

**I. Tantárgyleírás****1. Alapadatok***1.1 Tantárgy neve***ADJUSTMENT OF OBSERVATIONS***1.2 Azonosító (tantárgykód)***BMEEOAFMF53***1.3 Tantárgy jellege*

Kontaktórás tanegység

*1.4 Óraszámok*

| Típus             | Óraszám / (nap) |
|-------------------|-----------------|
| Előadás (elmélet) | 2               |
| Gyakorlat         | 1               |

*1.5 Tanulmányi teljesítményértékelés (minőségi értékelés) típusa*

Vizsga

*1.6 Kreditszám*

4

*1.7 Tárgyfelelős*

|          |                                                                  |
|----------|------------------------------------------------------------------|
| név      | Dr. Gyula Tóth                                                   |
| beosztás | Egyetemi docens                                                  |
| email    | <a href="mailto:toth.gyula@emk.bme.hu">toth.gyula@emk.bme.hu</a> |

*1.8 Tantárgyat gondozó oktatási szervezeti egység*

Általános- és Felsőgeodézia Tanszék

*1.9 A tantárgy weblapja*<https://epito.bme.hu/BMEEOAFMF53><https://edu.epito.bme.hu/course/view.php?id=3480>*1.10 Az oktatás nyelve*

magyar és angol

*1.11 Tantárgy típusa*

Kötelező az építőmérnöki (BSc) szak Szerkezet-építőmérnöki ágazatán

*1.12 Előkövetelmények*

Recommended prerequisites:

- Numerical Methods (BMEEOFTMK51)

*1.13 Tantárgyleírás érvényessége*

2021. szeptember 1.

## **2. Célkitűzések és tanulási eredmények**

### *2.1 Célkitűzések*

The aim of the course is to provide the student with knowledge of modern procedures for solving common measurement processing tasks in the field of surveying and GIS engineering. Students will be able to choose the appropriate methods for their own tasks and apply the computer tools learned in the subject in a creative way. The course also aims to introduce students to the specifics of each measurement processing procedure through some specific examples.

### *2.2 Tanulási eredmények*

A tantárgy sikeres teljesítése után a hallgató

#### **A. Tudás**

1. is familiar with the most important quantities used to describe the characteristic value and uncertainty of the measurement data (mean, mode, median, most frequent value, standard deviation, uncertainty, dihesion, interquartile and intersextile half-width),
2. understands the fundamental role of statistical efficiency in estimates in terms of the amount of data required to achieve a given accuracy,
3. understands the difference between the traditional and Bayesian statistical approaches,
4. is familiar with the possibilities of using Monte-Carlo methods for estimating the uncertainty of measurement data sets,
5. is aware of the relationship between the standard error in geodesy and the measurement uncertainty used in metrology and the principle and means of determining the measurement uncertainty according to the GUM (Guide to the Expression of Uncertainty in Measurement) specifications,
6. understands the essence of integer least squares estimation procedures and is aware of their application to the processing of GNSS measurements,
7. understands the basic idea of Kálmán filtering and is aware of its geodetic applications,
8. knows the concepts of robustness and resistance, understands the principle of maximum likelihood estimates,
9. is familiar with the most important methods of estimating PSD (power spectral density) of time series,
10. is aware of the basic idea of RANSAC (random sample consensus) estimation and the main steps of the procedure.

#### **B. Képesség**

1. is able to determine the most characteristic value of a measurement data set and the most important quantities characterizing the uncertainty of the data set (mean, mode, median, most frequent value, standard deviation, uncertainty, dihesion, interquartile and intersextile half-width),
2. be able to examine the type of distribution of any data system and give correct interpretation of the result of the statistical test,
3. is able to determine the measurement uncertainty according to the GUM specifications in simpler cases with the help of software suitable for the task,
4. is able to process the measurements of a simple GNSS network compiled by others independently with the help of suitable software,
5. able to estimate the PSD of time series data, to interpret the PSD,
6. it is also able to perform Kálmán filtering in the case of a linear task on its own.

#### **C. Attitűd**

1. understands the fundamental importance of robustness, statistical efficiency in the field of measurement processing,
2. open to a Bayesian statistical approach to data processing,
3. receptive to the knowledge and application of modern, efficient data processing procedures,
4. seeks to evaluate the advantages and disadvantages of various measurement processing procedures for the given task.

#### **D. Önállóság és felelősség**

1. independently analyzes simple tasks and problems arising in the field of processing geodetic and GIS measurements, solving them on the basis of the given sources and samples,
2. openly accept substantiated critical remarks.

### 2.3 Oktatási módszertan

Lectures and computer exercises. Use of computer presentations and interactive graphic web worksheets.

