Course outline

Semester 2 2016

Never Stand Still | Engineering | Mechanical and Manufacturing Engineering

MTRN 4030

OPTIMISATION METHODS FOR ENGINEERING SYSTEMS

Contents

1. Staff contact details

Contact details and consultation times for course convenor

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Consultation concerning this course will be by appointment. Direct consultation is preferred, email may also be used.

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

To be advised.

2. Course details

Credit Points

This is a 6 unit-of-credit (UoC) course, and involves 4 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.

There is no parallel teaching in this course.

Contact hours

	Day	Time	Location
Lectures	Tuesday	12noon – 2pm	Vallentine Annexe 121 (K-H22-121)
Laboratory	Thursday	10am – 12pm	Ainsworth Building 204 (K-J17-204)

Summary of the course

This course will enable students to acquire an understanding of optimization concepts in engineering system designs and the applications of optimization algorithms in mechanical, manufacturing, and mechatronic systems.

Aims of the course

This course enables you to explore the theories and concepts from the viewpoint of the application of optimization methods in engineering systems. The course will give you tools in the design of engineering systems for optimum characteristics. Example cases will be focused on mechanical system design, manufacturing task scheduling and robotics trajectory planning.

The course also provides you with the concepts employed in the development of classical optimisation methods and metaheuristic optimisation approaches. You will be provided with insights into the advantages and disadvantages of these optimisation methods when they are applied to solve engineering problems.

This course will further develop your computer based skills in implementing and developing algorithms to solve engineering optimisation problems. You will improve your Matlab programming techniques through laboratory based exercise. Your understanding of numerical methods, learned in MATH2089 (or equivalent), will be further enhanced. The assignments also build on the report-writing skills which you commenced in ENGG1000.

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.	Master the theory and concept of optimization techniques to engineering systems design, and to critically evaluate and apply for specific engineering problems.	PE1.1, PE1.2
2.	Understand the essences of classical optimisation methods, and metaheuristic optimisation algorithms. These include unconstrained and constrained optimisations, agent based and nature inspired approaches.	PE1.1, PE1.2
3.	Apply numerical techniques to complete the design of engineering systems for optimum performances. Discharge optimisation knowledge in the designs for mechanical, manufacturing and robotic systems.	PE2.1, PE2.2

4.	Develop computer programs to implement and analyse optimisation approaches in the engineering context. Apply learned programming skills to develop computer programs for optimisation.	PE2.1, PE2.2

3. Teaching strategies

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

The work in laboratory exercises involves self-directed work, in being theoretically sound in the design of your optimisation algorithms. It also allows you to integrate your theoretical basics into the construction of computer programs to solve optimisation problems.

Lectures and laboratory exercises are supported by current scientific publications as a means to let you explore the development in the field of engineering optimization. Thus, literature readings pre-laboratory preparations are strongly recommended.

4. Course schedule

Date	Topic	Location	Lecture Content	Demonstration/ Lab Content	Suggested Readings
Week 1 26/07/16	Introduction to optimization	Vallentine Annexe 121 (K-H22-121)	Course introduction, engineering optimization examples	N/A	Lecture handouts
Week 2 02/08/16	Mathematical foundations	Vallentine Annexe 121 (K-H22-121)	Review: differential equations	N/A	Lecture handouts
Week 3 09/08/16	Classical optimization - 1	Vallentine Annexe 121 (K-H22-121)	Unconstrained, constrained, gradient-based optimization, linear programming	N/A	Lecture handouts

Week 4 16/08/16	Classical optimization - 2	Vallentine Annexe 121 (K-H22-121)	Simplex method, Lagrange multiplier, Karush-Kuhn-Tucker condition	N/A	Lecture handouts
Week 5 23/08/16	Classical optimization - 3	Vallentine Annexe 121 (K-H22-121)	Modern optimization methods	N/A	Lecture handouts
Week 6 30/08/16	Classical optimization - 4	Vallentine Annexe 121 (K-H22-121)	Topics in optimal control	N/A	Lecture handouts
Week 7 06/09/16	Metaheuristics -1	Vallentine Annexe 121 (K-H22-121)	Markov chain, genetic algorithms	N/A	Lecture handouts
Week 8 13/09/16	Metaheuristics -2	Vallentine Annexe 121 (K-H22-121)	Simulated annealing, ant algorithms	N/A	Lecture handouts
Week 9 20/09/16	Metaheuristics -3	Vallentine Annexe 121 (K-H22-121)	Bee algorithm, particle swarm optimization	N/A	Lecture handouts
Week 10 04/10/16	Metaheuristics -4	Vallentine Annexe 121 (K-H22-121)	Harmony search, firefly algorithm	N/A	Lecture handouts
Week 11 11/10/16	Multi-objective optimization	Vallentine Annexe 121 (K-H22-121)	Weighted sum, utility functions, Pareto front	N/A	Lecture handouts
Week 12 18/10/16	Revision	Vallentine Annexe 121 (K-H22-121)	Lecture topics, sample examination	N/A	Lecture handouts

Laboratory exercises are scheduled as below. There are four exercises and two laboratory reports required. The due dates for the reports are one week, on Thursday COB, after the completion of each laboratory exercise (see also laboratory instructions). Individual reports are to be submitted online in Moodle.

