	Universitas Negeri Surabaya Faculty of Mathematics and Natural Sciences Undergraduate Physics Study Program	Document Code

SEMESTER LEARNING PLAN

Courses	CODE	Course Family	Credit Weight			SEMESTER	Compilation Date
Computational Physics	4520103061	Compulsory Study Program Subjects	T=3	P=0	ECTS=4.77	2	August 15, 2023

AUTHORIZATION	SP Developer	Course Cluster Coordinator	Study Program Coordinator
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Learning model: Project Based Learning

Program Learning Outcomes (PLO)

PLO study program which is charged to the course

PLO-9	Able to work as an individual or team effectively, have entrepreneurial skills, and care about environmental issues.

Program Objectives (PO)

PO - 1	Students are able to understand the relationship between theoretical physics, computational physics and experimental physics
PO - 2	Students are able to model physical phenomena based on computational and mathematical methods
PO - 3	Students are able to understand computational-based numerical approach methods and solutions
PO - 4	Students are able to simulate, model and visualize computationally based physics data
PO - 5	Able to work effectively independently or in groups to solve physical phenomena problems using computational and mathematical approaches

PLO-PO Matrix

P.O	PLO-9
PO-1	
PO-2	
PO-3	
PO-4	
PO-5	

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																
PO-5																

Short Course Description

This course examines techniques for solving problems numerically, error analysis, simple data analysis numerically, evaluating series, finding the roots of non-linear and polynomial equations, solving matrices, solving systems of linear equations, interpolation and extrapolation, forming equations from the resulting data measurement, inversion method, least-squares method, numerical differentiation, numerical integration, and solving ordinary differential equations numerically and solving partial differential equations numerically.

References

Main :

	1. Ayars, E. 2013. Computational Physics With Python. California State University. 2. Landau, R. H., Páez, M. J., and Bordeianu, C. C. 2015. Computational Physics 3rd ed. Wiley-VCH. 3. Chapra, S. and Clough, D. 2021. Applied Numerical Methods with Python for Engineers and Scientists. London: McGraw Hill. 4. Sholihun, Fatomi, Z. Y. 2021. Pemrograman dan Komputasi Numerik Menggunakan Python. Yogyakarta: UGM Press.
	Supporters:
	1. Conte, S. D. and Boor, C. D. 1982, Elementary Numerical Analysis an Algorithmic Approach, London: McGraw-Hill 2. Gerald, C. F. and Wheatley, P. O. 2004, Applied Numerical Analysis. 7th ed., International ed. Boston, Mass.;: Pearson, 2004. Print.
Supporting lecturer	Prof. Dr. Madlazim, M.Si. Dzulkiflih, S.Si., M.T. Dr. Eng. Evi Suaebah, M.Si., M.Sc. Arie Realita, M.Si. Dr. Muhimmatul Khoiro, S. Si. 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	Able to understand the concepts of variables, repetition, and branching in computational programming	Students understand the concepts of variables, repetition, and branching in computational programming	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	Model: PjBL Method: Discussion, question and answer, virtual simulation 3 x 50 minutes		**Material:** Basics of Python programming **Reference:** *Ayars, E. 2013. Computational Physics With Python. California State University.*	3%
2	Able to understand the concept of relative error from measuring quantities and calculating physical functions	Students are able to explain the concept of relative error from measuring quantities and calculating physical functions	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Tests	Model: PjBL Method: Discussion, question and answer, virtual simulation 3 x 50 minutes		**Material:** The concept of error in computing **References:** *Chapra, S. and Clough, D. 2021. Applied Numerical Methods with Python for Engineers and Scientists. London: McGraw Hill.* **Material:** Relative accuracy of measuring quantities and calculating physical functions **References:** *Chapra, S. and Clough, D. 2021. Applied Numerical Methods with Python for Engineers and Scientists. London: McGraw Hill.*	3%
3	1. Able to understand variations in root search methods using a numerical approach, and able to analyze to determine the most optimal method 2. Able to determine the most optimal root search method	1. Students are able to explain various root search methods using a numerical approach, and are able to analyze to determine the most optimal method 2. Students are able to determine the most optimal root search method	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment	Model: PjBL Method: Discussion, question and answer, virtual simulation 3 x 50 minutes		**Material:** Bisection Method, Newton-Raphson, Secant **References:** *Chapra, S. and Clough, D. 2021. Applied Numerical Methods with Python for Engineers and Scientists. London: McGraw Hill.*	3%

