PHY 101 College Physics Outline

Ch. 1. Introduction

1. Significant figures.
2. Units (MKS, CGS, 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.
6. Vector Addition.
7. Vector Components, $V_x = V\cos\theta$, $V_y = V\sin\theta$, $V = \sqrt{V_x^2 + V_y^2}$, $\tan\theta = \frac{V_x}{V_y}$.

Ch. 2. Kinematics-1D

1. Displacement, velocity, acceleration.
2. Average, Instantaneous values.
3. $\bar{v} = \frac{\Delta x}{\Delta t}$, $v = \lim_{\Delta t\to 0}\frac{\Delta x}{\Delta t}$.
4. Uniform acceleration,
5. Kinematic Equations, $v = v_0 + at$, $x = \bar{v}t$, $\bar{v} = \frac{1}{2}(v_0 + v)$, $v^2 = v_0^2 + 2ax$, $x = v_0 t + \frac{1}{2}at^2$.
6. Free fall, $a = -g$.

Ch. 3. Kinematics-2D

1. Displacement, Velocity, Acceleration
2. Projectile Motion ($a_x = 0, a_y = -g$)

Ch. 4. Forces and Newton's Laws of Motion

1. Law of Inertia, Mass.
2. $F = ma$.
3. Action-Reaction.
4. Gravitational Force,
$$F = G\frac{m_1 m_2}{r^2}.$$
5. Weight, Normal force, $W = mg, N, g = \frac{GM}{R^2}$.
6. Apparent Weight, $W_{app} = m(g + a)$.
7. Vector Forces, Free Body Diagrams.
8. Friction $f = \mu_s N$.
9. Equilibrium and Non-equilibrium,
$$\sum \mathbf{F} = \mathbf{0}, \quad \sum \mathbf{F} = m\mathbf{a}$$

Ch. 5. Uniform Circular Motion

1. Circular Motion, $v = \frac{2\pi r}{T}$.
2. Centripetal Acceleration, $a_c = \frac{v^2}{r}, \quad F_c = \frac{mv^2}{r}$.
3. Banked Curves, $\tan\theta = \frac{v^2}{rg}$.
4. Circular Orbits, $v = \sqrt{\frac{GM}{R}}$.
5. Weightlessness.

Ch. 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,
$$E = \frac{1}{2}mv^2 + mgh = \text{const.}$$
5. Power, $\bar{P} = \frac{W}{t}$, $P = Fv$.

Ch. 7. Impulse and Momentum

1. Momentum, $\mathbf{p} = m\mathbf{v}$.
2. Impuulse, $\mathbf{I} = \mathbf{F}\Delta t = \Delta\mathbf{p}$.
3. Conservation of Linear Momentum.
4. Elastic/Inelastic Collisions.

Ch. 8. Rotational Kinematics

1. Arclength, $s = r\theta$.
2. Kinematics, $\omega = \omega_0 + \alpha t$, $\theta = \bar{\omega}t$, $\bar{\omega} = \frac{1}{2}(\omega_0 + \omega)$, $\omega^2 = \omega_0^2 + 2\alpha\theta$, $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$.
3. Centripetal/Tangential Acceleration, $a + t = r\alpha$.
4. Rolling motion, $v = r\omega$.

Ch. 9. Rotational Dynamics

1. Torque, $\tau = F\ell = I\alpha$.
2. Moments of Inertia, $I = mr^2$ (particle), and rod, sphere, hoop, cylinder.
3. Parallel Axis Theorem.
4. Center of Gravity.
5. Angular Momentum, $L = I\omega$.
6. Kinetic Energy, $KE_{\text{rot}} = \frac{1}{2}I\omega^2$, $KE = KE_{\text{trans}} + KE_{\text{rot}}$. Rolling sphere,$KE = \frac{7}{10}mv^2$.
7. Equilibrium,
$$\sum \mathbf{F} = \mathbf{0}, \quad \sum \tau = \mathbf{0}.$$

Ch. 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, $\omega = \sqrt{\frac{g}{L}}$.

Ch. 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. Archimede's Principle, $B = \rho_f gh$.
5. Flow Rate,$Q = Av$.
6. Bernoulli's Equation,
$$P + \frac{1}{2}\rho v^2 + \rho gh = \text{const.}$$

Ch. 12. Temperature, Thermal Expansion, and Heat energy

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

Ch. 13. The Transfer of Heat

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

Ch. 14. Ideal Gas Law and Kinetic Theory

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

Ch. 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. $C_p - C_v = R$, $\gamma = C_p/C_v$.
5. Isothermal, isobaric, isochoric, adiabatic.
6. PV^γ =const (adiabatic).
7. 2nd Law, $\Delta S \geq 0$.
8. $e = \frac{W}{Q_H} = 1 - \frac{Q_C}{Q_H}$, $e\text{max} = 1 - \frac{T_C}{T_H}$.
9. Carnot Engines (reversible).
10. Entropy: $S = \frac{\Delta Q}{T}$.

Ch. 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. $\beta(\text{dB}) = 10\log\frac{I}{I_0}$.
7. $y = A\sin(kx \pm \omega t)$, $k = \frac{2\pi}{\lambda}, \omega = \frac{2\pi}{T} = 2\pi f$.
8. Doppler Effect, $f' = \frac{v + v_0}{v - v_0}f$ (towards).

Ch. 17. Superposition and Interference

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

Constants

1. $g = 9.8$ m/s^2
2. $G = 6.67 \times 10^{-11}$ Nm^2/kg^2
3. $N_A = 6.02 \times 10^{23}$ mol^{-1}
4. $R = 8.315$ J/(mol-K)
5. $k = 1.38 \times 10^{-23}$ J/K
6. $\sigma = 5.67 \times 10^{-8}$ W/(m$^2-$K^4)
7. 1 cal = 4.184 J.
8. 1 atm $= 1.013 \times 10^5$ N/m^2
9. $L_f = 80$ kcal/kg, $L_v = 540$ kcal/kg.