**KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS**

**DEPARTMENT OF PHYSICS**

**PHYS 301- Classical Mechanics I**

**TERM 151**

**Instructor** : Dr. Abdelkrim Mekki

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**Course Description:**

Topics covered include: Newton's laws of motion and conservation theorems **(2)**, oscillations **(3)**; non-linear oscillations (**4**), gravitation **(5)**; Hamilton's variational principle- Lagrangian and Hamiltonian Dynamics **(6, 7)**; Central force **(8)**; Motion in a non-inertial reference frame **(10)**.

**Prerequisite:** MATH 202, PHYS 101

**Textbook:** Thornton S. T. and Marion, J. B.: *Classical Dynamics of Particles and Systems*, 5th edition, Saunders College Publishing, 2004.

**References:**

* Goldstein H, Poole C, and Safko J, “Classical Mechanics”, Addison Wesley 3rd, edition 2002.
* Jose J and Saletan E, “Classical Dynamics: A Contemporary Approach”, Cambridge University Press (August 13, 1998)
* Symon K R: *" Mechanics* " , Addison-Wesley, 3rd Edition, 1977.
* Arya A, “*Introduction to* *Classical Mechanics”*, Allyn and Bacon, 1990.
* Fowles G. R., and Cassiday G. L.: “*Analytical Mechanics”*, 6th edition, Saunders College Publishing, 1999.
* Zimmerman R. L., and Olness F. I.: “*MATHEMATICA for Physics”*, Addison-Wesley Publishing Company, 1995.

**Grading:**

Quizzes 20%

Major exam1 20%

Major exam2 20%

Project 10%

Final Exam 30 %

**Quizzes:**

There will be a quiz at the end of every chapter.

**Project:**

The project is related to chapter 4, “Non-linear Oscillations”. Students will be requested to use Mathematica to solve differential equations numerically and plot phase diagram and paths of particles subjected to non-linear oscillations. Students need to review chapter 4 and discuss with the instructor any issues related to the topics in the chapter.

**Exams**:

18th Oct. 2015 – First Major Exam (Chapters 2, 3, 5)

