Department of Electrical Engineering

Radar Masters Programme

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EEE5108W MATHEMATICS FOR RADAR AND ELECTRONIC PROTECTION 2012

1 Prerequisites

This course requires students to have a good background in Engineering Mathematics, acquired as part of an Honours Level (4 years of study). The coursework consists of 'pencil and paper' problems, which will require a limited amount of numerical computation in some of their solutions; an acquaintance with Mathematica or Maxima would be useful, but not essential.

2 Course Format and Dates

The course begins on registration day with a self- study revision segment, before the formal lecture segment of 5 days. The first morning of the lecture segment is taken up with introductory material and a 3 hour test of the revision material. The formal part of the course is given in a 5 day, intensive format, followed by further tutorial and seminar sessions over the weeks following the intensive session, carrying on to the end of the semester, when the examination is held. The dates for the sessions are set during the intensive session, to accommodate as far as possible, student availability.

These follow on sessions are based on problem sets which the student must attempt in order to gain benefit from the seminars. In addition, students may book appointments with the Course Convener and the Tutor.

The course Calendar is the governing document for planning: please monitor it frequently on the web site:

https://sites.google.com/site/radarmasters/schedule

Course interaction is via the UCT Vula System. You will have access to this information once you have registered for the course. It is important that you provide your preferred email address (one that it checked frequently) for your Vula registration.

3 Staff

Convener	Prof. M.R. Inggs	UCT	mikings(a)gmail.com
Lecturers:	Dr. Pieter Uys	UCT	pieter(a)edserve.co.za
Tutor:	Roaldje Nasjiasnagar	UCT	neddje(a)gmail.com

4 Course description:

This course provides a useful mathematical toolkit for the Radar and Electronic Defence Engineer.; emphasis is on practical calculation and useful 'tricks of the trade' rather than mathematical rigour. The textbook, Advanced Engineering Mathematics, E. Kreyszig (Wiley)(with many editions available) is prescribed. Some notes are also made available to assist the student. Specific course topics include:

4.1 Course Topics (Estimated number of lectures and acronyms shown in brackets)

Ordinary differential equations (7)	(ODE)
Laplace transforms (2)	(LT)
Fourier analysis (3)	(FA)
Partial differential equations (2)	(PDE)
Complex analysis (8)	(CA)
Vector calculus (5)	(VC)

4.2 Software Expertise

Students must be sufficiently proficient in tools such as Mathematica or Simulink/Matlab to be able to construct 'scratch' numerical code for some of the exercises; some experience of Mathematica's formal manipulation capabilities would be useful, but is not essential.

4.3 Revision prerequisites

Students will write a three hour revision test on the first day of lectures for the course. The coverage is listed at the end of this document (Section 11). This material should all have been covered by students as part of their honours course (4 year degree) and it should be a matter of refreshing ideas rather than new work. The test will count 20% of the final course mark.

5 Learning outcomes

Having successfully completed this course, students should be able to:

- Understand calculus, linear algebra, special functions and at a level that enables them to access and make use of the radar research literature;
- Carry through detailed calculations based on this material;
- Be able to identify mathematical techniques most appropriate to the analysis of a particular application;

6 Lecture Programme

Table 1: EEE5108W Mathematics for Radar and Electronic Protection 2012 Programme

Time	**Mon 27/2**	**Tue 28/2**	**Wed 29/2**	**Thur 1/2**	**Fri 2/2**
9:00-9:45	*3-Hour test*	*ODE*	*FA*	*CA*	*CA*
10:00-10:45		*ODE*	*FA*	*CA*	*VC*
11:00-11:45		*Tut*	*Tut*	*Tut*	*Tut*
12:00-12:45		*ODE*	*FA*	*CA*	*VC*
13:00-14:00	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
14:00-14:45	*ODE*	*ODE*	*PDE*	*CA*	*VC*
15:00-15:45	*ODE*	*LT*	*PDE*	*CA*	*VC*
16:00-16:45	*ODE*	*LT*	*CA*	*CA*	*VC*

The tutorial sessions allow informal discussions of the presented material and provide practice in working together on problems and presenting results. The group breaks up into several subgroups, and attack selected examples from the exercises together and with input from the presenter. They then outline their solutions to the whole group, as preparation for the problems set as drill exercises. The informal Q&A sessions cater for any general issues arising and feedback.

