The University Of Sheffield.

Electronic & Electrical Engineering.

EEE349 POWER ENGINEERING ELECTROMAGNETICS

Credits: 10

Course Description including Aims

1. To develop an understanding of the physical behaviour of electric and magnetic fields.
2. To develop a mathematical basis for calculating electric and magnetic fields in engineering applications using analytical methods.
3. To apply these ideas to solve practical problems with a particular focus on electrical power applications.
4. To introduce students to numerical methods for calculating fields, including practical experience in using a commercial package for solving power engineering problems.

Outline Syllabus

- Review of vector quantities and operations
- Introduction to static electric fields
- Introduction to static magnetic fields
- Introduction to Maxwell's equations
- Application of Maxwell's equations to electrostatic fields
- Application of Maxwell's equations to magnetostatic fields
- Low frequency time-varying fields
- Numerical methods for calculating magnetic fields
- Magnetic field calculations in rotating electrical machines
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Time Allocation

24 lectures and 12 hours of tutorial support in support of lectures in weeks 1-12
3 hour introductory computer laboratory session for FEMM software
12 hours of timetabled computer laboratory drop-in sessions to assist with FEMM assignment – supported by demonstrators

Recommended Previous Courses

EEE223, MAS241

Assessment

The assessment will consist of two parts:

1. 2 hour written examination (accounts for 75% of final grade).
2. Individual assignment on using the FEMM finite element package to solve one electrostatic and one magnetostatic problem. This will be assessed by submission of a written report detailing results obtained and a 10 minute viva voce examination to explore understanding of the processes involved in the modelling (accounts for 25% of the final grade).

Recommended Books

Hammond, P.	*Electromagnetism for engineers*	Pergamon Press 1986
Cheng, D.K.	*Field and wave electromagnetics*	Addison-Wesley 1989
Demarest, K.R.	*Engineering Electromagnetics*	Prentice Hall, 1998
Hayt, W.H.	*Engineering Electromagnetics*	McGraw-Hill, 1989
Kraus J.D	*Electromagnetics*	McGraw-Hill, 1999

Objectives

On completion of the module successful students will be able to

1. perform a range of vector operations.
2. select and apply appropriate analytical techniques for calculating electrostatic or magnetic fields in a range of practical devices.
3. identify and specify approximate models and boundary conditions for a range of devices.
4. use a finite element package to solve 2D electrostatic and magnetostatic problems in practical electrical power devices
5. appreciate the link between electromagnetic field calculations and the features and design of practical power engineering components, devices and industrial processes.

Detailed Syllabus

- **Review of key vector techniques :** Coordinate Systems, Review of vector representation of field quantities; concepts of flux and field strength, principle of superposition, scalar and vector product, line and surface integrals, gradient operator and divergence operator.
- **Introduction to static electric fields:** Key physical quantities, Coulomb's Law, electric fields and electric potential, physics electrical breakdown, behaviour of dielectric materials.
- **Introduction to static magnetic fields:** Key physical quantities, Biot-Savart Law, Ampere's Law.
- **Introduction to Maxwell's equations:** Mathematical basis and key features, simplifications for static and power frequency problems
- **Application of Maxwell's equations to electrostatic fields:** Gauss's theorem, Laplace's equation, Poisson's equation; Analytical methods for calculating fields, application to parallel plate capacitors, high voltage transmission lines and cables. Practical aspects of high voltage cables.
- **Application of Maxwell's equations to magnetostatic fields:** Ampère's law, Stokes' theorem, scalar and vector magnetic potentials, boundary conditions, calculation of static fields in simplified geometries such as MAGLEV transportation system.
- **Low frequency time-varying fields:** Faraday's law, diffusion equation, skin depth, 1-D eddy current in thick and thin plates, AC resistance, proximity effects, application to induction heating.
- **Numerical methods for calculating magnetic fields:** Basic theory of finite element analysis, boundary conditions, periodicity, force calculation, examples of application to engineering problems using commercial FE package.
- **Finite element assignment:** Introduction to FEMM finite element package and the use of FEMM to solve one electrostatic and one magnetostatic problem.
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UK-SPEC/IET Learning Outcomes

Outcome Code **Supporting Statement**

SM1m/SM1p	Thorough grounding in the scientific principles of electric and magnetic field and the means by which these principles underpin many engineering devices. Assessed in both written examination and in FEA assignment.
SM2m/SM2p	Extensive exposure to, and practice in the use of, advanced mathematical techniques – primarily focussed on vector calculus. Assessed by way of problem solving and derivation in written examination
EA3m/EA3p	Application of both analytical and numerical methods to predict aspects of performance of many devices which exploit electric and magnetic fields. Comparison of advantages and disadvantages of the two types of methods in some cases by direct comparison of results produced by both types of methods. Assessed in both written examination and in FEA assignment. In the case of the latter, questions posed in comparing performance derived from ideal scaling and numerical solutions which include saturation.
EA1m/EA1p	Extensive practical activities in using FE analysis for solving a range of problems. Assessed by way of FEA assignment.