Date	Topic	Location	Lecture Content	Demonstration/ Lab Content	Suggested Readings
Week 2 04/08/16	Matlab programming review	Ainsworth Building 204 (K-J17-204)	N/A	Programming techniques	Laboratory instruction sheet
Week 3 11/08/16	Matlab based optimization programming	Ainsworth Building 204 (K-J17-204)	N/A	Graphical visualisation	Laboratory instruction sheet
Week 4 18/08/16	Classical optimization – A1	Ainsworth Building 204 (K-J17-204)	N/A	Unconstrained, constrained, gradient-based optimization, linear programming	Laboratory instruction sheet
Week 5 25/08/16	Classical optimization – A2	Ainsworth Building 204 (K-J17-204)	N/A	Simplex method, Lagrange multiplier, Karush-Kuhn-Tucker condition	Laboratory instruction sheet
Week 6 08/09/16	Classical optimization – A3	Ainsworth Building 204 (K-J17-204)	N/A	Modern optimization methods	Laboratory instruction sheet
Week 7 15/09/16	Review	Ainsworth Building 204 (K-J17-204)	N/A	Laboratory exercises in weeks 2 to 6	Laboratory instruction sheet
Week 8 22/09/16	Classical optimization – B1	Ainsworth Building 204 (K-J17-204)	N/A	Topics in optimal control	Laboratory instruction sheet
Week 9 29/09/16	Classical optimization – B2	Ainsworth Building 204 (K-J17-204)	N/A	Markov chain, genetic algorithms	Laboratory instruction sheet
Week 10 06/10/16	Classical optimization – B3	Ainsworth Building 204 (K-J17-204)	N/A	Simulated annealing, ant algorithms	Laboratory instruction sheet
Week 11 13/10/16	Metaheuristics optimization – 1	Ainsworth Building 204 (K-J17-204)	N/A	Harmony search, firefly algorithm	Laboratory instruction sheet

Week 12 20/10/16	Metaheuristics optimization – 2	Ainsworth Building 204 (K-J17-204)	N/A	Weighted sum, utility functions, Pareto front	Laboratory instruction sheet
Week 13 27/10/16	Revision	Ainsworth Building 204 (K-J17-204)	N/A	Review: laboratory exercises	Laboratory instruction sheet

5. Assessment

Assessment overview

Assessment	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Marks returned
Laboratory exercise – 1	Weeks 2 and 3	5% practical	4	Lecture material from weeks 1 and 2.	11/08/16 in laboratory class	One week after class
Laboratory exercise – 2	Weeks 4, 5 and 6	5% practical 10% report	1, 2, 3 and 4	Lecture material from weeks 3, 4 and 5.	15/09/16 COB via Moodle	Two weeks after submission
Laboratory exercise – 3	Weeks 8, 9 and 10	5% practical 10% report	1, 2, 3 and 4	Lecture material from weeks 6, 7 and 8.	13/10/16 COB via Moodle	Two weeks after submission
Laboratory exercise – 4	Weeks 11 and 12	5% practical	1, 2, 3 and 4	Lecture material from weeks 9, 10 and 11.	20/10/16 in laboratory class	One week after class
Final examination	2 hours	60%	1, 2 and 3	All course content from weeks 1-12 inclusive.	Exam period, date TBC	Upon release of final results

Assignments

Presentation

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

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

Submission

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

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

Examinations

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

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

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

Calculators

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

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

Special consideration and supplementary assessment

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

6. Expected resources for students

Textbook

X.S. Yang, "Engineering Optimization: An Introduction with Metaheuristic Applications," John Wiley & Sons, 2010. (available from UNSW library)

Recommended Readings

S.S. Rao, "Engineering Optimization: Theory and Practice," John Wiley & Sons, 2009.

P. Venkataraman, "Applied Optimization with MATLAB Programming," John Wiley & Sons, 2009.

Additional materials provided in UNSW Moodle

This course has a website on UNSW Moodle which includes:

- lecture materials
- laboratory instructions
- sample program codes
- selected scientific articles

Recommended Internet sites

IEEE Xplore digital library, accessible through UNSW library, for additional readings on scientific articles.

http://ieeexplore.ieee.org/Xplore/home.jsp

Other Resources

If you wish to explore any of the lecture topics in more depth, then other resources are available and assistance may be obtained from the UNSW Library. One starting point for assistance is:

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

7. Course evaluation and development

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

In this course, recent improvements resulting from student feedback include the hands-on exercises integrated with practical application of the theoretical knowledge.

8. Academic honesty and plagiarism

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

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

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

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

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

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

9. Administrative matters

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

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

Ngai Ming Kwok
08 July 2016

10. Appendix A: Engineers Australia (EA) 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