hrs	/ /20		Exams Office Use Only

University of the Witwatersrand, Johannesburg

Course or topic No(s)	ELEN3000
Course or topic name(s) Paper Number & title	Electromagnetics
Examination/Test* to be held during month(s) of (*delete as applicable)	October 2008
Year of Study (Art & Sciences leave blank)	Third
Degrees/Diplomas for which this course is prescribed (BSc (Eng) should indicate which branch)	BSc (Eng) Elec
Faculty/ies presenting candidates	Engineering
Internal examiners and telephone number(s)	Prof. A. R. Clark x7223
External examiner(s)	Prof. J. Joubert
Special materials required (graph/music/drawing paper) maps, diagrams, tables, computer cards, etc)	None

Time allowance

Course Nos	ELEN3000	Hours	Three

Instructions to candidates (Examiners may wish to use this space to indicate, inter alia, the contribution made by this examination or test towards the year mark, if appropriate)	Answer All questions. Type '2' exam---A4 formula sheet permitted. *Hand in your Smith Charts.*

Internal Examiners or Heads of Department are requested to sign the declaration overleaf

1. As the Internal Examiner/Head of Department, I certify that this question paper is in final form, as approved by the External Examiner, and is ready for reproduction.

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(1. is applicable to formal examinations as approved by an external examiner, while 2. is applicable to formal tests not requiring approval by an external examiner—Delete whichever is not applicable)

Name:______________________________ Signature:______________________________

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Note: Show ALL workings, complete with the necessary comments!!—regardless of how fast your calculator can print the results in one step. I am not interested in how well you can read your formulae from your formula sheet. I am marking your reasoning, not only the answer!! Marks are awarded for the reasoning as well as the "answer". A correct numerical answer will not necessarily attract any marks!

Question 1

This question is in a "***short*** question" format. Use point form if necessary.

(a) Lightning causes several deaths a year in rural areas. Explain how to protect a rural, traditional hut, from a nearby lightning strike. (5 marks)

(b) A cellphone base station offering HSDPA is erected in your neighbourhood school. Comment on its effect on the children. (5 marks)

(c) Explain why the theory of displacement current allows the propagation of an electromagnetic wave through space. (5 marks)

(d) Explain why your cellphone, when placed near a PC, makes an audible sound through the PC's speakers. How can this be stopped? (5 marks)

(e) From an intuitive perspective, explain the Three Terrors: Grad, Div, and Curl. (5 marks)

(f) Maxwell's fourth equation, in differential form, states simply:

$$\nabla \cdot \underset{\sim}{B} = 0$$

what does that mean? (5 marks)

(Total 30 marks)

Question 2

A radome is to be designed for the nose of an aircraft to protect an X-band weather radar operating between 8.5 and 10.3GHz. A new type of foam material with $\varepsilon_r = 2$ (assume lossless) is chosen for the design.

i) Assuming a flat planar radome, determine the minimum thickness of the foam that will give no reflections at the centre frequency of the band.

ii) What percentage of the transmitted power is reflected by the radome at either end of the band?

Hint: use a transmission line analogy.

(20 marks)

Question 3

An electromagnetic plane wave propagating in free space has an electric field given by:

$$\underset{\sim}{E}(x, z, t) = \hat{\mathbf{y}}4.9\cos(1.8 \times 10^9 \pi t - ax - 2.5az)\mathrm{V/m}$$

where a is a constant. Using Maxwell's Equations, find the value of a and the corresponding expression for the magnetic field. (20 marks)

Question 4

Air at "normal" temperature and pressure suffers dielectric breakdown at about 3kV/mm in a uniform field. Ignoring the fact that a commercial microwave oven is actually a resonant cavity, assume that you can develop a plane wave in the microwave oven. Stating all assumptions, calculate the power of a magnetron large enough to cause the air in the microwave to suffer dielectric breakdown.

(20 marks)

Question 5

Classic$f$m transmits from the Sentech Tower (better known as the Brixton Tower) at 102.7MHz.

