MODULE SPECIFICATION PROFORMA

Module Title:	Analytical Control Methods	**Level**:	5	**Credit Value**:	20

Module code:	ENG521	**Is this a new module?**	No	**Code of module being replaced**:	N/A

Cost Centre(s):	GAME	**JACS3 code**:	H660

With effect from:	May 17

School:	Applied Science, Computing & Engineering	**Module Leader:**	James Robinson

Scheduled learning and teaching hours	40 hrs
Guided independent study	160 hrs
Placement	0 hrs
Module duration (total hours)	200 hrs

Programme(s) in which to be offered	Core	Option
Stand-alone bridging module to be attached to BEng (Hons) Industrial Engineering for QA and assessment purposes.	☐	☐

Pre-requisites

Office use only
Initial approval: May 17
Date of revision: *Enter date of approval* Version: 1
Have any derogations received Academic Board approval? Yes ☐ No ☐ N/A ✓

Module Aims
To develop concepts of mathematical modelling in the area of control engineering and to extend established mathematical skills and thus to apply analytical methods to control analysis, system design, implementation and modification. To develop the ability to select and implement appropriate methods of solving mathematical and engineering problems, whilst evaluating the solutions found in relation to engineering problems.

Intended Learning Outcomes

Key skills for employability

KS1	Written, oral and media communication skills
KS2	Leadership, team working and networking skills
KS3	Opportunity, creativity and problem solving skills
KS4	Information technology skills and digital literacy
KS5	Information management skills
KS6	Research skills
KS7	Intercultural and sustainability skills
KS8	Career management skills
KS9	Learning to learn (managing personal and professional development, self-management)
KS10	Numeracy

	At the end of this module, students will be able to	Key Skills	
1	Apply correct mathematical techniques to analyse control systems up to second order.	KS3	
		KS10	
2	Implement partial differentiation for analysing functions of two variables;	KS10	
3	Apply mathematical methods of Fourier series and Laplace transform theory to solve engineering problems	KS5	
		KS10	
4	Design and/or modify a control system to meet a specified performance in the time domain using analytic, graphical, empirical and computer methods.	KS4	
		KS6	
5	Design and/or modify a control system to meet a specified performance in the frequency domain using analytic, graphical, empirical and computer methods.	KS4	
		KS6	

6	Design and/or modify a control system to meet a specified performance through root locus analysis.	KS4	
		KS6	

Transferable skills and other attributes
1. Critically analyse and solve some mathematical problems relevant to Engineering. 2. Show accurate, coherent and logical thinking in problem solving.

Derogations
N/A

Indicative Assessment:

Assessment 1 - in class test relating to the theoretical and mathematical content contained within the specified outcomes.
Assessment 2 - a series of tasks, involving computer simulations relating to control engineering problems.

Assessment number	Learning Outcomes to be met	Type of assessment	Weighting (%)	Duration (if exam)	Word count (or equivalent if appropriate)
1	1,2,3	In-class test	50	2 hrs	
2	4,5,6	Coursework	50		2000

Learning and Teaching Strategies:

The module will be presented to students through lectures, tutorials and practically-based assignments. Half of the time will be devoted to practical investigations and will include the use of computer simulation software.
The tutorials will be used for students to practice problem solving to reinforce the lecture material and to provide individual attention where needed.

Syllabus outline:

Laplace Transforms: The (one-sided) Laplace transform and its existence, standard functions and use of look-up tables. Use of Laplace transforms in solving simple ODEs with constant coefficients and given boundary conditions. Step functions and their transforms. Laplace transforms of standard functions. Uniqueness of the inverse. Elementary properties - linearity, first and second shifting theorems, change of scale. Transforms of derivatives and integrals and of products with powers of t. Transforms of periodic functions. The limit of F(s) as s->infinity. The initial and final value theorems and their uses. Laplace transforms of some further special functions - the saw-tooth function, the dirac delta function. Theorems relating to inversion. The solution of slightly more complicated ordinary differential equations with given initial or boundary conditions - constant coefficient equations, simultaneous equations, some equations with non-constant coefficients, equations with discontinuous forcing terms.
Define and Apply Fourier Series: Full-range and half-range series. Even and odd functions. Coefficients in exponential form of complex numbers. Elementary properties. Numerical harmonic analysis.
Modelling and Analytical Techniques: System models of physical/electrical systems; open and closed loop systems; similarities of models from different physical systems;

differences between servo systems, regulators and process control systems; steady state and transient response; Laplace transform solutions for step, ramp and sinusoidal inputs; final value theorem; transfer functions and characteristic equations; block diagram algebra; poles and zeros; stability; Routh Hurwitz stability criterion; use of computer software for correlation of open and closed loop transient responses. **Time Domain Analysis**: Performance criteria: damping ratio, natural frequency, rise time, overshoot, settling time, logarithmic decrement; system lags and time constants; system class and steady state errors for standard input functions; proportional, integral and derivative control. Empirical methods for determining controller parameters: Zeigler and Nicholls, quarter decrement and continuous cycling approaches; variations in system response for controller settings. **Frequency Domain Analysis**: Bode and Nyquist diagrams; stability criteria; relative stability; gain and phase margins; correlation between frequency response and transient response parameters; derivation of transfer function from Bode diagram. Compensation techniques: lag and/or lead networks; design for a specified performance; use of computer software for the above. **Root Locus Analysis**: Closed loop system root loci; Analysis of root locus diagrams; Stability analysis; Compensation design.

Bibliography:
Essential reading
Essential Reading: Bishop R.D., Dorf R.C.; (2017) Modern Control Systems; (13th Global Edn); Harlow, Pearson Education Ltd. Jordan, D. & Smith, P. (2008) Mathematical Techniques: An Introduction for the Engineering, Physical, and Mathematical Sciences, 4th Edn. Oxford, Oxford University Press.
Other indicative reading
Etter D M; (2007) Engineering problem solving with MATLAB; (3rd Edn); London; Printice Hall James G; (2008) Modern Engineering Mathematics, 4th Edn. Harlow, Pearson Education Ltd.