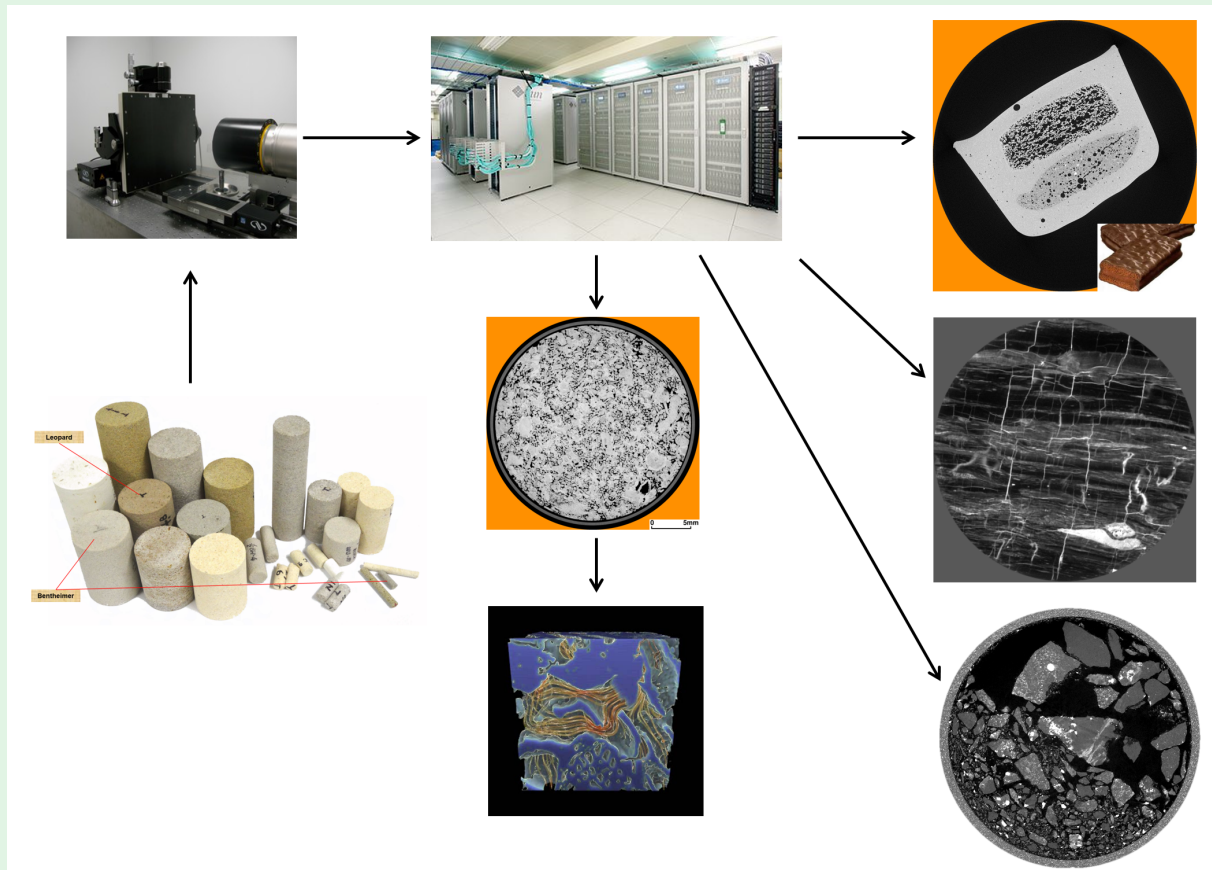# PTRL5102

Digital Core Analysis

Term 3, 2022

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Christoph Arns	c.arns@unsw.edu.au	Contact by email or teams	Tyree Energy Building, room 220	02 9385 5658

School Contact Information

School of Minerals and Energy Resources
Old Main Building, Level 1, 159 (K15)
UNSW SYDNEY NSW 2052 AUSTRALIA

Engineering Student Services
E: mere.teaching@unsw.edu.au
W: www.engineering.unsw.edu.au/minerals-energy-resources

Course Details

Units of Credit 6

Summary of the Course

This course introduces concepts of digital core analysis and provides petroleum engineers the knowledge to define the objectives of and execute a digital core analysis acquisition program. The course covers topics from sample preparation and image acquisition to image processing, rock-typing and petrophysical calculations, to pore-scale modeling.

Course Aims

This course aims to (1) introduce the student to the background knowledge in digital core analysis and (2) guide the student in the application of digital core analysis to practical problems.

