School of Civil and Environmental Engineering

Term 3, 2022

GMAT2120 Surveying and Geospatial Technology

COURSE DETAILS

Units of Credit	6 UoC	
Contact hours	5 hours per week	
Class/Workshop	Monday, 13:00 – 15:00	CLB5
	Tuesday, 13:00 - 15:00	CE G1
Field pracs	Friday, 12:00 – 17:00	CE G7 Survey Store
Course Coordinator and Lecturer	Dr Craig Roberts email: c.roberts@unsw.edu.au office: CE412 phone: 9385 4464	
Demonstrator	Dr Yincai Zhou email: y.zhou@unsw.edu.au office: CE407	

INFORMATION ABOUT THE COURSE

This course is a part of a three-year stream of 'pure' surveying measurement courses. It builds on GMAT1110. You should have already passed or been exempt from that course. If you have attempted but failed GMAT1110 then you should contact the course coordinator. This course also builds on GMAT2500 and GMAT2700. This course runs concurrently with GMAT2550 and some exercises have been structured to run concurrently. Elective GMAT3100 and GMAT3150 in third year will further extend this course.

Prerequisites: GMAT1110, GMAT2500, GMAT2700 Co requisite: MATH2019

HANDBOOK DESCRIPTION

See link to virtual handbook:

www.handbook.unsw.edu.au/undergraduate/courses/2022/GMAT2120.html

OBJECTIVES

The aim of the course is to study surveying instrumentation in depth, particularly precise digital levels, electronic total stations and electronic distance meters EDM.

This course will cover a detailed investigation of some contemporary terrestrial surveying instruments and their use. The course will commence with precise digital levelling (bar code) instruments covering design, accuracy, error sources, precise levelling techniques, errors and calibration. The theory will be supported with a practical exercise. Secondly electronic total stations will be analysed including, circle reading, level sensors, centring systems, constrained centring, precise horizontal and zenith angle measurement, observation procedures and elimination of errors. This theory will be exercised with a larger field project and some minor exercises. Robotic total stations and newer ATR technology will be presented. Leap frog EDM ht traversing will be introduced and a prac exercise will be run. Finally, principles and applications of EDM, phase and pulse measurement techniques, wave propagation in atmosphere, measurement of

atmospheric parameters, coefficient of refraction, velocity corrections, geometric reductions, reductions of distances to the ellipsoid and analysis of errors will be exercised with a field prac exercise. At the conclusion of this course students gain an understanding of the impact specific field techniques and instrumentation have on the attainable precision when conducting terrestrial surveys.

During this course the following attributes will be exercised:

- the skills involved in scholarly enquiry
- an in-depth engagement with relevant disciplinary knowledge in its interdisciplinary context
- the capacity for analytical and critical thinking and for creative problem solving
- the ability to engage in independent and reflective learning
- the skills to locate, evaluate and use relevant information (Information Literacy)
- the capacity for enterprise, initiative and creativity
- an appreciation of, and a responsiveness to change and the skills of effective communication

TEACHING STRATEGIES

The original material for this course was prepared by the previous lecturer, A/Prof Jean Rüeger and his expertise is gratefully acknowledged. The current material and the teaching methods have been modernised. Whilst using this material a focus on the understanding of the topics is sought and requirement to read the text-based material in detail.

I have considered feedback from last year's students in this course and in response will continue to supply electronic teaching materials on Moodle. Due to COVID-19 restrictions and the smaller class size, I will be able to offer the lectures face-to-face in a room and lectures live online (Hybrid) using Blackboard Collaborate (BBCU). I will endeavour to mark the reports promptly for effective student feedback. I have also made some improvements to the requirements of the pracs so that they can be more easily completed in one practical session. Attendance and attention at lectures will be expected but will not be sufficient to learn the topics to the level required. There will be a lot of reading required. You will also need to do the calculations, practical assignments and workshop problems. There is a significant practical component to this course. It is important that you prepare thoroughly for the practicals by reading the instructions, visiting the site, and familiarising yourself with the equipment prior to the practical classes. Previous students have found field practicals to be the most rewarding and enjoyable part of the course and for this reason they are compulsory for all students. **A doctor's certificate or other supporting documentation will be needed in the event that a student misses a field practical.**

