UNESA	**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
Mechanics	8420304130	Compulsory Study Program Subjects	**T=4**	**P=0**	**ECTS=6.36**	3	August 18, 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

Program Objectives (PO)

PO - 1	CPMK-5
PO - 2	CPMK-1: Mastering classical physics knowledge about concepts, principles and theories of mechanics
PO - 3	CPMK-2: Able to apply physical and mathematical analysis to formulate mechanical models
PO - 4	CPMK-3: Able to design and carry out mechanics experiments by applying scientific methods
PO - 5	CPMK-4: Able to communicate ideas and results of mechanical experiments in the form of written reports or presentations
PO - 6	CPMK-5: Demonstrate independence in working or collaborating in groups effectively to solve mechanical problems

PLO-PO Matrix

P.O
PO-1
PO-2
PO-3
PO-4
PO-5
PO-6

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																

Short Course Description	Study of concepts, principles and theories of mechanics and their application in various real cases in the student environment, including the concept of vectors and vector spaces, kinematics of particle motion in various coordinate systems, dynamics of object motion in various force functions (cases of object motion at any time, motion in fluids , motion of various oscillator systems, conservation of momentum, work and energy), cases of motion under the influence of a central force, transformations of reference frames, dynamics of particle systems (rigid body mechanics), Lagrangian mechanics and Hamilton's equations. The case-based study approach is applied through discussion methods, explanatory argumentative, independent and group assignments, and laboratory experimental activities which are arranged in the form of a self-portfolio.
References	**Main :**

1. Peter Dourmashkin. 2023. Classical-Mechanics. Massachusetts Institute of Technology. Open Education Resource (OER) LibreTexts Project.
2. MIT Open Course Ware. 2016. Classical-Mechanics. Massachusetts Institute of Technology. updated in 2022.
3. Greiner, W., 2004.Classical Mechanics-Point Particles and Relativity. Springer.
4. Fowles, G.R., 1999. Analytical Mechanics. New York: Saunders College Publishing
5. Arya, P. Atam, 1990. Introduction to Classical Mechanics. Prentice Hall.
6. Spiegel, M.R., 1982. Theory and Problems of Theoretical Mechanics. McGraw-Hill

Supporters:

1. Agus Suroso. 2018. 14 Pekan Kuliah Mekanika (Catatan Kuliah FI-2104 Mekanika B). Prodi Fisika. FMIPA-ITB.
2. Akhmad Jufriadi, Hena Dian Ayu. 2015. Mekanika. Prodi Pendidikan Fisika. Universitas Kajuruhan Malang.
3. Iqbal Ainur Rizki, Nina Fajriyah Citra, Hanandita Veda Shapira, Woro Setyarsih dan Nugraharani Primary Putri. 2021. Eksperimen dan Respon Mahasiswa terhadap Praktikum Fisika Non-Laboratorium Menggunakan Aplikasi Tracker Video Analysis untuk Percobaan Kinematika Gerak. JoTaLP: Journal of Teaching and Learning Physics 6, 2 (2021): 77-89.
4. Pasco Scientific. Intructional Manual and Experiment Guided for the PASCO scientific. (Mechanics series).
5. Sheldon, P. 2015. AP Physics 1 and 2 Lab Investigations: Student Guide to Data Analysis. New York: College Board.

Supporting lecturer	Prof. Dr. Budi Jatmiko, M.Pd. Woro Setyarsih, S.Pd., M.Si. Nugrahani Primary Putri, S.Si., M.Si. Abu Zainuddin, S.Pd., M.Pd. Dr. Rohim Aminullah Firdaus, S.Pd, 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	1. Able to master the concepts, principles and theory of vector spaces and coordinate systems well 2. Able to analyze the concept of vector space in coordinate system problems/cases to find the formulation 3. Able to work in groups effectively in solving coordinate system problems	1. Identify coordinate system case problems 2. Identify the concept of vector space and relate it to the case of coordinate systems 3. Analyze the problem to find the mathematical formula for the coordinate system 4. Actively discuss and interact in groups to produce completion of assigned tasks	**Criteria:** Resolve all coordinate system problems according to procedures, completely and on time **Form of Assessment** : Participatory Activities, Portfolio Assessment	Form: Classical discussion Contextual Learning Method: Case study Demonstration Assignment: 1. Draw various coordinate systems and their unit vectors 2. Determine the position vector of objects in various 2 X 50 coordinate systems	Virtual face-to-face lecture (Zoom) 2 x 50	**Materials:** [1], [2], [3], [4], [5], [6] (Visualization of various coordinate systems using materials found around) **References:**	5%

