Equation Sheet for PHYS-203A College Physics

(Last updated: August 18, 2020)

1. General mathematics:

   (a) Units:

$$c = 10^{-2}, \quad m = 10^{-3}, \quad \mu = 10^{-6}, \quad n = 10^{-9}, \quad p = 10^{-12}. \tag{1a}$$
$$d = 10^{2}, \quad k = 10^{3}, \quad M = 10^{6}, \quad G = 10^{9}, \quad T = 10^{12}. \tag{1b}$$

   (b) Trigonometry:

$$\sin\theta = \frac{\text{opp. to angle}}{\text{hypotenuse}}, \quad \cos\theta = \frac{\text{adj. to angle}}{\text{hypotenuse}}, \quad \tan\theta = \frac{\text{opp. to angle}}{\text{adj to angle}}. \tag{2}$$

   (c) Pythagorean theorem: $A^2 = A_x^2 + A_y^2$.

   (d) Quadratic equation: $a\,x^2 + b\,x + c = 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}. \tag{3}$$

2. Kinematic equations:

   (a) Constant speed ($a = 0$): $\Delta x = v\Delta t$.

   (b) Constant acceleration:

$$v_f = v_i + a\,\Delta t; \qquad \Delta x = v_i\Delta t + \frac{1}{2}\,a\,\Delta t^2; \qquad v_f^2 = v_i^2 + 2\,a\,\Delta x; \tag{4a}$$
$$\frac{\Delta x}{\Delta t} = \frac{v_i + v_f}{2}; \qquad \Delta x = v_f\Delta t - \frac{1}{2}\,a\,\Delta t^2. \tag{4b}$$

   (c) Acceleration due to gravity: $g = 9.80\,\text{m/s}^2$.

   (d) Time of flight, horizontal range, and maximum height in projectile motion:

$$T = \frac{2v_0\sin\theta_0}{g}, \qquad R = \frac{v_0^2\sin 2\theta_0}{g}, \qquad H = \frac{v_0^2\sin^2\theta_0}{2g}. \tag{5}$$

   (e) Relative velocity: $\vec{\mathbf{v}}_{AB} = \vec{\mathbf{v}}_{AG} - \vec{\mathbf{v}}_{BG}$.

3. Forces:

   (a) Newton's law:

$$\vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_2 + \vec{\mathbf{F}}_3 + \ldots = m\vec{\mathbf{a}}. \tag{6}$$

   (b) Gravitational force:

$$F_G = \frac{Gm_1m_2}{R^2}, \qquad G = 6.67\times10^{-11}\,\text{N}\,\text{m}^2/\text{kg}^2. \tag{7}$$

   (c) Force due to friction:

$$F_f \le \mu_s N, \quad \text{(static)}, \tag{8a}$$
$$F_f = \mu_k N, \quad \text{(kinetic)}. \tag{8b}$$

   (d) Force due to a spring:

$$F = -kx. \tag{8c}$$

   (e) Circular motion:

$$v = \omega r, \qquad \omega = 2\pi f, \qquad f = \frac{1}{T}, \tag{9}$$
$$a_c = \frac{v^2}{r} = \omega^2 r = 4\pi^2 f^2 r = \frac{4\pi^2}{T^2}r \tag{10}$$

4. Work and energy:

   (a) Kinetic energy:

$$K = \frac{1}{2}mv^2 \tag{11}$$

   (b) Work done by a force:

$$W = Fd\cos\theta \tag{12}$$

   (c) Work-kinetic energy theorem:

$$W_1 + W_2 + \ldots = \Delta K \tag{13}$$

   (d) Potential energy due to gravity:

$$U_g = mgh \tag{14}$$

   (e) Potential energy due to spring:

$$U_s = \frac{1}{2}kx^2 \tag{15}$$

   (f) Mechanical energy:

$$E_{\text{mech}} = K + U_g + U_s \tag{16}$$

5. Linear momentum:

$$\vec{\mathbf{p}} = m\vec{\mathbf{v}}, \qquad \vec{\mathbf{p}}_f - \vec{\mathbf{p}}_i = \vec{\mathbf{F}}\Delta t. \tag{17}$$

   (a) Conservation of linear momentum:

$$m_1\vec{\mathbf{v}}_{1i} + m_2\vec{\mathbf{v}}_{2i} + \ldots = m_1\vec{\mathbf{v}}_{1f} + m_2\vec{\mathbf{v}}_{2f} + \ldots. \tag{18}$$

(b) Elastic collision in 1-D:

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) v_{1i} + \left(\frac{2m_2}{m_1 + m_2}\right) v_{2i}, \tag{19}$$

$$v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right) v_{1i} + \left(\frac{m_2 - m_1}{m_1 + m_2}\right) v_{2i}. \tag{20}$$

(c) Center of mass:

$$X_{\mathrm{cm}} = \frac{m_1 x_1 + m_2 x_2 + \ldots}{m_1 + m_2 + \ldots}. \tag{21}$$

6. Rotational dynamics:

(a) Kinematic equations:

i. Constant angular speed ($\alpha = 0$): $\Delta\theta = \omega \Delta t$.

ii. Constant angular acceleration:

$$\omega_f = \omega_i + \alpha\,\Delta t, \qquad \Delta\theta = \omega_i \Delta t + \frac{1}{2}\alpha\,\Delta t^2, \tag{22}$$

$$\omega_f^2 = \omega_i^2 + 2\,\alpha\,\Delta\theta, \qquad \Delta\theta = \omega_f \Delta t - \frac{1}{2}\alpha\,\Delta t^2, \qquad \frac{\Delta\theta}{\Delta t} = \frac{\omega_i + \omega_f}{2}. \tag{23}$$

(b) Rotational inertia (moment of inertia) of a point mass:

$$I = MR^2. \tag{24}$$

(c) Torque:

$$\tau = RF \sin\theta. \tag{25}$$

(d) Rotational kinetic energy:

$$K_{\mathrm{rot}} = \frac{1}{2} I \omega^2. \tag{26}$$

(e) Angular momentum:

$$L = I\omega. \tag{27}$$