

I. Tantárgyleírás

1. Alapadatok

1.1 Tantárgy neve

THEORY AND APPLICATION OF GNSS

1.2 Azonosító (tantárgykód)

BMEEOAFMSFGG04-00

1.3 Tantárgy jellege

Kontaktórák tanegység

1.4 Óraszámok

Típus	Óraszám / (nap)
Előadás (elmélet)	1
Laboratóriumi gyakorlat	2

1.5 Tanulmányi teljesítményértékelés (minőségi értékelés) típusa

Vizsga

1.6 Kreditszám

5

1.7 Tárgyfelelős

név	Dr. Rózsa Szabolcs
beosztás	Egyetemi tanár
email	rozsa.szabolcs@emk.bme.hu

1.8 Tantárgyat gondozó oktatási szervezeti egység

Általános- és Felsőgeodézia Tanszék

1.9 A tantárgy weblapja

epito.bme.hu

<https://edu.epito.bme.hu/course/view.php?id=5087>

1.10 Az oktatás nyelve

magyar

1.11 Tantárgy típusa

Kötelező a Földmérő- és térinformatikai mérnök (MSc) szakon

1.12 Előkövetelmények

1.13 Tantárgyleírás érvényessége

2025. szeptember 1.

2. Célkitűzések és tanulási eredmények

2.1 Célkitűzések

The course aims at introducing the operational background of the global navigation satellite systems (GNSS), to discuss the underlying physical and mathematical models, systematic error sources and the standardized data formats of satellite positioning. The students gain extensive knowledge on the applications of GNSS positioning in geodesy, geomatics, civil engineering, navigation, precision agriculture, geodynamics, meteorology, hydrology. The course enables students to process GNSS observations for navigation as well as highly accurate positioning and to analyse GNSS observations and results to obtain valuable information for Earth observation.

2.2 Tanulási eredmények

A tantárgy sikeres teljesítése után a hallgató

A. Tudás

1. Understands the structure of Global Navigation Satellite Systems. 2. Knows the geodetic reference systems and frames used for GNSS positioning and their relationships. 3. Understands the principles of perturbed orbital motion and knows the methods of satellite position calculations (from osculating elements, orbit integration). 4. Knows the standard data formats used in geodetic GNSS positioning (RINEX, RTCM, NMEA, SP3, ERP). 5. Knows the systematic error affecting GNSS observations and understands the methods of their mitigation. 6. Knows the GNSS positioning techniques and their characteristics. 7. Understands the mathematical background of the GNSS positioning using pseudorange and phase observations. 8. Knows the linear combinations of multi-frequency observations and their use for positioning and atmospheric remote sensing. 9. Has an outlook to the wide area of GNSS applications with a special focus on applications in civil engineering and Earth Sciences.

B. Képesség

1. Ability to use various geodetic reference frames in positioning tasks; 2. Ability to understand the whole process of GNSS positioning with different techniques; 3. Ability to design the optimal realization of geodetic GNSS measurements tailored to the accuracy requirements 4. Ability to understand, interpret and use the standard data structures of GNSS 5. Ability to develop algorithms for GNSS data processing 6. Ability to solve coordinate transformation problems between reference systems and national grids 7. Ability to process GNSS data with software using rigorous observation modelling 8. Ability to do literature research, process the information and present it in a short presentation

C. Attitűd

1. Realizes the importance of GNSS observations for other branches of science 2. Open to the creative application of GNSS measurements 3. Open to the systematic way of thinking 4. Thrives to create elegant and effective programming codes 5. Thrives to document the program codes

D. Önállóság és felelősség

1. Carries out GNSS observation acquisition and observation processing calculations individually 2. Eager to receive feedback on the submitted homeworks/assessments 3. Processes the literature on his/her own and prepares a presentation on the topic

2.3 Oktatási módszertan

Lectures, instrumental observations and practicals in computer lab. Individual literature research homework on proposed topics and summarizing the results in an oral presentation.

2.4 Részletes tárgyprogram

1. Satellite positioning. Coordinate systems. Time systems. Physics of satellite motion. Global navigation satellite systems (NAVSTAR GPS, GLONASS, Galileo, Beidou, etc.). Coordinate systems. Transformation between coordinate systems. 2. Reference systems and their relationships. 3. Satellite orbits and the calculation of satellite coordinates. Planning GNSS observations. 4. Computation of satellite coordinates using broadcast ephemerides (HW1). 5. Error sources of GNSS positioning. Standard data formats of GNSS observations, data and coordinate solutions. 6. Calculation of atmospheric effects (ionosphere, troposphere) (HW2). 7. Error sources related to signal reception. The state-space and the observation space representation. The Precise Point Positioning technique. Computational exercise: calculation of absolute positioning using pseudoranges. (HW3) 8. Linear combinations of observations and their applications. 9. Geodetic GNSS positioning techniques. Static and kinematic, real-time and post-processing techniques. The Ground Based Augmentation Systems. Computational Exercise: The Precise Point Positioning technique. 10. Relative positioning using phase observations. 11.

