PHYS 20700 Formulas

Dr. James Hedberg

Updated: March 2021

Kinematics

$$\overline{\mathbf{v}} = \frac{\Delta \mathbf{x}}{\Delta t}$$

$$\mathbf{v} = \lim_{\Delta t \to 0} \frac{\Delta \mathbf{x}}{\Delta t} = \frac{d\mathbf{x}}{dt}$$

$$\overline{\mathbf{a}} = \frac{\Delta \mathbf{v}}{\Delta t}$$

$$\mathbf{a} = \lim_{\Delta t \to 0} \frac{\Delta \mathbf{v}}{\Delta t} = \frac{d\mathbf{v}}{dt}$$

$$\mathbf{v} = \mathbf{v}_0 + \mathbf{a}t$$

$$\mathbf{x} = \frac{1}{2}(\mathbf{v}_0 + \mathbf{v})t$$

$$\mathbf{x} = \mathbf{x}_0 + \mathbf{v}_0 t + \frac{1}{2}\mathbf{a}t^2$$

$$v^2 = v_0^2 + 2ax$$

Forces

$$\sum \mathbf{F} = \mathbf{F}_{\text{net}} = m\mathbf{a}$$

$$F_{\text{G}} = G\frac{m_1 m_2}{r^2}$$

$$g = \frac{GM_E}{r_E^2} = 9.8\ \text{m/s}^2 \approx 10\ \text{m/s}^2$$

$$f_s^{\max} = \mu_s F_N$$

$$f_k = \mu_k F_N$$

$$F_D = \frac{1}{2}C\rho A v^2$$

Circular Motion

$$v = \frac{2\pi r}{T}$$

$$a_c = \frac{v^2}{r}$$

$$v = \sqrt{\frac{GM_E}{r}}$$

Work and Energy

$$W = \mathbf{F} \cdot \mathbf{s}$$

$$W = \int_{x_i}^{x_f} F(x)\, dx$$

$$KE = \frac{1}{2}mv^2$$

$$W = KE_f - KE_i$$

$$W_{\text{grav}} = mg(h_0 - h_f)$$

$$PE = mgh$$

$$W_{\text{nc}} = E_f - E_0$$

$$\overline{P} = \frac{\Delta U}{\Delta t}$$

$$\overline{P} = \mathbf{F} \cdot \mathbf{v}$$

$$F = -\frac{dU}{dx}$$

Rotational Motion

$$\theta = \frac{s}{r}$$

$$\overline{\omega} = \frac{\Delta \theta}{\Delta t}$$

$$\overline{\alpha} = \frac{\Delta \omega}{\Delta t}$$

$$\theta = \frac{1}{2}(\omega_0 + \omega)t$$

$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$v_T = r\omega$$

$$a_T = r\alpha$$

$$a_c = r\omega^2$$

Rotational Dynamics

$$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$$

$$\tau = I\alpha$$

$$\tau = \frac{d\mathbf{L}}{dt}$$

$$I = \int r^2 dm$$

$$I = I_{\text{com}} + mh^2$$

$$KE_{\text{rot}} = \frac{1}{2}I\omega^2$$

$$L = I\omega$$

$$\mathbf{L} = \mathbf{r} \times \mathbf{p}$$

Simple Harmonic Motion

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

$$f = \frac{1}{T}$$

$$\omega = 2\pi f$$

$$\omega = \sqrt{\frac{k}{m}}$$

$$\mathbf{F}_{\text{sp}} = -k\mathbf{x}$$

$$U_{\text{sp}} = \frac{1}{2}kx^2$$

$$T_{\text{pend}} = 2\pi\sqrt{\frac{L}{g}}$$

Momentum and Impulse

$$\mathbf{J} = \overline{\mathbf{F}}\Delta t$$

$$\mathbf{p} = m\mathbf{v}$$

$$\mathbf{J} = \Delta\mathbf{p}$$

Fluids

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

$$P = \frac{F}{A}$$

$$P_2 = P_1 + \rho g h$$

$$F_B = W_{\text{fluid}}$$

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

Temperature and Heat

$$T = T_C + 273.15$$

$$T_C = (T_F - 32) * \frac{5}{9}$$

$$\Delta L = \alpha L_0 \Delta T$$

$$\Delta V = \beta V_0 \Delta T$$

$$Q = cm\Delta T$$

$$Q = mL_F \text{ or } mL_V$$

$$Q = \frac{kA\Delta T\, t}{L}$$

Thermodynamics

$$W = -\int PdV$$

$$PV = nRT = Nk_BT$$

$$U_{\text{th-IG}} = \frac{3}{2}Nk_BT$$

$$\Delta U = U_f - U_i = Q + W$$

Other/Constants/Physical Values

$$V_{\text{sphere}} = \frac{4}{3}\pi r^3$$

$1\text{mL} = 1\text{cc} = 1\text{gram}$

$\text{Mass of the Earth}(M_E) = 5.97 \times 10^{24}\ \text{kg}$

$\text{Radius of the Earth}(R_E) = 6,371\ \text{km}$

$\rho_{\text{air}} = 1.28\ \text{kg/m}^3$

$\rho_{\text{water}} = 1000\ \text{kg/m}^3$

$1\ \text{atm} = 101,325\ \text{Pa}$