UNSW AUSTRALIA

Course Outline

Semester 1, 2015

Never Stand Still | Faculty of Engineering | School of Mechanical and Manufacturing Engineering

MANF4611

PROCESS MODELING AND SIMULATION

CONTENTS

MANF4611 PROCESS MODELING AND SIMULATION

COURSE OUTLINE

1. STAFF CONTACT DETAILS:

Course coordinator: Erik van Voorthuysen
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Teaching staff: Ron Chan
James Baulch (SMS Modelling Services)
Erik van Voorthuysen

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

2. COURSE DETAILS

Class Times and Locations: Wednesday 1500-1700, Blockhouse, 203
Wednesday 1700-1800, TETB, G17

Units of credit

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.”

For a standard 24 UoC in the session, this means 600 hours, spread over an effective 15 weeks of the session (thirteen weeks plus stuvac plus one effective exam week), or 40 hours per week, for an average student aiming for a credit grade. Various factors, such as your own ability, your target grade, etc., will influence the time needed in your case. Some students spend much more than 40 h/w, but you should aim for not less than 40 h/w on coursework for 24 UoC.

This means that you should aim to spend not less than about 10 h/w on this course, i.e. an additional 7 h/w of your own time. This should be spent in making sure that

you understand the lecture material, completing the set assignments, further reading about the course material, and revising and learning for the quizzes and final exam.

There is no parallel teaching in this course.

Summary of the course

Key factors for success in modern manufacturing and management include efficient and effective allocation of resources, infrastructure, capacity and capital investment. Depending on the characteristics of the 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 changing business landscape.

This course focuses on analytical techniques for decision making and solving complex process and resource allocation problems encountered in industry. It includes the major analytical techniques as part of Operations Research as well as the theory and use of discrete event simulation. Specific techniques discussed include linear programming, project management theory, network optimisation, decision theory and simulation using Rockwell Arena ® software.

MANF4611 operates in conjunction with MANF4100 Design and Analysis of Product-Process Systems by focusing more so on the quantitative techniques in analysing, designing, managing and improving systems and processes. 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.

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
- Network analysis and shortest route problems
- Inventory theory
- Transportation models
- Decision analysis and decision trees

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

Aims of the course

The course aims to develop you into a skilled and all-rounded design engineer and industrial analyst, able to carry out and manage the key design, managerial and decision-making processes. Management and design is inherently complex and a systematic, yet flexible, agile and interdisciplinary approach is required to manage and improve complex systems. The course teaches this approach, at the manufacturing system and factory level, 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

At the conclusion of the course it is expected that you will be able to:

1) Formulate a real world problem and select an appropriate analytical technique for modeling and ultimately solving this problem.
2) Characterise the behavior of a system in terms of the nature of its variables, interactions and state changes as a function of time.
3) Apply linear programming techniques to solve resource allocation problems and issues.
4) Apply simulation techniques to solve complex system issues and to select feasible, if not optimum, solutions and configurations amongst competing designs.
5) Solve large infrastructure issues involving location decisions, as well as resourcing decisions using transportation methods.
6) Apply decision analysis methods to make sound decisions under risk and uncertainty.

Graduate attributes

UNSW's graduate attributes are shown at:

https://my.unsw.edu.au/student/atoz/GraduateAttributes.html

and are stated as:

Scholars who are:

1. understanding of their discipline in its interdisciplinary context
2. capable of independent and collaborative enquiry
3. rigorous in their analysis, critique, and reflection

4. able to apply their knowledge and skills to solving problems
5. ethical practitioners
6. capable of effective communication
7. information literate
8. digitally literate

Leaders who are:

9. enterprising, innovative and creative
10. capable of initiating as well as embracing change
11. collaborative team workers

Professionals who are:

12. capable of independent, self-directed practice
13. capable of lifelong learning
14. capable of operating within an agreed Code of Practice

Global Citizens who are:

15. capable of applying their discipline in local, national and international contexts
16. culturally aware and capable of respecting diversity and acting in socially just/responsible ways
17. capable of environmental responsibility

A statement of broad graduate attributes has meaning when expressed in the context of the discipline. The graduate attributes contextualised for engineering are shown at: http://teaching.unsw.edu.au/sites/default/files/upload-files/GradAttrEng.pdf

In this course, you will be encouraged to develop these Graduate Attributes, and more specifically 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15 and 17 by undertaking the selected activities and knowledge content. These attributes will be assessed within the prescribed assessment tasks, as shown in the assessment table on Page 7.