The learning outcomes are for the student to (1) demonstrate knowledge and skills needed to employ digital core analysis in the industry, (2) understand assumptions and limitations inherent to this technology, and (3) design and/or apply digital core analysis in the context of petroleum engineering applications.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Develop knowledge of image acquisition, image processing and pore scale modeling and its application in petroleum engineering.	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2
2. Identify future innovative pathways for petroleum engineering problems	PE2.3, PE2.4, PE3.2, PE3.3, PE3.5, PE3.6

Teaching Strategies

A combination of classroom lectures and individual or group projects (2-3 students max/project) constitute this course. The students will carry out a project of their own choice. While the project can be selected from a range of available ones, students may choose to bring their own datasets. In the first part of the course some of the problem/limitations of digital core analysis are introduced. This forms the basis for the project choice; the second part of the course is less formal, and lecture time slots are used for project-based (hands-on) learning.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Ongoing Quiz	10%	Not Applicable	1, 2
2. Project Design	30%	Week 5	1, 2
3. Project execution	60%	Week 10	1, 2

Assessment 1: Ongoing Quiz

Submission notes: Online weekly

Self-assessment of learned concepts uploaded after each lecture (weeks 1-5). Unlimited number of attempts

Assessment 2: Project Design

Due date: Week 5

After learning most of the basic concepts and becoming aware of some of the limitations of digital core analysis, the student is designing a project based on actual micro-CT images and focussing on specific problems. These can be negotiated with the lecturer. It is possible to form groups, in which case there would be a specific problem to be tackled by each student in the group.

Assessment 3: Project execution

Due date: Week 10

The hands-on project consists of presentation, report, and peer assessment. Students may have chosen to work in groups or on their own topic (maximum of 3 students/group). This project utilizes the problem statement evolved in the project design phase (assignment 1). The students are expected to work on actual micro-CT images and may choose from tackling image processing problems to solving for specific physical properties (e.g., elastic responses, electrical properties, fluid flow, NMR response, micro-structure characterisation).

Attendance Requirements

Students need to participate in the discussions held during class hours. Without this a constructive group project design and following execution of the group projects will not result in the expected student learning.

Course Schedule

[View class timetable](#)

Timetable

Date	Type	Content
O-Week: 5 September - 9 September	Blended	1. Introduction: overview and objectives of digital core analysis 2. Fundamentals I: Sample preparation and image acquisition
Week 1: 12 September - 16 September	Blended	1. Fundamentals II: Image processing and segmentation 2. Fundamentals III: Morphological characterisation of structure
Week 2: 19 September - 23 September	Blended	1. Fundamentals IV: Electrical Conductivity 2. Fundamentals V: Elastic Properties
Week 3: 26 September - 30 September	Blended	1. Fundamentals VI: Permeability 2. Multi-phase flow imaging and simulation
Week 4: 3 October - 7 October	Blended	Project start: refinement/problem definition
Week 5: 10 October - 14 October	Blended	This is flexibility week. It is best used to review the group project problem definition on the basis of the material introduced in weeks 1-5. Please complete all outstanding quizzes and make sure you choose a project you enjoy doing.
	Assessment	Project Design
Week 6: 17 October - 21 October	Group Work	This is a much less formal and hands-on phase of the course. We are now chiefly in the group work phase. In this phase problems have been defined and the projects are progressing. In this practise part of the course methods of image acquisition/image processing/property calculation are applied and sensitivity of measures to image processing parameters studied on the actual samples chosen by students.

Week 7: 24 October - 28 October	Group Work	This is a much less formal and hands-on phase of the course. We are now chiefly in the group work phase. In this phase problems have been defined and the projects are progressing. In this practise part of the course methods of image acquisition/image processing/property calculation are applied and sensitivity of measures to image processing parameters studied on the actual samples chosen by students.
Week 8: 31 October - 4 November	Group Work	This is a much less formal and hands-on phase of the course. We are now chiefly in the group work phase. In this phase problems have been defined and the projects are progressing. In this practise part of the course methods of image acquisition/image processing/property calculation are applied and sensitivity of measures to image processing parameters studied on the actual samples chosen by students.
Week 9: 7 November - 11 November	Group Work	This is a much less formal and hands-on phase of the course. We are now chiefly in the group work phase. In this phase problems have been defined and the projects are progressing. In this practise part of the course methods of image acquisition/image processing/property calculation are applied and sensitivity of measures to image processing parameters studied on the actual samples chosen by students.
Week 10: 14 November - 18 November	Presentation	The project phase concludes with a set of presentations by each group to the other groups and instructors.
	Assessment	Project execution

Resources

Prescribed Resources

The students are expected to read relevant literature where suggested by the convenor or as appropriate given the chosen problem statement.

