Physics 308: Advanced Classical Mechanics
Fall 2007

Study Suggestions for the Final Exam

Format of the exam:

The format of the final exam is very similar to that of Quizes 1 and 2. It is a closed book exam, but a formula reference is provided on the first four pages of the exam. You have up to 3 hours to complete your solutions. Part I is short answer. Part II consists of two mandatory questions. Part III is a choice of two out of the four problems. Though the exam covers the entire course, it focuses on the second half, especially Chapter 8 onward.

The exam is long, so don’t worry if you cannot finish.

Suggestions for study:

You have already received some very big hints for the final:

1. **Particle on a cone.** No one chose to do this problem on Part III of Quiz 2. It will come back on the final. At least some aspect of the final exam problem differs or goes beyond what was asked on Quiz 2.

2. **Coupled oscillators.** There will be a coupled oscillator problem. Two degrees of freedom is the limit of what I would consider reasonable to do in the time allotted. Think of the various possibilities for what you could build with masses and springs.

Items 1 and 2 are the single most important topics to understand for the final. Next on the list of priorities:

3. **The effective (radial) potential energy** $U_{rad}(r)$ **in the context of Kepler orbits.** See Ex. 8.1 and 8.2 in Taylor. (See also Taylor Problem 8.12, which was Problem 3 on Set 9.)

4. **Coriolis force.** You should be able to determine the Coriolis force on an object moving north/south/east/west at various points on the earth’s surface.
Finally, after you are happy with your preparation for items 1–4, here is an assortment of other topics to think about:

We devoted two weeks to Hamiltonian mechanics. It’s a safe bet that this will appear on the final, though there will be some choice involved.

5. **Hamiltonian mechanics:** You should be able to write down the Hamiltonian for simple systems like the harmonic oscillator, or derive the Hamiltonian from the Lagrangian for more exotic (but still one dimensional) systems. (Remember that the generalized momentum is \( p_i \equiv \partial L/\partial \dot{q}_i \). In simple cases this reduces to the usual momentum, but in exotic cases we need the definition.) Given a Hamiltonian, you should be able to write down the corresponding Hamilton’s Equations.

6. **Canonical transformations:** Given a system with a single pair of phase space coordinates \( q \) and \( p \), you should be able to check whether a transformation to new phase space coordinates \( Q \) and \( P \) is canonical.

Some other possible topic/hints:

7. **Lagrangian in various coordinate systems.** Starting from the expression for \( ds^2 \) in a coordinate system on the list of formulae, what is the corresponding expression for the kinetic energy in these coordinates?

8. **Damped harmonic oscillations, no driving force.** In the solutions for overdamped, underdamped and critically damped motion, two constants appear. These constants can be determined by the initial conditions \( x(t_0) \) and \( \dot{x}(t_0) \) at some time \( t_0 \). Alternatively, one might try to specify \( x(t) \) at two different times \( t_1 \) and \( t_2 \). In this case, there might or might not be a solution.

9. **Oscillation about a point of stable equilibrium.** (This comes up only in one isolated part of one problem on the final, but I thought I’d mention it, since it goes back to Quiz 1 material.) Near a point of stable equilibrium \( x_0 \), we can Taylor expand the potential energy or restoring force to find the effective spring constant \( k \). For example, expanding the force as \( F(x) \approx F'(x_0)(x-x_0) \) gives \( k = -F'(x_0) \) and expanding the potential energy gives \( U(x) \approx U(x_0) + \frac{1}{2} U''(x_0)(x-x_0)^2 \) gives \( k = U''(x_0) \).

Finally, take a look at the formula sheet handed out in class on Friday. See if you understand these formulae and how to apply them.