

## Module specification

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**Refer to the module guidance notes for completion of each section of the specification.**

Module code	ENG5AQ
Module title	Instrumentation and Control
Level	5
Credit value	20
Faculty	FAST
Module Leader	Dr Zheng Chen
HECoS Code	100166
Cost Code	GAME

### Programmes in which module to be offered

Programme title	Is the module core or option for this programme
BEng (Hons) Mechatronics Engineering	Core

### Pre-requisites

None

### Breakdown of module hours

Learning and teaching hours	60 hrs
Placement tutor support	0 hrs
Supervised learning e.g. practical classes, workshops	0 hrs
Project supervision (level 6 projects and dissertation modules only)	0 hrs
<b>Total active learning and teaching hours</b>	<b>0 hrs</b>
Placement / work based learning	0 hrs
Guided independent study	140 hrs
<b>Module duration (total hours)</b>	<b>200 hrs</b>

For office use only	
Initial approval date	24/09/2020
With effect from date	24/09/2020
Date and details of revision	
Version number	1

## Module aims

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To develop methods of obtaining measurements of system variables in an industrial environment and to compare the operation of differing transducers by analysing response time, accuracy, stability and cost. To understand the transduction process and analyse various transducer types;

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 knowledge and skills to plan, manage and conduct control system design with consideration of social, economic and commercial constraints, to conduct the simulation, tuning and testing to evaluate and optimise a continuous control system.

## Module Learning Outcomes - at the end of this module, students will be able to:

1	Analyse the measurements of an industrial process in terms of the physical quantities which constitute the measured variables; Define the principles of operation of common transducers and match these to the requirements of the measured variables.
2	Compare the parameters of a range of transducers for a given task (eg the measurement of flow) and hence select an appropriate device; Define and apply the criteria for evaluating the validity of measurements.
3	Plan, manage and conduct control system design with consideration of social, economic and commercial constraints.
4	Understand and use correct mathematical techniques to model and simulate system/process dynamics; conduct detailed practical analyses of continuous control systems.
5	Design and/or modify a control system to meet a specified performance in the time domain and through root locus analysis using analytic, graphical, empirical and computer methods.
6	Design and/or modify a control system to meet a specified performance frequency domain using analytic, graphical, empirical and computer methods and understand the impact of uncertainties to control system design.

## Assessment

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This section outlines the type of assessment task the student will be expected to complete as part of the module. More details will be made available in the relevant academic year module handbook.

Indicative Assessment Tasks:

Assessment One: is by means of a portfolio of work covering learning outcomes 1, 2, and 3, made up of theoretical aspects, research elements and practical results.

Assessment Two: is by means of an examination covering outcomes 4, 5 and 6. It is an unseen time-constrained examination.

Assessment number	Learning Outcomes to be met	Type of assessment	Weighting (%)
1	1, 2, 3	Portfolio	50%
2	4, 5, 6	Examination	50%

## Derogations

A derogation from regulations has been approved for this programme which means that whilst the pass mark is 40% overall, each element of assessment (where there is more than one assessment) requires a minimum mark of 30%.

## Learning and Teaching Strategies

The module will be presented to students through lectures, tutorials and practically-based exercises. Approximately one-third of the time will be devoted to practical investigations and will include the use of computer simulation software.

The 'Instrumentation' part will be delivered through lectures supported by pre-written notes, tutorials and laboratory exercises. Practical work will take up approximately 30% of the time allocated to this component. Where possible, industrial visits to observe different process applications will be included.

In 'Continuous Control' the emphasis will be on dynamic system modelling and simulation, and the use of different traditional control system analysis and synthesis approaches for control system design.

## Indicative Syllabus Outline

Physical Variables: linear and angular displacement, velocity, strain, flow, level, etc.. Selection of appropriate transducers for above with signal conditioners where required.

Errors in measurement systems: Accuracy, precision, hysteresis, zero shift, resolution, linearity, sensitivity. Maximum possible and probable errors. Response and dead time.

Transducers: potentiometers, optical encoders, variable reactance transducers, piezoelectric devices, dc and ac tachogenerators, synchro resolvers.

Comparison of the Measurement Techniques: force, pressure and strain; strain gauges, diaphragm, piezo-electric, Hall effect transducers; analysis of performance parameters of the measurement techniques - for each of the physical variables listed above - in terms of accuracy, resolution, sensitivity and repeatability. Selection of appropriate components for a given measurement system.

Measurement: flow, temperature; optical intensity measurement; proximity detectors.

Control Systems Configuration: Sensors, transducers and actuators; specifications of constituent elements in a control system; electrical, pneumatic and hydraulic actuators; Comparison of pneumatic, electrical and hydraulic systems for various control tasks; Plan, manage and conduct control system design with consideration of social, economic and commercial constraints.

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 tuning; 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 control system analyses, syntheses and simulations; Uncertainties in control systems design.

Root Locus Analysis: Closed loop system root loci; Analysis of root locus diagrams; Stability analysis; Compensation design.

Case studies of industrial applications and subject-relevant systems. Selection of appropriate components for a given measurement system.

## **Indicative Bibliography:**

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Please note the essential reads and other indicative reading are subject to annual review and update.

### **Essential Reads**

Bolton W. (2015) Instrumentation and Control Systems, Newnes.

### **Other indicative reading**

Bishop, R.D. and Dorf, R.C. (2013) Modern Control Systems, 13th Edn., London: Prentice-Hall.

Dunn, W.C. (2005) Fundamentals of Industrial Instrumentation and Process Control, McGraw Hill.

Morris, A.S. (2006) Measurement and Instrumentation Principles, Butterworth-Heinemann.

## **Employability skills – the Glyndŵr Graduate**

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Each module and programme is designed to cover core Glyndŵr Graduate Attributes with the aim that each Graduate will leave Glyndŵr having achieved key employability skills as part of their study. The following attributes will be covered within this module either through the content or as part of the assessment. The programme is designed to cover all attributes and each module may cover different areas. [Click here to read more about the Glyndwr Graduate attributes](#)

### **Practical Skillsets**

Digital Fluency  
Critical Thinking  
Communication