Physics 8.03
Vibrations and Waves

Lecture 1

Organizational things

- Staff
  - Nergis Mavalvala (L)
  - Alexander van Oudenaarden (R)
  - Matt Borthwick (R)
  - Chris Kouvaris (tutor)
- Grades
  - 10 problem sets = 25% total
    - Posted on Sundays, due at 4pm Fridays
  - 3 in-class exams = 15% each
    - Exam reviews will be held, look at web site for details
  - 1 final exam = 30%
    - During finals week
  - Take-home experiments (incomplete)

Outline of course

- Mechanical oscillators
  (and some electrical circuit analogs)
- Mechanical waves
- Electromagnetic waves
- Optical phenomena

Why oscillations and waves?
And all semester long?

- Because oscillations in nature are ubiquitous (and we know how to solve the eqn. of motion)
  - Periodic motion + circular orbits
  - Optical, electrical and mechanical structures + resonance
- Because waves pervade the universe
  - Mechanical waves (sound, water, phonons…)
  - Electromagnetic waves (radiation, visible light…)
  - Matter waves (atoms, BECs, QM)
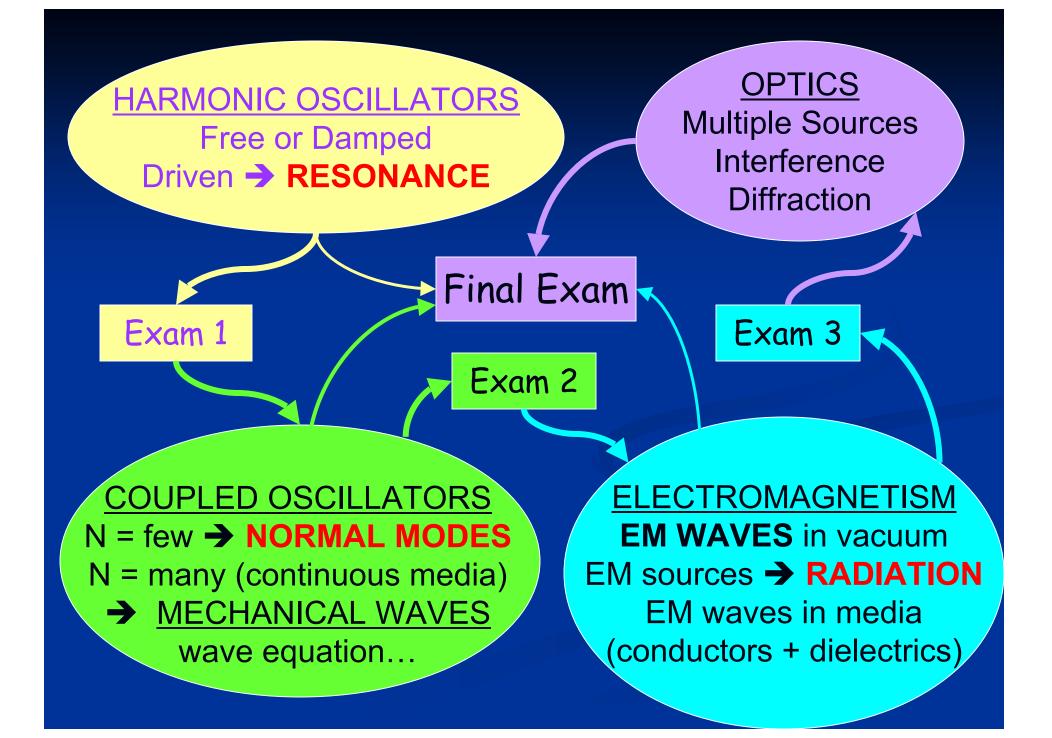 - Gravitational waves (neutron stars, black holes, GR)

Phasing in music

- Steve Reich: "Violin Phase" (1967)
- A repeated segment of music is played simultaneously by three violins at slightly different tempos (phases)
- Musically gifted folks will notice that the violins come in and out of phase periodically
- He discovered this when he was trying to play back an identical music piece with two tape recorders that ran at slightly different speeds (?)

Formation of a BEC

- When a gas of atoms is cooled to absolute zero, the atoms congregate in the ground state
- The wave functions of the particles overlap and their phases get locked to each other
- All the atoms are in a single quantum state and form a strong matter wave
- The laser power changes the shape of the potential in which the atoms are trapped

Gravitational waves from a pair of black holes

- **Two black holes coalesce**
  - The emerging GWs carry signature of the quasi-normal oscillation mode of the final black hole

Today:
SIMPLE HARMONIC MOTION

- Announcements
- Equation of motion for SHM
- Solutions to equation of motion
  - Harmonic functions
  - Complex numbers
  - (Periodic functions)
- Energy in oscillators
- Conservative forces, quadratic potentials and SHM
- Approximate SHOs: the pendulum