

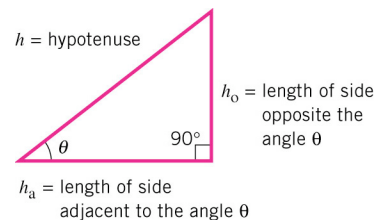
PHYSICS 201 — FORMULA SUMMARY — MODULE 1

Quadratic Equation

$$ax^2 + bx + c = 0 \Rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Trigonometry

$$\sin \theta = \frac{h_o}{h} \quad \cos \theta = \frac{h_a}{h} \quad \tan \theta = \frac{h_o}{h_a} \quad h^2 = h_a^2 + h_o^2$$



Scalar Components of a Vector

$$A_x = |\vec{A}| \cos \theta \quad \text{and} \quad A_y = |\vec{A}| \sin \theta$$

Magnitude / Direction of a Vector

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2} \quad \theta = \tan^{-1} \left(\frac{|A_y|}{|A_x|} \right)$$

Vector Addition

$$\vec{C} = \vec{A} + \vec{B} \Rightarrow C_x = A_x + B_x \quad \text{and} \quad C_y = A_y + B_y$$

Kinematic Displacement

$$\Delta \vec{r} = \vec{r}_{\text{final}} - \vec{r}_{\text{initial}} = (\Delta r_x) \hat{x} + (\Delta r_y) \hat{y} = (\Delta x) \hat{x} + (\Delta y) \hat{y} = (x(t) - x_o) \hat{x} + (y(t) - y_o) \hat{y}$$

Kinematic Velocity / Kinematic Acceleration

$$\vec{v}_{\text{average}} = \frac{\Delta \vec{r}}{\Delta t} \quad \vec{v}_{\text{instantaneous}} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{r}}{\Delta t} \quad \vec{a}_{\text{average}} = \frac{\Delta \vec{v}}{\Delta t} \quad \vec{a}_{\text{instantaneous}} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{v}}{\Delta t}$$

Motion with Constant Acceleration

$$\begin{aligned}v_x(t) &= v_{ox} + a_x \cdot t \\x(t) &= x_o + \frac{1}{2}(v_{ox} + v_x) \cdot t \\x(t) &= x_o + v_{ox} \cdot t + \frac{1}{2}a_x \cdot t^2 \\v_x^2(x) &= v_{ox}^2 + 2a_x \cdot (x - x_o)\end{aligned}$$

$$\begin{aligned}v_y(t) &= v_{oy} + a_y \cdot t \\y(t) &= y_o + \frac{1}{2}(v_{oy} + v_y) \cdot t \\y(t) &= y_o + v_{oy} \cdot t + \frac{1}{2}a_y \cdot t^2 \\v_y^2(y) &= v_{oy}^2 + 2a_y \cdot (y - y_o)\end{aligned}$$

Acceleration due to the Earth's Gravity

$$g = 9.80 \text{ m/s}^2$$

Newton's Second Law of Motion

$$\vec{a} = \frac{\sum \vec{F}}{m} \quad \text{or} \quad \sum \vec{F} = m\vec{a}$$

Dynamic Equilibrium

$$\sum F_x = 0 \quad \text{and} \quad \sum F_y = 0$$

Force Exerted by an Ideal Spring

$$\vec{F}_{\text{spring}} = -k\Delta\vec{r} \quad \text{or} \quad F_x = -kx$$

Static / Kinetic Friction

$$\left| \vec{f}_s^{\text{maximum}} \right| = \mu_s |\vec{n}| \quad \text{and} \quad \left| \vec{f}_k \right| = \mu_k |\vec{n}|$$

PHYSICS 201 — FORMULA SUMMARY — MODULE 2

Uniform Circular Motion

$$\left| \vec{v}_{\text{tangential}} \right| = \frac{2\pi |\vec{r}|}{T} \quad \text{or} \quad v_{\text{tangential}} = \frac{2\pi R}{T} \qquad \left| \vec{a}_{\text{radial}} \right| = \frac{|\vec{v}|^2}{|\vec{r}|} \quad \text{or} \quad a_{\text{radial}} = \frac{v^2}{R}$$

