Course guide
310610 - 310610 - Observation Adjustment in Geomatics

Unit in charge: Barcelona School of Building Construction
Teaching unit: 749 - MAT - Department of Mathematics.
Degree: BACHELOR'S DEGREE IN GEOINFORMATION AND GEOMATICS ENGINEERING (Syllabus 2016). (Compulsory subject).
Academic year: 2022 ECTS Credits: 6.0 Languages: Catalan, English

LECTURER

Coordinating lecturer: Joan J. Rodríguez Jordana

PRIOR SKILLS

It is essential to have basic knowledge of lineal algebra, infinitesimal calculus in one and various variables, descriptive statistics, probability and random variables.

REQUIREMENTS

It is recommended to have successfully taken the subjects Algebra and Calculus of the semester 1A and the subject Mathematical Methods of the semester 1B

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Knowledge, use and application of instruments and fotogrametric methods and topographic adequate to the realization of non-cartographic raisings.
2. Knowledge and application of methods of minimum adjust quadratic in the scope of topo-geodesic observations, photogrametric and cartographic.

Transversal:
5. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

The following methodologies will be used:
Expository method for strictly theoretical content topics.
Expository-participatory class for most topics.
Solving exercises and problems
Practices in the calculation laboratory
Directed work and self-employment
LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, students must have expanded their knowledge of statistics to inductive statistics and must have acquired the fundamentals of adjusting observations. More specifically, you must have learned to calculate confidence intervals, test hypotheses, calculate how the variance-covariance matrix propagates through the calculations, and do parametric estimation in scenarios of direct, indirect, conditional and mixed observations, with models linear and nonlinear mathematics. All this using the least squares method and robust estimation methods.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours medium group</td>
<td>36,0</td>
<td>24.00</td>
</tr>
<tr>
<td>Hours large group</td>
<td>24,0</td>
<td>16.00</td>
</tr>
<tr>
<td>Self study</td>
<td>90,0</td>
<td>60.00</td>
</tr>
</tbody>
</table>

Total learning time: 150 h

CONTENTS

C1. Inductive Statistics

Description:
In this content the following topics are developed:
- Parameters, statistics and estimators
- The sample mean and variance estimators
- Estimation by intervals. Central limit theorem
- Confidence interval for the population mean and standard deviation
- Hypothesis contrast
- Hypothesis testing of a distribution function

Specific objectives:
At the end of this content, the student body must be able to:
- Define parameters, statistics and estimators and their properties
- Define and calculate the sample mean and variance estimators
- Define estimation by intervals. State the central limit theorem
- Define and calculate confidence intervals for the population mean and standard deviation
- Test hypothesis on means and standard deviations
- Test the hypothesis of a distribution function

Related activities:
- Theory classes
- Kinds of problems
- Practice in the calculation laboratory with Maple. Activity L1
- Practical examination of questions. Activity Q1
- Theoretical multiple choice test. Activity T1

Full-or-part-time: 16h
- Theory classes: 3h
- Practical classes: 3h
- Self study : 10h
C3. Variance-Covariance Matrix

Description:
In this content the following topics are developed:
- Joint probability distributions
- Independent random variables
- Covariance
- Variance covariance matrix
- Propagation of the variance covariance matrix in linear and nonlinear expressions

Specific objectives:
At the end of this content, the student body must be able to:
- Define joint probability distributions and marginal distributions
- Define independent random variables and check if two variables are independent
- Define and calculate the covariance of random variable residuals
- Define variance covariance matrix of a set of observations
- Calculate the spread of the variance covariance matrix in linear and nonlinear expressions

Related activities:
- Theory classes
- Kinds of problems
- Practical examination of questions. Activity Q1
- Theoretical multiple choice test. Activity T1

Full-or-part-time: 16h
- Theory classes: 3h
- Practical classes: 3h
- Self study: 10h

C3. Indirect Observations. Linear Model

Description:
In this content the following topics are developed:
- Linear Systems of Observation Equations
- Mathematical and stochastic models
- Resolution according to the criterion of maximum likelihood and least squares
- Calculation of residuals, a posteriori reference variance and propagation of the error

Specific objectives:
At the end of this content, the student body must be able to:
- Given a system of indirect observations with a linear model, propose the mathematical and stochastic models, define the least squares criterion, propose and solve the normal system and calculate the residuals, the posterior reference variance and the propagation of the error.

