 5**	**Suitable for Exchange: Y**

Required prerequisites

Note: It is the responsibility of ALL students to ensure that they satisfy the prerequisite knowledge for this module BEFORE adding as part of curriculum selection. If unsure, please contact the Module Registrar or discuss with your Programme/Year Adviser of Studies.

PLEASE NOTE THAT THE FIRST WEEK OF LECTURES WILL REVISE THE TOPICS BELOW BUT THERE WILL BE NO FURTHER REVISION AFTER THAT. IT IS THEREFORE VERY IMPORTANT THAT THE PREREQUISITES BELOW ARE FULLY IN PLACE IN ORDER TO BE SUCCESSFUL AT THIS COURSE.

Computer programming:
Knowledge of basic programming principles, particularly in Matlab as this is the principal language used for control.
Manipulation of variables.
Use of operators, expressions and statements (including conditional statements).
Coding of algorithms, use of structured programming logic, and flow diagrams.
Appreciation of the significance of computer arithmetic and errors.

Mathematical methods:
Calculus – differentiation and integration.
Trigonometry – identities and also the form and use and interpretation of harmonic functions.
Solution of linear second order ordinary differential equations and the role of the complementary function and particular integral, the characteristic equation, and the significance of a harmonic excitation function.
Laplace Transforms and Inverse Laplace Transforms, and how to use them.
Time domain responses, transients and steady-states.
Damping, and how the damping ratio represents underdamped, critically damped, and overdamped systems.
Taylor and MacLaurin series.

Mechanical and Electrical systems:
Principles of mechanics (forces, torques, work, energy, conservation of energy, conservation of angular momentum).
Fundamental circuit theory – Ohm and Kirchhoff laws, voltage, current, power, frequency, capacitance, inductance, resistance.

Control theory:
Open loop systems and how they are expressed and how they work.
Closed loop systems – the use of block diagrams, feedback, transfer functions, and disturbances.
Stability of linear systems.

Module Format and Delivery (HOURS i.e. 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	**Total**
11	11	16					32	30	100

Educational Aim

This module covers techniques for the design of control laws for engineering systems. The material builds on the fundamentals learned in 16318 Control, or 16361 Dynamics and Control, on the modelling and analysis of open and closed loop control for engineering systems. This module emphasises the development of computer models for the simulation and analysis of linear control systems, the design of PI, PD, and PID control laws, and the Routh-Hurwitz and Root Locus methods for calculating stability. Bode stability theory is also discussed, and the foundations of nonlinear control are introduced.

The education aims of the module are to:

- examine techniques for the analysis and understanding of the control of continuous-time linear systems,
- implement methods for determining the stability of a linear system, and interpreting what this may mean in practice,
- gain practice in developing computer models for linear systems, and in determining appropriate control techniques,
- introduce further stability theory, and nonlinear systems.

Learning Outcomes

On completion of the module the student is expected to be able to:

LO1 Synthesise mathematical models for the dynamics, control, and stability of a range of engineering systems.

LO2 Analyse stability, and then appreciate what this information reveals systematically about practical performance.

LO3 Develop control laws for practical and contemporary engineering systems.

LO4 Understand the advantages and disadvantages of various controllers, and their impact on system performance.

Syllabus

The module will teach the following:

- Modelling of system dynamics through ordinary differential equation models and the use of Laplace transforms.
- Construction of block diagrams and formal reduction techniques for complicated systems.
- Calculation of stability by means of the Routh-Hurwitz method, the Root Locus method, and Bode stability theory.
- Controllability and sensitivity of a systems dynamics to key parameters.
- The use of PI, PD, and PID controllers.
- Simulation and analysis of systems to be controlled using MATLAB / Simulink, including implementation of control laws.
- Fundamentals of nonlinear system control by means of Feedback Linearisation.

Assessment of Learning Outcomes

Criteria

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

LO1
C1 Model system dynamics in the time domain and use Laplace transforms in practice.
C2 Develop mathematical models for a range of different transfer functions and use them to determine, analytically and numerically, system outputs and overall control structures using block diagrams.

LO2
C1 Determine if a system is Lyapunov stable, asymptotically stable, exponentially stable, or unstable.
C2 Analyse the stability of practical systems employing the: a) Routh-Hurwitz theorem, b) Root Locus method, c) Bode stability in the frequency domain.

