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

SEMESTER LEARNING PLAN

Courses	CODE	Course Family	Credit Weight			SEMESTER	Compilation Date
Modern Physics	8420303076		T=3	P=0	ECTS=4.77	4	July 17, 2024

AUTHORIZATION	SP Developer	Course Cluster Coordinator	Study Program Coordinator
	Dra. Suliyanah, M. Si.	Dra. Suliyanah, M. Si.	Mita Anggaryani, M.Pd., Ph.D.

Learning model	**Project Based Learning**	
Program Learning Outcomes (PLO)	**PLO study program that is charged to the course**	
	Program Objectives (PO)	
	PO - 1	Students can master and demonstrate knowledge of relativity and are able to communicate scientifically and work effectively both individually and in groups.
	PO - 2	Students can master and demonstrate knowledge of relativity and are able to communicate scientifically and work effectively both individually and in groups.
	PO - 3	Students can master and demonstrate knowledge of relativity and are able to communicate scientifically and work effectively both individually and in groups.
	PO - 4	Students can master and demonstrate knowledge of atomic structure, as well as be able to communicate scientifically and work effectively both individually and in groups.
	PO - 5	Students can master and demonstrate knowledge of quantum mechanics, as well as be able to communicate scientifically and work effectively both individually and in groups.
	PO - 6	Students can master and demonstrate knowledge about atoms with many electrons, as well as being able to communicate scientifically and work effectively both individually and in groups.
	PO - 7	Students can master and demonstrate knowledge of core structures, as well as being able to communicate scientifically and work effectively both individually and in groups.
	PO - 8	Students can master and demonstrate knowledge of core transformations, as well as being able to communicate scientifically and work effectively both individually and in groups.
	PO - 9	Students can master and demonstrate knowledge of elementary particles, as well as be able to communicate scientifically and work effectively both individually and in groups.
	PLO-PO Matrix	

P.O
PO-1
PO-2
PO-3
PO-4
PO-5
PO-6
PO-7
PO-8
PO-9

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																
PO-6																
PO-7																
PO-8																
PO-9																

Short Course Description	The Modern Physics course discusses the concepts/principles/theories/basic laws of Modern Physics (physics content knowledge) which underlie the study material in the SMA/SMK Physics curriculum in depth which includes Relativity, Particle Properties of Waves, Wave Properties of Particles, Structure Atoms, Quantum Mechanics, Atoms with Many Electrons, Nuclear Structure, Nuclear Transformation, Elementary Particles, as well as being able to communicate scientifically and work effectively both individually and in groups.
References	**Main :**
	1. Beiser A, 2006, “Consepts of Modern Physics”, Sixth Edition. McGraw Hill Inter. BookCompany 2. Prastowo, T. 2014. Lecture Notes on Modern Physics Unpublished work. 3. Serway, R. A. et al. 2005. Modern Physics. California, US: Thomson Learning Inc. 4. Harris, R. 2007. Modern Physics. California, US: Pearson, Addison-Wesley.
	Supporters:
	1. Zettili, N. 2009. Quantum Mechanics. West Sussex, UK: John Wiley and Sons. 2. Patil, S.H. 2021, “Element of Modern Physics”, First Edition. Springer Nature. Springer. 3. Supangkat, Haryadi, 1990. “Fisika Modern”, Jurusan Fisika ITB.
Supporting lecturer	Dra. Suliyanah, M.Si. Dr. Dwikoranto, M.Pd. Prof. Dr. Wasis, M.Si. Abu Zainuddin, S.Pd., M.Pd. Lydia Rohmawati, S.Si., M.Si. Utama Alan Deta, S.Pd., M.Pd., M.Si. Dr. Fitriana, 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	Students are able to understand the theory of relativity, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explaining Special Relativity, Time Dilation, Doppler Effect, Length Contraction, Twin Paradox 2. Explain Electricity and Magnetism 3. Explaining the Relativity of Momentum, Mass and Energy, Energy and Momentum 4. Explaining General Relativity	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	• Learning Form: Lecture • Learning Method: Question and answer, discussion, presentation, and case method • Student Assignment: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Relativity **Bibliography:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Relativity **References:** *Prastowo, T. 2014. Lecture Notes on Modern Physics Unpublished work.*	2%