Mathematical solution of relative positioning using phase observations. The principle of differentiation. Phase ambiguities and their resolution: the integer least-squares problem. Mathematical solution of positioning. Coordinate transformations (HW4) 12. Rigorous GNSS observation processing 1.: data acquisition, preprocessing, orbit determination. 13. GNSS Integrity and safety-of-life applications. Space-based Augmentation Systems. Earth Science Applications. Rigorous GNSS observation processing 2: screening of phase observations, float solution, network solution. Stacking normal equations. 14. Application of GNSS: geodesy, surveying, geodynamics, geophysics, meteorology, Earth observation. (SP)

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 material: Manuals, handouts of the applied software and algorithms. Lecture notes and syllabus of practicals on the website of the course. b) Textbook: Bernhard Hofmann-Wellenhof, Herbert Lichtenegger, Elmar Wasle: GNSS - Global Navigation Satellite Systems, Springer Verlag, ISBN: 978-3-211-73017-1

2.6 Egyéb tudnivalók

Attendance requirement on the practicals is 70%.

2.7 Konzultációs lehetőségek

Personal consultation in the consultation hours defined on the course webpage or upon personal appointment request via e-mail.

Jelen TAD az alábbi félévre érvényes:

II. Tárgykövetelmények

3. A tanulmányi teljesítmény ellenőrzése és értékelése

3.1 Általános szabályok

The learning outcomes defined in Section 2.2 are assessed with an oral exam, 4 homeworks and 5 online short tests measuring the prerequisite knowledge for the continuous development of knowledge. The results of the literature research (SP) is presented in an oral presentation on the lecture specified in the detailed course plan. Lecture notes and handouts are available for download on the course webpage for continuous studying.

3.2 Teljesítményértékelési módszerek

Assessment Name (Type)	Code	Assessed Learning Outcomes
Homework 1	HW1	A2;B1, B4-B6; C3-C5;
Homework 2	HW2	A3;B2, B4-B5; C3-C5;D1-D2
Homework 3	HW3	A5;B2, B4-B5; C3-C5;D1-D2
Homework 4	HW4	A6;B4-B5; C3-C5;D1-D2
Online tests	OT1-5	A1-A9;B1-B7;C1-C2;
Students' Presentation	SP	A9;B8;C1-C2;D2-D3
Exam	E	A1-A9;B1-B7;C1-C2;

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

Code	Weight
HW1	6%
HW2	6%
HW3	6%
HW4	6%
OT1-5	10%
SP	6%
E	60%
Total	100%

3.4 Az aláírás megszerzésének feltétele, az aláírás érvényessége

The signature can be obtained when all the homeworks and the student's presentation has been fulfilled at the minimally accepted level (pass level). The accepted level is defined as: Homeworks: the calculation does not contain any significant error, the exercise and the calculations are documented and the used software code is available. Presentations: the student is able to hold a presentation with the length of 10 minutes about the chosen topic. The presentation should include the introduction of the topic, the motivation, the state-of-the-art approaches as well as the conclusions. Related GNSS observations and data processing is a plus.

3.5 Érdemjegy megállapítása

Grade	Score (P)
excellent (5)	$88 \leq P$
good (4)	$76 \leq P < 88\%$
satisfactory (3)	$63 \leq P < 76\%$
pass (2)	$50 \leq P < 63\%$
fail (1)	$P < 50\%$

3.6 Javítás és pótlás

1) Homeworks can be submitted - with an extra fee - up to 16 o'clock on the last day of the retake period (or up to 23:59 in electronic form through the Moodle system on the same day). 2) Submitted homeworks can be corrected and re-submitted until the deadline given in 1) without paying an extra fee. 3) Submitting the students' presentation late and failing to present it on the last week leads to a "pass" grade of the presentation as a maximum. 4) The online short tests can be retaken unlimited times during a predefined two-week-period.

3.7 A tantárgy elvégzéséhez szükséges tanulmányi munka

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Activity	Hours/Semester
Participation on lectures and practical	14×3=42
Preparation of homework (HW1-4)	40
Preparation for the Students' Presentations	30
Preparation for the exam	48
Total	

3.8 A tárgykövetelmények érvényessége

2025. szeptember 1.

Jelen TAD az alábbi félévre érvényes: