PHYSICS I: An Outline

Chap 1. Introduction

1. Significant Figures
2. Units (MKS, CGS, SI, British)
3. Dimensional Analysis
4. Trigonometry
   $\sin\theta = \frac{\text{opp}}{\text{hyp}}$, $\cos\theta = \frac{\text{adj}}{\text{hyp}}$, $\tan\theta = \frac{\text{opp}}{\text{adj}}$
5. Vectors and Scalars
   $\mathbf{V} = V_x\mathbf{i} + V_y\mathbf{j} + V_z\mathbf{k}$
6. Vector Addition
7. 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. Displacement, velocity, acceleration, derivatives
   $\bar{v} = \frac{\Delta x}{\Delta t},\ v = \lim_{\Delta t\to 0}\frac{\Delta x}{\Delta t}$
3. Uniform Acceleration
   $v = v_0 + at,\ \bar{v} = \frac{1}{2}(v + v_0)$,
   $v^2 = v_0^2 + 2ax$,
   $x = v_0 t + \frac{1}{2}at^2$.
4. Falling Bodies $a = -g$.

Chap 3. Kinematics - 2D

1. Displacement, Velocity, Acceleration
2. 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
   $F_{app} = m(g + a)$
7. Vector Forces, Free Body Diagrams
8. Friction $f = \mu_s N$
9. Equilibrium and Non-Equilibrium
   $\Sigma\mathbf{F} = \mathbf{0}, \Sigma\mathbf{F} = m\mathbf{a}$

Chap 5. Dynamics 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. Banked Curves $\tan\theta = \frac{v^2}{rg}$
4. Circular Orbits $v = \sqrt{\frac{GM}{R}}$
5. Weightlessness

Chap 6. Work and Energy

1. $W = \mathbf{F} \cdot \mathbf{d} = Fd\cos\theta$
2. $W = \Delta KE,\ KE = \frac{1}{2}mv^2$
3. $PE = mgh$(gravitation)
4. Conservation of Energy:
   $E = \frac{1}{2}mv^2 + mgh =$const
5. Power $\bar{P} = \frac{W}{t},\ P = Fv$

Chap 7.Impulse and Momentum

1. Momentum $\mathbf{p} = m\mathbf{v}$
2. Impulse $\mathbf{I} = \bar{\mathbf{F}}\Delta t = \Delta\mathbf{p}$
3. Conservation of Linear Momentum, collisions

Chap 8. Rotational Kinematics

1.Arclength $s = r\theta$

2.Kinematics
$\omega = \omega_0 + \alpha t$,
$\theta + \omega_0 t + \frac{1}{2}\alpha t^2$,
$\omega^2 = \omega_0^2 + 2\alpha\theta$

3. Centripetal/Tangential Acceleration $a_T = r\alpha$
4. Rolling motion $v = r\omega$
Conservation of Linear Momentum, collisions

Chap 9. Rotational Dynamics

1. Torque: $\tau = Fl = I\alpha$.
2. Moment of Inertia
   $I = mr^2$, (particle) and rod, sphere, cylinder
3. Parallel Axis Theorem
4. Center of Gravity
5. Angular Momentum:
   $L = I\omega$
6. Kinetic Energy
   $KE_{rot} = \frac{1}{2}I\omega^2$
   $KE_{rot} + KE_{trans}$
   (Rolling Sphere = $\frac{7}{10}mv^2$)
7. Equilibrium
   $\Sigma\mathbf{F} = 0,\ \Sigma\,\mathrm{t} = 0$

Chap 10. Elasticity and Simple Harmonic Motion

1. stress = $\frac{F}{A}$, strain = $\frac{\Delta L}{L_0}$
2. Elastic Moduli
3. Springs $F = -kx, \omega = \sqrt{\frac{k}{m}}$,
   $PE = \frac{1}{2}kx^2$
4. Pendula $\omega = \sqrt{\frac{g}{L}}$

Chap 11. Fluids

1. $m = \rho V,\ P = \frac{F}{A}$
2. $P = P_0 + \rho gh$
3. Pascal's Principle $P_o = P_i$
4. Archimedes' Principle
   $B = \rho_f gV$
5. Flow rate: $Q = Av$
6. Continuity
7. Bernouli's Equation
   $P + \frac{1}{2}\rho v^2 + \rho gh =$ const.

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

1. Temperature Scales
2. Expansion $\Delta L = \alpha L_0\Delta T$,
   $\Delta V = \beta V_0\Delta T$
3. $Q = mc\Delta T,\ Q = mL$

Chap 13. The Transfer of Heat

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

Chap 14. Ideal Gas Law and Kinetic Theory

1. $PV = nRT = NkT$
2. $\frac{1}{2}(mv^2)_{ave} = \frac{3}{2}kT$
   $\Rightarrow v_{rms} = \sqrt{\frac{3kT}{m}}$
3. $U = \frac{3}{2}nRT = \frac{3}{2}NkT$

Chap 15. Thermodynamics

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

Chap 16. Waves and Sound

1. $v = f\lambda$
2. $v = \sqrt{\frac{F}{\mu}}$ (string)
3. $v = \sqrt{\frac{B}{\rho}}$, $v \approx 331 + 0.60T$
4. loudness, pitch, audible range
5. Intensity $I = \frac{\bar{P}}{A} \propto \{A^2, \frac{1}{r^2}\}$
6. β(dB) $= 10\log\frac{I}{I_0}$
7. $y = A\sin(kx \pm \omega t)$
8. $k = \frac{2\pi}{\lambda},\ \omega = \frac{2\pi}{T} = 2\pi f$
9. Doppler Effect
   $f' = f(\frac{v+v_o}{v-v_s})$
   (signs - towards)

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

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