Newton's Law of Universal Gravitation

$$\left| \vec{F}_{\text{gravity}} \right| = G \frac{m_1 m_2}{r^2}$$

Universal Gravitation and Weight

$$G \frac{m_E m}{R_E^2} = mg$$

Kepler /Newton Law of Periods for Satellite and Planetary Motion

$$\frac{T^2}{r^3} = \frac{4\pi^2}{Gm_E} \quad \text{and} \quad \frac{T^2}{r^3} = \frac{4\pi^2}{Gm_{\text{Sun}}}$$

Mechanical Work

$$W = F_x \Delta x + F_y \Delta y \quad \text{or} \quad W = \left| \vec{F} \right| \left| \Delta \vec{r} \right| \cos \theta$$

Work–Energy Theorem

$$W_{\text{total}} = \Delta K = \frac{1}{2} m v_{\text{final}}^2 - \frac{1}{2} m v_{\text{initial}}^2$$

Gravitational Work

$$W_{\text{gravity}} = mgy_{\text{initial}} - mgy_{\text{final}}$$

Gravitational Potential Energy

$$\Delta U_{\text{gravity}} = mgy_{\text{final}} - mgy_{\text{initial}} = -W_{\text{gravity}}$$

Elastic Work

$$W_{\text{elastic}} = \frac{1}{2}kx_{\text{initial}}^2 - \frac{1}{2}kx_{\text{final}}^2$$

Elastic Potential Energy

$$\Delta U_{\text{elastic}} = \frac{1}{2}kx_{\text{final}}^2 - \frac{1}{2}kx_{\text{initial}}^2 = -W_{\text{elastic}}$$

Conservation of Total Mechanical Energy

$$\Delta E = \Delta(K + U_{\text{gravity}} + U_{\text{elastic}}) = W_{\text{nonconservative}}$$

Instantaneous Power

$$P = \lim_{\Delta t \rightarrow 0} \frac{\Delta W}{\Delta t} \quad \text{or} \quad P = F_x v_x + F_y v_y \quad \text{or} \quad P = |\vec{F}| |\vec{v}| \cos \theta$$

Simple Harmonic Motion

$$\begin{aligned} x(t) &= A \cos \omega t \\ v_x(t) &= -A\omega \sin \omega t \\ a_x(t) &= -A\omega^2 \cos \omega t \end{aligned} \quad \text{where} \quad \omega = \frac{2\pi}{T} = 2\pi f = \sqrt{\frac{k}{m}}$$

Period of an Ideal Pendulum

$$T = 2\pi \sqrt{\frac{L}{g}}$$

Center of Mass for a System of Particles

$$\vec{r}_{\text{CM}} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2 + \dots + m_N \vec{r}_N}{m_1 + m_2 + \dots + m_N}$$

$$\vec{v}_{\text{CM}} = \frac{m_1 \vec{v}_1 + m_2 \vec{v}_2 + \dots + m_N \vec{v}_N}{m_1 + m_2 + \dots + m_N}$$

$$\vec{a}_{\text{CM}} = \frac{m_1 \vec{a}_1 + m_2 \vec{a}_2 + \dots + m_N \vec{a}_N}{m_1 + m_2 + \dots + m_N}$$

Newton's Laws for a System of Particles

$$M \vec{a}_{\text{CM}} = (m_1 + m_2 + \dots + m_N) \vec{a}_{\text{CM}} = m_1 \vec{a}_1 + m_2 \vec{a}_2 + \dots + m_N \vec{a}_N = \sum \vec{F}_{\text{external}}$$

$$\sum \vec{F}_{\text{internal}} = 0$$

Linear Momentum of a System of Particles

$$M \vec{v}_{\text{CM}} = m_1 \vec{v}_1 + m_2 \vec{v}_2 + \dots + m_N \vec{v}_N = \vec{p}_1 + \vec{p}_2 + \dots + \vec{p}_N = \vec{P}_{\text{CM}}$$

