Course Specification

(Postgraduate Programs)

Course Title:	Classical Mechanics
Course Code:	PHY 6101
Program:	Master of Science in Physics
Department:	Physics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University
Version:	3
Last Revision Date:	*26/09/2024*

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A. General information about the course:

1. Course Identification:

1. Credit hours: 4					
2. Course type					
A.	☐ University	☐ College	☒ Department	☐ Track	
B.	☒ Required			☐ Elective	
3. Level/year at which this course is offered: Level 1/Year 1					
4. Course General Description:					
This course is intended to develop and apply the Lagrangian and Hamiltonian mechanics to systems with constraints, rigid body dynamics, vibrations, central forces, and continuous systems. The emphasis is on the canonical structure of classical mechanics, in which the parallels to quantum mechanics are most transparent. The course starts with Hamilton's principle of least action to derive Lagrange's equations, and applies the formalism to dynamical systems with constraints. Conservation of energy, momentum, and angular momentum are linked to symmetry principles. Canonical transformation theory is also discussed with applications to rigid body motion, including the dynamics of tops.					
5. Pre-requirements for this course (if any): None					
6. Pre-requirements for this course (if any): None					
7. Course Main Objective(s):					
At the end of this course, students will be able to: • Demonstrate advanced knowledge and understanding of the following specific fundamental concepts in classical mechanics: Conservation laws and symmetries in physical systems, Motion of particle and systems of particles in three dimensions, Lagrangian formulation of mechanics, Dynamics of rigid bodies, Hamiltonian formulation of mechanics; • Demonstrate an ability to effectively apply the abovementioned knowledge in solving problems involving motion in the following classic areas of mechanics: Motion of bodies with variable mass, 1D-oscillators and pendulums, Motion of 2D, 3D oscillators, central force problems, spherical pendulums, Numerical solution of non-linear problems leading to chaotic behavior, Use of Lagrangian method in systems with holonomic constraints, Motion of rigid bodies such as spinning tops,					

wheels, and low-symmetry objects, Use of Hamiltonian formulation in central force problems and rigid body motion;

- Demonstrate advanced quantitative reasoning and mathematical analysis skills;
- Demonstrate ability to use computational tools in the numerical solution of problems in classical mechanics.

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	75	100%
2	E-learning		
3	Hybrid • Traditional classroom • E-learning		
4	Distance learning		

3. Contact Hours: (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	**45**
2.	**Laboratory/Studio**	**0**
3.	**Field**	**0**
4.	**Tutorial**	**30**
5.	**Others (specify)……**	**0**
	Total	**75**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods:

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	Knowledge and understanding			
1.1	**State the elementary principles in classical mechanics.**	**K1**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Participation. ▪ Discussions.
1.2	**Describe the variational and Hamiltonian methods.**	**K1, K3**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Homework. ▪ Quizzes.
1.3	**Outline the central Force and rigid body dynamics.**	**K1**	• Lectures. • Class discussions. • Tutorials.	▪ Participation. ▪ Exams. ▪ Discussions. ▪ Homework.

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.4	**Interpret oscillations and canonical transformations.**	**K1, K3**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Participation. ▪ Discussions.
2.0	**Skills**			
2.1	**Explain and summarize the basic knowledge gained from studying Classical mechanics course.**	**S1, S2**	• Lectures. ▪ Class discussions. ▪ Tutorials.	▪ Exams. ▪ Discussions. ▪ Participation.
2.2	**Develop the students ability to solve and analyze problems in physics related the topics covered by the course.**	**S2, S3**	▪ Problem classes and group tutorial. ▪ Homework assignments as well as problems solutions.	▪ Exams. ▪ Discussions. ▪ Homework.
2.3	**Communicate in a clear and concise manner orally, and using IT for acquiring and analyzing information.**	**S4**	▪ Lectures. ▪ Class discussions. ▪ Tutorials. ▪ Encourage students to use electronic mail and internal network for submitting homework and assignments. ▪ Use digital library.	▪ Exams. ▪ Participation and activities of students in the course community and blackboard. ▪ Homework.
3.0	**Values, autonomy, and responsibility**			
3.1	**Show the collaboration and inter-professionalism in class discussions or team works, as well as solve problems independently.**	**V1, V2, V3**	▪ Small team tasks ▪ Open discussion at classroom. ▪ Office hours.	▪ Participation ▪ Homework. ▪ Mini-project(s).

