School of Electrical and Information Engineering

University of the Witwatersrand, Johannesburg

ELEN2003 Electric and Magnetic Systems

Course Brief and Outline: 2017

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1 Course Background and Purpose

This is an introductory course into the application of electric and magnetic fields in engineering systems. It builds on first year courses in physics and circuits to provide a general foundation of the engineering science associated with the coupling and energy conversion characteristics of electric and magnetic fields as well as simple electromagnetic wave propagation. The course also provides an introduction to the principles of electricity supply and tariffs. This course is an essential foundation in the engineering science associated with electric and magnetic fields and power supply for students proceeding with the standard electrical engineering curriculum and those who intend taking the information engineering option.

2 Course Outcomes

On successful completion of this course, the student is capable of:

- The ability to analyse linear and non-linear magnetic circuits and to determine reactances and losses;
- The ability to analyse the performance of a single-phase transformer;
- The ability to predict the static and dynamic performance of a range of elementary transducers up to a second order level;
- The ability to determine force and torque in a range of elementary electro-mechanical devices;
- The ability to assess electric coupling in a range of simple geometries;
- The ability to predict reflection and transmission in two-wire, lossless transmission systems;
- An understanding of the components of electrical power systems and issues of environmental impact;
- The ability to analyse simple balanced three-phase circuits;
- An understanding of tariff-structures and the impact of power factor correction;
- The ability to perform an experiment, taking the necessary precautions for the level of voltage involved and, in a written report, relate the observations to the predictions made using methods taught in the lectures.

3 Course Content

The content of this course is as per *Rules & Syllabuses: Faculty of Engineering and the Built Environment.*

4 Prior Knowledge Assumed

The pre-requisites and co-requisites for this course are as per *Rules & Syllabuses: Faculty of Engineering and the Built Environment*.

- The basic equations for, and an understanding of, electric fields associated with isolated charges and lines of charge, as covered in a first-year university physics course;
- The basic equations for, and an understanding of, magnetic fields associated with current-carrying conductors, as dealt with in a first-year university physics course;
- The use of phasors in the representation and analysis of AC circuits;
- The modelling and analysis of second order linear systems.

5 Assessment

All submissions must be in strict accordance with the guidelines contained in the *School's Blue Book* and the rules contained in the *School's Red Book*. No exceptions will be considered.

5.1 Components of the Assessment

This is described in the School's document entitled *Application of Rule G.13 and Calculator Requirements* on the School notice board.

5.2 Assessment Criteria

Rule G.13 and the School's documents entitled *Application of Rule G.13 and Calculator Requirements* and the *School's Red Book* (see the School notice board) apply.

In the class tests and examination, the ability of the student to meet the course outcomes will be assessed by the solving of problems, and justifying of explanations, to issues related to the material presented in the course.

The course is divided into several knowledge areas. Students will have to have mastered all of the knowledge areas to pass the course. These include:

- Magnetic fields in static structures;
- Electro-magnetic interactions;
- Power systems;
- Electro-mechanical energy conversion.

The course comprises a component of laboratory work, in which a written report will be assessed to determine whether the experiment has been correctly conducted, whether the relationship of the observations to theoretical predictions is understood, and whether the quality of the report as a communication document is appropriate to an engineer in training.

5.3 Satisfactory Performance (SP) Requirements

Rule G.13 and the School's documents entitled *Application of Rule G.13 and Calculator Requirements* and the *School's Red Book* (see the School notice board) apply. In addition, all assessments (test, lab and project reports) must be submitted, all tutorial sessions must be attended, and all students must be present to demonstrate their projects.

5.4 Use of Calculators in Examinations

See the School's document entitled *Application of Rule G.13 and Calculator Requirements* on the School notice board.

6 Teaching and Learning Process

Lectures

Three lectures (three slots) and one tutorial period (two slots) have been allocated each week. Details of the lecture timetable and venues can be found on the 2nd year timetable. Students are expected to attend all lectures and make their own notes. In the event of a power failure, a suitable alternative venue for lectures will be advised.

Tutorial sessions are compulsory. For the majority of the tutorial classes, a Class Tutorial will be issued at the beginning of the tutorial session. Students, working in small groups, will then use the time to tackle the given problem. Towards the end of the session, time will be allocated for the tutor to volunteer a candidate to present their solution and to have a general discussion of the solution with the class.

Additional tutorial sheets, with some numerical answers, will be issued to the class with each module. Working through these sheets will ensure that the material presented in the class is well understood and that the necessary skills are developed to solve relevant problems.

Laboratories

All students are required to do the laboratories, even if they are repeat students. There are no exemptions. In general, the Genmin Labs will be used in the allocated times, unless otherwise stated.

Project

A course project is undertaken and a full report is written and submitted. Each year the project is different and will be described in the project brief.

Class test

Refer to the School's schedule for test and hand-in dates. The test will be a short 45 or 60 minute test in which material recently covered will be examined. Note that this does not imply that the material covered in the class test will not be examined later in the course.

Consultation

Consultation times will be arranged with the class at the start of the course.

7 Information to Support the Course

7.1 Recommended Reading

The reference below is most useful in this, and the Elen3003 course:

[1] Sen PC, Principles of Electric Machines and Power Electronics. 2nd edition, John Wiley & Sons, 1997.

7.2 Other References

A list of recommend reading material is listed below. In general, these books may be found in the library.

[2] Matsch LW and Morgan JD, Electromagnetic and Electromechanical Machines. 3rd edition, Wiley 1987 (This book is also used in Elen3003).

[3] Inan US and Inan AS, Engineering Electromagnetics. Addison Wesley Longman Incorporated, 1999.

[4] Ulaby FT, Fundamentals of Applied Electromagnetics. 1999 edition, Prentice-Hall 1999.

[5] Fitzgerald AE, Kingsley Jr C, and Kusko A, Electric Machinery. 3rd edition, McGraw-Hill 1971.

[6] Hayt Jr WH, Buck JA, Engineering Electromagnetics. 6th edition, McGraw-Hill 2001.

[7] Guru B, Hiziglu H, Electromagnetic Field theory Fundamentals. 2nd edition, Cambridge University Press 2004.

[8] Yamayee ZA, Bala Jr JL, Electromechanical Energy Devices and Power Systems. John Wiley & Sons 1994.

[9] Rizzoni G, Principles and Applications of Electrical Engineering, 4th edition, McGraw-Hill, 2003.

[10] Tyler DW, Electrical Applications 2, Heinemann, London, 1987.

Although all modules are supported by class notes, further reading of material in the text books is required.

7.3 Course Home Page and Notice board

Further information and announcements regarding the course will be posted on the course home page on SAKAI.

All students are expected to consult the course home page at regular intervals. The course notice board is located on the third floor of the Chamber of Mines building.

8 Other Information

Below, additional references to the stipulated course outcomes and the corresponding recommended references, are listed:

- Magnetic fields and circuits: [1, 2, 4, 5 – 8, 10];
- The transformer: [1, 2, 5, 8];
- The electric field and coupling in engineering geometries: [3, 4, 7];
- Fundamental machine considerations and transducers: [1, 2, 5, 8, 9];
- Electro-magnetic energy conversion: [1, 2, 5, 8];
- The elementary rotating machine: [1, 2, 5, 8];
- The wave equation for lossless transmission lines: [3, 4, 6, 7];
- The elements of power systems and their environmental impact: [8];
- Balanced three-phase systems: [1, 2, 5, 8];
- Power factor correction and tariff structures: [10].