- Co-ordinates: 26:11:31 S 28:00:26 E
- Site Height: 1777m
- Mid Antenna Height: 190m
- Power: 35kW (ERP)
- Polarization: Mixed

Safety regulations require that the time averaged power density be less than $2\mathrm{W/m^2}$ in any unregulated environment.

i) Assuming, for simplicity, that the antenna is an isotropic source (radiates equally well in all directions), calculate the time averaged power density for someone standing 25m away from the antenna.

ii) Calculate how far you need to be away from the antenna to meet the Regulations.

iii) Assuming the antenna is now mounted on the Brixton Tower at the Mid Antenna Height. Calculate the time averaged power density for someone standing 25m away from the base of the tower. (20 marks)

(Exam Total 110 marks)

(Full marks 100 marks)

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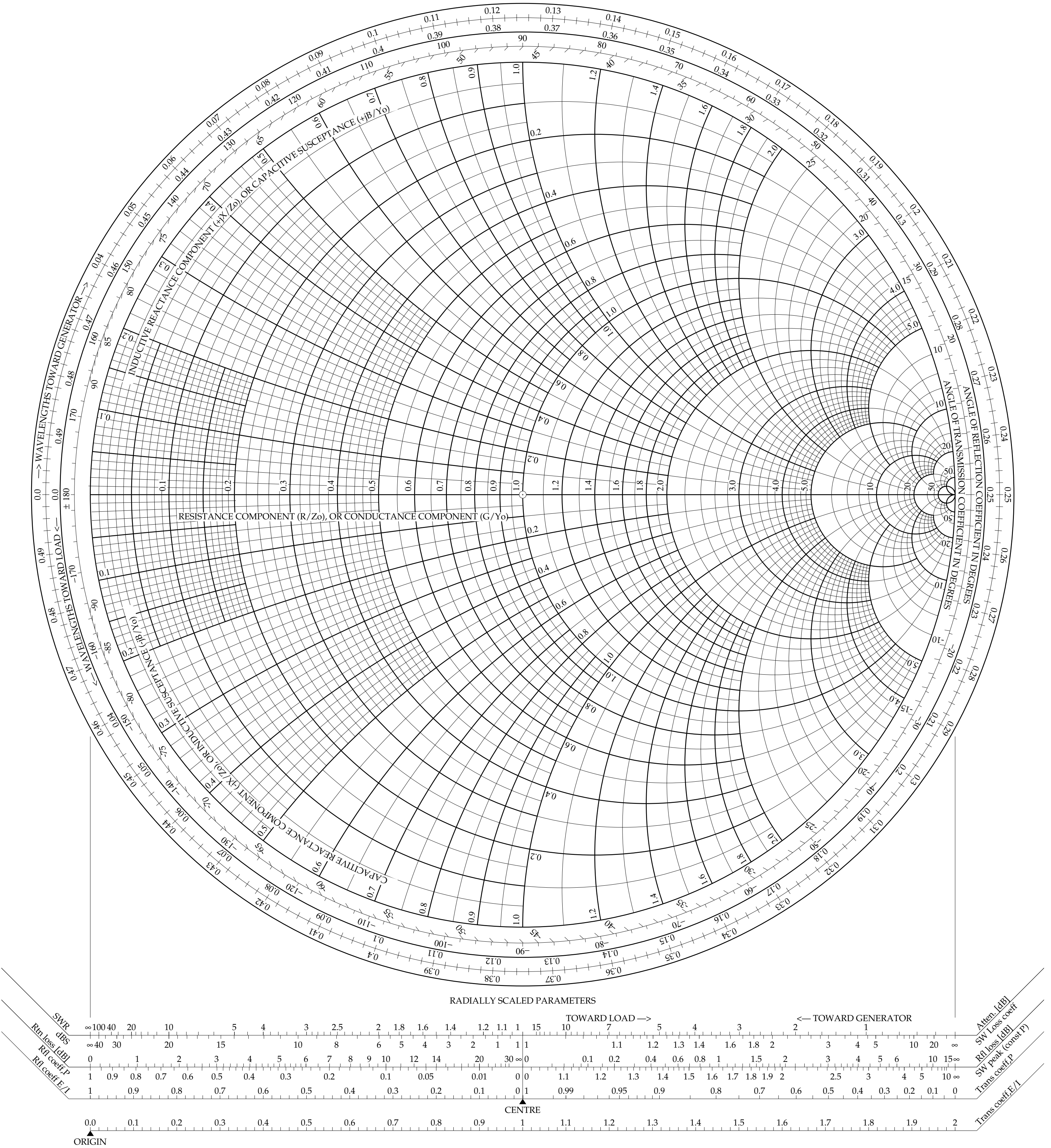
The Smith Chart Calculator

Student No:____________________________



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The Smith Chart Calculator

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