4	1. Able to understand the concept of interpolation 2. Able to understand the types of interpolation and their implementation on physics data	1. Students are able to describe the concept of interpolation 2. Students are able to use types of interpolation and their implementation on physics data	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Portfolio Assessment	Model: PjBL Method: Discussion, question and answer, virtual simulation Assignments 3 x 50 minutes		**Material:** linear interpolation, Lagrange interpolation, Newton interpolation, Splines interpolation **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	3%
5	1. Able to understand the concept of interpolation 2. Able to understand the types of interpolation and their implementation on physics data	1. Students are able to describe the concept of interpolation 2. Students are able to use types of interpolation and their implementation on physics data	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment	Model: PjBL Method: Discussion, question and answer, virtual simulation Assignments 3 x 50 minutes		**Material:** linear interpolation, Lagrange interpolation, Newton interpolation, Splines interpolation **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	3%
6	Able to understand the concept of solving linear equations in computing	Students are able to explain the concept of solutions to linear equations in computing	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	Model: PjBL Method: Discussion, question and answer, virtual simulation 3 x 50 minutes		**Material:** Gauss Elimination method, Gauss-Jordan, Cholesky, LU Factorization, Gauss Seidel method **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	3%
7	Able to understand the method and operating system of matrix eigenvalues	Students understand the method and operating system for matrix eigenvalues	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	Model: PjBL Method: Discussion, question and answer, virtual simulation 3 x 50 minutes		**Material:** Householder tridiagonalization method, QR factorization method **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	4%
8	1. Able to complete UTS properly and correctly 2. Able to solve physics problems using computational and mathematical approaches	1. Students complete UTS well and correctly 2. Students solve physics problems using computational and mathematical approaches	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment, Portfolio Assessment	Instructions for completing the 100 minute UTS		**Material:** Midterm Exam **Literature:**	20%

9	1. Able to master the curve optimization method through the application of the Curve Fitting method with the least squares approach 2. Able to apply the least squares approach method to physics data	1. Students master curve optimization techniques through the application of the Curve Fitting method with a least squares approach 2. Students apply the least squares approach method to physics data	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	Model: PjBL Method: Discussion, question and answer, 100 minute virtual simulation		**Material:** straight line models, nonlinear curve models (power functions, exponential functions, high degree polynomial functions) **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	4%
10	1. Able to master the curve optimization method through the application of the Curve Fitting method with the least squares approach 2. Able to apply the least squares approach method to physics data	1. Students master curve optimization techniques through the application of the Curve Fitting method with a least squares approach 2. Students apply the least squares approach method to physics data	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment	Model: PjBL Method: Discussion, question and answer, virtual simulation Assignment 100 minutes		**Material:** straight line models, nonlinear curve models (power functions, exponential functions, high degree polynomial functions) **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	4%
11	1. Able to understand numerical differentiation methods in computing 2. Able to apply numerical differentiation methods to simulate physical phenomena	1. Students understand numerical differentiation methods in computing 2. Students apply numerical differentiation methods to simulate physical phenomena	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	Model: PjBL Method: Discussion, question and answer, virtual simulation 3 x 50 minutes		**Material:** Numerical Differentiation, Differential schemes with a combination of Taylor series, development of Lagrange interpolation **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	4%
12	1. Able to understand and master numerical differentiation methods in computing 2. Able to apply numerical differentiation methods to simulate physical phenomena	1. Students understand and master numerical differentiation methods in computing 2. Students apply numerical differentiation methods to simulate physical phenomena	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment	Model: PjBL Method: Discussion, question and answer, virtual simulation Assignments 3 x 50 minutes		**Material:** Numerical Differentiation, Differential schemes with a combination of Taylor series, development of Lagrange interpolation **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	4%

13	1. Able to understand and master numerical integration methods in computing 2. Able to apply numerical integration methods to simulate physical phenomena	1. Students understand and master numerical integration methods in computing 2. Students apply numerical integration methods to simulate physical phenomena	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	Model: PjBL Method: Discussion, question and answer, virtual simulation 3 x 50 minutes		**Material:** Trapezoid rule, Simpson's rule, Newton-Cotes formula, Gauss-Legendre formula, Gauss-Hermite formula, Gauss-Laguerre formula References **:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	4%
14	1. Able to understand and master numerical integration methods in computing 2. Able to apply numerical integration methods to simulate physical phenomena	1. Students understand and master numerical integration methods in computing 2. Students apply numerical integration methods to simulate physical phenomena	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment	Model: PjBL Method: Discussion, question and answer, virtual simulation Assignments 3 x 50 minutes		**Material:** Trapezoid rule, Simpson's rule, Newton-Cotes formula, Gauss-Legendre formula, Gauss-Hermite formula, Gauss-Laguerre formula References **:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	4%
15	Able to understand types of Ordinary Differential Equations (PDB) with initial values determined on a computational basis	Students understand the types of Ordinary Differential Equations (PDB) with initial values determined on a computational basis	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment	Model: PjBL Method: Discussion, question and answer, virtual simulation 3 x 50 minutes		**Material:** Trapezoid rule, Simpson's rule, Newton-Cotes formula, Gauss-Legendre formula, Gauss-Hermite formula, Gauss-Laguerre formula References **:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.* **Material:** Euler's method, Heun's method, Runge-Kutta method, higher order PDB and GDP systems **References:** *Landau, RH, Páez, MJ, and Bordeianu, CC 2015. Computational Physics 3rd ed. Wiley-VCH.*	4%
16	1. Able to complete UAS projects well 2. Able to solve physics problems using computational and mathematical approaches	1. Students are able to complete the UAS project well 2. Students are able to solve physics problems using computational and mathematical approaches	**Criteria:** Quantitative **Forms of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment, Portfolio Assessment	Group Presentation 100 minutes		**Material:** Final Semester Exam **Literature:**	30%

Evaluation Percentage Recap: Project Based Learning

No	Evaluation	Percentage
1.	Participatory Activities	35%

2.	Project Results Assessment / Product Assessment	42%
3.	Portfolio Assessment	21.5%
4.	Test	1.5%
		100%

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.