



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

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## Course Brief and Outline—2024

### Academic Staff:

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## 1 Course Background

Electromagnetics pervades almost every aspect of our everyday lives, WiFi, 5G, 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

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.

### 6.1 Formative Assessment

Tuts.

### 6.2 Summative Assessment

Assessment Contributor	Duration (hours)	Component Yes/No	Method & Weight%	Calculator Type	Permitted Supporting Material
Test	1	No	40%	2	Note
Lab	6	No	20%	3	N/A
Exam	3	No	40%	2	Note

Note:

- Dictionary permitted,
- Handwritten A4 formula sheet permitted<sup>1</sup>.
- Closed book—"Type 2"
- The examination is subject to the *Sub-Minimum* rule.

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](http://ytdp.eie.wits.ac.za/ExamWritingSkills.html).

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<sup>1</sup>All 6 sides may be used

## 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.

## 8 Teaching and Learning Process

### 8.1 Teaching and Learning Approach

Covid-19 is not Covid-23: and thus we are fully back to Face-to-Face, not even Mask-to-Mask. But the (Hastily Assembled) material is still available on *Ulwazi*. Interaction is thus via lectures for those that wish to engage with real input. For those that eschew that, *Ulwazi* can work, but good luck to you :-)

A form of interaction is the *Ulwazi Discussions* which does support Mathematics (via Math-Jax). The advantage is that the *Discussion* is open to all in the class, and can be accessed at any time. I will thus also be using the *Discussion asynchronously*, checking in several times per week. Please stick to using the Pinned *Generalised ChatRoom Facility*.

Please do not *email* me questions, as the rest of the class will not benefit: use *Discussions*.

### 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” and one ”tut” per week, all of which are Q&A sessions. Students are expected to attend the Q&A sessions in *Discussions* and/or *BigBlueButton* and be participative.

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:

As above.

**Project:**

There is no project associated with this course.

**Laboratory:**

There will be a laboratory associated with this course normally held in the Basic Laboratory, but will no doubt be Covidly appropriate, 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:**

Via Ulwazi *Discussions*.

## 9 Course Home Page

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

The online version is <https://ytdp.eie.wits.ac.za/elen3000outline.html>