



# Course Outline

Semester 1 2017

Never Stand Still

Engineering

Mechanical and Manufacturing Engineering

## **MANF4611**

### **PROCESS MODELING AND SIMULATION**

# Contents

1. Staff Contact Details.....	2
Contact details and consultation times for course convenor .....	2
2. Course details .....	2
Credit Points .....	2
Contact Hours .....	2
Summary of the Course .....	2
Aims of the Course.....	3
Student learning outcomes.....	3
3. Teaching strategies.....	4
<i>Teaching Strategies and their rationale</i> .....	4
4. Course schedule .....	5
5. Assessment .....	8
Assessment Overview.....	8
Assignments .....	8
Presentation .....	9
Submission.....	9
Marking .....	9
Examinations .....	10
Calculators .....	10
Special Consideration and Supplementary Assessment.....	10
6. Expected Resources for students.....	10
7. Course evaluation and development .....	11
8. Academic honesty and plagiarism.....	11
9. Administrative Matters.....	12
Appendix A: Engineers Australia (EA) Professional Engineer Competency Standards.....	13

# 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	10am – 12noon	Colombo Theatre A
Demonstrations	Thursday	12:30 – 2pm	Ainsworth 203 & 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 statistical characterisation and analysis of systems 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 statistical and regression 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
- Design of experiment techniques
- Regression analysis and Partial Least Squares
- Decision analysis

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:

<b>Learning Outcome</b>	<b>EA Stage 1 Competencies</b>
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 DoE techniques to efficiently analyze multi-variate systems.	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 statistical and simulation modelling. 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 A) 10:00-12:00	Lab Content (Ainsworth 203/4) 12:30-14:00
<b>Week 1</b> Thu 2/3/17	<b>Introduction to Process and Operations Modeling</b> <ul style="list-style-type: none"> <li>• Characteristics of Processes and Operations</li> <li>• Flow Systems, Manufacturing Systems, Business Systems, Engineering Systems</li> <li>• What are Models</li> <li>• Stochastic Processes</li> <li>• Dynamic Models</li> <li>• Continuous – Discrete Time Models</li> <li>• Input, Output and Disturbance Variables</li> <li>• The Process of Modeling</li> <li>• Introduction to Operations Research</li> <li>• Introduction to Simulation and Arena</li> </ul>	No labs in Week 1
<b>Week 2</b> Thu 9/3/17	<b>Random Variables and Probability Distributions</b> <ul style="list-style-type: none"> <li>• Observing, Measuring and Analysing Random Behaviour</li> <li>• Binomial, Poisson, Geometric, Exponential, Normal Distribution</li> <li>• Fitting a Distribution and Goodness of Fit</li> <li>• Random Number Generators</li> <li>• Generating Random Observations</li> <li>• Stationary – non-Stationary Processes</li> <li>• Introduction to Arena Input Analyser</li> </ul>	Introduction to Arena Input Analyser – Demonstration Set 1  Discussion of the major Assignment
<b>Week 3</b> Thu 16/3/17	<b>Model Design</b> <ul style="list-style-type: none"> <li>• Model Characteristics</li> <li>• Model Scope</li> <li>• Model Detail</li> <li>• Model Identification</li> <li>• Model Quality</li> <li>• Verification and Validation</li> <li>• Model Documentation</li> <li>• Basic Arena simulation constructs</li> </ul>	Introduction to modelling with Arena – Demonstration Set 2

<p><b>Week 4</b> Thu 23/3/17</p>	<p><b>Application of Simulation Modeling</b></p> <ul style="list-style-type: none"> <li>• Modeling Production Systems in Arena</li> <li>• Arena variables, logic control and expressions: Variables, Attributes, Record, Assign, Expressions, While, Separate, Batch</li> <li>• Flow Control in Arena</li> <li>• Interfacing to Excel</li> </ul>	<p>Communicating between Arena and Excel</p> <p>Demonstration Set 3 <i>Assignment Part 1 due</i></p>
<p><b>Week 5</b> Thu 30/3/17</p>	<p><b>Design of Experiment Theory (DOE)</b></p> <ul style="list-style-type: none"> <li>• Single factor experiments – ANOVA</li> <li>• Introduction to factorial designs</li> <li>• Response surface methods</li> <li>• Introduction to Minitab</li> </ul>	<p>Minitab Tutorial</p>
<p><b>Week 6</b> Thu 6/4/17</p>	<p><b>Analyzing Simulation Output 1</b></p> <ul style="list-style-type: none"> <li>• Within – Across Replication Statistics</li> <li>• Types of Statistical Variables</li> <li>• Confidence Intervals and Determining the Number of Replications</li> <li>• Sequential Sampling</li> <li>• Interpreting Arena Output Files</li> <li>• Finite – Infinite Horizon Simulations</li> <li>• Effect of Initial Conditions, Warming-up Period</li> <li>• Comparison of Different System Configurations and Designs</li> </ul>	<p>Further Arena Modelling – Demonstration Set 4</p> <p>On-going Arena support for Assignments</p>
<p><b>Week 7</b> Thu 13/4/17</p>	<p><b>Advanced Arena Concepts</b></p> <ul style="list-style-type: none"> <li>• Transportation</li> <li>• Materials Handling</li> <li>• Model Animation</li> <li>• Sub-Models</li> <li>• Documentation</li> </ul>	<p>Advanced Arena Modelling – Demonstration Set 5</p>
<p><b>Week 8</b> Thu 27/4/17</p>	<p><b>Analysing Simulation Output 2</b></p> <ul style="list-style-type: none"> <li>• ANOVA</li> <li>• Process Analyzer</li> <li>• Sensitivity Analysis</li> <li>• Parametric vs non-parametric analysis in Minitab</li> </ul>	<p>Minitab Tutorial</p> <p>On-going Arena support for Assignments</p>

