GMAT2550 Surveying Computations B

Semester 2, 2016

Never Stand Still | Faculty of Engineering | School of Civil and Environmental Engineering

COURSE DETAILS

Units of Credit	6		
Contact hours	5 hours per week		
Lecture Class	Wednesday:	10:00 – 12:00	Quadrangle 1049
	Thursday:	14:00 – 16:00	CE201
Computer Lab	Thursday:	16:00 – 17:00	CE 201

Course Coordinator and Lecturer & Tutor

A/Prof Jinling Wang
email: Jinling.Wang@unsw.edu.au
office: CE413
phone: 9385 4203

INFORMATION ABOUT THE COURSE

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, (GMAT1110 Surveying and Geospatial Engineering, GMAT2500 Survey Computations A and GMAT2120 Surveying & Geospatial Technology). It assumes you have knowledge of the material in year one Maths (Maths 1A and 1B or higher) and year 2 Math / Statistics courses. 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. 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).

Prerequisite: MATH1231 Corequisite: GMAT2500

HANDBOOK DESCRIPTION

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.

See link to virtual handbook as
www.handbook.unsw.edu.au/undergraduate/courses/2016/GMAT2550.html

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. In addition, the course will provide opportunities for programming skill training to develop in-house software for LS and statistical quality control by students.

This course provides an environment that fosters in our students the following attributes, while 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 professional 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 as well as seek insights into theoretical concepts through numerical analysis with programming.
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 and field

TEACHING STRATEGIES

This course has been taught within the surveying and geospatial engineering programs at UNSW for many years. 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. While the well-written textbook (Monograph 13) is available, additional reading material is also provided on the class web site for students who prefer to learn by independent reading.

The main software for least squares adjustment used to be provided for students in this course. In 2016, more programming exercises with the least squares estimation and statistical quality control to assist students in gaining insights into key concepts in the course.

The most important factors in learning are students' commitment and learning methods. You are encouraged to attend all the lectures and other teaching activities. In addition, relevant resources on the web (visit the course website for details) are of great help in understanding the basic concepts discussed in the lectures and the trends in the discipline of surveying and geospatial engineering.

Based on some studies by a higher education research expert John Biggs, most active students in the class do not just listen, see, collect notes and take notes, but most importantly, they will *"express understanding; raise issues, speculate, solve problems, discuss, answer questions and reflect"*.

Students are strongly encouraged to do sufficient preparation for class discussions on selected topics. An example of the approaches to learning is:

Lectures	• Find out what you must learn • See methods that are not in the textbook • Follow worked examples
Field data collection and analysis	• Understand the concepts through hands-on work, • Set studies in context • Demonstrate data analysis and presentation skills
Exercises	• Practice solving set problems with theoretical and numerical analysis • Design and develop computer programs for least squares adjustment and statistical quality control • Ask questions
Assessments (Quizzes, etc.)	• Demonstrate your knowledge and skills • Demonstrate higher understanding and problem solving
Private Study	• Review lecture material and textbook • Do set problems and assignments • Reflect on class problems and assignments

EXPECTED LEARNING OUTCOMES

By the end of this course you should be able to:

- 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 functional and stochastic models
- 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, redundancy number as well as reliability/separability investigations
- Develop in-house software for LS and statistical quality control
- Calibrate and EDM instrument, including measurements and analysis.

At UNSW, the normal workload expectations of a student are 24-28 hours per semester for each unit of credit, including class contact hours, preparation and time spent on all assessable work.

For each hour of contact it is expected that you will put in at least 2.5 hours of self-centred and self-directed study: for example, reading the course related materials provided through the course website and reflect on the conceptual framework discussed in the classes.

ASSESSMENT

Assessment for the course includes:

- Mid-Session Test 15% (Week 5)
- Roof Pillar Network Assignment 10% (Week 6)
- EDM Calibration Assignment 10% (Week 9)
- Case Study Report 15% (Week 11)
- Problem Based Learning Quizzes 15% (Weekly, Complete before end Week 13)
- Final Exam 35% (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.

Overall rationale for and further details about field data collection and analysis assignments, case study report, and the mid-session test will be given in class. The final exam will cover all aspects of the course, not just those covered in the quizzes and the mid-session test during the semester.

Any changes to the above assessment details will be notified in class and on the class web site. After each submission of the assignment/report, detailed feedback will be given to the students. The students are encouraged to visit the office of the course convenor for discussions on the course related topics. 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. Note that the quiz marks will be determined at the end of week 13, not later.

Details about the assignment are supplied in a separate document.

COURSE PROGRAM

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

(The time slots for **field data collection** for **Roof Pillar Network** Assignment, **EDM Calibration** Assignment, as well as any other changes will be notified in the class and at the course website).

