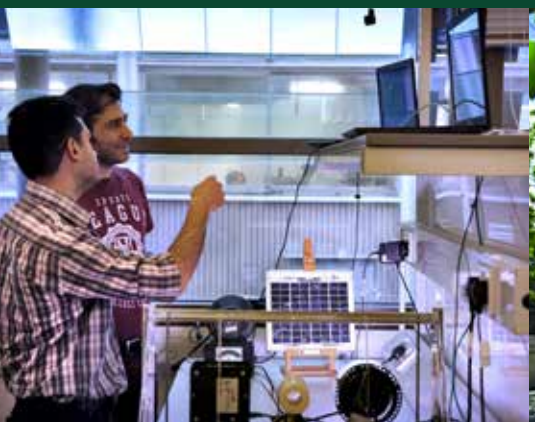
THE UNIVERSITY *of* EDINBURGH
School of Engineering

2019-2020

MSc Electrical Power Engineering (1 year)
MSc Advanced Power Engineering (2 years)

Two innovative postgraduate programmes with a strong focus on modern power engineering technologies including renewable energy conversion, advanced electric machines and smart grids, delivered by the world-leading Institute for Energy 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 either of the MSc programmes, 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 MScs in Electrical Power Engineering and Advanced Power Engineering.

Welcome from the MSc Programme Director

Thank you for your interest in the Edinburgh Masters in Power Engineering. This brochure provides a comprehensive presentation of the two programmes we offer, namely the one-year MSc in Electrical Power Engineering and the new for 2018-19, two-year MSc in Advanced Power Engineering.

The one-year MSc in Electrical Power Engineering (EPE) degree covers the fundamentals of electrical power as well as the state of the art in industry. Students of this degree follow a structured taught programme during the two semesters, and then carry out a dissertation during the summer term, working alongside our world-leading researchers, within the Institute for Energy Systems.

Our new, two-year full-time MSc in Advanced Power Engineering (APE) degree shares the same structured taught component with the MSc EPE, but following the summer break, students carry out a much larger research project spanning over the two semesters of their second year of study. Our students have the option to either conduct academic research in collaboration with one of our research groups, or an industrial project with one of our partnering companies.

We very much hope you will select Edinburgh as the next step of your academic life and become a member of our international community of learners, for life. See you in King's Buildings, in September!

With warm regards,

Dr Aristides E Kiprakis SMIEEE MIET

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

The Power Engineering Industry

As the demand for electrical power is set to increase worldwide over the next few decades, electrical power systems will need to be continuously upgraded and expanded, but modern power systems must be designed with the challenge of addressing the Global Energy Trilemma in mind, i.e. provision of secure, equitable and environmentally sustainable energy.

The increased energy demand, the uptake of environmentally friendly but intermittent renewable generation, and the introduction of new technologies such as electric vehicles, LED lighting and battery storage, impose technical challenges that traditional power engineering equipment, systems and processes can only address with limited success. Disruptive solutions such as novel electric machines, advanced power electronic devices, systems and control, as well as emerging network topologies and operating paradigms, such as microgrids and the smart grid, will be required to be adopted if the above challenges are to be met.

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

For this to happen, a new generation of highly skilled electrical power engineers is required, able to analyse, design and operate power components and systems at a wide range of different scales. Making use of its world-leading teaching and research track record, facilities and academic staff, the University of Edinburgh offers these Master's degrees in Electrical and Advanced Power Engineering, specifically tailored to the interests of our students and the needs of the industry.

Why Pursue a Power Engineering MSc at Edinburgh?

Now celebrating its 150th year since its establishment, engineering research and education at Edinburgh is one of the best in the country and highly respected at international level. In the 2019 QS University Rankings the University is placed 18th in the world; within this ranking we are in the top-3 UK universities offering power engineering Masters and the top UK university offering a 2-year programme in this area.

The School of Engineering has also been awarded the highest possible ratings for 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.

Our teaching staff are in the forefront of the sector, conducting cutting-edge research. A few of the flagship current and recent projects include:

- The UK EPSRC Centre for Energy Systems Integration (CESI)
- The EU FP7 Initial Training Network 'ADVANTAGE' on Smart Grids
- The UK EPSRC Centre for Advanced Materials for Renewable Energy Generation (CAMREG)
- The UK EPSRC Centre for Marine Energy Research (UKCMER)
- The EU FP7 DTOCEAN on Marine Energy Optimisation and Integration

Our objective is to train the next generation of power engineers who are aware of the most recent, cutting edge developments in power engineering, and have the skills and training needed for the most demanding industrial and academic settings. These postgraduate programmes are designed to provide a solid basis in current developments associated with the trends in the power industry through a combination of taught modules, workshops, a summer dissertation (MSc EPE) or a full-year research project (MSc APE), and a number of supporting activities delivered by our internationally leading experts in the field.

What Do the Degree Involve?

The programmes develop throughout the first two semesters from advanced fundamental topics and research tools and techniques in electrical power engineering (1st semester), to specialist courses on emerging technologies and advanced numerical methods for power engineering problems (2nd semester). The taught component of the programmes is then followed by the summer dissertation (MSc EPE) or the year 2 reseasrch projects (MSc APE), where the acquired skills in various areas are put into practice in application to an actual power engineering problem.

For their year 2 research project, students of the MSc in Advanced Power Engineering have two options:

- undertake an industry-led project in collaboration with one of our partnering companies
- conduct academic research within one of our reserach groups

Upon completion of the programme our graduates are up-to-date in topics covering the current state-of-the-art developments in electrical power engineering, including modern approaches to the analysis of properties, dynamics and control of power networks, machines and converters.

We also will help you develop your conceptual and analytical skills for the critical evaluation of the current scientific literature in specialised topics within the electrical power engineering realm. You will have training in teamwork, innovation and scientific communication and will develop skills in the planning and execution of a tailored research project.

Teaching and Assessment Methods

Teaching is comprised of a broad range of learning methods including conventional classroom and laboratory based lectures, tutorials and student-directed learning, backed up by a range of innovative teaching activities, and assessed by means of written examinations and project work. 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. The University has an expanding network of video capture-ready classrooms which are utilised for most of our courses.

Supervised Research

The research projects are determined early during second semester. Students have occasional meetings with academic supervisors and do some initial work such as literature review, preparatory work required by the topic, and determination of a work plan. The Mission Statement is submitted in April.

For the MSc in Electrical Power Engineering, the main phase of the research work starts after the May exams. In mid-June a project seminar takes place, where students present their plans for their research. Around mid-August, the work is completed and the dissertation is submitted. A poster, presented to the Institute for Energy Systems is the final deliverable.

For the MSc in Advanced Power Engineering the Year 2 research project starts in early September, following the

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

summer break. In mid-October students attend the project seminar, setting out a detailed work plan for their research work. At the end of December the students submit the Phase 1 report and receive formative feedback. Following the Christmas break, they attend a 1:1 progress review with their project examiner. Work is completed in April and the final report is submitted. Students are then required to prepare the final project deliverable, which is a presentation of their research and results, given to the Institute of Energy Systems.

Our Power Engineering Community

At Edinburgh we treat our students as our extended family and we hope that they see us, the staff, in the same way. Throughout the year, there are many events that bring together everyone associated with Power Engineering at Edinburgh: students, staff and industrial partners. Many of these events are organised by the students themselves, who run a series of seminars, industrial visits and socials including BBQs. We hope to see you there and welcome you into our community!

Links to Industry

The Edinburgh Masters in Power Engineering make use of the extensive links the Institute for Energy Systems has built over the years with industry, including companies such as Scottish Power, Scottish & Southern Energy, Costain Group, Arup, Flexitricity and General Electric. An Industrial Advisory Board has been set up to provide advice and feedback on the content of the programme and we have industrialists providing regular and direct input to the teaching process, such as invited lectures and topics and industrial advice to the MSc projects. We also utilise the recruitment events organised by or for the School of Engineering. Throughout the year there are a multitude of networking opportunities and events oriented at introducing our MSc students to the industrial representatives, but also encouraging their engagement with the wider vibrant University of Edinburgh power engineering community.

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Scholarships and Bursaries

The School of Engineering and the University of Edinburgh offer many scholarships and bursaries. Three programmes that regularly support our MSc students are the Chevening, the Avangrid and the Engineering International Scholarship schemes. If you fit the criteria, we would encourage you to apply to any of these funding programmes. For more information visit the University's scholarships website: www.ed.ac.uk/student-funding/ postgraduate or the MSc EPE webpage: https://edin.ac/msc-epe. and the MSc APE webpage: https://edin.ac/msc-ape.

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.

The Institute for Energy Systems at the School of Engineering has strong links with industry, including companies such as Scottish Power, Scottish & Southern Energy, Costain Group, Arup, Flexitricity, General Electric and more. Graduates of our programmes regularly take up posts within these and other companies.

A strong transferrable skills programme is available to our students through the university's Institute for Academic Development, which includes the opportunity to attend workshops on writing and presentation skills, advanced English courses, CV surgery workshops etc. The Careers Service at

At the heart of ideas and inspiration

the University of Edinburgh (www.ed.ac.uk/careers/postgrad/taught-pg) offers our graduates support throughout their degree and for two years afterwards. The Careers Service can help with your job search and marketing yourself effectively, as well as making career decisions to ensure that you are moving towards your goals.

What is the Admissions Team Looking for?

The minimum entry requirement for both programmes is a UK 2:1 degree, or its international equivalent, in electrical/electronic engineering or a closely related subject. Other related backgrounds may be considered on a case-by-case basis. Appropriate professional experience will also be considered. You will find our most up to date entry requirements at: www.ed.ac.uk/pg/937 (MSc EPE) and www.ed.ac.uk/pg/960 (MSc APE). A personal statement is also required, outlining your motivation for postgraduate study in power engineering. You will also need to provide a recent 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. Getting to and from King’s Buildings is easy due to its excellent public transport, walking and cycling links. King’s Buildings campus is approximately 2.5 kilometres from the Central Area and 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.

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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Timeplan: MSc EPE & 1st year MSc APE

Semester 1: September – December

Welcome Week

Semester 1: Fundamentals

During this first semester you will study fundamental material on electrical power engineering.

Exam Revision

Semester 1 Exam Diet

University closes for Christmas

Semester 2: January – April

University reopens after Christmas break

January Welcome Week

Semester 2: Application

During the second semester you will build on the knowledge gained in first semester and study advanced and modern topics in power engineering. Dissertation topics will be determined in late January.

Flexible Learning Week

A week of university-wide extracurricular activities to augment your learing experience. (mid-February).

