Course Outline

Semester 1 2016

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

MANF4611

PROCESS MODELING AND SIMULATION

Contents

1. Staff Contact Details 1
Contact details and consultation times for course convenor 1
2. Course details 1
Credit Points: 1
Contact Hours 1
Summary of the Course 2
Aims of the Course 2
Student learning outcomes 2
3. Teaching strategies 3
Teaching Strategies and their rationale 3
4. Course schedule 4
5. Assessment 7
Assessment Overview 7
Presentation 8
Submission 8
Examinations 8
Calculators 9
Special Consideration and Supplementary Assessment 9
6. Expected Resources for students 9
7. Course evaluation and development 10
8. Academic honesty and plagiarism 10
9. Administrative Matters 11
Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards 12

1. Staff Contact Details

Contact details and consultation times for course convenor

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Consultation concerning this course is available immediately after the classes. Direct consultation is preferred.

2. Course details

Credit Points:

This is a 6 unit-of-credit (UoC) course, and involves three hours per week (h/w) of face-to-face contact.

The UNSW website states “The normal workload expectations of a student are approximately 25 hours per semester for each UoC, including class contact hours, other learning activities, preparation and time spent on all assessable work. Thus, for a full-time enrolled student, the normal workload, averaged across the 16 weeks of teaching, study and examination periods, is about 37.5 hours per week.”

This means that you should aim to spend about 9 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Contact Hours

	Day	Time	Location
Lectures	Thursday	12noon – 1:30pm	Colombo Theatre B
Demonstrations	Thursday	1:30pm – 3pm	Ainsworth 204

Summary of the Course

Key factors for success in modern engineering systems include efficient and effective allocation of resources, infrastructure, capacity and capital investment. Depending on the characteristics of the system, for example a product and its market, appropriate processes, resources, entity flows, layouts and systems need to be designed. The focus of this course is precisely that – the understanding, analysis, design and, to some extent, the optimisation of resourcing and processes in line with practical requirements and a constantly evolving set of task and operational requirements.

This course focuses on analytical techniques for decision making and solving complex process and resource allocation problems. It includes the major analytical techniques as part of Operations Research, statistical system characterisation as well as the theory and use of discrete event simulation. It covers the essential mathematical, statistical and computer simulation techniques for modelling and analysing complex systems involving multiple variables, internal, external and disturbances. Depending on the scope of the system to be analysed and the nature of its behaviour, different analytical techniques apply. Specific techniques discussed include linear programming, statistical analysis and simulation using Rockwell Arena ® software.

The course is focused on analysing, modelling and finally understanding and solving complex systems under multiple constraints. These may be manufacturing systems, but they can also be service systems, transportation systems, in fact any system involving multiple entities, processes, resources and constraints.

Topics include:

- Discrete event simulation and associated analysis techniques, using Rockwell Arena© simulation software.
- Linear programming and the simplex method
- Transportation models
- Regression analysis and Partial Least Squares

The course will combine lectures with practical case studies that require the theory taught to be applied to actual manufacturing and industrial systems.

Aims of the Course

The course aims to develop you into a skilled and all-rounded design engineer and operational analyst, able to carry out and manage the key design, operations and decision-making processes. Operations and design are inherently complex and a systematic, yet a flexible, agile and interdisciplinary approach is required to manage and improve complex systems. The course teaches this approach, at the system and managerial levels, based on global best-practice methodologies, industry lecturers, and incorporates case studies and projects, to apply these methodologies and become proficient at them.

Student learning outcomes

This course is designed to address the below learning outcomes and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

After successfully completing this course, you should be able to:

Learning Outcome		EA Stage 1 Competencies
1.	Formulate a real world system or problem and select an appropriate analytical technique for modeling and ultimately solving or optimizing it.	PE1.2, PE2.1, PE3.2, PE3.4
2.	Characterize the behavior of a system in terms of the nature of its variables, interactions using regression methods.	PE1.3, PE1.4
3.	Apply linear programming techniques to solve resource allocation problems and issues.	PE1.2, PE2.3
4.	Apply simulation techniques to solve complex system issues and to select feasible, if not optimum, solutions and configurations amongst competing designs.	PE1.2, PE1.3, PE2.1, PE1.6

3. Teaching strategies

Lectures in the course are designed to cover the terminology and core concepts and theories in the area of manufacturing process design. They do not simply reiterate the texts, but build on the lecture topics using examples taken directly from industry to show how the theory is applied in practice and the details of when, where and how it should be applied.

Teaching Strategies and their rationale

This course will be presented using PowerPoint presentations as well as case studies and real-life designs. The material will be presented in the lecture and the student is expected to actively participate in discussion, analysis and design. Assignments to develop the understanding of the key methodologies and theories and how to apply them will be provided as part of the course. There will be a final exam.

The major assignment is based on a real-life case study and has been developed in conjunction with a consulting company that specializes in developing simulation models for industry. The assignment has been designed to develop best practice skills directly relevant to industry requirements.

