ELECTRICAL AND ELECTRONIC ENGINEERING

Timetables can be accessed at  http://timetable.ucc.ie/1213/department.asp

For information on building codes click on:  http://timetable.ucc.ie/1213/buildingcodes.asp

Students studying at UCC for the Autumn Semester – please check with the International Education Office to confirm the method of assessment for each module.

Autumn Semester - Teaching Period 1 Modules

EE2007 Electronic Circuits  (5 credits; Teaching Period 1)
EE2012 Linear Circuit Analysis (5 credits; Teaching Period 1)
EE3009 RF Circuit Theory  (5 credits; Teaching Period 1)
EE3011 Power Electronic Systems (5 credits; Teaching Period 1)
EE3013 Electromagnetic Fields for Engineers (5 credits; Teaching Period 1)
EE3901 Biomedical Design  (5 credits; Teaching Period 1)
EE4012 Biomedical Design (5 credits; Teaching Period 1)

Spring Semester - Teaching Period 2 Modules

EE1005 Electrical and Electronic Systems  (5 credits; Teaching Period 2)
EE2011 Digital Electronics (5 credits; Teaching Period 2)
EE2013 Non-Linear Circuit Analysis (5 credits; Teaching Period 2)
EE3012 Electromechanical Energy Conversion (5 credits; Teaching Period 2)

Full Academic Year - Period 1 and 2 Modules

EE2001 Power Engineering  (10 credits; Teaching Period 1 & 2)
EE2008 Signals and Systems (10 credits; Teaching Period 1 & 2)
EE3001 Control Engineering (10 credits; Teaching Period 1 & 2)
EE3010 Analogue and Digital Signal Processing (10 credits; Teaching Period 1 & 2)
EE4001 Power Electronics, Drives and Energy Conversion (5 credits; Teaching Period 1 & 2)
EE4002 Control Engineering (5 credits; Teaching Period 1 & 2)
EE4004 Telecommunications (5 credits; Teaching Period 1 & 2)

EE4007 Optical Electronics (5 credits; Teaching Period 1 & 2)

EE4008 Digital Signal Processing (5 credits; Teaching Period 1 & 2)

EE4009 Mechatronics and Industrial Automation (5 credits; Teaching Period 1 & 2)

EE4010 Electrical Power Systems (5 credits; Teaching Period 1 & 2)

EE4011 RF IC Design (5 credits; Teaching Period 1 & 2)

EE4013 Renewable Energy Systems (5 credits; Teaching Period 1 & 2)

EE4020 Project (15 credits; Teaching Period 1 & 2)

EE4021 Electrical and Electronic Engineering in the Commercial World (5 credits; Teaching Period 1 & 2)

ELECTRICAL AND ELECTRONIC ENGINEERING MODULE DESCRIPTIONS

Autumn Semester/Teaching Period 1 Modules

EE2007 Electronic Circuits (5 credits; Teaching Period 1)

The objective of the module is to further the analysis and design of analogue circuits. The contents of the module are Power Amps: Classes A, B and C; JFETs: Characteristics, biasing and operation; Op-amps: analysis and circuit elements; application examples of above: Design and implementation issues.

On successful completion of this module, students should be able to:
· Analyse and design linear operational amplifier circuits (including, but not limited to, inverting/non inverting amplifiers, summer, differential amplifier, integrator and differentiator).
· Analyse and design such common non-linear operational amplifier circuits as a comparator and a Schmitt trigger.
· Report upon the operating characteristics of Op-amp based amplifiers and comparators they have built in the laboratory.
· Analyse and design suitable DC biasing circuits for bipolar Class A and B power amplifiers.
· Calculate the power consumption, output power and efficiencies of bipolar Class A and B power amplifiers, and determine their DC and AC load lines.
· Report upon the static (e.g. biasing) and dynamic (e.g. load line analyses) operating characteristics of bipolar Class A and B power amplifiers they have built in the laboratory.
· Analyse and design suitable DC biasing circuits for field effect transistor based Class A power amplifiers.
· Calculate the power consumption, output power and efficiencies of field effect transistor based Class A power amplifiers, and determine their DC and AC load lines.

Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (Laboratory and Written Reports; software based assignment and report; design and construction of electronic circuits).
EE2012 Linear Circuit Analysis (5 credits; Teaching Period 1)

The objective of the module is to teach the fundamentals of linear electrical circuit analysis. The contents of the module are circuit elements, laws and theorems of linear circuit analysis; application of circuit theorems to DC circuits; nodal analysis of DC circuits; Thevenin and Norton network theorems; maximum power transfer and superposition; network i-v characterisation, time-varying signals, complex magnitude and phase; AC circuit analysis, resonance, damping and Q factor; introduction to filters, first-order RC and RL networks, second order networks, step response.

