

PHY 303K Master Equation Sheet

Understanding the meaning of these equations and learning to successfully apply them to solve physics problems is a major learning goal of this course. They

can empower you to understand physics in your everyday life, prepare you for physics contexts found in your career, and deepen appreciation of the world around us.

Geometry, Kinematics, and Statics

Units and Constants

SI Mass: kg SI Distance: m SI Time: s

1 kilo (k) = 10^3 1 centi (c) = 10^{-2}

1 milli (m) = 10^{-3} 1 nano (n) = 10^{-9}

1 angstrom (\AA) = $10^{-10} m$

$g \approx 9.81 \frac{m}{s^2}$

$\rho = \frac{m}{V}$

$s = \frac{d}{t}$

$\dot{m} = \frac{m}{t}$

Geometry

$$c^2 = a^2 + b^2 - 2ab \cos \theta$$

$$A = \frac{1}{2}lh$$

$$A = (\alpha + \beta + \gamma - \pi)R^2$$

$$\sin \theta = \frac{o}{h} \quad \cos \theta = \frac{a}{h}$$

$$\tan \theta = \frac{o}{a}$$

$$\sin^2 \theta + \cos^2 \theta = 1$$

$$C = 2\pi r \quad A = \pi r^2$$

$$A = 4\pi r^2 \quad V = \frac{4}{3}\pi r^3$$

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$y = ax^2 + bx + c$$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

Calculus

$$\frac{d}{dx} x^n = n x^{n-1}$$

$$\frac{d}{dx} \sin x = \cos x \quad \frac{d}{dx} \cos x = -\sin x$$

Vectors and Coordinates

$$\vec{A} = (x, y, z) \quad \vec{A} + \vec{B} = (x_A + x_B, y_A + y_B, z_A + z_B)$$

$$A = |\vec{A}| = \sqrt{x^2 + y^2 + z^2}$$

$$\vec{A} \cdot \vec{B} = AB \cos \Delta\theta$$

$$x \times y = z \quad y \times z = x \quad z \times x = y$$

$$|\vec{A} \times \vec{B}| = AB \sin \Delta\theta$$

$$x = r \cos \theta \quad y = r \sin \theta$$

Motion in 1, 2, and 3D

$$\dot{x}_{avg} = \frac{\Delta x}{\Delta t} \quad v(t) = \dot{x}(t) \quad a(t) = \dot{v}(t) = \ddot{x}(t)$$

$$x(t) = x_0 + v_0 t + \frac{1}{2} a t^2 \quad a_g = -g$$

$$\theta(t) = \theta_0 + \omega t + \frac{1}{2} a t^2$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$\omega_f^2 = \omega_i^2 + 2a\Delta\theta$$

$$\frac{\Delta A}{\Delta t} = \text{constant} \quad \frac{r^2}{r^3} = \eta_{Kepler} = \text{constant}$$

$$\vec{r}(t) = (x(t), y(t), z(t)) \quad a_c = \frac{v^2}{r}$$

Statics, Friction, and Linear Elasticity

$$x_{com} = \frac{1}{m} \int \rho dx \quad \sigma_{stress} = F/A$$

$$\sum \vec{F} = 0 \quad \sum \vec{\tau} = 0$$

$$\tau = \vec{r} \times \vec{F} \quad F_W = mg \quad F_B = \rho g V$$

$$F_{static} \leq \mu_s N \quad F = -k\Delta X$$

$$Y = \frac{F/A}{\Delta L/L} \quad B = \frac{\Delta P}{\Delta V/V} \quad S = \frac{F/A}{\Delta x/l}$$

Newton's Laws, Linear and Angular Dynamics

$$1. \dot{v}_{free} = 0 \quad 2. F = \frac{d}{dt}(mv) \quad 3. F_{act} = -F_{react}$$

$$F_{kinetic} = \mu_k N$$

$$I = \sum m_i R_i^2 = \int \rho R^2 dV \quad \tau = \frac{d}{dt}(I\omega)$$

$$I_{||} = mx^2 + I_{com} \quad I_{disk} = \frac{1}{2} mR^2$$

$$I_{rod} = \frac{1}{12} mL^2 \quad I_{Ball} = \frac{2}{5} mR^2 \quad I_{sphere} = \frac{2}{3} mR^2$$

Terrestrial and Celestial Mechanics

Work and Energy

$$W = \vec{F} \cdot \vec{r} \quad KE = \frac{1}{2} mv^2 \quad \Delta KE = W_{on} = -W_{by}$$

$$E_{mech} = KE + U \quad \Delta U = W_{on} = -W_{by}$$

$$\Sigma E = \text{constant} \quad U = \frac{1}{2} kx^2 \quad U = mgh$$

$$KE_{rot} = \frac{1}{2} I\omega \quad \Delta KE_{rot} = \tau \Delta\theta \quad P = \frac{dE}{dt}$$

Momentum and Collisions

$$p = m\vec{v} \quad \Sigma \vec{p} = \text{constant}$$

$$\Delta v = u \ln \frac{m_0}{m} \quad m_0 = m + m_{fuel}$$

$$\Delta p = J = F\Delta t$$

$$L = I\omega$$

Gravitation

$$\vec{F}_g = \vec{g}m = -\frac{GMm}{r^2} \hat{r} \quad U = -\frac{GMm}{r}$$

$$E_{escape} = 0 \quad E_{orbit} = -\frac{1}{2} \frac{GMm}{r} \quad E_{surf} = -\frac{GMm}{R}$$

$$\eta_{Kepler} = 4 \frac{\pi^2}{GM}$$

Oscillations, Waves, and Sound

Simple Harmonic Oscillations

$$\omega_{sho} = \sqrt{k/m} \quad \omega_{pend} = \sqrt{g/l}$$

$$x(t) = A \cos(\omega t + \phi)$$

Waves

$$f\lambda = c = \frac{\omega}{k}$$

$$f(x, t) = A \cos(kx - \omega t + \phi)$$

$$f(x, t) = \frac{1}{2} (f(x - vt, 0) + f(x + vt, 0))$$

$$\lambda_{fixed} = \frac{2L}{n} \quad n = 1, 2, 3 \dots$$

$$c_{string} = \sqrt{T/\mu} \quad \mu = m/L$$

Sound

$$p = \frac{1}{A}$$

$$dB = 10 \log_{10}\left(\frac{I}{I_0}\right) \quad I_0 = 10^{-12} \frac{W}{m^2}$$

$$c_{air} \approx 343 \text{ m/s}$$

$$c = \sqrt{\gamma P/\rho} = \sqrt{\gamma kT/m} \quad PV = nkT$$

$$f_0 = \frac{v + v_0}{v + v_s} f_s$$