Semester 2 resumes

Spring Vacation

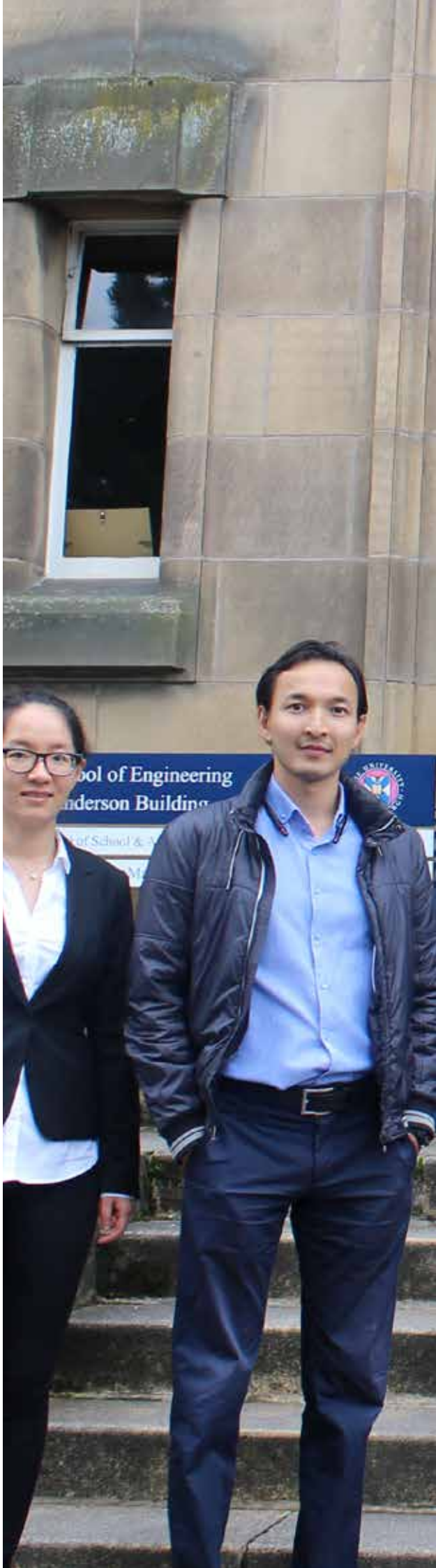
Exam Revision

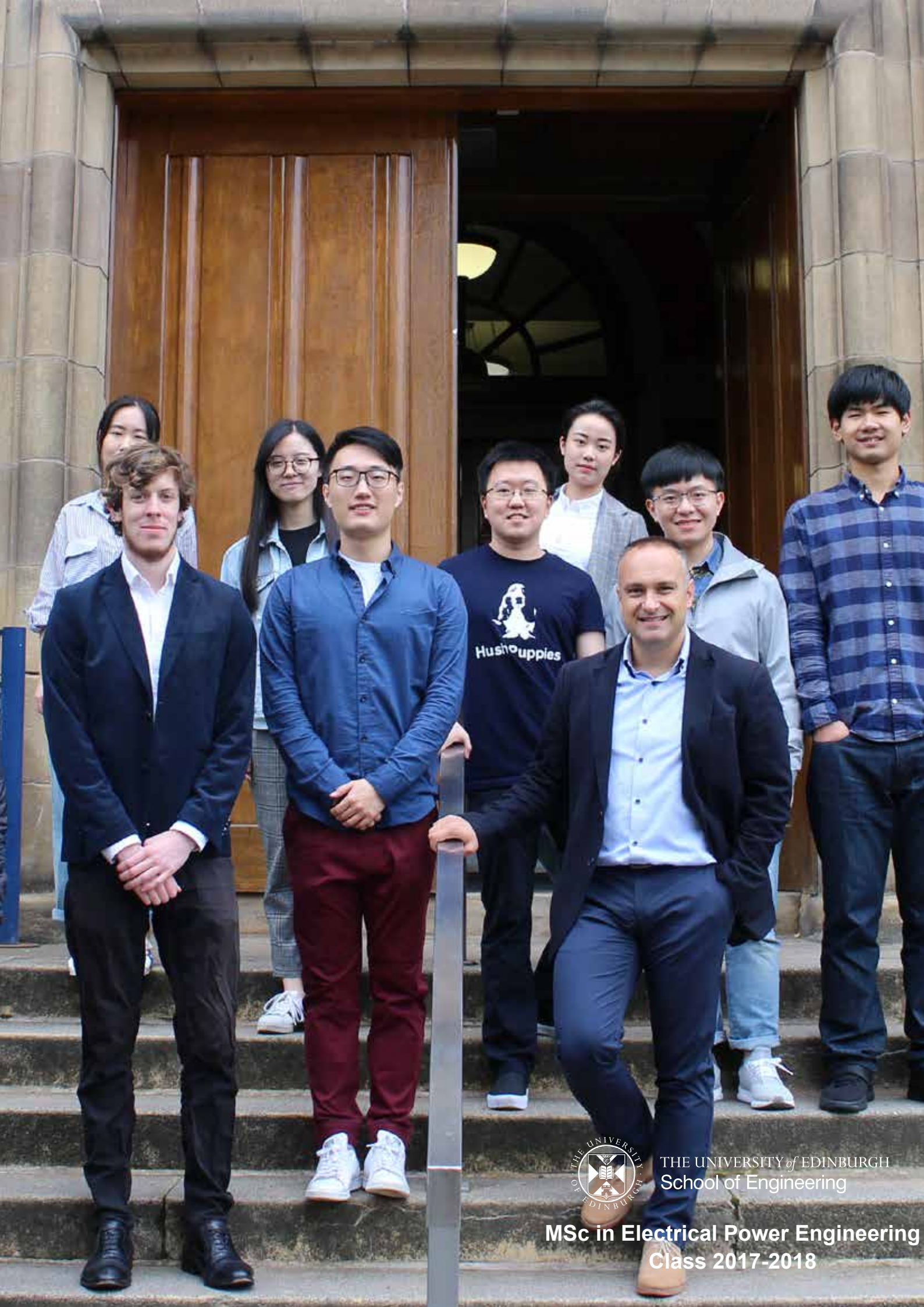
Semester 2 Exam Diet

Dissertation: May - August (MSc EPE only)

Dissertation

Dissertation Submission





THE UNIVERSITY *of* EDINBURGH
School of Engineering

MSc in Electrical Power Engineering
Class 2017-2018

Timeplan: Year 2 (MSc APE)

Semester 1: September – December

Welcome Week

Semester 1: Project Phase 1

First phase of research work commences in September

Project Seminar

You will present your inital work and project plan to supervisors and the class.

Submission of Phase 1 Report

Short report of progress submitted and feedback is provided

University closes for Christmas

Semester 2: January – April

University reopens after Christmas break

January Welcome Week

Progresss Review

You will attend a 1:1 interview with your project examiner to review your progress and discuss remaining work.

Flexible Learning Week

A week of university-wide extracurricular activities to augment your learing experience. (mid-February).

Semester 2 resumes

Spring Vacation

Final Report Submission

Final report is submitted around the third week of April.

