Subject Information Guide

Asymptotic methods and perturbation theory

Semester 1, 2019

Administration and contact details

Host Department	School of Mathematics and Statistics
Host Institution	University of Sydney
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Subject details

Handbook entry URL	
Subject homepage URL	
Honours student hand-out URL	
Start date:	20th February 2019 (Introductory Lecture)
End date:	22nd May 2019
Contact hours per week:	2 hours per week
Lecture day and time:	Wednesday 11:00-13:00 (except Introductory Lecture, Wednesday 20th February 14:00-16:00)
Description of electronic access arrangements for students (for example, WebCT)	Materials will be available on the University Learning Management System.

Subject content

1. Subject content description

Asymptotic methods are vital techniques to make analytic progress in all areas of applied mathematics. They aid in the determination of the dominant physical mechanisms. Problems involving different length scales or timescales are widespread in physical applications. Perturbation methods take advantage of these differing scales or small parameters in the problem to provide rational approximations to the governing differential equations.

2. Week-by-week topic overview

Syllabus

- **Assumed knowledge**

  Solutions of ordinary differential equations; complex variable theory.

- **Introduction**

  Definition of an asymptotic expansion; the O, o and ~ symbols.

- **Asymptotic expansion of integrals**

  Laplace's method; Watson's lemma; method of stationary phase; method of steepest descents.

- **Regular perturbation theory**

  The Lindstedt-Poincare technique.

- **Singular perturbation theory**

  Matched asymptotic expansions; Van Dyke's matching principle.

- **Multiple-scale analysis**

  Multiple time scales.

- **WKB theory for ordinary differential equations**

  Liouville's problem; eigenvalue problems; turning point problems.

3. Assumed prerequisite knowledge and capabilities

Theory of, and solutions of, ordinary differential equations, including nonlinear equations, second order and non-constant coefficients. Complex variable theory, including contour integration.

4. Learning outcomes and objectives

At the end of this subject students will be able to: determine the asymptotic expansions of functions defined by integrals; and find approximate solutions to regular and singular perturbation problems.

AQF specific Program Learning Outcomes and Learning Outcome Descriptors (if available):

AQF Program Learning Outcomes addressed in this subject	Associated AQF Learning Outcome Descriptors for this subject
To be able to derive asymptotic expansions	K1
To know the appropriate method to obtain asymptotic expansions of various types of integrals	K1, S3, A1
To be able to solve regular and singular perturbation problems	K1, S2, A1
To be able to perform a multiple scale analysis	K1, S2, A1
To be able to apply WKB theory for the approximate solution of ordinary differential equations	K1, S2, A1

Learning Outcome Descriptors at AQF Level 8

Knowledge

K1: coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines

K2: knowledge of research principles and methods

Skills

S1: cognitive skills to review, analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problem with intellectual independence

S2: cognitive and technical skills to demonstrate a broad understanding of a body of knowledge and theoretical concepts with advanced understanding in some areas

S3: cognitive skills to exercise critical thinking and judgement in developing new understanding

S4: technical skills to design and use in a research project

S5: communication skills to present clear and coherent exposition of knowledge and ideas to a variety of audiences

Application of Knowledge and Skills

A1: with initiative and judgement in professional practice and/or scholarship

A2: to adapt knowledge and skills in diverse contexts

A3: with responsibility and accountability for own learning and practice and in collaboration with others within broad parameters

A4: to plan and execute project work and/or a piece of research and scholarship with some independence

5. Learning resources

Recommended text books

- *Introduction to Perturbation Techniques*, A. H. Nayfeh, Wiley, 1981
- *Advanced Mathematical Methods for Scientists and Engineers*, C. M. Bender and S. A. Orszag, McGraw-Hill, 1978
- *Perturbation Methods*, E. J. Hinch, Cambridge University Press, 1991
- *Nonlinear Ordinary Differential Equations* (second ed.), D. W. Jordan and P. Smith, Oxford University Press, 1987

6. Assessment

Exam/assignment/classwork breakdown					
Exam	60%	**Assignment**	40%	**Class work**	
Assignment due dates		2nd April 2019 (TBC)	21st May 2019 (TBC)		
Approximate exam date				Week beginning 3rd June 2019	

Institution Honours program details

Weight of subject in total honours assessment at host department	10%
Thesis/subject split at host department	40% thesis, 60% coursework (6 courses x 10%)
Honours grade ranges at host department:	
H1	80-100
H2a	75-79
H2b	70-74
H3	65-69