PHYSICS I: An Outline

Chap 1. Introduction

1. Significant Figures
2. Units (MKS, CGS, SI, British)
3. Prefixes: Mega, Kilo, Deci, Centi, Milli, Micro, Nana
4. Dimensional Analysis
5. Trigonometry
   $\sin\theta = \frac{\text{opp}}{\text{hyp}},\ \cos\theta = \frac{\text{adj}}{\text{hyp}},$
   $\tan\theta = \frac{\text{opp}}{\text{adj}}$
6. Vectors and Scalars
   $\mathbf{V} = V_x\mathbf{i} + V_y\mathbf{j} + V_z\mathbf{k}$
7. Vector Addition
8. Vector Components
   $V_x = V\cos\theta,\ V_y = V\sin\theta$
   $V = \sqrt{V_x^2 + V_y^2}\ ,\ \tan\theta = \frac{Vy}{Vx}$

Chap 2. Kinematics -1D

1. Average, Instantaneous
2. Position, Displacement, velocity, acceleration
   $\bar{v} = \frac{\Delta x}{\Delta t},\ v = \lim_{\Delta t\to 0}\frac{\Delta x}{\Delta t}\ a = \frac{\Delta v}{\Delta t}$
3. Uniform Acceleration
   $x = \bar{v}t,\ \bar{v} = \frac{1}{2}(v + v_0),$
   $v = v_0 + at,\ v^2 = v_0^2 + 2ax,$
   $x = v_0 t + \frac{1}{2}at^2.$
4. Falling Bodies $a = -g$.
5. Graphical Analysis

Chap 3. Kinematics - 2D

1. Position, Displacement, Velocity, Acceleration
2. Motion in 2D
3. Projectile Motion
   $(a_x = 0,\ a_y = -g)$.

Chap 4. Forces and Newton's Laws of Motion

1. Law of Inertia, Mass
2. $F = ma$
3. Action-Reaction
4. Gravitational Force
   $F = \frac{Gm_1m_2}{r^2}$
5. Weight, Normal Force
   $W = mg,\ N,\ g = \frac{GM}{R^2}$
6. Apparent Weight
   $W_{app} = m(g + a)$
7. Forces as Vectors
8. Free Body Diagrams
9. Friction $f = \mu_s N$
10. Equilibrium and Non-Equilibrium Problems
    $\Sigma\mathbf{F} = \mathbf{0}, \Sigma\mathbf{F} = m\mathbf{a}$

Chap 5. Dynamices of Uniform Circular Motion

1. Circular Motion $v = \frac{2\pi r}{T}$
2. Centripetal Acceleration
   $a_C = \frac{v^2}{r},\ F_C = \frac{mv^2}{r}$
3. Unbanked Curves
   $v = \sqrt{\mu_s gr}$
4. Banked Curves $\tan\theta = \frac{v^2}{rg}$
5. Circular Orbits $v = \sqrt{\frac{GM}{R}}$

Chap 6. Work and Energy

1. $W = Fs\cos\theta$
2. $W = \Delta KE,\ KE = \frac{1}{2}mv^2$
3. $PE = mgh$ (gravitation)
4. Conservation of Energy:
   $E = \frac{1}{2}mv^2 + mgh = \text{const}$
5. Nonconservative Forces
   $W_{nc} = \Delta KE + \Delta PE$
6. Power $\bar{P} = \frac{W}{t},\ \bar{P} = F\bar{v}$

Chap 7.Impulse and Momentum

1. Momentum $\mathbf{p} = m\mathbf{v}$
2. Impulse $\mathbf{J} = \bar{\mathbf{F}}\Delta t$
3. Impulse Momentum Thm
   $\bar{\mathbf{F}}\Delta t = \Delta\mathbf{p}$
4. Conservation of Linear Momentum,
5. Elastic Collisions
   $v_{f1} = \frac{m_1 - m_2}{m_1 + m_2}v_{01},$
   $v_{f2} = \frac{2m_1}{m_1 + m_2}v_{02}$
6. Center of Mass
   $x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$, etc.

Chap 8. Rotational Kinematics

1. Radian Measure
2. Arclength $s = r\theta$
3. Kinematics
   $\omega = \omega_0 + \alpha t,$
   $\theta + \omega_0 t + \frac{1}{2}\alpha t^2,$
   $\omega^2 = \omega_0^2 + 2\alpha\theta$
4. Centripetal/Tangential
   $v_T = r\omega,\ a_T = r\alpha$
5. Rolling motion
   $v_{cm} = v_T = r\omega$

Chap 9. Rotational Dynamics

1. Torque: $\tau = Fl = I\alpha$.
2. Moments of Inertia
   $I = mr^2$, (particle)
   $I = \frac{1}{12}ML^2$ (rod),
   $I = \frac{2}{5}MR^2$ (sphere),
   $I = \frac{1}{2}MR^2$ (disk),
   $I = MR^2$ (hoop)
3. Center of Gravity
4. Angular Momentum:
   $L = I\omega$
5. Work/Kinetic Energy
   $W = \tau\theta,\ KE_{rot} = \frac{1}{2}I\omega^2$
   $K_{TOT} = KE_{rot} + KE_{trans}$
   (Rolling Sphere = $\frac{7}{10}mv^2$)
6. Equilibrium
   $\Sigma\mathbf{F} = 0,\ \Sigma\,\text{t} = 0$

