MASSACHVSETTS INSTITVTE OF TECHNOLOGY

Joint Subject Offering: 6.946J, 8.351J, 12.620J

Classical Mechanics: A Computational Approach

Red Tape—Fall 2016

Classes: Monday, Wednesday, and Friday 11AM–12N, Room 54-819

Lecturers:

Gerald Jay Sussman, 32-G514, x3-5874, gjs@mit.edu

Jack Wisdom, 54-414, x3-7730, wisdom@mit.edu

Web Page:

`http://groups.csail.mit.edu/mac/users/gjs/6946`

Laboratory: Wednesday, 7PM, Athena classroom, Room 14-0637.

The Laboratory is an integral part of the subject. We expect you to be there. You will need an Athena account to participate in the laboratory. You will be programming in Scheme, using software that we provide. A review of Scheme will be given in the laboratory on Wednesday, 7 September 2016. Be sure you have an Athena account.

Readings: The readings for this subject will be taken from the book entitled *Structure and Interpretation of Classical Mechanics, second edition.* We will provide a schedule of assignments, with readings for each lecture. We will assume that you read the material before the lecture.

Assignments: We expect that you will turn in an assignment on Friday of each week. The problems are assigned from the book. Many assignments will require the use of the computer.

Projects: Some of the assigned work will be extended projects that may require work over a substantial period.

Grades: The grades for this subject will be determined by a combination of classroom participation, homework, and laboratory work. There are no examinations in this subject.

Collaborative work: Many people learn more effectively when they study in small groups and cooperate in various other ways on homework. We are very much in favor of this kind of cooperation *so long as all participants actively involve themselves in all aspects of the work.* When you hand in a paper with your name on it we assume that you are certifying it as your work and that you were involved in all aspects of it. Even if you work with others you should do the writeup yourself, and you should indicate the names of any collaborators for each part of the assignment.

Approximate order of topics

- **Introduction**
  - Mechanics is more than equations of motion
- **Lagrangian Mechanics**
  - Configuration Space and the Principle of Stationary Action
  - Lagrange Equations
  - Hamilton's Principle
  - Coordinate transformations
  - Rigid Constraints
  - Non-Uniqueness of Lagrangian and Total Time Derivatives
  - State and evolution - Chaos
  - Conserved quantities and Noether's Theorem
- **Rigid Bodies**
  - Kinematics; existence of angular velocity
  - Moments of inertia
  - Generalized coordinates for rigid bodies
  - Motion of a free rigid body; Euler's equations
  - Axisymmetric top
  - Spin-orbit coupling
  - Quaternions
- **Hamiltonian Mechanics**
  - Hamilton's equations
  - Legendre transformation
  - Hamiltonian action and Poisson brackets
  - Phase space reduction
  - Evolution in phase space
  - Surfaces of Section
  - Henon-Heiles
  - Lyapunov Exponents—Variational Equations
  - Liouville theorem

- **Phase Space Structure**
  - Linear stability
  - Homoclinic tangle
  - Integrable systems
  - Poincare-Birkhoff theorem
  - Invariant Curves
- **Canonical Transformations**
  - Point transformations
  - General canonical transformations
  - Generating functions
  - Hamilton-Jacobi Equation
  - Time Evolution is Canonical
  - Lie transforms
- **Perturbation Theory**
  - Perturbation theory with Lie series
  - Small Denominators
  - Non-linear resonance
  - Resonance overlap - transition to chaos
  - Secondary resonances and Inverted Pendulum

Sign-up sheet

We need the following information from you to help us organize this subject. Please fill out this form and hand it in at the end of the class today.

Name:

Email:

Course:

Year:

MIT address:

Phone:

Have you used a functional programming language? (Such as Lisp, Scheme, Python, Ruby, Haskill, ML, etc.)

Have you had a class in Hamiltonian mechanics?

How did you find out about this class?