### 2.4 Részletes tárggyprogram

| Week | Topics of lectures and/or exercise classes                                      |
|------|---------------------------------------------------------------------------------|
| 1.   | Determination of most frequent value and measurement uncertainty                |
| 2.   | Cramer-Rao bound, statistical efficiency, statistical tests                     |
| 3.   | Introduction to Bayesian statistics                                             |
| 4.   | Monte-Carlo procedures, measurement uncertainty based on GUM                    |
| 5.   | Processing of GNSS measurements, integer LKN procedures                         |
| 6.   | Sequential adjustment and adjustment in groups, processing with Bernese         |
| 7.   | Photogrammetric bundle and DLT adjustment                                       |
| 8.   | Kalman filtering in the linear case                                             |
| 9.   | Kalman filtering in the nonlinear case                                          |
| 10.  | Characterization of time series in the frequency domain. PSD and its estimation |
| 11.  | Maximum likelihood estimates                                                    |
| 12.  | The concept and role of robustness and resistance                               |
| 13.  | Data processing with RANSAC                                                     |
| 14.  | Determination of functions, processing point cloud data                         |

A félév közbeni munkaszüneti napok miatt a program csak tájékoztató jellegű, a pontos időpontokat a tárgy honlapján elérhető "Részletes féléves ütemterv" tartalmazza.

### 2.5 Tanulástámogató anyagok

a) Downloadable materials:

- Manuals for applied programs, web help, forums ... etc.
- Interactive workbooks on the subject's github page ([https://github.com/gyulat/adjustment\\_computations](https://github.com/gyulat/adjustment_computations))

b) presentations, descriptions, tasks in the educational framework

c) other materials:

- Vanicek P., Krakiwsky E. J.: Geodesy: The Concepts, Part III: Methodology (North-Holland, 1986)
- Steiner F. (ed.): The most frequent value. Introduction to a modern concept of statistics. Akadémiai Kiadó, Budapest, 1991. ISBN-10: 9630556871
- Steiner F. (ed.): Optimum Methods in Statistics. Akadémiai Kiadó, Budapest, 1997. ISBN 10: 963057439X
- Szabó, N. P.: Geostatistics. Lecture slides. Univ. of Miskolc, online: <https://www.uni-miskolc.hu/~geofiz/Geostatistics.pdf>

### 2.6 Egyéb tudnivalók

During the teaching and learning of the subject we use almost exclusively freely available software.

### 2.7 Konzultációs lehetőségek

Consultation dates: as specified on the website of the department or in consultation with the lecturers of the

subject by e-mail.

*Jelen TAD az alábbi félésre érvényes:*

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## II. Tárgykövetelmények

### 3. A tanulmányi teljesítmény ellenőrzése és értékelése

#### 3.1 Általános szabályok

The assessment of the learning outcomes set out in 2.2 is based on a written exam, 2 homework assignments and 1 midterm test.

#### 3.2 Teljesítményértékelési módszerek

| Evaluation form                                             | Abbreviation | Assessed learning outcomes      |
|-------------------------------------------------------------|--------------|---------------------------------|
| Written exam (summary performance evaluation)               | E            | A.1-A.10; B.1-B.4; C.1-C.4; D.1 |
| Homework 1 (small homework, partial performance evaluation) | HW1          | A.9; B.5; D.2                   |
| Homework 1 (small homework, partial performance evaluation) | HW2          | A.7; B.6; C.3; D.2              |
| Midterm test (partial performance evaluation)               | MT           | A.1-A.6; B.1-B.4; C.1; D.1      |

A szorgalmi időszakban tartott értékelések pontos idejét, a házi feladatok ki- és beadási határidejét a "Részletes féléves ütemterv" tartalmazza, mely elérhető a tárgy honlapján.

#### 3.3 Teljesítményértékelések részaránya a minősítésben

| Abbreviation               | Score       |
|----------------------------|-------------|
| HW1                        | 10%         |
| HW2                        | 10%         |
| MT                         | 30%         |
| Total during the semester: | 50%         |
| E                          | 50%         |
| <b>Sum</b>                 | <b>100%</b> |

#### 3.4 Az aláírás megszerzésének feltétele, az aláírás érvényessége

The requirement for obtaining the signature is that according to 3.3., the student must complete all the homeworks at a sufficient level (50%). We do not prescribe a condition for the success of the midterm test.

#### 3.5 Érdemjegy megállapítása

| Grade            | Points (P)       |
|------------------|------------------|
| excellent (5)    | $80 \leq P$      |
| good (4)         | $70 \leq P < 80$ |
| satisfactory (3) | $60 \leq P < 70$ |
| passed (2)       | $50 \leq P < 60$ |
| failed (1)       | $P < 50$         |

#### 3.6 Javítás és pótlás

- 1) The midterm test is not compulsory, therefore no re-takes are possible.
- 2) Homework - in addition to paying the fee specified in the regulations - can be submitted late until 16:00 on the last day of the delayed submission week or sent electronically until 23:59.
- 3) The submitted and accepted homework can be corrected free of charge till the deadline and in the manner specified in point 2.

#### 3.7 A tantárgy elvégzéséhez szükséges tanulmányi munka

| Activity                                  | Hours/semester     |
|-------------------------------------------|--------------------|
| participation in contact classes          | $14 \times 3 = 42$ |
| mid-term preparation for practice classes | $14 \times 1 = 14$ |
| preparation for tests                     | 10                 |
| preparation of homeworks                  | $5 + 5 = 10$       |
| preparation for the exam                  | 40                 |

|     |     |
|-----|-----|
| Sum | 120 |
|-----|-----|

3.8 A tárgykövetelmények érvényessége

2021. szeptember 1.

Jelen TAD az alábbi félévre érvényes: