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| UNESA | **Universitas Negeri Surabaya**<br>**Faculty of Mathematics and Natural Sciences**<br>**Undergraduate Physics Study Program** | **Document Code** |

# SEMESTER LEARNING PLAN

| Courses | CODE | Course Family | Credit Weight | | | SEMESTER | Compilation Date |
|---|---|---|---|---|---|---|---|
| **PHYSICS DATA INVERSION METHODS** | 4520102135 | | **T=2** | **P=0** | **ECTS=3.18** | 6 | July 17, 2024 |

| AUTHORIZATION | SP Developer | Course Cluster Coordinator | Study Program Coordinator |
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| | Muhammad Nurul Fahmi, M.Si. | Prof. Dr. Madlazim, M.Si. | Prof. Dr. Munasir, S.Si., M.Si. |

**Learning model:** **Project Based Learning**

**Program Learning Outcomes (PLO)**

**PLO study program that is charged to the course**

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| **PLO-15** | Solve problems in physical systems comprehensively using mathematics and computational tools. |

**Program Objectives (PO)**

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| **PO - 1** | Able to explain modeling theories and concepts in geophysics, especially inversion modeling |
| **PO - 2** | Able to convert linear equations into matrix form |
| **PO - 3** | Able to apply linear and non-linear inversion methods as well as geophysical modeling |
| **PO - 4** | Able to analyze non-linear inversion problems with a global approach and its application in the field of geophysics |

**PLO-PO Matrix**

| P.O | PLO-15 |
|---|---|
| PO-1 | |
| PO-2 | |
| PO-3 | |
| PO-4 | |

**PO Matrix at the end of each learning stage (Sub-PO)**

| P.O | Week | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| PO-1 | | | | | | | | | | | | | | | | |
| PO-2 | | | | | | | | | | | | | | | | |
| PO-3 | | | | | | | | | | | | | | | | |
| PO-4 | | | | | | | | | | | | | | | | |

**Short Course Description**

This course provides geophysical modeling theories and concepts including forward modeling and inversion modifiers, as well as their application in geophysical problems. This lecture examines model parameter estimation, linear and non-linear inversion methods and their solutions, the use of a priori information, and the use of damping parameters.

**References**

**Main :**


1. Menke, W., Geophysical Data Analysis: Discrete Inverse Theory, Academic Press, 1989.
2. Tarantola, A., Inverse Problem Theory: Methods for Data Fitting and Model Parameter Estimation, Elsevier, 1987.
3. Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.


**Supporters:**

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| | 1. Sen, MK, Stoffa, PL, Global Optimization Methods in Geophysical Inversion, Elsevier, 1995 |
| **Supporting lecturer** | Arie Realita, M.Si.<br>Muhammad Nurul Fahmi, S.Si., M.Si. |