C. Course Content:

No	List of Topics	Contact Hours
1.	**Survey of the Elementary Principles:** Mechanics of a particle, Mechanics of a system of particles, Constraints, D'Alembert principle and Lagrange's	**7**

	equations, Velocity-dependent potentials and the dissipation function, Simple applications of the Lagrangian formulation.	
2.	**Variational Principles and Lagrange's Equations:** Hamilton's principle, Some techniques of the calculus of variations, Derivation of Lagrange's equations from Hamilton's principle, Extension of Hamilton's principle to nonholonomic systems, Advantages of a variational principle formulation, Conservation theorems and symmetry properties.	**12**
3.	**The Central Force Problems:** Reduction to the equivalent one-body problem, The equations of motion and first integrals, The equivalent one-dimensional problem and classical orbits, The Virial theorem, The differential equation for the orbit.	**12**
4.	**The Kinematics of Rigid Body Motion:** The independent coordinates of a rigid body, Orthogonal transformations, Formal properties of the transformation matrix, The Euler angles, The Cayley-Klein parameters and related quantities, Euler's theorem on the motion of a rigid body, Finite rotations, Infinitesimal rotations, Rate of change of a vector, The Coriolis effect.	**12**
5.	**The Rigid Body Equations of Motion:** Angular momentum and kinetic energy of motion about a point, Tensors, The inertia tensor and the moment of inertia, The eigenvalues of the inertia tensor and the principal axis transformation, Solving rigid body problems and the Euler equations of motion, Torque-free motion of a rigid body, The heavy symmetrical top with one point fixed.	**8**
6.	**Oscillations:** Formulation of the problem, The eigenvalue equation and the principal axis transformation, Frequencies of free vibration and normal coordinates, Free vibrations of a linear triatomic molecule, Forced vibrations and the effect of dissipative forces.	**8**
7.	**The Hamilton Equations of Motion:** Legendre transformations and the Hamiltonian equations of motion, Cyclic coordinates and conservation theorems, Derivation of Hamilton's equations from a Variational principle, The principle of least action.	**8**
8.	**Canonical Transformations:** The equations of canonical transformation, Examples of canonical transformations, The harmonic oscillator, Poisson brackets and other canonical invariants, The angular momentum Poisson bracket relations.	**8**
Total		**75**

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	**Class Activities (class quizzes, homework, solving problems, etc......)**	**weekly**	**20 %**
2.	**Midterm Exam 1**	**6th week**	**20 %**

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
3.	Midterm Exam 2	12th week	20 %
4.	Final Exam	16th week	40 %

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.)

E. Learning Resources and Facilities:

1. References and Learning Resources:

Essential References	*H. Goldstein, C.P. Poole, J. Safko, Classical Mechanics, 3rd Edition, Addison-Wesley, 2001.*
Supportive References	*-L.D. Landau, E.M. Lifshitz, Mechanics, 3rd Edition, Butterworth–Heinemann, 1976.* *-S.T. Thornton, J.B. Marion, Classical Dynamics of particles and Systems, 5th Edition, Thomson Learning, 2004.*
Electronic Materials	https://units.imamu.edu.sa/colleges/en/science/Pages/default.aspx
Other Learning Materials	Multimedia associated with the textbook and the relevant websites.

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	- Classrooms
Technology equipment (Projector, smart board, software)	- Classroom equipped with a whiteboard and a projector.
Other equipment (Depending on the nature of the specialty)	

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	- Students. - Second examiner.	Indirect (The student will complete evaluation forms at the end of semester. Final exam is evaluated by the second examiner)
Effectiveness of students' assessment	- Instructors.	Direct (exams, HW, project, …)
Quality of learning resources	- Faculty. - Students.	Indirect (surveys)

Assessment Areas/Issues	Assessor	Assessment Methods
The extent to which CLOs have been achieved	- Instructors. - Program Leaders.	Direct (excel sheet)
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	Quality Unit-Physics Department
REFERENCE NO.	Department council No. 6
DATE	26/09/2024