Classical Mechanics

Phys105A, Winter 2007

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Midterm

- Midterm is this Thursday Feb 15, 9:30–10:45
- The material is Taylor’s Chapters 1–4: "Newton's Laws of Motion", "Projectiles and Charged Particles", "Momentum and Angular Momentum", and "Energy".
- No electronics are allowed, it is not open book, but you are allowed a letter sized, double sided ‘cheat sheet’.

Chapter 1: "Newton"

Things you need to know: vector notation, vector operations, rules for taking derivatives in $\mathbb{R}^3$, Newton's 3 laws, definition of an inertial frame, linear momentum, conservation of linear momentum as a consequence of Newton's laws, polar coordinates, how to do rewrite Newton's laws in polar coordinates, cylindrical coordinates, solutions to simple differential equations like $d^2x/dt^2 = kx$.

Pay special attention to: why and how you use polar coordinates and the unit vectors $\mathbf{e}_r$ and $\mathbf{e}_\varphi$ that come with it (especially look at 1.7 with its $d\mathbf{e}_r/dt = d\varphi/dt\ \mathbf{e}_\varphi$ and $d\mathbf{e}_\varphi/dt = -d\varphi/dt\ \mathbf{e}_r$ and Example 1.2).

Chapter 2: “Projectiles…”

Things you need to know: how to set up differential equations that capture various kinds of friction, how to solve such equations, how to extract crucial quantities from such equations without solving them completely (for example terminal speed), using the vector product to model forces that act perpendicular on the velocity of particles, using complex variables to model 2d motion.

Pay special attention to: the various kinds of complex valued functions and their nice behavior when taking derivatives, how to rescale variables/use substitution to get standard forms of equations (including integrals), separation of variables.

Chapter 3: “Momentum…”

What you need to know: Linear momentum, conservation of linear momentum, center of mass, angular momentum (of one and several particles), central forces, conservation of angular momentum, Keppler’s 2nd Law, angular momentum around the CM.

Pay special attention to: the fact that angular momentum depends on the chosen origin, the usage of the ‘trick’ $\mathbf{r}\times\mathbf{r}=\mathbf{0}$ in various guises, the reason of the conservation laws and their requirements (central forces in the case of angular momentum), the reason why we are allowed to use the CM as a summary.

Chapter 4: “Energy”

What you need to know: Kinetic energy (as expressed in vector notation), work, path (in)dependency of work, adding of forces, Work-KE Theorem, requirements for a force to be conservative, potential energy, U = –work, total mechanical energy, E=T+U, conservation of total mechanical energy, use of gradient in $\mathbf{F} = -\nabla U$, use of curl in $\nabla\times\mathbf{F}=\mathbf{0} \Longleftrightarrow \mathbf{F}$ is conservative, time dependent U, how to reason about and solve one dimensional systems, central forces that are conservative, spherical coordinates, ∇ for cylindrical and spherical coordinates, energy of multiple particles.

General Advice

Calculators are not allowed, so you can expect the questions to be phrased in terms of variables, try to get a clear idea of what the requirements are for the various conservation laws (see elastic versus inelastic collisions), when dealing with non Cartesian coordinates: train yourself to understand what is going on and why ("Do you know where your origin is?").

The homework is a good indication of the kind of questions that you can expect.

First solve the questions that you know you can answer, then work on the others.