SEMESTER LEARNING ACTIVITY PLANS (SLAP)
SEMESTER ODD 2022/2023

Geophysics Inversion

MFF5933 / 2 Credits

Lecturer Coordinator:

Dr. Ing. Ari Setiawan, M.Si.

UNIVERSITAS GADJAH MADA
FACULTY OF MATHEMATICS AND NATURAL SCIENCE
2022

<table>
<tr><td></td><td colspan="5">Universitas Gadjah Mada
Faculty of Mathematics and Natural Science
Physics Department / Study Program Master Physics
Semester Odd 2022/2023</td></tr>
<tr><td colspan="6">SEMESTER LEARNING ACTIVITY PLANS (SLAP)</td></tr>
<tr><td>Code</td><td>Course Name</td><td>Credits (credits)</td><td>Semester</td><td>Status</td><td>Prerequisite</td></tr>
<tr><td>MFF5933</td><td>Geophysics Inversion</td><td>2</td><td>Odd</td><td>Elective</td><td>None</td></tr>
<tr><td>Short Description</td><td colspan="5">Geophysics Inversion course is Elective course 2 credits (Theory) in the 2022 Curriculum Master Physics Study Program, Faculty of Mathematics and Natural Science UGM.

The syllabus of this course is as follows:
Introduction to inversion theory, review of linear and statistical algebra, Inverse method based on length, Linearization of nonlinear problems, eigenvalue problems, decomposition of single values (svd), general inverse and quality measures, general inversion variations. Characterization of inversion problems, linear, discrete inversion problems, nonlinear linearization problems, discrete problems of unclear inversion, regularization, inversion and search of nonlinear parameters, probability inference.

The courses are held in class for 14 weeks, each week's session last for 2 x 50 minutes. Four weeks of course period is used for Midterm Exam and Final Exam, each held for two weeks as scheduled.

Student evaluation for course assessments is performed summative and formative. The summative evaluation is implemented as written exams, both Midterm and Final Exam, which take a maximum of 120 minutes. The formative evaluation is implemented as individual assignments for each student in the form of completing an assignment individually. Monitoring is carried out by observing student activities during the course, such as attendance, Q&A and discussion about the material presented, and student performance in completing individual assignments.</td></tr>
<tr><td>Program Learning Outcomes (PLO) Imposed on the Course</td><td colspan="5">
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<tr><td>PLO 3</td><td>Mastering further knowledge of classical and modern physics theory, and its relationship with other disciplines, and has mastered an advanced field of physics specialization that allows him to keep up with the latest international research developments.</td></tr>
<tr><td>PLO 4</td><td>Mastering various mathematical disciplines related to an advanced field of physics, and able to develop physical models using various mathematical and computational tools with an inter or multidisciplinary approach to solving problems related to an advanced field of physics.</td></tr>
<tr><td>PLO 6</td><td>Able to apply knowledge to analyze, synthesize, formulate problems and solve problems comprehensively in one of advanced field of physics, through experimental or theoretical research, then be able to classify and draw conclusions about their findings for the development of science and technology.</td></tr>
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<tr><td></td><td colspan="5">Upon completion of this course, students should be able to:</td></tr>
<tr><td></td><td>CO1</td><td colspan="4">Understand the inverse theory and examples of Forwarding Problems.</td></tr>
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Course Outcomes (CO)	***CO2***	Master the concepts of linear algebra and statistics.
	CO3	Master the Inverse Method based on length.
	CO4	Master the linearization of nonlinear problems.
	CO5	Master the eigenvalue problem and singular-value decomposition (SVD).
	CO6	Generalize the measurement quality inversion.
	CO7	
	CO8	

The Correlation of CO to Learning Materials and Methods, and Time Allocation		**Learning Materials**	**Learning Methods**	**Time Allocation**
	CO1	1. Inverse Theory 2. Useful Definitions 3. Possible Goals of an Inverse Analysis 4. Nomenclature	Lecture, discussion	2 x 50 minutes
	CO1	1. Introduction 2. Probabilistic and Statistics	Lecture, discussion	2 x 50 minutes
	CO1	1. Introduction 2. Data Error and Model Parameter Vectors 3. Measures of Length 4. Minimizing the Misfit: Least Squares	Lecture, discussion	2 x 50 minutes
	CO2	1. Derivation of the General Least Squares Solution 2. Two Examples of Least Squares Problems 3. Four-Parameter Tomography Problem 4. Determinacy of Least Squares Problems	Lecture, discussion	2 x 50 minutes
	CO2	1. Minimum Length Solution 2. Weighted Measures of Length 3. A Priori Information and Constraints 4. Variance of the Model Parameters	Lecture, discussion	2 x 50 minutes
	CO2	1. Introduction 2. Linearization of Nonlinear Problems 3. General Procedure for Nonlinear Problems 4. Three Examples 5. Creeping vs. Jumping (Shaw and Orcutt, 1985)	Lecture, discussion	2 x 50 minutes
	CO2	1. Introduction 2. The Eigenvalue Problem for Square (M × M) Matrix A 3. Geometrical Interpretation of the Eigenvalue Problem for Symmetric A	Lecture, discussion	2 x 50 minutes

