CHAPTER 5

Center of Mass

$$x_c = \frac{\sum m_i x_i}{\sum m_i}$$

$$x_c = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3 + \cdots + m_n x_n}{m_1 + m_2 + m_3 + \cdots + m_n}$$

$$y_c = \frac{\sum m_i y_i}{\sum m_i}$$

$$y_c = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3 + \cdots + m_n y_n}{m_1 + m_2 + m_3 + \cdots + m_n}$$

$$z_c = \frac{\sum m_i z_i}{\sum m_i}$$

$$z_c = \frac{m_1 z_1 + m_2 z_2 + m_3 z_3 + \cdots + m_n z_n}{m_1 + m_2 + m_3 + \cdots + m_n}$$

Torque

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$|\tau| = rF sin\theta$$

$$\tau = \begin{vmatrix} i & j & k \\ x & y & z \\ F_x & F_y & F_z \end{vmatrix}$$

Conditions of Equilibrium

1st:

$$\sum \vec{F}_{net} = 0$$

$$\sum \vec{F}_x = 0, \sum \vec{F}_y = 0, \sum \vec{F}_z = 0$$

2nd:

$$\sum \vec{\tau} = 0$$

$$\sum \vec{\tau}_{\text{clockwise}} + \sum \vec{\tau}_{\text{anti-clockwise}} = 0$$

Angular Momentum:

$$\vec{L} = \vec{r} \times \vec{P}$$

$$|L| = rPsin\theta$$

$$L = \begin{vmatrix} i & j & k \\ x & y & z \\ P_x & P_y & P_z \end{vmatrix}$$

Torque in terms of angular momentum and time:

$$\vec{\tau} = \frac{\Delta\vec{L}}{\Delta t}$$

CHAPTER 6

Universal Law of Gravitation

$$F = \frac{Gm_1m_2}{r^2}$$

Value of 'g' at surface of Earth

$$g = \frac{GM_E}{R_E^2}$$

Value of 'g' at some height 'h'

$$g = \frac{GM_E}{(R_E+h)^2}$$ (Use this formula for any altitude)

$$g' = \left(1 - \frac{2h}{R_E}\right) g$$ (When $h \ll R_E$)

Value of 'g' with depth 'd'

$$g' = \left(1 - \frac{d}{R_E}\right) g$$

Artificial Gravity

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{R}}$$

CHAPTER 7

Work $W = FS\cos\theta$

Kinetic Energy $K.E = \frac{1}{2}mv^2$

Work-Energy Equation $W = \Delta K.E$

Gravitational Potential Energy $P.E = mgh$

Power $P = \frac{W}{t}$; $P = Fv\cos\theta$

Law of Conservation of Energy (When there is no air friction)

loss of potential energy = gain of kinetic energy

Law of Conservation of Energy (When there is air friction)

loss of potential energy − work done against friction = gain of kinetic energy

$$mgh = \frac{1}{2}mv^2 + fh$$

Also,

mechanical energy = heat energy + losses

chemical Energy = mechanical energy + losses

burning fuel = kinetic energy + potential energy

Absolute Gravitational Potential Energy

$$(P.E)_{abs} = -\frac{GM_E m}{r}$$

CHAPTER 8

Simple Harmonic Motion $a \propto -x$

Mass Spring System

Acceleration $a = -\frac{k}{m}x$

Time Period $T = 2\pi\sqrt{\frac{m}{k}}$

Frequency $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

Projection of Uniform Circular Motion

Acceleration $a_x = a_c \cos\theta$

Displacement $x = x_0 \cos\theta$

Velocity $V_x = \omega\sqrt{x_0^2 - x^2}$

Kinetic Energy $K.E = \frac{1}{2}k(x_0^2 - x^2)$

Potential Energy $P.E = \frac{1}{2}kx^2$

Simple Pendulum

Time Period $T = 2\pi\sqrt{\frac{l}{g}}$

Wave Equation $V = \nu\lambda$

Fundamental Frequency and Harmonics

1st Harmonics or Fundamental Frequency

$$\nu_1 = \frac{V}{2L}$$

2nd Harmonics or 1st overtone

$$\nu_2 = \frac{V}{L}$$

$$\nu_2 = 2\nu_1$$

3rd Harmonics or 2nd overtone

$$\nu_3 = \frac{3V}{2L}$$

$$\nu_3 = 3\nu_1$$

For N harmonics

$$\nu_n = \frac{nV}{2L}$$

$$\nu_n = n\nu_1$$

Sonometer

$$\nu_n = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$$

Speed of Sound

$$V = \sqrt{\frac{\gamma P}{\rho}}$$

$$V_T = 332\sqrt{\frac{T_K}{273}}$$

Doppler's Effect

Case 1

a) $v' = \frac{V+V_0}{V} v$

b) $v' = \frac{V-V_0}{V} v$

Case 2

a) $v' = \frac{V}{V-V_S} v$

b) $v' = \frac{V}{V+V_S} v$

Case 3

a) $v' = \left(\frac{V+V_0}{V-V_S}\right) v$

b) $v' = \left(\frac{V-V_0}{V+V_S}\right) v$

Open Pipe (Open at both Ends)

$$v_1 = \frac{V}{2L}$$

$$v_n = nv_1$$

Closed Pipe (Closed at both Ends)

$$v_1 = \frac{V}{2L}$$

$$v_n = nv_1$$

Open at one end / Closed at one end

$$v_1 = \frac{V}{4L}$$

$$v_n = (2n-1)v_1$$

CHAPTER 9

Thomas Young's Double Slit Experiment

For Bright Fringe

Condition $dsin\theta = m\lambda$

Position $y_m = \frac{m\lambda L}{d}$

Fringe Spacing $\Delta y = \frac{\lambda L}{d}$

For Dark Fringe

Condition $dsin\theta = \left(m + \frac{1}{2}\right)\lambda$

Position $y_d = \left(m + \frac{1}{2}\right)\frac{\lambda L}{d}$

Fringe Spacing $\Delta y = \frac{\lambda L}{d}$

Thin Film Interference

Condition for Bright Fringe $2nt = \left(m + \frac{1}{2}\right)\lambda$

Condition for Dark Fringe $2nt = m\lambda$

Newton's Ring

For Bright Ring

$$r_N = \sqrt{\left(N - \frac{1}{2}\right)\lambda R}$$

When angle is given then,

$$r_N = \sqrt{\frac{\left(N - \frac{1}{2}\right)\lambda R}{\cos\theta}}$$

For Dark Ring

$$r_m = \sqrt{m\lambda R}$$

When angle is given then,

$$r_m = \sqrt{\frac{m\lambda R}{\cos\theta}}$$

Diffraction by Diffraction Grating

$$d\sin\theta = m\lambda$$

X-Ray Diffraction (Bragg's Law)

$$m\lambda = 2d\sin\theta$$

CHAPTER 10

Thin lens formula (For Concave and Convex Both)

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Power of a Lens $$P = \frac{1}{f_{(meters)}}$$

Lens Combination

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$
$$P = P_1 + P_2$$

Magnification

Linear: $$M = \frac{q}{p}, \qquad M = \frac{h_i}{h_o}$$

Angular: $$M = \frac{\beta}{\alpha}$$

Simple Microscope

$$M = \frac{d}{f} + 1$$

Compound Microscope

$$M = \frac{q_o}{p_o}\left(1 + \frac{d}{f_e}\right)$$
$$L = q_o + p_e$$

Astronomical Telescope

$$M = \frac{f_o}{f_e}$$
$$L = f_o + f_e$$

Galilean Telescope

$$M = \frac{f_o}{f_e}$$
$$L = f_o - f_e$$