School of Civil and Environmental Engineering

Term 3, 2021

GMAT2550 SURVEYING COMPUTATIONS B

COURSE DETAILS

Contact hours	6 hours per week, 6 UoC	
Lecture Class	Wednesday, 10am-12 noon	CLB5 & Hybrid BBCU
	Thursday, 2-4pm	CLB5 & Hybrid BBCU
		or CE201 (see timetable below)
Computer Lab	Thursday, 4-6pm	CE 201 or online BBCU
Course Coordinator and sole Teacher	Dr Bruce Harvey	
	email: B.Harvey@unsw.edu.au	office: CE207 phone: (02) 9385 4178 (MS Teams)

INFORMATION ABOUT THE COURSE

The mode of delivery of the course in T3 2021 might change and this course profile will be updated if necessary. The current plans are for classes to be in interactive Hybrid mode. The lectures will all be conducted via Blackboard Collaborate Ultra (BBCU) and can be accessed from the class Moodle site. The lectures will be recorded and available for download, though live participation is preferred. Hybrid mode is where some students attend campus (when permitted) in the classroom where the lecturer presents the lecture and other students attend online via BBCU. Lab sessions are not recorded.

This course is a key element in the measurement and calculation part of the degree program. It builds on previous surveying calculation courses in first and second year, (1110 Surveying and Geospatial Engineering, 2500 Survey Computations A and 2120 Surveying & Geospatial Technology). It assumes you have knowledge of the material in year one Maths (Maths 1A and 1B or higher). You should have already passed or been exempt from those courses. If you have attempted but failed any of the above courses then you should contact the course coordinator. Knowledge from the Statistics component of CVEN2002 course is related to this course. The topics in this course are useful for year 3 and 4 survey courses (Survey Applications and Design, Field Projects, GNSS and perhaps your thesis).

Assumed knowledge: basic plane survey computations, statistics, matrices, differentiation, solution of linear equations, and use of Excel including matrix operations.

HANDBOOK DESCRIPTION

See virtual handbook: *http://www.handbook.unsw.edu.au/undergraduate/courses/2021/GMAT2550.html*

Least Squares measurement adjustment principles and concepts, with particular reference to surveying observations of distance, height difference, angular directions, GPS solutions. Determining input into, and analysing output from, typical Least Squares adjustment software. Inside Least Squares: Modelling observations, observation equations, parametric method, condition and combined methods, linearisation of equations, derivation of Least Squares algorithm, methods of forming normal equations. Variance-covariance matrices, measurement uncertainty, and error ellipses, and in particular the application of statistics and error analysis in surveying. Worked examples and case studies from various areas of cadastral and engineering surveys. Calibration of EDM instruments.

COURSE PROGRAM TERM 3, 2021

Wk	**Wednesday** 10am – 12 noon Lec CLB5 & BBCU	**Thursday** 2-4 pm Lec CLB5 & BBCU or Lab CE201 / BBCU	**Thursday** 4-6pm Lab in CE201 / BBCU
1	Course Outline. Least Squares concepts & principles Why use LS? LS & means. Ch1.	Revision matrix algebra, differentiation, Excel. Ch 1. Statistics applied to surveying problems. Ch2.	LS Treasure Hunt game. Matrix algebra, differentiation, Excel. Statistics problems
2	Input to LS programs. Preprocessing obs and std devs. Ch 3.	Modelling observation equations, Parametric method. Linearisation – Partial derivatives Ch 4.	Statistics and input to LS. Data collection, Pillar trilateration or traverse
3	Derivation of LS equations. Ch 4. Least Squares step by step worked examples Ch4.	Forming and solving normal equations. Ch 4. (about 1 hr) then lab CE201	Modelling & linearization LS software FIXIT4. Input trilateration data.
4	VCV matrices, residuals, VF. Ch4	Lab: Forming & solving normal equations in Excel. CE201	**Test 1 in CE computer lab**
5	Analysis of Output. Ch 5.	Analysis of Output	Analysis of Output
6	**No lecture classes**	Optional Field: EDM baseline prac	Optional lab class
7	Outliers. Ch 6.	Redundancy. Ch 6. Survey Design. Ch 7.	Analysis of Output
8	Survey Design. Ch 7	Lab: Outliers. Simulations CE201	**Test 2 in CE computer lab**
9	EDM Calibration procedure. LS aspects of EDM calibration	Combined and condition methods. Ch 8.	Combined and condition methods
10	Advanced LS. Ch9. LS Essentials and Predicting results. Ch 10.	Case Studies: OH, SHB, CD control surveys - examples of network analysis. Exam discussion.	Final Lab class – analysis of past papers

Chapters in the table above refer to Monograph 13, third edition.

