TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

CLASSICAL MECHANICS

by

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PREFACE

The Learning Design Book or abbreviated as BRP contains lesson plans for one semester. BRP was prepared to be used as a reference for learning Classical Mechanics courses at the Physics Department of FMIPA UI.

The Classical Mechanics course is scheduled to be followed by all 4th semester physics students as the basic physics course that must be mastered to take the next course, namely Quantum Mechanics. In the Classical Mechanics course, students will study Newtonian single particle mechanics, oscillations, non-linear and chaotic oscillations, gravity, several methods in the calculus of variations, Hamilton-Lagrange-Hamiltonian dynamics, Central Force Motion, particle system dynamics, motion in the reference frame. non-linear, coupled oscillations and continuous systems.

With the preparation of this BRP, it is hoped that it can become a reference for the learning process for lecturers and for students participating in lectures in particular and for people who want to learn it.

Depok, Mei 2016

Dr. Budhy Kurniawan

I. Informasi Umum

1.	Name of Program / Study Level	:	Physics / Undergraduate
2.	Course Name	:	Classical Mechanics
3.	Course Code	:	SCFI602113
4.	Semester	:	4
5.	Credit	:	3 credits
6.	Teaching Method(s)	:	Cooperative & Self-Directed Learning
7.	Prerequisite course(s)	:	Mathematical Physics 1 and Basic Physics (Mechanics)
8.	Requisite for course(s)	:	Quantum Mechanics
9.	Integration Between Other Courses	:	-
10.	Lecturer(s)	:	Dr. Budhy Kurniawan
11.	Course Description	:	Understand the basic concepts of classical mechanics to apply them in solving various problems of classical mechanics.

II. Capaian Pembelajaran Mata Kuliah (CPMK) dan Kemampuan pada Akhir Tahap Pembelajaran (Sub-CPMK)

A. CLO

Students are competent in understanding the basic concepts of classical mechanics in the form of single particle Newton mechanics, oscillations, nonlinear and chaotic oscillations, gravity, several methods in the calculus of variations, Hamilton-Lagrange-Hamiltonian dynamics, Central Force Motion, particle system dynamics, motion in the framework, non-linear reference, coupled oscillations and continuous systems so as to be able to apply them in solving various problems of classical mechanics (C2) (CLO 1, 2, 5, 6, 7)

B. Sub-CLOs

1	Learn and discuss the concept of Central Force Motion (C1, C2)	1
2	Learn and discuss the concepts of Oscillation, non-linear oscillations, and chaos (C1, C2)	1
3	Learn and discuss about Gravity (C1, C2)	1
4	Learn and discuss several methods in the calculus of variations (C1, C2)	1
5	Learn and discuss the concepts of the Hamiltonian Principle - Lagrange and Hamilton dynamics (C1, C2)	1
6	Learn and discuss the concept of Central Force Motion (C1, C2)	2
7	Learn and discuss the system dynamics with many particles (C1, C2)	2
8	Learn and discuss about Motions in non-linear frame of references (C1, C2)	1
9	Learn and discuss about rigid body dynamics (C1, C2)	2
10	Learn and discuss Coupled Oscillation and Continuous Systems (C1, C2)	2

III. Lesson Plan

Week	Sub-CLO	Study Materials	Teaching Method	Time Required	Learning Experiences (*O-E-F)	Sub-CLO Weight on Course (%)	Sub-CLO Achievement Indicator	References
1	1	Single Particle Newtonian Mechanics	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Basic Calculus / Mathematics b. Newton's Laws c. Equation of motion for one particle d. Conservation theory e. Energy f. Rocket motion g. Limitations of Newtonian Mechanics	No. 1 chapter 1-2 p. 1-90
2	2	Harmonic oscillation, non-linear and chaotic oscillations	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. harmonic oscillation motion b. two-dimensional harmonic oscillations c. phase diagram d. non-linear oscillations e. non-linear phase diagram f. chaos	No.1 Chapter 3-4 p. 99-178 No.2 p, 239-265 484-516
3	3	Gravity	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Potential Gravity b. Line of style c. Equipotential surface d. Tidal wave	No. 1 Chapter 5 p. 82-204

