

GUIDE TO EXAM AND PROBLEMS:

We really only have time for about two problems.

- You should review HW1-8
- You should review the relevant problems on the 2018 and 2019 midterm and final. I have put these online.

The ideal problem is not easy to write, but would go something like this: – write down the hamiltonian or lagrangian, identify first integrals, conserved quantities, symmetries, analyze the motion in a harmonic approximation, how would non-linearities change the motion. Other good problems might examine rotational motion, or the dynamics in the presence rapidly oscillating external forces, etc. The problems will necessarily be easier and shorter than the homework. A list of topics is given below.

1 Lagrangian, Hamiltonians, Action

- Write down action, vary it to determine the equations of motion both in the Lagrangian and Hamiltonian setup.
- Recognize cyclic coordinates, first integrals etc.
- Use the symmetries of the problem to identify conserved quantities. Noether theorem.

2 Motion in a central potential and scattering

- Know how to arrive at Kepler's Laws and other central force problems. How to use the integrals of motion to simplify the motion.
- Understand what is the cross section and how to compute it.

3 Oscillations:

- For a coupled system of oscillators (with and without external forces). Find the Lagrangian, know how to break up the system into normal modes – including when external forces are present, and in simplified cases when dissipation is present.
- Know how to use the retarded Green function to find solutions of the driven harmonic oscillator, and or transients, with and without dissipation.
- Analyze non-linear oscillations. Understand how to shift the frequency, or change the amplitude as a function of time etc, to eliminate secular divergences.
- Pondermotive approximation.

4 Rotational Motion and non-inertial frames

- Motion in non-inertial frames coriolis forces etc.
- How to describe the rotation of a rigid body
- How to find the moment of inertia tensor and why we care about it. Parallel axis theorem.
- The euler equations.
- Motion of a symmetric top.

5 General Math:

- Dimensional reasoning
- How to solve first order equations of the form (with M a positive definite symmetric matrix)

$$\begin{pmatrix} m_{11} & m_{12} \\ m_{12} & m_{22} \end{pmatrix} \frac{d}{dt} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} F_1 \\ F_2 \end{pmatrix} \quad (1)$$

- How to solve second order equations of the form (with M a positive definite symmetric matrix)

$$\begin{pmatrix} m_{11} & m_{12} \\ m_{12} & m_{22} \end{pmatrix} \frac{d^2}{dt^2} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} F_1 \\ F_2 \end{pmatrix} \quad (2)$$