Design and Application of Materials in Science and Engineering 3: Computational Modelling

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Course Staff

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>A/Prof. Runyu Yang</td>
<td>Consultation hours: by appointment</td>
<td></td>
<td></td>
</tr>
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<td>Consultation hours: by appointment</td>
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<tr>
<td>Lecturer</td>
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Course Objective
This is a capstone course, which will integrate the knowledge learnt in years 1 and 2 and apply the knowledge to numerical modelling in materials engineering. The aims are to understand the fundamentals of computer modelling and to develop numerical skills necessary for solving problems in material design and application using common commercial software.

Your Course at a Glance

<table>
<thead>
<tr>
<th>What you will learn</th>
<th>Weeks</th>
<th>Assessment task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction - What is computational modelling and design? Why do we need it and where is it used? CAD and CFD fundamentals.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CFD principles and governing equations, discretisation techniques, finite difference (FD) and finite volume (FV) methods, direct and iterative methods, determination of convergence and accuracy.</td>
<td>2-3</td>
<td>Assignment 1</td>
</tr>
<tr>
<td>Basic CFD techniques and applications: grid generation, boundary conditions, SIMPLE algorithm and turbulence modelling, reporting of results.</td>
<td>4-5</td>
<td></td>
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<tr>
<td>Application of CFD modelling to fluid flow and heat transfer in materials processing.</td>
<td>6</td>
<td></td>
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<tr>
<td>Use of ANSYS Workbench and Fluent</td>
<td>1-6</td>
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Assignment 1 due Week 6

Mid-session exam (written and practical) – held in Week 7

<table>
<thead>
<tr>
<th>What you will learn</th>
<th>Weeks</th>
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<tbody>
<tr>
<td>Revision of elasticity theory, plane stress and plane strain elasticity, beam theory, axisymmetric and Cartesian coordinates.</td>
<td>7</td>
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<tr>
<td>Finite element modeling (FEM): - building a numerical model using FE modeling, discretization of structures.</td>
<td>7</td>
<td></td>
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<tr>
<td>Bar and beam elements, the stiffness method</td>
<td>8</td>
<td></td>
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<tr>
<td>Principle of virtual work, constant strain triangle, axisymmetric FE analysis</td>
<td>9,10</td>
<td></td>
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<tr>
<td>4-noded rectangular element</td>
<td>10</td>
<td></td>
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<tr>
<td>Non-linear analysis</td>
<td>11</td>
<td></td>
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<tr>
<td>Use of ANSYS FE software: model design, meshing, solving and analysis of results.</td>
<td>8-12</td>
<td></td>
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<tr>
<td>Applications of finite element modeling in research</td>
<td>8-12</td>
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</tbody>
</table>

Assignment 2 due Week 12

Final exam – written

Final exam – practical
Course Content

Principles of computation modelling, computer-aided drawing, computation fluid dynamics, finite difference and finite volume methods, use of FLUENT, finite element modeling, principle of virtual work, uniaxial and planar finite elements, elastic and non-linear analysis, designing a finite element problem, use of ANSYS.

Timetable

<table>
<thead>
<tr>
<th>Week</th>
<th>Day</th>
<th>Time</th>
<th>Location</th>
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<tbody>
<tr>
<td>1-12</td>
<td>Wednesday</td>
<td>15:00 – 17:00</td>
<td>Macauley Theatre (K-E15-1027)</td>
</tr>
<tr>
<td>1-12</td>
<td>Thursday</td>
<td>11:00 – 13:00</td>
<td>Mathews Theatre C (K-D23-303)</td>
</tr>
<tr>
<td>Lab Practice</td>
<td>TBA</td>
<td>TBA</td>
<td>MSE (E10) Room 123</td>
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Laboratory Classes

Laboratories will be scheduled as appropriate with progress in theory and will comprise approximately 1/3 of scheduled class time. You will be asked to use commercial software to apply the theory to real-world problems. Students will be allocated to different groups for the lab practices. Note there is no lecture when a lab is scheduled.