On successful completion of this module, students should be able to:
- Carry out nodal analysis of (i) passive, and (ii) first and second order DC and AC circuits.
- Analyse, by hand calculation, the time and (where applicable) frequency response of first and second order DC circuits composed of resistors, capacitors and inductors.
- Describe second-order circuit response in terms of Q factor, damping factor, natural frequency and damped natural frequency.
- Design simple first and second-order filter circuits which perform important electrical functions (e.g., filtering).
- Perform computer simulation of the circuits described above in the time and (where applicable) frequency domains.
- Construct first and second-order filter circuits and characterise their behaviour in the time and frequency domain.

Assessment: Total Marks 100: End of Year Written Examination 50 marks; Continuous Assessment 50 marks (Laboratories 40 marks; In-class Written Examination 10 marks).

EE3009 RF Circuit Theory (5 credits; Teaching Period 1)

The objective of the module is to study high frequency circuit theory applicable to RF and microwave electronics.

The contents of the module are analysis of transmission lines and reflection phenomena, Impedance matching techniques; analysis of coupled lines; S parameters and their applications; Masons signal flow rules; Smith Chart.

On successful completion of this module, students should be able to:
- Use the lumped element equivalent circuit model of a transmission line to derive relationships between the primary (i.e. R, L, G and C) and secondary (i.e. characteristic impedance and propagation constant) line constants.
- Formulate and solve phasor-based equations governing, for example, the input impedance, SWR, incident, reflected and total voltages and currents at arbitrary locations in both lossless and lossy transmission lines with load termination ZL.
- Deduce the S-parameters for one and two port circuits via phasor-based analysis of the appropriately terminated circuits.
- Deduce and apply, using Mason's Signal Flow rules or algebraic manipulation, specified circuit ratios (e.g. effective input/output reflection coefficients, voltage gain, transducer and operating power gains etc.) to characterise linear two port networks.
- Employ the Smith chart to graphically estimate such parameters as reflection coefficients, impedances and standing wave ratios of lossy and lossless transmission line circuits.

Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (Project/Laboratory work).
EE3011 Power Electronic Systems (5 credits; Teaching Period 1)

The objective of the module is to provide an understanding of the theory of power electronic converters and their applications in electrical motor drives and switched mode power supplies. The contents of the module are review of ac circuit theory; static magnetic circuits; transformers; review of dc machines; power semiconductor devices; phase controlled rectifier circuits; Dc-dc converter circuits.

On successful completion of this module, students should be able to:
- Analyse and solve problems in single-phase and three-phase sinusoidal voltage and current-fed electrical systems.
- Appreciate the different forms of magnetic materials available for a given application and understand their associated loss mechanisms.
- Analyse, solve and design magnetic circuits for inductors and transformers.
- Analyse, simulate, solve and design the fundamental power converter circuits used in the efficient processing of electrical power in both motor drives and power supply systems.
- Analyse, simulate (via PSpice), design and construct the fundamental power electronic topologies, including line commutated ac/dc converters and non-isolated dc/dc converters.

Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (Laboratory Classes 10 Marks; In-Class Test 10 marks.).

EE3013 Electromagnetic Fields for Engineers (5 credits; Teaching Period 1)

The objective of the module is to gain an understanding of electromagnetism and its application in Electrical Engineering. This module will focus on a physical understanding of electromagnetism using mathematics as a tool to solve problems. The contents of the module are Static Electric and Magnetic Fields; Moving Charges; Dynamic Electromagnetic Fields, Boundary Conditions; Interaction of Electromagnetic waves with matter; Plane Wave Solutions; Poynting Vector, and Waveguides.

On successful completion of this module, students should be able to:
- Give a description of what causes electromagnetic waves and what is a photon.
- Solve problems in electrostatics and magnetostatics using fundamental laws/equations of electromagnetism.
- Give a physical description of how electric and magnetic polarizability arise and their equation representations.
- Demonstrate an understanding of Maxwell’s Equations and be able to apply them to solve some basic problems in linear homogeneous isotropic media.
- Demonstrate knowledge of how to solve problems involving electromagnetic waves at boundary interfaces.
- Give a description of the physical and mathematical basis of polarization of an electromagnetic wave.
- Solve for power flow of an electromagnetic wave.
- Describe the electromagnetic wave solutions in waveguides.

Assessment: Total Marks 100: End of Year Written Examination 70 marks; Continuous Assessment 30 marks (Two In-Class Tests, each 15 marks).
**EE3901 Biomedical Design** (5 credits; Teaching Period 1)

The objective of the module is to introduce the student to the process of innovation and design in the biomedical/clinical environment through a combination of lectures, problem-based and mentored learning (with both engineering and clinical mentors).