| Week- | Final abilities of each learning stage (Sub-PO) | Evaluation | | Help Learning, Learning methods, Student Assignments, [ Estimated time] | | Learning materials [ References ] | Assessment Weight (%) |
|---|---|---|---|---|---|---|---|
| | | Indicator | Criteria & Form | Offline ( *offline* ) | Online ( *online* ) | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1 | Students are able to explain the concepts of geophysical modeling, forward modeling and inversion modeling | Perceptual Similarity | **Criteria:** Test and non-test<br><br>**Form of Assessment** : Participatory Activities | Blended learning method (combination of face to face and e-learning 2 x 50 minutes | | **Material:** Concepts of geophysical modeling, forward modeling and inversion modeling<br>**References:** *Menke, W., Geophysical Data Analysis: Discrete Inverse Theory, Academic Press, 1989.* | 3% |
| 2 | Students are able to formulate linear inversion problems and solve them in general using matrix equations | Accuracy of analysis and reasoning | **Criteria:** Test and non-test<br><br>**Form of Assessment** : Project Results Assessment / Product Assessment | Blended learning method (combination of face to face and e-learning 2 x 50 minutes | | **Material:** Least square method (LS): a. Straight line regression linear inversion problem formulation<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 3% |
| 3 | Students are able to formulate linear inversion problems and solve them in general using matrix equations | Accuracy of analysis and reasoning | **Criteria:**<br>1. Test and non-test<br>2. Task<br><br>**Form of Assessment** : Project Results Assessment / Product Assessment | Blended learning method (combination of face to face and e-learning 2 x 50 minutes | | **Material:** Examples of linear inversion problems in geophysics and linear inversion in simple geophysical data problems/modeling<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 3% |
| 4 | Students are able to demonstrate the effect of data uncertainty on linear inversion solutions and solution uncertainty in the form of a model co-variance matrix | Accuracy of analysis and reasoning | **Criteria:**<br>1. Test and non-test<br>2. Task<br><br>**Form of Assessment** : Project Results Assessment / Product Assessment | Blended learning method (combination of face to face and e-learning 2 x 50 minutes | | **Material:** Data uncertainty, standard deviation, data co-variance matrix, model co-variance matrix, Weighted linear inversion problem formulation and solution<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 3% |
| 5 | Students are able to demonstrate the effect of data uncertainty on linear inversion solutions and solution uncertainty in the form of a model co-variance matrix | Accuracy of analysis and reasoning | **Criteria:**<br>1. Test and non-test<br>2. Task<br><br>**Form of Assessment** : Project Results Assessment / Product Assessment | Blended learning method (combination of face to face and e-learning 2 x 50 minutes | | **Material:** The concept of "a priori" information and model complexity (norm model, reference model, variation of model parameters) and damped linear inversion problem formulation and solution.<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 3% |

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| **6** | Students are able to demonstrate the effect of data uncertainty on linear inversion solutions and solution uncertainty in the form of a model co-variance matrix | Accuracy of analysis and reasoning | **Criteria:**<br>1. Test and non-test<br>2. Task<br><br>**Form of Assessment** :<br>Project Results Assessment / Product Assessment | Blended learning method (combination of face to face and e-learning<br>2 x 50 minutes | | **Material:** Damped least squares method (damped LS) (2): a. Application of damped linear inversion in modeling geophysical data (norm model, reference model)<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 3% |
| **7** | Students are able to demonstrate the effect of data uncertainty on linear inversion solutions and solution uncertainty in the form of a model co-variance matrix | Accuracy of analysis and reasoning | **Criteria:**<br>1. Test and non-test<br>2. Task<br><br>**Form of Assessment** :<br>Project Results Assessment / Product Assessment | Blended learning method (combination of face to face and e-learning<br>2 x 50 minutes | | **Material:** Damped least squares method (damped LS) (2): a. Application of damped linear inversion in modeling geophysical data (norm model, reference model)<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 4% |
| **8** | Students are able to solve UTS questions well | Students are able to solve UTS questions well | **Criteria:**<br>Full marks if the project meets the assessment rubric<br><br>**Form of Assessment** :<br>Project Results Assessment / Product Assessment | Midterm<br>100 minutes | | **Material:** Midterm Exam<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 20% |
| **9** | Students are able to formulate non-linear inversion problems using a linear approach | Accuracy of analysis and reasoning | **Criteria:**<br>Task | Blended learning method (combination of face to face and e-learning)<br>2 x 50 minutes | | **Material:** Linearization of non-linear functions and iterative formulation of non-linear inversion solutions (Gauss Newton, gradient)<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 4% |
| **10** | Students are able to apply non-linear inversion with a linear approach to geophysical data | Accuracy of analysis and reasoning | **Criteria:**<br>Task | Blended learning method (combination of face to face and e-learning)<br>2 x 50 minutes | | **Material:** Non-linear inversion with linear / local approximation (2): a. Application of non-linear inversion in geophysical data modeling<br>**References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 4% |