Related activities:
- Theory classes
- Kinds of problems
- Practice in the calculation laboratory with Maple. Activity L2
- Practical examination of questions. Activity Q1
- Theoretical multiple choice test. Activity T1

Full-or-part-time: 27h
- Theory classes: 4h 30m
- Practical classes: 7h 30m
- Self study: 15h
C4. Indirect Observations. Non Linear Model

Description:
In this content the following topics are developed:
Nonlinear Systems of Observation Equations
Mathematical and stochastic models
Linearization
Resolution according to the least squares criterion
Successive iterations
Calculation of residuals, goodness of fit test, a posteriori reference variance and propagation of the error

Specific objectives:
At the end of this content, the student body must be able to:
Given a system of indirect observations, propose the mathematical model of non-linear observation equations and the stochastic model, linearize the mathematical model, define the least squares criterion, propose and solve the normal system, iterate the process, calculate the residues, the a posteriori reference variance and error propagation and do a goodness-of-fit test. In your case, calculate the error ellipse.

Given a system of indirect observations with a non-linear model, propose the mathematical and stochastic models, linearize the mathematical model, define the criteria of maximum likelihood and least squares, propose and solve the normal system, iterate the process, calculate the residuals, do a goodness-of-fit test and calculate the posterior reference variance and the spread of the error.

Related activities:
Theory classes
Kinds of problems
Practice in the calculation laboratory with Maple. activity L2
Practical examination of questions. Q1 activity
Theoretical multiple choice test. T1 activity
Job. activity T

Full-or-part-time: 37h
Theory classes: 4h 30m
Practical classes: 7h 30m
Self study : 25h
C5. Robust Methods in Geomatics

Description:
This content introduces robust estimation methods useful when there are observational data affected by gross errors.
Robust estimators
Least median method
RANSAC method

Specific objectives:
At the end of this content, the student should be able to
Define robust estimators of central tendency and dispersion
Make parametric estimation using the least median method and the RANSAC method

Related activities:
Theory classes
Kinds of problems
Practice in the calculation laboratory with Maple. Activity L3
Practical examination of questions. Activity Q2
Theoretical multiple choice test. Activity T2

Full-or-part-time: 27h
Theory classes: 4h 30m
Practical classes: 7h 30m
Self study: 15h

C6. Condition Equation Model and General Least Squares Model

Description:
In this content the following topics are developed:
Fitting Observations Using a Linear Model of Condition Equations
Criteria of maximum likelihood and least squares
Precision in least squares estimation
Nonlinear equations of condition
General method of least squares

Specific objectives:
At the end of this content, the student body must be able to:
Formulate a system of condition equations corresponding to a set of observations
Define the least squares criterion
Make a least squares fit of observations in a linear and nonlinear model of condition equations and calculate the error of the fitted observations
Create a system of equations with observable variables and unknowns, solve it by least squares and calculate the error of the unknowns and of the adjusted observations

Related activities:
Theory classes
Kinds of problems
Practice in the calculation laboratory with Maple. Activity L4
Practical examination of questions. Activity Q2
Theoretical multiple choice test. Activity T2

Full-or-part-time: 27h
Theory classes: 4h 30m
Practical classes: 7h 30m
Self study: 15h
### ACTIVITIES

#### Coursework

**Description:**
Work consisting of the design of a system of indirect observations, the corresponding compensation and the public presentation of the results

**Specific objectives:**
- To design the observation system, the student body must have understood the concept of indirect observation, observation equation, error and weight.
- To perform the calculations, the student body must have understood the compensation by least squares and acquired the necessary skills to carry it out with a symbolic calculation program.
- To make the presentation, the student body must have developed transversal skills such as teamwork, oral and written expression and the solvent use of ICT resources.

To develop generic competence in a third language, the work must be written and defended in a third language.

**Material:**
Maple and ppt programs

**Delivery:**
Maple file with calculations and ppt file with presentation

**Full-or-part-time:** 8h
- Theory classes: 4h
- Self study: 4h

#### GENERIC COMPETENCE IN ENGLISH LANGUAGE

**Description:**
Practices in the calculation laboratory

**Specific objectives:**
When doing the practice, the student must be able to understand the sentences, move through the "help" of the program and express the results in English.