ASSESSMENT COMPONENTS

We have a class with < 40 students so we have considerable flexibility with assessment methods. For example, tests can be conducted in our computer lab with all students present at one time or via email in 2021. Computers used in CE201 in tests will not have network or email access.

Assessment for the course includes:

- Mid-term test 1 — 20% — On Thursday week 4
- Mid-term test 2 — 25% — On Thursday week 8
- Problem Based Learning 'Quizzes' — 15% — Complete before end of Friday Week 10
- Final Exam — 40% — In formal exam period

The final grade for this course will normally be based on the sum of the scores from each of the assessment tasks.

The final exam may cover all aspects of the course, not just those covered after the second midterm test.
Any changes to the above assessment details will be notified in class and on the class web site. After each test each student will be given individual and detailed feedback on their test or exam paper soon after it has been marked by visiting the office of the course convenor. Further details of assessment and exam rooms will be given in classes, if in doubt contact the lecturer.

The PBL and lab work in this course will be assessed via Moodle quizzes and auditing. Feedback will be given to any student who requests it by viewing the students' notes or computer screens. Some of the quizzes require students to submit their work on that question, by email. Some quizzes and the mid-term test 1 will be completed with feedback

prior to the census date = 10 Oct 2021.

Supplementary Examinations for Term 3 2021 will be held on Monday 10 to Friday 14 January 2022 (inclusive) should you be required to sit one. You are required to be available during these dates. Please do not to make any personal or travel arrangements during this period.

OBJECTIVES

This course aims to introduce students to the analysis of surveying observations primarily by the least squares method and associated statistical analysis. One part of the course is applied LS, that is, how to use LS programs. The other part of the course is the theoretical aspects of LS and "what's inside LS programs". So the course studies both the application of software packages and the detailed calculations within such software. This course provides an environment that fosters in our students the following attributes, those not covered in this course are dealt with in other courses in your program.

the skills involved in scholarly enquiry	Significant. As you will see *understanding* Least Squares data analysis can be challenging. It requires a lot more than just learning formula or procedures.
an in-depth engagement with relevant disciplinary knowledge in its interdisciplinary context	Significant. You will be able to do the calculations that are often hidden inside commercial software packages, and you will learn how to professionally analyse the results. You will apply your knowledge from year 1 mathematics and year 2 statistics courses, to real surveying problems.
the capacity for analytical and critical thinking and for creative problem solving	Significant. You are especially encouraged to find more than one solution for some of the problems.
the ability to engage in independent and reflective learning	Optional. There is opportunity for students to learn more about other commercial LS CAD software, to read ahead through the text book, or to write your own computer programs for some of the tasks.
the skills to locate, evaluate and use relevant information (Info. Literacy)	Minor. Study the textbook provided and explore the software options.
the capacity for enterprise, initiative and creativity	Some – find alternative solution methods to some challenging problems – especially in the network design topic.
the skills required for collaboration	Some group work in lab

TEACHING STRATEGIES

This course and similar previous courses have been taught by the lecturer for many years, at UNSW and elsewhere. The teaching strategies have been refined over the years based on student feedback and student performance in exams and assignments. Generally lectures are presented on each topic via PowerPoint presentations. These PowerPoint files are available in pdf format for download from the class web site. Some students have said they don't like ppt in lectures, others do. So I try not to have static slides that are read, instead I ask students questions and use computer demonstrations. I also wrote the textbook (Monograph 13) and provide additional reading material on the class web site for students who prefer to learn by independent reading.

An important element of the teaching is the lab classes where students are encouraged to work on problems in class with direct assistance from the lecturer. The small class sizes currently in this course make it possible to follow these strategies. Another important aspect is that the main software used in this course has been written by the lecturer specifically for students in this course.

Suggested Learning Methods

You are encouraged to ask questions and participate in class discussions during lectures, computer labs. Read the text and lecture slides. Attempt the computer lab questions and worked examples yourself. Get feedback: Ask the lecturer for help and help each other. After the mid-term tests visit me individually for feedback. AND after the end of the course you are welcome to see me and get feedback on your final exams and assignments and to collect any of your remaining submissions.

