



Mechanical and Manufacturing Engineering

# Course Outline

Term 2 2019

**MANF4611**

## **PROCESS MODELLING AND SIMULATION**

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# 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.

## Contact details and consultation times for additional lecturers/demonstrators/lab staff

Please see the course [Moodle](#).

# 2. Important links

- [Moodle](#)
- [Lab Access](#)
- [Computing Facilities](#)
- [Student Resources](#)
- [Course Outlines](#)
- [Engineering Student Support Services Centre](#)
- [Makerspace](#)
- [UNSW Timetable](#)
- [UNSW Handbook](#)
- [UNSW Mechanical and Manufacturing Engineering](#)

# 3. Course details

## Credit points

This is a 6 unit-of-credit (UoC) course and involves 3.5 hours per week (h/w) of face-to-face contact.

The normal workload expectations of a student are approximately 25 hours per term for each UOC, including class contact hours, other learning activities, preparation and time spent on all assessable work.

You should aim to spend about 15 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

	<b>Day</b>	<b>Time</b>	<b>Location</b>
<b>Lectures</b>	Monday	14:00 – 16:00	Colombo Theatre A
<b>Demonstrations</b>	Tuesday	16:00 – 17:30	Ainsworth 203 & 204

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

### Summary and 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.

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 aim 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.

### Student learning outcomes

This course is designed to address the learning outcomes below 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 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

## 4. Teaching strategies

This course consists of lectures, live demonstrations of models and online assignment support material. The lectures focus on theory underpinning simulation modelling and experimental design and, most importantly, provide in-class explanations and demonstrations of critical programming techniques related to the assignment. Attendance at lectures and demonstrations is therefore very important. The Assignment deals with analysing a complex system, similar to many real-world problems. It involves a substantial amount of work and effective team collaboration is very important. This is one of the reasons that the assessment strategy includes of two face-to-face 'viva' examinations, one in week 5 and the second in week 10. Each class member is expected to actively participate in model design and analysis. There will be a final exam that will cover key theoretical aspects of the entire course.

## 5. Course schedule

Week	Lecture Content	Lab Content
1	<p><b>Introduction to Process and Operations Modeling</b></p> <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>• Why build Models               <ul style="list-style-type: none"> <li>○ Stochastic Processes</li> <li>○ Dynamic Models</li> <li>○ Continuous – Discrete Time Models</li> <li>○ Input, Output and Disturbance Variables</li> </ul> </li> <li>• The Process of Modeling</li> <li>• Introduction to Operations Research</li> <li>• Introduction to Simulation and Arena</li> </ul>	<p>Introduction to Arena Input Analyser – Demonstration Set 1</p> <p>Discussion of the major Assignment</p>
2	<p><b>Public Holiday</b></p>	
3	<p><b>Random Variables and Probability Distributions</b></p> <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>	<p>Introduction to Arena Input Analyser – Demonstration Set 2</p> <p>On-going Arena support for Assignments</p>
4	<p><b>Model Design</b></p> <ul style="list-style-type: none"> <li>• Modeling Operations and Processes in Arena</li> <li>• Model Characteristics, scope and detail</li> <li>• Live demonstration of model building</li> <li>• Rockwell Arena simulation constructs</li> </ul>	<p>Introduction to modelling with Arena – Demonstration Set 3</p> <p>On-going Arena support for Assignments</p>
5	<p><b>Simulation Modeling Techniques and Strategies Part I</b></p> <ul style="list-style-type: none"> <li>• Basic modules, elements and blocks</li> <li>• Flow Control in Arena: Queues, Hold, Signal</li> <li>• Live demonstration of model building</li> <li>• Interfacing to Excel</li> </ul>	<p>Communicating between Arena and Excel</p> <p>On-going Arena support for Assignments</p>

<b>Week</b>	<b>Lecture Content</b>	<b>Lab Content</b>
<b>6</b>	<b>Simulation Modeling Techniques and Strategies Part II</b> <ul style="list-style-type: none"> <li>• Arena variables, logic control and expressions: Variables, Attributes, Record, Assign, Expressions, Separate, Batch, Decide</li> <li>• Data manipulation</li> </ul>	Further Arena Modelling – Demonstration Set 4  On-going Arena support for Assignments
<b>7</b>	<b>Verification, Validation and Documentation of Models</b> <ul style="list-style-type: none"> <li>• Verification and Validation</li> <li>• Model Documentation</li> </ul>	Further Arena Modelling – Demonstration Set 5  On-going Arena support for Assignments
<b>8</b>	<b>Creating Simulation Scenarios, Generating Data and Analysis of Output</b> <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>	Further Arena Modelling – Demonstration Set 6  On-going Arena support for Assignments
<b>9</b>	<b>Design of Experiment Theory (DOE) Part I</b> <ul style="list-style-type: none"> <li>• Single factor experiments</li> <li>• Introduction to factorial designs</li> <li>• Introduction to DOE in Minitab</li> </ul>	Minitab Tutorial on DOE Set 1  On-going Arena support for Assignments
<b>10</b>	<b>Design of Experiment Theory (DOE) Part II</b> <ul style="list-style-type: none"> <li>• Blockings in factorial design</li> <li>• Screening and characterization of models</li> <li>• Best practice in DOE</li> </ul>	Minitab Tutorial on DOE Set 2  On-going Arena support for Assignments
<b>11</b>	<b>Decision Analysis</b> <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>	Ongoing Arena support for Assignments