4. Course schedule

Date	Lecture Content (Colombo Theatre B) 12:00-13:30	Lab Content (Ainsworth 204) 13:30-15:00
Week 1 Thu 3/3/16	**Introduction to Process and Operations Modeling** • Characteristics of Processes and Operations • Flow Systems, Manufacturing Systems, Business Systems, Engineering Systems • What are Models • Stochastic Processes • Dynamic Models • Continuous – Discrete Time Models • Input, Output and Disturbance Variables • The Process of Modeling • Introduction to Operations Research • Introduction to Simulation and Arena	No labs in Week 1
Week 2 Thu 10/3/16	**Random Variables and Probability Distributions** • Observing, Measuring and Analysing Random Behaviour • Binomial, Poisson, Geometric, Exponential, Normal Distribution • Fitting a Distribution and Goodness of Fit • Random Number Generators • Generating Random Observations • Stationary – non-Stationary Processes • Introduction to MINITAB	Introduction to Minitab – Demonstraton Set 1
Week 3 Thu 17/3/16	**Model Design** • Model Characteristics • Model Scope • Model Detail • Model Identification • Model Quality • Verification and Validation • Model Documentation • Basic Arena simulation constructs	Introduction to modelling with Arena – Demonstraton Set 2 Discussion of the major Assignment

Week 4 Thu 24/3/16	**Application of Simulation Modeling** • Modeling Production Systems in Arena • Arena variables, logic control and expressions: Variables, Attributes, Record, Assign, Expressions, While, Separate, Batch • Flow Control in Arena	Communicating between Arena and Excel – Demonstraton Set 3
Week 5 Thu 7/4/16	**Analysing Simulation Output** • Within – Across Replication Statistics • Types of Statistical Variables • Confidence Intervals and Determining the Number of Replications • Sequential Sampling • Interpreting Arena Output Files • Finite – Infinite Horizon Simulations • Effect of Initial Conditions, Warming-up Period • Comparison of Different System Configurations and Designs • ANOVA • Process Analyser • Sensitivity Analysis	Further Arena Modeling – Demonstraton Set 4
Week 6 Thu 14/4/16	**Advanced Arena Concepts** • Transportation • Materials Handling • Model Animation • Sub-Models • Variable Tables • Interfacing to Excel	Advanced Arena Modeling – Demonstraton Set 5 *Assignment Part 1 due*
Week 7 Thu 21/4/16	**Resource Allocation Problems: Linear Programming 1** • Formulating an LP problem • Simplex Method • Geometry of the Simplex Method	Ongoing Arena support for Assignments LP Demonstraton Set 6
Week 8 Thu 28/4/16	**Applications of Linear Programming** • Multi-goal Programming • Sensitivity Analysis • Applications	Ongoing Arena support for Assignments LP Demonstraton Set 7

Week 9 Thu 5/5/16	**Transportation Models** • Northwest Corner Method • Stepping Stone Method • Intuitive Method	Ongoing Arena support for Assignments LP Demonstraton Set 8
Week 10 Thu 12/5/16	**Decision Analysis** • Overcoming risk and uncertainty • Decision Trees • Decision tables • Decision methods: Maximax, Maximin, Equally Likely • Expected monetary value • Value of information	Ongoing Arena support for Assignments LP Demonstraton Set 9 *Assignment Part 2 due*
Week 11 Thu 19/5/16	**Introduction to Statistical Learning** • Prediction vs Inference • Regression • Simple linear regression • Polynomial regression • Multiple linear regression • Principal component analysis	Ongoing Arena support for Assignments LP Demonstraton Set 10
Week 12 Thu 26/5/16	**Partial Least Squares** • PLS regression • PLS path modeling	Ongoing Arena support for Assignments
Week 13 Thu 2/6/16	**Summary of the course**	Ongoing Arena support for Assignments *Assignment Part 3 due*

5. Assessment

Assessment Overview

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Marks returned
Group assignment – Part 1	3000 words	10%	1 and 4	Problem formulation, system representation, flowcharts, data structures	End of Week 6 – Fri 15 April	Two weeks after submission
Group Assignment – Part 2	3000 words	15%	1 and 4	Model design and documentation, verification (& limited validation)	End of Week 10 – Fri 13 May	Two weeks after submission
Group assignment – Part 3	3000 words	25%	1 and 4	System analysis and design using the simulation model, statistical analysis, final documentation	End of Week 13 – Fri Week 3 June	Upon release of final results
Final exam	3 hours	50%	2 and 3	All content except simulation	Exam period, date TBC	Upon release of final results
TOTAL		**100%**				

The assessments are designed to bolster your understanding of the material being presented and focus on the key learning points. The assignments will allow you to apply the concepts learnt in the course in a professional context whereas the final exam will test your understanding of the basic theory.

Assignments

Each of you will undertake a major assignment consisting of three parts, each building on the previous. You will undertake this in a team of three. The assignments will cover important areas of manufacturing system design.

Each part of the assignment requires a write-up and these are due in week 6, 10 and 13.

You need to ensure that you use both an appropriate writing style as well as professional formatting and editing of style and content in your report.