I encourage attendance in class and participation because I think it is better for your education than just reading the PowerPoint. You will also notice that I say more in class than what is written on PowerPoint slides. I do not like lectures that read the screen to you. So for example their might be a graphic chart, plan, map or photograph or table of numbers on the screen and we talk about it. If you want to learn by reading then that's what my textbook (monograph) is for, because the lecture PowerPoint are missing some information.

At UNSW, the normal workload expectations of a student are about 150 hours per term for a 6 unit of credit course, including class contact hours, preparation and time spent on all assessable work. Are you a full time student spending less than 40 hours per week on uni studies, including class time? Are you balancing time between courses, i.e. one 6 unit course should get close to the same amount of time as another 6 unit course?

Downloading from Moodle and lecture recordings

Apparently downloading files is addictive. The amount of class and reference material that students can read is now enormous. Most people will download files because they think that if they have the file, they can read it at any time … so they don't have to read it now. So hardly anyone reads anymore and people only collect files and store them away. Is getting copies of all the material the only way you can keep up?

Have you tried an alternative? It's an old fashioned process where you attend the class live or place the reading material in front of your eyes and you let it go through there into the brain and it is much better than a download. [Paraphrased by Bruce Harvey from an article on Neuroxing (source unknown).] Even better than reading, is to do something to apply the knowledge, e.g. calculate the numerical problems. In GMAT2550 course, getting the textbook is a good step. But you need to use it too!

UNSW provides a recording of the lectures. This is a good thing but be careful how you use it. If you go to lectures with our small classes you can ask questions and hear other students asking questions. You can see the lecturer their face and hands and movements. You can see what they point to or objects they bring to class. You can see what they write on the board. If most of the students attend and participate the lecturer feels good and usually gives a better lecture than if not many students attend or those there seem not interested. Lectures often partly prepare students for lab and field classes later in the same week. If you don't understand parts of the lecture then watching a replay of a recording can help. That is, seeing and hearing it for a second time.

If you don't go to lectures because you can watch the recording instead then you take some risk. If you can watch the recording later you might not watch it in time to prepare for the lab class that follows. If you leave it too late to watch the recording s then you will have many to watch in the limited time before exams and midterm tests. So, please come to lecture classes as well as labs.

EXPECTED LEARNING OUTCOMES

The learning outcomes that students should achieve upon successful completion of this course are listed in the table below. This course is designed to address the 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.

	Learning Outcome	**Assessment Methods**	**EA Stage 1 Competencies**
1.	Understand the basic principles of Least Squares analysis and their application to engineering surveying	Test 1, and labs	PE1.1, PE1.2
2.	Setup the equations within a parametric method least squares adjustment	Test 1, and labs	PE1.3
3.	Calculate a least squares adjustment of data step by step without using computer programs designed for Least Squares	Test 1, and labs	PE1.3
4.	Properly prepare data for Least Squares analysis, including a priori statistics	Lab exercises	PE2.1
5.	Professionally interpret output from Least Squares analysis	Final exam, and labs	PE2.2, PE2.3, PE3.4

	software, including variance factor and outlier investigations		
6.	Design a survey network using least squares analysis, including error ellipses and redundancy number investigations	Test 2, Final exam and labs	PE1.5, PE2.2, PE2.4
7.	Be familiar with computer programming aspects used within LS software	Not assessed, discussed in class	PE1.2

