EQUATIONS

Uncertainty
- $u_p = (\delta A / A) \times 100\%$

Kinematics
- $\Delta x = x_f - x_0$
- $\Delta t = t_f - t_0$
- $\bar{v} = \Delta x / \Delta t = (x_f - x_0) / (t_f - t_0)$
- $\bar{a} = \Delta v / \Delta t = (v_f - v_0) / (t_f - t_0)$
- $x = x_0 + \bar{v}\, t$
- $\bar{v} = (v_0 + v) / 2$
- $v = v_0 + a\, t$
- $x = x_0 + v_0\, t + ½\, a\, t^2$
- $v^2 = v_0^2 + 2\, a\, (x - x_0)$

Two-Dimensional Kinematics
- $a^2 + b^2 = c^2$
- $c = \sqrt{(a^2 + b^2)}$
- $\mathbf{A} - \mathbf{B} = \mathbf{A} + (-\mathbf{B})$
- $\mathbf{A}_x + \mathbf{A}_y = \mathbf{A}$
- $\mathbf{A}_x = \mathbf{A} \cos\theta$ $\mathbf{A}_y = \mathbf{A} \sin\theta$
- $A = \sqrt{(\mathbf{A}_x^2 + \mathbf{A}_y^2)}$ $\theta = \tan^{-1}(\mathbf{A}_y / \mathbf{A}_x)$
- $R_x = A_x + B_x$ $R_y = A_y + B_y$
- $h = v_{0y}^2 / 2g$
- $R = v_0^2 \sin 2\theta_0 / g$

Dynamics - Force and Newton's laws of Motion
- $\mathbf{a} = \mathbf{F}_{net} / m$ $\mathbf{F}_{net} = m\, \mathbf{a}$
- $w = m\, g$

Applications of Newton's Laws
- $f_s \leq \mu_s N$ $f_{s(\max)} = \mu_s N$
- $f_k = \mu_k N$
- $F_D = C \rho A v^2$
- $v = \sqrt{(2 m g / \rho C A)}$
- $F_s = 6 \pi r \eta v$
- $F = k\, \Delta L$ $k = Y A / L_0$
- $F / A = Y (\Delta L / L_0)$
- $\Delta x = (1 / S)(F / A) L_0$
- $\Delta V = (1 / B)(F / A) V_0$

Uniform Circular Motion and Gravitation
- $\Delta\theta = \Delta s / r$ 2π rad $= 1$ rev
- $\omega = \Delta\theta / \Delta t$
- $a_c = v^2 / r$ $v = \omega r$
- $F = G m M / r^2$
- $g = G M / r^2$
- $T_1^2 / T_2^2 = r_1^3 / r_2^3$

Work Energy and Energy Resources
- $W = F d \cos\theta$
- $W_{net} = ½ m v^2 - ½ m v_0^2$
- $K = ½ m v^2$
- $W = F d = m g h$
- $U_g = m g h$ $U_s = ½ k x^2$
- $K_i + U_i = K_f + U_f$
- $K_i + U_i + W_{nc} + O_i = K_f + U_f + O_f$
- $E_{eff} = W_{out} / E_{in}$
- $P = W / t = E / t$ $E = P\, t$

Linear Momentum and Collisions
- $p = m v$
- $F_{net} = \Delta p / \Delta t$
- $\Delta p = F_{net}\, \Delta t$
- $(p_1 + p_2)_f = (p_1 + p_2)_i =$ constant
- $m_1 v_1 = m_1 v'_1 \cos\theta_1 + m_2 v'_2 \cos\theta_2$
- $m_1 v_1 = m_1 v'_1 \sin\theta_1 + m_2 v'_2 \sin\theta_2$
- $a = [(v_e / m)(\Delta m_b / \Delta t)] - g$

Statics and Torque
- $\tau = r F \sin\theta$
- $A_M = F_o / F_i = l_i / l_o$ $l_i F_i = l_o F_o$

Rotational Motion and Angular Momentum
- $\omega = \Delta\theta / \Delta t$
- $v = r\omega$ $\omega = v / r$
- $\alpha = \Delta\omega / \Delta t$
- $a_t = r\alpha$ $\alpha = a_t / r$
- $\theta = \theta_0 + \omega t$
- $\omega = \omega_0 + \alpha t$
- $\theta = \omega_0 t + ½ \alpha t^2$
- $\omega^2 = \omega_0^2 + 2\alpha\theta$
- $I = \Sigma m r^2$
- $\tau_{net} = I\alpha$ $\alpha = \tau_{net} / I$
- $K_{rot} = ½ I \omega^2$
- $L = I\omega$
- $\tau = \Delta L / \Delta t$
- $I\omega = I'\omega'$

Fluids
- $P = h \rho g$ $P_{abs} = P_g + P_{atm}$
- $F_B = w_{fl}$
- $Q = V / t = A d / t = A (d / t) = A v$
- $A_1 v_1 = A_2 v_2$
- $P_1 + (½) \rho v_1^2 + \rho g h_1 = P_2 + (½) \rho v_2^2 + \rho g h_2$
- $E / t = P Q$
- $\eta = F L / v A$
- $R = 8 \eta l / \pi r^4$
- $Q = (P_2 - P_1) \pi r^4 / 8 \eta l$
- $N_R = 2 \rho v r / \eta$

Temperature Kinetic Theory and Gas laws
- $T_C = (5/9)[T_F - 32^\circ]$ $\Delta T(\text{K}) = \Delta T(^\circ\text{C})$
- $T = T_C + 273.15$
- $\Delta L = \alpha L \Delta T$ $\Delta V = \beta V \Delta T$
- $P V = N k T$
- $k = 1.38 \times 10^{-23}$ J/K
- $N_A = 6.02 \times 10^{23}$ mol^{-1}
- $P V = n R T$
- $R = N_A k = 8.31$ J/mol K
- $P = F / A$
- $v_{rms} = \sqrt{(v^2)_{avg}}$
- $K_{ave} = (3/2)\, k_B T$

Heat and Heat Transfer Methods
- $Q = m c \Delta T$
- $Q = m L_f$ $Q = m L_v$
- $Q / t = k A (T_2 - T_1) / d$
- $Q / t = \sigma e A T^4$
- $Q_{net} / t = \sigma e A (T_2^4 - T_1^4)$

Thermodynamics
- $\Delta U = Q - W$ $\Delta U = U_2 - U_1$
- $E_{eff} = W / Q_h$ $W = Q_h - Q_c$
- $E_{eff} = (Q_h - Q_c) / Q_h = 1 - (Q_c / Q_h)$
- $Q_c / Q_h = T_c / T_h$ $E_{effc} = 1 - (T_c / T_h)$
- $C_{PH} = Q_h / W_{in} = T_h / (T_h - T_c)$
- $C_{PC} = Q_C / W_{in} = T_C / (T_H - T_C)$
- $\Delta S_{rev} = Q / T$

Constants
- $g = 9.80$ m/s^2
- 1 lb = 4.44822 N   1 kg = 2.2 lb
- 1 hp = 746 W   1 cal = 4.184 J
- 1 atm = 1.013 x 10^5 Pa   1 m^3 = 10^3 L
- $G = 6.67384(80) \times 10^{-11}$ N m^2/kg^2

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