2	Students are able to understand the nature of particles from waves, and are able to communicate scientifically and work effectively both individually and in groups	1. Explaining Electromagnetic Waves 2. Explaining Black Body Radiation 3. Explain the Photoelectric Effect 4. Explaining Light 5. Explaining X-Rays 6. Explaining X-Ray Diffraction 7. Explaining the Compton Effect 8. Explaining Pair Production 9. Explaining Photons and Gravity	**Criteria:** Quantitative **Forms of Assessment** : Participatory Activities, Portfolio Assessment, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Matter:** Particle Properties of Waves **Bibliography:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Particle Properties of Waves **Reference:** *Prastowo, T. 2014. Lecture Notes on Modern Physics Unpublished work.*	5%
3	Students are able to understand the wave nature of particles, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explaining de Broglie Waves 2. Explaining Waves 3. Explain Phase and Group Speed 4. Explaining Particle Diffraction 5. Explaining Particles in a Box 6. Explain the Uncertainty Principle and its application	**Criteria:** Quantitative **Forms of Assessment** : Participatory Activities, Portfolio Assessment, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Matter:** Wave properties of particles **Reference:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Wave properties of particles **Reference:** *Prastowo, T. 2014. Lecture Notes on Modern Physics Unpublished work.*	5%
4	Students can understand atomic structure, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explaining the Atomic Nucleus 2. Explaining Electron Orbits 3. Explaining the Atomic Spectrum 4. Explaining the Bohr Atom 5. Explaining Energy Levels and Spectrum	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Atomic Structure **References:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Atomic Structure **Reference:** *Prastowo, T. 2014. Lecture Notes on Modern Physics Unpublished work.*	2%

5	Students can understand atomic structure, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explaining the Atomic Nucleus 2. Explain the Correspondence Principle 3. Explaining Core Movements 4. Explaining Atomic Excitation 5. Explaining Lasers	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Portfolio Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Atomic Structure **References:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Atomic Structure **Reference:** *Prastowo, T. 2014. Lecture Notes on Modern Physics Unpublished work.*	3%
6	Students are able to understand Quantum Mechanics and are able to communicate scientifically and work effectively both individually and in groups.	1. Explaining Quantum Mechanics 2. Explaining the Wave Equation 3. Explaining Schrodinger's Equation: Time Dependent 4. Explaining Linearity and Superposition 5. Explain the expected price 6. Explaining Operators	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Portfolio Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Quantum Mechanics **Bibliography:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Quantum Mechanics **Reference:** *Zettili, N. 2009. Quantum Mechanics. West Sussex, UK: John Wiley and Sons.*	2%
7	Students are able to understand Quantum Mechanics and are able to communicate scientifically and work effectively both individually and in groups.	1. Explaining Schrodinger's Equation: Steady state 2. Explaining Particles in a Box 3. Explaining Specific Potential Walls 4. Explaining the Tunnel Effect 5. Explain Harmonic Oscillator	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Portfolio Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Quantum Mechanics **Bibliography:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Quantum Mechanics **Reference:** *Zettili, N. 2009. Quantum Mechanics. West Sussex, UK: John Wiley and Sons.*	3%
8	Sub CPMK 1; Sub CPMK 2; Sub CPMK 3; Sub CPMK 4; Sub CPMK 6	1. Students can analyze and calculate De-Broglie wavelength values 2. Students can analyze and calculate phase velocity and group velocity values 3. Students can analyze and calculate the value of A when the Schrodinger wave equation is normalized and calculate the	**Criteria:** Quantitative **Form of Assessment** : Test	Midterm 2 x 50 minutes		**Matter:** Relativity, wave-particle dualism, atomic structure, quantum mechanics **Bibliography:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Relativity, particle-wave dualism, atomic structure,	20%

		expectation value				quantum mechanics **References:** *Prastowo, T. 2014. Lecture Notes on Modern Physics Unpublished work.* **Material:** Relativity, particle-wave dualism, atomic structure, quantum mechanics **References:** *Serway, RA et al. 2005. Modern Physics. California, US: Thomson Learning Inc.* **Matter:** Relativity, wave-particle dualism, atomic structure, quantum mechanics **References:** *Harris, R. 2007. Modern Physics. California, US: Pearson, Addison-Wesley.* **Material:** Quantum Mechanics **Reference:** *Zettili, N. 2009. Quantum Mechanics. West Sussex, UK: John Wiley and Sons.* **Material:** Relativity, wave-particle dualism, atomic structure, quantum mechanics **Reference:** *Patil, SH 2021, "Elements of Modern Physics", First Edition. Springer Nature. Springer.* **Material:** Relativity, wave-particle dualism, atomic structure, quantum mechanics **Reference:** *Supangkat, Haryadi, 1990. "Modern Physics", ITB Physics Department.*	