4	4	Variational Calculus Method	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Euler's Equation b. The second form of Euler's equation c. Functions with multiple dependent variables d. Kronecker delta notation	No. 1 Chapter 6 p. 207-226 No. 2 Hal 353-365
5	5	The Hamilton-Lagrange principle and Hamiltonian dynamics	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	8	Basic concept of: a. Hamilton Principle b. Generalized coordinates c. Lagrange's Equation d. Lagrange's equation with a multiplier e. Lagrange's Equivalents and Newton's Law Equations f. Theory of Kinetic Energy g. Canonical equations h. Virial's theorem	No. 1 Chapter 7 p. 228-280 No. 2 p. 334-356
6	6	Central Force Motion	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Reduced mass b. Conservation theory c. Equations of motion d. Orbit in a central field	No. 1 Chapter 8 p. 287-316 No. 2 p. 70-121

							e. Effective centrifugal and potential energy	
7	7	Central Force Motion	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Kepler's planetary motion b. Orbital dynamics c. Apsidal angle and precession d. Circular orbit stability	No. 1 Chapter 8 p. 287-316 No. 2 Hal 70-121
	Midterm Exam							
8	8	Many-particle system dynamics	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Center of mass b. Linear momentum of the system c. The angular momentum of the system d. System energy	No. 1 Chapter 9 p. 328-378 No. 2 p. 106-114
9	9	Many-particle system dynamics	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Elastic collision of two particles b. Inelastic collisions c. Cross section d. Rutherford Scattering	No. 1 Chapter 9 p. 328-378 No. 2 p. 106-114
10	10	Motion in a non-linear frame of reference	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Rotation coordinate system b. Centrifugal and coriolis force c. Motion relative to the earth	No. 1 Chapter 10 p. 387-408 No. 2 p. 161-174
11	11	Rigid Body Dynamics	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%)	7	Basic concept of: a. Moment of Inertia	No. 1

					F: Plenary & Feedback (30%)		b. Angular momentum c. The main axis of the moment of inertia d. Moment of inertia for different coordinate systems e. Inertia tensor	Chap 11-12 p. 411-495 No. 2 p. 184-230 601-605
12	12	Coupled oscillations and continuous systems	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Eulerian angle b. Euler's equation for rigid bodies c. Free motion of the force at the top of the symmetry with a fixed point d. Rigid body rotation stability	No. 1 Chap 11-12 p. 411-495 No. 2 p. 184-230 601-605
13	13	Coupled oscillations and continuous systems	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	7	Basic concept of: a. Coupled harmonic oscillator b. Weak coupling c. A common problem of coupled oscillation d. The orthogonality of the eigenvectors e. Normal coordinates f. Molecular vibration	No. 1 Chapter 13 p. 512-542 No. 2 Hal 558-589
14	14	Coupled oscillations and continuous systems	Cooperative & Self-Directed Learning	150 minutes	O: Preface (30%) E: Individual & Group Assignments (40%) F: Plenary & Feedback (30%)	8	Basic concept of: a. The strings are weighted b. Continuous strings c. The vibrational energy of the strings	No. 1 Chapter 13 p. 512-542 No. 2 p. 558-589

							d. Forced muffled motion e. General solution of the wave equation f. Phase velocity, group, wave package, dispersion and attenuation	
	Final Exam							

*) O : Orientation
E : Exercise
F : Feedback

References:

1. J.B. Marion and S.T. Thornton, Classical Dynamic of Particles and Systems, Saunder College Publishing, 1995
2. H. Goldstein, C. Poole and J. Safko, Classical Mechanics, 3rd edition, Addison Wesley, 2000