Private Study	• Review lecture material and literature on Moodle • Do set problems and assignments • Reflect on class problems and assignments • Download materials from Moodle • Keep up with notices and find out marks via Moodle
Lectures	• Attend lectures!!! • Find out what you must learn • See methods that are not in the textbook • Follow worked examples • Hear announcements on course changes – there will be plenty!!!
Workshops	• Be guided by Demonstrators • Practice solving set problems • Ask questions
Assessments (multiple choice questions, quizzes, tests, examinations, practical exercise reports etc.)	• Demonstrate your knowledge and skills • Demonstrate higher understanding and problem solving
Laboratory Work	• Hands-on work, to achieve practical field work tasks • Prepare concise reports in the field • Practice working in groups • Attempt, fail, learn, repeat, improve

EXPECTED 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.	*Know how to perform a precise digital levelling survey using a modern bar-code instrument, leap frog EDM height traverse using a modern total station to achieve first/second order quality, high precision horizontal and vertical directions using a modern total station and medium length EDM distance measurement.*	*PE1.1, PE1.5, PE2.2, PE2.3, PE2.4,*
2.	*Develop efficient field work practices such as skill with various surveying instruments, forward planning and logistics for complex survey tasks, production of clear field notes and redundant field checks to ensure accuracy.*	*PE1.2, PE1.3, PE1.5, PE2.1, PE2.2, PE2.4, PE3.2, PE3.3, PE3.6*
3.	*Perform reductions of observations from various field exercises and all associated statistical analysis.*	*PE1.1, PE1.3, PE1.4, PE2.1, PE3.4*
4.	*Understand the relationships between the various instruments, techniques and errors that indicate the accuracy of the resulting measurements.*	*PE1.1, PE1.2, PE1.6, PE2.3*

For each hour of contact it is expected that you will put in at least 1.5 hours of private study.

ASSESSMENT

Assessment for the course includes:

P1 Laser levelling prac	5%		Due on the day
P2 report (Levelling prac)	10%		Due 2 weeks after fieldwork (Thurs)
Moodle quiz Levelling	5%		As per allocation on Moodle
P3 report (Angle resec + Ht)	10%	(7 + 3)	Due 2 weeks after fieldwork (Thurs) (Ht – 27/10)
P4 report (Mini Prac)	5%		Due 14/10 (Friday of week 5)
P5 report (Leap Frog)	10%		Due 2 weeks after fieldwork (Thurs)
P6 report (EDM)	10%		Due 2 weeks after fieldwork (Thurs)
Practical Exam	10%		Friday Week 10
Final Exam	35%		In formal exam period

Practicals:

Each student will be a member of a group of 3 (or occasionally 2) students. Groups will be established during the first lecture and may change at the lecturer's discretion as the term progresses. Students are free to select their partners; however, students are advised to select their partners very carefully. Students that do not attend the first lecture, or cannot find a partner, will be put in a group by the lecturer. Get the address, mobile phone number, e-mail address, etc. of your group members immediately after the formation of the group. The joint (or individual) submissions for the practicals require considerable interaction between the students. Make sure that all field data are copied immediately after the fieldwork, so that all the students in the group have access to the data. Further information about the practicals will be distributed during the lectures and are available on the class web site. Rules for practicals are given below.

Some practicals require individual reports by the students, even if the fieldwork was shared (See instructions). Submissions are to be handed to the lecturer supervising the practical (or slip under their office door with appropriate title page) or emailed (see submission instructions) before the due date.

Reports must follow the instructions given in the handout "Submission of Reports". (A sample report is given on the course web site). Submissions must include a declaration on the authorship of the work. Each submission is to have a title page (title of assignment, date of submission, course code, course name, student number, name of student) and a summary of results page. Word processed submissions are not required but encouraged. Spreadsheets may be used for computations as long as they are designed by the student. This should also be emailed with an appropriate file name ie John_Smith_GMAT2120_Prac 2.xls to aid organisation for the lecturer.

Each practical has instructions about computations and reporting. It is strongly recommended that student reports are written in the same sequence and with the same headings.

