	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
Mathematical Physics III	4520103233	Compulsory Study Program Subjects	**T=3**	**P=0**	**ECTS=4.77**	4	January 1, 2021

AUTHORIZATION	SP Developer	Course Cluster Coordinator	Study Program Coordinator
	Nugrahaning Primary Putri, M.Si.	Dr. Muhimmatul Khoiro, S.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

PLO-9	Able to work as an individual or team effectively, have entrepreneurial skills, and care about environmental issues.
PLO-10	Analyze physical systems by applying mathematics and computing/ICT tools.
PLO-15	Solve problems in physical systems comprehensively using mathematics and computational tools.

Program Objectives (PO)

PO - 1	Students master classical and modern physics knowledge to identify the properties of a simple physical system using a mathematical physics approach
PO - 2	Students are able to formulate the problems of a simple physical system into a mathematical model using relevant symbolic/numerical language
PO - 3	Students are able to use high-level thinking processes to form solutions from simple physical models
PO - 4	Students are able to use a scientific attitude, critical thinking and innovation skills to examine physics learning problems assisted by mathematics

PLO-PO Matrix

P.O	PLO-9	PLO-10	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 examines: matrices and vector spaces, 3-dimensional vector analysis, tensor analysis, and complex variable functions through active learning with a combination of discussion methods, question and answer and IT-assisted assignments.

References

Main :

1. Boas, M.L. 2006. Mathematical Methods in the Physical Science , edisi 3, John Wiley & Sons, New York.
2. Anton, H. and Kaul, A., 2019. Elementary linear algebra 12th Edition. John Wiley & Sons. New York

Supporters:

	1. Arfken, G. 1995. Mathematical Methods for Physicists , Academic Press. 2. Riley, K.F., Hobson, M.P., Bence, S.J. 2006. Mathematical Methods for Physics and Engineering, edisi 3, Cambridge Univ. Press. 3. Hassani, Sadri. 2009. Mathematical methods for students of physics and related fields , 2nd ed. Springer, Illinois.
Supporting lecturer	Dr. Zainul Arifin Imam Supardi, M.Si. Nugrahani Primary Putri, S.Si., M.Si. Dr. Muhimmatul Khoiro, S. 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	1.Students master wave knowledge and modern physics to identify the relevant properties of a simple physical system 2.Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 3.Students are able to use a scientific attitude, critical thinking and innovation skills to examine the problems of studying waves and modern physics in secondary schools with the help of mathematics	1.Students are able to perform row reduction in a matrix 2.Students are able to determine the determinant of a matrix using Cramer's rule	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Linear Algebra: Introduction, Matrices Row Reduction, Determinants, Cramer's Rule **Bibliography:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	3%
2	1.Students master wave knowledge and modern physics to identify the relevant properties of a simple physical system 2.Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 3.Students are able to use a scientific attitude, critical thinking and innovation skills to examine the problems of studying waves and modern physics in secondary schools with the help of mathematics	1.Students are able to perform row reduction in a matrix 2.Students are able to determine the determinant of a matrix using Cramer's rule	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Linear Algebra: Vectors, Lines and Planes, Matrix Operations, Linear Combination, Linear Function, Linear Operation **References:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	4%

3	1. Students master wave knowledge and modern physics to identify the properties of a relevant physical system 2. Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 3. Students are able to use a scientific attitude, critical thinking and innovation skills to examine the problems of studying waves and modern physics in secondary schools with the help of mathematics	1. Students understand the concept of linear vector spaces 2. Students can determine eigenvalues and eigenfunctions	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Linear Algebra: Linear Vector Spaces Eigenvalues and Eigenvectors, Diagonalizing Matrices **References:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	3%
4	1. Students master wave knowledge and modern physics to identify the relevant properties of a simple physical system 2. Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 3. Students are able to use a scientific attitude, critical thinking and innovation skills to examine the problems of studying waves and modern physics in secondary schools with the help of mathematics	Students are able to solve wave and modern physics problems using matrix and vector space concepts	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Linear Algebra: Application of Diagonalization **Bibliography:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	3%

5	1. Students master wave knowledge and modern physics to identify the properties of a physical system 2. Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 3. Students are able to use a scientific attitude, critical thinking and innovation skills to examine the problems of studying waves and modern physics in secondary schools with the help of mathematics	1. Students are able to use the vector operator del in cylindrical and spherical 3D coordinates 2. Students are able to perform gradient, divergence and curl operations on cylindrical and spherical 3D coordinates	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Vector Analysis: Introduction, Application of Vector Multiplication, Triple Product, Differentiation Vectors, Field, Directional Derivative Gradient **Bibliography:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	4%
6	1. Students master wave knowledge and modern physics to identify the properties of a relevant simple physical system 2. Students are able to formulate problems of simple physical systems related to waves and modern physics into mathematical models using relevant symbolic and numerical language 3. Students are able to use a scientific attitude, critical thinking and innovation skills to examine the problems of studying waves and modern physics in secondary schools with the help of mathematics	Students are able to use line integrals to solve physics problems	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Vector Analysis: Line Integrals, Green Theorem in the Plane **References:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	4%