2	1. Able to master the concepts, principles and theory of particle kinematics in various coordinate systems well 2. Able to analyze the characteristics of object motion in various coordinate systems to find the formulation 3. Able to work independently in solving vector problems in various coordinate systems	1. Identifying problems in cases of object motion in a coordinate system 2. Identify the characteristics of object motion in various coordinate systems 3. Analyze the characteristics of object motion until mathematical formulas are found for the characteristics of object motion in various coordinate systems 4. Work diligently, ask questions if you don't understand, focus on solving the problem given.	**Criteria:** Resolve all cases/problems according to procedures, completely and on time **Form of Assessment** : Participatory Activities	Form: Classical classroom discussion Method: Case study Demonstration Assignment: 1. Trace the characteristics of object motion (position, velocity and acceleration) in various vector coordinate systems (polar, Cartesian, cylindrical and spherical) 2. Trace the formulation r, v, a particle motion in each 3 X 50 coordinate system	Virtual face-to-face lecture (Zoom)	**Material:** [1], [2], [3], [4] (Demonstration of the process of tracking the characteristics of an object's motion in one coordinate system, then individually applying it to another coordinate system) **References:**	10%
3	1. Able to master the concepts, principles and theory of particle dynamics due to force as a function of time, f(t). 2. Able to analyze the characteristics of object motion due to the influence of forces as a function of time to find the formulation. 3. Develop experimental designs according to scientific procedures and conduct experiments to solve problems of motion due to force as a function of time 4. Able to convey ideas and findings of time function style experiments in the form of written reports	1. Identifying problems in cases of object motion under the influence of forces as a function of time 2. Find a procedure to track the characteristics of an object's motion due to force as a function of time 3. Analyze the characteristics of object motion due to force as a function of time 4. Obtain a formula for the characteristics of an object's motion due to force as a function of time 5. Prepare a written report on the results of experiments on the motion of objects due to force as a function of time	**Criteria:** Resolve all problems according to procedures, completely and on time **Form of Assessment** : Participatory Activities, Portfolio Assessment	Form: Classical classroom Experiment laboratory Method: Case study Assignment: 1. Create an experimental design for the movement of objects due to force as a function of time 2. Conduct an experiment 3. Prepare a report on experimental activities 3 X 50	Virtual face-to-face lecture (Zoom)	**Materials:** [1], [2], [3], [4] (Pasco Scientific-Air Track Photogate Timing System: Newton's Law Experiment) **References:** **Material:** [1], [2], [3], [4] (Tracker Video Analysis (TVA): various object motions) **References:**	10%

4	1. Able to master the concepts, principles and theory of particle dynamics due to force as a function of time, f(v). 2. Able to analyze the characteristics of object motion due to the influence of force as a function of speed to find the formulation 3. Able to work in groups effectively in solving particle dynamics problems	1. Determine the relationship between the speed function force and the dynamics of the object's motion 2. Trace the process of forming a formulation of the characteristics of an object's motion 3. Obtain a formulation of the characteristics of object motion due to velocity-dependent forces 4. Actively discuss and interact in groups to produce completion of assigned tasks	**Criteria:** Resolve all problems according to procedures, completely and on time **Form of Assessment** : Participatory Activities, Portfolio Assessment	Form: Classical classroom group discussion Method: Case method Explanatory argumentation Presentation Assignment: Trace the characteristics of an object's motion to obtain a 3 X 50 formulation of the dynamics of its motion	Virtual face-to-face lecture (Zoom)	**Material:** [1], [2], [3], [4] (several cases/problems of speed-dependent force: motion of a parachute jumper, motion of a falling object in a viscous fluid, influence of air resistance on motor vehicles) **References:** **Material:** [1], [2], [3], [4] (Tracker Video Analysis (TVA): various object motions) **References:**	5%
5	1. Able to master the concepts, principles and theory of particle dynamics due to force as a function of time, 2. Able to analyze the characteristics of an object's motion due to the influence of force and function of position to find the formulation 3. Develop experimental designs according to scientific procedures and conduct experiments to solve motion problems due to position function forces 4. Able to convey ideas and findings of position function style experiments in the form of written reports	1. Identifying problems in cases of object motion under the influence of position function forces 2. Find a procedure to track the characteristics of an object's motion due to force as a function of position 3. Analyze the characteristics of object motion due to force as a function of position 4. Obtain a formula for the characteristics of object motion due to force as a function of position 5. Prepare a written report on the results of experiments on the motion of objects due to forces as a function of position	**Criteria:** Resolve all problems according to procedures, completely and on time **Form of Assessment** : Participatory Activities, Portfolio Assessment	Form: Classical classroom Group discussion Experiment laboratory Method: Case study Assignment: 1. Create an experimental design for the movement of objects due to force as a function of time 2. Conduct an experiment 3. Prepare a report on 3 X 50 experimental activities	Virtual face-to-face lecture (Zoom)	**Materials:** [1], [2], [3], [4] (several cases/problems of speed-dependent forces: spring motion in fluid, mathematical swings, physical pendulums, oscillations of electric circuits) **References:**	10%

