PHYSICS I: An Outline

Chap 1. Introduction
1. Significant Figures, Uncertainty
2. Units (MKS, CGS, SI, British)
3. Dimensional Analysis
4. Estimation

Chap 2. Kinematics -1D
1. Average, Instantaneous
2. Displacement, velocity, acceleration, derivatives
$\bar{v} = \frac{\Delta x}{\Delta t}$, $v = \frac{dv}{dt}$
3. Uniform Acceleration
$v = v_0 + at$, $\bar{v} = \frac{1}{2}(v + v_0)$,
$v^2 = v_0^2 + 2a(x - x_0)$,
$x = x_0 + v_0 t + \frac{1}{2}at^2$.
4. Falling Bodies $a = -g$.

Chap 3. Kinematics - 2-3D
1.Vectors and Scalars:
$\mathbf{V} = V_x\mathbf{i} + V_y\mathbf{j} + V_z\mathbf{k}$
2. Addition, Scalar Multiplication, Length
3. Components
$V_x = V\cos\theta$, $V_y = V\sin\theta$.
$V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = \frac{Vy}{Vx}$.
4. Displacement, Velocity, Acceleration
5. Projectile Motion
$(a_x = 0,\ a_y = -g)$.
6. Circular Motion: Uniform
$a_R = \frac{v^2}{r}$, $T = \frac{2\pi r}{v}$, $f = \frac{1}{T}$
Nonuniform: $a_T = \frac{dv}{dt}$
7. Angular Variables

Chap 4. Newton's Laws of Motion
1. Law of Inertia
2. $F = ma$
3. Action-Reaction
4. Weight, Normal Force
$W = mg$, N
5. Vector Forces, Free Body Diagrams

Chap 5. Friction, Circular Motion, ...
1. Friction $f = \mu_s N$
2. Circular Motion
$a_R = \omega^2 r$, $F = m\omega^2 r$
3. Banked Curves

Chap 6. Gravitation
1. $F = \frac{Gm_1m_2}{r^2}$, $g = \frac{GM}{R^2}$
2. Weightlessness
3. Kepler's Laws of Motion
(3rd $\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$)

Chap 7. Work and Energy
1. $W = \mathbf{F}\cdot\mathbf{d} = Fd\cos\theta$
2. $W = \int_a^b \mathbf{F}\cdot d\mathbf{l}$
3. $W = \Delta KE$, $KE = \frac{1}{2}mv^2$

Chap 8. Energy Conservation
1. $U = mgy$ (gravitation),
$U = \frac{1}{2}kx^2$ (spring)
2. $\Delta U = -\int_1^2 \mathbf{F}\cdot d\mathbf{l}$, $F = -\frac{dU}{dx}$
3. Conservation of Energy:
$E = \frac{1}{2}mv^2 + U$, .
4. Power
$\bar{P} = \frac{W}{t}$, $P = \frac{dW}{dt} = \mathbf{F}\cdot\mathbf{v}$

Chap 9. Conservation of Linear Momentum
1. Center of Mass:
$\mathbf{r}_{cm} = \frac{1}{M}\Sigma m_i\mathbf{r}_i$,
$\mathbf{r}_{cm} = \frac{1}{M}\int \mathbf{r}\, dm$
2. Motion $M\mathbf{r}_{cm} = \Sigma m_i\mathbf{r}_i$,
$\mathbf{v}_{cm} = \frac{1}{M}\Sigma m_i\mathbf{v}_i$,
3. $\mathbf{F}_{ext} = M\mathbf{a}_{cm}$, $\mathbf{F}_{ext} = \frac{d\mathbf{P}}{dt}$,
4. Conservation of Linear Momentum, collisions
5. Impulse: $J = \Delta mv = F\Delta t$

Chap 10-11. Rotation
1. Kinematics
$\omega = \omega_0 + \alpha t$,
$\theta + \omega_0 t + \frac{1}{2}\alpha t^2$,
$\omega^2 = \omega_0^2 + 2\alpha\theta$
2. $\omega = \frac{d\theta}{dt}$, $\alpha = \frac{d\omega}{dt}$
3. Torque: $\boldsymbol{\tau} = \mathbf{r}\times\mathbf{F} = I\alpha$.
4. Moment of Inertia
$I = mr^2$, (particle) and rod, sphere, cylinder
5. Parallel Axis Theorem
6. Angular Momentum:
$\mathbf{L} = \mathbf{r}\times\mathbf{p} = I\omega$, $\tau = \frac{d\mathbf{L}}{dt}$
7. Conservation Law
8. $KE_{rot} + KE_{trans}$
(Rolling Sphere = $\frac{7}{10}mv^2$)