7	1. Students master wave knowledge and modern physics to identify the relevant properties of a simple physical system 2. Students are able to formulate problems of simple physical systems related to waves and modern physics into mathematical models using relevant symbolic and numerical language 3. Students are able to use a scientific attitude, critical thinking and innovation skills to examine the problems of studying waves and modern physics in secondary schools with the help of mathematics	1. Students understand the Divergence theorem and its application in physics 2. Students are able to solve problems related to waves and modern physics with vector concepts	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Vector Analysis: The Divergence and the Divergence Theorem, The Curls and Stokes Theorem **Reference:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	4%
8	1. Students master wave knowledge and modern physics to identify the relevant properties of a simple physical system 2. Students are able to formulate problems of simple physical systems related to waves and modern physics into mathematical models using relevant symbolic and numerical language 3. Students are able to use a scientific attitude, critical thinking and innovation skills to examine the problems of studying waves and modern physics in secondary schools with the help of mathematics	Students are able to understand and solve USS questions that are relevant to the teaching material of linear algebra and vector analysis	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment	100 Minute written test	100 minute written test	**Material:** UTS Material **Reference:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	20%
9	1. Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 2. Students are able to use high-level thinking processes to form solutions from simple physical models related to waves and modern physics	1. Students understand tensor notation in Cartesian coordinates 2. Students are able to perform tensor operations	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Tensor Analysis: Introduction, Cartesian Tensors, Tensor Notation and Operations **References:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	3%

10	1. Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 2. Students are able to use high-level thinking processes to form solutions from simple physical models related to waves and modern physics	Students understand the concepts of inertia tensor and Kronecker delta	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Tensor Analysis: Inertia Tensor, Kronecker Delta and Levi-Civita Symbol, Pseudovectors and Pseudotensors **References:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	4%
11	1. Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 2. Students are able to use high-level thinking processes to form solutions from simple physical models related to waves and modern physics	1. Students understand curvilinear coordinates 2. Students can perform vector operations on curvilinear coordinates	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions	**Material:** Tensor Analysis: More about Applications, Curvilinear Coordinates, Vector Operators in Orthogonal Curvilinear Coordinates **Bibliography:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	4%
12	1. Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 2. Students are able to use high-level thinking processes to form solutions from simple physical models related to waves and modern physics	1. Students understand the form of analytical functions 2. Students can do integral contours	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Functions of A Complex Variable: Analytic Function, Contour Integral **Bibliography:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	3%
13	1. Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 2. Students are able to use high-level thinking processes to form solutions from simple physical models related to waves and modern physics	1. Students understand the Laurent series 2. Students understand the residue theorem	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Functions of A Complex Variable: Laurent Series, The Residue Theorem **Bibliography:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	3%

14	1.Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 2.Students are able to use high-level thinking processes to form solutions from simple physical models related to waves and modern physics	1.Students can determine residues using several methods 2.Students understand the mapping process	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Functions of A Complex Variable: Methods of Finding Residues, The Point at Infinity; Residues at Infinity, Mapping **Bibliography:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	4%
15	1.Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 2.Students are able to use high-level thinking processes to form solutions from simple physical models related to waves and modern physics	Students are able to apply the concept of complex variable functions to solve problems in the field of physics	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Project Results Assessment / Product Assessment	Lectures, Discussions, Questions and Answers and Practice Questions 150 minutes	Lectures, Discussions, Questions and Answers, Watching Learning Videos and Practice Questions 150 minutes	**Material:** Functions of A Complex Variable: Some Applications of Conformal Mapping **References:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	4%
16	1.Students are able to formulate simple physical system problems related to waves and modern physics into mathematical models using relevant symbolic/numerical language 2.Students are able to use high-level thinking processes to form solutions from simple physical models related to waves and modern physics	Students are able to understand and apply teaching material about linear algebra, vector analysis, tensor analysis and complex variable functions to solve physics problems	**Criteria:** Quantitative **Form of Assessment** : Project Results Assessment / Product Assessment	Presentation of Project Results 25 minutes	Presentation of Project Results 25 minutes	**Material:** UTS Material **Reference:** *Boas, ML 2006. Mathematical Methods in the Physical Science, 3rd edition, John Wiley & Sons, New York.*	30%

Evaluation Percentage Recap: Project Based Learning

No	Evaluation	Percentage
1.	Participatory Activities	26.5%
2.	Project Results Assessment / Product Assessment	73.5%
		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.