The contents of the module are Introduction to design of clinical devices and process; design strategies (e.g., TRIZ) (considering product development techniques, human factor engineering, safety and testing); market analysis techniques, medical device intellectual property, patents and an introduction to IP law with particular application to biomedical systems and devices; commercialisation pathway (e.g., device regulation, insurance etc.); case studies, team project to design a biomedical device, processor system.

On successful completion of this module, students should be able to:

- Describe and apply design strategies such as TRIZ;
- Describe the fundamentals of intellectual property law and patents with application to biomedical devices;
- Describe the commercialisation pathway for biomedical devices;
- Perform a preliminary market survey to identify commercial conditions for a new concept/device and critically assess the feasibility of a new concept or device in the biomedical field;
- Evaluate the intellectual property landscape for a new biomedical concept;
- Design a solution for a well-defined biomedical engineering device or system as part of a team of 3-5 students.

**Assessment:** Total Marks 100: Continuous Assessment 50 marks (Continuous Assessment (In-class tests - 20 marks; individual goal attainment within team - 25 marks; team written report - 30 marks; team seminar presentation - 25 marks)).

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**EE4012 Biomedical Design** (5 credits; Teaching Period 1)

The objective of the module is to introduce the student to the process of innovation and design in the biomedical/clinical environment through a combination of lectures, problem-based and mentored learning (with both engineering and clinical mentors).

The contents of the module are introduction to human anatomy and physiology (including the cardiovascular, neural, musculoskeletal, and digestive systems); Design strategies (e.g., TRIZ) considering product development techniques, human factor engineering, safety and testing; Market analysis techniques; Medical device intellectual property, patents and an introduction to IP law with particular application to biomedical systems and devices; Commercialisation pathway (e.g., device regulation, insurance etc.); Case studies; Team mini-project to design a biomedical device or system.

On successful completion of this module, students should be able to:

- Describe and apply design strategies such as TRIZ;
- Describe the fundamentals of intellectual property law and patents with application to biomedical devices;
- Describe the commercialisation pathway for biomedical devices;
- Perform a preliminary market survey to identify commercial conditions for a new concept/device and critically assess the feasibility of a new concept or device in the biomedical field;
- Evaluate the intellectual property landscape for a new biomedical concept;
- Design a solution for a well-defined biomedical engineering device or system as part of a team of 3-5 students.

**Assessment:** Total Marks 100: Continuous Assessment 100 marks (Continuous assessment (In-class tests - 20 marks; individual goal attainment within team - 25 marks; team written report - 30 marks; team seminar presentation - 25 marks)).
Spring Semester/Teaching Period 2 Modules

EE1005 Electrical and Electronic Systems
(5 credits; Teaching Period 2)

The objective of this module is to develop provide students with a broad overview and introduction to Electrical and Electronic Engineering. The contents of this module are electrical and electronic systems examples; system block diagrams, introductory circuit theory, electrical and electronic components, sensors and actuators; amplifiers and amplification; introduction to op-amps, principles of control and feedback, basic digital and sequential logic, signals, phasors, measurement and noise, introduction to semiconductor devices, basic electrical machines, data acquisition and communication.

On successful completion of this module students should be able to:
· Describe complex systems using block diagrams and divide a complex system into component sub-systems
· Solve elementary circuit problems
· Identify and describe the purpose of electrical and electronic components, including diodes, transistors, capacitors, inductors, resistors and operational amplifiers, as well as basic electrical machines.
· Design elementary analogue and digital circuits
· Design and implement a complex system using a “black-box” approach
· Work in a team-environment to solve engineering problems and communicate their work effectively using reports and oral presentations in groups and as individuals.

Assessment: Total Marks 100: End of Year Written Examination 50 marks; Continuous Assessment 50 marks ((In class examination, Group projects, Project demonstrations, Oral presentation, Individual Project Report). A detailed description of the Continuous Assessment will be provided to the students at the beginning of the Teaching Period).

EE2011 Digital Electronics (5 credits; Teaching Period 2)

The student should have learned the fundamentals of Boolean algebra as applied to the analysis and design of Digital Electronic Circuits. The student should have developed the capacity to simulate, analyse, design and implement a variety of combinational and sequential digital logic circuits.

The Contents of the module are Boolean algebra; combinational logic design and minimisation; Synchronous circuit design: Moore and Mealy state machines, asynchronous circuit design, state assignment and circuit hazards; Programming Micro Controllers; Analog to Digital and Digital to Analog conversion.