Conservation of Linear Momentum for a System of Particles

$$\sum \vec{F}_{\text{external}} = 0 \Rightarrow \vec{P}_{\text{CM}} = \text{constant}$$

$$\Delta \vec{P}_{\text{CM}} = (m_1 \vec{v}_1 + m_2 \vec{v}_2 + \dots + m_N \vec{v}_N)_{\text{final}} - (m_1 \vec{v}_1 + m_2 \vec{v}_2 + \dots + m_N \vec{v}_N)_{\text{initial}} = 0$$

PHYSICS 201 — FORMULA SUMMARY — MODULE 3

Angular Displacement / Arc Length

$$\Delta\theta \text{ (radians)} = \theta(t) - \theta_o = \frac{s}{r}$$

Angular Velocity / Angular Acceleration

$$\omega_{\text{average}} = \frac{\Delta\theta}{\Delta t} \quad \omega_{\text{instantaneous}} = \lim_{\Delta t \rightarrow 0} \frac{\Delta\theta}{\Delta t}$$

$$\alpha_{\text{average}} = \frac{\Delta\omega}{\Delta t} \quad \alpha_{\text{instantaneous}} = \lim_{\Delta t \rightarrow 0} \frac{\Delta\omega}{\Delta t}$$

Corresponding Linear Velocity / Linear Acceleration

$$v_{\text{tangential}} = r\omega \quad a_{\text{tangential}} = r\alpha \quad a_{\text{radial}} = r\omega^2$$

Rotation with Constant Angular Acceleration

$$\begin{aligned}\omega(t) &= \omega_o + \alpha \cdot t \\ \theta(t) &= \theta_o + \frac{1}{2}(\omega_o + \omega) \cdot t \\ \theta(t) &= \theta_o + \omega_o \cdot t + \frac{1}{2}\alpha \cdot t^2 \\ \omega^2(\theta) &= \omega_o^2 + 2\alpha \cdot (\theta - \theta_o)\end{aligned}$$

Torque about an Arbitrary Axis

$$\tau = \left| \vec{F}_{\text{tangential}} \right| \left| \vec{r} \right| = \left| \vec{F} \right| \left| \vec{r} \right| \sin \theta = \left| \vec{F} \right| \ell$$

Newton's Laws for Fixed–Axis Rotation

$$\sum \vec{\tau}_{\text{external}} = I\vec{\alpha} \quad \text{where} \quad I = \sum mr^2$$

$$\sum \vec{\tau}_{\text{internal}} = 0$$

Rotational Equilibrium

$$\sum \vec{\tau}_{\text{external}} = 0$$

Work–Energy Theorem for Fixed–Axis Rotation

$$\tau_{\text{external}}\Delta\theta = W_{\text{rotation}} = \frac{1}{2}I\omega_{\text{final}}^2 - \frac{1}{2}I\omega_{\text{initial}}^2$$

Work–Energy Theorem for Combined Rotation and Translation

$$W_{\text{translation}} + W_{\text{rotation}} = \left(\frac{1}{2}Mv_{\text{CM final}}^2 - \frac{1}{2}Mv_{\text{CM initial}}^2\right) + \left(\frac{1}{2}I\omega_{\text{CM final}}^2 - \frac{1}{2}I\omega_{\text{CM initial}}^2\right)$$

$$W_{\text{translation}} = F_x\Delta x_{\text{CM}} + F_y\Delta y_{\text{CM}}$$

Conservation of Angular Momentum for a Rotating Body

$$\sum \vec{\tau}^{\text{external}} = 0 \Rightarrow \vec{L} = I\vec{\omega} = \text{constant}$$

Conservation of Angular Momentum for a System of Rotating Bodies

$$\sum \vec{\tau}^{\text{external}} = 0 \Rightarrow \vec{L} = \sum I\vec{\omega} = \text{constant}$$

