PS 320 – Classical Mechanics
Embry-Riddle University
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Required text:	*Introduction to Classical Mechanics*, by David Morin
Recommended in the library:	*Lectures on Physics, Volume I*, by Feynman
	Mechanics, by Symon
	Classical Mechanics, by Kibble
	Classical Mechanics: A Modern Perspective, by Barger and Olsson
	An Introduction to Mechanics, by Kleppner and Kolenkow

Percentage system:

1 final exam	20%
3 tests	60% (20% each)
Problem sets	20%

Grading scale:

A	90% –
B	75% – 89%
C	60% – 74%
D	50% – 59%

IMPORTANT NOTE

Listening to lectures is not enough (*you retain only 10% of what you hear* …). All processes of learning are somehow connected to active participation, and the learning of physics is no exception. Therefore, it is imperative that you work diligently at your own desk (… *80% of what you practice* …). However, this does not mean that you should only work alone. I encourage you to form study groups and collaborate with your classmates (… *and 90% of what you teach to others!*).

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* This syllabus incorporates all existing University policies, especially those sections of the *Student Handbook* pertaining to academic integrity, civility, and respect. *

Course Description: Fundamentals of Mechanics; oscillatory motion; systems of particles; varying mass; motion under central forces; motion in three dimensions; gyroscopic motion; generalized coordinates; normal coordinates; Lagrangian and Hamiltonian formulations. **Prerequisites**: MA345, ES204.

Goals: This course is required in the Engineering Physics degree program and is a technical elective for other science and engineering programs. It is a one-semester upper level undergraduate course in classical dynamics. Its goal is to provide the theoretical and mathematical foundations that underlie more advanced courses in electrodynamics, quantum mechanics, and field theory, and to emphasize the applications of those theoretical and mathematical techniques of classical dynamics to modern celestial mechanics, space exploration, and aerospace technology.

Learning Outcomes:

1. Analyze the motion of systems of varying mass (e.g., multi-stage rockets) and of multi-dimensional, damped, and driven harmonic oscillations; model mechanical oscillating systems by electrical circuit analogs.
2. Calculate expressions for gravitational potentials for symmetric mass distributions; analyze gravitational fields in symmetric geometries using Gauss' Law.
3. Solve geodesic motion and “isoperimetric” variety problems using methods of calculus of variations; determine constraint forces in mechanical systems using the method of Lagrange undetermined multipliers.
4. Find appropriate generalized coordinates to form the Lagrangian function for a mechanical system and use it to cast the equations of motion of the system into Lagrangian form.
5. Cast the equations of motion of mechanical systems into canonical Hamiltonian form; analyze conservation of physical quantities in terms of ignorable coordinates and Poisson brackets.
6. Categorize possible orbit types and conserved quantities for various central forces and solve the inverse problem of determining central force law from given forms of orbits; derive Kepler's laws of planetary motion from inverse-square force law; analyze stability of circular orbits; compute energy requirements and times-of-flight for inter-planetary journeys.
7. Analyze motion in accelerated and rotating frames of reference; identify and compute "fictitious" inertial forces (centrifugal and Coriolis) in such frames.
8. Compute inertia tensor and perform rotations using matrix methods; transform from "fixed" to "body" systems of coordinates by principal-axis transformations; analyze rotation and rotational stability using Euler angles and Euler equations of motion.
9. Decompose coupled oscillations into normal modes of vibration; find eigen-frequencies and normal coordinates for coupled vibrating systems.
10. Fourier-analyze wave motions given various types of boundary conditions; decompose complex waves in terms of normal-mode oscillations; determine group and phase velocities of wave packets.

RULES

1. Arrive on time; depart on time.
2. Take notes.
3. No eating, no cell phones.

Final Exam

Comprehensive; two-hour; closed book; closed notes.
Tools: pen or pencil.
Date: Saturday, 1 May, 2:45 pm – 4:45 pm.

Tests

One-hour; closed book; closed notes.
Tools: pen or pencil.
Dates: Wed 10 Feb, Mon 29 Mar, Fri 23 Apr.
Final exam will replace lowest test.

Problems

10 problems each week; must be neat and stapled.
Due Dates: every Friday – see schedule.
Graded on completeness and effort.

All assignments are due at the *beginning* of class on the due date, after which they will be considered late and the score will be reduced by 50%. After the *beginning* of the *next* class period, they will not be accepted.