LO3
C1 Design and tune PI/PD/PID controllers for a complex engineering system.
C2 Understand how to use the Root Locus method in the context of pole placement.

LO4
C1 Understand the advantages and disadvantages of using different methods to develop a control law for a closed loop feedback system of significant complexity.
C2 Apply different controllers to a modelled engineering system in order to achieve a set of predefined goals for performance of the system and to be able to rationalise objectively how well the controllers behave.

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

Principles of Assessment and Feedback
(within Assessment and Feedback Policy at: https://www.strath.ac.uk/professionalservices/staff/policies/academic/)

Non-marked tutorial exercises offered throughout the course provide an informal first opportunity for students to implement methods and techniques learned through the lectures, and give a chance to receive immediate feedback through personal and online contact with the class instructor, as well as by peer discussion. Fully worked solutions to all tutorial questions are supplied and discussed, to encourage private study and learning.

An extended individual coursework encourages peer learning and problem-solving skills, and this is based upon the principles of authentic assessment. Additional facilitation and interim feedback are provided through the weekly coursework tutorials in the computing laboratory. Coursework marks and individualised feedback are communicated using Myplace, with a general discussion on the assessment methodology for the coursework and the examination provided in advance during the lectures. A 5-minute assessed presentation on the coursework will be given to the class by each individual student at the end of the course. Written feedback on the presentation is included in the individual feedback statement provided to each student on his/her coursework report submission. An unassessed 5-minute presentation on the initial stages of the coursework will be given in week 6 to enable some formative feedback to be provided.

The individual coursework offers each student the chance to engage directly with the material within the course to solve a significant problem set to the class. The coursework assesses the students' ability to work independently and creatively to solve the problem set.

Assessment Method(s) Including Percentage Breakdown and Duration of Exams *(individual weightings)*

Examination				**Coursework**		**Presentation**		**Project**	
Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***	Number	***Weighting***
				1	90%	1	10%		
				* LO 1-4		*LO 1-4			

* ***L/Os:*** *Indicate which Learning Outcomes (L01, L02, etc) are to be assessed by exam/coursework/practical/project as required.*

Coursework / Submissions deadlines (*academic weeks*):

Coursework deadline: week 11
Coursework discussions in class for interim formative feedback: week 6
Coursework presentations: week 10

Resit Assessment Procedures:
2hr examination in July/August diet

PLEASE NOTE:
Students must gain a summative mark of 50% to pass the module. Students who fail the module at the first attempt will be re-assessed during the July/August exam diet. This re-assessment will consist entirely of an exam. No marks from any previous attempts will be transferred to a new resit attempt.

Recommended Reading

*****Purchase recommended **Highly recommended reading *For reference**

* *Modern Control Systems: International Edition*, 12th edition (2010), R Bishop and R Dorf, Pearson. ISBN-10: 0131383108, ISBN-13: 978-0131383104.

* *Feedback Control of Dynamic Systems*, 7th edition (2014), G Franklin, J Powell and A Emani-Naeini. ISBN-10: 0135001501, ISBN-13: 978-0135001509.

* *Control systems engineering*, 6th International edition (2011), N Nise, John Wiley & Sons Publishing. ISBN-10: 0470646128, ISBN-13: 978-0470646120

Additional Student Feedback
(Please specify details of when additional feedback will be provided)

Date	Time	Room No
		Check timetable webpages for details

Session: 2024/25

Approved:

Programme Lead/Director Signature: Dr A McLaren
Date of Last Modifications: 23/08/2024

(MAE template updated July 2024)

MODULE TIMETABLE

Module Code:	**ME528**	**Module Title:**	**Control Systems Design**

Brief Description of Assessment:

The course is assessed through an individual coursework.

Assessment Timing

Indicate on the table below the start/submission dates for each assignment/project and the timing of each exam/assessment using the dropdowns provided.

Please note: Timings can and will change, this should only be used as a guide.

Semester One	W&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Project Set	Choose an item. Choose an item.	Choose an item. Choose an item.	Course work Set	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Presentation	Course work Submit	Choose an item.

Semester Two	C&D Wk	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item.