Chap 10. Elasticity and Simple Harmonic Motion

1. Stress = $\frac{F}{A}$, Strain = $\frac{\Delta L}{L_0}$
2. Elastic Moduli $\frac{F}{A} = Y\frac{\Delta L}{L_0}$
3. Springs $F = -kx, \omega = \sqrt{\frac{k}{m}}$,
   $PE = \frac{1}{2}kx^2$
4. Pendula $\omega = \sqrt{\frac{g}{L}}$
5. Frequency: $\omega = 2\pi f = \frac{2\pi}{T}$

Chap 11. Fluids

1. Mass Density: $m = \rho V$,
2. Pressure: $P = \frac{F}{A}$
3. Pressure at a Depth:
   $P = P_0 + \rho gh$
4. Pascal's Principle $P_o = P_i$
5. Archimedes' Principle
   $B = \rho_f gV$

Chap 12. Temperature, Thermal Expansion and the Ideal Gas Law

1. Temperature Scales
2. Thermal Expansion
   $\Delta L = \alpha L_0\Delta T,\ \Delta V = \beta V_0\Delta T$
3. Heat Energy
   $Q = mc\Delta T,\ Q = mL$
4. Mechanical Equiv of Heat

Chap 13. The Transfer of Heat

1. Conduction $Q = \frac{kA\Delta Tt}{L}$
2. Convection
3. Radiation $Q = e\sigma T^4At$

Chap 14. Ideal Gas Law and Kinetic Theory

1. Molecular Mass, Moles
2. $PV = nRT = NkT$
3. $\frac{1}{2}(mv^2)_{ave} = \frac{3}{2}kT$
   $\Rightarrow v_{rms} = \sqrt{\frac{3kT}{m}}$
4. $\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}Nk\Delta T$

Chap 15. Thermodynamics

1. Isobaric $W = P\Delta V,$
2. Isothermal $W = nRT\ln\frac{V_2}{V_1}$
3. 1st Law $\Delta U = Q - W$
4. Molar Sp Heat $Q = nC\Delta T$
5. $C_p - C_v = R,\ \gamma = \frac{C_p}{Cv}$
6. Isochoric, Adiabatic
7. $PV^\gamma = \text{const}$ (adiabatic)
8. 2nd Law
9. $e = \frac{W}{Q_H} = 1 - \frac{Q_C}{QH} = 1 - \frac{T_C}{T_H}$
10. Carnot engines
11. Entropy: $\Delta S = \frac{Q}{T},\ \Delta S > 0$

Chap 16. Waves and Sound

1. $v = f\lambda$
2. $v = \sqrt{\frac{F}{\mu}}$ (string)
3. $v \approx 331 + 0.60T$ (air)
4. loudness, pitch, audible range
5. Intensity $I = \frac{\bar{P}}{A} \propto \{A^2, \frac{1}{r^2}\}$
6. $\beta(\text{dB}) = 10\log\frac{I}{I_0}$
7. $y = A\sin(kx \pm \omega t)$
8. $k = \frac{2\pi}{\lambda},\ \omega = \frac{2\pi}{T} = 2\pi f$

Chap 17. Superposition and Interference

1. Superposition, reflection, refraction, interference
2. Diffraction $\lambda = D\sin\theta$
3. Standing Waves - String
   $f = n\frac{v}{2L},\ n = 1, 2, \ldots$
4. Standing Waves - open and closed tubes

Miscellaneous Constants

$g = 9.8\ \text{m/s}^2$
$G = 6.67\times10^{-11}\text{Nm}^2/\text{kg}^2$
$N_A = 6.02\times10^{23}\ \text{mol}^{-1}$
$R = 8.315\ \text{J/(mol-K)}$
$k = 1.38\times10^{-23}\ \text{J/K}$
$\sigma = 5.67\times10^{-8}\ \text{W/(m}^2\text{-K}^4\text{)}$
1 cal= 4.184 J
$0^o\text{K} = -273.15^o\text{C}$
1 atm = $1.013 * 10^5\ \text{N/m}^2$
$L_f = 80$ kcal/kg
$L_v = 540$ kcal/kg
$\rho_{water} = 1.0 * 10^3\ \text{kg/m}^3$
$\rho_{air} = 1.29\ \text{kg/m}^3$
$v_{air} = 331\ \text{m/s}\ (0^o\text{C})$
$v_{air} = 343\ \text{m/s}\ (20^o\text{C})$
$I_0 = 1.0\times10^{-12}\ \text{W/m}^2$
$c_{water} = 1.0\ \text{kcal/(kg-}^o\text{C)}$