ASSIGNMENTS

Assessment Criteria for Field Practicals

Comments: Field practicals are a great opportunity to put theory into practice. Previous students have always rated field practicals very highly. Field practicals are group work (usually 3 per group) with either group or individual submissions (see details in separate prac exercises) usually 2 weeks after the exercise. As there is much to do in a short period of time, marks are deducted strictly for lateness. Field practicals are compulsory. Students must wear closed shoes or will be asked to leave and receive zero marks. This is a strict WHS requirement. Students are expected to rotate the work amongst themselves and will be encouraged to do this by prac supervisors.

Marking scheme: Depending on the exercise, marks will be allotted for clear and concise field notes, computations as per instructions, correctness of working, accuracy of observations, completion of all tasks, field sketches (where required), relevant comments or answers to specific questions asked in instructions and submission by allotted deadline. Details of individual assessment are contained in prac instructions for each prac available on Moodle.

Penalties: 1 day late = 10% mark lost, 2 days late = 20% marks lost etc. The lecturer reserves the right to deduct marks for poor participation during the practical exercise at their discretion.

Feedback: The prac supervisor will attempt to mark the prac exercise within 2 weeks of completion and return the marked exercise with annotations to the prac group/ individual. An overall report will be sent to all students with generic feedback for all and a class discussion in the lecture period will also take place to reinforce any issues that arose.

Objectives and learning outcomes: The student will learn about group work, time management, meeting time constraints, producing results in the field, logistics, field preparation, concise report writing and field note taking, producing results to tolerance despite conditions, working safely and in accordance with WHS.

Assessment Criteria for Moodle levelling quiz

Comments: The levelling assignment replaces a former mid-session test. It is a moodle quiz designed to test your understanding of precise levelling after lectures, tutorials and a prac exercise.

Marking scheme: See moodle.

Penalties: See moodle.

Feedback: The lecturer is available for questions about the quiz.

Objectives and learning outcomes: The moodle levelling quiz is designed to reinforce the statistics and calculations involved in precise levelling. Students who perform poorly should seek extra help from the lecturer and work harder.

Assessment Criteria for workshops

Comments: The workshops build on the lecture notes and some time is allocated to support practical calculations with your lecturer available to answer questions and assist. Only one workshop in week 9 will attract any assessment and this is aligned with the angle resection practical exercise.

Marking scheme: Only one workshop will attract assessment (3% of total course). Details given in the workshop instructions.

Penalties: Students are encouraged to attend the workshops, engage and ask questions. There are some challenging concepts in this course and this time is very valuable. The only penalty for not attending is you not getting the full benefit of your fees and missing out on valuable education. From experience, this will be reflected in your final mark.

Feedback: Workshops are great opportunities for in-depth feedback. Please come.

Objectives and learning outcomes: Workshops give students an opportunity to deepen their learning and understand concepts given in lectures and exercised in pracs. Please come.

Assessment Criteria for final exam

Comments: The final exam covers all material. It will be a paper style exam in a room. The questions will be a mixture of theoretical and applied questions relying heavily on the practical and workshop exercises which are underpinned by the lecture slides. Coming to all lectures and workshops (pracs are compulsory) will give the student a significant advantage in the final exam.

Marking scheme: The marks (and part marks) will be listed at the start of each question. The exam is written with a mix of computational and theory style questions. Students should look at how many marks are allocated to each question and provide answers in accordance with the value of the marks allocated (ie don’t spend 30 mins on a question worth only 2 marks out of 100!).

Penalties: Penalties are in accordance with standard UNSW exam practice.

Feedback: Students may contact the lecturer after the final exam for individual feedback.

Objectives and learning outcomes: The exam is designed to cover the broad range of topics covered in GMAT2120. Some questions will be applied and require the student to use their knowledge to answer a question that may require aspects from various topics within the curriculum. A practice exam is used for revision in week 11.

Supplementary Examinations for Term 3 2022 will be held on ???? 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.