9. $\mathbf{A}\times\mathbf{B} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$

Chap 12. Equilibrium
1. $\Sigma\mathbf{F} = 0$, $\Sigma\tau = 0$
2. stress = $\frac{F}{A}$, strain = $\frac{\Delta L}{L_0}$

Chap 13. Hydrostatics
1. $m = \rho V$, $P = \frac{F}{A}$
2. $\frac{dP}{dy} = -\rho g \Rightarrow P = P_0 + \rho gh$
3. Pascal's Principle $P_o = P_i$
4. Archimedes' Principle
$B = \rho_f gV$

Chap 14. Hydrodynamics
1. Flow rate: $Q = Av$
2. Continuity
3. Bernouli's Equation
$P + \frac{1}{2}\rho v^2 + \rho gh = \text{const.}$

Chap 15. Oscillations
1. Hooke's Law $F = -kx$
2. $m\ddot{x} + kx = 0 \Rightarrow \ddot{x} + \omega^2 x = 0$
3. $x(t) = a\sin\omega t + b\cos\omega t$,
$x(t) = A\cos(\omega t + \phi)$
4. $\omega = \sqrt{\frac{k}{m}}$ (spring),
$\omega = \sqrt{\frac{g}{L}}$ (pendulum)
5. Energy
$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$
6. Physical Pendulum
$T = 2\pi\sqrt{\frac{I}{mgh}}$

Chap 16. Wave Motion
1. $v = \lambda f$
2. $v = \sqrt{\frac{T}{\mu}}$ (string)
3. Intensity $I = \frac{\bar{P}}{A} \propto \{A^2, \frac{1}{r^2}\}$
4. $D = D_M\sin(kx \pm \omega t)$
5. $k = \frac{2\pi}{\lambda}$, $\omega = \frac{2\pi}{T} = 2\pi f$
6.Superposition, reflection, refraction, interference, diffraction
7.Standing Waves - String
$\lambda_n = \frac{2L}{n}$, $n = 1, 2, \ldots$

Chap 17. Sound
1. $v = \sqrt{\frac{B}{\rho}}$, $v \approx 331 + 0.60T$
2. loudness, pitch, audible range
3. $\beta(\text{dB}) = 10\log\frac{I}{I_0}$
4. Standing Waves - open and closed tubes
5. Beats
6. Doppler Effect $f' = f(\frac{v+v_o}{v-v_s})$
(signs - towards)
7. Shock Waves

Chap 18. Temperature, Thermal Expansion and the Ideal Gas Law
1. Expansion $\Delta L = \alpha L_0\Delta T$,
$\Delta V = \beta V_0\Delta T$
2. $PV = nRT = NkT$

Chap 19. Kinetic Theory of Gases
1. $\frac{1}{2}(mv^2)_{ave} = \frac{3}{2}kT$
$\Rightarrow v_{rms} = \sqrt{\frac{3kT}{m}}$
2. $N = \int_0^\infty f(v)dv$,
$f(v) = 4\pi N\left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-mv^2/2kT}$

Chap 20. Heat
1. Mechanical Equiv of Heat
2. $U = \frac{3}{2}NkT$
3. $Q = mc\Delta T$, $Q = mL$
4. Conduction: $\frac{dQ}{dt} = -kA\frac{dT}{dx}$
5. Radiation: $\frac{\Delta Q}{\Delta t} = e\sigma AT^4$

Chap 21. The First Law of Thermodynamics
1. $W = \int PdV$, $W = nRT\ln\frac{V_2}{V_1}$
2. $\Delta U = Q - W$
3. $C_p - C_v = R$, $\gamma = \frac{C_p}{Cv}$
4. isothermal, isobaric, adiabatic
5. $PV^\gamma = \text{const}$ (adiabatic)

Chap 22. The Second Law of Thermodynamics
1. $e = \frac{W}{|Q_H|} = 1 - |\frac{Q_L}{Q_H}|$
2. Carnot engines
3. Kelvin-Planck, Clausius
4.$\oint\frac{dQ}{T} = 0$ (reversible)
5. Entropy: $dS = \frac{dQ}{T}$
6.$\Delta S > 0$

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)