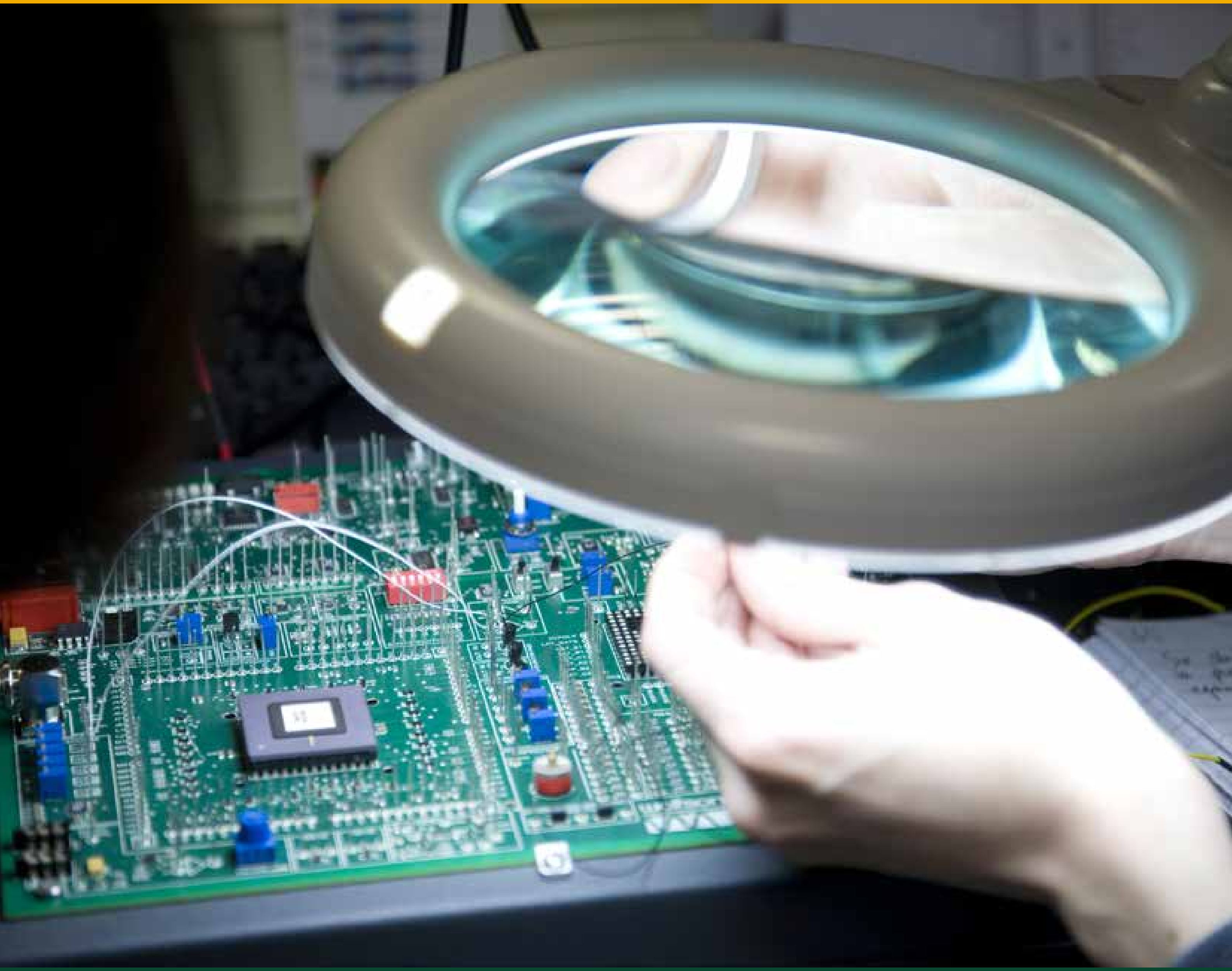
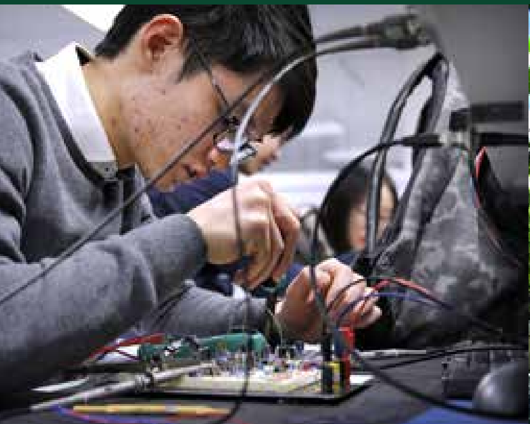
THE UNIVERSITY *of* EDINBURGH
School of Engineering

2019-2020



MSc Electronics

A world class degree in Electronics, designed to provide students with a broad understanding of modern electronics giving expertise in design, simulation and construction of electronic systems.

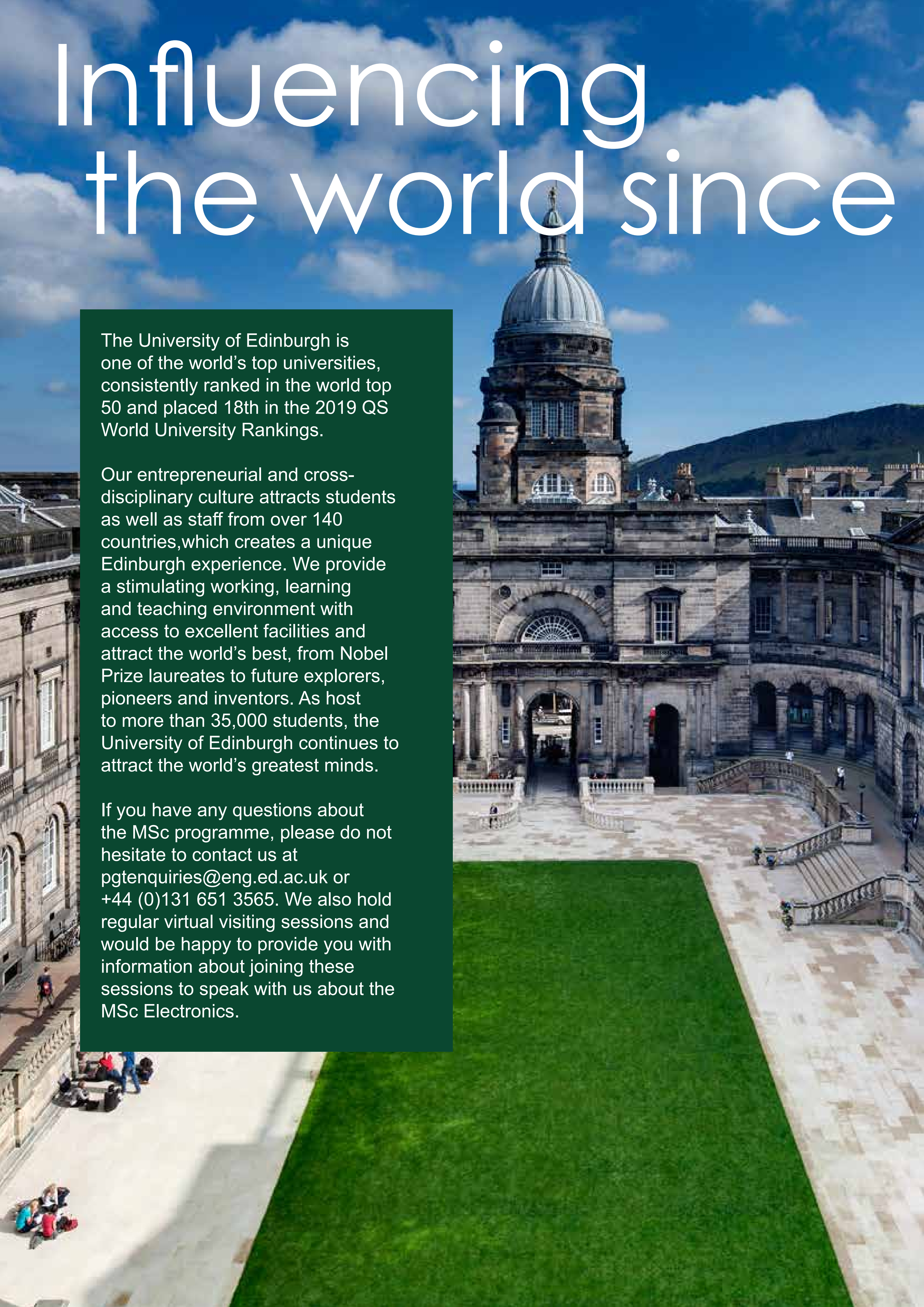


Influencing the world since

The University of Edinburgh is one of the world's top universities, consistently ranked in the world top 50 and placed 18th in the 2019 QS World University Rankings.

