Hong Kong Baptist University
Faculty of Science – Department of Physics

Title (Units): **PHYS 2027** **MECHANICS (3, 3, 1)**

Course Aims: This course deals with the basic theory of Lagrangian and Hamiltonian mechanics, coupled oscillations, and central force motion. It extends the basic discussions on mechanical motion in the lower level course, Heat and Motion, to a more general mathematical and theoretical framework, and provides a broader foundation for understanding and employing classical mechanics in physical science and energy science applications.

Pre-requisite: PHYS 2005 Heat and Motion or Consent of Instructor

Course Reviewed by: Dr. Jue Shi and Dr. Changsong Zhou

Course Intended Learning Outcomes (CILOs):

No.	Upon successful completion of this course, students should be able to:
1	Apply Newtonian mechanics to analyze harmonic oscillations.
2	Use Lagrangian and Hamiltonian mechanics to analyze particle dynamics.
3	Analyze central force motion.
4	Analyze coupled oscillations.
5	Demonstrate a progressive understanding of the above CILOs, from first recalling definitions and explaining concepts, then plugging in equations, to ultimately modeling real world systems.

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Teaching & Learning Activities (TLAs)

CILOs	TLAs will include the following:
1-5	**Lectures.** The instructor will use the following teaching approaches, • Orient and motivate the students whenever a new idea is introduced, verbally explaining why it is needed, where it comes from and where it is leading to. • Relate new concepts to the overall logical structure • Visualization: Ketches and figures will be used as frequently as possible to illustrate physical systems, concept comparisons, mind maps etc. • Do worked examples as much as possible. Will first describe and rationalize the approach before plugging in equations; will show ways to check the consistency of answers; will invite student participation throughout. • One or two real world problems will be presented near the end of each chapter. The instructor will guide the students to understand the system, identify the essence, formulate the model, and analyze it qualitatively and quantitatively. •
1-5	**Tutorials.** Students can learn interactively in the tutorial through, • Questions and answers. • Worked examples with active student participation. • Small group discussions.
1-5	**Homework assignments.** Students are assigned readings and problem sets. Solving homework problems is probably the most important learning activity. Students are encouraged to discuss with classmates and consult the instructor and TA, though they have to write up their solution independently. In some cases, students are required to verbally explain their approach. Homework solutions will be provided after the due date.

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Assessment:

No.	Assessment Methods	Weighting	CILOs to be addressed	Remarks
1	Problem Assignments	20%	1-5	Problem sets to measure how well the students have learned the basic concepts and fundamental theory of mechanics.
2	Mid Term Test	30%	1,2,5	A one hour test mainly to assess the first two CILOS.
3	Final Examination	50%	1-5	Final Examination questions are designed to see how far students have achieved their intended learning outcomes. Part A emphasizes breadth (CILOS 1-4) while Part B emphasizes depth (CILOS 5)

Learning Outcomes and Weighting:

Content	LO No.	Teaching (in hours)
I. Review of Newtonian Mechanics	1	4
II. Harmonic Motion	1, 5	6
III. Lagrangian and Hamiltonian Mechanics	2, 3, 4	10
IV. Central Force Motion	3, 5	10
V. Small Oscillations	1,4, 5	6

Textbook: S.T. Thornton and J.B. Marion, Classical Dynamics of Particles & Systems, 5th Ed. (Thomson, 2004).

References:
1. D. Morin, Introduction to Classical Mechanics, 1st Ed., Cambridge 2008.
2. H. Goldstein, C. Poole, and J. Safko, Classical Mechanics, 3rd Ed., Addison Wesley, 2001.

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Course Content in Outline:

	Topic	**Hours**
I.	Review of Newtonian mechanics	4
	A. Newtonian theory.	
	B. Solving differential equations for Newtonian mechanics .	
II.	Harmonic Motion	6
	A. Simple harmonic oscillator.	
	B. Damped harmonic oscillator.	
	C. Forced harmonic oscillator.	
	D. Conservation laws.	
III.	Lagrangian and Hamiltonian mechanics	10
	A. Hamilton's principle and Lagrangian equations.	
	B. Generalized coordinates and generalized momentum.	
	C. Hamiltonian equation.	
	D. Symmetry and conservation laws.	
IV.	Central Force Motion	10
	A. Two-body central force problem.	
	B. Equation of motion in central force field.	
	C. Orbits in central force field.	
	D. Kepler's law, gravity and planetary motion.	
	E. Scattering in central force field.	
V.	Small oscillations	6
	A. Lagrangian equations for small oscillations.	
	B. Matrix analysis of linear differential equations.	
	C. Coupled oscillator.	
	D. Normal modes (eigenvalues and eigenvectors) .	