



The University of Southern Queensland

Course Specification

Description: Chaos

| Subject | Cat-Nbr | Class | Term | Mode | Units | Campus |
|---------|---------|-------|---------|------|-------|--------|
| MAT | 4102 | 20369 | 1, 2003 | ONC | 1.00 | TWMB |

| | |
|------------------------|--------|
| Academic Group: | FOSCI |
| Academic Org: | FOS003 |
| HECS Band: | 2 |
| ASCED Code: | 010101 |

STAFFING

Examiner: Tony Roberts

Moderator: Peter Dunn

RATIONALE

Dynamical systems describe how any system of interest evolves in time. Nonlinear dynamics generally give rise to chaos. A modern understanding and appreciation of chaos is essential for all scientists in any field of endeavour which seeks to understand and quantify evolution.

SYNOPSIS

This course introduces concepts, analysis and appearances of chaos in dynamical systems, both theoretically and in applications. The approach is in the context of modern dynamical systems theory and relies mainly upon geometrical intuition rather than algebraic virtuosity. Starting from a classical view of dynamics, the course discusses strange attractors, the analysis of chaotic data series, and the period doubling and intermittent routes to chaos.

OBJECTIVES

On successful completion of this course students will be able to:

- appreciate the classic view of nonlinear dynamics;
- demonstrate an understanding of the generic features of chaos and strange attractors in continuous time dynamical systems, and in discrete maps;
- analyse an experimental data series for signs of chaos, and to compute some quantifiable characteristics;
- demonstrate an understanding of some of the finer features of chaotic dynamics through analysis of the period doubling and intermittent routes to chaos.

TOPICS

| Description | Weighting (%) |
|---|---------------|
| 1. Order: state space, equilibria, oscillations, quasi-periodic dynamics, Fourier transforms | 20.00 |
| 2. Strange attractors: stretching and folding, Lyapunov exponents, 1D return maps, fractal microstructure | 20.00 |
| 3. Data analysis: state space reconstruction, inverse problem, chaotic prediction, noise | 20.00 |
| 4. Subharmonic cascade: return maps, period doubling, inverse cascade, renormalisation, universality | 20.00 |
| 5. Intermittency: bursts and laminar phases, $1/f$ noise, renormalisation | 20.00 |

REFERENCE MATERIALS

Reference materials are materials that, if accessed by students, may improve their knowledge and understanding of the material in the course and enrich their learning experience.

Abraham, R.H. & Shaw, C.D. 1992, *Dynamics, The Geometry of Behaviour: Part 1, Periodic Behaviour; Part 2, Chaotic Behaviour; Part 3, Global Behaviour; Part 4, Bifurcation Behaviour*, Addison Wesley, Redwood City.

Baker, G.L. & Gollub, J.P. 1996, *Chaotic Dynamics: An Introduction*, 2nd edition, C.U.P. Cambridge.

Berge, P., Pomeau, Y. & Vidal, C. 1984, *Order Within Chaos: Towards a Deterministic Approach to Turbulence*, Wiley, New York.

Ford, J. 1989, *What is Chaos, That We Should Be Mindful of It? Chapter 12 in {The New Physics}*, P. Davies (ed.), C.U.P. Cambridge.

Gleick, J. 1988, *Chaos: Making of A New Science*, Penguin, New York.

Hall, N. 1992, *New Scientist Guide to Chaos*, Penguin, London.

Nicolis, G. 1989, *Physics of Far-From-Equilibrium Systems and Self Organisation, Chapter 11 in {The New Physics}*, P. Davies (ed.) C.U.P. Cambridge.

Ruelle, D. 1993, *Chance and Chaos*, Penguin, London.

Ruelle, D. 1989, *Chaotic Evolution and Strange Attractors*, C.U.P. Cambridge.

Schroeder, M. 1990, *Fractals, Chaos, Power Laws: Minutes From An Infinite Paradise*, Freeman, New York.

Schuster, H.G. 1995, *Deterministic Chaos, An Introduction*, 3rd edition, Physik-Verlag, Weinheim.

Stewart, I. 1987, *The Problems of Mathematics, Chapters 13-16*, O.U.P. New York.

STUDENT WORKLOAD REQUIREMENTS

| ACTIVITY | HOURS |
|---------------|-------|
| Assessment | 40 |
| Examinations | 3 |
| Lectures | 39 |
| Private Study | 80 |

ASSESSMENT DETAILS

| Description | Marks Out of | Wtg(%) | Required | Due Date |
|-------------------------------|--------------|--------|----------|----------------------------|
| ASSIGNMENT 1 | 20.00 | 5.00 | Y | 04 Mar 2003 (see note) |
| ASSIGNMENT 2 | 20.00 | 5.00 | Y | 04 Mar 2003 (see note) |
| ASSIGNMENT 3 | 20.00 | 5.00 | Y | 04 Mar 2003 (see note) |
| ASSIGNMENT 4 | 20.00 | 5.00 | Y | 04 Mar 2003 (see note) |
| 3 HOUR RESTRICTED EXAMINATION | 100.00 | 80.00 | Y | END S1 (see note) |

NOTES:

- . Further details about the due dates will be advised by the Examiner.
- . As in Note 1.
- . As in Note 1.
- . As in Note 1.
- . Examination dates will be available during the Semester. Please refer to Examination timetable when published.

IMPORTANT ASSESSMENT INFORMATION

- 1 Attendance requirements:
It is the students' responsibility to attend and participate appropriately in all activities (such as lectures, tutorials, laboratories and practical work) scheduled for them, and to study all material provided to them or required to be accessed by them to maximise their chance of meeting the objectives of the course and to be informed of course-related activities and administration.
- 2 Requirements for students to complete each assessment item satisfactorily:
To complete each of the assessment items satisfactorily, students must obtain at least 50% of the marks available for each assessment item.
- 3 Penalties for late submission of required work:
If students submit assignments after the due date without prior approval then a penalty of 20% of the total marks available for the assignment will apply for each working day late.

- 4 Requirements for student to be awarded a passing grade in the course:
To be assured of a passing grade, students must demonstrate, via the summative assessment items, that they have achieved the required minimum standards in relation to the objectives of the course by satisfactorily completing all summative assessment items (the examination and assignments).
- 5 Method used to combine assessment results to attain final grade:
The final grades for students will be assigned on the basis of the weighted aggregate of the marks obtained for each of the summative assessment items in the course.
- 6 Examination information:
In a Restricted Examination, candidates are allowed access to specific materials during the examination. The only materials that candidates may use in the restricted examination for this course are: writing materials (non-electronic and free from material which could give the student an unfair advantage in the examination); calculators which cannot hold textual information (students must indicate on their examination paper the make and model of any calculator(s) they use during the examination). Students whose first language is not English, may, with the Examiner's approval, take an appropriate non- electronic translation dictionary into the examination. Students who wish to use a translation dictionary **MUST** request and receive written approval from the Examiner at least one week before the examination date. Translation dictionaries will be subject to perusal and may be removed from the candidate's possession until appropriate disciplinary action is completed if found to contain material that could give the candidate an unfair advantage.
- 7 Examination period when Deferred/Supplementary examinations will be held:
Any Deferred or Supplementary examinations for this course will be held during the examination period at the end of the semester of the next offering of this course.
- 8 University Regulations:
Students should read USQ Regulations 5.1 Definitions, 5.6. Assessment, and 5.10 Academic Misconduct for further information and to avoid actions which might contravene University Regulations. These regulations can be found at the URL <http://www.usq.edu.au/SECARIAT/calendar/Part5/> or in the printed version of the current USQ Handbook.

ASSESSMENT NOTES

- 9 The due date for an assignment is the date by which a student must despatch the assignment to the USQ. The onus is on the student to provide proof of the despatch date, if requested by the Examiner. Students must retain a copy of each item submitted for assessment. This must be produced within five days if required by the Examiner. The examiner may grant an extension of the due date of an assignment in extenuating circumstances.