		4. Decomposition Theorem for Square A. 5. Eigenvector Structure of mLS		
	CO3	1. Introduction 2. Formation of a New Matrix B 3. The Eigenvalue Problem for B 4. Solving the Shifted Eigenvalue Problem	Lecture, discussion	2 x 50 minutes
	CO3	1. How Many 2. Introducing Singular Values 3. Derivation of the Fundamental Decomposition Theorem for General G	Lecture, discussion	2 x 50 minutes
	CO3	1. Singular-Value Decomposition (SVD). 2. Mechanics of Singular -Value Decomposition 3. Implications of Singular -Value Decomposition	Lecture, discussion	2 x 50 minutes
	CO4	1. Introduction 2. The Generalized Inverse Operator Gg-1 3. Measures of Quality for the Generalized Inverse 4. Quantifying the Quality of R, N, and [covu m] 5. Resolution Versus Stability	Lecture, discussion	2 x 50 minutes
	CO4	1. Linear Transformations 2. Including Prior Information, or the Weighted Generalized Inverse 3. Damped Least Squares and the Stochastic Inverse 4. Ridge Regression 5. Maximum Likelihood	Lecture, discussion	2 x 50 minutes
	CO4	1. Introduction 2. The Backus - Gilbert Approach 3. Neural Networks	Lecture, discussion	2 x 50 minutes
	CO4	1. The Radon Transform and Tomography (Approach 1) 2. A Review of the Radon Transform (Approach 2) 3. Alternative Approaches to Tomography	Lecture, discussion	2 x 50 minutes
	Final Exam/ Project Task Results/ Case Analysis Results			
Learning Methods	Lecture, discussion			
Student Learning Experience	Learn to analyze and review: 1. Inverse Theory 2. Useful Definitions 3. Possible Goals of an Inverse Analysis 4. Nomenclature, 1. Introduction			

	2. Probabilistic and Statistics, 1. Introduction 2. Data Error and Model Parameter Vectors 3. Measures of Length 4. Minimizing the Misfit: Least Squares, 1. Derivation of the General Least Squares Solution 2. Two Examples of Least Squares Problems 3. Four-Parameter Tomography Problem 4. Determinacy of Least Squares Problems, 1. Minimum Length Solution 2. Weighted Measures of Length 3. A Priori Information and Constraints 4. Variance of the Model Parameters, 1. Introduction 2. Linearization of Nonlinear Problems 3. General Procedure for Nonlinear Problems 4. Three Examples 5. Creeping vs. Jumping (Shaw and Orcutt, 1985), 1. Introduction 2. The Eigenvalue Problem for Square (M × M) Matrix A 3. Geometrical Interpretation of the Eigenvalue Problem for Symmetric A 4. Decomposition Theorem for Square A. 5. Eigenvector Structure of mLS, 1. Introduction 2. Formation of a New Matrix B 3. The Eigenvalue Problem for B 4. Solving the Shifted Eigenvalue Problem, 1. How Many 2. Introducing Singular Values 3. Derivation of the Fundamental Decomposition Theorem for General G, 1. Singular-Value Decomposition (SVD). 2. Mechanics of Singular -Value Decomposition 3. Implications of Singular -Value Decomposition, 1. Introduction 2. The Generalized Inverse Operator Gg-1 3. Measures of Quality for the Generalized Inverse 4. Quantifying the Quality of R, N, and [covu m] 5. Resolution Versus Stability, 1. Linear Transformations 2. Including Prior Information, or the Weighted Generalized Inverse 3. Damped Least Squares and the Stochastic Inverse 4. Ridge Regression 5. Maximum Likelihood, 1. Introduction 2. The Backus - Gilbert Approach 3. Neural Networks, 1. The Radon Transform and Tomography (Approach 1) 2. A Review of the Radon Transform (Approach 2) 3. Alternative Approaches to Tomography.
Access to Learning Media/ LMS and Offline and Online Percentage	Texts, presentations, pictures, assignments
Assessment Methods and Synchronization with CO	

Assessment Methods	Assessment Percentage	Criteria/Indicators	CO1	CO2	CO3	CO4
Participatory Activity*						
Project Results/ Case Study Results/ PBL Results*						
Cognitive						

Assignment	30%		7,5%	7,5%	7,5%	7,5%
Quiz						
Midterm Exam	35%		17,5%	17,5%		
Final Exam	35%				17,5%	17,5%

*) can also be obtained from the Midterm or Final Exam as the result of participatory activities or project/ case study results. According to IKU 7, the percentage of project results/ case study/ PBL results is at least 50%.

References	**Main references:** 1. Albert Tarantola, 2005, Inverse Problem Theory and Methods for Model Parameter Estimation, Siam. 2. Robert L. Parker, 1994, Geophysical Inverse Theory, 3. Richard C. Aster, Brian Borchers, 2012, Parameter Estimation and Inverse Problems, Elsevier. 4. Menke, 1989, Geophysical data analysis: discrete inverse theory, Academic Press. 5. Randall M. Richardson and George Zandt, 2007, Inverse Problems in Geophysics, Department of Geosciences, University of Arizona, Tucson, Arizona 85721. 6. Scales, J.A., Smith, L. M., and Treitel, S., 1997, Introductory Geophysical Inverse Theory, Samizdat Press. 7. Snieder R., dan Trampert, T., Inverse Problems in Geophysics, (http://samizdat.mines.edu/snieder tra).
Lecturers (*Team Teaching*)	1. Dr. Ing. Ari Setiawan, M.Si. 2. 3. 4.

Authorization	**Date of Drafting**	**Lecturer Coordinator**	**Head of Curriculum Committee**	**Head of Study Program**
		Dr. Ing. Ari Setiawan, M.Si.	Dr.Ing. Ari Setiawan	Mirza Satriawan, M.Si., Ph.D