School of Electrical and Information Engineering
University of the Witwatersrand, Johannesburg
ELEN3000A—Electromagnetics

Course Brief and Outline—2020

Academic Staff:

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1 Course Background

Electromagnetics pervades almost every aspect of our everyday lives, WiFi, 4G, LTE, Bluetooth, GPS, Microwave Ovens, Radar, Remote Sensing, Medical Electronics, Roving Mars Robots, Pictures of Pluto...

All these interact with one another and with humans, but this is unseen: Hence the need for *knowledge* in this area to minimise nonsense!

In many ways, Electromagnetics can be viewed as a superset of circuit theory, with the power flow through the mysterious "ether" as opposed to a physical circuit. Thus the student is exposed to a broader and more general context than before.

2 Course Objectives

Electromagnetics lays the foundation for the High Frequency course, where antenna design is important for the eventual implementation of any wireless communication system. Any high-speed (Analogue or Digital) electronic circuit cannot be understood without these techniques.

3 Course Outcomes

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

1. understanding electromagnetics terminology;
2. understanding the circuit limitations at high frequency;
3. designing simple transmission line systems, including matching circuits;
4. understanding antenna and radiation fundamentals; and
5. understanding electromagnetic compatibility issues.

4 Course Content

Transmission Lines Introduction, infinite transmission line, terminated transmission line, input impedance, standing and travelling waves, VSWR, power flow

Smith Chart Development, use, matching—single and double stub. Scattering parameters

Static Fields Basic revision of electric fields, flux, duality, field plotting

Maxwell's Equations For plane waves; boundary conditions—conductors and dielectrics; Depth of penetration (skin depth)

Antennas Basic radiation fundamentals, launching and receiving radiating waves.

Applications EMC, Shielding effectiveness, remote sensing, waveguides

5 Prior Knowledge Assumed

Thorough knowledge of basic physics, especially the field components, and a thorough grasp of mathematics, especially vector calculus.

6 Assessment

6.1 Formative Assessment

None.

6.2 Summative Assessment

Assessment Contributor	Duration (hours)	Component Yes/No	Method & Weight%	Calculator Type	Permitted Supporting Material
Test	1	No	20%	2	Note
Lab	6	No	20%	3	N/A
Exam	3	No	60%	2	Note

Note:

- Dictionary permitted,
- Handwritten A4 formula sheet permitted[1].
- Closed book—"Type 2"

The examination will cover *all* material covered in the course, and especially discussion topics in lectures and tutorials.

6.3 Assessment Criteria

The student's understanding of the fundamental aspects of the course will be probed. Exam questions etc will need to be answered in order to answer the question: "WHY?" as opposed to the simplistic "HOW". I am not attempting to assess a simple methodology, I will assess fundamental understanding of concepts.

Note that the onus is upon the student to convey this understanding in an examination. A terse, correct "answer" may not necessarily attract marks! Please refer to my exam writing skills notes at `ytdp.eie.wits.ac.za/ExamWritingSkills.html`.

7 Satisfactory Performance (SP) Requirements

For the purpose of Rule G.13, *satisfactory performance in the work of the class* means attendance and completion of prescribed laboratory activities, attendance at tutorials designated as compulsory in this CB&O, submission of assignments, writing of scheduled tests unless excused in terms of due procedure.

[1] All 6 sides may be used

8 Teaching and Learning Process

8.1 Teaching and Learning Approach

My lecturing style is highly interactive, and largely of the "chalk and talk" variety. This means that the emphasis during lectures is upon understanding, and not on "transferring the lecturer's notes to those of the student, without passing through the minds of either". Interaction on the part of the student is required.

One negative consequence of an interactive lecturing style (as opposed to a transfer of notes style), is that the student actually gains *an* understanding in the lecture. If it assumed that this *initial* understanding is all that is required, disaster occurs. Learning is an *iterative* exercise, and requires constant re-inforcement. My lecturing style can thus lead to a complacency which is rudely interrupted at examination time. HENCE:

Tutorial exercises are designed to complement and probe material *currently being taught.* They are *not* necessarily designed as examination questions, which typically cover more comprehensive, integrated material. Doing these tutorial exercises only just before the exams will not help. They are to be done concurrently with the material being explored. The past exam papers are to be used as a benchmark for examination questions.

8.2 Information to Support the Course

No text perfectly covers the course material: all books have flaws. The Prescribed Text is:

- Cheng, D.K (1989) "Field and Wave Electromagnetics" Second Edition, Addison Welsey Publishers.

There are no notes handed out for this course.

In addition, there is a 122 page "Study Guide", by some obscure bloke:

- Clark A. R. (2004) "SuperNEC Study Guide for Electromagnetics and Antennas", Poynting Innovations, Wynberg, Sandton.

available from the Course Home Page. (See below).

There are some excellent eTexts available, see Course Home Page...

If it can be obtained the *Third Edition* of "Electromagnetics" by J.D. Kraus (McGraw-Hill) is definitive. The *Fourth Edition* is OK, the *Fifth Edition*, co-authored by Fleisch, is completely useless.

8.3 Learning Activities and Arrangements

Lectures:

There will be three lectures per week. Students are expected to attend all lectures and to make their own notes.

I keep strictly to South African Standard Time (SAST). I respect your time, and will not drag on my lectures, and I expect you to respect my time, and that of your colleagues, by arriving on time, so that latecomer disruption is avoided.

Tutorials:

There will also be one tutorial per week.

Project:

There is no project associated with this course.

Laboratory:

There will be a laboratory associated with this course held in the Basic Laboratory, covering topics taught in the course, as well as topics not formally dealt with in lectures.

Students who have not done the lab preparations will be asked to leave the laboratory.

School Policy states that there are no lab exemptions.

Consultation:

I have what I call a "Modified Open Door" policy. You can come and see me at any time, but only in groups! I have a great regard for the peer-support system; you only really understand something if you can explain it to your peers. I have long ago forgotten the particular difficulties I had with some of the concepts taught in this course, they now appear to me as "obvious"; peers do not have this myopia.

The preferred method of contact, however, is email.

It is generally convenient to grab me between and after lectures.

9 Course Home Page

For other information related to the course, please refer to the Course Home page at
`http://ytdp.eie.wits.ac.za/elen3000Home.html`

The online version is `http://ytdp.eie.wits.ac.za/elen3000outline.html`