PS 320 – Classical Mechanics
Embry-Riddle University
Spring 2004

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Required text:	There once was a classical theory ..., by 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

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Grading:	20%	weekly homework
	60%	three one-hour exams (20% each)
	20%	two-hour final exam

Homework:	Assigned weekly, and due at the beginning of class. Graded for correctness. Late homework will not be accepted. The lowest homework score will be dropped.
Exams:	Three one-hour exams. No make-ups. The score on the final exam will replace the lowest score.
Final exam:	Wed 28 Apr, 08:00 – 10:00. Two-hours. Comprehensive.

Holidays:	Mon, Jan 19 (Martin Luther King day)
	Mon, Feb 16 (President's day)
	Mon-Fri, Mar 15-19 (Spring break)

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!*).

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.

Prerequisite Knowledge by Topic:

1. Solid analytical geometry.
2. Vector functions in three dimensions.
3. Series expansions.
4. Directional derivative and gradient; multiple integrals.
5. Matrix algebra and applications; eigenvalues and eigenvectors; matrix inverses and determinants
6. Ordinary differential equations, including principal types of first and second order equations.
7. Systems of linear differential equations; methods of undetermined coefficients and variation of parameters.
8. Fourier series.
9. Classical electromagnetism; wave interference and diffraction.
10. Special relativity; relativistic dynamics.
11. Wave-particle duality; uncertainty principle.
12. Non-relativistic quantum mechanics based on Schrodinger equation.

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.

Code of Behavior

In order for learning to take place, we all must act with civility (formal politeness) and respect (polite consideration, courtesy) toward each other. My responsibilities include coming to class prepared and on time, and evaluating you in a fair and impartial manner. Your responsibilities include coming to class prepared and on time, not disrupting the class (for example, talking without being called on, eating, reading newspapers, shuffling papers, talking on cell phones, etc.), and treating your fellow students as colleagues (see the Student Handbook). Violations of this code can result in your removal from the class.

Academic Integrity

Issues of academic integrity are discussed on page 24 of the Student Handbook. They include plagiarism, cheating and fraud. Please read this section, and if you do not understand it, come see me. Some important passages are reproduced here:

"Sanctions [for academic dishonesty] may include failure of a test or assignment, failure of a course, suspension, or dismissal from the University."

"Plagiarism is recognized by the University as an act of academic dishonesty. It is defined as taking the ideas, writings, work, and/or words of another and representing them as one's own. Two common forms of plagiarism involve the use of written or oral work of another person without giving proper acknowledgment and the use of the oral work of another person as one's own."

Office hours

I am always in my office during my office hours, and this is your time to speak with me about any aspect of the course. Also, I am generally in my office between 9 am and 5 pm, and available at times other than my office hours. However, I may be teaching or doing research, and not available immediately. If you need to speak with me, drop by or call me and set up an appointment.

Attendance

Class attendance is mandatory although I will not take attendance. I will call on several of you each day to answer questions relating to the reading and the current material – not being present and prepared will affect your grade. Even though I will readily allow you to miss a class for a legitimate reason, you are still responsible for the material in lectures whether you are present or not.

Reading and Notes

The textbook is your primary source of information – not lecture. If you don't like the assigned text, find one that you do like (they are all essentially equivalent) – check one out of the library or buy one from a used bookstore. Reading the text is mandatory and is to be done *before* each class. It is extremely important that you come to class prepared to think and discuss the day's topic. Not knowing that topic is a serious detriment to learning. The schedule is listed at the end of this syllabus. *How* to read the textbook is suggested below.

Taking notes during lecture is also important – but you must review those notes after class (within a few hours). Notes that are never reviewed are less than worthless: they give you a false sense of security.

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: skim lightly 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!).

Homework

Five problems will be assigned weekly, and are due at the beginning of the class period on the due date. Each problem will be graded on a scale of 0 to 10. These problem sets are **critical** to your success in this course. Not only are they worth 20% of your grade, but also because the exam problems will be very similar to the homework problems, doing the homework well will boost your exam performance. I will post solutions of the assigned problems on Blackboard. I suggest that you solve other problems as well, as practice for the exam, and my suggestions as to which extra problems to solve will be listed with the assigned problems.

In order to obtain full credit for each homework problem, you must solve the problem 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 (see the statement about plagiarism above), 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.

Exams

Three one-hour in-class exams, and one two-hour final exam will be given. All exams 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. These rules will be strictly enforced.

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. If you can do this with several problems from each chapter, you should do fine on the exams. To help you, I have added extra problems from each chapter that can be used for this purpose. They are NOT to be turned in.

Grading System

From page 26 of the Student Handbook: "The following grades are used by the faculty to indicate the quality of work performed." (*I have added my own interpretations in italics – including the percentage score to attain this level.*)

A = Superior (*Performance of the student has been of the highest level, showing sustained excellence in meeting course responsibilities – 90%*)
B = Above Average (*Performance of the student has been good, though not of the highest level – 75%*)
C = Average (*Performance of the student has been adequate, satisfactorily meeting the course requirements – 60%*)
D = Below Average (*Performance of the student has been less than adequate – 50%*)
F = Failure (*Performance of the student has been such that course requirements have not been met.*)

Your success in this course depends on you alone. You must be self-critical and determine the method by which you study best. Whatever method you use, I believe that success requires a minimum of **six (6)** hours per week **outside** of lecture. Come see me if you desire suggestions on time management, study hints, or anything that will help you succeed in this course.

You also need adequate sleep and exercise. If you don't get these, your body will not be able to function well (even though your mind is willing).

"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	2, 4
4-5	Gravitation & field theory	handout
	Exam 1 – Mon Feb 9	
6-7	Linear (& coupled) oscillations	3
8	Nonlinear dynamics	handout
9-10	Lagrangian & Hamiltonian dynamics	5
	Exam 2 – Fri Mar 12	
11-12	Central force motion	6
13-14	Non-inertial reference frames	9
	Exam 3 – Mon Apr 19	
	Final Exam – Wed Apr 28	All

Homework schedule

There will be 12 homework sets, due on Wednesdays. The due dates will be:

January 14, 21, 28
February 4, 18, 25
March 3, 10, 31
April 7, 14, 21