3. RATIONALE FOR INCLUSION OF CONTENT AND TEACHING APPROACH

This course is included to support the professional and practical skills required to become a manufacturing and industrial engineer by offering a comprehensive grounding in key analytical methods and techniques that can be employed in understanding and improving complex systems. The course is offered concurrently with MANF4100 Analysis and Design of Product-Process Systems and MMAN4400 Engineering Management. In combination with the other core manufacturing engineering courses, the knowledge and capabilities gained from this course will allow you to become a skilled and all-rounded manufacturing and industrial engineer.

Effective learning is supported when you are actively engaged in the learning process and by a climate of enquiry, and these are both an integral part of the lectures and practica.

You become more engaged in the learning process if you can see the relevance of your studies to professional, disciplinary and/or personal contexts, and the relevance is shown in the lectures and assignments by way of examples drawn from industrial situations as well as designs that are discussed in class.

Dialogue is encouraged between you, others in the class and the lecturers. Diversity of experiences is acknowledged, as some students in each class have prior experience. Your experiences are drawn on to illustrate various aspects, and this helps to increase your motivation and engagement.

Since you will work closely with your lecturers and colleagues, you will have almost instant feedback and discussion and this greatly enhances the learning experience.

4. 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 quizzes to support the learning experience, and in addition, there will be a final exam.

Suggested approaches to learning in the course

Suggested approaches to learning in this course include:

- Careful reading, discussion and understanding of the material presented in lectures.
- Additional reading on and about the material presented in lectures to broaden the knowledge base.

- Paying attention throughout the lectures/practica, and asking questions when anything is not understood.
- Conscientiously working through assignments.
- Learning of the lecture material in preparation for quizzes.

Student-centered and self-directed learning (expectations of the students)

This course involves four hours per week of face-to-face contact, and it is expected that you will put in, on average, an additional seven hours per week of your own time. This time should be spent in revising lecture material and further reading, completing assignments, and revising and learning for the quizzes.

Expected learning outcomes; their association with the teaching strategies and with the suggested approaches to learning

The lectures are designed to teach you the underlying theory and key methodologies and analytical techniques centered on factory design, flexible and automated manufacturing. These methodologies are state-of-the-art and used by leading industrials. The assignments are designed to use these methodologies on real case-studies and give you the confidence and ability to make important design and manufacturing decisions. This helps to prepare you for a rewarding career in this field.

The course has been designed to support academic learning, by understanding the theory and philosophy of design for manufacturing, but also to support developing practical skills that industry needs.

5. ASSESSMENT

General

You are assessed by way of assignments, quizzes, and a final exam. Quizzes involve both calculations and descriptive material.

Assignment 1	10%	Due end-of-week 6 – Monday 13 April	(Graduate Attributes: 1, 2, 3 and 4)
Assignment 2	15%	Due end-of-week 9 – Monday 4 May	(Graduate Attributes: 1, 2, 3, 4, 7, 8 and 17)
Assignment 3	25%	Due end-of-week 12 – Monday 25 May	(Graduate Attributes: 1, 2, 3, 4, 7 and 8)
Final Exam	50%	To be advised	(Graduate Attributes: 1, 2, 3, 4, 6, 7,13,14,15 and 17)
TOTAL	100%		

The assessments are designed to bolster your understanding of the material being presented and focus on the key learning points. The quizzes will test the understanding of the sections being presented while the assignments will allow you to apply the concepts learnt in the course.

Assignments

The assignments will be posted on Moodle 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.

The School guidelines recommend that late submissions incur a penalty of 10% of the total marks awarded for each calendar day the assignment is late. For example, if you received a mark of 40 out of 50 for an assignment that you handed in 2 days late you would receive a penalty of 8 marks and your mark would be reduced to 32. If the same assignment were handed in 4 days late the mark would be reduced to 24. 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: https://student.unsw.edu.au/special-consideration

Please note that late penalties are at the discretion of the course convenor and in

some cases late work may not be assessed. Please carefully check course outlines for more detailed information regarding late penalties.

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.

Submission of Assignments

Each of you will undertake two assignments. You can undertake this by yourself or in a team of two. 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 8 and 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.