Assessment

<table>
<thead>
<tr>
<th>Assessment Task</th>
<th>Fraction</th>
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<tr>
<td><strong>CFD Lab attendance</strong>: You are required to attend the lab practices and submit the results at the end of the practices.</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Assignment 1</strong>: You are required to solve a partial differential equation using finite difference and finite volume methods. You will also need to develop a CFD model using Pro/E and FLUENT software packages on the ANSYS Workbench platform to solve a typical fluid and heat flow problem in material processing. <strong>Due</strong>: Week 6</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Mid-session Exam – theory and practical</strong>: The exam will be held in Week 7. It will assess understanding of the CFD theory and ability to solve materials problems encountered in design using the FLUENT CFD package; both on the ANSYS Workbench platform.</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Assignment 2</strong>: You will develop analytical solutions, using finite element theory, to basic mechanical loading problem. You will also use ANSYS FE software to solve a complex mechanical loading problem involving a range of materials. <strong>Due</strong>: Week 12</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Final Exam – theory</strong>: The exam will be 2 hours duration held in the final exam period. It assesses understanding of the CFD and FE theory learnt in the course with equal weighting to each.</td>
<td>25%</td>
</tr>
<tr>
<td><strong>Final Exam – practice</strong>: The exam will be 2 hours duration held in the final exam period. The exam will be held in a computer lab and will be open book. It will assess the ability to solve materials problems encountered in design using the FLUENT CFD package and ANSYS finite element modeling package; both on the ANSYS Workbench platform.</td>
<td>25%</td>
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</table>
NOTE: Students who fail to achieve a score of at least 40% for the overall exam component (i.e., mid-session exam and final exam marks combined), but achieve a final mark >50% for the course, will be awarded a UF (Unsatisfactory Fail) for the course.

Please refer to the UNSW guide to grades: https://student.unsw.edu.au/grades

References

- J. Tu, G. H. Yeoh and C. Liu, “Computational Fluid Dynamics – A Practical Approach”
- D. Gaskell, “An Introduction to Transport Phenomena in Materials Engineering”
- J.D. Anderson, “Computational Fluid Dynamics – The Basics with Applications”
- R. F. Cooke, “Finite Element Modelling for Stress Analysis”
- J. Fish, T. Belytschko, “A First Course in Finite Elements” (Available online)

Learning and Teaching Philosophy Underpinning the Course

(based on UNSW Learning Guidelines)

- **Students are actively engaged in the learning process.**
  It is expected that, in addition to attending classes, students will read, write, discuss, and engage in analysing the course content.

- **Effective learning is supported by a climate of inquiry where students feel appropriately challenged.**
  Students are expected to be challenged by the course content and to challenge their own preconceptions, knowledge, and understanding by questioning information, concepts, and approaches during class and study.

- **Learning is more effective when students’ prior experience and knowledge are recognised and built on.**
  Coursework, tutorials, assignments, laboratories, examinations, and other forms of learning and assessment are intended to provide students with the opportunity to cross-reference these activities in a meaningful way with their own experience and knowledge.

- **Students become more engaged in the learning process if they can see the relevance of their studies to professional and disciplinary contexts**
  The course content is designed to incorporate both theoretical and practical concepts, where the latter is intended to be applicable to real-world situations and contexts.

Course Information

<table>
<thead>
<tr>
<th>Units of credit</th>
<th>6</th>
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<tr>
<td>How the course relates to other course offerings and overall program(s) in the discipline</td>
<td>The course applies heat transfer and mechanical and fluid mechanics theory to complex engineering design through the application of computational modelling. Mathematical knowledge associated with differential equations and matrix theory is also called upon.</td>
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<tr>
<td>Graduate attributes which will be gained through the course</td>
<td>• Ability to communicate effectively</td>
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• Capacity for creativity and innovation
• Ability to manage information and documentation
• Understanding of professional and ethical responsibilities, and commitment to them
• Ability to function effectively as an individual
• Capacity for lifelong learning and professional development
• Professional attitudes

