UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Semester 1 2018

MANF4611

PROCESS MODELING AND SIMULATION

Contents

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
- UNSW Mechanical and Manufacturing Engineering
- Course Outlines
- Student intranet
- UNSW Mechanical and Manufacturing Engineering Facebook
- UNSW Handbook

3. Course details

Credit Points

This is a 6 unit-of-credit (UoC) course, and involves 3 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	Tuesday	9:00 – 11:00	Chemical Sciences K-F10-M18
Demonstrations	Tuesday	11:30 – 13:00	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

Date	**Lecture Content** **(Chemical Sciences M18)** **9:00-11:00**	**Lab Content** **(Ainsworth 203/4)** **11:30-13:00**

Week 1
Tue 27/2/18
	Introduction to Process and Operations Modeling
	• Characteristics of Processes and Operations
	• Flow Systems, Manufacturing Systems, Business Systems, Engineering Systems
	• What are Models
	• Why build 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
		
		Discussion of the major Assignment

Week 2 Tue 6/3/18	**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 Arena Input Analyser	Introduction to Arena Input Analyser – Demonstration Set 1 Discussion of the major Assignment

Date	Lecture Content (Chemical Sciences M18) 9:00-11:00	Lab Content (Ainsworth 203/4) 11:30-13:00
Week 3 Tue 13/3/18	**Model Design** • Modeling Operations and Processes in Arena • Model Characteristics, scope and detail • Verification and Validation • Model Documentation • Live demonstration of model building • Rockwell Arena simulation constructs • Interfacing to Excel	Introduction to modelling with Arena – Demonstration Set 2
Week 4 Tue 20/3/18	**Application of Simulation Modeling** • Arena variables, logic control and expressions: Variables, Attributes, Record, Assign, Expressions, Separate, Batch, Decide • Flow Control in Arena: Queues, Hold, Signal • Live demonstration of model building	Communicating between Arena and Excel *Assignment Part I due* Demonstration Set 3
Week 5 Tue 27/3/18	**Design of Experiment Theory (DOE)** • Single factor experiments – ANOVA • Introduction to factorial designs • Response surface methods • Introduction to Minitab	Minitab Tutorial *Viva examinations for Part 1*
Week 6 Tue 10/4/18	**Analyzing Simulation Output 1** • 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	Further Arena Modelling – Demonstration Set 4 On-going Arena support for Assignments
Week 7 Tue 17/4/18	**Advanced Arena Concepts** • Transportation • Materials Handling • Model Animation • Sub-Models • Documentation	Advanced Arena Modelling – Demonstration Set 5

Date	Lecture Content (Chemical Sciences M18) 9:00-11:00	Lab Content (Ainsworth 203/4) 11:30-13:00
Week 8 Tue 24/4/18	**Analysing Simulation Output 2** • ANOVA • Process Analyzer • Sensitivity Analysis • Parametric vs non-parametric analysis in Minitab	Minitab Tutorial On-going Arena support for Assignments *Assignment Part II due*
Week 9 Tue 01/5/18	**Regression Analysis** • Simple linear • Polynomial regression • Multiple linear • Principal component analysis	Regression Tutorial On-going Arena support for Assignments *Viva examinations for Part 2*
Week 10 Tue 08/5/18	**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
Week 11 Tue 15/5/18	**Partial Least Squares** • PLS regression • PLS path modeling	Ongoing Arena support for Assignments
Week 12 Tue 22/5/18	**Summary of the course**	Ongoing Arena support for Assignments

Date	Lecture Content (Chemical Sciences M18) 9:00-11:00	Lab Content (Ainsworth 203/4) 11:30-13:00
Week 13 Tue 29/5/18	**Tutorial support**	Ongoing Arena support for Assignments *Assignment Part 3 due*

6. 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	20 minute Viva	10%	1 and 4	Problem formulation, system representation, flowcharts	Week 4 – Fri 23/03/18	Fri 13/04/18	Two weeks after submission
Group Assignment – Part 2	20 minute Viva	20%	1 and 4	Model design and documentation, data structures, verification (& limited validation)	Week 8 – Fri 20/04/18	Fri 11/05/18	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 01/06/18	Fri 8/06/18	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
TOTAL		**100%**					

Assignments

Parts 1 and 2 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 in weeks 5 and 10. 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 (Part 3) requires a write-up and this is due in week 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. For Part 3, completed assignments will be submitted electronically on Moodle by the end of week 13. 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 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

Late submissions will be penalised 5 marks per calendar day (including weekends). An extension may only be granted in exceptional circumstances. Special consideration for assessment tasks 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.

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

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.

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, were 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 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.

7. Attendance

You are required to attend a minimum of 80% of all classes, including lectures, labs and seminars. It is possible to fail the course if your total absences equal to more than 20% of the required attendance. Please see the School intranet and the UNSW attendance page for more information.

8. Expected resources for students

UNSW Library website: https://www.library.unsw.edu.au/
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

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, 6th edition, McGraw Hill.

Simulation Modeling and Arena, M.D. Rossetti, John Wiley & Sons, 2009.

9. 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.

10. 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.

11. Administrative matters and links

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 2018

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	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