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 practica.
- 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

6. ACADEMIC HONESTY AND PLAGIARISM

Plagiarism is using the words or ideas of others and presenting them 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 booklet which provides essential information for avoiding plagiarism: https://my.unsw.edu.au/student/academiclife/Plagiarism.pdf

There is a range of resources to support students to avoid 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. Information is available on the dedicated website Plagiarism and Academic Integrity website: http://www.lc.unsw.edu.au/plagiarism/index.html

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 a honours thesis) even suspension from the university. The Student Misconduct Procedures are available here: http://www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Further information on School policy and procedures in the event of plagiarism is presented in a School handout, Administrative Matters for All Courses, available on the School website.

7. COURSE SCHEDULE

Week	Topic	Lecturer
1	**Introduction to Process and Operations Modeling** • Characteristics of Processes and Operations • Flow Systems, Economic Systems, Business Systems • What are Models • Stochastic Processes • Dynamic Models • Continuous – Discrete Time Models • Input, Output and Disturbance Variables • The Process of Modeling (lower level) • The Process of Using Modeling to Make Decisions (higher level) • Introduction to Operations Research • Introduction to Simulation and Arena • Key Arena Constructs: Process, Entity, Create, Dispose, Resource, Queues, Schedule, Set, TNOW • Seize – Delay – Release • One-Shot	EVV
2	**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	RC
3	**Model Design** • Model Characteristics • Model Scope • Model Detail • Model Identification • Model Quality • Verification and Validation • Model Documentation • Modeling Production Systems in Arena • Advanced Arena Constructs: Variables, Attributes, Record, Assign, Expressions, While, Separate, Batch, • Flow Control in Arena	JB
4	**Application of Simulation Modeling**	JB

5	**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	JB
6	**Advanced Arena Concepts** • Transportation • Materials Handling • Model Animation • Sub-Models • Variable Tables • Interfacing to Excel	JB
7	**Inventory Theory and Queueing** • Forecasting Time Horizons • Types of Forecasts • The Forecasting Process • Time Series Forecasting • Moving Average • Exponential Smoothing • Measuring Forecasting Error • Trend Adjustment • Seasonal Variation • Regression Analysis in Forecasting • Goodness of Fit	RC
8	**Resource Allocation Problems: Linear Programming 1** • Simplex Method • Geometry of the Simplex Method • Duality Theory	RC
9	**Applications of Linear Programming** • Multi-goal Programming • Sensitivity Analysis • Applications	RC
10	**Transportation Models** • Northwest Corner Method • Stepping Stone Method • Intuitive Method	EVV
11	**Network Analysis** • Deterministic Networks: Process sequencing, aggregate production planning • Stochastic Networks: Probabilistic Networks with certain outcomes, Markov Networks with uncertain outcomes	EVV

12	**Decision Analysis** • Overcoming risk and uncertainty • Decision Trees • Decision tables • Decision methods: Maximax, Maximin, Equally Likely • Expected monetary value • Value of information	EVV
13	**Summary of course**	RC/JB/EVV

Please note that the some of the topics may run over the indicated period if there are questions and the discussions are long.

8. RELEVANT RESOURCES FOR STUDENTS ENROLLED IN THE COURSE

Textbooks:

No formal textbook is required at this time. Lecture notes will be available on Moodle.

Reference books:

1. Operations Management – Sustainability and Supply Chain Management, J. Heizer and B. Render, 2014, Pearson Education. This textbook is available through the bookstore at UNSW.
2. Manufacturing Process Selection Handbook: From Design to Manufacture, Swift K.G., Booker J.D., 2013, Burlington, Elsevier Science, ISBN 9780080993607 – available from our library electronically
3. Fundamentals of Modern Manufacturing, Groover M.P., 2nd ed., 2002 John Wiley

9. COURSE EVALUATION AND DEVELOPMENT

The course has been completely redesigned in 2015 and will be evaluated at the end of this semester. 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 practica 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.

10 USE OF CALCULATORS

You will need to provide your own calculator, of a make and model approved by UNSW. The list of approved calculators is shown at:
https://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.

11. ADMINISTRATIVE MATTERS

You are expected to have read and be familiar with Administrative Matters, available on the School website. This document contains important information on student responsibilities and support, including special consideration, assessment, health and safety, and student equity and diversity.

Erik van Voorthuysen
February 2015