Physics 1401
Formula Sheet

Chapter 2: One Dimensional Kinematics

- $\Delta x \equiv x_f - x_i$
- $\text{average speed} \equiv \dfrac{\text{total distance traveled}}{\text{total time}}$

  $v_{av} \equiv \dfrac{\Delta x}{\Delta t} = \dfrac{x_f - x_i}{t_f - t_i}$
- $v \equiv \lim_{\Delta t \to 0} v_{av} = \lim_{\Delta t \to 0} \dfrac{\Delta x}{\Delta t}$
- $a_{av} \equiv \dfrac{\Delta v}{\Delta t} = \dfrac{v_f - v_i}{t_f - t_i}$
- $a \equiv \lim_{\Delta t \to 0} a_{av} = \lim_{\Delta t \to 0} \dfrac{\Delta v}{\Delta t}$
- Constant linear acceleration
  - $v = v_0 + at$
  - $x = x_0 + \dfrac{1}{2}(v_0 + v)t$
  - $x = x_0 + v_0 t + \dfrac{1}{2}at^2$
  - $v^2 = v_0^2 + 2a(x - x_0)$

Chapter 5: Newton's Laws of Motion

- $\sum \vec{F} = m\vec{a}$
- $W = mg$

Chapter 6: Applications of Newton's Laws

- $f_s \le \mu_s N$
- $f_k = \mu_k N$
- $|\vec{F}| = kx$.
- $a_{cp} = \dfrac{v^2}{r}$

Chapter 7: Work and Kinetic Energy

- $W \equiv Fd\cos\theta$
- $K \equiv \dfrac{1}{2}mv^2$
- $W_{net} = \Delta K$
- $W = \dfrac{1}{2}kx^2$
- $P = \dfrac{W}{t} = Fv$

Chapter 8: Potential Energy and Conservation of Energy

- $W_c = -\Delta U$,
- $U_{grav} \equiv mgy$
- $E \equiv K + U$
- $U_{spring} \equiv \dfrac{1}{2}kx^2$
- $W_{nc} = \Delta E$

Chapter 9: Linear Momentum and Collisions

- $\vec{p} \equiv m\vec{v}$
- $\sum \vec{F} = \lim_{\Delta t \to 0} \dfrac{\Delta \vec{p}}{\Delta t}$
- $\left(\sum \vec{F}\right)_{av} = \dfrac{\Delta \vec{p}}{\Delta t}$
- $\vec{I} \equiv \left(\sum \vec{F}\right)_{av} \Delta t$
- $\vec{I} = \Delta \vec{p}$
- $X_{cm} = \dfrac{\Sigma m_i x_i}{\Sigma m_i} = \dfrac{m_1 x_1 + m_2 x_2 + \ldots}{m_1 + m_2 + \ldots}$
- $Y_{cm} = \dfrac{\Sigma m_i y_i}{\Sigma m_i} = \dfrac{m_1 y_1 + m_2 y_2 + \ldots}{m_1 + m_2 + \ldots}$
- $v_{1i} + v_{1f} = v_{2i} + v_{2f}$ (1-D elastic)
- $m_1 \vec{v}_{1i} + m_2 \vec{v}_{2i} = m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f}$

Formula Sheet

Chapter 10: Rotational Kinematics and Energy

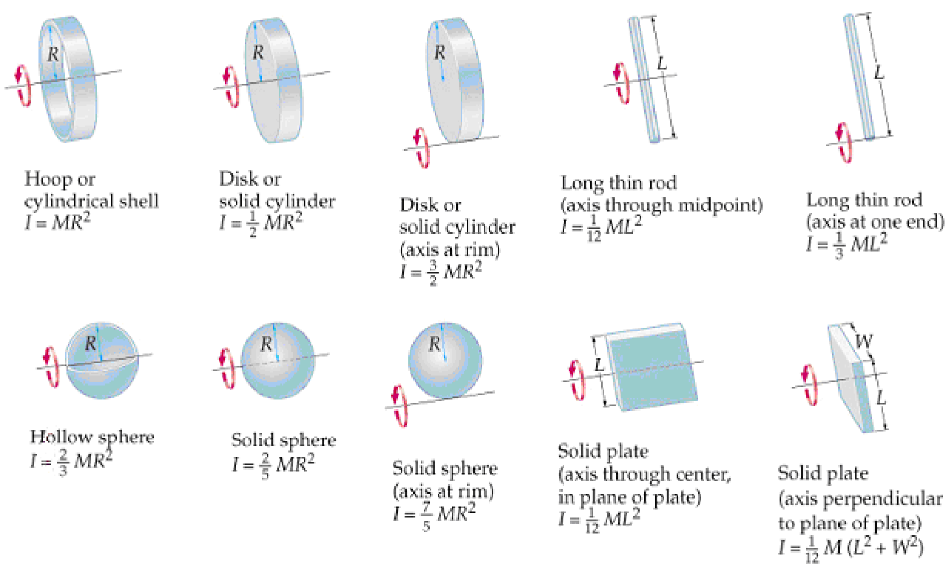
- $\theta \equiv \frac{s}{r}$
- $\Delta\theta \equiv \theta_f - \theta_i$
- $\omega_{av} \equiv \frac{\Delta\theta}{\Delta t} = \frac{\theta_f - \theta_i}{t_f - t_i}$
- $\omega \equiv \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t}$
- $\alpha_{av} \equiv \frac{\Delta\omega}{\Delta t} = \frac{\omega_f - \omega_i}{t_f - t_i}$
- $\alpha \equiv \lim_{\Delta t \to 0} \frac{\Delta\omega}{\Delta t}$
- $T = \frac{2\pi}{\omega}$
- $v_t = r\omega$
- $a_t = r\alpha$
- $a_{cp} = r\omega^2$