6	1. Able to master the concepts, principles and theory of particle dynamics due to force as a function of time, 2. Able to analyze the characteristics of an object's motion due to the influence of force and function of position to find the formulation 3. Develop experimental designs according to scientific procedures and conduct experiments to solve motion problems due to position function forces 4. Able to convey ideas and findings of position function style experiments in the form of written reports	1. Identifying problems in cases of object motion under the influence of position function forces 2. Find a procedure to track the characteristics of an object's motion due to force as a function of position 3. Analyze the characteristics of object motion due to force as a function of position 4. Obtain a formula for the characteristics of object motion due to force as a function of position 5. Prepare a written report on the results of experiments on the motion of objects due to forces as a function of position	**Criteria:** Resolve all problems according to procedures, completely and on time **Form of Assessment** : Participatory Activities, Portfolio Assessment	Form: Classical classroom Group discussion Experiment laboratory Method: Case study Assignment: 1. Create an experimental design for the movement of objects due to force as a function of time 2. Conduct an experiment 3. Prepare a report on 3 X 50 experimental activities	Virtual face-to-face lecture (Zoom)	**Materials:** [1], [2], [3], [4] (several cases/problems of speed-dependent forces: spring motion in fluid, mathematical swings, physical pendulums, oscillations of electric circuits) **References:**	10%
7	1. Able to master the concepts, principles and theories of conservation of momentum and impulse, conservation of work and energy well 2. Able to analyze cases/problems of object motion to find formulations for conservation of momentum and impulse, conservation of work and energy 3. Able to work independently to solve object motion problems	1. Determine the relationship between impulse, momentum, work, and energy 2. Trace the process of forming the formulation of object motion due to conservation 3.. Obtain a formulation of the characteristics of object motion due to conservation of impulse, momentum, work and energy 4. Work diligently, ask questions if you don't understand, focus on solving the problem given.	**Criteria:** resolve all problems according to procedures and completely **Form of Assessment** : Participatory Activities, Portfolio Assessment	Form: Classical classroom Group discussion Method: Case Study Assignment: Apply the principle of conservation of momentum-impulse, work-energy in various motions of objects 3 X 50	Virtual face-to-face lecture (Zoom)	**Material:** [1], [2], [3], [4] (several cases/problems of the motion of objects with forces of various functions: f(t), f(v), f(x)) **References:**	5%
8							0%

9	1. Able to master the concepts, principles and theory of the central force field 2. Able to analyze cases/problems of object motion under the influence of a central force field to find a formulation of the motion characteristics 3. Able to work in groups effectively in solving central force field problems	1. Determine the influence of the central force field on the dynamics of object motion 2. Trace the process of forming a formulation of object motion due to a central force field 3. Obtain a formulation of the characteristics of object motion due to the central force field 4. Actively discuss and interact in groups to produce completion of assigned tasks	**Criteria:** resolve all problems according to complete procedures and on time **Form of Assessment** : Participatory Activities	Form: Classical classroom Discussion classroom Method: Case study Assignments: 1. Determination of conservative force criteria, 2. force system potential, 3. central force path formulation, and 4. force system path eccentricity	Virtual face-to-face lecture (Zoom)	**Material:** [1], [2], [3], [4] (motion due to central force field & motion due to gravitational force field) **References:**	10%
10	1. Able to master the concepts, principles and theory of the central force field 2. Able to analyze cases/problems of object motion under the influence of a central force field to find a formulation of the motion characteristics 3. Able to work in groups effectively in solving central force field problems	1. Determine the influence of the central force field on the dynamics of object motion 2. Trace the process of forming a formulation of object motion due to a central force field 3. Obtain a formulation of the characteristics of object motion due to the central force field 4. Actively discuss and interact in groups to produce completion of assigned tasks	**Criteria:** resolve all problems according to complete procedures and on time **Form of Assessment** : Participatory Activities	Form: Classical classroom Discussion classroom Method: Case study Assignments: 1. Determination of conservative force criteria, 2. force system potential, 3. central force path formulation, and 4. force system path eccentricity	Virtual face-to-face lecture (Zoom)	**Material:** [1], [2], [3], [4] (motion due to central force field & motion due to gravitational force field) **References:**	10%
11	1. Able to master the concepts, principles and theory of frame of reference transformation well 2. Able to analyze cases/problems of object motion under the influence of a central force field to find a formulation of the motion characteristics	1. Determine the influence of transformations of reference frames on the dynamics of object motion 2. Trace the process of forming a formulation of object motion due to transformation of the reference frame 3. Obtaining a formulation of the characteristics of object motion due to coordinate transformation	**Criteria:** resolve all problems according to complete procedures and on time **Form of Assessment** : Participatory Activities, Portfolio Assessment	Form: Classical classroom group discussion Method: Case study Assignment: Applying the principles of Galileo and Lorenz to the motion of various objects	Virtual face-to-face lecture (Zoom)	**Material:** [1], [2], [3], [4] (Galileo Transformation & Lorenz Transformation) **References:**	10%