Our entrepreneurial and cross-disciplinary culture attracts students as well as staff from over 140 countries,which creates a unique Edinburgh experience. We provide a stimulating working, learning and teaching environment with access to excellent facilities and attract the world's best, from Nobel Prize laureates to future explorers, pioneers and inventors. As host to more than 35,000 students, the University of Edinburgh continues to attract the world's greatest minds.

If you have any questions about the MSc programme, please do not hesitate to contact us at pgtenquiries@eng.ed.ac.uk or +44 (0)131 651 3565. We also hold regular virtual visiting sessions and would be happy to provide you with information about joining these sessions to speak with us about the MSc Electronics.



Welcome from the MSc Programme Director

Thank you for your interest in the MSc Electronics at the University of Edinburgh which has been running since 2010. This programme attracts students from all over the world because of the international reputation of the University of Edinburgh and the discipline of Electronics at the School of Engineering. After graduation from the programme, our students move on to top jobs in industry or research at world class universities.

The MSc Electronics degree has many unique resources specific to the programme. These include a specialised Analogue VLSI teaching chip developed for our students and state of the art commercial software tools for integrated circuit design. In addition, we are home
to the Institute for Integrated Micro and Nanosystems' Cleanroom, a world class microfabrication facility focusing on smart microsystems technology and postprocess CMOS wafer research.

As well as lectures and tutorials to develop intellectual skills, as a student you will make extensive use of state-of-the-art laboratories, where you can develop hands on practical skills in analogue and digital electronics, preparing you for future success in industry or research.

I look forward to seeing you in September.

Dr Adam A. Stokes

Welcome From the Director of Discipline for Electronic and Electrical Engineering

The School of Engineering is proud to host a number of high quality degree programmes in the Electrical & Electronic Engineering (EEE) discipline, both at undergraduate and Masters level. Last year we had over 330 undergraduate students in Electrical Engineering from around the world, and over 100 students on EEE-related MSc programmes. These students were taught by over 30 research-active academic staff, including several industrial professors.

The vibrant set of MSc programmes included within our discipline covers Signal Processing & Communications, Sustainable Energy Systems, Electrical Power Engineering, and Electronics. These programmes give our students a unique opportunity to study their chosen field to an advanced level.

Our academic staff work across seven research institutes within the School of Engineering which covers Digital Communications, Bioengineering, Integrated Micro & Nano Systems, Energy Systems, Infrastructure & Environment, Multiscale Thermofluids and Materials & Processes. Over 300 PhD and Post-doctoral Research Associates are actively engaged in state-of-the-art research projects.

Our advanced research feeds into teaching through the MSc research projects, and up-to-date teaching materials and examples in our lecture courses. The School of Engineering continually invests in teaching, including increasing the number of teaching, support and technical staff, investing in equipment to support teaching and research projects, and ensuring lecture recording is available through the newly introduced University “Media Hopper Relay” service.

The School of Engineering is delighted that you are interested in our Masters in Signal Processing & Communications, one of our most dynamic and challenging programmes. I wish you every success in your studies.

Professor John Thompson

“We are consistently ranked in the top 50 universities in the world

At The University of Edinburgh members of the academic staff involved in teaching are also actively involved in pushing forward the boundaries of electronics research in new technology and application domains. In the field of electronics there is considerable scope for innovation that excites, such as:

- Graphene for MEMS microphones
- The application of single photon avalanche diodes
- Bioengineering and Bioelectronics
- Robotics
- Li-Fi (Light Fidelity) Wireless Communications
- Implantable Microsystems for Personalised Anti-Cancer Therapy

In today’s world it is hard to find an area of industry, business or personal life that has not benefitted from the research and skills of electronic engineers.

Introduction to Electronic Engineering

Electronic Engineering is about using technology to enhance the standard of living for everyone. Electronics focuses on the design, fabrication and application of complex integrated circuits and systems.

The subject is based upon the founding principles of electronics, but taken to advanced levels on our MSc programme, in areas such as:

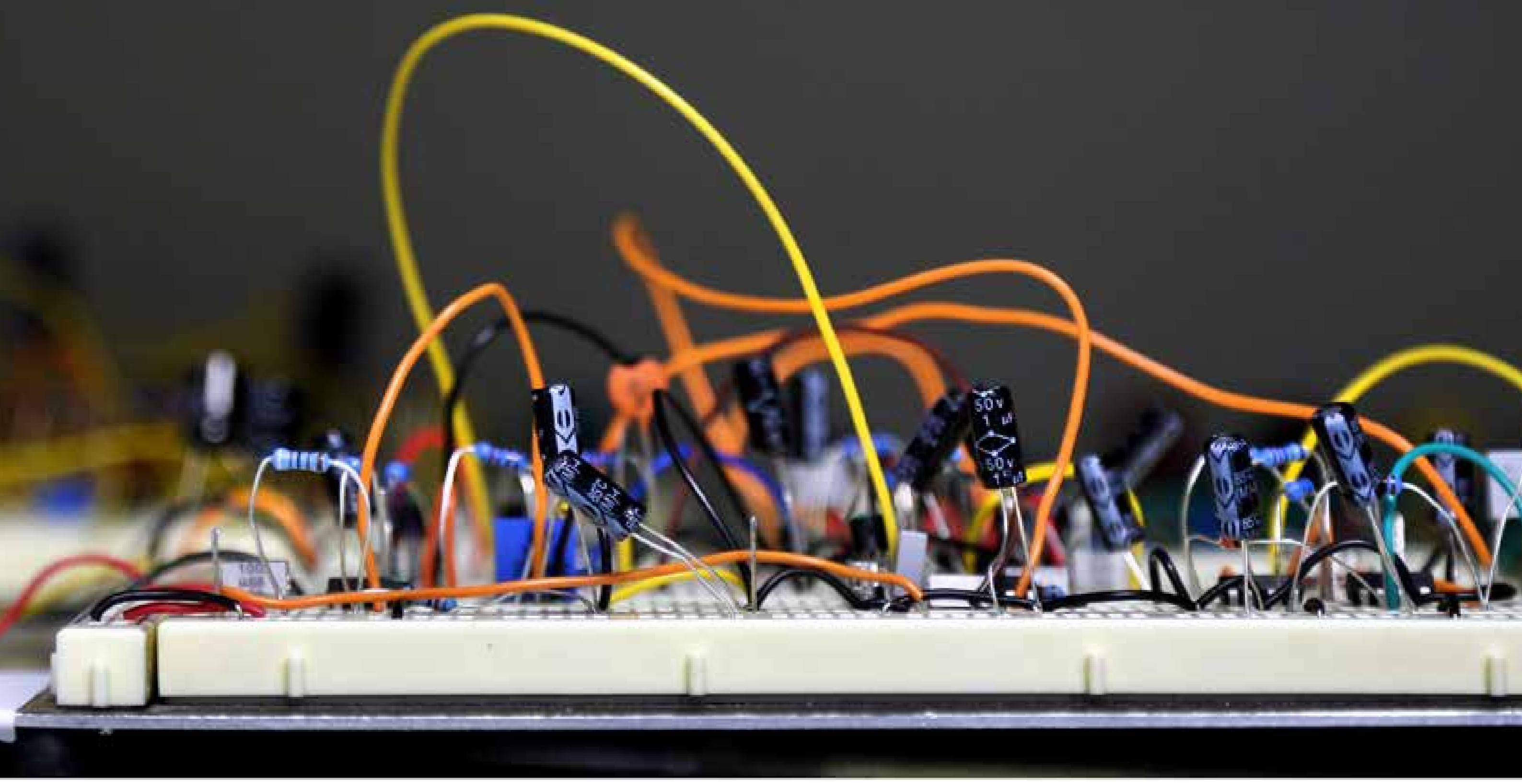
- The design of analogue electronics in VLSI systems
- The design of digital systems in application specific integrated circuits or field programmable gate arrays
- System-on-chip computing and applications
- Microfabrication processes
- Power electronics
- Bioelectronics, biophotonics and bio-MEMS

Why Pursue an Electronics MSc at Edinburgh?

Academic staff who teach on the MSc Electronics are at the leading edge of some of the most exciting advances in electronic engineering research. Electronics engineering at Edinburgh has been awarded very high ratings for both teaching and research.

In the 2014 REF results, 94% of the overall research activity produced by the Edinburgh Research Partnership in Engineering (ERPE) was assessed as world-leading or internationally excellent. You will therefore be taught by academics who are leaders in their respective fields. We also work with industry at the forefront of technologies who ensure that our teaching is relevant and up to date.

Students applying for an Electronics MSc degree will find that there is a great deal of flexibility in our degree programme with three distinct streams as follows:



- Analogue VLSI
- Analogue/Digital Electronics
- Bioelectronics

Within these streams there is a certain degree of choice over individual course selection, allowing you to tailor your degree programme to your interests.

What Does the Degree Involve?