9	Students are able to understand atoms with many electrons, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explain electron spin, Zeeman effect, exclusion principle 2. Explain symmetric and asymmetric wave functions	**Criteria:** Quantitative **Form of Assessment** : Portfolio Assessment, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Atoms with many electrons **Reference:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Atoms with many electrons **Reference:** *Patil, SH 2021, "Elements of Modern Physics", First Edition. Springer Nature. Springer.*	5%
10	Students are able to understand atoms with many electrons, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explain the periodic table 2. Explain atomic structure 3. Explain Spin-orbit Coupling	**Criteria:** Quantitative **Form of Assessment** : Portfolio Assessment, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Atoms with many electrons **Reference:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Atoms with many electrons **Reference:** *Patil, SH 2021, "Elements of Modern Physics", First Edition. Springer Nature. Springer.*	5%

11	Students are able to understand the core structure, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explaining the core structure 2. Explain Some core properties 3. Explains Stable core 4. Explain binding energy	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Core Structure **Bibliography:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Core Structure **References:** *Serway, RA et al. 2005. Modern Physics. California, US: Thomson Learning Inc.* **Material:** Core Structure **References:** *Harris, R. 2007. Modern Physics. California, US: Pearson, Addison-Wesley.* **Material:** Core Structure **Bibliography:** *Supangkat, Haryadi, 1990. "Modern Physics", ITB Physics Department.*	2%
12	Students are able to understand the core structure, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explain the liquid drop model 2. Explaining the skin model 3. Explain the meson theory of the nuclear force	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Portfolio Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Core Structure **Bibliography:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Core Structure **References:** *Serway, RA et al. 2005. Modern Physics. California, US: Thomson Learning Inc.* **Material:** Core Structure **References:** *Harris, R. 2007. Modern Physics. California, US: Pearson, Addison-Wesley.* **Material:** Core Structure **Bibliography:** *Supangkat, Haryadi, 1990. "Modern Physics", ITB Physics Department.*	3%

13	Students are able to understand core transformations, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explain Radioactive Decay 2. Explain half-life 3. Explain the radioactive series 4. Explain alpha decay, beta decay, gamma decay	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Portfolio Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Core transformations **References:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Core transformations **Reference:** *Supangkat, Haryadi, 1990. "Modern Physics", ITB Physics Department.*	2%
14	Students are able to understand core transformations, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explain Cross section 2. Explain core reactions 3. Explain nuclear fission 4. Explain the core reactor 5. Explaining nuclear fusion in stars 6. Explain Fusion Reactor	**Criteria:** Quantitative **Form of Assessment** : Participatory Activities, Portfolio Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Core transformations **References:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Core transformations **Reference:** *Supangkat, Haryadi, 1990. "Modern Physics", ITB Physics Department.*	2%
15	Students are able to understand elementary particles, and are able to communicate scientifically and work effectively both individually and in groups.	1. Explaining Interactions and particles 2. Explaining Leptons, Hadrons 3. Explaining the quantum numbers of elementary particles 4. Explaining Quarks, Boson fields	**Criteria:** Quantitative **Forms of Assessment** : Participatory Activities, Portfolio Assessment, Practical Assessment	• Learning Form: Lecture • Learning Method: Question and answer, discussion, and presentation, and case study • Student Assignments: Giving individual and group assignments [3 x 50 Minutes]		**Material:** Elementary particles **Bibliography:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Elementary particles **Reference:** *Supangkat, Haryadi, 1990. "Modern Physics", ITB Physics Department.*	8%

16	Sub CPMK 9; Sub CPMK 11; Sub CPMK 13; Sub CPMK 15	1. Students can analyze electron configurations and calculate total angular momentum 2. Students can analyze and calculate the binding energy of nucleons 3. Students can analyze and calculate the interactions of charged particles	**Criteria:** Quantitative **Form of Assessment** : Test	UAS 2 x 50 minutes		**Material:** Atoms with many electrons, nuclear structure, nuclear transformations, elementary particles **References:** *Beiser A, 2006, "Concepts of Modern Physics", Sixth Edition. McGraw Hill Inter. BookCompany* **Material:** Atoms with many electrons, nuclear structure, nuclear transformations, elementary particles **Reference:** *Supangkat, Haryadi, 1990. "Modern Physics", ITB Physics Department.*	30%

Evaluation Percentage Recap: Project Based Learning

No	Evaluation	Percentage
1.	Participatory Activities	19.51%
2.	Portfolio Assessment	18.51%
3.	Practical Assessment	11.01%
4.	Test	50%
		99.03%

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** abilities in the process and student learning outcomes are specific and measurable statements that identify the abilities 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.