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

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

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

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

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

$\rho = \frac{m}{V}$ $s = \frac{d}{t}$ $\dot{m} = \frac{m}{t}$

Geometry

$c^2 = a^2 + b^2 - 2ab\cos\theta$ $A = \frac{1}{2} lh$

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

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

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

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

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

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

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

Calculus

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

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

Vectors and Coordinates

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

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

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

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

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

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

Motion in 1, 2, and 3D

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

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

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

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

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

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

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

Statics, Friction, and Linear Elasticity

$\vec{x}_{com} = \frac{1}{m}\int \rho\vec{x}dx$ $\sigma_{stress} = F/A$

$\vec{x}_{com} = \frac{1}{m_{total}}\sum m_i\vec{x}_i$

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

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

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

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

Newton's Laws, Linear and Angular Dynamics

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

$F_{kinetic} = \mu_k N$

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

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

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

Terrestrial and Celestial Mechanics

Work and Energy

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

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

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

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

Momentum and Collisions

$p = m\vec{v}$ $\Sigma\,\vec{p} = constant$

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

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

$L = I\omega$

Gravitation

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

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

$\eta_{Kepler} = 4\frac{\pi^2}{GM}$ $G \approx 6.67430 \times 10^{-11} Nm^2/kg^2$

Oscillations, Waves, and Sound

Simple Harmonic Oscillations

$\omega_{sho} = \sqrt{k/m}$ $\quad \omega_{pend} = \sqrt{g/l}$ $\qquad \omega = 2\pi f = \frac{2\pi}{T}$

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

$x(t) = A\cos(\omega t) + B\sin(\omega t)$

Waves

$f\lambda = c = \frac{\omega}{k} \qquad k = \frac{2\pi}{\lambda}$

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

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

$\lambda_{fixed} = \frac{2L}{n} \qquad n = 1,2,3 \ldots$

$c_{String} = \sqrt{T/\mu} \qquad \mu = m/L$

Sound

$I = \frac{\mathrm{P}}{\mathrm{A}}$

$dB = 10\log_{10}(\frac{I}{I_0}) \qquad I_0 = 10^{-12}\,\frac{W}{m^2}$

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

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

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

(For the source, $+v_s$ means away from the observer)

(For the observer, $+v_0$ means towards the source)