The Electronics MSc degree involves two taught semesters in addition to a project and thesis completed over the summer period. The programme has been designed with a slightly lighter course load in the first semester to help students who are new to the city of Edinburgh and the University acclimatise to your surroundings and a new university environment. During the second semester, you will prepare for your project and thesis with discussions with your supervisor to pick out a topic and plan your research schedule.

> "Every one of our departments conducts world-leading research

Teaching and Assessment Methods

Teaching is comprised of lectures, tutorials and laboratories. Some courses have elements of continuous assessment, while others are purely examination based. Lectures are larger-scale learning environments, where a member of academic staff teaches a group of students directly.

Tutorials are more personalised learning in which smaller groups of students discuss lecture topics with a member of academic staff and complete set problems based around those topics. You will also spend a good deal of time in the laboratories, building your practical skills and putting your theoretical knowledge to the test in practical situations. Examinations follow at the end of the first semester and after the Easter break in the second semester.

Early in the New Year, you are assigned a project supervisor who you will meet with to agree a project title. You will research your project subject in the Research Project Preparation course, giving short presentations to the academic member of staff and your classmates. You will submit a report at the end of the Research Project Preparation course, which contains a summary of your background research and a plan for your project execution following the second semester examinations.

You will be guided by regular meetings with your project supervisor in the project execution phase to ensure that you are on track for thesis submission and the viva-voce examination.

What can I do after my Degree?

A select number of top performing students who excel in their research project and demonstrate the critical thinking necessary to proceed to further study may be invited to apply for a PhD with us. For further information on PhD projects, please visit: www.eng.ed.ac.uk/postgraduate/degrees/phd. For those graduates not interested in further studies, opportunities in

“We are in the top 5 for research funding in the UK

industry can be explored through our Careers Service: www.ed.ac.uk/careers/postgrad/taught-pg.

The Careers Service at the University of Edinburgh offers our graduates support throughout their degree and for two years afterwards, helping with your job search and marketing yourself effectively, as well as making career decisions to ensure that you are moving. Ranked 6th in the UK and 32nd in the world for employability*, the University of Edinburgh is an excellent choice for a postgraduate education with prospects.
*latest emerging Global Emplyability University Rankings

Within six months of finishing their MSc Electronics degree, some of our graduates were working with Pyreos, BMW Brilliance Automotive and Kongsberg Maritime.

Scholarships and Bursaries

The School of Engineering offers several scholarships and bursaries alongside those offered by the University. For more information please visit: www.scholarships.ed.ac.uk.

To find a comprehensive list of the funding opportunities that are available to you, please use the search function on the Scholarships website, found at: www.ed.ac.uk/student-funding/search-scholarships.

What is the Admissions Team Looking For?

The minimum entry requirement is a UK 2:1 degree, or its international equivalent, in electronics, electrical engineering or a closely related subject. Any appropriate professional experience will also be considered.

You will find our most up to date entry requirements at: www.ed.ac.uk/pg/669. You will also need to submit a personal statement outlining why you want to attend the MSc Electronics and an academic reference.

To read further information about the application process and advice on submitting an application please either visit the “Apply Now” page on the University of Edinburgh Postgraduate Online here: www.ed.ac.uk/studying/postgraduate/applying or email the Postgraduate Taught Office at the School of Engineering at pgtenquiries@eng.ed.ac.uk.

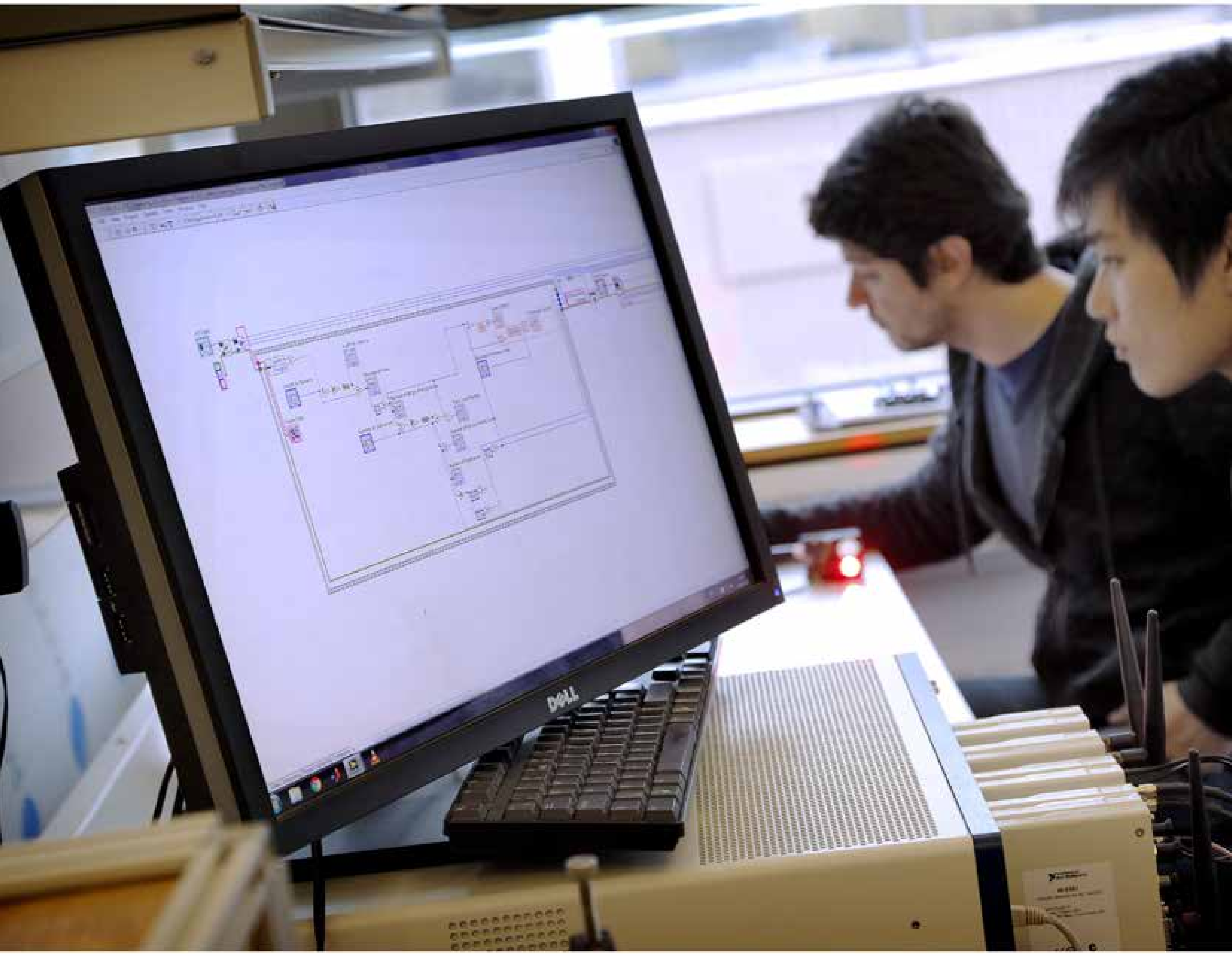
If you receive an offer to study at the School of Engineering you will be invited to attend a virtual visit session. The sessions run regularly throughout the year and you will have an opportunity to hear more about the University of Edinburgh and the School of Engineering. Applicants and prospective students can meet with staff in an online setting, listen to presentations and chat with the them using audio or text to find our more about the School and the programmes we offer.

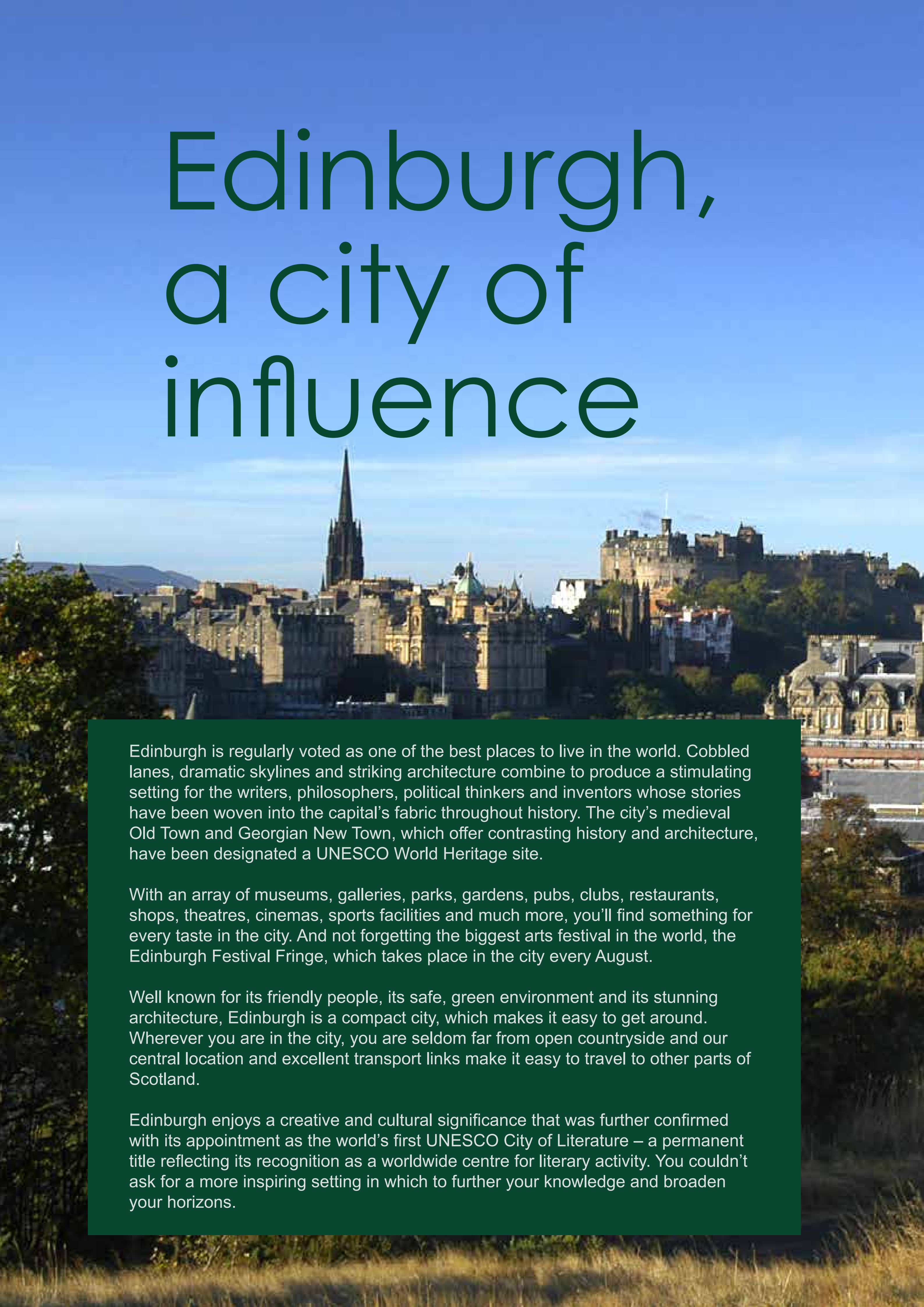
Where Are We Located?

The School of Engineering is located on the Kings Buildings campus, which is located on the south side of Edinburgh, approximately 2.5 kilometres from the Central Area. Getting to and from King’s Buildings is easy due to its excellent public transport, walking and cycling links, it is extremely well served by the public bus system. The University provides a shuttle bus between the King’s Buildings and the Central Area during term time.

For more information on travel please visit: www.ed.ac.uk/transport/travelling-here.

“At the heart of ideas and inspiration





Edinburgh, a city of influence

Edinburgh is regularly voted as one of the best places to live in the world. Cobbled lanes, dramatic skylines and striking architecture combine to produce a stimulating setting for the writers, philosophers, political thinkers and inventors whose stories have been woven into the capital's fabric throughout history. The city's medieval Old Town and Georgian New Town, which offer contrasting history and architecture, have been designated a UNESCO World Heritage site.

With an array of museums, galleries, parks, gardens, pubs, clubs, restaurants, shops, theatres, cinemas, sports facilities and much more, you'll find something for every taste in the city. And not forgetting the biggest arts festival in the world, the Edinburgh Festival Fringe, which takes place in the city every August.

Well known for its friendly people, its safe, green environment and its stunning architecture, Edinburgh is a compact city, which makes it easy to get around. Wherever you are in the city, you are seldom far from open countryside and our central location and excellent transport links make it easy to travel to other parts of Scotland.

Edinburgh enjoys a creative and cultural significance that was further confirmed with its appointment as the world's first UNESCO City of Literature – a permanent title reflecting its recognition as a worldwide centre for literary activity. You couldn't ask for a more inspiring setting in which to further your knowledge and broaden your horizons.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Semester 1: September – December

Welcome Week

Semester 1: Taught courses

Depending on which stream you take, your first semester will consist of both compulsory and optional courses that are related to Analogue VLSI, Analogue/Digital Electronics or Bioelectronics.

Exam Revision

Semester 1 Exam Diet

University closes for Christmas

Semester 2: January – April

University reopens after Christmas break

January Welcome Week

Semester 2: Taught courses

Depending on which stream you take, your second semester will consist of both compulsory and optional courses that are related to Analogue VLSI, Analogue/Digital Electronics or Bioelectronics.

