UNIVERSITY OF MISKOLC
FACULTY OF EARTH SCIENCE AND ENGINEERING
1735

BASIC DATA PROCESSING METHODS FOR OILFIELD GEOPHYSICS AND PETROPHYSICS

Petroleum Geoengineering MSc course

2024/25 1st Semester

COURSE COMMUNICATION FOLDER

University of Miskolc
Faculty of Earth and Environmental Sciences and Engineering
Institute of Exploration Geosciences

Course datasheet

Course Title: Basic data processing methods for oilfield geophysics and petrophysics (Petroleum Geoengineering MSc, Optional courses II.)	**Credits: 4**

Type (lec. / sem. / lab. / consult.) and Number of Contact Hours per Week: lec.1 + sem.1

Neptun code: MFGFT730013

Type of Assessment (exam. / pr. mark. / other): **pr. mark**
Signature requirements: attendance on minimum 51 percent of the seminars and pass grade on two midterm exams.
Practical mark: the arithmetical mean of the result of two midterm exams if both results were at least satisfactory.

Grading scale:

% value	Grade
86 –100%	5 (excellent)
71 – 85%	4 (good)
56 – 70%	3 (satisfactory)
41 – 55%	2 (pass)
0 – 40%	1 (failed)

Position in Curriculum (which semester): third

Pre-requisites *(if any)*: no

Course Description:
The course gives mathematical fundamentals of spectral data processing methods and its usage in fields of oilfield geophysics and petrophysics.
Competencies to evolve:
Knowledge: T1, T5, T7, T10, T11, T12.
Ability: K2, K3, K7, K10.
Attitude: A1, A9.
Autonomy and responsibility: F2.

The short curriculum of the subject:
Basis of information theory. Signal theory. Discretization. Errors of discretization. A/D conversion. A/D converters. Spectral transformation (Fourier-transform, Discrete Fourier Transform, Fast Fourier Transform, Z-transform). Spectrum calculation using Z-transformation. Convolution. Discrete convolution. Correlation functions. Discrete correlation functions. Basis of deterministic and stochastic filtering. Image processing.
Education method: Practices using software and ppt presentation to learn processing methods.

The compulsory, or recommended literature (textbook, book) resources:

- Meskó A, 1984: Digital filtering. Academic Press Inc, Budapest.
- Menke, W, 1984: Geophysical Data Analysis: Discrete Inverse Theory. Academic Press Inc.
- Candy, J V, 1986: Signal Processing, McGraw-Hill Book Co.

- Bath, M, 1974: Spectral Analysis in Geophysics, Elsevier Scientific Publishing Co.
- Bracewell, R N, 1978: The Fourier Transform and its Applications, McGraw-Hill Book Co.

Course Managed by (*name, position, scientific degree):*
Endre Kázmér Nádasi, assistant professor, PhD

Other Faculty Member(s) Involved in Teaching, if any (*name, position, scientific degree*):
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Syllabus of the semester

Week	Lecture and seminar
13/09/2024	Starting test. Basis of information theory. Signal theory.
20/09/2024	Discretization. Errors of discretization.
27/09/2024	A/D conversion. A/D converters.
04/10/2024	Fourier-transform. Discrete Fourier Transform (DFT). Fast Fourier Transform. Z-transform. Spectrum calculation using Z-transformation.
11/10/2024	Convolution. Discrete convolution.
18/10/2024	1st written midterm exam.
25/10/2024	Holiday declared by Rector.
01/11/2024	All Saints' Day.
08/11/2024	Correlation functions (auto- and cross-correlation function).
15/11/2024	Discrete correlation functions (discrete auto- and cross-correlation function).
22/11/2024	Basis of deterministic and stochastic filtering.
29/11/2024	Image processing.
06/12/2024	2nd written midterm exam.
13/12/2024	Semester closing.

