CSUC Fall Term 2018

DEPARTMENT OF PHYSICS
Physics 301A : ***Classical Mechanics***

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Text: - ***Classical Mechanics***, John R. Taylor

Physics References:

- ***Introduction to Classical Mechanics***, David Morin
- ***Classical Mechanics***, Herbert Goldstein (Third edition)
- ***Mechanics***, Landau & Lifschitz
- Class lecture notes and problem solutions

Math Reference:

- ***Mathematical Handbook of Formulas and Tables***, 2nd ed.
  Murray R. Spiegel (Schaum Outline Series) ISBN 0 – 07 – 038203 - 4
- ***Mathematica*** or some equivalent graphing utility.

The Course:

This course endeavors to provide a thorough grounding in ***Newtonian Mechanics*** at the upper division undergraduate level. In this semester we will cover roughly half of the class text plus additional topics from extra handouts. The chapters to be included this semester are 1 - 5, 7-8. The pace will include consideration of student feedback. We will schedule *at least* one optional (but really important!) regular problem solving session at a time and place to be determined by class vote.

Grading:

There will be seven regular problem sets to be handed out at roughly two week intervals. In addition, there will be three ***Portfolio Problems*** (described below). Thus, there are ten contributions to the work to be completed and each will constitute 10% of the possible points. Anyone submitting 90% × (*adequate solutions* to all the problems) will receive an A for the course. All other grades will be assigned using standard percentages of the minimum number of points necessary for an A. Solutions of superior quality will accrue extra credit which may be used to offset the absence of other problems according to the scheme:

adequate solutions	3 points
superior solutions	4 points
superlative solutions	5 points

Each regular problem is rated with a difficulty index (or, equivalently in your text, by a number of stars ★★★), which serves as a problem ``point” multiplier. Difficult work receives more value and superlative solutions to difficult problems score really big ! Regular problem sets are due on the date indicated: ***No Late Work Accepted !*** If you haven’t finished the set completely, hand in what you have !

Submitted Work:

Style:

Write-ups should be quite formal. In this class (as in all of life!) your logic, clarity, style and grammar *will count*. Thoroughness, physical insight, and technical facility are all treasured qualities in the treatment of any physics problem. Professional presentation of your work begins here and lasts for the rest of your life. Never hand in scratch work. In general, you will work through a problem several times (occasionally ***many*** times) before deciding that you understand it well enough to draft your submission copy.

Format:

Please use fresh clean paper for your final copy (engineering paper of any tint is excellent for hand written work) and NEVER use the back-side of any sheet. Make sure you identify your name, the date and the set # in addition to the problem number on each sheet. NEVER put more than one problem on any one sheet (i.e. "new problem implies new sheet"). In addition, good format will include a page sequence number in "ratio" style (e.g. 15/27) in the upper right hand corner of each sheet. Most students adopt a stylized "compressed notation" of this information on every sheet following the cover-sheet. At this stage in your career, you should be "aiming" at world standards. Ultimately, the use of LATEX for all your work is highly desirable and you should "shoot" for achieving that proficiency by the end of your college career. Some students prefer to use MATHEMATICA for all purposes. That, too, is perfectly workable.

Portfolio Problems:

There will be three "***Portfolio Problems***" which serve, for Physics, as the equivalents of "short term papers". They are due as given on the problem sheets … about once a month. Please don't put them off! Some techniques in Physics are of such importance that we need to emphasize them. The ones I've chosen for this semester are:

1.) **Numerical Integration** of an Initial Value Problem (in this case F = ma) ,
2.) **Fourier Series** analysis of an oscillation problem , and
3.) **Perturbation Analysis** (you will be offered a set of problems to choose from among – each of these illustrate, in different ways, the amazing power of skillful approximation. Pick one!).

In these problems you will take the problem "further" than usual. You will have the occasion to express yourself both more fully and more speculatively. Show what you can do! In physics, a problem is ***never*** "just a problem". It is an opportunity for exploration, linkage, presentation, alternative viewpoint … and so much more!

Graphing:

Yours is both the "digital" and the "visual" generation ! YOU MUST GRAPH ! Do it at every opportunity! Learning to use graphics for: … numeric solutions, understanding and clarity, and effective presentation … is ESSENTIAL ! And never has it been so easy (and cheap)! Please find a graphing routine you like. I use a low-end one (Logger-Pro) for all simple purposes (including my car's mileage and the family budget plus elementary analysis) and a high-end one (IGOR) for professional-looking "publication ready" graphs and more complex analysis. One popular choice is MATHEMATICA, which is owned by CSUC on a site license – so don't tell me you don't have access. There are tons of good and free graphing routines "out-there", please find one.

I. Introduction to **Newtonian** Mechanics: Chapter 1

2 Weeks
- Fundamentals: *Assumptions* and *Concepts*
- Dimensional Analysis and the forms of a physical equation:
  proportionalities, active and passive equalities. (notes)
- Geometry: Euclidean, Cartesian, Vector (and other) formulations.
- Calculus, Newtonian differential expressions.
- Kinematics in one dimension and *Frames of Reference*
- Newton's laws

II. Significant Problem #1: *Ballistics* Chapter 2

1-2 Weeks
- Standard methods of solution in special cases.
- What are "Numbers" anyway ? Our first inquiry.
  ("complex" numbers are actually simpler!)
- Numerical solutions

III. General Theorems: – Momentum and energy: Chapters 3 & 4

2-3 Weeks
- Momentum conservation implies the Center of Mass!
- Angular Momentum (? …What is this?)
- First integrals and Potential functions, Stability etc.
- Central Forces

IV. Significant Problem #2: *The 1-D Simple (?) Harmonic Oscillator*: Chapter 5

2 Weeks
- Un-driven and Un-damped case: Forms of the solution
- Un-driven but damped case: *Quality Factor:* "**Q**"
- Driven Systems: *Causal Response and Causal Green's Functions*
- Driven Systems: *Steady State Response and Fourier Series*
- Energy, Power, Response-curves and the many meanings of "**Q**" .
- The necessity of complex (better known as *"simple"* !) numbers!
  (i.e. … just "get over it" …!)

V. Significant Problem #3: *Central Force Motion*: Chapter 8

2 Weeks
- General results (importance of center of mass and conservation laws)
- The Kepler Problem: *Kepler's Laws*
- The Kepler Problem: *Advanced Results*

stability, uniqueness, precession, Runge-Lenz vector, mechanical similarity

VI. Technical Unit: Orthogonal Curvilinear Coordinates & Vector Component Relations

(as time permits)
- Orthogonal Curvilinear Coordinates (notes)
- Component symbols and their use: ε_{ijk} , δ_{ij}
- Gradient and Curl

VII. A Critique of Newtonian Mechanics and an Intro to Lagrangian Mechanics: Chapter 7

• A serious critique of Newton …
• The Lagrangian equations of motion - derivation following the *"Principle of Virtual Work"*.
A new point of view: *"degrees of freedom"* ➥**generalized coordinates**.
• conserved quantities, form invariance, general properties.
• Obtaining the forces of constraint, typical elementary problems.
• Elementary problems.
• Non-inertial coordinate frames (again!)