Semester 2 Exam Diet

You will present your findings to the Institute for Energy Systems in the last week of April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Course Information

Semester 1 Courses

Power Systems & Machines

Compulsory course; 10 credits; 22 Lecture hours, 10 Tutorial hours. Assessment: 100% exam based

This course provides students with a good knowledge and understanding of: the steady state performance, the transient behaviour and control of synchronous machines; power system protection equipment; principles of overcurrent protection of power systems and machines; operation and protection of distributed generators. A number of relevant technical and engineering aspects of the analysis of steady state and transient performance of electrical machines and power supply systems will be considered in the context of operation, protection and control of power supply systems with distributed generation, including their application during the system design and operational stages.

Power Conversion

Compulsory course; 10 credits; 22 Lecture hours, 10 Tutorial hours. Assessment: 100% exam based

This course will develop understanding of fundamental power electronic building blocks and modulation techniques, employed in solid-state power converters. The concept of switch mode power conversion will be developed starting with basic circuits and extended to more complex topologies and functions, including the generation of two and three phase ac waveforms. The course will introduce a range of power electronic devices and show how the properties these devices affect the design and performance of power converters. A range of case studies will be used to illustrate how power electronics may be applied to a real world applications.

Power Engineering Research Techniques

Compulsory course; 10 credits; 9 Lecture hours, 12 Lab hours, 9 Project Workshop hours. Assessment: 100% coursework based

This course aims to equip students with essential skills for power engineering research and comprises three parts:

Research Methods: students study essential topics for the completion of a research project such as literature surveying, project planning
& reporting, time management, Gantt charts, plagiarism & Intellectual Property issues, presentation of research outcomes etc.

Power Engineering Modelling Techniques: working in the computer laboratory, in the following four weeks students will gain experience in using software tools such as Matlab/Simulink to model power systems & machines.

Power Engineering Group Project: the final part of this course will require students to work in small groups and deliver a research project in power engineering. The project will allow them to use all the skills and tools they learned earlier in this course and will conclude with the submission of a report and preparation and presentation of a poster.

Technologies for Sustainable Energy

Compulsory course; 10 credits; 22 Lecture hours, 10 Tutorial hours. Assessment: 100% exam based

This course aims to provide an introduction to the engineering principles and designs underpinning key sustainable / renewable energy technologies. It is structured to familiarise students with an analytical toolkit to allow them to independently appraise such technologies and their role in the energy system. The course offers a reasonably in-depth introduction to renewable energy technologies. It sets renewable energy in the wider context and develop a basic qualitative and quantitative toolkit for appraising technologies. It examines each of the major technologies covering aspects such as: resource, conversion technologies, practicalities, economics and environmental impacts. Finally it briefly examines how renewables can be integrated effectively within the energy system.

Energy and Environmental Economics

Compulsory course; 10 credits; 22 Lecture hours. Assessment: 100% coursework based

The aim of this course is to provide a theoretical grounding in economics from first principles, exploring the fundamental principles of efficiency in the distribution of resources in society. These principles are then applied in the fields of energy and the environment. No prior knowledge of economics is assumed.

Advanced Control for Power Engineering

Compulsory course; 10 credits; 22 Lecture hours, 11 Tutorial hours. Assessment: 100% exam based

The course starts with a revision of dynamic systems, in the context of electrical power systems, leading to the derivation of state space models. Criteria for system stability and observability of multivariable systems are studied. The methods to design control structures based on feed-forward and feedback loops are then presented, using techniques such as pole placement or optimal regulator methods.

The course develops the analytical tools for the design of appropriate controllers to improve system performance. The design of observers to supplement measurements from sensors will be also introduced. The development of the theoretical and practical frameworks around discrete-time systems will then allow the implementation of controllers on digital platforms.

The students will be asked to implement the control techniques learned during the course in Matlab / Simulink models to familiarize themselves with control dynamics and design of MIMO systems.

Semester 2 Courses

Power Electronics for Energy Systems

Compulsory course; 10 credits; 20 Lecture hours, 11 Tutorial hours. Assessment: written exam 70%, coursework 30%

This course builds on the material covered in the 1st semester Power Conversion course. It expands the study of power electronic converters in high power utility scale and drive system applications. Topics covered include applications of power electronics in energy systems; modelling and modulation of three phase inverters including the use of two axis representations; high capacity, high voltage power converters including thyristor based and modern multi-level voltage source converters; Flexible AC Transmission Systems (FACTS); power electronics for HVDC systems.

The course focuses on circuit topologies, modulation and models for power converters. Example applications are used to illustrate the role of these devices in modern power systems.

