York University
Faculty of Science and Engineering

SC/EATS 3620 4.0 and SC/ENG 3120 4.0

# Adjustment Calculus

Fall 2008

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**Course Director** Dr.-Ing. Jian-Guo Wang
*Phone:* (416) 736-2100 ext. 20761
*Fax:* 416-650-8135
*E-mail:* jgwang@yorku.ca
*Office:* CSEB 1012T


**Teaching Assistant** *Nilesh Gopaul*

**Lectures** *Tuesdays & Thursdays*, 13:00 – 14:30 (1:00p.m. – 2:30p.m.)
Room: BC225

**Laboratory exercises** *Thursdays*, 15:00-18:00 (3:00p.m. – 6:00p.m.)
Room: PSE 020

**Office Hours** 15:00 – 17:30 (3:00p.m. – 5:30p.m.), Tuesdays

**Assessment**

| | |
|---|---|
| Lab Assignments | 40% |
| Mid-term test | 15% |
| Participation | 5% |
| Final Exam | 40% |

**Grade System**

| | |
|---|---|
| ≥90% | A+ |
| 80-89% | A |
| 75-79% | B+ |
| 70-74% | B |
| 65-69% | C+ |
| 60-64% | C |
| 55-59% | D+ |
| 50-54% | D |
| 40-49% | E |
| <39% | F |

**Students who miss maximum 3 lab assignments for any reason will prevent from passing this course without exception.**

## GENERAL COURSE INFORMATION

### 1. Objectives

- Mastering the stat-of-art of adjustment theory and its applications in Geomatics engineering practice
- Establishing the solid fundation of the analytical approaches of error analysis and

parameter estimations of Least Squares and being capable of applying the fundamtental principles of error analysis and parameter estimation to the Engineering practice in Geomtatics,

- Being able to execute comprehensive error analysis in Engineering project design including project proposal, quality reqiurements, field procedures, network data processing and results reports in Geomatics Engineering,
- Obtaining compherehesive understanging of the internal mechanisms of surveying adjustemnt through constructing different geomatric constraints for data quality assurance in geodetic networks,
- Experiencing of modeling different types of geodetic observations in Geomatics practice,
- Developing skills in the integrated data processing via advanced and complex calculations and computer programming,
- Building up the essential basis for further advanced Geomatics subjetcs.

## 2. Format

Since every individual responds to different stimuli in his or her learning process, the presentation of the material will be done in a variety of ways. All of them will require work on your part to be effective. We will take a participative approach to learning. This means that faculty and students learn **together** by doing. We will learn **with** each other and **from** each other. **Therefore, we are all responsible for being prepared for class:**

- Lecture sessions will be conducted in form of discussion and participation. Students are required to participate actively, and design and solve problems by synthesizing knowledge, experience and skills from previous courses.
- The course will be closely related and will be running parallel to other Geomatics subjects.
- Each session will normally commence with a brief review of the concepts treated previously. New subject(s) will be presented immediately after the review, according to the tentative lecture schedule provided in this handout. **Participation** is an essential element of learning: It will be **encouraged** and **assessed**.
- All sessions will based on, but not limited to the textbook. Additional materials may also be supplied by the instructor for further studies upon the potential needs. The students will be required to actively search relevant literature to further their knowledge.

## 3. Laboratory Assignemnts and Exercises

- Laboratory assignments are most essential for the development of skills and experience. They will comprise a variety of activities that are usually required in the design, planning, execution, analysis and interpretation of data, and preparation of comprehensive reports.
- Laboratory exercises will be conducted in the lab.
- Laboratory reports will have clear due dates. You are expected to describe data processing and analysis in details, to summarize the results and hand in reports and developed software, where applicable.
- Participation in all laboratory exercises is **mandatory**.
- Grades for late laboratory reports will be decreased by 20% per day for each day overdue. Late lab reports must be handed in personally to your INSTRUCTOR

**4. Getting feedback on your progress**

Feedback on your progress will be provided in four different ways:

- Each class session should give you a fair idea how well you have understood the relevant material.
- Laboratory exercises: You will be asked to execute mandatory laboratory assignments, to solve specific problems and to write reports. Your participation is essential and will be assessed.
- Mid-term test.
- Final exam.

**5. Announcements**

Announcements and information related to the course, such as special lectures, class cancellations, change of due dates, professional activities, Internet links, and others will be emailed to the students. Please check regularly for up-to-date announcements and information.

## COURSE OUTLINE

1. Theory of random errors
2. Accuracy indexes, Error propagation and determination of standard deviations and weights of measurements
3. Principles of Least Squares.
4. Conditional adjustment, geometrical conditions of observations in Geomatics practice and their use in measurement quality assurance
5. Parametric adjustment and observation equations of different types of measurements
6. Conditional adjustment with parameters and applications
7. Parametric adjustment with constraints and applications
8. Error ellipses, error ellipsoids and accuracy evaluation in geodetic adjustment
9. Network pre-analysis, introduction to network design

## TEXT BOOKS

Ghilani, C.D. and Wolf, P.R. (2006): Adjustment Computations: - Spatial Data Analysis, John Wiley & Sons (4th edition), 2008.

Wang, Jian-Guo (2008): Adjustment Calculus, lecture handouts, 2008.

## SUGGESTED REFERENCES

1. Anderson, J. M. and E. M. Mikhail (1998): Surveying, theory and practice, McGraw-Hill, Boston ($7^{th}$ edition)
2. Wells, D.E. and Krakiwsky, E.J. (1997): The method of Least Squares, UNB, Lecture Notes 18, 1997.
3. Vanicek, P. (1995): Introduction to Adjustment Calculus, UNB, Lecture Notes 35, 1995.
4. Krakiwsky, E.J. (1994): A Synthesis of Recent Advances in the Method of Least Squares, UNB, Lecture Notes 42, 1994.