## 6. Assessment

### Assessment overview

Assessment	Group Project? (# Students per group)	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Group assignment 1	Yes (4)	20 minutes VIVA	10%	1, 2,3 and 4	Process flowchart and scope	VIVA – Week 3	Friday Week 5	On-the-spot feedback VIVA
Group assignment 2	Yes (4)	20 minutes VIVA	20%	1, 2,3 and 4	Model design, data structures, verified	VIVA – Week 7/8	Friday Week 9	On-the-spot feedback VIVA
Group assignment 3	Yes (4)	2500 words	30%	1, 2,3 and 4	Design of Experiment, simulation, statistical analysis, documentation	Friday 5pm, Week 11	Friday Week 12	Upon release of final results
Final exam	No	2 hours	40%	1, 2,3 and 4	All course content from weeks 1-11 inclusive.	Exam period, date TBC	N/A	Upon release of final results



## Assignments

Part of the assignment will be assessed in person and feedback given as part of an oral examination or 'viva'. Each team member must be present during this formal examination. A system will be implemented on Moodle for booking a time with your lecturers. The team will still need to prepare appropriate documentation and material as preparation for this assessment. Details will be posted on Moodle. The final part of the assignment requires a write-up and this is due at the end of Week 11.

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. The final report will be submitted electronically on Moodle by the end of week 11. The assignments support the learning outcomes by incorporating an appropriate mix of analytical techniques, enabling software, and 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 and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

### *Submission*

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 20 percent (20%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day.

Work submitted after the 'deadline for absolute fail' is not accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by the specified date. Examples include:

- a. Weekly online tests or laboratory work worth a small proportion of the subject mark,  
or
- b. Online quizzes where answers are released to students on completion, or
- c. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
- d. Pass/Fail assessment tasks.

## Marking

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.

The following criteria will be used to grade Viva examinations (Detailed instructions will be posted on Moodle):

- The level of progress achieved by the team at Stages 1 and 2 of the assignment. Stage 1 focuses on understanding the process flow and logic (flow charts and documentation) as well as identifying the issues, aims and scope of the model. Stage 2 needs to deliver a model, coded in Arena, appropriately verified, validated and documented that will be the engine for generating data from appropriate scenarios that the team will test and analyse (and ultimately submit as Part 3 of the assignment).
- The quality of work produced by the team at each of these stages. This includes the correctness of the work produced, an appropriate level of detail and documentation.
- The contribution of each team member to the efforts of the team. Each team member will be expected to present his or her part of the work and answer questions by the examiner(s).

The following criteria will be used to grade written 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

## Examinations

The end-of-session exam will cover all material including the simulation part of the course. It will specifically examine statistical analysis, simulation theory and design of experiment (DOE).

You must be available for all tests and examinations. Final examinations for each course are held during the University examination periods: February for Summer Term, May for T1,

August for T2, and November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates.

For further information on exams, please see the [Exams](#) webpage.

### *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 available 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 [Engineering Student Support Services Centre](#) prior to the examination. Calculators not bearing an “Approved” sticker will not be allowed into the examination room.

### **Special consideration and supplementary assessment**

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to submitting an assessment or sitting an exam.

**Please note** that UNSW now has a [Fit to Sit / Submit rule](#), which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW’s [Special Consideration page](#).

## **7. Expected resources for students**

### **References**

Simulation modeling and analysis with Arena, Tayfur. Altioek 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.

UNSW Library website: <https://www.library.unsw.edu.au/>

Moodle: <https://moodle.telt.unsw.edu.au/login/index.php>

## 8. 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 improved tutorial and example models that align better with the requirements of the assignment. This will allow for faster and more efficient model development for all teams.

## 9. 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, visit: [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)

## 10. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and policies. In particular, students should be familiar with the following:

- [Attendance](#)
- [UNSW Email Address](#)
- [Computing Facilities](#)
- [Special Consideration](#)
- [Exams](#)
- [Approved Calculators](#)
- [Academic Honesty and Plagiarism](#)
- [Student Equity and Disabilities Unit](#)
- [Health and Safety](#)
- [Lab Access](#)

# Appendix A: Engineers Australia (EA) Competencies

## Stage 1 Competencies for Professional Engineers

	<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