MODULE DESCRIPTION FORM

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

ME528 CONTROL SYSTEMS DESIGN

Module Registrar: Prof Matthew P. Cartmell **matthew.cartmell@strath.ac.uk**	**Taught To (Course): Cohorts for whom class is compulsory / optional / elective**		
Other Lecturers Involved: None	**Credit Weighting: 10**	**Semester: 1**	
Assumed Prerequisites: 16361 Dynamics and Control, 16318 Measurement, Instrumentation and Control, or equivalent control course.	**Optional**	**Academic Level: 5**	**Suitable for Exchange: Y**

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:

- Continuous differential equation models and the use of Laplace transforms.
- Calculation of stability by means of the Routh-Hurwitz method, the Root Locus method, using principles of Lyapunov stability, and Bode stability theory and calculation.
- Controllability and sensitivity of system dynamics.
- PI, PD, and PID controllers.
- Simulation and analysis 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 – students' ability to:
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 – students' ability to:
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. Understand how to use Lyapunov stability in general and also how to calculate Bode stability in the frequency domain.

LO3 – students' ability to:
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 – students' ability to:
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/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 contact with the class instructor, as well as by peer discussion. Fully worked solutions to all tutorial questions are presented to the class to encourage self-assessment and to promote discussion and class feedback from the instructor.

The individual project encourages peer learning and problem-solving skills. Additional facilitation and interim feedback is provided through the weekly project tutorials in the computing laboratory. Project marks and individualised feedback are communicated using MyPlace, with a general discussion on the assessment methodology for the project and the examination provided in advance during the lectures. A 5-minute presentation on the project 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 project report submission.

An exam is used to assess the students' understanding of the theory and analytical problem solving skills developed during the course. The individual project offers each student the chance to engage directly with the material within the course to solve a significant problem set to the class. The project assesses the students' ability to work independently and creatively to solve the problem set. This year the exam will be open-book format.

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

Examination				Coursework		Practical		Project	
Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***	Number	***Weighting***
1	Dec	2 hours Online	50%					1	50%
* 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*):

Project deadline: week 9
Project presentations: week 10

Resit Assessment Procedures:
2hr examination in 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 August 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: 2020/21

Approved:

Course Director Signature:	**Dr Stuart Grey**
Date of Last Modifications:	**15 September 2020**

(Updated August 2020)

MODULE TIMETABLE

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

Brief Description of Assessment:

The course is assessed through an individual project and an online final exam. The project requires the students to implement different methods and design approaches to find a solution to a practical problem using mathematical and simulation software.

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. Dropdowns can be left blank. Add extra notes below the dropdowns.

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.	Choose an item. Choose an item.	Choose an item. Choose an item.	Choose an item. Choose an item.	Project Submission	Presentation	Choose an item. Choose an item.	Exam

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.