- Constant angular acceleration
  - $\omega = \omega_0 + \alpha t$
  - $\theta = \theta_0 + \frac{1}{2}(\omega_0 + \omega)t$
  - $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
  - $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$
- $I \equiv \sum_{i=1}^{N} m_i r_i^2 = m_1 r_1^2 + m_2 r_2^2 + \ldots$

  (N point masses)
- $K_{rot} \equiv \frac{1}{2} I\omega^2$
- $K_{total} = K_{trans} + K_{rot} = \frac{1}{2} M v_{CM}^2 + \frac{1}{2} I_{CM}\,\omega^2$

  (CM is center of mass)

Moments of Inertia for Uniform, Rigid Objects of Various Shapes



Chapter 11: Rotational Dynamics and Static Equilibrium

- $\tau \equiv rF\sin\theta$
- $\Sigma\tau = I\alpha$
- $L \equiv I\omega$.
- $L = rmv\sin\theta$.
- $\Sigma\tau = \frac{\Delta L}{\Delta t}$.
- $W = \tau\theta$

Formula Sheet

Chapter 12: Gravity

- $F_{grav} = G\frac{m_1 m_2}{r^2}$

  $G = 6.67\times10^{-11}\ \frac{\mathrm{N\cdot m^2}}{\mathrm{kg^2}}$
- $U_{grav} = -G\frac{m_1 m_2}{r}$
- $T^2 = \frac{4\pi^2}{GM} r^3$
- $v_e = \sqrt{\frac{2GM}{R}}$

A list of solar system data is located at the end of the formula sheet

Chapter 13: Oscillations about Equilibrium

- $f = \frac{1}{T}$
- $\omega = 2\pi f$
- $T = \frac{2\pi}{\omega}$
- $x = A\cos(\omega t)$
- $v = -A\omega\sin(\omega t)$
- $a = -A\omega^2\cos(\omega t)$
- $\omega = \sqrt{\frac{k}{m}}$
- $T = 2\pi\sqrt{\frac{m}{k}}$
- $T = 2\pi\sqrt{\frac{L}{g}}$

Chapter 14: Waves and Sound

- $v = \lambda f$
- $v = 343\ \mathrm{m/s}$ (speed of sound in air at standard temperature and pressure)
- $f' = \left(\frac{1 \pm \frac{u_o}{v}}{1 \mp \frac{u_s}{v}}\right) f$

Chapter 16: Temperature and Heat

- $T_F = \frac{9}{5}T_C + 32$
- $T_C = \frac{5}{9}(T_F - 32)$
- $T_K = T_C + 273.15$
- $\Delta L = \alpha L_0 \Delta T$
- $\Delta A = 2\alpha A_0 \Delta T$
- $\Delta V = 3\alpha V_0 \Delta T = \beta V_0 \Delta T$
- $1\,\mathrm{cal} = 4.186\ \mathrm{J}$
- $Q = mc\Delta T$

Chapter 17: Ideal Gas Law

- $PV = NkT$
  - $k = 1.38\times10^{-23}\ \mathrm{J/K}$ (Boltzmann's constant)
- $PV = nRT$

  $R = 8.31\ \frac{\mathrm{J}}{\mathrm{mol\cdot K}}$ (universal gas constant)
- $Q = mL$

Formula Sheet

Chapter 18: The Laws of Thermodynamics

- $\Delta U = Q - W$
- $W = P\Delta V$
- $e = 1 - \frac{Q_c}{Q_h}$
- $e_{\max} = 1 - \frac{T_c}{T_h}$
- $\Delta S = \frac{Q}{T}$

Solar System Data

- radius of Earth: $R_E = 6.37 \times 10^6$ m
- radius of Moon: $R_M = 1.74 \times 10^6$ m
- mass of Earth: $M_E = 5.97 \times 10^{24}$ kg
- mass of Moon: 7.35×10^{22} kg
- mass of Sun: 2.00×10^{30} kg
- Earth-Moon distance: 3.84×10^8 m
- Earth-Sun distance: 1.50×10^{11} m