

Equation Sheet for PHYS-203B College Physics

(Last updated: September 11, 2025)

This list will evolve during the semester.

1. Electrostatics:

(a) Charge and masses:

$$e = 1.60 \times 10^{-19} \text{ C}, \quad m_e = 9.11 \times 10^{-31} \text{ kg}, \quad m_p = 1.67 \times 10^{-27} \text{ kg}. \quad (1)$$

(b) Coulomb's law:

$$\vec{\mathbf{F}} = \frac{kq_1q_2}{r^2}\hat{\mathbf{r}}, \quad k = \frac{1}{4\pi\epsilon_0}, \quad k = 8.99 \times 10^9 \frac{\text{N m}^2}{\text{C}^2}, \quad \epsilon_0 = 8.85 \times 10^{-12} \frac{\text{C}^2}{\text{N m}^2}. \quad (2)$$

(c) Electric fields:

$$\vec{\mathbf{E}} = \hat{\mathbf{n}} \frac{\sigma}{2\epsilon_0}, \quad \vec{\mathbf{E}} = \hat{\mathbf{n}} \frac{\sigma}{\epsilon_0}, \quad \vec{\mathbf{E}} = \frac{kq}{r^2}\hat{\mathbf{r}}, \quad \vec{\mathbf{F}} = q \vec{\mathbf{E}}. \quad (3)$$

(d) Electric flux and Gauss' law:

$$\Phi_E = \vec{\mathbf{E}} \cdot \vec{\mathbf{A}} = EA \cos \theta, \quad \Phi_E = \frac{Q_{\text{en}}}{\epsilon_0}. \quad (4)$$

(e) Electric potential energy and electric potential:

$$U = \frac{kq_1q_2}{r}, \quad V = \frac{kq}{r}, \quad U = Vq. \quad (5)$$

(f) Capacitance:

$$C = \frac{Q}{V}, \quad U = \frac{1}{2}QV, \quad u = \frac{1}{2}\epsilon_0 E^2. \quad (6)$$

(g) Parallel-plate capacitor:

$$E = \frac{Q}{\epsilon_0 A}, \quad C = \frac{\epsilon_0 A}{d}, \quad V = Ed. \quad (7)$$

Equation Sheet for PHYS-203A College Physics

(Last updated: August 19, 2025)

1. General mathematics:

(a) Units:

$$\begin{aligned} c &= 10^{-2}, & m &= 10^{-3}, & \mu &= 10^{-6}, & n &= 10^{-9}, & p &= 10^{-12}. \end{aligned} \quad (1a)$$

$$d = 10^2, \quad k = 10^3, \quad M = 10^6, \quad G = 10^9, \quad T = 10^{12}. \quad (1b)$$

(b) Trigonometry:

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

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

(d) Quadratic equation: $ax^2 + bx + c = 0$

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

2. Kinematic equations:

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

(b) Constant acceleration:

$$v_f = v_i + a\Delta t; \quad \Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2; \quad v_f^2 = v_i^2 + 2a\Delta x; \quad (4a)$$

$$\frac{\Delta x}{\Delta t} = \frac{v_i + v_f}{2}; \quad \Delta x = v_f\Delta t - \frac{1}{2}a\Delta t^2. \quad (4b)$$

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

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

$$T = \frac{2v_0 \sin \theta_0}{g}, \quad R = \frac{v_0^2 \sin 2\theta_0}{g}, \quad H = \frac{v_0^2 \sin^2 \theta_0}{2g}. \quad (5)$$

(e) Relative velocity: $\vec{v}_{AB} = \vec{v}_{AC} - \vec{v}_{BC}$.

