Lecture 4 1/22/03

This lecture introduces dynamics in one-dimension.

Section 4.1 Overview

~~Reactilinear~~ Rectilinear Motion = Motion in a straight line.

<u>Newton's Laws</u>

II. Defn Force - Time rate of change of momentum

$$F \equiv \frac{dp}{dt}$$

I. Isolated object experiences no force.

III. Momentum is conserved in each interaction pair

$$\Delta p_{12} + \Delta p_{21} = 0$$

$$\Rightarrow \frac{\Delta p_{12}}{\Delta t} + \frac{\Delta p_{21}}{\Delta t} = 0$$

$$F_{12} = -\vec{F}_{21}$$

<u>What are we doing?</u>

(mass constant)

Solve $F = \dfrac{dp}{dt} \overset{*}{=} m\dot{v} = m\ddot{x}$

for

<u>Trajectory</u> - $x(t)$

<u>Velocity</u> $v(t)$ or $v(x)$

<u>Turning Points</u> (x_t) $\dot{x} = 0$

<u>Terminal Velocity</u> (v_t) $\dot{v} = 0$

What can we find out from trajectory?

Work Done on Particle – $W = \int_{x_i \to x_f} F \, dx$

Rate Work is Done (Power)

$$P = \frac{dW}{dt} = \frac{d}{dt} \int_{x_i}^{x} F \, dx$$

$$= \frac{dx}{dt} \frac{d}{dx} \int_{x_i}^{x} F \, dx = v F$$

Impulse $\Delta p = \int_{t_i}^{t_f} F \, dt$

Rate momentum is transferred

$$\frac{d \Delta p}{dt} = \frac{d}{dt} \int F \, dt = F$$

Different Ways to Write $F = ma$

$$a = \ddot{x} = \dot{v} = m \frac{dv}{dx} \frac{dx}{dt} \qquad (1)$$

$$= m v \frac{dv}{dx} \qquad (2)$$

$$= \frac{1}{2} m \frac{d v^2}{dx} \qquad (3)$$

$$W = \int F\,dx = \int \frac{1}{2} m \frac{dv^2}{dx}\,dx$$

$$= \int \frac{1}{2} m\,dv^2 = T_f - T_i$$

change in kinetic energy.

Section 4.2 - Potential

The force can be separated into a reversible and non-reversible parts

$$F = F_{rev} + F_{non}$$

Reversible ~~Forces~~ (Conservative) Forces - When system is returned to original configuration, universe returns to original configuration.

$\Longrightarrow$ State of system independent of trajectory.

Potential Energy - $V(x)$

$$F_{rev} = -\frac{dV}{dx}$$

Example $\quad$ F_g is conservative

$$F_g = -mg$$

$$V(x) = mgx$$

$$F_g = -\frac{dV}{dx} = -mg$$

4.2 (b)

$$T(x) - T(x_i) = \int_{x_i}^{x} F\,dx$$

$$= \int_{x_i}^{x} -\frac{dV}{dx}\,dx + \int F_{non}\,dx$$

$$= -V(x) + V(x_i) + \int F_{non}\,dx$$

$$E = T + V = T(x_i) + V(x_i) + \underbrace{\int F_{non}\,dy}_{\text{Energy provided to or dissipated by system.}}$$

Section 4.3 – Viscous Forces

The chapter introduces a new kind of force, ~~the~~ air drag

$$F_{drag} = c_1 V + c_2 V_2^2$$

$c_1 = 1.55 \times 10^{-4} D$

$c_2 = 0.22 \quad D^2$

arbitrary units

$D \equiv$ Diameter.

<u>Caveats</u>

* For smooth spheres
* Fluid Flow is complex
* Depends on fluid density.