Review Notes for chapters 1 – 4 : Kinematics

Introduction
These chapters examine the basics of ***Kinematics*** in 1,2, and 3 dimensions.

I **Concepts:** … you should know and understand:

1. **Dimensionality**, *Units* and *changing Units*.
2. **Vectors,** their properties, and the basics of vector algebra.
3. The **Kinematic-Ladder** of *displacement*, *velocity* and *acceleration*.

II **Capabilities:** ... *you should be able to ...*
* change units in arbitrary pure and compound dimensions
* use scientific notation properly (recall: every number has *3 parts*!)
* employ vectors to simplify your geometrical reasoning
* use the *vector dot product* to compute *components*
* differentiate 'down' and integrate 'up' the kinematic ladder
* simplify kinematic problems by changing your *Reference Frame*
* explain the importance of using *Radian Measure* for angles
* translate between the digital (tabular), graphical (visual), and algebraic (symbolic) expressions of our knowledge
* explain the meaning of *Random* and *Systematic* uncertainties and list their characteristic properties
* explain *Mean* and *Standard Deviation* in reference to the *Normal Distribution*

III **Techniques:** ... *Technical Tools you will need ...*
* familiarity with basic trig-functions, law of sines and law of cosines
* familiarity with basic calculus and a sense of the simple underlying idea which clarifies it.

Typical Problems to Know About (derive! don't memorize)...
* boats on rivers, airplanes in winds
* ballistics: free fall and projectiles
* circular motion

Review Notes for chapters 5 – 8: Dynamics

Introduction
The central content of these chapters is the statement of Newton's laws and the development of the necessary machinery for their use. The central abstract concept defined here is ***" Force".*** ***Energy,*** in its appearance as "Kinetic Energy" is introduced by way of the central concept "***Work***". The central derived result is the ***Work-Energy Theorem.***

I **You should know and understand:**
1. What an inertial reference frame is.
2. The *operational definition* of the comparison of two masses.
3. The *operational definition* of the comparison of two forces.
4. **Newton's three laws in order.**
5. What a free-body diagram is and how to use it.

II **Capabilities:** ... *you should be able to ...*

* draw a free-body diagram for simple settings.
* apply Newton's laws to an arbitrary free-body diagram to generate the necessary *Component Equations*.

…*Typical Problems to Know About (derive! don't memorize)...*
* masses on inclined planes: normal forces
* ropes and pulleys: tensions
* static and kinetic friction
* circular motion of a point mass
* cars on banked turns

Review Notes for chapters 9 – 12: Conservation Laws

Introduction

The central content of these chapters is the statement of the of the ***Three Great Conservation Laws***. Newton's laws (including the Third Law) are expressed in terms of ***Momentum***. We include, here, the key concept of "***Center of Mass***" (which derives from momentum) and use it as a central problem solving tool.
Energy, in its manifold appearances: i.e. "Kinetic" as well as many different "Potential" forms (e.g. gravitational, elastic, electrostatic etc.), is introduced, again, by way of the central concept "***Work***". It is important to focus, again, on the central derived result viz. the ***Work-Energy Theorem*** which leads to the expression of the ***Conservation of Energy*** in an Isolated System . We derive the conservation of ***Linear Momentum*** and ***Angular Momentum*** straight from Newton's second two laws using our vector tools.

Review Notes for chapters 9-11: Energy&Momentum

I **You should know and understand:**

1. What an ***Isolated System*** is
2. Newton's second and third laws in terms of momentum
3. *Conservative* vs. *Dissipative* forces. When is a force conservative?
4. The *operational and "Physical Integral" definitions* of the Potential Function which attends any Conservative Force
5. What totally elastic and totally inelastic collisions are
6. What the *Center-of-Mass* is
7. What the *Center-of-Mass* Reference Frame is

II **Capabilities:** ... *you should be able to state and use ...***:**

1. The (differential) definition of ***Work***
2. The line integral expression for the ***Work*** done along any path
3. The derivation of the **3-D *Work Energy Theorem***
4. The 3-D expression for Kinetic Energy

... *you should be able to ...*
* apply the conservation of energy to simple settings.
* apply the conservation of momentum to simple settings
* apply center of mass reasoning to simple settings
* find the potential energy function for a given conservative force

Typical Problems to Know About (derive! don't memorize)...

- * masses sliding on inclined planes … with and without friction!
- * ballistics
- * masses sliding along curves
- * basic collision analysis (find outgoing velocities from incoming)
- * center of mass view of collisions

Review Notes for chapter 12: Rotation

Introduction

The central content of this chapter is the statement of Newton's laws for Rotational Dynamics. A central derived result is the "Third Great Conservation Law" the ***Conservation of Angular Momentum*** in an Isolated System .

I You should know and understand:

1. What the ladder of rotational kinematic quantities is, in *exact analogy* to translational systems.
2. Moment of inertia **I**, and Torque
3. Newton's second law for rotation
4. The Parallel Axis Theorem
5. The Laws of Equilibrium
6. How to compute the Angular Momentum of a given system about a chosen axis.

... you should be able to ...

- * apply Newton's ***Law of Rotation*** to simple settings.
- * apply the ***Conservation of Angular Momentum*** to simple settings
- * combine the universal laws of ***Rotation*** and ***Translation of C.M.***

Typical Problems to Know About (derive! don't memorize)...

- * rolling masses on inclined planes … with and without friction!
- * ballistic pendulums

... Technical Tools you will need ...

- * familiarity with the concept ***lever arm***
- * familiarity with the ***vector cross product***
- * familiarity with *angular velocity*, *angular momentum* and *torque* as vector quantities.

Review Notes for chapters 13 – 15: Special Problems

Introduction
The central content of these chapters is the introduction of a few very special problems of "archetypal" interest. These problems will serve as starting models for a very wide range of further problems to come. Among these are ***Gravitation, Static Equilibrium,*** and ***S.H.O.*** i.e. ***Simple Harmonic Oscillation.***

I You should know and understand:

1. what the Universal Law of Gravitation is
2. What the Potential Function for gravitation is
3. the importance of "spherical shapes" for gravitation
4. The characteristic "shape" of the law yielding SHO
5. The basic vocabulary of SHO
6. The requirements for Static Equilibrium

... *you should be able to* ...
* apply the law of gravitation to simple settings.
* state Kepler's three laws
* apply the law of SHO to simple settings
* apply the laws translation and rotation to obtain the equations of equilibrium in simple settings

Typical Problems to Know About (derive! don't memorize!)...
* escape velocity for a projectile
* orbital motion for a satellite
* simple pendulums

... *Technical Tools you will need* ...
* familiarity with sines and cosines as solutions of Newton's laws

General Semester Skills ...

* Vector expression of Geometry
* Trigonometry: double angle formulae & laws of sines and cosines
* Dimensions Express the *dimension* of each of the following in terms of the three basic ones:
  { Momentum, Force, Torque, Energy, Power, Tension, Angular Momentum, Angle, Velocity, Acceleration, Impulse, Work, Area, Volume, Speed, Pressure, α, ω, θ ,τ}
* Parameterization of "Physical" Integrals to produce "Analytic" Integrals
* Uncertainty Analysis
* Scientific Notation and Simple Estimation