Concluding Remarks about Phys 410

In this course, we have …

Developed a quantitative and precise description of classical mechanical systems

Re-visited Newtonian mechanics at a slightly higher level

- Momentum, angular momentum, work, kinetic energy, conservative forces, potential energy

Detailed examination of some interesting forces:

- drag force (both linear and quadratic in v)
- Lorentz force
- Rocket motion
- Central force
- Coriolis and Centrifugal forces

Learned about inertial and non-inertial reference frames,
and how they affect the equations of motion (Coriolis, centrifugal)

Lagrangian and Hamiltonian mechanics

- generalized coordinates, constraints, calculus of variations, Lagrange's and Hamilton's equations

The physics of small oscillations about stable equilibrium points

- Driven damped oscillations, resonance, Fourier series

Considered orbits for inverse-square-law forces, and scattering

Concluding Remarks about Phys 410

Rotation of rigid bodies about an arbitrary axis

Inertia tensor, principal moments, principal axes

The motion of coupled oscillators

Normal modes, normal coordinates

Considered nonlinear mechanics: Driven damped pendulum: attractors, harmonics, sub-harmonics, period doubling bifurcations, Feigenbaum number, sensitivity to initial conditions, the Lyapunov exponent, period-doubling cascade, chaos, bifurcation diagrams, state-space orbits, and the Poincaré section

Relativistic Mechanics: Kinematics and Dynamics

Time dilation, length contraction, Lorentz transformation, Lorentz invariance
four-vectors (momentum, force)

A Graduate Classical Mechanics class covers essentially the same topics…

Some “Take-Away” Skills for Phys 410

Recognize $m\ddot{\vec{r}} = -k\,\vec{r}$ and recall the general solution …

Know how to write down vector quantities in terms of components in various coordinate systems (Cartesian, spherical, cylindrical), and take dot products, cross products, etc.

Identify constraints, choose appropriate generalized coordinates, write down the
Lagrangian, find the conjugate momenta, write down the Hamiltonian. Solve them.
Exploit ‘ignorable coordinates’ and the associated conservation laws (know what is conserved)

Recognize ‘small oscillations’ situations and attack them systematically (normal modes, coords)

Transform a 2-body problem to the CM + relative coordinates, solve each problem systematically

Recognize and exploit conservation laws (know when they apply and when they do not)

Recognize the presence of nonlinearity and utilize nonlinear dynamics concepts to understand the motion

Understand that details matter in nonlinear dynamics, but systematic analysis is still useful

Understand and utilize the power of simple principles to explain complex physical phenomena
Einstein’s postulates of special relativity