Flexible Learning Week

Semester 2 resumes

Spring Vacation

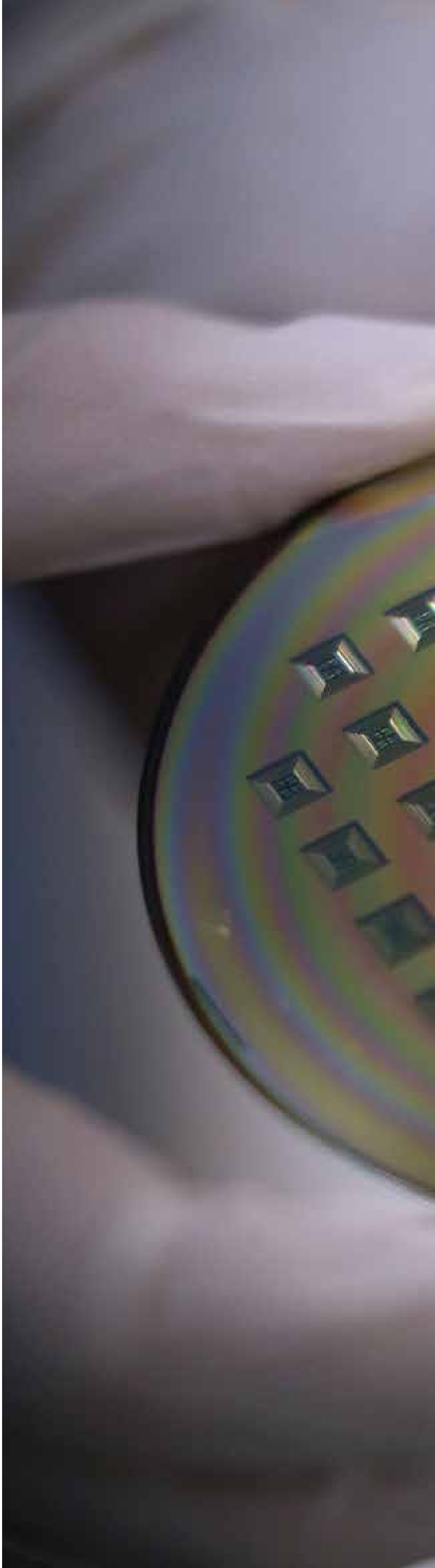
Revision Week

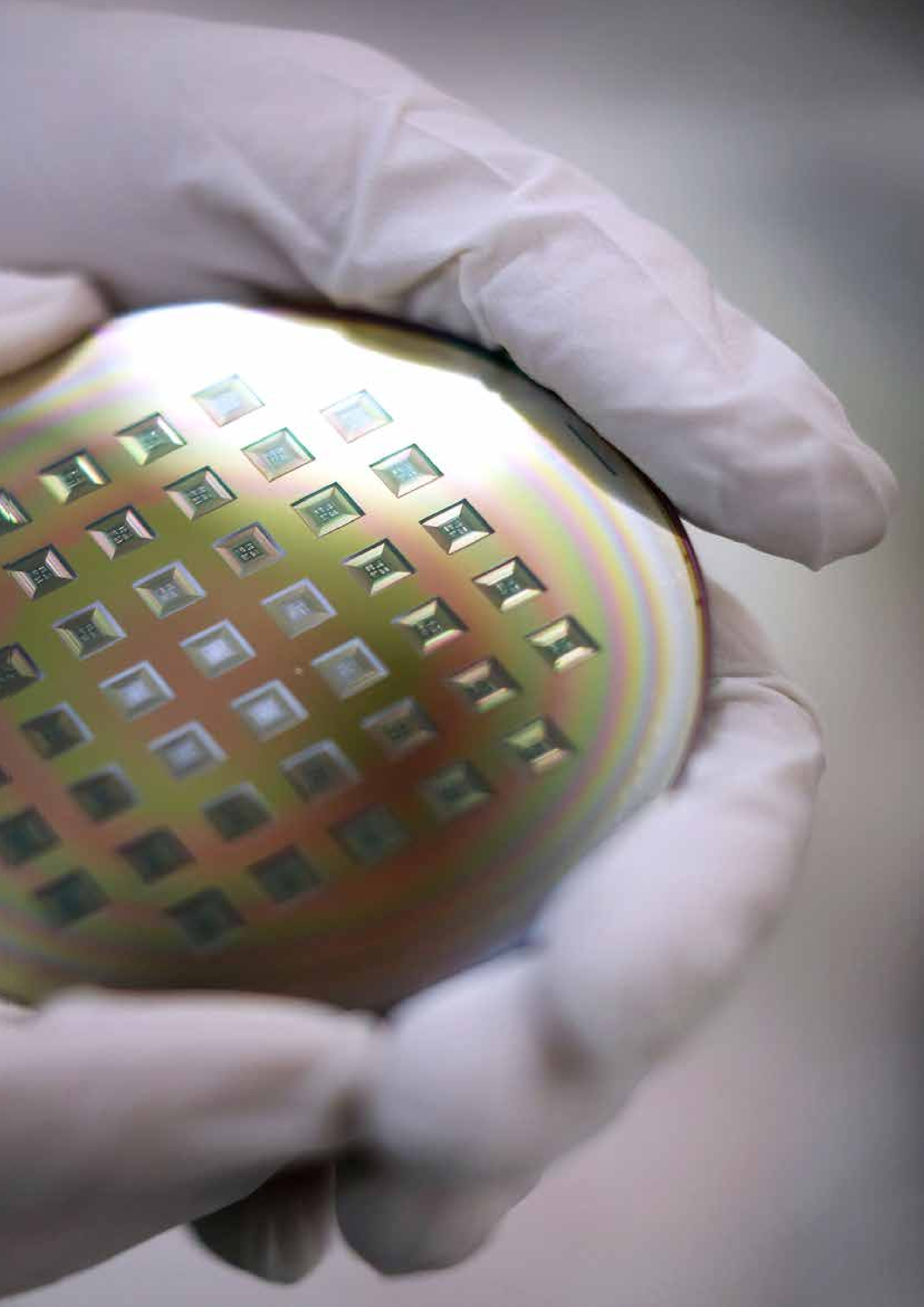
Semester 2 Exam Diet

Dissertation: May - August

Dissertation

Dissertation Submission





Course Information

All Streams: Compulsory courses

There are four compulsory courses for all students on the MSc Electronics programme: Anaolgue VSLI, Analogue IC Design, Research Project Preparation and the MSc Research Dissertation.

Students then select from one of the three streams: Analogue Stream, Analogue and Digital Stream or Bioelectronics Stream.

Students must choose compulsory and optional courses from corresponding groups. For example if you choose compulsory courses from the Analogue Stream, you must choose optional courses from the Analogue Stream.

Analogue VLSI A (20 Credits)

2 x 3 hour laboratory sessions per week; Taught in Semesters 1 and 2

The lab is centred on a custom designed ASIC. The ASIC, which was fabricated on the AMS 0.35m CMOS process, contains a number of single transistors and small sub-circuits such as current mirrors, differential stages, a bandgap reference, a simple DAC and a set of passive components.
The ASIC is mounted on a sophisticated, purpose-designed PCB that includes a PIC, a liquid crystal display, DACs, a Direct Digital Synthesis chip and many other devices that serve to support and augment the analogue ASIC. This PCB can communicate directly with a PC via a USB link. The result is a purpose-designed mixed-signal environment where analogue and mixed signal phenomena can be examined in detail.
The whole laboratory course is supported throughout by Cadence simulation, so you will see how simulation and reality fit together, where the differences lie, and how to account for them.

Analogue IC Design (10 Credits)

3 Lecture hours per week; Taught Semester 1

This module is a general introduction to analogue integrated circuit design. It will cover the following areas:

- Use of IDS equations in circuit calculations
- Use of large signal models to calculate and design transistor biasing
- Use of small signal models to calculate gain-bandwidth, transfer functions
- The operation & use of analogue circuit building blocks;
    - current sources/sinks
    - simple amplifiers
    - differential stages
    - output stages
    - basic op-amp design
    - gain and phase margin, stability, compensation
    - more advanced op-amp concepts
    - digital to analogue, and analogue to digital, converters
- Use of SPICE to simulate MOS circuits;
- Types of analysis available in SPICE, starting with level 1 MOSFET models and moving to BSIM3v3 models
- Use of SPICE to investigate the effects on performance caused by component variation, process variation, temperature changes, etc.
- Parasitic components and their importance for circuit modelling
- Sources of noise and distortion in MOS analogue circuits

Research Project Preparation (10 Credits)

3 Lecture hours per week; Taught Semester 2

This course is taken by all students and is in preparation for the MSc project. Learning Outcomes for this course are:

- Relationship with the supervisor, what can be expected from him/her and what is expected of the student.

- Time management, project planning, Gantt charts and resource planning.
- How to do a literature review.
- Use of computers during a project.
- Plagiarism. What it is and how to avoid it - the techniques employed to detect it.
- What is added value?
- How to write a MSc thesis.
- Presentation and communication skills.
- Background material including data protection, copyright and patent law, IP issues, enterprise topics, health and safety and ethics.

Electronics: Project and Thesis (MSc) (60 Credits)

Dissertation; Must be taken during Block 5 (Semester 2) and beyond

You will be able to research and carry out a project in the general field of Electronics and present your results in a viva-voce examination. The course will be assessed by consideration of the practical work you have produced via your lab notebooks and by the quality of the submitted thesis. A short viva will form part of the assessment of the thesis.

Analogue Stream: Compulsory courses

Students select exactly 60 credits of the following compulsory courses:

Analogue VLSI B (20 Credits)

2 x 3 hour laboratory sessions per week; Taught Semester 2

This course will extend your knowledge of analogue integrated circuit design to a variety of common blocks found in mixed-signal systems.

- To extend your proficiency and understanding of the design flow for analogue and mixed-signal circuits using industry-standard computer-aided design tools.
- To advance design knowledge of common analogue circuits used within mixed-signal systems.
- To carry out a design project of an integrated circuit block from specifications to layout and verification using state-of-the-art CAD tools.

This course will prepare you for work within a design team involving interaction between analogue and digital design engineers. The lecture series covers all the concepts necessary to complete the design of a cyclic analogue to digital converter in a submicron CMOS technology. The practical work of the course involves the design from specifications to layout of a 200MHz GBW fully-differential amplifier in a foundry 0.35um CMOS process. The amplifier forms the core of a 10-bit cyclic ADC covered in the lecture material. Students employ Cadence mixed-signal design tools and gain a familiarity of the complete design flow from schematic capture, analogue simulation, worst-case and yield prediction, custom layout, verification and post-layout extraction. The course is assessed on the basis of a design report (85%) and an oral design review (15%) conducted at a workstation with the design database and report available.

The lecture course synopsis is as follows: cyclic ADC operation, ADC specifications, INL, DNL, SINAD, digital error correction, differential signals, fully-differential amplifiers, common-mode feedback, cascode biasing, power-down, settling, gain, phase, output swing requirements, transistor sizing methodology, switched-capacitor circuit operation, switches, charge injection, clock feedthrough, bottom plate sampling, latched-comparators, auto-zeroed comparators, voltage reference generation, timing generation, non-overlapping clock generators, ADC system operation and simulation techniques.

Analogue Circuit Design (10 Credits)

2 Lecture hours per week; 2 Tutorial hours per week.; Taught Semester 2

This course introduces you to the important analogue circuits of active filters, sine wave oscillators, relaxation oscillators, switched capacitor circuits and phase-locked loops. The aim is to present and instil the principles of circuit operation and the essential circuit analysis and design techniques to enable students to understand and design the simpler variants of the above circuits and to be capable of extending their understanding to more complex variants. On completion of this course, you will be able to:

- Demonstrate and work with a full knowledge and understanding of the principles, terminology and conventions of analogue circuits, especially active filter circuits, oscillator circuits, switched capacitor circuits and Phase-Locked Loops (PLL)
- Use a wide range of prior knowledge (including algebraic manipulation, calculus, nodal analysis, Laplace Transforms, operational amplifier circuits, feedback, bode plots, pole/zero analysis) to analyse and design circuits in the categories given in 1 above, and to apply them to different filter sections, sine wave oscillators, relaxation oscillators, multiplier circuits, phase detector circuits, and sub-circuits that may be used in such circuits
- Analyse, specify, conceptualise and synthesise systems and applications that require the use of the circuits in 1 and 2 above, including some that were previously unknown
- Understand, and be able to analyse and mitigate, the effect of component tolerances on the performance of the circuits in 1 and 2, including the ability to select appropriate component values and types to achieve a specification.

