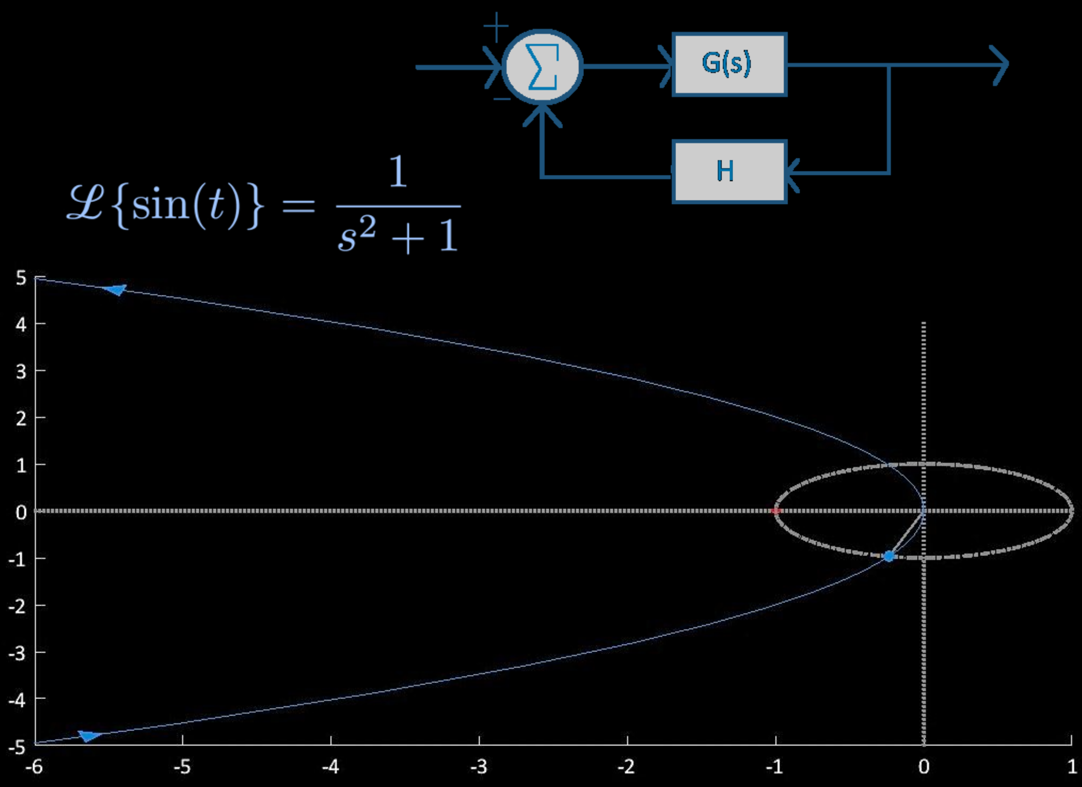
University of Glasgow | School of Physics & Astronomy



PHYS4003 Circuits & Systems

Course Information Guide 2023-24

1 Course Details

Lecturer:	Dr Stephen Webster	Schedule:	18 lectures, Wed. 11am; Fri. 11am
SCQF Credits:	10	ECTS Credits:	5
Assessment:	Examination (100%)	Co-requisites	None
Level:	Honours		
Typically Offered:	Semester 1	Prerequisites:	Physics 2

2 Course Aims

This course is compulsory for third year single BSc (Honours), MSci Physics and MSci Physics with Astrophysics students and is an elective course for Theoretical Physics and Designated Degree programmes in the School of Physics & Astronomy. It aims to provide students with an opportunity to develop their knowledge and understanding of the key principles and applications of circuits & systems, and their relevance to current developments in physics. In particular, it will provide a working knowledge of:

- Revision of Kirchhoff's circuit laws;
- Thevenin and Norton's theorems for equivalent circuits;
- Tuned circuits;
- Filters, frequency response and amplifiers;
- System analysis;
- Introduction to feedback;
- Stability of feedback systems;
- Feedback applications.

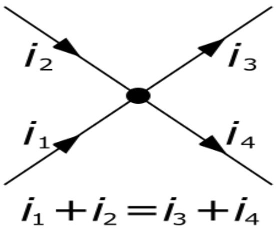


Figure 1: Kirchhoff's law of charge conservation.

3 Intended Learning Outcomes

By the end of the course students will be able to:

- Demonstrate knowledge and a broad understanding of circuits & systems;
- Describe qualitatively and quantitatively process, relationships and techniques relevant to the topics included in the course outline, and apply these techniques to solve general classes of problems;
- Write down and, where appropriate, either prove or explain the underlying basis of physical laws relevant to the course topics, discussing their applications and appreciating their relation to the topics to the topics of other courses taken.

4 Course Outline

Introduction: Kirchhoff's circuit laws in elementary and network forms for resistive and reactive circuit elements; transfer functions in the frequency domain for such circuits. Decibels for specifying gain or attenuation. Input and output impedance; Thevenin's and Norton's Theorems for equivalent circuits; impedance matching for optimum power transfer between circuits.

Tuned Circuits: Analysis of simple series and parallel L-C-R circuits; the resonant frequencies of these circuits and their quality factors (Q values). Voltage magnification in series circuits and current magnification in parallel circuits; the application of tuned circuits in providing selectivity in simple radio circuits. Amplitude modulation and sidebands.

Filters, Frequency Response, Amplifiers: Frequency response of simple R-C filters and cut-off points. Gain of inverting and non-inverting operational amplifier circuits. The transfer function in the frequency domain and the response in the time domain of simple low-pass, high-pass and band-pass filters based on operational amplifiers. Analysis of the responses of more complicated filters. Bode Plots for the transfer function of simple filters.

System Analysis: Representation of sinusoidal signals on the complex plane and on the complex s-plane. The meaning and mechanics of the Laplace Transform. Use of the Laplace Transform to transform some simple waveforms in the time domain into the complex frequency (s) domain. Use of tables of important Laplace Transform pairs. The defining differential equations for some simple circuits or mechanical systems and the use of the Laplace Transform to determine their transfer functions in the s-domain. The response in the time domain of a circuit or system to a delta function impulse and the application to simple examples such as an R-C circuit and a series L- C-R circuit.

Introduction to Feedback: The principle of negative feedback and its use in control systems. The terminology of feedback systems, including use of block diagrams. Poles and zeros of a transfer function and the significance of position of poles in the s-plane for stability. The characteristic equation. Polar plots of transfer functions. Open and closed loop transfer functions. An example of an electronic amplifier with feedback. Summary of the characteristics of feedback.

Stability of Feedback Systems: Nyquist analysis including gain and phase margins, and Bode analysis methods for determining stability, with examples of 1st, 2nd and 3rd order systems. Introduction to Root Locus analysis method.

Feedback Applications: Application of feedback to a mechanical system, in particular a pendulum accelerometer. Simulation of the feedback system as an aid to analysis.

5 Further Information

Further information can be found on the course Moodle page and also using the link below:

- Course specification