COURSE PROGRAM

Week start	Monday 13 – 15 CLB5	Tuesday 13 - 15 CE G1	Friday 12 – 17 CE G1 – Survey store
1 **12/9**	**L1:** Intro to Course (C) **L2:** Levelling revision, rotating & digital levels and errors (C)	**L3A:** Precise levelling, errors & remedy (C) **L3B:** Prep for prac 1 (C)	**P1:** Collimation Test mini prac & rotating laser levelling of grid (C) Practice precise level run around campus (Y/P)
2 **19/9**	**L4A:** Data analysis & reductions (C) **T:** Prep for prac 2, booking, recording of precise levelling (C)	**L4B:** Adjust levelling data (C) **T:** Statistics of precise level reductions (C) (Moodle quiz)	**P2:** Precise level run prac around campus (C/Y) *(Level Prac due 6/10)*
3 **26/9**	**L5:** Intro to Elec Theods, using a theod. for precision (C) **L6:** Theodolite use for precise direction measurement (C)	**L8:** Electronic Level Sensors, Electronic Data Recording (C) **L9:** Error of Horizontal Coll, Incl of Trunn axis, Circle Eccentricity (C)	
4 **3/10***	*PUBLIC HOLIDAY*	**L7:** Booking and reduction of directions, arcs, and stats (C) **T:** Booking / reduction of directions and zenith angles (C) **T:** Prac Briefing (C)	**P3:** Angle Resection and Trig. Heighting Obs (C/Y) *(Angle prac due 20/10)*
5 **10/10**	**L10:** Correction of Dir and Zen Angles for non-vert of VA, Index Corr of Vertical Circle / Level Sensor, circle graduation and other errors (C) **L11:** Robotic Total Stations (C)	**T:** Principle of Digital Theods (C) **T:** Angles prac computations in CE201 lab	**P4:** Mini prac/ total station exercises (C/Y) *(Mini prac due 14/10)*
6 **17/10**	**L12:** Trig heighting, effects of Earth curvature and refraction (C)	**T:** Trig heighting questions – create excel sheet CE201	
7 **24/10**	**L13:** Trig heighting observation procedures, precision of heights. EDM-height traversing (C)	**T:** Computations for heights in Prac 3 (Due 27/10) CE201	**P5:** Leap frog EDM Height traversing (C/Y) *(Prac due 10/11)*
8 **31/10**	**L14:** EDM history, physical laws **L15:** Principles/apps of EDM **L16:** EDM components (C)	**T:** Demonstration of meteorological instruments, Prac Briefing (C) CE G7	**P6:** EDM long line measurement and reduction (C/Y) *(EDM Prac due 17/11)*
9 **7/11**	**L17:** Propagation of radiowaves, coefficient of refraction **L18:** Refractive index 1st vel corr (C)	**L19:** Geometrical corrections **T:** EDM Prac comps (C) *CE201*	
10 **14/11**	**L20:** Classification of EDM, EDM reflectors, Legal traceability (C) **T:** Practice exam and revision of theodolite errors (C)	**T:** Prac 6 comps	*Industry visit 12-1* ***Practical Exam (C/Y)***

C – Craig Roberts, Y – Yincai Zhou, P – Peter Mumford

RELEVANT RESOURCES

Lecture Material (check the course website):

http://moodle.telt.unsw.edu.au

The Powerpoint lecture slides and other documents are available for download as PDF files at the course website.

Lectures can also be viewed as Echo/ BBCU recordings.

Text and Reference Books

Text book:

Uren, J & Price, WF. "Surveying for Engineers", 5th edition, 2010

(available in bookshop – compulsory to purchase for B Eng(Surveying) and Dual award (3776) students only. Optional for other students)

Reference book:

- Uren, J & Price, WF. "Surveying for Engineers", 4th edition, 2006

- Schofield, W. "Engineering Surveying", 4th edition, 1993

- Bannister, A., Raymond, S. Baker, R. (1992) Surveying, 6th Edition, Pitman, London.

- Kavanagh, B.F. (2003) Surveying: Principles and Applications, 6th Ed, Prentice Hall, ISBN 0-13-099582-7

Computational Aids

Pocket calculators are required during lecturing hours, for workshops, field practicals as well as exams in this course. They have to be hand-held, internally powered and silent. They must be brought to all lectures and practicals.