Recommended Resources

There are not too many textbooks available about this subject yet, as it is rather new. At the same time I am one of the leading pioneers in this area. Consequently, the references to relevant literature will be provided on a week-by-week basis through "further readings" or chosen subject to specific learning goals developed for specific group projects. Some material is listed below nevertheless:

1. Martin Blunt, "Multiphase Flow in Permeable Media", Cambridge University Press, 2017; https://doi.org/10.1017/9781316145098.
2. Colin McPhee, Jules Reed, Izaskun Zubizarreta, "Core Analysis: A Best Practice Guide", in series "Developments in Petroleum Science", vol. 64. Elsevier 2015; https://www.sciencedirect.com/science/bookseries/03767361/64.
3. API RP 40, "Recommended Practices for Core Analysis", American Petroleum Institute, 1998.

Course Evaluation and Development

At the end of each course, all students will have the opportunity to complete a course evaluation form. These anonymous surveys help us understand your views of the course, your lecturers and the course materials. We are continuously improving our courses based on student feedback, and your perspective is valuable.

Feedback is given via https://student.unsw.edu.au/myexperience and you will be notified when this is available for you to complete.

We also encourage all students to share any feedback they have any time during the course – if you have a concern, please contact us immediately.

Laboratory Workshop Information

Under non-COVID circumstances (and for students on campus, subject to social distancing requirements):

TETB LG24, Avizo workstation(s) as required

Additionally, linux workstations with advanced software will be made available for group projects for remote access (tomogram data is stored on these machines for a variety of samples, defining student projects):

- TETB 220, sca00.mere.unsw.edu.au (WKS of Christoph Arns' group)
- TETB 265, ct00.mere.unsw.edu.au (WKS of Christoph Arns' group)

If needed, supercomputing facilities will be added (gadi.nci.org.au).

Submission of Assessment Tasks

The School has developed a guideline to help you when submitting a course assignment.

We encourage you to retain a copy of every assignment submitted for assessment for your own record either in hardcopy or electronic form.

All assessments must have an assessment cover sheet attached.

Course completion

Course completion requires submission of all assessment items. Failure to submit all assessment items may result in the award of an Unsatisfactory Failure (UF) grade for the Course unless special consideration has been submitted and approved.

Late Submission of an Assignment

Full marks for an assessment are only possible when an assessment is received by the due date. Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) of the maximum mark possible for that assessment item. 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. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be 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 will be indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

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

We understand that at times you may not be able to submit an assignment on time, and the School will accommodate any fair and reasonable extension. We would recommend you review the UNSW Special Consideration guidelines – see section below.

Special Consideration

You can apply for special consideration through [The Nucleus Student Hub](#) when illness or other circumstances interfere with your assessment performance. Sickness, misadventure or other circumstances beyond your control may:

- Prevent you from completing a course requirement
- Keep you from attending an assessable activity
- Stop you submitting assessable work for a course
- Significantly affect your performance in assessable work, be it a formal end-of-semester

examination, a class test, a laboratory test, a seminar presentation or any other form of assessment

We ask that you please contact the Course Convenor immediately once you have completed the special consideration application, no later than one week from submission.

More details on special consideration can be found at: www.student.unsw.edu.au/special-consideration

Student Support

The University and the Faculty provide a wide range of support services for students, including:

- Library training and support services - www.library.unsw.edu.au
- UNSW Learning Centre - www.lc.unsw.edu.au
- Counselling support - www.counselling.unsw.edu.au

Equitable Learning Services aims to provide all students with a free and confidential service that provides practical support to ensure that your health condition doesn't adversely affect your studies. https://student.unsw.edu.au/els

Academic Honesty and Plagiarism

Your lecturer and the University will expect your submitted assignments are truly your own work. UNSW has very clear guidelines on what plagiarism is and how to avoid it. 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. The University has adopted an educative approach to plagiarism and has developed a range of resources to support students. All the details on plagiarism, including some useful resources, can be found at www.student.unsw.edu.au/plagiarism.

All MERE students are required to complete a student declaration for academic integrity which is outlined in the assignment cover sheets. By signing this declaration, you agree that your work is your own original work.

If you need some additional support with your writing skills, please contact the Learning Centre or view some of the resources on their website: www.lc.unsw.edu.au. The Learning Centre is designed to help you improve your academic writing and communication skills. Some students use the Centre services because they are finding their assignments a challenge, others because they want to improve an already successful academic performance.

Academic Information

Course Results

For details on UNSW assessment policy, please visit: www.student.unsw.edu.au/assessment

In some instances your final course result may be withheld and not released on the UNSW planned date. This is indicated by a course grade result of either:

- LE – indicates you have not completed one or more items of assessment; or
- WD – indicates there is an issue with one or more assignment; or
- WC – which indicates you have applied for Special Consideration due to illness or misadventure and the course results have not been finalised.