Principles of Microelectronic Devices (10 Credits)

2 Lecture hours per week; 1 Tutorial hour per week; Taught Semester 1

The aim of this course is to provide a understanding of the physics, fabrication technology and operation of (a) a range of advanced micro technologies and (b) contemporary electronic information displays. After successful completion of this course you will or will be able to:

- Understand wave-particle duality
- Solve Schroedinger's equation for electron tunnelling
- Understand the origin of free electrons, periodic potentials and energy bands
- Know about electron transport and scattering mechanisms
- Derive the density of states in 3D, 2D, 1D
- Explain the impact of design and material properties on device performance
- Know the difference between ohmic and Schottky contacts; homo- and hetero- junctions
- Use bandgap engineering to design high electron mobility transistors, low dimensional structures
- Design simple microelectromechanical systems
- Appreciate the ubiquity and diversity of Electronic Information Displays (EIDs)
- Calculate fundamental parameters of Liquid Crystal Displays (LCDs) such as threshold voltage and switching time
- Understand, explain and design basic passive- and active-matrix addressing schemes (and their relative advantages and disadvantages) for mainstream LCD and Organic Light Emitting Diode (OLED) technologies
- Understand the manufacturing process for LCD, OLED and Thin Film Transistor (TFT) technologies
- Understand the underlying technology of emerging technologies such as microdisplays and electronic paper
- Assess the potential of emerging technologies such as microdisplays and electronic paper
- Choose an appropriate display technology to suit the constraints of a given application
- Have some appreciation of the part the human visual system plays in determining the quality of images displayed on an EID

Power Electronics (MSc) (10 Credits)

2 Lecture hours per week; 1 Tutorial hour per week; Taught Semester 1

This course introduces students to the design of power electronic circuits for low power applications. It concentrates primarily on power supplies for electronic circuits, and covers the operation and design of the most common power supply circuit topologies. Also included in this course are the design of the magnetic components required in such applications, and the design of the feedback control circuit. Students are introduced to the main characteristics of power semiconductor devices and their drive requirements. A continuous theme throughout this course is designing circuits for 'worst case' conditions, and taking into account commercial requirements as well as practical realities such as device and circuit imperfections.

Discrete-Time Signal Analysis (MSc) (10 Credits)

2 Lecture hours per week; 2 Tutorial hours per week; Taught Semester 1

You will study the theory, and the practical application, of statistical analysis to signals and systems described by random processes. The topic will be approached from both time and frequency domains with an emphasis on studying the effect that analysis tools have on the resulting analysis. The course provides in-depth coverage of the discrete Fourier transform, and its role in spectrum estimation, as well as the design of finite impulse response filters, and their role in signal identification. In particular, issues such as resolution and dynamic range of an analysis system are dealt with, to give you an appreciation of how to apply the theory to engineering problems.
You will explore the analysis of practical signals through time and frequency analysis techniques, and understand the effect of each step in the process. After successful completion of this course you should be able to:

- Explain the relationships between and be able to manipulate time domain and frequency domain representations of signals
- Apply correlation techniques to an analytic or numerical problem, and relate the outcome to the statistical properties of the signal source(s)
- Correctly define probability density functions and cumulative distribution functions, and be able to manipulate them to find moments of random variables and their sums
- Define the distinctions between wide-sense stationary, stationary, and ergodic processes, and be able to reason to which category a random process belongs
- Derive the power spectrum of a signal
- Define techniques for calculating moments in spectral and temporal domains
- Explain the importance of linear phase filter design and apply time and frequency techniques to design a FIR filter
- Evaluate power spectral density at the output of a linear filter given the PSD at the input
- Recognise the effect of resolution and windowing functions upon the discrete Fourier transform
- Analyse the effects of downsampling and upsampling on a signal and recognise the importance of decimation and interpolation filtering
- Explain the basis of matched filtering and be able to determine an appropriate filter for a given problem
- Apply a Wiener filter to the detection of a signal corrupted by additive noise, and for signal prediction.

Analogue Stream: Optional courses

Students select exactly 20 credits of the following optional courses:

Microfabrication Techniques (10 Credits)

1 Tutorial hour per week; Taught Semester 2

This module will examine the fabrication processes employed in the manufacture of microelectronic devices and microsystems. Initial lectures will cover the well-established, industry standard steps used in silicon CMOS technology. The basic science underlying the individual process steps will be presented, along with key aspects of manufacturing and production strategies. Building on this knowledge base, you will study the enabling technologies required for future advanced MEMS devices and microsystems. The lectures will not be exclusive to silicon processing, but will also examine increasingly important areas such as plastic and organic electronic device manufacture. The cleanroom facilities of the Scottish Microelectronics Centre, based at the University of Edinburgh, will allow you a unique, first-hand experience of a diverse microfabrication toolset, providing the ideal backdrop to this MSc course.

Sigma Delta Data Converters (MSc) (20 Credits)

1 x 4 hour laboratory session per week; Taught Semester 2

This course will equip you with an understanding of sigma-delta data converters at a theoretical and practical level. The coursework makes a link between the digital signal processing concepts of sigma delta conversion and implementation in integrated circuit hardware. The course will briefly review the basics of discrete-time signals and systems, before looking at block diagrams and circuit implementations of modulator structures. Saturation, stability and limit cycle behaviour of modulator loops will be described and related to circuit structure. Non-ideal behaviour of modulators such as noise, matching, finite gain and settling will be related to circuit level implementations. The course will be illustrated throughout with MATLAB, Simulink and Cadence Verilog A examples linking to laboratory sessions and a design exercise issued at the start of semester.

Technology and Innovation Management (MSc) (10 Credits)

2 Lecture hours per week; Taught Semester 2

In an increasingly competitive and fast changing economic climate innovation represents a key route for organisations that want to survive and prosper. This course addresses the area of the management of technological innovation with a critical perspective on the key role of technology.

Analogue and Digital Stream: Compulsory courses

Students select exactly 40 credits of the following compulsory courses:

Principles of Microelectronic Devices (10 Credits)

2 Lecture hours per week; 1 Tutorial hour per week; Taught Semester 1

The aim of this course is to provide a understanding of the physics, fabrication technology and operation of (a) a range of advanced micro technologies and (b) contemporary electronic information displays. After successful completion of this course you will or will be able to:

- Understand wave-particle duality
- Solve Schroedinger's equation for electron tunnelling
- Understand the origin of free electrons, periodic potentials and energy bands
- Know about electron transport and scattering mechanisms
- Derive the density of states in 3D, 2D, 1D
- Explain the impact of design and material properties on device performance
- Know the difference between ohmic and Schottky contacts; homo- and hetero- junctions
- Use bandgap engineering to design high electron mobility transistors, low dimensional structures
- Design simple microelectromechanical systems
- Appreciate the ubiquity and diversity of Electronic Information Displays (EIDs)
- Calculate fundamental parameters of Liquid Crystal Displays (LCDs) such as threshold voltage and switching time
- Understand, explain and design basic passive- and active-matrix addressing schemes (and their relative advantages and disadvantages) for mainstream LCD and Organic Light Emitting Diode (OLED) technologies
- Understand the manufacturing process for LCD, OLED and Thin Film Transistor (TFT) technologies
- Understand the underlying technology of emerging technologies such as microdisplays and electronic paper
- Assess the potential of emerging technologies such as microdisplays and electronic paper
- Choose an appropriate display technology to suit the constraints of a given application
- Have some appreciation of the part the human visual system plays in determining the quality of images displayed on an EID

Digital System Design (MSc) (10 Credits)

2 Lecture hours per week; 1 Tutorial hour per week; Taught Semester 2

This course is lecture based and is taken by all students taking the MSc in Electronics in Semester 2. It comprises one 20 lecture module. The course aims to present the principles of design re-use in the context of System-on-Chip (SoC) technology. The design and selection of soft, firm, and hard IP blocks are considered. Emerging design practices and standards are reviewed. Two target technologies are addressed: deep-submicron ASICs and field programmable gate arrays (FPGAs). On completion of this course, the student will be able to:

- Understand digital logic
- Understand the different types of computer: embedded, PCs, data-centres, supercomputing and be able to evaluate the design trade-offs
- Discern the differences between software and hardware description languages
- Evaluate processor performance: CPU time, instruction count, CPI, benchmarks, power consumption and cost effectiveness
- Evaluate the performance improvements from parallel computing architectures.

Discrete-Time Signal Analysis (MSc) (10 Credits)

2 Lecture hours per week; 2 Tutorial hours per week; Taught Semester 1

You will study the theory, and the practical application, of statistical analysis to signals and systems described by random processes. The topic will be approached from both time and frequency domains with an emphasis on studying the effect that analysis tools have on the resulting analysis. The course provides in-depth coverage of the discrete Fourier transform, and its role in spectrum estimation, as well as the design of finite impulse response filters, and their role in signal identification. In particular, issues such as resolution and dynamic range of an analysis system are dealt with, to give you an appreciation of how to apply the theory to engineering problems.
You will explore the analysis of practical signals through time and frequency analysis techniques, and understand the effect of each step in the process. After successful completion of this course you should be able to:

- Explain the relationships between and be able to manipulate time domain and frequency domain representations of signals
- Apply correlation techniques to an analytic or numerical problem, and relate the outcome to the statistical properties of the signal source(s)
- Correctly define probability density functions and cumulative distribution functions, and be able to manipulate them to find moments of random variables and their sums
- Define the distinctions between wide-sense stationary, stationary, and ergodic processes, and be able to reason to which category a random process belongs
- Derive the power spectrum of a signal
- Define techniques for calculating moments in spectral and temporal domains
- Explain the importance of linear phase filter design and apply time and frequency techniques to design a FIR filter
- Evaluate power spectral density at the output of a linear filter given the PSD at the input
- Recognise the effect of resolution and windowing functions upon the discrete Fourier transform
- Analyse the effects of downsampling and upsampling on a signal and recognise the importance of decimation and interpolation filtering
- Explain the basis of matched filtering and be able to determine an appropriate filter for a given problem
- Apply a Wiener filter to the detection of a signal corrupted by additive noise, and for signal prediction.