<p><b>Week 9</b> Thu 4/5/17</p>	<p><b>Regression Analysis</b></p> <ul style="list-style-type: none"> <li>• Simple linear</li> <li>• Polynomial regression</li> <li>• Multiple linear</li> <li>• Principal component analysis</li> </ul>	<p>Regression Tutorial</p> <p>On-going Arena support for Assignments</p> <p><i>Assignment Part 2 due</i></p>
<p><b>Week 10</b> Thu 11/5/17</p>	<p><b>Decision Analysis</b></p> <ul style="list-style-type: none"> <li>• Overcoming risk and uncertainty</li> <li>• Decision Trees</li> <li>• Decision tables</li> <li>• Decision methods: Maximax, Maximin, Equally Likely</li> <li>• Expected monetary value</li> <li>• Value of information</li> </ul>	<p>Ongoing Arena support for Assignments</p>
<p><b>Week 11</b> Thu 18/5/17</p>	<p><b>Partial Least Squares</b></p> <ul style="list-style-type: none"> <li>• PLS regression</li> <li>• PLS path modeling</li> </ul>	<p>Ongoing Arena support for Assignments</p>
<p><b>Week 12</b> Thu 25/5/17</p>	<p><b>Summary of the course</b></p>	<p>Ongoing Arena support for Assignments</p>
<p><b>Week 13</b> Thu 1/6/17</p>	<p><b>Tutorial support</b></p>	<p>Ongoing Arena support for Assignments</p> <p><i>Assignment Part 3 due</i></p>



# 5. Assessment

## Assessment Overview

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Group assignment – Part 1	≤ 6 pages*	10%	1 and 4	Problem formulation, system representation, flowcharts	End of Week 4 – Fri 24/03/17	Fri 31/03/17	Two weeks after submission
Group Assignment – Part 2	≤ 10 pages*	20%	1 and 4	Model design and documentation, data structures, verification (& limited validation)	End of Week 9 – Fri 05/05/17	Fri 12/05/17	Two weeks after submission
Group assignment – Part 3	≤ 12 pages*	30%	1 and 4	System analysis and design using the simulation model, statistical analysis, final documentation	End of Week 13 – Fri 02/06/17	Fri 9/06/17	Upon release of final results
Final exam	2 hours	40%	2 and 3	All content	Exam period, date TBC	N/A	Upon release of final results
<b>TOTAL</b>		<b>100%</b>					

- Assignment length specified as single sided A4 page size with a minimum font size of 11.

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 4, 9 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 submitted electronically on Moodle 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.

### *Presentation*

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 at the rate of 10% per calendar day (including weekends), limited to 7 days, after which the mark awarded for that assignment will be zero. 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](http://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.

Where there is no special consideration granted, the 'deadline for absolute fail' in the table above indicates the time after which a submitted assignment will not be marked, and will achieve a score of zero for the purpose of determining overall grade in the course.

### *Marking*

The following criteria will be used to grade assignments:

- Analysis and evaluation of requirements by integrating knowledge and methods learned in lectures and demonstrations.
- 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, where appropriate, to support or illustrate the calculations
- Use of tables, where appropriate, to support or shorten the calculations
- Neatness

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

In addition to the formal marking guidelines, the awarded mark will include a peer assessment component to ensure a fair distribution of workload and contribution on behalf of each team member.

### **Examinations**

The end-of-session exam will cover all material except for the simulation part of the course. It will specifically examine statistical analysis, simulation theory 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](http://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:

<https://www.library.unsw.edu.au/>

## References:

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.

Design and Analysis of Experiments, Douglas C. Montgomery, Wiley, 8th Edition, ©2013

Introduction to Linear Regression Analysis, Douglas C. Montgomery, Wiley, 5th Edition, ©2013

Simulation with Arena, W.D. Kelton, R.P. Sadowski and N.P. Zupick, 6<sup>th</sup> edition, McGraw Hill.

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 UNSW **myExperience** 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](http://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](http://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 policies, 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 2017*

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

	<b>Program Intended Learning Outcomes</b>
<b>PE1: Knowledge and Skill Base</b>	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
<b>PE2: Engineering Application Ability</b>	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
<b>PE3: Professional and Personal Attributes</b>	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