
# GEOPHYSICAL INVERSION

Earth Science Engineering MSc / Geophysical Engineering specialization

2017/2018 2. Semester

COURSE COMMUNICATION FOLDER

**University of Miskolc**
**Faculty of Earth Science and Engineering**
**Institute of Geophysics and Geoinformatics**

## *Course datasheet*

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|---|---|
| **Course Title:** Geophysical inversion<br>**Responsible instructor** (name, position, scientific degree)**:** Dr. Fancsik Tamás, associate professor | **Neptun code:** MFGFT720014<br>**Responsible department/institute:**<br>Institute of Geophysics and Geoinformatics / Department of Geophysics |
| | **Type of course: C** |
| **Position in Curriculum (which semester):** 2 | **Pre-requisites (if any):** none |
| **Number of Contact Hours per Week (lec.+prac.):** 0+2 | **Type of Assessment (examination / practical mark / other):** practical mark |
| **Credits:** 4 | **Course:** full-time<br>**Program:** Earth Science Engineering MSc / Geophysical Engineering |

**Course Description:**
In the frame of the course learn the Geophysical Engineering MSc students how can be the geological and geophysical information from the measured data obtained by recent inversion methods.

**Competencies to evolve:**

**Knowledge:** T1, T2, T3, T6, T7

**Ability:** K2

**Attitude:** A1, A2, A3, A4, A5, A7

**Autonomy and responsibility:** F1, F2, F3, F4, F5

**The short curriculum of the subject:**
Solution of the mixed determined inverse problem: solution of the weighted Least Squares method, Marquardt-algorithm. Relationship between the optimization of the damping factor and the condition number. Solution based on the weighted least squares method in data space. Solution based on the weighted Least Squares method in case of mixed determined inverse problem. Solution based on the weighted Least Squares method in the parameter space. Solution of the inverse task by the minimizing of $L_p$-norm, the method of iterative re-weighting. The qualification of accuracy and reliability of parameter-estimation: covariance and correlation matrices in the parameter space: dissolving matrix, in data and parameter space, generalized inverse, sub-division by singular values. Solutions of the nonlinear inverse task by global optimization methods. The Simulated Annealing and Genetic Algorithm methods. The joint inversion. The series expansion inversion method. Applying the inversions methods in case of different geophysical datasets.

**Assessment and grading:**
Attendance at lectures is regulated by the university code of education and examination. Writing two tests at least satisfactory level, respectively during the semester is the requirement of signature.

**Exam grading scale**: unsatisfactory (0-45%), satisfactory (46-60%), medium (61-70%), good (71-85%), excellent (86-100%).

**The 3-5 most important compulsory, or recommended literature (textbook, book) resources:**
1 Dobróka M., 2001: The Methods of Geophysical Inversion. University textbook, University of Miskolc.
2. W. Menke, 1984: Geophysical Data Analysis: Discrete Inverse Theory. Academic Press Inc.
3. Mrinal Sen and Paul L. Stoffa: Seismic Exploration - Global Optimization: Methods In Geophysical Inversion. Software, Elsevier Science Ltd. 1997.
4. Szabó N.P., Dobróka M.: Float-encoded genetic algorithm used for the inversion processing of well-logging data Global Optimization: Theory, Developments and Applications: Mathematics Research Developments, Computational Mathematics and Analysis Series. New York: Nova Science Publishers Inc., 2013. pp. 79-104.
6. P.J.M. van Laarhoven, E.H.L. Aarts, 1987: Simulated Annealing: Theory and Applications. D. Reidel Publishing Company, ISBN 90-277-2513-6
Dobróka, M., Völgyesi, L. 2008. Inversion Reconstruction of Gravity Potential based on Gravity Gradients. Mathematical Geoscience, Vol. 40, pp. 299-311

## *Syllabus of the semester*

| Week | Seminar |
|---|---|
| 1 | Solution of the mixed determined inverse problem: solution of the weighted Least Squares method, Marquardt-algorithm. |
| 2 | Relationship between the optimization of the damping factor and the condition number. |
| 3 | Solution based on the weighted least squares method in data space. |
| 4 | Solution based on the weighted Least Squares method in case of mixed determined inverse problem. |
| 5 | Solution based on the weighted Least Squares method in the parameter space. |
| 6 | 1st mid-term test. |
| 7 | Solution of the inverse task by the minimizing of $L_p$-norm, the method of iterative re-weighting. |
| 8 | The qualification of accuracy and reliability of parameter-estimation: covariance and correlation matrices in the parameter space: dissolving matrix, in data and parameter space, generalized inverse, sub-division by singular values. |
| 9 | Solutions of the nonlinear inverse task by global optimization methods. |
| 10 | The Simulated Annealing and its variations. |
| 11 | The Genetic Algorithm methods. |
| 12 | The joint inversion method. Applying the inversions methods in case of different geophysical datasets. |
| 13 | The series expansion inversion method. Applying the inversions methods in case of different geophysical datasets. |
| 14 | 2nd mid-term test. |

## *Sample for the mid-term exam*

Please, describe the basics of damped LSQ method (Marquardt algorithm), deduce the normal equation. Please, determine the condition number of normal equation's matrix and show how you choose the appropriate damping factor.

*The solution can be found in the university text book „The methods of geophysical inversion".*