On successful completion of this module, students should be able to:
· Manipulate, minimise and implement Boolean expressions using digital electronics.
· Prove and use the various theorems of Boolean Algebra.
· Use Karnaugh-maps for the minimisation of Boolean expressions up to 5 variables.
· Design and implement synchronous and asynchronous sequential logic circuits
· Describe the internal architecture and operation of a microcontroller device.
· Apply the principles of A/D and D/A conversion for the capture and analysis of signals.
· Complete a digital system design project with aspects of teamwork, project management,
project budgeting, problem solving, report writing, circuit design, trade-off analysis and presentation skills.

**Assessment: Total Marks 100: End of Year Written Examination 50 marks; Continuous Assessment 50 marks (Continuous Assessment (10 Marks Class Test, 20 marks Group Assignments, 20 marks Individual Assignment)).**

### EE2013 Non-Linear Circuit Analysis (5 credits; Teaching Period 2)

The objective of the module is to teach the fundamentals of non-linear electrical circuit analysis.

The contents of the module are Non-linear circuit elements, diodes and their application, linearization and DC operating points, small signal circuit models, transistors as digital switches, transistors as amplifiers, fundamental MOSFET circuits, load lines, amplifier configurations and applications; input and output impedance, voltage and current gain; frequency response characteristics.

On successful completion of this module, students should be able to:
- Carry out small-signal linearization of a two terminal non-linear device about a DC operating point
- Predict, by hand calculation, the time domain waveforms and behaviour of common diode circuits (e.g., clipper, rectifier, clamp).
- Implement Boolean functions with MOSFET circuits operating as digital switches.
- Implement and analyse common amplifier configurations and calculate important figures of merit.
- Perform computer simulation of the circuits described above.
- Design and construct non-linear electronic circuits and characterise their behaviour in the time and frequency domains.

**Assessment: Total Marks 100: End of Year Written Examination 50 marks; Continuous Assessment 50 marks (Continuous Assessment Laboratories 40 marks; In-class Written Examinations 10 marks.).**

### EE3012 Electromechanical Energy Conversion (5 credits; Teaching Period 2)

The objective of the module is to provide an understanding of the fundamental principles of electromechanical energy conversion systems including solenoids, contactors, reluctance motors, stepper motors, synchronous machines, dc machines and three-phase induction machines.

The contents of the module are the generalised theory of electromagnetic energy conversion; practical applications of electromechanical energy conversion systems; solenoids and contactors; Reluctance machines; Stepper motors and positioning systems, Synchronous machines; Dc machines: three-phase induction machines and wind generator systems.

On successful completion of this module, students should be able to:
- Understand and appreciate the generalised theory of electromechanical energy conversion based on the fundamental principle of conservation of energy.
- Analyse and solve the magnetic circuits which underpin the principal forms of electrical machines, including singly-fed and doubly-fed magnetic devices, based on both linear and rotary motion.
- Analyse and solve application-oriented problems involving the major electromechanical energy conversion devices, specifically contactors and relays, reluctance machines and
synchronous machines, stepper motors, dc and universal motors as well as induction motors and generators.

- Set up and operate in practice a typical electrical machine drive system. The student will also develop expertise in the modelling and simulation of complex electromechanical systems.

**Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (Laboratory Classes 10 marks; In-Class Test 10 marks).**

**Full Academic Year - Period 1 and 2 Modules**

**EE2001 Power Engineering (10 credits; Teaching Period 1 & 2)**

The objective of the module is to teach the fundamentals of power engineering. The Contents of the module are Electromagnetism revision; self inductance; Transformer Inductances; Ferromagnetism; DC Machines (brushed); Single-Phase and Three-Phase Power Circuits: AC Circuit Analysis, Real, Reactive and Complex Power, Power Factor Correction, Star, Delta Circuits, Thyristor Converters, Electrical Safety and Wiring.

On successful completion of this module, students should be able to:
- Apply the laws of electromagnetism to power components.
- Characterize these power components for their electrical properties.
- Apply these power components in suitable circuits and applications.
- Provide an overview of power systems.
- The student will be able to test, characterize, experiment with, and report on commonly-used power machines.

**Assessment: Total Marks 200: End of Year Written Examination 130 marks; Continuous Assessment 70 marks (Power Laboratory Sessions and Laboratory Examination 30 marks; In-class Written Examinations 40 marks).**

**EE2008 Signals and Systems (10 credits; Teaching Period 1 & 2)**

The objective of the module is to teach the fundamentals of signals and systems in the context of Electrical and Electronic Engineering. The Contents of the module are continuous and discrete-time systems analysis with illustrative applications, linear and time-invariant systems, transfer functions, Fourier series, Fourier transform, Laplace and Z-transforms, sampling and reconstruction.

On successful completion of this module, students should be able to:
- Be familiar with the abstraction concepts of signals and systems, understand the uses and properties of fundamental signals (step, ramp, impulse, pulse, exponentials and sinusoids), understand the uses and properties associated to systems (stability, memory, invertibility, time (in)variance and linearity);
- Be familiar with the time representation of signals and systems (convolution and impulse response), understand the uses and solutions of difference and differential equations to describe the behavior of systems;
- Be familiar with the spectral representation of signals and systems (Fourier analysis, Laplace and z-transform), understand the use of frequency response to characterize linear systems, analyze the response of linear systems to periodic and non-periodic signals, utilize the four Fourier representations and Laplace and z transforms to analyze linear systems;
- Be able to use Matlab to analyze discrete and continuous time signals and systems;
- Understand various disciplines within Electrical Engineering and how they relate to signals and systems.
EE3001 Control Engineering (10 credits; Teaching Period 1 & 2)

The objective of the module is to teach the fundamentals of control engineering. The Contents of the module are Classical Control: Principles of control, modelling and simulation, frequency and time responses, properties of feedback, Stability-Routh-Hurwitz, Nyquist; Relative Stability, design of compensators in the frequency domain, Root Locus design, PID controllers – tuning, practical issues - cascade control, windup, etc., introduction to digital control.

On successful completion of this module, students should be able to:
· Appreciate the need for and the benefits that come from automatic control.
· Model, simulate and linearise basic non-linear dynamic processes.
· Identify a process transfer function model from its time or frequency responses.
· Analyse the stability and performance of a closed-loop system from its Nyquist and Nichols plots.
· Design PID, phase-lead and phase-lag controllers in the frequency domain.
· Predict the closed-loop performance of a process from its open-loop poles and zeros, using the root-locus method.
· Design PID, tacho-feedback and phase-lead compensators using the root-locus method.
· In the laboratory they will observe some of the practical issues of both computer and analog implementation of controllers for the closed-loop control of a wide variety of realistic processes.
· In the case-study design exercise students learn how to apply what they have learnt to set realistic design objectives, to design a controller, test the design in simulation and justify their results.

Assessment: Total Marks 200: End of Year Written Examination 160 marks; Continuous Assessment 40 marks (Laboratory and Class Study).

EE3010 Analogue and Digital Signal Processing (10 credits; Teaching Period 1 & 2)

The objectives of the module are to apply frequency-domain techniques for the analysis of signals in both the analogue and digital domains and to apply such frequency-domain techniques for the design of analogue and digital filters. The Contents of the module are Analogue Signal Analysis - Application of Fourier Series and Fourier Transforms, s-plane analysis and Design methods, transient responses - relationship to poles, etc., frequency response, filter design, Common Filter Types - Butterworth, Chebyshev, Bessel, Elliptic, active network synthesis with ideal op-amps, design of Passive Networks for Filter Implementation, digital Signal Analysis - Application of Discrete Time Fourier Series and Fourier Transforms; Analogue to Digital Conversion, Shannon Sampling Theorem, Linear Time Invariant Systems, FIR Filter design - Frequency Sampling and Windows Method.

On successful completion of this module, students should be able to:
· Apply s-domain and s-plane techniques to represent transfer functions and use these to analyse simple passive networks.
· Perform in-depth analysis of low pass, high pass, band stop and band pass, Butterworth and Chebyshev filters, in addition to an appreciation of the relative merits of these filters and of Bessel and Elliptic filters.
· Design the filters listed in 2 above, as both active and passive circuits.
· Use the Discrete Time Fourier Transform to determine the frequency response of FIR digital filters and the spectral response of a range of waveforms.
· Design standard FIR filters using the window and frequency sampling techniques.
· Apply the Fast Fourier Transform to spectral analysis and filter design.
· Design, simulate (via Matlab), build (using breadboards), measure (using signal generators and oscilloscopes) and compose a written performance report pertaining to:
  · (a) Analogue filters (two sample op-amp-based filters will be designed and constructed);
  · (b) Digital filters (an example FIR digital filter will be designed and simulated).

**Assessment: Total Marks 200: End of Year Written Examination 160 marks; Continuous Assessment 40 marks (Laboratory Work plus Written Reports; Software-based Assignment and Report; Design and Construction of Electronic Circuits; DSP Project).**

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**EE4001 Power Electronics, Drives and Energy Conversion** (5 credits; Teaching Period 1 & 2)

The objective of the module is to study power electronics and motor drives following an integrative approach.

The Contents of the module are Isolated and Non-isolated Power Electronic Converters, Power Semiconductors, AC Machines Analysis and Control, dq Modelling of AC machines, Operation and modelling of Permanent-Magnet AC Machines, Modelling, Characterization, Operation, Speed and Vector Control of Squirrel-cage Induction Machines, Operation and modelling of Doubly-fed Induction Machines.

On successful completion of this module, students should be able to:

· characterize, analyze, solve, design and specify components, circuits, and systems for power electronics and electric drives. The following technical areas are studied:
  · I. Power electronics circuits
  · II. Power semiconductors
  · III. DC motors and generators
  · IV. AC machine steady state operation and characterization
  · V. Induction machine wiring configurations and speed control
  · VI. AC machine space vector control and modulation

In relation to I and II, the student will be able to:

· i. Analyse and design power electronics converters and specify circuit components based on converter requirements.

In relation to III through VI, the student will be able to:

· ii. Determine machine parameters based on various characterization tests

· iii. Analyse and specify an electric drive system based on the application.

**Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (In-class Written Examinations).**

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**EE4002 Control Engineering** (5 credits; Teaching Period 1 & 2)

The objective of the module is the application of modern, non-linear and digital control techniques.

The Contents of the module are Modern Control: Introduction to state-space techniques, solution of state equations; Controllability; Pole placement regulator design; Observability; Full and reduced order estimator design; Non-linear Control; Digital Control: Review of Digital Control basics; Direct design techniques; State-space control; System identification; Self-tuning control.

On successful completion of this module, students should be able to:

· Correctly specify sampling rates and anti-aliasing filters for digital control applications.

Analyse the dynamics of discrete and mixed signal systems.

Implement digital controllers through emulation.
· Design digital controllers using inverse model, root-locus and polynomial pole-placement techniques.
· Identify discrete time models from experimental data, using the least square algorithm.
· Develop an adaptive controller based on the recursive least squares algorithm and the polynomial pole-placement control scheme.
· Model and simulate basic nonlinear dynamic processes. Linearise a nonlinear system to obtain a state-space model. Analyse the dynamics of a state-space process.
· Utilise state space theory for: conversion of state-space models to transfer functions and vice-versa; transforming state-space models into other representations; solve for the state trajectory; determine the transition matrix; convert a continuous model into a discrete time model.
· Design a state space controller. This includes: how to analyse the state space model for controllability; regulator design using the pole-placement technique for high order processes; the design of controllers for tracking applications; how to use Ackermann’s gain formula.
· Design an estimator for use within a state space control scheme. Understand the separation principle and be able to design a state space compensator which uses a full state estimator.
· In the design exercise, students learn how to use Matlab and Simulink for the design and testing of a controller for a realistic case-study system.

Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (Design exercise).

EE4004 Telecommunications (5 credits; Teaching Period 1 & 2)

The objective of the module is to study the principles of modern digital telecommunication systems.

The Contents of the module are Digital communications; PCM, ADM, FSK, DPSK, QAM; ATM; ISDN; MPEG; DVB; Source coding techniques; Error control coding; Line codes; Statistical decision theory; Digital modulation and detection techniques; Signal space concepts, Correlation and matched filter receivers, Single symbol detection of known signals in AWGN.

On successful completion of this module, students should be able to:
· Describe the basic digital modulation formats for communications links.
· Describe common standards for communication systems such as the OSI model.
· Describe and perform calculations on link-level attributes such as ARQ schemes and utilization in the presence of errors and in error-free conditions.
· Describe the architecture and operation of wire-based communications systems for LANs and WANs including Ethernet, X25, ATM and DSL.
· Describe the basic structure and operation of wireless telecommunications systems including 2G and 3G networks.
· State and use information-theoretic constructs to characterise channel capacity.
· Perform relevant Galois field calculations and analyse the performance of BCH error correcting codes.
· Derive optimum detection conditions, in terms of signal to noise ratio, for digitally modulated data subject to additive white Gaussian noise (AWGN).

Assessment: Total Marks 100: End of Year Written Examination 100 marks.

EE4007 Optical Electronics (5 credits; Teaching Period 1 & 2)

The objective of the module is to present the principles and applications of semiconductor optoelectronics and photonics.

The Contents of the module are introduction to semiconductor physics (revision); introduction to quantum mechanics and application to semiconductor optoelectronic devices; quantum confinement, elementary band structure; fundamentals of laser operation and design.
Semiconductor emitters: Light Emitting Diodes and Lasers; wavelength stability in semiconductor laser devices; non communications based applications of lasers; introduction to properties of light: geometric optics, coherence and dispersion; optical fibre designs and application in communication and other systems; optical communication system design and limits on transmission rates; Maxwell's equations as applied to light, behaviour of light in materials and at interfaces; optical antennas and analogy to RF antennas; applications of signal to noise ratio in photonic system; polarisation of light and modification; principles and applications of interferometry.