Students may bring their own calculators to the exam but they must be approved calculators. The list of "approved" calculators is the same as that published by the Board of Studies NSW at

https://my.unsw.edu.au/student/academiclife/assessment/examinations/Calculator.html

Students must attain a tamper proof sticker from the Engineering Student Centre to guarantee that their calculator is approved for the final exam.

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

ACADEMIC ADVICE

(Formerly known as Common School Information)

For information about:

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

Refer to Academic Advice on the School website available at:

https://www.engineering.unsw.edu.au/civil-engineering/student-resources/policies-procedures-and-forms/academic-advice

RULES FOR PRACTICAL FIELD CLASSES

ISSUING OF EQUIPMENT

During the issue of equipment, one group collects their equipment and the remaining groups should stand well back. A group is responsible for all equipment issued to it, with the student checking the list of equipment as the representative.

1. *You should first inspect all equipment and make sure that it is in working order.* When returning equipment at the end of the field class, it should be handed back to the practical supervisor, piece by piece, so that it can be checked off. Not until all your equipment has been returned, does your responsibility end. Students are encouraged to report any breakages or faulty equipment and remember to get batteries charged after pracs.

2. *It is not sufficient to leave the equipment near the store and depart. Students should seek to return prior to the timetabled time for completion of the class, even if the fieldwork is not complete. Arrangements with the practical supervisor can be made in special circumstances in the field.*

3. In the field, there is less danger of losing items if everything is laid close to an instrument box or in a group where pedestrians can safely bypass it. No equipment is to be left unattended in the field at any time.

INSTRUMENTS

The equipment used in surveying is usually delicate and often valuable (> $10,000). Please make sure that you take due care of the equipment and give some thought to the way in which you handle it. The staff member in charge of your class will give detailed instructions about its use. *Electronic total stations*, have fragile optical mechanical and electronic components and are delicately adjusted. *Shut instrument boxes immediately after removing/replacing the instrument.* Carrying total stations (on tripods) over the shoulder will not be tolerated in this School. Do not force any parts to move, check whether clamps are set, and do not over tighten clamps. Leave boxes open after rain.

IN THE PUBLIC EYE

It is hoped that students taking part in surveying practicals on the campus will create a favourable impression on passers-by, **so behave like professionals**. The field classes give you an opportunity to handle interesting equipment and should be a welcome break from lectures. It is hoped you find the pracs enjoyable as well as instructive.

Students should not normally leave the field work location during the practical sessions. However students leaving the field for short periods must ask another student to look after their equipment and must inform the student (and the supervisor, if present) of their time of return. No equipment is to be left unattended in the field at any time.

SUMISSION OF REPORTS ON PRACTICAL FIELD CLASSES

Time: Reports will generally be submitted as per the assessment timetable. Note this could change depending on circumstances. Please come to lectures and read emails in case of changes. Late submissions will be penalised, unless accompanied by an appropriate reason and supported by relevant documentation (doctor's certificate).

Format: Bigger is not necessarily better. Be concise but explain everything. Please do not write in the first/ second person (ie I, we,our, us). It is unprofessional. Follow submission instructions for all reports. Usually submitted in A4 size either in paper, on Moodle or via email. Reports may be submitted in hand-written, typed or word-processed form. They should be presentable and readable. Attached plans must be folded to A4 size. Computer outputs should be neatly cut/paste into the report. Reports should show how the results were obtained from the field data, that the relevant theory has been understood, and that the computation processes have been competently carried out. Comments and discussion will demonstrate your knowledge.

The basic structure of each report should be as follows:

1) Title Page
   Include course number and name, title of exercise, student's name, group number

2) Table of Contents
   Pages should be numbered consecutively, including those of the appendix.

3) Introduction and Locality sketch
   - Discuss briefly (one sentence each) **what** was done, **where** it was done, **when** it was done, **who** did what.
   - Confirm that the procedures prescribed by the practical instructions were followed (or list deviations and give reasons).
   - Include a locality sketch and a list of (essential) equipment (make, type, serial number, any instrument correction that might apply).
   - Confirm that all computations on the field forms and those in the report have been checked.)

4) Summary of Relevant Results (and Precisions) (Table form, one page)

5) Body of Report
   - Follow the numbering systems used in the prac instructions. Where applicable show abstracts of field data, calculation of corrections, necessary theory and/or statement of equation used, calculation of 'results', calculation of precisions. The practical instructions give some guidance on what processing and analysis is required.
   - Explain your calculation steps and comment on results.
   - All calculations must be fully documented and traceable.
   - When using spreadsheets, put the relevant result values into the Body of Report part and any long-winded results can be placed in the appendix and referred to.

6) Conclusion and Comments
   This should include a critical appraisal of the methods used and of the results obtained. Discuss successes, failures, problems, defective equipment, how the practical could be made more effective, time spent in the field and the time spent for computation and the preparation of the report, etc.

7) References (author, year, title, edition, publisher, city of publication, no of pages)

8) Appendix (field sheets, field sketches, plans, check computations, etc.)

The following notes should be used for guidance in preparing reports:

Equations used in calculations must be listed in variable form and the source of the equation given (e.g. text book, lecture notes, etc.).

Where calculations are of a repetitive nature they should be set out in tabular form. Spreadsheets may be used. The marker may request emailing the spreadsheet to check equations for unorthodox results.

Significant intermediate results in the computation process should be shown.

Any rejection of field data must be justified and discussed with the supervisor and in the report.

A concise appraisal or criticism of the methods or techniques involved in the exercise should be included in the conclusion. (Comments based on guesses or intuition are to be avoided. Try to justify your conclusions.)

It is not necessary to describe, in detail, the methods used unless for some reason they varied from the instructions. (However, summarise methods and techniques in "Introduction".)

Compute to one decimal more than the input or measured data but truncate this extra decimal when presenting final results. This avoids round-off error.

Instructions on field notes and plans

It is essential that the course number, group number and the student(s) name(s) appear prominently on all field books, field sheets, reports, plans, etc.

Each student should bring along to all practicals good quality pencils (H, 2H, 4H) or a neat pen for field notes, calculator, metric scale, printed field sheets as supplied in the prac instructions (Moodle).

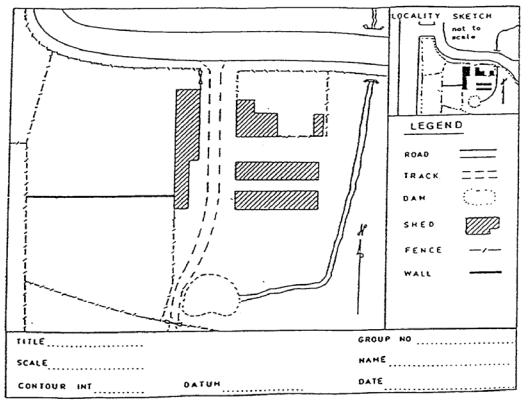
Take neat field notes of all measurements taken in the field and not overcrowded. Best to use pencil if rainy weather. Use the given field form from practical instructions. If no printed forms are distributed by the lecturer, these notes should be tabulated in a field book, and if necessary, referred to a diagram for clarification. Draw neat sketches or diagrams where appropriate. Use tables where appropriate.

The field book (or form) must also contain the following information on every page: title, date, site, course number, group number, names of students in group, make, type and serial number of all important instruments, observer, booker, time of observations, general weather, etc. A locality sketch showing the area of the survey should be prepared at the beginning of each practical.

Erasures and overwriting are not permissible. Errors may be struck out and the correct value neatly written (above). NEVER EVER USE LIQUID PAPER OR SIMILAR ON FIELD NOTES. PLEASE DO NOT REWRITE FIELD NOTES TO LOOK PRETTY. There is a danger of transcription errors. It is better to see slightly messy ORIGINAL field notes than pretty BUT possibly erroneous field notes with no way of detecting an error.

Whenever possible, plans should be drawn with the North direction towards the upper edge of the paper. Plans should carry the following information in a block in the lower right-hand corner:

- a heading, indicating the nature of the plan (eg Contour Plan, Detail Plan) and the general locality
- the scale of the plan, north point
- the datum for elevations and contours and for any grids shown on the plan
- the student's name, group number and course number, date of the survey



A conventional arrangement of detail on a plan is given above.

I hope you enjoy GMAT2120 – Surveying & Geospatial Technology

Craig Roberts, Aug 2022

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