7 Text Book

Advanced Engineering Mathematics. E. Kreyszig. Wiley Ed.8 or 9.

8 Exercises

Students are expected to work through a selection of the exercises that accompany the course, with the aim of consolidating and extending their understanding of the material presented. Interaction and discussion with fellow attendees are encouraged, rather than solitary competitiveness. Each session will include a preliminary run through the exercises to highlight their salient features and provide some guidance in their solution.

Model solutions, though quite possibly sub-optimal, of the exercises are provided to supplement the seminar opportunities of about an hour each with the lecturer, convener and tutors; students will be expected to attend seminars, and attendance is only credited if the solutions have been submitted. The student's solutions to the problem set must be submitted on Vula before the start of the seminar. The seminars will be carried out with access by Skype for students off campus after the lecture session. For bandwidth reasons, the number of parallel sessions will have to be limited. For example, all students resident in the same city will be expected to attend at a common venue, and students will have to organise their own venue and projection facilities. Within reason, and with prior arrangement, students can approach the tutor / and / or the lecturer for help with problem sets.

9 Course Assessment and Examination

The final assessment of this course is dependent on a three hour, written examination (80%), with the Duly Performed (DP) requirement of 80% of seminars attended. The remaining 20% is from the revision test. The examination is closed book, i.e. no notes may be brought into the examination venue. Students are not expected to memorise any formulas: all formulas and results will be supplied on the examination paper. Students may write the examination in their home location, provided satisfactory supervision of the examination can be arranged in good time.

10 Course Load

Item	Number	hrs/per	Hours
Revision	1	70	70
Lectures	30	1	30
Lecture assimilation	30	1	30
Seminar Attendance	10	2	20
Seminar Drill Problems	10	3	30
Examination preparation	1	20	20
Examination	1	3	3
TOTAL			203

11 Self-Study Revision

This section outlines mathematical topics that we find necessary for the students to be fully familiar with before attempting the mathematics course offered in the masters in radar program. We found that last terms low success rate is due to students' lack of in-depth knowledge in these preliminary topics. This is the material covered by the three hour revision test on the first day of lectures for the course.

11.1 Vector analysis

11.1.1 Vectors and scalars

Vectors, scalar, vector algebra, laws of vector algebra. Unit vectors, Rectangular unit vectors. Components of a vector. Scalar fields. vector fields. The dot and the cross product.

11.1.2 Vector Differentiation

Ordinary derivatives of vectors, space curves, continuity and differentiability. Differentiation formulas. partial derivatives of vectors. Differentials of vectors

11.1.3 Gradient, Divergence and curl

The vector differential operator del. Gradient. Divergence. Curl

11.1.4 Vector integration

Ordinary integrals of vectors. Line integrals. Surface integrals. Volume integrals.

11.1.5 The Divergence Theorem, Stokes Theorem, and related integral theorems

11.1.6 Coordinates transformation

Cartesian to polar transformation. Cylindrical coordinates, Spherical coordinates

11.2 Matrix operations

11.2.1 Basic operations

Matrices. Vectors and dot products. Matrix addition and matrix subtraction. Scalar multiplication and matrix multiplication. Row-echelon form. Elementary row and column operations. Rank. Trace.

11.2.2 Square matrices

Diagonals. Elementary matrices. LU decomposition. Simultaneous linear equations. Powers of a matrix.

11.2.3 Determinants and Matrix inversion

Determinants. Properties of determinants. The inverse, properties of the inverse

11.2.4 Vectors

Dimension. Linear dependence and independence. Linear combinations. Properties of Linearly independent vectors. Row rank and column rank.

11.2.5 Eigenvalues and Eigenvectors

Characteristics equation. Properties of eigenvalues and eigenvectors. Linearly independent eigenvectors.

11.3 Complex variables

11.3.1 Complex Numbers

Fundamental operation with complex numbers. Graphical representation of complex numbers. Polar form of complex numbers. De Moivre's Theorem. Euler's Theorem. Vector interpretation of Complex numbers.

11.3.2 Complex function, limits and Continuity

Elementary complex functions. Branch points and branch lines. Limits. Continuity

11.3.3 Series

Finite and infinite series. Taylor series expansion of fundamental functions