ASSESSMENT

Assessment Title		Assessment Type	Weight (%)
1	Mid Term Test 1	Test	20%
	Assessment description and feedback process:	Test in computer lab, using special software, in week 4. Students visit lecturer's office for individual feedback after their test is marked. This will continue while the class remains small. If campus is in lockdown this will be done online.	
2	Mid Term Test 2	Test	25%
	Assessment description and feedback process:	Test in computer lab, using special software, in week 8. Students visit lecturer's office for individual feedback after their test is marked. This will continue while the class remains small. If campus is in lockdown this will be done online.	
3	Computer Lab exercises	Lab Work	15%
	Assessment description and feedback process:	An important element of the teaching is the computer lab classes where students are encouraged to work on problems in class with direct assistance from the lecturer. Lab exercises are set for each week. Moodle Quizzes will be used to describe the tasks and manage students' progress. The small class sizes currently in this course make it possible to follow the following strategies. The work will be audited in the student' presence by viewing the students' notes or computer screens and immediate feedback will be given. There is no need to rewrite the work or to submit formal well written reports. Generally the work will not be collected or be examined in detail unless a student has had difficulties getting correct or good quality output. Generally, lab marks will be assigned using a mastery scheme, i.e. if the work is acceptable it will get full marks if it is not acceptable it will get zero marks, students can resubmit in this case. There will also be a time limit for lab work submissions; the deadlines are given in the settings for each quiz.	
4	Final Exam	Examination	40%
	Assessment description and feedback process:	Final exam is in a computer lab using supplied software. Some questions involve analysing real survey data sets that include challenging data analysis aspects. Typically one of the questions involves many hundreds of observations. Students are invited to visit the lecturer after the examination period for individual feedback on their exam. The class size is currently small. If campus is in lockdown this will be done online.	
Total Weight			**100%**

Assessment items and their relationship to Course Learning Outcomes:

1. Mid Term Test 1

- Understand the basic principles of Least Squares analysis and their application to engineering surveying
- Setup the equations within a parametric method least squares adjustment
- Calculate a least squares adjustment of data step by step without using computer programs designed for Least Squares

2. Mid Term Test 2

- Professionally interpret output from Least Squares analysis software, including variance factor and outlier investigations
- Design a survey network using least squares analysis, including error ellipses and redundancy number investigations

3. Computer Lab exercises

- Understand the basic principles of Least Squares analysis and their application to engineering surveying
- Setup the equations within a parametric method least squares adjustment
- Calculate a least squares adjustment of data step by step without using computer programs designed for Least Squares
- Properly prepare data for Least Squares analysis, including a priori statistics
- Professionally interpret output from Least Squares analysis software, including variance factor and outlier investigations
- Design a survey network using least squares analysis, including error ellipses and redundancy number investigations
- Setup the equations within a parametric method least squares adjustment
- Calculate a least squares adjustment of data step by step without using computer programs designed for Least Squares
- Professionally interpret output from Least Squares analysis software, including variance factor and outlier investigations

4. Final Exam

- Understand the basic principles of Least Squares analysis and their application to engineering surveying
- Setup the equations within a parametric method least squares adjustment
- Calculate a least squares adjustment of data step by step without using computer programs designed for Least Squares
- Properly prepare data for Least Squares analysis, including a priori statistics
- Professionally interpret output from Least Squares analysis software, including variance factor and outlier investigations
- Design a survey network using least squares analysis, including error ellipses and redundancy number investigations
- Be familiar with computer programming aspects used within LS software

The final grade for this course will normally be based on the sum of the scores from each of the assessment tasks.

PENALTIES

Late work will be penalised at the rate of 10% per day after the due time and date have expired.

RELEVANT RESOURCES AND BLENDED LEARNING

Lecture Material, Lab quizzes, and custom learning software for this course are available on the course website): moodle.telt.unsw.edu.au

Text Book Harvey B.R., 2016, Practical Least Squares and Statistics for Surveyors, Monograph 13, Third Edition, Available from UNSW Bookshop. ISBN 0733423396 $40.

Software Free copies of the FIXIT4 survey network analysis program and of the LSTH game are available (via the Moodle website) for students to use in class or at home for educational purposes.

Further references are described in the text book.

Computer software relevant to this course and available in the School's computer labs includes: FIXIT4 and MS Excel

DATES TO NOTE

Refer to MyUNSW for Important Dates available at: https://student.unsw.edu.au/dates

PLAGIARISM

Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise are also liable to disciplinary action, including exclusion from enrolment.
Plagiarism is the use of another person's work or ideas as if they were your own. When it is necessary or desirable to use other people's material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at: student.unsw.edu.au/plagiarism

ACADEMIC ADVICE

For information about:

- Notes on assessments and plagiarism,
- School policy on Supplementary exams,
- Special Considerations: student.unsw.edu.au/special-consideration
- General and Program-specific questions: The Nucleus: Student Hub
- Year Managers and Grievance Officer of Teaching and Learning Committee, and
- CEVSOC or SURVSOC

Refer to Academic Advice on the School website available at: https://intranet.civeng.unsw.edu.au/key-staff-to-contact-during-your-studies-at-unsw

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