General study habits

Repetition is critical for creating long-term memories. A good method for learning is the following sequence: read, listen, write, re-read, re-write, practice, and review. The textbook should be read THREE times: read once before class, read deeply (at least) once after class, and once as a review. In addition, you do not read textbooks as you would the newspaper. You must work through the examples, all mathematical steps should be confirmed, and you should write notes in the margins (it is your book, you can write in it!).

Notes

Taking notes during lecture is important – but you must review and re-copy those notes after class (within a few hours) for them to be useful. Notes that are never reviewed are less than worthless: they give you a false sense of security. It is important that you get into the habit studying every day.

Study Groups

I strongly suggest that you form study groups. “For most individuals, learning is most effectively carried out via social interactions.” (Ed Redish)

Problem Solving

Solving problems is **critical** to your success in this course. An excellent method to prepare for the exams is to attempt problems at home in an exam-type environment. That is, once you have solved a group of problems, put aside the solutions and pretend that they are questions on an exam – attempt to solve them again, but without any help. Solve problems according to the following rules of coherence and readability:

- Describe *briefly*, but in clear and complete sentences, the basic principles used to solve the problem and explain the basic equations that are used in the solution [DO NOT simply rewrite the question]. This is the most important component of coherence and full credit will not be given for any problem solution that does not contain such a description.
- If a physical situation is discussed in the problem, draw an appropriate diagram.
- Identify in words, or by clear references to the diagram, all the symbols you use.
- Work through the problem symbolically, getting a simplified symbolic answer, and only substitute numbers (if appropriate at all) at the very end.
- If you obtain an explicit numerical solution, comment on whether the value you get is reasonable.
- Put boxes around your final answers.
- Write up the problem sets neatly.

Do not simply copy another student's work, and do not simply copy from the solutions manual, but I recommend that you form study groups and work together. This can help you through difficult sections and problems. I encourage you to discuss, argue, arm-wrestle, and finally master the problems. However, I expect you to write up your solutions individually, showing your own insights.

Final Exam and Tests

Three one-hour in-class tests, and one two-hour final exam will be given. All are closed book and closed notes. Calculators are NOT allowed on any exam. This course will hopefully teach you to think and increase your physics intuition. An excellent method to prepare for the exams is to attempt problems at home in an exam-type environment. That is, once you have solved a group of problems, put aside the solutions and pretend that they are questions on an exam – attempt to solve them again, but without any help.

"An important objective of a first course in mechanics is to train the student to think about physical phenomena in mathematical terms, and to develop an intuitive feeling for the precise mathematical formulation of physical problems and for the physical interpretation of the mathematical solutions. After working an assigned problem, the student should study it until she is sure she understands the physical interpretation of every feature of the mathematical treatment. If the answer is fairly complicated, she should try to see whether it can be simplified in certain special or limiting cases." - Keith R. Symon, *Mechanics*

SCHEDULE

Week	Topics	Chapters in Morin
1-3	Newton's laws & conservation laws	1, 3, 5
4-5	Gravitation & field theory	Handouts
	Exam 1 – Wed Feb 10	
6-7	Linear (& coupled) oscillations	4
8	Nonlinear dynamics	handout
9-10	Lagrangian & Hamiltonian dynamics	6, handout
	Exam 2 – Mon Mar 29	
11-12	Central force motion	7
13-14	Non-inertial reference frames	10
	Exam 3 – Fri Apr 23	
	Final Exam – Sat May 1	All

Homework schedule

Problem Set #1 due Fri 22 Jan Morin: 1.1, 1.2, 1.4, 1.9, 1.12, 1.18, 3.2
Reynolds: 4, 5, 7

date	Reading due	Problem Sets due	topics
13-Jan			syllabus, problems, dimensions
15-Jan	preface, Ch 1		Newton, dimensions
20-Jan	3.1-2		machines
22-Jan	3.3-5	Set #1	solving Newton's Laws
25-Jan	5.1-2		energy conservation
27-Jan	5.3-4		gravity, Newton
29-Jan	FT Primer	Set #2	field theory
1-Feb	Gravity field		Earth's gravity field
3-Feb	5.5		momentum I, nonlinear ODE
5-Feb	5.6-7	Set #3	momentum II
8-Feb	5.8		momentum III
10-Feb			Test #1