Frequency / Wavelength / Speed of Periodic Waves

$$v = \frac{\lambda}{T} = f\lambda \quad \text{where} \quad y(x,t) = A \sin 2\pi \left(\frac{t}{T} - \frac{x}{\lambda} \right) = A \sin 2\pi f \left(t - \frac{x}{v} \right)$$

Speed of (Transverse) Mechanical Waves on a String

$$v = \sqrt{\frac{F}{m/L}}$$

Speed of (Longitudinal) Sound Waves in an Ideal Gas

$$v = \sqrt{\frac{\gamma k_B T}{m}} \quad \text{where} \quad \gamma = C_p / C_v$$

Standing Waves for a String Clamped at Both Ends or a Tube Open at Both Ends

$$\lambda_n = \frac{2L}{n} \quad \text{or} \quad f_n = n \left(\frac{v}{2L} \right)$$

Density / Pressure

$$\rho = \frac{m}{V} \qquad p = \frac{F_{\perp}}{A}$$

Atmospheric Pressure

$$1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 1.013 \times 10^3 \text{ mbar} = 760 \text{ Torr}$$

Barometric Pressure Formula

$$p(h) = p(h=0) - \rho g h \quad \text{or} \quad p(h_{<}) = p(h_{>}) + \rho g (h_{>} - h_{<})$$

Buoyant Force

$$F_B = \rho_{\text{fluid}} V_{\text{displaced}} g = m_{\text{fluid}} g$$

PHYSICS 201 — FORMULA SUMMARY — MODULE 4

Thermal Expansion of Solids

$$\frac{\Delta L}{L_o} = \alpha \Delta T \quad \text{and} \quad \frac{\Delta V}{V_o} = \beta \Delta T \quad \text{where} \quad \beta = 3\alpha$$

Specific Heat Capacity / Latent Heats

$$c = \frac{1}{m} \frac{Q}{\Delta T} \qquad L_{f,v,s} = \frac{1}{m} |Q_{f,v,s}|$$

Avogadro Number / Ideal Gas Constant / Boltzmann Constant

$$N_A = 6.02 \times 10^{23} \qquad R = 8.31 \text{ J/mole} \cdot \text{K} \qquad k_B = 1.38 \times 10^{-23} \text{ J/K}$$

Ideal Gas Law

$$pV = nRT \quad \text{or} \quad pV = Nk_B T$$

Average Translational Kinetic Energy per Molecule

$$\left\langle \frac{1}{2} m v^2 \right\rangle = \frac{1}{2} m v_{\text{rms}}^2 = \frac{3}{2} k_B T$$

Total Internal Energy of an Ideal (Monatomic) Gas

$$U = \frac{3}{2} nRT \quad \text{or} \quad U = \frac{3}{2} Nk_B T$$

Constant Volume Heat Capacity of an Ideal (Monatomic) Gas

$$C_V = \frac{3}{2} R \text{ (per mole)} \quad \text{or} \quad C_V = \frac{3}{2} k_B \text{ (per molecule)}$$

Constant Pressure Heat Capacity of an Ideal (Monatomic) Gas

$$C_p = \frac{5}{2}R \text{ (per mole)} \quad \text{or} \quad C_p = \frac{5}{2}k_B \text{ (per molecule)}$$

First Law of Thermodynamics

$$\Delta U_{\text{system}} = U_{\text{final}} - U_{\text{initial}} = Q - W$$

Isobaric (Constant Pressure) Work

$$W = p\Delta V = p(V_{\text{final}} - V_{\text{initial}})$$

Adiabatic Work for an Ideal (Monatomic) Gas

$$W = \frac{3}{2}nR(T_{\text{initial}} - T_{\text{final}}) \quad \text{or} \quad W = \frac{3}{2}Nk_B(T_{\text{initial}} - T_{\text{final}})$$

Adiabatic Expansion (Compression) of an Ideal (Monatomic) Gas

$$p_{\text{initial}}V_{\text{initial}}^{5/3} = p_{\text{final}}V_{\text{final}}^{5/3}$$