In either event it would be your responsibility to contact the Course Convener as soon as practicable but no later than five (5) days after release of the course result. If you don't contact the convener on time, you may be required to re-submit an assignment or re-sit the final exam and may result in you failing the course. You would also have a NC (course not completed) mark on your transcript and would need to re-enroll in the course.

Studying a course in the School of Minerals and Energy Resources Engineering at UNSW

Report writing guide

The School has a [Report Writing Guide (RWG)](#) available. A copy of this is available on the course Moodle site.

Computing Resources and Internet Access Requirements

UNSW Minerals and Energy Resources Engineering provides blended learning using the on-line Moodle LMS (Learning Management System). Also see - Transitioning to Online Learning: www.covid19studyonline.unsw.edu.au

It is essential that you have access to a PC or notebook computer. Mobile devices such as smart phones and tablets may compliment learning, but access to a PC or notebook computer is also required. Note that some specialist engineering software is not available for Mac computers.

- Mining Engineering Students: OMB G48
- Petroleum Engineering Students: TETB LG34 & LG 35

It is recommended that you have regular internet access to participate in forum discussion and group work. To run Moodle most effectively, you should have:

- broadband connection (256 kbit/sec or faster)
- ability to view streaming video (high or low definition UNSW TV options)

More information about system requirements is available
at www.student.unsw.edu.au/moodle-system-requirements

Accessing Course Materials Through Moodle

Course outlines, support materials are uploaded to Moodle, the university standard Learning Management System (**LMS**). In addition, on-line assignment submissions are made using the assignment dropbox facility provided in Moodle. All enrolled students are automatically included in Moodle for each course. To access these documents and other course resources, please visit:
www.moodle.telt.unsw.edu.au

This course outline sets out description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle should be consulted for the up to date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline (as updated in Moodle), the description in the Course Outline/Moodle applies.

How We Contact You

At times, the School or your course convenors may need to contact you about your course or your enrolment. Your course convenors will use the email function within Moodle or we will contact you on your @student.unsw.edu.au email address.

We understand that you may have an existing email account and would prefer for your UNSW emails to be redirected to your preferred account. Please see instructions on how to redirect your UNSW emails: "How can I forward my emails to another account?"

How You Can Contact Us

We are always ready to assist you with your inquiries. To ensure your question is directed to the correct person, please use the email address below for:

- Enrolment or other admin questions regarding your program:
  https://unswinsight.microsoftcrmportals.com/web-forms/
- Course inquiries should be directed to the Course Convenor

Image Credit

Christoph Arns

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✔
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✔
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✔
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✔
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✔
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering 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	✔
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in 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	✔

School of Minerals and Energy Resources Engineering
Assessment Cover Sheet

Course Convenor: _____

Course Code: _____ Course Title: _____

Assignment: _____

Due Date: _____

Student Name: _____ Student ID: _____

ACADEMIC REQUIREMENTS

Before submitting this assignment, the student is advised to review:

- the assessment requirements contained in the briefing document for the assignment;
- the various matters related to assessment in the relevant Course Outline; and
- the *Plagiarism and Academic Integrity* website at < http:/www.lc.unsw.edu.au/plagiarism/pintro.html > to ensure they are familiar with the requirements to provide appropriate acknowledgement of source materials.

If after reviewing this material there is any doubt about assessment requirements, then in the first instance the student should consult with the Course Convenor and then if necessary with the Director – Undergraduate Studies.

While students are generally encouraged to work with other students to enhance learning, all assignments submitted for assessment must be their entire own work and duly acknowledge the use of other person's work or material. The student may be required to explain any or all parts of the assignment to the Course Convenor or other authorised persons. *Plagiarism* is using the work of others in whole or part without appropriate acknowledgement within the assignment in the required form. *Collusion* is where another person(s) assists in the preparation of a student's assignment without the consent or knowledge of the Course Convenor.

Plagiarism and *Collusion* are considered as Academic Misconduct and will be dealt with according to University Policy.

STUDENT DECLARATION OF ACADEMIC INTEGRITY

I declare that:

- This assessment item is entirely my own original work, except where I have acknowledged use of source material [such as books, journal articles, other published material, the Internet, and the work of other student/s or any other person/s].
- This assessment item has not been submitted for assessment for academic credit in this, or any other course, at UNSW or elsewhere.

I understand that:

- The assessor of this assessment item may, for the purpose of assessing this item, reproduce this assessment item and provide a copy to another member of the University.
- The assessor may communicate a copy of this assessment item to a plagiarism checking service (which may then retain a copy of the assessment item on its database for the purpose of future plagiarism checking).

Student Signature: Date:

Students are advised to retain a copy of this assessment for their records and submission should be made in accordance to the assessment details available on the course Moodle site.