Week Start	Wednesday – Lecture 10:00 – 12:00, Quadrangle 1049	Thursday - Lecture 14:00 – 16:00, CE 201	Thursday – Exercises 16:00 – 17:00, CE201
1 25/7	Course Outline; Fundamentals of Positioning; Introduction to Least Squares; Class Discussions	Revision matrix algebra, differentiation, Excel, Ch 1.	
2 1/8	Statistics applied to surveying problems. Ch2	First part of Input to LS programs. Ch 3.	LS Treasure Hunt game. Matrix algebra, differentiation, Excel
3 8/8	Second part of Input to LS programs. Preprocessing obs & std devs. Ch 3.	LS software FIXIT4 and other commercial software packages	Use Matlab for in-house LS program development
4 15/8	Modelling observation equations, Parametric method. Linearisation. Ch 4.	Functional Model and Stochastic Model; Derivation of LS equations. Ch 4.	Modelling & linearization
5 22/8	Forming and solving normal equations. Ch 4.	Least Squares step by step worked examples Ch4.	Mid-Session Test
6 29/8	No Class (This time slot is rescheduled for Roof Pillar Network)	*No Class (This time slot is rescheduled for Roof Pillar Network)*	No Class (This time slot is rescheduled for Roof Pillar Network)
7 5/9	VCV matrices, residuals & VF. Ch 4. Review of Test	LS aspects of EDM calibration	Forming and solving normal equations
8 12/9	Analysis of Output. Ch 5.	LS Results and analysis: Case Studies	Update in-house LS software
9 19/9	Outliers. Redundancy. Ch 6.	Investigative Study on Reliability and Separability Measures	Outlier detection
Break 26/9	**Mid-Session Break**	**Mid-Session Break**	**Mid-Session Break**
10 3/10	No Class (This time slot is rescheduled for EDM Calibration)	No Class (This time slot is rescheduled for EDM Calibration)	No Class (This time slot is rescheduled for EDM Calibration)
11 10/10	Survey Design. Ch 7. Case Studies: OH, SHB, CD control surveys.	Lab: Simulations	Case Study Report
12 17/10	Combined and condition methods. Ch 8.	Examples of network analysis	Combined and condition methods: Numerical Analysis
13 24/10	Advanced LS. Ch9 LS Essentials and Predicting results. Ch 10.	Revisions/Exam discussion.	

RELEVANT RESOURCES

Lecture Materials

The course materials will be available through "Moodle": http://moodle.telt.unsw.edu.au/
The Power Point lecture slides are available for download as PDF files at the course website.
Electronic resources on the lecture topics are available at the course website.

The class notes, latest journal articles and references related the course topics will be referred to and/or distributed during the lectures.

Text and Reference Books

Bruce R. Harvey, Practical Least Squares and Statistics for Surveyors, Monograph 13, Third Edition, School of Surveying & Geospatial Engineering UNSW, 2009

Charles D. Ghilani, Adjustment Computations: Spatial Data Analysis, John Wiley & Sons, 2011

Gilbert Strang and Kai Borre, Linear Algebra, Geodesy, and GPS, SIAM, 624 pages, 1997.

Karl-Rudolf Koch, Parameter Estimation and Hypothesis Testing in Linear Models, 2a ed., Springer, 2000

P.J.G. Teunissen, Adjustment theory, an introduction, Delft Academic Press, 2000

Computational Aids

Free copies of the FIXIT4 survey network analysis program, Matlab program for LS adjustment and Statistical Quality Control, and of the LSTH game are available (via the Moodle website) for students to use in class or at home for educational purposes.

Pocket calculators are required during lecturing hours, for computer labs and practicals in this course. They have to be hand-held, internally powered and silent. They must be brought to all classes

Computer tools software relevant to this course and available in the School's computer labs includes: FIXIT4, MATLAB 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: **https://student.unsw.edu.au/plagiarism**

All assignments and assessment items should be submitted with a signed Assessment Cover Sheet:

I declare that this assessment item is my own work, except where acknowledged, and has not been submitted for academic credit elsewhere, and acknowledge that the assessor of this item may, for the purpose of assessing this item:

Reproduce this assessment item and provide a copy to another member of the University; and/or,

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).

I certify that I have read and understood the University Rules in respect of Student Academic Misconduct.

Signed: .....date: ☐☐ ☐☐ ☐☐

ACADEMIC ADVICE

For information about:

- Notes on assessments and plagiarism,
- School policy on Supplementary exams,
- Special Considerations,
- Solutions to Admin Problems,
- Year Managers and Grievance Officer of Teaching and Learning Committee, and

Refer to Academic Advice on the School website available at:

http://www.engineering.unsw.edu.au/civil-engineering/resources/academic-advice