## School of Information and Physical Sciences

# STAT3800: Deterministic and Stochastic Optimisation

Callaghan

Semester 1 - 2024

COURSE OUTLINE

# OVERVIEW

**Course Description**

From finance and health to science and engineering, optimisation has many applications and is at the heart of several modern technologies such as machine learning for big data and deep neural networks. This course develops the student's ability to understand and apply the fundamental analytical, computational and statistical techniques for optimising deterministic and stochastic problems in practice.The first part of the course deals with deterministic optimisation problems where all parameters are known, including linear and nonlinear programs. In practice, however, we often encounter systems, for which parameters are uncertain. The focus of the second part of the course is on methods for optimising stochastic systems, particularly where the dynamic of the system is governed by a Markov chain, such as in supply chains and queueing networks.The written assignments give students the opportunity to apply the concepts they learn in lectures and labs to a number of theoretical and computational problems. The topics align with the course content covered by that stage of the semester.The project gives students the opportunity to experience applying the concepts they learn in the course to a more applied problem as a teamwork. The project output involves a written report and verbal presentation.

**Academic Progress Requirements**

Nil

**Assumed Knowledge**

One course from: MATH1120 or MATH1220 and one course from: STAT1300 or STAT2110 or STAT1070.

**Contact Hours**

**Callaghan**
**Computer Lab**
Face to Face On Campus
2 hour(s) per week(s) for 12 week(s) starting Week 1

**Lecture**
Face to Face On Campus
2 hour(s) per week(s) for 12 week(s) starting Week 1

**Unit Weighting Workload**

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Students are required to spend on average 120-140 hours of effort (contact and non-contact) including assessments per 10 unit course.

# CONTACTS

**Course Coordinator**

**Callaghan**
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Consultation: To be advised on Canvas

**Teaching Staff**

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**School Office**

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# SYLLABUS

**Course Content**

- Foundations of Optimisation
- Unconstrained Optimisation
- Nonlinear Optimisation
- Markov Decision Processes
- Stochastic Dynamic Programming
- Optimisation under Uncertainty for Big Data

**Course Learning Outcomes**

**On successful completion of this course, students will be able to:**
1. Formulate real-world problems in the mathematical language of optimisation.

2. Solve problems using analytical and computational techniques.

3. Interpret solutions of optimisation problems as they apply to scientific, financial and industrial applications.

4. Optimise systems under uncertainty using analytical and computational techniques.

5. Apply, as part of a team, optimisation and stochastic modelling to industry, business, engineering, psychology, health and broader scientific fields.

**Course Materials**

**Lecture Materials:**

- Lecture notes will be delivered through the course Canvas site.

**Other Resources:**

- **Software.** One pacakge -- Sagemath or MATLAB -- will be used throughout the course. The package is taught from scratch with the focus on optimisation.

**Recommended Reading:**

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Lecture Notes
Slides
Other suggestions given in class and Canvas, if necessary

**Other material of potential interest:**
The course is based on materials related to the following literature and we refer here to the following works to acknowledge its use in the preparation of the course.
I. Griva, S.G. Nash and A. Sofer. Linear and Nonlinear Optimization. SIAM, second edition, 2009
D.G. Luenberger and Y. Ye. Linear and Nonlinear Programming. Springer, 2008.
S. Ross. Introduction to Stochastic Dynamic Programming. Academic Press, 2014.
D.P. Bertsekas. Reinforcement Learning and Optimal Control. Athena Scientific, 2020.
M.L. Puterman. Markov Decision Processes: Discrete Stochastic Dynamic Programming. Wiley-Interscience, 2005.
S.E. Dreyfus. The art and theory of dynamic programming, 1977.
C.C. Ferrante Neri and P. Moscato. Handbook of memetic algorithms. Studies in Computational Intelligence, 2012.

# SCHEDULE

# ASSESSMENTS

This course has 3 assessments. Each assessment is described in more detail in the sections below.

| | Assessment Name | Due Date | Involvement | Weighting | Learning Outcomes |
|---|---|---|---|---|---|
| **1** | Formal examination | Formal examination period. | Individual | 30% | 1, 2, 3, 4 |
| **2** | Written assignments | Weeks 4, 6, 9 and 11. | Individual | 40% | 1, 2, 3, 4 |
| **3** | Project | Week 13 | Group | 30% | 1, 2, 3, 4, 5 |

**Late Submissions** The mark for an assessment item submitted after the designated time on the due date, without an approved extension of time, will be reduced by 10% of the possible maximum mark for that assessment item for each day or part day that the assessment item is late. Note: this applies equally to week and weekend days.

## Assessment 1 - Formal examination

**Assessment Type** Formal Examination
**Purpose** To determine each student's level of mastery of the material of the course.
**Description** Written answer questiions.
**Weighting** 30%
**Length** 2 hours
**Due Date** Formal examination period.
**Submission Method** Formal Exam
**Assessment Criteria** Accuracy and clarity of solutions
**Return Method** Not Returned
**Feedback Provided** No Feedback - .
**Opportunity to Reattempt** Students WILL NOT be given the opportunity to reattempt this assessment.