Digital Systems Laboratory (MSc) (10 Credits)

1 x 3 hour laboratory per week; Taught Semester 1

The laboratory aims to produce students who are capable of developing hardware-software digital systems from high level functional specifications and prototyping them on to FPGA hardware using a standard hardware description language and software programming language. The course objectives are to:

- Provide knowledge and understanding of:
  - Data paths and Control paths
  - Design options in the design of Data paths and Control paths
  - Instruction-set based Control path design
  - Control and Data path integration
  - Design capture of hardware-software digital systems in standard hardware description language.
- Intellectual:
  - Ability to use and choose between different techniques for digital system design and capture
  - Ability to evaluate implementation results (e.g. speed, area, power) and correlate them with the corresponding high level design and capture.

- Practical:
    - Ability to use a commercial digital system development tool suite to develop a hardware-software digital system and prototype them on to FPGA hardware.

Analogue and Digital Stream: Optional courses

Students select exactly 10 credits of the following optional courses:

Power Electronics (MSc) (10 Credits)

2 Lecture hours per week; 1 Tutorial hour per week; Taught Semester 1

This course introduces students to the design of power electronic circuits for low power applications. It concentrates primarily on power supplies for electronic circuits, and covers the operation and design of the most common power supply circuit topologies. Also included in this course are the design of the magnetic components required in such applications, and the design of the feedback control circuit. Students are introduced to the main characteristics of power semiconductor devices and their drive requirements. A continuous theme throughout this course is designing circuits for 'worst case' conditions, and taking into account commercial requirements as well as practical realities such as device and circuit imperfections.

Digital Systems Laboratory A (MSc) (10 Credits)

1 x 3 hour laboratory session per week; Taught Semester 1

The aim of this lab course is to produce students who are capable of developing synchronous digital circuits from high level functional specifications and prototyping them on to FPGA hardware using a standard hardware description language.

- Knowledge and understanding of:
    - Combinatorial and sequential circuits and number of ways of designing them
    - Basic and linked state machines and a number of ways of designing them
    - The importance of modular design, and design for reuse
    - The importance of a structured circuit development flow including functional specification, design, simulation, synthesis, implementation and testing
    - A standard hardware description language and how it can be used to capture digital circuit designs at different levels of abstraction
- Intellectual
    - Ability to use and choose between different techniques for digital circuit design and capture
    - Ability to evaluate synthesis results and correlate them with the corresponding high level design and capture
- Practical

Ability to use a commercial digital circuit development tool suite to develop synchronous digital circuits and prototype them on to FPGA hardware.

Analogue and Digital Stream: Optional courses

Students select exactly 30 credits of the following optional courses:

Microfabrication Techniques (10 Credits)

1 Tutorial hour per week; Taught Semester 2

This module will examine the fabrication processes employed in the manufacture of microelectronic devices and microsystems.

Initial lectures will cover the well-established, industry standard steps used in silicon CMOS technology. The basic science underlying the individual process steps will be presented, along with key aspects of manufacturing and production strategies. Building on this knowledge base, you will study the enabling technologies required for future advanced MEMS devices and microsystems. The lectures will not be exclusive to silicon processing, but will also examine increasingly important areas such as plastic and organic electronic device manufacture. The cleanroom facilities of the Scottish Microelectronics Centre, based at the University of Edinburgh, will allow you a unique, first-hand experience of a diverse microfabrication toolset, providing the ideal backdrop to this MSc course.

Modern Economic Issues in Industry (MSc) (10 Credits)

3 Lecture hours per week; Taught Semester 2

The course aims to develop an understanding of economic principles and apply them to current industrial issues. Topics covered include investment, Pricing, sustainability and the EU. On completion of the module, you should be able to:

- Assess the importance of the EU in trade.
- Appraise different methods of dealing with environmental issues in manufacturing.
- Apply economic principles to market situations (e.g. pricing and investment).

Sigma Delta Data Converters (MSc) (20 Credits)

1 x 4 hour laboratory session per week; Taught Semester 2

This course will equip you with an understanding of sigma-delta data converters at a theoretical and practical level. The coursework makes a link between the digital signal processing concepts of sigma delta conversion and implementation in integrated circuit hardware. The course will briefly review the basics of discrete-time signals and systems, before looking at block diagrams and circuit implementations of modulator structures. Saturation, stability and limit cycle behaviour of modulator loops will be described and related to circuit structure. Non-ideal behaviour of modulators such as noise, matching, finite gain and settling will be related to circuit level implementations. The course will be illustrated throughout with MATLAB, Simulink and Cadence Verilog A examples linking to laboratory sessions and a design exercise issued at the start of semester.

Embedded Mobile and Wireless Systems (EWireless) (MSc) (20 Credits)

1 x 3 hour laboratory session per week; Taught Semester 2

The course will explain the architecture of advanced wireless and Mobile systems making use of embedded processor. The course will also enable you how to design and develop such systems targeting new applications. You will be able to:

- Appreciate the hardware architecture of modern mobile phones, tables, and emerging mobile and wireless smart electronic systems
- Understand the firmware and software architecture for embedded wireless and mobile systems
- Understand the programming model associated with mobile and wireless systems
- Understand the various Interfaces such as Application Peripheral Interfaces (APIs) associated with various hardwarecomponents of the mobile and wireless systems such as sensors for example
- Understand the various Interfaces such as Application Peripheral Interfaces (APIs) associated with various software components of the mobile and wireless systems at the operating system and application levels
- Appreciate an example echo system such as Google's Android Operating system and framework
- Be able to design new components and applications for the above systems
- Will be able to design a basic embedded mobile systems with sensors and APIs
- Will be able to design and develop modules/applications or applications using the various sensors with a smart mobile phone as an example
- Will be able to design and develop modules/applications using the various wireless protocol drivers, such as Bluetooth, Wi-Fi, NFC, etc.
- Appreciate whether their new modules and applications could be exploited deeper within the smart system firmware structure
- Appreciate how various services (e.g. cloud based services) could exploit their developed software modules and applications.

Technology and Innovation Management (MSc) (10 Credits)

2 Lecture hours per week; Taught Semester 2

In an increasingly competitive and fast changing economic climate innovation represents a key route for organisations that want to survive and prosper. This course addresses the area of the management of technological innovation with a critical perspective on the key role of technology giving rise to new knowledge, products and processes. In so doing, it provides students with a clear understanding and appreciation of innovation dynamics both within and across organisational boundaries. The course draws from state of the art science, technology and innovation literatures in which Edinburgh has longstanding strengths. By making extensive use of in-depth case study materials, the course analyses opportunities and challenges related to creating, sustaining and managing innovation with a specific focus on technology-based organisations.

Bioelectronics Stream: Compulsory courses

Students select exactly 70 credits of the following optional courses:

Analogue Circuit Design (10 Credits)

2 Lecture hours per week; 2 Tutorial hours per week.; Taught Semester 2

This course introduces you to the important analogue circuits of active filters, sine wave oscillators, relaxation oscillators, switched capacitor circuits and phase-locked loops. The aim is to present and instil the principles of circuit operation and the essential circuit analysis and design techniques to enable students to understand and design the simpler variants of the above circuits and to be capable of extending their understanding to more complex variants. On completion of this course, you will be able to:

- Demonstrate and work with a full knowledge and understanding of the principles, terminology and conventions of analogue circuits, especially active filter circuits, oscillator circuits, switched capacitor circuits and Phase-Locked Loops (PLL)
- Use a wide range of prior knowledge (including algebraic manipulation, calculus, nodal analysis, Laplace Transforms, operational amplifier circuits, feedback, bode plots, pole/zero analysis) to analyse and design circuits in the categories given in 1 above, and to apply them to different filter sections, sine wave oscillators, relaxation oscillators, multiplier circuits, phase detector circuits, and sub-circuits that may be used in such circuits
- Analyse, specify, conceptualise and synthesise systems and applications that require the use of the circuits in 1 and 2 above, including some that were previously unknown
- Understand, and be able to analyse and mitigate, the effect of component tolerances on the performance of the circuits in 1 and 2, including the ability to select appropriate component values and types to achieve a specification.