On successful completion of this module, students should be able to:
- Solve problems related to the design of enhanced efficiency light emitting devices, the use of semiconductor lasers in optical communications, optical data storage applications and other applications.
- Solve problems related to the propagation of light in and between optical components and the impact polarization, dispersion, electrical signal modulation bandwidth and other factors may have on system bandwidth or sensitivity.
- Describe, analyse, compare and utilise a variety of passive and active optical components, particularly optical waveguides, modulators, amplifiers, light-emitting devices, and optical detectors.
- Describe and design simple systems using the above components, particularly for communications, but also for other applications, showing knowledge of the relevant limitations that may be expected.
- Describe Fermat's principle and optical path length, the derivation of laws of geometrical optics and application to optical sensor design.

Assessment: Total Marks 100: End of Year Written Examination 70 marks; Continuous Assessment 30 marks (two separate 1 hour in-class examinations - 15 marks each covering the semiconductor optoelectronics (Exam A) and photonics content (Exam B) of the course.).

**EE4008 Digital Signals Processing (5 credits; Teaching Period 1 & 2)**

The objective of the module is to study the design and implementation of Digital Filtering and spectral analysis techniques.

The Contents of the module are FIR Filter Design; Z-Transforms; IIR Filter Design; Bilinear Transformation; Fast Fourier Transform; Autocorrelation; Spectral Estimation; Statistical Digital Signal Processing.

On successful completion of this module, students should be able to:
- Derive the Fast Fourier Transform implementation of the Discrete Fourier Transform.
- Use the Z-transform for the analysis and design of Infinite Impulse Response Filters.
- Determine the performance of classical methods of Spectral Estimation.
- Design an appropriate FIR or IIR Filter, given a filter specification.
- Design an appropriate digital filter and compose a written report outlining the design choices, given an unseen signal and filtering requirement.

Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (Design Exercise).

**EE4009 Mechatronics and Industrial Automation (5 credits; Teaching Period 1 & 2)**

The objective of the module is to provide an insight into various mechatronic components and to consider the design of automation systems.

The Contents of the module are Mechatronics: Integrated product design; Sensors (Non Vision); Use of software observers; Vision Systems: Image processing techniques; Perspective Transformations; Robotics: Basic Configurations; Spatial descriptions and transformations;
Kinematics; Contromechanics with examples; Work Cells PLCs (Programmable Logic Controllers); Industrial Communications.

On successful completion of this module, students should be able to:
- Analyze a wide variety of previously unseen robotic structures including frame assignment and forward kinematic analysis, principally for the purpose of hand matrix derivation.
- Develop inverse kinematic equations and perform numerical solutions of inverse kinematics problems for robotic structures.
- Formulate interpolation-based strategies for trajectory generation for robots and other automation and servo-based systems.
- Perform analytical calculations for design purposes, and to describe and analyse some of the fundamental technologies (sensors and drives) associated with workcells and robotic systems.
- Design algorithms for the filtering of camera images and the identification of the objects therein.
- Perform calculations and develop transformations for camera-based systems relating world and image frames.
- Develop a ladder-diagram, PLC-based controller for a wide variety of automation systems.
- Carry out as a student-centred library-type project in the field of industrial communications, exemplified by the serial fieldbus, Profibus.

Assessment: Total Marks 100: End of Year Written Examination 100 marks.

EE4010 Electrical Power Systems (5 credits; Teaching Period 1 & 2)

The objective of the module is to develop the theory and application of electrical power systems tracing the processing of energy from generation, through transmission and distribution to final utilization in electrical form.

The Contents of the module are Overview of electrical power supply systems; Energy sources. Generation, transmission and distribution of electrical energy; Three-phase ac circuit theory, network equations and power flow; Unbalanced three-phase systems; Symmetrical components and sequence networks; Synchronous generators: torque equation and equivalent circuit, real and reactive power flow; Power transformers: equivalent circuit, per-unit theory, three-phase and auto-transformers, Transmission lines and faults: symmetrical and asymmetrical faults, protection, utility/consumer interface: loads, wiring, protection, system modelling.

On successful completion of this module, students should be able to:
- Appreciate the trends in global electrical energy requirements.
- Analyse the options available for bulk electrical power generation.
- Assess the environmental impact of fossil fuel, nuclear fission and hydroelectric power generation technologies and perform a critical comparison of the choices.
- Analyse the operation of synchronous generators, transformers, transmission lines and other equipment in the electrical grid.
- Analyse and solve the normal balanced operation of electrical power generation and transmission systems.
- Develop a familiarity with modern industry-standard computer aided engineering software for electrical power systems analysis and design.
- Analyse and solve the abnormal operation and protection of electrical power systems which arise from the onset of asymmetrical faults within the network.

Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (Continuous Assessment (In-class Written Examinations)).
EE4011 RF IC Design (5 credits; Teaching Period 1 & 2)

The objective of the module is to present design techniques for integrated RF transceivers. The Contents of the module are Building blocks of Radio Frequency (RF) transceivers for mobile telephone and wireless networks; Review of Active and Passive Integrated Components at RF; Measurement and Analysis Techniques for RF; RF Amplifiers; Oscillators and Frequency Synthesizers; Mixers; Modulators; Integrated RF Filters.
On successful completion of this module, students should be able to:
· Determine the 2-port parameters for RF transistors using small-signal equivalent circuit analysis and vice-versa.
· Use the Smith Chart to illustrate important RF characteristics such as matching, gain and noise performance.
· Design RF Low Noise Amplifiers using Smith Chart technique for optimum gain and noise performance.
· Partition an RF system into functional sub-blocks and describe the trade-offs between the different options for this partitioning.
· Determine the characteristics of an RF system such as noise figure, gain compression and inter-modulation.
· Analyse and Design RF Oscillators.
· Analyse and Design RF Mixers.
· Analyse and Design RF Phase Locked Loops and Frequency Synthesizers.
· Design, simulate (using a commercial standard simulator as recommended in class), and compose a written performance report pertaining to an RF element chosen from the following: RF Amplifier, RF Oscillator, RF Mixer, RF Filter, RF Frequency Synthesizer or RF System-on-Chip.

Assessment: Total Marks 100: End of Year Written Examination 80 marks; Continuous Assessment 20 marks (Design exercise).

EE4013 Renewable Energy Systems (5 credits; Teaching Period 1 & 2)

The objectives of the module are to teach the fundamental principles relating the generation of electrical energy from renewable energy sources and to examine the integration of energy from such sources into the electrical grid and to study electric and hybrid-electric vehicles and the associated energy storage and power conversion technologies.
The Contents of the module are Overview of global energy requirements; Renewable energy systems and grid integration; Basic principles of photovoltaics and cells; Concentrator photovoltaic systems; Solar tracking; Operation and control of wind farms; Electric and hybrid-electric vehicles. Fuel cells and advanced battery technology.
On successful completion of this module, students should be able to:
· Appreciate present-day global energy needs and understand the technical and environmental implications of growing electrical energy demands.
· Analyse renewable energy sources and assess the impact which the use of these devices has on the operation of the electrical grid.
· Describe the different photovoltaic technologies currently available and identify the differences between them.
· Appreciate the challenges facing the development of high-efficiency photovoltaic systems for meeting future energy needs.
· Model and simulate key wind-turbine paradigms and analyse the dynamic systems present within a typical wind-farm.
· Appreciate the need for control within a modern wind-farm and be able to design controllers for maximum power tracking, power regulation, grid support, etc.
· Analyse and model electric and hybrid-vehicle systems and components.
EE4020 Project (15 credits; Teaching Period 1 & 2)

The objective of the module is to provide students with the opportunity to apply their theoretical knowledge to a substantial electrical engineering problem requiring analytical and/or design and/or experimental effort.

The Content of the module is a topic chosen in consultation with supervisor.

On successful completion of this module, students should be able to:

- Plan an engineering project with resource and time constraints.
- Conduct research into an engineering problem including the use of printed and computer-based literature.
- Apply technical knowledge and skills to solving an engineering problem as part of a project team.
- Manage an engineering project with respect to a plan incorporating intermediate and final goals.
- Communicate the results of an engineering project by means of an oral presentation, by means of written reports and by means of a practical demonstration of the project outcomes during a public open day.

Assessment: Total Marks 300: Continuous Assessment 300 marks (Preliminary Report 15 marks; Seminar 30 marks; Open Day 30 marks; Performance 75 marks; Final Report 150 marks). (Oral if required).

EE4021 Electrical and Electronic Engineering in the Commercial Worlds (5 credits; Teaching Period 1 & 2)

The objective of the module is to introduce students to the world of commerce and broaden their engineering experience by (i) assisting students in obtaining a work placement in a commercial organisation or research institute (ii) developing career planning and transferrable skills, and (iii) developing a business understanding, with lectures, readings, and workshops on current business leaders and practices.

The Contents of the module are developing job search and transferable skills; Internship or placement in an enterprise relevant to Electrical, Electronic or Microelectronic Engineering; Commercialisation of engineering ideas and exposure to current business issues.

On successful completion of this module, students should be able to:

- (i) experience work placement in a commercial organisation or research institute; (ii) begin career planning and develop transferable skills and (iii) develop a business understanding with lectures and readings on current business leaders and thinkers.
- The student will be assisting in developing the following life skills:
  I. Researching job and careers options
  II. Developing transferable skills, such as report writing and seminar presentation.
  III. Work experience by placement in an enterprise relevant to Electrical, Electronic or Microelectronic Engineering.
  IV. Commercialization of engineering ideas and exposure to current business issues.

Assessment: Total Marks 100: Continuous Assessment 100 marks (Based on assessment of written assignments (70%) and student seminars (30%))