Advanced Electrical Machines

Compulsory course; 10 credits; 22 Lecture hours, 10 Tutorial hours. Assessment: 100% exam based

The course introduces students to the more fundamental design aspects of electrical machines, rotary and linear, in particular electromagnetic analysis for machines. Magnetic circuit modelling and finite element modelling methods are introduced to enable calculation of magnetic fields and forces within electromagnetic devices. Modelling of different materials are included. These techniques are then applied to induction machines, permanent magnet machines and switched reluctance machines. For induction machines stator winding and squirrel cage rotor design is included. D-Q analysis is introduced as a way of modelling transient behaviour of machines. Real-world examples are used troughout for applications such as electric vehicles, MAGLEV systems, and renewable energy converters.

Power Systems Engineering & Economics

Compulsory course; 20 credits; 50 computer workshop hours. Assessment: 100% coursework based

This course provides students with a good theoretical knowledge and understanding of power system analysis and operation, including hands-on power system modelling experience. Operation of electricity generation, transmission and distribution systems with increasing renewable content will be analysed using iterative methods for solving network power flow equations and simulated in a power-flow simulation software package (PowerWorld). The basic principles of power system economics (main regulatory regimes and pricing principles) will be analysed in order to combine power system analysis and economic appraisal, providing an insight and ability to estimate future developments. Technical and economic implications of transition to a low-carbon energy systems will be discussed.

Semester 2 Optional Courses

In the 2nd semester the students must select one of two sets of course options: the first option is suited to students mostly interested in the distibution and utilisation of electricity, while the second is suited to students wanting to specialise in renewable energy conversion technologies.

Option A: 1 x 20 credit course

Distributed Energy Resources and Smart Grids

Compulsory course; 20 credits; 33 Lecture hours, 11 Tutorial hours. Assessment: written exam 75%, coursework 25%

This course introduces existing and emerging power engineering technologies in the areas of distributed energy resources (DERs) and the smart grid, from concept and basic theory to real-world applications. It covers distributed renewable generation including wind, solar and hydro plants, various energy storage technologies as well as the impact of modern loads such as electric vehicles, heat pumps and LED lighting on the power system. It introduces the concepts of load management, demand response and active network management. Finally it gives a holistic overview of the constituent technologies of the smart grid, including power network components, control, information and communications technologies and smart metering.

Option B: 2 x 10 credit courses

Solar Energy & Photovoltaic Systems

Compulsory course; 10 credits; 20 Lecture hours, 6 Tutorial hours. Assessment: written exam 80%, coursework 20%

This course presents and assesses the fundamentals of solar energy conversion. It starts with a discussion of the resource and the mechanisms of its propagation through the atmosphere up to the point of conversion. It then discusses the various conversion processes (photovoltaic converters, concentrated thermal power generation and solar heating/cooling). Grid-tied and islanded systems are considered and storage for solar energy is also covered. The state-of-the-art of each of these technologies is discussed, including their market and economic aspects.

The course includes a project, for which the students working in groups, undertake the design and dimensioning of a solar energy conversion system. Their results are submitted as a group report and presented at a poster session during the last week of the term.

Principles of Wind Energy

Compulsory course; 10 credits; 22 Lecture hours, 11 Tutorial hours. Assessment: 100% exam based

Wind energy is the fast growing renewable source for electricity generation. The objective of this course is to present a broad overview of the technology covering aspects such as the history of wind turbine development, the characteristics of the wind and its impact on site selection, and the design, manufacture, and operation of modern wind turbines. The course course covers both the mechanical and electrical aspects of wind energy conversion and has a practical flavour, drawing on examples from the wind turbine engineering and development sectors. The political and economic implications of wind energy are explored in the final lecture.

In our graduates' words

"The best thing about the programme is that although it's a very challenging course, there is plenty of support on offer to help understand the content and keep pace."

"In the MSc I enjoyed the range of guest lectures that were incorporated into the courses to give insight into the work going on beyond the classroom."

"I've really enjoyed the MSc courses. I enjoyed going to lectures and learning new things; the lecturers radiate enthusiasm about the subjects, which in turn gets people interested."

"Before I even graduated I received a job offer from a major UK power company as a graduate engineer. This year was rewarding for me and unforgettable. The programme and the prestige of the university really helped me in my job search".

Rula Sha, MSc EPE 2018

One-year MSc in Electrical Power Engineeing: https://edin.ac/msc-epe
Two-year MSc in Advanced Power Engineering: https://edin.ac/msc-ape

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

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