Microfabrication Techniques (10 Credits)

1 Tutorial hour per week; Taught Semester 2

This module will examine the fabrication processes employed in the manufacture of microelectronic devices and microsystems. Initial lectures will cover the well-established, industry standard steps used in silicon CMOS technology. The basic science underlying the individual process steps will be presented, along with key aspects of manufacturing and production strategies. Building on this knowledge base, you will study the enabling technologies required for future advanced MEMS devices and microsystems. The lectures will not be exclusive to silicon processing, but will also examine increasingly important areas such as plastic and organic electronic device manufacture. The cleanroom facilities of the Scottish Microelectronics Centre, based at the University of Edinburgh, will allow you a unique, first-hand experience of a diverse microfabrication toolset, providing the ideal backdrop to this MSc course.

Biosensors and Instrumentation (10 Credits)

2 Tutorial hours per week; Taught Semester 2

The Biosensors and Instrumentation course examines the methods used to interface sensors for biological and biomedical applications with electronics. One focus will be on transducers, meaning devices which convert information from one form of energy to another. In this case the final form for the information will be an electrical signal but the transducers themselves could be optical, mechanical, etc., and operate in a number of different ways (eg., capacitive, potentiometric, photonic). The objective is to build upon the knowledge that you will have gained in the introductory courses in Semester 1 on bioelectronics and biosensors but with more of an electronics and electrical engineering focus. This course will also go beyond sensing to look at methods of actuation for closed loop “smart” systems. Examples from the state of the art in biosensor research will be provided and a number of guest lectures from active researchers in this field will provide context. You will undertake a “horizon scanning” research exercise to investigate the industrial and research potential of a specific type of biosensor. This will be assessed by both formal reports and a presentation given to and marked by the whole class.

Biosensors (10 Credits)

2 Tutorial hours per week; Taught Semester 1

This course provides instruction in the basic science and engineering concepts required to understand the design and application of biosensors. These are defined as self-contained integrated devices capable of providing analytical information, using a biological recognition element in conjunction with a secondary transduction element. Different biosensor systems are explored, ranging from electrochemical devices, through to optical or thermal systems. Instruction is also given in the general principles of sampling and analysis, statistical presentation and manipulation of data. This module serves as an introduction to some of the biosensors and measurement techniques covered in the semester 2 course Biosensors & Instrumentation. This introductory course begins by defining the basic concept of a biosensor and what differentiates this from any other chemical sensor. Additional background reading is supplied providing information on basic concepts in chemistry, thermodynamics and cell biology. The course is taught through lectures and tutorials by two academics with research experience in this field. Typically there will be 2-3 additional guest lectures on current active biosensors research at The University of Edinburgh. The course is partly assessed through a final exam and partly through an assignment where students will research a particular biosensor topic and present their critical review in the form of a written report.

Lecture topics include (but are not limited to):

- Chemical Sensors and Biosensors
- Biosensor Design
- Introduction to Electrochemistry
- Electrochemical Sensors
- Control of Electrode Reactions
- 3-Electrode Systems and Reference Electrodes
- Ion Sensitive Electrodes
- Electrochemical Biosensors
- Electrochemical Impedance Spectroscopy
- Molecular bonds and spectroscopy
- Fluorescence in Biosensing

You will be expected both to gain an understanding of the basic concepts of biosensing technology, and an appreciation of the state of the art and future directions.

Lab-on-Chip Technologies (10 Credits)

1 hour per week; 1 Tutorial hour per week; Taught Semester 2

This module will outline the basic concept of devices that integrate one or several laboratory functions on a single chip, and how they can offer advantages specific to their application. Such advantages include: low fluid volumes that lead to lower reagent costs and smaller biological samples for diagnostic purposes; faster analysis and response times that also provide better process control; the ability through parallel processing to provide high-throughput screening; and inherent low fabrication costs that make disposable chips economically viable. The influence of the scaling-down of dimensions on the physico-chemical behaviour of fluids and chemical reactions will also be covered. Current applications of lab-on-chip devices will be given.

Introduction to Bioelectronics (MSc) (10 Credits)

2 Lecture hours per week; Taught Semester 1

Bioelectronics involves the application of electronic engineering principles to biology, medicine, and the health sciences. An important part of this is the development of the communication interface between biological materials (cells, tissue and organs) and electronic components. This course introduces the biochemical, biophysical and physiological concepts that are of relevance to bioelectronics, and will also serve to provide introductory material that will be extended in other courses (namely BioSensors, Biosensors and Instrumentation, and Lab-on-Chip Technologies). Upon completion of this course, you will develop an understanding that will form of the basic physico-chemical properties of proteins and DNA, and the physiological properties of membranes, cells, tissues and some organs, together with an appreciation of the relationship between structure and function. The distinction between the passive and active electrical properties of membranes will be understood, along with the origins of electrical signals emanating from the brain (electroencephalography) and heart (electrocardiogram). A working understanding of the design and use of bioelectrodes will also be attained.

Applications of Sensor and Imaging Systems (10 Credits)

1 Lecture hour per week; 1 Tutorial hour per week; Taught Semester 2

You will apply the knowledge gained from the taught courses in Semester 1 and Semester 2, to an individual project on an intellectually demanding R&D topic under the guidance of a supervisor. It consists of two main elements and you will perform the research project independently with the minimal of practical supervision necessary to meet your projects' broad aim and objectives. By the end of the course you should be able to

- Understand and appreciate the constraints and limitations of a given ISM system in a given application or range of applications
- Compare, contrast and select the most appropriate sensor modality(s) to meet the requirements of an application or range of applications
- Prepare or assimilate a detailed sensor system specification or application requirement.

Bioelectronics Stream: Optional courses

Students select exactly 10 credits of the following optional courses:

Principles of Microelectronic Devices (10 Credits)

2 Lecture hours per week; 1 Tutorial hour per week; Taught Semester 1

The aim of this course is to provide a understanding of the physics, fabrication technology and operation of (a) a range of advanced micro technologies and (b) contemporary electronic information displays. After successful completion of this course you will or will be able to:

- Understand wave-particle duality
- Solve Schroedinger's equation for electron tunnelling
- Understand the origin of free electrons, periodic potentials and energy bands
- Know about electron transport and scattering mechanisms
- Derive the density of states in 3D, 2D, 1D
- Explain the impact of design and material properties on device performance
- Know the difference between ohmic and Schottky contacts; homo- and hetero- junctions
- Use bandgap engineering to design high electron mobility transistors, low dimensional structures
- Design simple microelectromechanical systems
- Appreciate the ubiquity and diversity of Electronic Information Displays (EIDs)
- Calculate fundamental parameters of Liquid Crystal Displays (LCDs) such as threshold voltage and switching time
- Understand, explain and design basic passive- and active-matrix addressing schemes (and their relative advantages and disadvantages) for mainstream LCD and Organic Light Emitting Diode (OLED) technologies

- Understand the manufacturing process for LCD, OLED and Thin Film Transistor (TFT) technologies
- Understand the underlying technology of emerging technologies such as microdisplays and electronic paper
- Assess the potential of emerging technologies such as microdisplays and electronic paper
- Choose an appropriate display technology to suit the constraints of a given application
- Have some appreciation of the part the human visual system plays in determining the quality of images displayed on an EID

Digital Systems Laboratory A (MSc) (10 Credits)

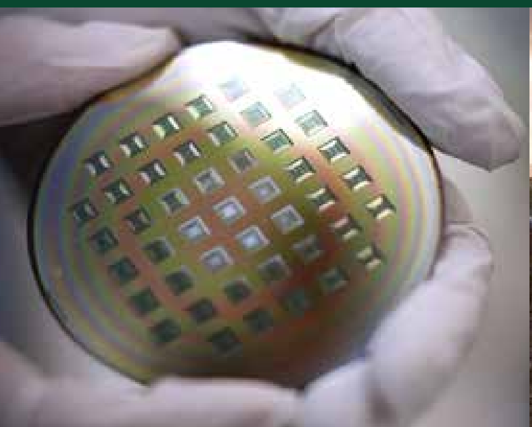
1 x 3 hour laboratory session per week; Taught Semester 1

The aim of this lab course is to produce students who are capable of developing synchronous digital circuits from high level functional specifications and prototyping them on to FPGA hardware using a standard hardware description language.

- Knowledge and understanding of:
    - Combinatorial and sequential circuits and number of ways of designing them
    - Basic and linked state machines and a number of ways of designing them
    - The importance of modular design, and design for reuse
    - The importance of a structured circuit development flow including functional specification, design, simulation, synthesis, implementation and testing
    - A standard hardware description language and how it can be used to capture digital circuit designs at different levels of abstraction
- Intellectual
    - Ability to use and choose between different techniques for digital circuit design and capture
    - Ability to evaluate synthesis results and correlate them with the corresponding high level design and capture
- Practical

Ability to use a commercial digital circuit development tool suite to develop synchronous digital circuits and prototype them on to FPGA hardware.

The University of Edinburgh is ranked 18th in the world by the QS World University Rankings 2019.



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