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| **11** | Students are able to explain the characteristics of linear approaches to non-linear problems and formulate grid search and random search techniques | Accuracy of analysis and reasoning | **Criteria:** Task | Blended learning method (combination of face to face and e-learning) 2 x 50 minutes | | **Material:** Concept of local minimum and global minimum and grid search and random search techniques. **Reference:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 4% |
| **12** | Students are able to explain the concept of guided random search and the simulated annealing method | Accuracy of analysis and reasoning | **Criteria:** Task | Blended learning method (combination of face to face and e-learning) 2 x 50 minutes | | **Material:** Guided random concept and Simmullated Annealing Method **References:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 4% |
| **13** | Students are able to explain the concept of genetic algorithms | Accuracy of analysis and reasoning | **Criteria:** Task | Blended learning method (combination of face to face and e-learning) 2 x 50 minutes | | **Material:** Genetic Algorithms **Literature:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 4% |
| **14** | Students are able to explain the concept of genetic algorithms | Accuracy of analysis and reasoning | **Criteria:** Task | Blended learning method (combination of face to face and e-learning) 2 x 50 minutes | | **Material:** Discussion of examples of non-linear inversion applications on geophysical data. **Reference:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 4% |
| **15** | Students are able to explain the concept of genetic algorithms | Accuracy of analysis and reasoning | **Criteria:** Task | Blended learning method (combination of face to face and e-learning) 2 x 50 minutes | | **Material:** Discussion of examples of non-linear inversion applications on geophysical data. **Reference:** *Grandis, H., Introduction to Geophysical Inversion, HAGI, 2009.* | 4% |
| **16** | Able to understand UAS projects well | Understand UAS projects well | **Criteria:** Full marks if the project meets the assessment rubric<br><br>**Form of Assessment** : Project Results Assessment / Product Assessment | UAS 100 minutes | | **Material:** Final Semester Exam **References:** *Menke, W., Geophysical Data Analysis: Discrete Inverse Theory, Academic Press, 1989.* | 30% |

**Evaluation Percentage Recap: Project Based Learning**

| No | Evaluation | Percentage |
|---|---|---|
| 1. | Participatory Activities | 3% |
| 2. | Project Results Assessment / Product Assessment | 69% |
| | | 72% |

**Notes**

1. **Learning Outcomes of Study Program Graduates (PLO - Study Program)** are the abilities possessed by each Study Program graduate which are the internalization of attitudes, mastery of knowledge and skills according to the level of their study program obtained through the learning process.

2. **The PLO imposed on courses** are several learning outcomes of study program graduates (CPL-Study Program) which are used for the formation/development of a course consisting of aspects of attitude, general skills, special skills and knowledge.
3. **Program Objectives (PO)** are abilities that are specifically described from the PLO assigned to a course, and are specific to the study material or learning materials for that course.
4. **Subject Sub-PO (Sub-PO)** is a capability that is specifically described from the PO that can be measured or observed and is the final ability that is planned at each learning stage, and is specific to the learning material of the course.
5. **Indicators for assessing** ability in the process and student learning outcomes are specific and measurable statements that identify the ability or performance of student learning outcomes accompanied by evidence.
6. **Assessment Criteria** are benchmarks used as a measure or measure of learning achievement in assessments based on predetermined indicators. Assessment criteria are guidelines for assessors so that assessments are consistent and unbiased. Criteria can be quantitative or qualitative.
7. **Forms of assessment:** test and non-test.
8. **Forms of learning:** Lecture, Response, Tutorial, Seminar or equivalent, Practicum, Studio Practice, Workshop Practice, Field Practice, Research, Community Service and/or other equivalent forms of learning.
9. **Learning Methods:** Small Group Discussion, Role-Play & Simulation, Discovery Learning, Self-Directed Learning, Cooperative Learning, Collaborative Learning, Contextual Learning, Project Based Learning, and other equivalent methods.
10. **Learning materials** are details or descriptions of study materials which can be presented in the form of several main points and sub-topics.
11. **The assessment weight** is the percentage of assessment of each sub-PO achievement whose size is proportional to the level of difficulty of achieving that sub-PO, and the total is 100%.
12. TM=Face to face, PT=Structured assignments, BM=Independent study.