22 Nov. 2015 – Second Major Exam (Chapters 6-8)

28 Dec. 2015 - Final Exam (comprehensive)

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| ***Week***  | ***Date*** | ***Topics*** | ***Chapter*** | ***Sec*** |
| **1** | 23 Aug. 15 | General Introduction to the course |  | --- |
| 25 | Newton’s Laws, The Equation of motion of a particle | 2 | 2.1, 2.2 |
| 27  | The Equation of motion of particle (Examples ) | 2 | 2.3, 2.4 |
| **2** | 30 | The Equation of motion of particle (Examples ) | 2 | 2.4 |
| 1st Sept. | Conservation Theorems | 2 | 2.5 |
| 03 | Energy  | 2 | 2.6 |
| **03 Sept. - Last day for dropping course(s) without permanent record** |
| **3** | 06 | Chapter 2 Tutorial |  |  |
| 08 | Harmonic Oscillator in 1D  | 3 | 3.1, 3.2 |
| 10 | Harmonic Oscillator in 2D  |  3 | 3.3 |
| **4** | 13 | Phase Diagrams, Damped Oscillations | 3 | 3.4, 3.5 |
| 15 | Sinusoidal driving force – Physical systems | 3 | 3.6, 3.7 |
| 17 | Chapter 3 Tutorial |  |  |
| **5** | 29 | Non-Linear Oscillations – Discussion of the project – Mathematica | 4 | Discussion |
| 01 Oct. | Gravitational Potential | 5 | 5.1, 5.2 |
| **6** | 04 | Lines of force and Equipotential Surfaces, Potential concept | 5 | 5.3, 5.4 |
| 06 | Ocean Tides | 5 | 5.5 |
| 08 | Chapter 5 Tutorial |  |  |
| **08 Oct. - Last day for dropping course(s) with grade of "W"** |
| **7** | 11 | Calculus of Variations | 6 | 6.1, 6.2 |
| 13 | Euler’s Equation | 6 | 6.3 |
| 15 | Second Form of Euler Equation, Functions with several Variables | 6 | 6.4, 6.5 |
| **18 Oct. 2015 – First Major Exam (Chapters 2, 3, 5)** |
| **8** | 18 | Auxiliary Conditions , The Delta Notation | 6 | 6.6, 6.7 |
| 20 | Chapter 6 Tutorial |  |  |
| 22 | Review  |  |  |
| **9** | 25 | Hamilton’s Principle | 7 | 7.1, 7.2 |
| 27 | Generalized Coordinates | 7 | 7.3 |
| 29 | Lagrange’s Equation of Motion | 7 | 7.4 |
| **10** | 1st Nov. | Undetermined Multipliers | 7 | 7.5 |
| 03 | Equivalence of Lagrange and Newton’s Equations | 7 | 7.6 |
| 05 | Kinetic Energy | 7 | 7.7, 7.8 |
| **11** | 08 | Conservation Theorems Revisited | 7 | 7.9 |
| 10 | Hamiltonian Dynamics | 7 | 7.10 |
| 12 | Dynamical Variables and Variational Calculations | 7 | 7.11 |
| **12** | 15 | Chapter 7 Tutorial |  |  |
| 17 | Central Force Motion, Conservations Theorems | 8 | 8.1-8.3 |
| 19 | Equations of Motion | 8 | 8.4 |
| **22 Nov. 2015 – Second Major Exam (Chapters 6-8.3)** |
| **13** | 22 | Orbits in a Central Field,  | 8 | 8.5 |
| 24 | Centrifugal Energy |  | 8.6 |
| 26 | Chapter 8 Tutorial |  |  |
| **14** | 29 | Center of mass | 9 | 9.1-92  |
| 01 Dec. | Linear and Angular Momenta of a System  | 9 | 9.3-9.4 |
| 03 | Energy of a System | 9 | 9.5 |
|  | **18 Dec. - Last day for withdrawal from all courses with grade of "W"** |
| **15** | 06 | Elastic and Inelastic Collisions | 9 | 9.6-9.8 |
| 08 | Chapter 9 Tutorial |  |  |
| 10 | Two Coupled Harmonic Oscillators-Weak Coupling | 12 | 12.1-12.4 |
| **16** | 13 | Eigenvectors and Normal Modes | 12 | 12.5-12.6 |
| **30 Dec. 2015: Final Exam (comprehensive)** |

**Course learning outcomes**

On successfully completing the course the students can:

1. Analyze and apply Newton’s laws that govern the mechanics of a point object in one ant two dimension problems with an overall average of 50% in exams.
2. Analyze and apply conservations laws that govern the mechanics of a point object with an overall average of 50% in exams.
3. Describe linear oscillatory motion in one and two dimension problems for simple mechanical systems and analyze problems on damped and forced oscillatory systems with an overall average of 50% in exams.
4. Explain the nonlinear oscillations Chaos; explain how the nature of the dynamics is reflected in the properties of the phase space trajectories; Describe and use numerical method to analyze the nonlinear dynamics with an overall average of 50% in exam.
5. Compute and simulate the dynamic behaviour of nonlinear oscillation numerically by using Mathematica ( or any suitable program such as Matlab, Mathcad, C++ ) software with an overall average of 50% in total grade.
6. Calculate and explain problems in the gravitational potential and forces with an overall average of 50% in exam.
7. Apply Euler’s Equations in some classical problems with an overall average of 50% in exam.
8. Solve the mechanics problems using Lagrangian formalism, a different method from Newtonian mechanics with an overall average of 50%.
9. Solve dynamical problems involving classical particles by using Hamiltonian formulation with an overall average of 50% in the exam.
10. Describe and solve problems related to motion of bodies in non-inertial frames with an overall average of 50% in the exam.