IV. Design of Assignments and Exercises

Week	Assignment Name	Sub-CLO	Assignment	Scope	Working Procedure	Deadline	Outcome
1	Individual & Group Assignment	1	Question(s)	a. Basic Calculus / Mathematics b. Newton's Laws c. Equation of motion for one particle d. Conservation theory e. Energy Rocket motion f. Limitations of Newtonian Mechanics	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments
2	Individual & Group Assignment	2	Question(s)	a. harmonic oscillation motion b. two-dimensional harmonic oscillations c. phase diagram d. non-linear oscillations e. non-linear phase diagram f. chaos	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments
3	Individual & Group Assignment	3	Question(s)	a. Potential Gravity b. Line of style c. Equipotential surface d. Tidal wave	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments
4	Individual & Group Assignment	4	Question(s)	a. Euler's Equation b. The second form of Euler's equation c. Functions with multiple dependent variables d. Kronecker delta notation	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments
5	Individual & Group Assignment	5	Question(s)	a. Hamilton Principle b. Generalized coordinates c. Lagrange's Equation d. Lagrange's equation with a multiplier e. Lagrange's Equivalents and Newton's Law Equations f. Theory of Kinetic Energy g. Canonical equations h. Virial's theorem	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments

6-7	Individual & Group Assignment	6	Question(s)	a. Reduced mass b. Conservation theory c. Equations of motion d. Orbit in a central field e. Effective centrifugal and potential energy f. Kepler's planetary motion g. Orbital dynamics h. Apsidal angle and precession i. Circular orbit stability	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments
9-10	Individual & Group Assignment	7	Question(s)	a. Center of mass b. Linear momentum of the system c. The angular momentum of the system d. System energy e. Elastic collision of two particles f. Inelastic collisions g. Cross section h. Rutherford Scattering	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments
11	Individual & Group Assignment	8	Question(s)	a. Rotation coordinate system b. Centrifugal and coriolis force c. Motion relative to the earth	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments
12-13	Individual & Group Assignment	9	Question(s)	a. Moment of Inertia b. Angular momentum c. The main axis of the moment of inertia d. Moment of inertia for different coordinate systems e. Inertia tensor f. Eulerian angle g. Euler's equation for rigid bodies h. Free motion of the force at the top of the symmetry with a fixed point i. Rigid body rotation stability	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and group assignments
14-15	Individual & Group Assignment	10	Question(s)	a. Coupled harmonic oscillator b. Weak coupling c. A common problem of coupled oscillation d. The orthogonality of the eigenvectors e. Normal coordinates	Individual, by group, and online	150 minutes	Lecturer's powerpoint presentation, individual and

				f. Molecular vibration g. The strings are weighted h. Continuous strings i. The vibrational energy of the strings j. Forced muffled motion k. General solution of the wave equation l. Phase velocity, group, wave package, dispersion and attenuation			group assignments

V. Assessment Criteria (Learning Outcome Evaluation)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Individual Assignment	1 - 10	Evaluation Sheet	3	25
Group Assignment	1 - 10	Evaluation Sheet	2	25
Exam 1	1 - 5	Essay	1	25
Exam 2	6 - 10	Essay	1	25
Total				**100**

VI. Rubric

A. Criteria of Presentation Assessment

Score	Presentation Delivery
85-90	The groups are proficient to convey explanations logically, smoothly, and on time and competent in answering questions from fellow students and lecturers.
75-84	The groups are proficient to convey explanations logically and smoothly and can answer questions from fellow students and lecturer, but cannot manage time well.
65-74	The groups are proficient to convey explanations fluently but cannot convey the logic of their reasoning.
55-64	The groups are less proficient to convey explanations well and on time, and are less able to convey the logic of their reasoning.
<55	

B. Criteria of Essay Assessment

Score	Answers Quality
100	Answers are very precise and all the concept and main component are explained completely.
76-99	Answers are fairly precise and the concept and main component are explained fairly complete.
51-75	Answers are less precise and the concept and main component are explained less complete.
26-50	Answers are poorly precise and the concept and main component are explained poorly complete.
<25	Answers are wrong.