MATH4104
Semester 1, 2003
Advanced Hamiltonian Dynamics & Chaos

Lecturers
Name: Dr Cathy Holmes
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Consultation hours or Office hours: Mon 11-12am and Fri 12-1pm

Name: Prof. Gerard Milburn
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Lecture times Tue 11am -12am, Thurs 10am-11am, Fri 11am –12pm.
Tutorial Thur 11am-12pm

Course Outline

1. Classical Dynamics
   1.1 Lagrangian Mechanics
   1.2 Hamiltonian Mechanics
   1.3 Canonical Transformations
   1.4 Canonical Perturbation Theory
   1.5 Resonances and the KAM theorem
   1.6 Twist Maps
   1.7 The Standard Map
   1.8 Measures of Chaos
   1.9 Chaos in Billiards

2. Quantum Dynamics
   2.1 Review of Quantum Theory
   2.2 Atoms in Optical potentials
   2.3 Integrable Non-linear Quantum Dynamics
   2.4 Quasi-Integrable Non-linear Quantum Dynamics
   2.5 Dynamical Localisation
   2.6 Non-Linear Quantum Maps
   2.7 Random matrices
   2.8 Trace Formulae and Periodic orbits
   2.9 Quantum Billiards
   2.10 Mesoscopic Systems
Reference Books

*Random and Stochastic Motion,*
A.J. Lichtenberg and M.A. Lieberman, Applied mathematical Sciences

*The Transition to Chaos, in conservative classical systems: quantum manifestations.*

*Introduction to Applied Nonlinear Dynamical Systems and Chaos,*

*Nonlinear Oscillations, Dynamical Systems, and Bifurcations of vector Fields,*
J. Guckenheimer and P. Holmes, Applied Mathematical Sciences vol 42,
Springer Verlag, New York, 1983.

*Chaos, an introduction to Dynamical Systems,*
K.T. Alligood, T.D. Sauer,

*Structure and Interpretation of Classical Mechanics,*
G.J. Sussman, J.Wisdom, MIT Press 2001,

*Quantum Signatures of Chaos,*

*Quantum chaos : an introduction,*
Hans-Jurgen Stockmann, Cambridge UP.

*Quantum chaos : between order and disorder*
:a selection of papers compiled
and introduced by Giulio Casati, Boris
Chirikov.

*A modern approach to quantum mechanics,*
Townsend, Mcgraw-Hill (this is the level of QM assumed)

Assessment

<table>
<thead>
<tr>
<th>Two Assignments each worth in total</th>
<th>20%</th>
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<tr>
<td>Final Exam (two hours long)</td>
<td>60%</td>
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Course goals/rationale:

On completing this course students will:
- Understand the topics given in the course outline.
- Be able to investigate a given Hamiltonian system with reference to those topics, and hence give an understanding of the classical and quantum dynamics of that system.

Graduate Attributes  
*The following graduate attributes will be developed in the course:

In-Depth Knowledge of the Field of Study

- A comprehensive and well-founded knowledge of the field of study.
- An understanding of how other disciplines relate to the field of study.
- An international perspective on the field of study.

Effective Communication

- The ability to collect, analyse, and organise information and ideas, and to convey those ideas clearly and fluently, in both written form.

Independence and Creativity

- The ability to work and learn independently.
- The ability to generate ideas.

Critical Judgement

- The ability to define and analyse problems
- The ability to apply critical reasoning to issues through independent thought and informed judgement
- The ability to evaluate opinions, make decisions and to reflect critically on the justifications for decisions.

Teaching and Learning Methods

*During the semester problem sheets involving training problems are handed out. These are discussed in the tutorials and then detailed solutions are made available.*
In addition there are two-project style assignments, where students use theory and numerical work to fully analyse a particular Hamiltonian system. They then produce a report of their findings. This encourages them to think more broadly about the power of the tools they have learnt and about how and when they can be applied.

**ASSESSMENT**

Two Project type assignments each worth **20%**

Exam (two hours) **worth 60%**

**Assessment criteria**

On completing this course students should:
- Understand the topics given in the course outline.
- Be able to tackle relatively simple problems, as defined by the problems sheets or exercises given during the semester, under exam conditions.
- Be able to investigate a more complex Hamiltonian system in detail, with reference to the topics covered in the course and hence give a fairly detailed understanding of the classical and quantum dynamics of a Hamiltonian system in written form.

**Criteria for the award of grades**

To earn a Grade of 7, a student must demonstrate an excellent understanding of the course material. This includes clear expression of nearly all their deductions and explanations, the use of appropriate and efficient mathematical techniques and accurate answers to nearly all questions and tasks with appropriate justification. They will be able to apply mathematical techniques to completely solve both theoretical and practical problems.

To earn a Grade of 6, a student must demonstrate a comprehensive understanding of the course material. This includes clear expression of most of their deductions and explanations, the general use of appropriate and efficient mathematical techniques and accurate answers to most questions and tasks with appropriate justification. They will be able to apply mathematical techniques to partially solve both theoretical and practical problems.

To earn a Grade of 5, a student must demonstrate an adequate understanding of the course material. This includes clear expression of some of their deductions and explanations, the use of appropriate and efficient mathematical techniques in some situations and accurate answers to some questions and tasks with appropriate justification. They will be able to apply mathematical techniques to solve fundamental problems.

To earn a Grade of 4, a student must demonstrate an understanding of the basic concepts in the course material. This includes occasionally expressing their deductions and explanations clearly, the occasional use of appropriate and efficient mathematical techniques and accurate answers to a few questions and tasks with appropriate justification. They will have demonstrated knowledge of techniques used to solve problems and applied this knowledge in some cases.

To earn a Grade of 3, a student must demonstrate some knowledge of the basic concepts in the course material. This includes occasional expression of their deductions and explanations,
the use of a few appropriate and efficient mathematical techniques and attempts to answer a few questions and tasks accurately and with appropriate justification. They will have demonstrated knowledge of techniques used to solve problems.

To earn a Grade of 2, a student must demonstrate some knowledge of the basic concepts in the course material. This includes attempts at expressing their deductions and explanations and attempts to answer a few questions accurately.

A student will earn a Grade of 1 if they show a poor knowledge of the basic concepts in the course material. This includes attempts at answering some questions but showing an extremely poor understanding of the key concepts.

Assessment policy

Students should be familiar with the rules which relate to assessment in their degrees as well as general university policy such as found in the General Award Rules. These are all set out on the Program and Course Information page on the UQ website http://www.uq.edu.au/student/courses/.

Plagiarism

Below is the University’s definition of plagiarism

Plagiarism is the action or practice of taking and using as one’s own the thoughts or writings of another (without acknowledgement). The following practices constitute acts of plagiarism and are a major infringement of the University’s academic values:

(a) where paragraphs, sentences, a single sentence or significant part of a sentence which are copied directly, are not enclosed in quotation marks and appropriately footnoted;

(b) where direct quotations are not used, but are paraphrased or summarised, and the source of the material is not acknowledged either by footnoting or other simple reference within the text of the paper;

(c) where an idea which appears elsewhere in print, film or electronic medium is used or developed without reference being made to the author or the source of that idea.

When a student knowingly plagiarises someone’s work, there is intent to gain an advantage and this may constitute misconduct.

Students are encouraged to study together and to discuss ideas, but this should not result in students handing in the same or similar assessment work. Do not allow another student to copy your work. While students may discuss approaches to tackling a tutorial problem, care must be taken to submit individual and different answers to the problem. Submitting the same or largely similar answers to an assignment or tutorial problem may constitute misconduct.

For more information on the University policy on plagiarism, please refer to http://www.uq.edu.au/hupp/contents/view.asp?s1=3&s2=40&s3=12
Supplementary examinations

In some programs, a supplementary examination may be awarded in one course to students who obtain a grade of 2 or 3 in the final semester of their program and require this course to finish their degree. You should check the rules for your degree program for information on the possible award of supplementary examinations. Applications for supplementary examinations must be made to the Director of Studies in the Faculty.

Special examinations

If a student is unable to sit a scheduled examination for medical or other adverse reasons, she/he can and should apply for a special examination. Applications made on medical grounds should be accompanied by a medical certificate; those on other grounds must be supported by a personal declaration stating the facts on which the application relies.

Applications for special examinations for central and end-of-semester exams must be made through the Student Centre. Applications for special examinations in school exams are made to the course coordinator.

More information on the University’s assessment policy may be found http://www.uq.edu.au/hupp/contents/view.asp?s1=3&s2=30&s3=5

EPSA Faculty policy on the award of special and supplementary exams may be found at http://www.epsa.uq.edu.au/pdf/specialexam.pdf

Feedback on assessment

You may request feedback on assessment in this course progressively throughout the semester from the course coordinator. Feedback on assessment may include discussion, written comments on work, model answers, lists of common mistakes and the like.

Students may peruse examinations scripts and obtain feedback on performance in a final examination provided that the request is made within six months of the release of final course results. After a period of six months following the release of results, examination scripts may be destroyed.

Information on the University’s policy on access to feedback on assessment may be found at http://www.uq.edu.au/hupp/contents/view.asp?s1=3&s2=30&s3=5

EPSA Faculty policy on feedback and re-marking may be found at http://www.epsa.uq.edu.au/student/current/assessmentfeedback.pdf
Textbook and references

Library contact

The liaison librarian for Earth Sciences/Maths/Physics is located in the Physical Sciences and Engineering Library in the Hawken Building and may be consulted for assistance in the course:

Earth Sciences: Leith Woodall  
Email: l.woodall@library.uq.edu.au  
Extension: 52367

Maths: Larah Seivl-Keevers  
Email: l.seivl-keevers@library.uq.edu.au  
Extension: 52367

Physics: Nicole Clark  
Email: n.clark@library.uq.edu.au  
Extension: 53974

Students with disabilities

Any student with a disability who may require alternative academic arrangements in the course is encouraged to seek advice at the commencement of the semester from a Disability Adviser at Student Support Services.

Assistance for Students

Students with English language difficulties should contact the course coordinator or tutors for the course.

Students with English language difficulties who require development of their English skills should contact the Institute for Continuing and TESOL Education on extension 56565.

The Learning Assistance Unit located in the Relaxation Block in Student Support Services. You may consult learning advisers in the unit to provide assistance with study skills, writing assignments and the like. Individual sessions are available. Student Support Services also offers workshops to assist students. For more information, phone 51704 or on the web http://www.sss.uq.edu.au/index.html.

Student Liaison Officer

The School of Physical Sciences has a Student Liaison Officer as an independent source of advice to assist students with resolving academic difficulties.

- The Student Liaison officer during semester 1 2003 will be Assoc Prof Bevan Thompson, Room 651 Priestley building, (email hbt@maths.uq.edu.au)
- The Student Liaison officer during semester 2 will be Dr Rodney Wolff, Room 751 Priestley building (email rcw@maths.uq.edu.au)