1 MODULE 3: INSTRUMENTATION B

This module will comprise **7 lectures** and will be given by Dr J. G. Robertson.

1.1 TEXT

There is no textbook which covers all aspects of this module. There is some useful material in the Junior Physics textbook 'Fundamentals of Physics' by Halliday, Resnick and Walker.
A good reference book is 'Principles of Electronic Instrumentation' (3rd edition) by Diefenderfer and Holton. A copy is held in closed reserve in the Physics Library.

The examinable content of the module is defined by the lecture material.

1.2 ASSIGNMENTS

There are no compulsory written assignments in this module. Students are encouraged to attempt the problems provided in optional assignements, which will be handed out at intervals during the module. Solutions will be distributed at later lectures.

1.3 ASSESSMENT

Assessment is by written examination of material presented in the lectures (25 marks) and by one Computer-Based Assignment (CBA) (5 marks). The examination and CBA will include both qualitative and quantitative questions. Approximately 25% to 30% of written examination questions will be similar to a selection of questions previously given in the optional written assignments.

1.4 GENERAL AIMS

(a) the use of operational amplifiers to provide a variety of signal-processing functions
(b) how to analyse the operation of a simple op-amp based circuit
(c) the role and use of transducers in measuring various physical quantities
(d) the nature, effects and minimisation of noise and interference in electronic circuits

1.5 SPECIFIC OBJECTIVES

Operational amplifiers (3 lectures)
(Diefenderfer & Holton Chap. 9; Intermediate Physics Experimental Physics Notes C6)

After studying this part you will be able to:

- interpret and use notation and circuit symbols for operational amplifiers (op amps)
- explain the concept of open loop gain
- interpret the equivalent circuit of an op amp
- explain and apply the use of negative feedback in op amp circuits
- discuss and apply the Golden Rules for analysis of op amp circuits

- explain the operation of the inverting amplifier; derive and use the expression for its gain
- explain the operation of the summing amplifier; derive and use the expression for its output
- explain the operation of the difference (differential) amplifier; derive and use the expression for its output
- discuss the immunity of the difference amplifier to common-mode signals
- explain the operation of the op amp integrator; derive and use the expression for its output, and explain how the basic circuit is converted into a working practical circuit
- discuss the comparison of the op amp integrator with a passive integrator, and its relation to a low-pass filter
- explain the operation of the op amp differentiator, derive and use the expression for its output, and explain how the basic circuit is converted into a working practical circuit
- discuss the comparison of the op amp differentiator with a passive differentiator, and its relation to a high-pass filter
- discuss and explain the limitations of real op amps: input offset voltage and its nulling; bias current; bandwidth; slew rate limit

Transducers (2 lectures)

After studying this part you will be able to:

- discuss the role of transducers and identify the physical principle on which a given transducer is based
- discuss in general terms a variety of different transducers
- explain the use of a strain gauge as a sensor (transducer)
- explain the use and advantages of a Wheatstone bridge as a transducer interface circuit, and calculate the value of the unknown resistance in such a circuit
- discuss and apply the expression for sensitivity of a bridge circuit
- discuss the important general properties of sensors
- discuss and explain the operation and applicability of three different magnetic field sensors: (a) Hall effect probe - for steady or slowly varying fields; (b) Integrating fluxmeter - for steady fields, individual readings; (c) Search coil - for AC fields

Noise and Interference (2 lectures)

After studying this part you will be able to:

- discuss sources of noise and interference in general
- explain and apply the use of mean square and root mean square (RMS) voltages or currents in characterising noise signals
- discuss the nature and origin of Johnson (thermal) noise, its effect on amplifiers and its minimisation; apply the equation for calculation of Johnson noise
- discuss the nature and origin of shot noise, and its minimisation
- discuss the nature and origin of 1/f noise, and its minimisation
- discuss interference and the modes of pickup for radio frequency (RF) and mains effects
- discuss shielding, earthing and earth loops