## Assessment 2 - Written assignments

**Assessment Type** Written Assignment
**Purpose** To expand on the course material and give students an opportunity to demonstrate their ability

| | |
|---|---|
| | to employ the techniques developed in the course. |
| **Description** | Four written assignments. |
| **Weighting** | 40% |
| **Due Date** | Weeks 4, 6, 9 and 11. |
| **Submission Method** | Online |
| **Assessment Criteria** | Clarity and accuracy of solutions. |
| **Return Method** | Online |
| **Feedback Provided** | Online - Within 5 working days after submission.. |
| **Opportunity to Reattempt** | Students WILL NOT be given the opportunity to reattempt this assessment. |

## Assessment 3 - Project

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|---|---|
| **Assessment Type** | Project |
| **Purpose** | To demonstrate the students' ability to employ the techniques of the course to real-world problems; to develop the communication skills of the students. |
| **Description** | Working in groups of 2 or 3, students produce a poster, including problem description, model and results. Poster are presented by students at a presentation day in week 13. |
| **Weighting** | 30% |
| **Due Date** | Week 13 |
| **Submission Method** | Online |
| **Assessment Criteria** | Will be announced on Canvas. |
| **Return Method** | Online |
| **Feedback Provided** | Online - Within 5 working days after submission.. |
| **Opportunity to Reattempt** | Students WILL NOT be given the opportunity to reattempt this assessment. |

# ADDITIONAL INFORMATION

**Grading Scheme**

This course is graded as follows:

| Range of Marks | Grade | Description |
|---|---|---|
| 85-100 | High Distinction (HD) | Outstanding standard indicating comprehensive knowledge and understanding of the relevant materials; demonstration of an outstanding level of academic achievement; mastery of skills*; and achievement of all assessment objectives. |
| 75-84 | Distinction (D) | Excellent standard indicating a very high level of knowledge and understanding of the relevant materials; demonstration of a very high level of academic ability; sound development of skills*; and achievement of all assessment objectives. |
| 65-74 | Credit (C) | Good standard indicating a high level of knowledge and understanding of the relevant materials; demonstration of a high level of academic achievement; reasonable development of skills*; and achievement of all learning outcomes. |
| 50-64 | Pass (P) | Satisfactory standard indicating an adequate knowledge and understanding of the relevant materials; demonstration of an adequate level of academic achievement; satisfactory development of skills*; and achievement of all learning outcomes. |
| 0-49 | Fail (FF) | Failure to satisfactorily achieve learning outcomes. If all compulsory course components are not completed the mark will be zero. A fail grade may also be awarded following disciplinary action. |

*Skills are those identified for the purposes of assessment task(s).

**Communication Methods**

Communication methods used in this course include:

- Canvas Course Site: Students will receive communications via the posting of content or announcements on the Canvas course site.
- Email: Students will receive communications via their student email account.

- Face to Face: Communication will be provided via face to face meetings or supervision.

**Course Evaluation**

Each year feedback is sought from students and other stakeholders about the courses offered in the University for the purposes of identifying areas of excellence and potential improvement.

**Oral Interviews (Vivas)**

As part of the evaluation process of any assessment item in this course an oral examination (viva) may be conducted. The purpose of the oral examination is to verify the authorship of the material submitted in response to the assessment task. The oral examination will be conducted in accordance with the principles set out in the Oral Examination (viva) Procedure. In cases where the oral examination reveals the assessment item may not be the student's own work the case will be dealt with under the Student Conduct Rule.

**Academic Misconduct**

All students are required to meet the academic integrity standards of the University. These standards reinforce the importance of integrity and honesty in an academic environment. Academic Integrity policies apply to all students of the University in all modes of study and in all locations. For the Student Academic Integrity Policy, refer to https://policies.newcastle.edu.au/document/view-current.php?id=35.

**Adverse Circumstances**

The University acknowledges the right of students to seek consideration for the impact of allowable adverse circumstances that may affect their performance in assessment item(s). Applications for special consideration due to adverse circumstances will be made using the online Adverse Circumstances system where:

1. the assessment item is a major assessment item; or
2. the assessment item is a minor assessment item and the Course Co-ordinator has specified in the Course Outline that students may apply the online Adverse Circumstances system;
3. you are requesting a change of placement; or
4. the course has a compulsory attendance requirement.

Before applying you must refer to the Adverse Circumstance Affecting Assessment Items Procedure available at:
https://policies.newcastle.edu.au/document/view-current.php?id=236

**Important Policy Information**

The Help button in the Canvas Navigation menu contains helpful information for using the Learning Management System. Students should familiarise themselves with the policies and procedures at https://www.newcastle.edu.au/current-students/respect-at-uni/policies-and-procedures that support a safe and respectful environment at the University.

*This course outline was approved by the Head of School. No alteration of this course outline is permitted without Head of School approval. If a change is approved, students will be notified and an amended course outline will be provided in the same manner as the original.*