3. Forces:

(a) Newton's law:

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots = m\vec{a}. \quad (6)$$

1

(b) Elastic collision in 1-D:

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

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

(c) Center of mass:

$$X_{\text{cm}} = \frac{m_1 x_1 + m_2 x_2 + \dots}{m_1 + m_2 + \dots}. \quad (21)$$

6. Rotational dynamics:

(a) Kinematic equations:

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

ii. Constant angular acceleration:

$$\omega_f = \omega_i + \alpha \Delta t, \quad \Delta \theta = \omega_i \Delta t + \frac{1}{2} \alpha \Delta t^2, \quad (22)$$

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

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

$$I = MR^2. \quad (24)$$

(c) Torque:

$$\tau = RF \sin \theta. \quad (25)$$

(d) Rotational kinetic energy:

$$K_{\text{rot}} = \frac{1}{2} I \omega^2. \quad (26)$$

(e) Angular momentum:

$$L = I \omega. \quad (27)$$

7. Gravitation:

(a) Gravitational constant: $G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$

(b) Gravitational force versus gravitational field:

$$F_{12} = m_1 g_2, \quad g_2 = \frac{G m_2}{R^2}. \quad (28)$$

(c) Gravitational potential energy versus gravitational potential:

$$U_{12} = m_1 V_2, \quad V_2 = \frac{G m_2}{R}. \quad (29)$$

3

(b) Gravitational force:

$$F_G = \frac{G m_1 m_2}{R^2}, \quad G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2. \quad (7)$$

(c) Force due to friction:

$$F_f \leq \mu_s N, \quad (\text{static}), \quad (8a)$$

$$F_f = \mu_k N, \quad (\text{kinetic}). \quad (8b)$$

(d) Force due to a spring:

$$F = -kx. \quad (8c)$$

(e) Circular motion:

$$v = \omega r, \quad \omega = 2\pi f, \quad f = \frac{1}{T}, \quad (9)$$

$$a_c = \frac{v^2}{r} = \omega^2 r = 4\pi^2 f^2 r = \frac{4\pi^2}{T^2} r \quad (10)$$

4. Work and energy:

(a) Kinetic energy:

$$K = \frac{1}{2} m v^2 \quad (11)$$

(b) Work done by a force:

$$W = Fd \cos \theta \quad (12)$$

(c) Work-kinetic energy theorem:

$$W_1 + W_2 + \dots = \Delta K \quad (13)$$

(d) Potential energy due to gravity:

$$U_g = mgh \quad (14)$$

(e) Potential energy due to spring:

$$U_s = \frac{1}{2} k x^2 \quad (15)$$

(f) Mechanical energy:

$$E_{\text{mech}} = K + U_g + U_s \quad (16)$$

5. Linear momentum:

$$\vec{p} = m\vec{v}, \quad \vec{p}_f - \vec{p}_i = \vec{F}\Delta t. \quad (17)$$

(a) Conservation of linear momentum:

$$m_1 \vec{v}_{1i} + m_2 \vec{v}_{2i} + \dots = m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f} + \dots \quad (18)$$

2

8. Waves and oscillations:

$$T = \frac{1}{f} = \frac{2\pi}{\omega}, \quad \lambda = \frac{2\pi}{k}, \quad v = \lambda f. \quad (30)$$

(a) Simple pendulum:

$$T = 2\pi \sqrt{\frac{L}{g}}. \quad (31)$$

(b) Mass-spring system:

$$T = 2\pi \sqrt{\frac{m}{k}}. \quad (32)$$

(c) Speed of a wave on a string:

$$v = \sqrt{\frac{F_T}{\mu}}. \quad (33)$$

9. Sound waves:

(a) Speed of sound in air:

$$v = 331 + 0.6T, \quad (34)$$

measured in m/s, where T is the temperature in $^{\circ}\text{C}$. $v = 343 \text{ m/s}$ at 20°C .

(b) Resonance in strings and tubes:

$$L = n \frac{\lambda}{2}, \quad L = (2n - 1) \frac{\lambda}{4}, \quad n = 1, 2, 3, \dots \quad (35)$$

(c) Intensity in decibels:

$$\beta = 10 \log \left(\frac{I}{I_0} \right), \quad I_0 = 10^{-12} \frac{\text{W}}{\text{m}^2}, \quad I = \frac{\text{Power}}{\text{Area}}, \quad (36)$$

measured in decibels.

(d) Doppler effect:

$$f' = f \frac{v_0 \pm v_D}{v_0 \pm v_S} \quad (37)$$

4