5. Mikhail, E. D. and G. Gracie (1981): Analysis & adjustment of survey measurements, Van Nostrand Reinhold.

## TENTATIVE CLASS SCHEDULE

**Fall Classes Start**: Sep. 03, 2008
**Fall Classes End**: Dec. 02, 2008

***Date*** ***Subject***

Week 1: Thursday, Sept. 04, 2008
**Lecture**: Introduction, Basic concepts in adjustment theory

Week 2: Tuesday, Sept. 09, 2008/Thursday, Sept. 11, 2008
**Lecture**: Theory of random errors: Accuracy Indexes and Basis of Random error distribution

Week 3: Tuesday, Sept. 16, 2008/Thursday, Sept. 18, 2008
**Lecture**: Error Propagation

Week 4: Tuesday, Sept. 23, 2008/Thursday, Sept. 25, 2008
**Lecture**: Error Propagation – Student presentations from the Assignment 2 (30min each)/Estimation of Standard Deviation from true errors/ Weights of Observations

Week 5: Tuesday, Sept. 30, 2008 (no class held on Rosh Hashanah)/Thursday, Oct. 02, 2008
**Lecture**: Principles of Least Squares

Week 6: Tuesday, Oct. 07, 2008/Thursday, Oct. 09, 2008 (no class held on Yom Kippur)
**Lecture**: Conditional Adjustment/Geometrical Constraints

Week 7: Tuesday, Oct. 14, 2008/Thursday, Oct. 16, 2008
Midterm Examination (Oct. 16, 2008)
**Lecture**: Derivation of the tolerance Errors for Observation Quality Assurance

Week 8: Tuesday, Oct. 21, 2008/Thursday, Oct. 23, 2008
**Lecture**: Parametric Adjustment/Software introduction

Week 9: Tuesday, Oct. 28, 2008/Thursday, Oct. 30, 2008
**Lecture**: Different Types of Observation Equations

Week 10: Tuesday, Nov. 04, 2008/Thursday, Nov. 06, 2008
**Lecture**: Network Pre-analysis/Quality Control of Parametric Adjustment

Week 11: Tuesday, Nov. 11, 2008/Thursday, Nov. 13, 2008
**Lecture**: The mixed adjustment models

Week 12: Tuesday, Nov. 18, 2008/Thursday, Nov. 20, 2008
**Lecture**: Error ellipses, error elliposoids and accuracy evaluation in adjustment

Week 13: Tuesday, Nov. 25, 2008/Thursday, Nov. 27, 2008
**Lecture**: Network Design and Preanalysis

Week 14: Tuesday, Dec. 02, 2008
**Lecture**: Course review

## TENTATIVE LABORATORY ASSIGNMENTS SCHEDULE

**Fall Classes Start**: Sept. 03, 2008
**Fall Classes End**: Dec. 02, 2008

***Date*** ***Subject***

Week 1: Thursday, Sept. 04, 2008 Due Date: Sept. 10, 2008
**Lab Assignment 1**: Programming of Vector & Matrix Computation
(C/C++ or MatLab, C/C++ prefered)

Week 2: Thursday, Sept. 11, 2008
No lab held and the time reserved for the Lab# 5 within the Week 6

Week 3: Thursday, Sept. 18, 2008 Due Date: Sept. 24, 2008
**Lab Assignment 2**: Error Propagation in Angle and Distance (2 persons)
Error Propagation in Traverse Surveys (2 person)
Error Propagation in Elevation Determination (2 person)
Error Propagation in 3D resection (1 person)
Homework (all)

Week 4: Thursday, Sept. 25, 2008 Due Date: Oct. 01, 2008
**Lab Assignment 3**: Estimation of Standard Deviation from true errors and Weights of Observations

Week 5: Thursday, Oct. 02, 2008 Due Date: Oct. 08, 2008
**Lab Assignment 4**: Constructions of Geometrical Conditions

Week 6: Tuesday, Oct. 07, 2008 Date: Oct. 13, 2008
**Lab Assignment 5**: Numerical computation of conditions /obervation quality checks through misclosues using $3\sigma$ rule

Week 7: Thursday, Oct. 16, 2008 Due Date: Oct. 22, 2008
**Lab Assignment 6**: Parametric Adjustment of Leveling Network

Week 8: Tuesday, Oct. 23, 2008 Due Date: Oct. 29, 2008
**Lab Assignment 7**: Parametric Adjustment of 2D Combined Network (directions and distances)

Week 9: Thursday, Oct. 30, 2008 Due Date: Nov. 05, 2008
**Lab Assignment 8**: Parametric Adjustment of 3D GPS Baseline network

Week 10: Thursday, Nov. 06, 2008 Due Date: Nov. 12, 2008
**Lab Assignment 9**: 2D Conformal Coordinate Transformation using the Conditioanl Adjustment with parameters

Week 11: Thursday, Nov. 13, 2008 Due Date: Nov. 19, 2008
**Lab Assignment 10**: Parametric Adjustment with Constraints

Week 12: Thursday, Nov. 20, 2008 Due Date: Nov. 26, 2008

**Lab Assignment 11**: modeling and Data Processing in industrial surveying using parametric adjustment with constraints

Week 13: Thursday, Nov. 27, 2008 Due Date: Dec. 03, 2008

**Lab Assignment 12**: Preanylsis of Combined Network (2D with distances and directions)