6102- Classical Mechanics II (Spring 2013)

Course Informations *(return to main page)*

- **Textbooks**
  - Arnol'd V.I., (1989), ***Mathematical Methods of Classical Mechanics***, Springer-Verlag,
  - Abraham R., Marsden J.E. (1978), ***Foundations of Mechanics***, London: Benjamin-Cummings.
  - Arnol'd V. I., Kozlov V. V., Neïshtadt A. I., (1988), ***Mathematical Aspects of Classical and Celestial Mechanics***, **3**, Springer-Verlag.
  - Goldstein, H., (2002), ***Classical Mechanics***, Addison Wesley.
  - Landau L. D., Lifshitz L. M., (1975), ***Mechanics***, Amsterdam, Elsevier.

- **Office Hours**

  Office Hours: ***Monday 2:30-3:30pm Skiles 132***.

- **Report** ***(to main page)***

  Each student is requested to choose a topic related to the content of the course, in agreement with the Instructor, for a 20-25 pages written report.
  The content of this report will be explained by the student to the class in a 40 minutes presentation.
  This report will be submitted to the Instructor before the talk and NOT after April 29, 2013.
  This talk will be scheduled during the last three weeks of the semester.
  The evaluation of the written report and of the quality of the talk will provide ***the grade for the Final Exam.***

  To prepare the report:

  1)-**Summary:** a document of 10-15 lines maximum, ***in a pdf format***, including (i) a title, (ii) the author's name, (iii) one or two references (book or article) (iv) a short description. The summary must be sent to the Instructor by email before ***Friday February 15, 2013 at 12:05pm.***

  2)-**Preliminary Report:** it is a document of more than 20 and less than 25 pages, presented in pdf format and sent to the Instructor.
  This preliminary version should be sent before Friday April 5, 12:05pm for corrections and comments. It should be organized as follows
  (i) A title and an abstract (5 lines maximum)
  (ii) An Introduction (2 pages maximum) explaining the problem, some history with references,
  (iii) Various Sections introducing the notations, the framework and
  (iv) At least one Section describing in detail the derivation of one result (either a proof, or a calculation, or the description of an experiment and its results)
  (v) A conclusion, summarizing the results and indicating some prospects.
  (vi) A list of references. ***A special attention will be given by the grader to evaluate whether the references have been read and correctly cited within the text. The instructor will read this preliminary version during the month of April and will send suggestions comments and corrections back to the student.***

3)-**Final Report:** to be sent before ***Monday April 29, 2013 at 6:00pm*** for final evaluation.

Oral Presentation:

The oral presentation will last 35 minutes and it is recommended to use a computer, either a Power Point presentation or a ***pdf*** one. 15 minutes will be used for questions and comments.

The final grade will include an evaluation of the Talk, of the Summary and of the Final Report.

Final Exam

April 29th 2013

The individual report written and presented by each student will be the basis for the final grade.
No formal final exam will be offered.

Course Outline

Completely Integrable Systems	***5 weeks***
- Historical background ***Kepler's Laws, Newton's Principles, gravitation law, planetary motion, first integrals.*** - Coupled Harmonic Oscillators ***Action-Angle variables, vibrational mode distribution.*** - Conserved Quantities and Symmetries ***Liouvill'es integrability, Liouville's Theorem, invariant tori.*** ***Angular Momentum and rotation invariance,*** ***Poisson's brackets, commutation rules, Noether's Theorem.*** - Inverse Spectral Method ***Lax pairs, the Toda lattice, KdV equations, a list of models***	Week 1  nnnn Week 2 Week 3 Week 4 Week 5
Differential Geometry & Mechanics	***4 weeks***
- Manifolds ***Charts, change of charts, tangent and cotangent space,*** ***Phase space, systems with constraints, geometry of speed and momentum.*** - Fiber Bundles ***Vector bundles, sections, connections, horizontal transport, curvature, torsion.*** ***Examples: rolling ball, spinor field, the Hopf fibration, Bloch waves.*** - Differential Calculus ***Differential of functions, 1-forms, 2-forms, n-forms, exterior calculus,*** ***Symplectic forms, Hamilton equations, canonical transformations, Liouville form.*** ***Integration of forms, Stokes Theorem, Poincaré invariants, homology, cohomology.*** ***Berry's phase, Chern numbers, Chern classes, integrality.*** - Group Action ***Lie groups, Lie algebra, commutation rules.*** ***Hamiltonian symmetries, moment map.*** ***Co-adjoint representation as an example of completely integrable system.***	Week 6  Week 7 Week 8 Week 9
Global Properties	***3 weeks***
- Long Time Behavior ***The Poincaré recurrence theorem, concept of ergodicity, the Birkhoff Theorem.*** ***Time and ensemble averaging, foundation of Statistical Mechanics.***	Week 10 

- Phase Space Portrait ***Poincaré section, first return map, computer simulation, orbits.*** ***Periodic orbits, linear stability, Lyapounov exponents, hyperbolicity.*** ***Bifurcation, the Hopf bifurcation, the Ruelle-Takens Theorem.*** - Invariant Tori and Cantori ***Perturbation of invariant tori, the KAM theorem, the Poincaré conjecture,*** ***Aubry-Mather's theory, the Frenkel-Kontorova model, Peierls barrier.***	Week 11 Week 12
Student Report Presentation	***3 weeks***
Each student will be asked tho prepare a report on a topic related with the content of the course and will present his work in front of other in a 35 minute talk and 15 minutes for questions and comments.