12	1. Able to master the concepts, principles and theory of frame of reference transformation well 2. Able to analyze cases/problems of object motion under the influence of a central force field to find a formulation of the motion characteristics	1. Determine the influence of transformations of reference frames on the dynamics of object motion 2. Trace the process of forming a formulation of object motion due to transformation of the reference frame 3. Obtaining a formulation of the characteristics of object motion due to coordinate transformation	**Criteria:** resolve all problems according to complete procedures and on time **Form of Assessment** : Participatory Activities, Portfolio Assessment	Form: Classical classroom group discussion Method: Case study Assignment: Applying the principles of Galileo and Lorenz to the motion of various objects	Virtual face-to-face lecture (Zoom)	**Material:** [1], [2], [3], [4] (Galileo Transformation & Lorenz Transformation) **References:**	10%
13	1. Able to master the concepts, principles and theories of particle system dynamics (Fixed Bodies) 2. Able to analyze cases/problems of motion of rigid bodies to find formulations of motion characteristics 3. Able to work in groups effectively in solving rigid body problems	1. Determine the dynamics of motion of rigid bodies 2. Trace the process of forming the motion formulation of a rigid body 3. Obtaining a formulation of the motion characteristics of a rigid body 4. Actively discuss and interact in groups to produce completion of assigned tasks	**Criteria:** resolve all problems according to procedures and completely **Form of Assessment** : Participatory Activities	Form: Classical classroom Team group discussion Method: Case study Assignment: Investigate the coordinates of the position of the center of mass of an object	Virtual face-to-face lecture (Zoom)	**Materials:** [1], [2], [3], [4] (make a shape in the shape of the letter AZ from drinking water packaging cartons, find the location of the center of mass of the shape of the letter) **References:**	10%
14	1. Able to master the concepts, principles and theory of the Lagrange-Hamiltonian equation well 2. Able to analyze cases/problems of object motion through the application of the Lagrange-Hamiltonian equation to find a formulation of the characteristics of object motion	1. Determining the Lagrange Hamiltonian equation in various cases of object motion 2. Trace the process of forming the Lagrange-Hamiltonian equation in various cases of object motion 3. Obtaining a characteristic formulation of object motion through solving the Lagrange-Hamiltonian equation	**Form of Assessment** : Participatory Activities	Form: Classical classroom Method: Case study Explanatory argumentation Presentation Assignment: Lagrange-Hamiltonian equations in various cases of motion of systems of objects	Virtual face-to-face lecture (Zoom)	**Materials: [** 1]	10%

15	1. Able to master the concepts, principles and theory of the Lagrange-Hamiltonian equation well 2. Able to analyze cases/problems of object motion through the application of the Lagrange-Hamiltonian equation to find a formulation of the characteristics of object motion	1. Determining the Lagrange Hamiltonian equation in various cases of object motion 2. Trace the process of forming the Lagrange-Hamiltonian equation in various cases of object motion 3. Obtaining a characteristic formulation of object motion through solving the Lagrange-Hamiltonian equation	**Form of Assessment** : Participatory Activities	Form: Classical classroom Method: Case study Explanatory argumentation Presentation Assignment: Lagrange-Hamiltonian equations in various cases of motion of systems of objects	Virtual face-to-face lecture (Zoom)	**Materials: [** 1]	10%
16							0%

Evaluation Percentage Recap: Project Based Learning

No	Evaluation	Percentage
1.	Participatory Activities	92.5%
2.	Portfolio Assessment	32.5%
		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.