Expected learning outcomes
In doing this course, you will learn to:
• Use computational modelling to apply physical theory to complicated engineering problems.
• Apply the principles of computer aided design and use basic drafting software such as Pro/E.
• Use basic discretisation techniques to solve problems in materials engineering.
• Apply CFD fundamentals to heat and fluid transfer problems
• Apply the principles of finite element modelling to trusses and plates and axisymmetric analysis
• Use commercial software (FLUENT and ANSYS) to solve real problems in material engineering

You will also learn to:
• Think critically in decision making and problem-solving
• Communicate with correct terminology
• Conduct online research

Teaching strategies
• Core concepts, theories and approaches will be covered in lectures.
• These concepts will be synthesised in a practical context in the laboratory sessions.
• Extensive use will be made of exemplary case studies
• Problem design and solution will be learnt through assignments
• Teaching material, including course outline, notes, problems, assignments, case studies and course announcements are available on the Course Moodle website.

1 Based on the professional attributes given in Engineers Australia National Generic Competency Standards - Stage 1 Competency Standard for Professional Engineers and UNSW Graduate Attributes.

Academic Honesty and Plagiarism

What is Plagiarism?
All details regarding plagiarism can be found here: https://student.unsw.edu.au/plagiarism

It is important to understand what plagiarism is. The general concept is plagiarism is using the words or ideas of others and passing them off as your own. Examples of plagiarism, including self-plagiarism, are:

• Copying

  Using the same or very similar words to the original text or idea without acknowledging the source or using quotation marks. This includes copying materials, ideas or concepts from a book, article, report or other written document, presentation, composition, artwork, design,
drawing, circuitry, computer program or software, website, internet, other electronic resource, or another person’s assignment, without appropriate acknowledgement.

- **Inappropriate paraphrasing**

Changing a few words and phrases while mostly retaining the original structure and/or progression of ideas of the original, and information without acknowledgement.

This also applies in presentations where someone paraphrases another’s ideas or words without credit and to piecing together quotes and paraphrases into a new whole, without appropriate referencing.

- **Collusion**

Presenting work as independent work when it has been produced in whole or part in collusion with other people. Collusion includes,

- students providing their work to another student before the due date, or for the purpose of them plagiarising at any time
- paying another person to perform an academic task and passing it off as your own
- stealing or acquiring another person’s academic work and copying it
- offering to complete another person’s work or seeking payment for completing academic work.

This should not be confused with academic collaboration.

- **Inappropriate citation**

Citing sources which have not been read, without acknowledging the ‘secondary’ source from which knowledge of them has been obtained.

- **Self-plagiarism**

‘Self-plagiarism’ occurs where an author republishes their own previously written work and presents it as new findings without referencing the earlier work, either in its entirety or partially.

Self-plagiarism is also referred to as ‘recycling’, ‘duplication’, or ‘multiple submissions of research findings’ without disclosure. In the student context, self-plagiarism includes re-using parts of, or all of, a body of work that has already been submitted for assessment without proper citation.

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.

Students 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 items.

**Continual Course Improvement**

- At the end of the course, students will be asked to provide evaluative feedback through myExperience, the University’s course and teaching evaluation and improvement process
• Students are encouraged to address any problems regarding teaching of this course at the annual staff-student meeting
• Student comments on teaching during the session are welcome and will be appreciated
• At times students may be asked to answer a short questionnaire for feedback on the course

Administrative Matters
• Students should attend at least 80% of all classes.
• Students unable to submit assignments on time or attend the mid-session quizzes or final exams on health grounds should make a request for special consideration. Information on this process can be found here: https://student.unsw.edu.au/special-consideration. Medical certificates or other appropriate documents must be included. Students should also advise the lecturer of the situation.
• Unless otherwise specified in the task criteria, all assignments must be uploaded via Moodle prior to the due date for submission.
• Assignments/lab reports submitted after the due date for submission will receive a 10% of maximum grade penalty for every day late, or part thereof.
• Students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equity and Diversity Unit: https://student.unsw.edu.au/disability. Early notification is essential to enable any necessary adjustments to be made.

Rules for Exams
Rules governing conduct during exams are given at: https://student.unsw.edu.au/exam-rules