The assignments will be posted on Moodle and discussed in class (as shown in the teaching schedule) and the due dates shown are firm. Completed assignments will be handed in hard copy by the end of the week the assignment is due. The assignments support the learning outcomes by incorporating an appropriate mix of analytical techniques, enabling software, data analysis that supports achievement of appropriate solutions.

Criteria for Marking

The following criteria will be used to grade assignments:

- Analysis and evaluation of requirements by integrating knowledge and methods learned in lectures and demonstratons.
- Sentences in clear and plain English—this includes correct grammar, spelling and punctuation
- Correct referencing in accordance with the prescribed citation and style guide
- Appropriateness of engineering techniques and methodologies used
- Accuracy of numerical answers and comprehensiveness of methods and techniques employed.
- Evidence of quality data and analysis-based decision making
- All working shown
- Use of diagrams, where appropriate, to support or illustrate the calculations
- Use of graphs, were appropriate, to support or illustrate the calculations
- Use of tables, where appropriate, to support or shorten the calculations
- Neatness

Presentation

All submissions should have a standard School cover sheet which is available from this subject's Moodle page.

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work. Presenting them clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Submission

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Where an assessment task is worth less than 20% of the total course mark and you have a compelling reason for being unable to submit your work on time, you must seek approval for an extension from the course convenor ***before the due date***. Special consideration for assessment tasks of 20% or greater must be processed through student.unsw.edu.au/special-consideration.

It is always worth submitting late assessment tasks when possible. Completion of the work, even late, may be taken into account in cases of special consideration.

Examinations

The end-of-session exam will cover all material except for the simulation part of the course. It will specifically examine statistical analysis, linear programming and regression methods.

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods, which are June for Semester 1 and November for Semester 2.

Provisional Examination timetables are generally published on myUNSW in May for Semester 1 and September for Semester 2

For further information on exams, please see the Exams section on the intranet.

Calculators

You will need to provide your own calculator, of a make and model approved by UNSW, for the examinations. The list of approved calculators is shown at student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an “Approved” sticker for it from the School Office or the Engineering Student Centre prior to the examination. Calculators not bearing an “Approved” sticker will not be allowed into the examination room.

Special Consideration and Supplementary Assessment

For details of applying for special consideration and conditions for the award of supplementary assessment, see the School intranet, and the information on UNSW’s Special Consideration page.

6. Expected Resources for students

Lecture notes for all topics will be posted on Moodle. For all e-Books and reference books please visit the UNSW Library website on:

http://info.library.unsw.edu.au/web/services/services.html

Textbooks:

Simulation modeling and analysis with Arena, Tayfur. Altiok Benjamin Melamed, Warren, N.J. : Cyber Research and Enterprise Technology Solutions, 2001. UNSW Library – High Use Collection.

Griva, I., Nash, S., Sofer, A., & Books24x7, Inc. (2009).Linear and nonlinear optimization, second edition (2nd ed.). Philadelphia: Society for Industrial and Applied Mathematics. e-Book available through UNSW Library.

Vanderbei, R., & Ebooks Corporation. (2008). Linear Programming Foundations and Extensions. (International Series in Operations Research & Management Science, v. 114). Dordrecht: Springer. e-Book available through UNSW Library.

Reference books:

1 Introduction to Operations Research, F. Hillier and G. Lieberman, Holden Day Inc, San Francisco, 1980.
2 Operations Management – Sustainability and Supply Chain Management, J. Heizer and B. Render, 2014, Pearson Education. This textbook is available through the bookstore at UNSW.
3 Fundamentals of Modern Manufacturing, Groover M.P., 2nd ed., 2002 John Wiley
4 Simulation with Arena, W.D. Kelton, R.P. Sadowski and N.P. Zupick, 6th edition, McGraw Hill.
5 Simulation Modeling and Arena, M.D. Rossetti, John Wiley & Sons, 2009.

7. Course evaluation and development

Feedback on the course is gathered periodically using various means, including the Course and Teaching Evaluation and Improvement (CATEI) process, informal discussion in the final class for the course, and the School's Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

In this course, recent improvements resulting from student feedback include a newly designed case study and the inclusion of Partial Least Squares.

8. Academic honesty and plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism: student.unsw.edu.au/plagiarism The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis) even suspension from the university. The Student Misconduct Procedures are available here:
www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is available on the intranet.

9. Administrative Matters

All students are expected to read and be familiar with School guidelines and polices, available on the intranet. In particular, students should be familiar with the following:

- Attendance, Participation and Class Etiquette
- UNSW Email Address
- Computing Facilities
- Assessment Matters (including guidelines for assignments, exams and special consideration)
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Student Support Services

Erik van Voorthuysen and Ron Chan
February 2016

Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving
	PE2.2 Fluent application of engineering techniques, tools and resources
	PE2.3 Application of systematic engineering synthesis and design processes
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (professional and lay domains)
	PE3.3 Creative, innovative and pro-active demeanour
	PE3.4 Professional use and management of information
	PE3.5 Orderly management of self, and professional conduct
	PE3.6 Effective team membership and team leadership