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Basic data processing methods for oilfield geophysics and petrophysics. **1st midterm practical exam, A**
(Solution time: 50 minutes)
Petroleum Geoengineering MSc

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Name with Neptun code

1. Draw up the error vector of discretization in a complex plan when there is an angle of 60 degrees between the error vector and horizontal axis (10 points).

2. Give the sampling error in percent when sampling number is $5 \cdot 10^3$ (10 points).

3. Give the conversion error (amplitude resolution error) of ***10*** bits A / D converter in percent (10 points).

4. Derive dimension right Inverz DFT formula (8 points) and index right Inverz DFT formula (4 points) from analytic Fourier-transform.

5. Calculate and give the type of following filter (10 points).

$$\{w_n\} = \left(\overset{\downarrow}{-1}, 2, -1, 1 \right), \quad \Delta t = 0.5 \text{ sec} .$$

6. Calculate the ***6*** bits digital code of ***651 mV*** in ***0 mV*** and ***1024 mV*** signal interval (24 points).

7. Calculate the complex spectrum - F(f) - of the following discrete data series using Z-transformation and give real spectra – Re(f), Im(f), A(f) and Φ(f) - of the complex spectrum (24 points).

$$\left[\overset{\downarrow}{1}, -1, 2, 1, -2 \right], \quad \Delta t = 2 \text{ sec}, \quad f = 0{,}125 \text{ Hz}.$$

Result:

80.5-100.0 points:	A1 level (5),
70.5-80.0 points:	A2 level (4.5),
60.5-70.0 points:	B level (4),
50.5-60.0 points:	C level (3.5),
40.5-50.0 points:	D level (3),
30.5-40.0 points:	E1 level (2.5),
20.5-30.0 points:	E2 level (2),
0.0-20.0 points:	F level (1).

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Basic data processing methods for oilfield geophysics and petrophysics. **2nd midterm practical exam**
Petroleum Geoengineering MSc. *(Solution time: 75 minutes)*

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Name with Neptun code

1. Given the following time series: $\Delta t = 0.5\ sec$,

$$\{x_n\} = (\overset{\downarrow}{1}, -1, 1, 2, -2), \qquad \{y_n\} = (\overset{\downarrow}{1}, -2, 2, 2, -1).$$

1.a., Calculate the discrete corrected cross-correlation function $\{R_{xy}(k)\} = (R_{-3}, R_{-2}, R_{-1}, R_0, R_1, R_2, R_3)$, and illustrate the result in figure using Dirac pulse sequence (24 points).

1.b., Calculate the discrete corrected autocorrelation function: $\{R_{xx}(k)\} = (R_{-3}, R_{-2}, R_{-1}, R_0, R_1, R_2, R_3)$, and illustrate the result in figure using Dirac pulse sequence (16 points).

2. Derive the dimension right discrete cross-correlation formula (6 points) and index right discrete cross-correlation formula (4 points) from analytic cross-correlation.

3. Given the following discrete time series: $\Delta t = 2\ sec$,

$$\{x_n\} = (\overset{\downarrow}{2}, 1, -2, 1, 0, 2, -1, 2), \qquad \{w_n\} = \left(1, -1, \overset{\downarrow}{3}, -2\right)$$

Determine the values of discrete convolution $\{x_n\} * \{w_n\}$ and the draw the functions w_n, x_n and y_n in figure using Dirac pulse sequence (30 points).

4. Calculate and give the type of following filter (10 points).

$$\{w_n\} = \left(2, -2, \overset{\downarrow}{4}, -1, 1\right), \qquad \Delta t = 0.5\ sec\ .$$

7. Give and draw up the $A(f)$ spectrum of transmission characteristics ($W(f)$) of an ideal bandpass filter (10 points).

Result:

80.5-100.0 points:	A1 level (5),
70.5-80.0 points:	A2 level (4.5),
60.5-70.0 points:	B level (4),
50.5-60.0 points:	C level (3.5),
40.5-50.0 points:	D level (3),
30.5-40.0 points:	E1 level (2.5),
20.5-30.0 points:	E2 level (2),
0.0-20.0 points:	F level (1).