## MAXXXX – OPERATIONAL RESEARCH 3

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| **School** | Cardiff School of Mathematics |
| **Department Code** | MATHS0 |
| **Module Code** | MAXXXX |
| **External Subject Code** | G120 |
| **Number of Credits** | 20 |
| **Level** | 3 |
| **Language of Delivery** | English |
| **Module Leaders** | Professor Jeff Griffiths, Dr Vince Knight |
| **Semester** | Spring Semester |
| **Academic Year** | 2013/14 |

### Outline Description of Module

This module consists of two distinct parts, the first dealing with Queueing Theory and Stock Control and the second with Game Theory.  The Queueing Theory section develops methodology introduced in MA0261 in order to analyse more realistic queueing systems.  Embedded Markov Chain Methods are introduced for solving systems with either general arrival distributions or general service patterns.  Some case studies and cost analyses are undertaken.  The Stock Control section is an introduction to one of the most important management decision processes.  Efficient control of stock levels is an essential feature in the financial well-being of any company.  Again the emphasis is on the solution of real-life problems, with mini-case studies and cost analyses playing a major role. The Game Theory section will introduce students to the mathematical study of multiple interactive agent decision making. This part of the module provides an introduction to Game Theory through notions such as Nash Equilibria, Evolutionary Game Theory and Bayesian Games. Students will learn Game Theory in an active way through role playing and student lead activities.

Pre-requisite information. Students must have successfully completed the second-year OR course MA0261

This module provides a background in Queueing Theory, Stock Control and Game Theory which is more than adequate for the several MSc courses available in other UK universities.  Careers in this subject area are plentiful, interesting and well-paid.

### On completion of the module a student should be able to

1. set up differential-difference equations for the method of phases as applicable to Erlang service times.
2. use generating function techniques to provide steady-state solutions of such equations.
3. set up steady state equations for M/G/1 and GI/M/1 queues using the imbedded Markov Chain technique.
4. undertake simple cost analyses relating to the above queues.
5. understand the assumptions behind Cyclical Review and Re-order Level stock control systems.
6. recognise the cost implications relevant to different stock control models.
7. formulate and analyse simple models of Stock control situations in both deterministic and stochastic forms.
8. represent games in both Extensive Form and Normal Form.
9. understand concepts linked to mixed strategies.
10. compute dominant strategies.
11. identify best responses.
12. define and compute Nash Equilibria.
13. understand and carry out backward induction.
14. understand concepts of subgame perfection.
15. compute equilibria and best responses in repeated games.
16. understand concepts of Evolutionary Game Theory
17. compute evolutionary Stable Strategies
18. represent incomplete information games
19. understand concepts of Bayesian Nash Equilibria and rationalizability

### How the module will be delivered

44 fifty-minute lectures

10 fifty-minute tutorial classes.

Both parts of the course will be presented in parallel (2.5 hours per week for each part, for a total of 5 hours per week)

Students are also expected to undertake at least 100 hours private study including preparation of worked solutions for tutorial classes.

### Skills that will be practised and developed

Problem solving, logical thinking, mathematical formulation of real-life situations.

### How the module will be assessed

Formative assessment is carried out by means of regular tutorial exercises.  Feedback to students on their solutions and their progress towards learning outcomes is provided during tutorial classes.

There is no summative coursework assessment for this module

Summative assessment is by means of the written examination at the end of the module.  This gives students the opportunity to demonstrate their overall achievement of learning outcomes.  It also allows them to give evidence of the higher levels of knowledge and understanding required for above average marks.

The examination paper has a choice of four from six equally weighted questions.

### Assessment Breakdown

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| **Type** | **%** | **Title** | **Duration** | **Period** | **Week** |
| Examination - Spring Semester | 100 | OPERATIONAL RESEARCH 3 | 3 hrs | 2 | N/A |

### Syllabus content

Queueing Theory: Derivation of the Erlang service time distribution.  Setting up differential-difference equations for queueing systems with Erlang service time distributions.  The method of phases.  Use of p.g.f.'s in solution of queueing equations.  Derivation of summary measures of queues.  Cost Analyses

The imbedded Markov Chain technique.  M/G/1 and GI/M/1 queues.  Cost Analyses.  Case studies.

Stock Control: Deterministic models involving cyclical review and re-order level methods.  Costing in inventory control.  Power-demand and Time-dependent demand patterns.  Constrained systems.  Simple stochastic models.

Game Theory : Representations and basic concepts. Analysing behaviour in static settings. Further analysis of extensive form games. Repeated games. Evolutionary Game Theory. Games with incomplete information

### Indicative Reading and Resource List

Queues, Cox D R and Smith W L, Chapman and Hall

Operations Research : An Introduction, Taha H A, MacMillan

Strategy: An Introduction to Game Theory, Watson J, Norton