**Material:**
Maple program

**Delivery:**
Practice result file

**Full-or-part-time:** 1h
- Theory classes: 1h
<table>
<thead>
<tr>
<th>Activity L1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Practice in the calculation laboratory with the Maple program on random variables and samples</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>Learn to work with random variables and sample statistics with the Statistics package of the Maple program</td>
</tr>
<tr>
<td><strong>Material:</strong></td>
<td>Maple program</td>
</tr>
<tr>
<td><strong>Delivery:</strong></td>
<td>Maple file with results</td>
</tr>
<tr>
<td><strong>Full-or-part-time:</strong></td>
<td>2h</td>
</tr>
<tr>
<td><strong>Theory classes:</strong></td>
<td>2h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity L2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Practice in the calculation laboratory on indirect observations, with the Maple program</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>Learn to work with indirect observations with the Linear Algebra package of the Maple program</td>
</tr>
<tr>
<td><strong>Material:</strong></td>
<td>Maple program</td>
</tr>
<tr>
<td><strong>Delivery:</strong></td>
<td>Maple file</td>
</tr>
<tr>
<td><strong>Full-or-part-time:</strong></td>
<td>2h</td>
</tr>
<tr>
<td><strong>Theory classes:</strong></td>
<td>2h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity L4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Practice in the calculation laboratory on conditional observations and general method, with the Maple program</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>Learn to work with conditional observations and general method with the Linear Algebra package of the Maple program</td>
</tr>
<tr>
<td><strong>Material:</strong></td>
<td>Maple program</td>
</tr>
<tr>
<td><strong>Delivery:</strong></td>
<td>Maple file with the result</td>
</tr>
<tr>
<td><strong>Full-or-part-time:</strong></td>
<td>2h</td>
</tr>
<tr>
<td><strong>Theory classes:</strong></td>
<td>2h</td>
</tr>
</tbody>
</table>
### Activity L3

**Description:**
Practice in the calculation laboratory with the Maple program on robust estimation

**Specific objectives:**
Learn to work with the Statistics and combinat packages of the Maple program, to solve estimation problems using robust methods

**Material:**
Maple program

**Delivery:**
File on Maple support

**Full-or-part-time:** 2h
Theory classes: 2h

### Activities T1 and T2

**Description:**
Theoretical content test

**Specific objectives:**
At the end of these activities, the student body must have verified the degree of achievement of the theoretical concepts corresponding to contents 1, 2, 3 and 4 for activity T1 and 5 and 6 for activity T2 respectively

**Material:**
Test

**Delivery:**
Answered test

**Full-or-part-time:** 1h
Theory classes: 1h

### Activities Q1 and Q2

**Description:**
Practical question tests

**Specific objectives:**
At the end of these activities, the student body must have verified the degree of achievement of the practical concepts and mechanisms for solving exercises, corresponding to contents 1, 2, 3 and 4 for activity Q1 and 5 and 6 for activity Q2 respectively.

**Material:**
Statements

**Delivery:**
Solved exercises

**Full-or-part-time:** 5h
Theory classes: 5h
GRADING SYSTEM

Contents 1 to 4
A test with questions and theory test: 30% of the final grade
Two practices in the calculation laboratory: 2.5% of the final mark each

Contents 5 and 6
A test with questions and theory test: 30% of the final grade
Two practices in the calculation laboratory: 2.5% of the final mark each

Work: 10% of the final grade
Attendance and class work: 20% of the final grade
Students who obtain a grade between 3.5 and 4.9 will have the right to a make-up test for the questions and test tests that add up to 6% 5 of the final grade

EXAMINATION RULES

The tests will be carried out in the mid-term and final exam weeks of the semester.

The practices will be done with the MAPLE program during school weeks number 3, 7, 12 and 15. The work will be the subject of an oral presentation and will be defended at school week number 10

BIBLIOGRAPHY

Basic:

Complementary:

RESOURCES

Audiovisual material:
- Nom recurs. Resource

Other resources:
The course has a space in the virtual campus ATENEA where you can find
A link to the teaching guide
A PDF document where you can follow the activities while being developed
A repository of practices to resolve