$$v_{average} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

$$a_{\text{average}} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

$v = \sqrt{v_x^2 + v_y^2}$ and $\theta = \tan^{-1}\frac{v_y}{v_x}$

Linear Motion with *a* Constant	Rotational Motion about a Fixed Axis with α constant
$x = x_0 + v_0 t + \frac{1}{2}at^2$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$
$v = v_0 + at$	$\omega = \omega_0 + \alpha t$
$v^2 = v_0^2 + 2a\Delta x$	$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

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

$g = 9.80\ m/s^2$

$\sin\theta = \frac{opposite\ side}{hypotenuse}$ $\cos\theta = \frac{adjacent\ side}{hypotenuse}$ $\tan\theta = \frac{opposite\ side}{adjacent\ side}$

$F = ma$ $F = -kx$ $PE_s = ½kx^2$ $KE = ½mv^2$ $PE_g = mgh$ $W \equiv \vec{F}\cdot\overrightarrow{\Delta x}$ $W \equiv (F\cos\theta)\Delta x$ $\vec{\mathbf{I}} = \vec{\mathbf{F}}\Delta t$ $f_s \le \mu n$ $f_k = \mu n$

$\vec{p} = m\vec{v}$ $W_{nc} = \left(KE + PE_g + PE_s\right)_f - \left(KE + PE_g + PE_s\right)_i$

$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$ $\vec{\mathbf{F}}\Delta t = \Delta\vec{\mathbf{p}} = m\vec{\mathbf{v}}_f - m\vec{\mathbf{v}}_i$ $A_1v_1 = A_2v_2$ $P = \frac{F_1}{A_1} = \frac{F_2}{A_2}$

$\frac{1}{2}m_1v_{1i}^2 + \frac{1}{2}m_2v_{2i}^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$ $\frac{\Delta\vec{\mathbf{p}}}{\Delta t} = \frac{m(v_f - v_i)}{\Delta t} = \vec{\mathbf{F}}_{net}$ $m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)v_f$ $v_{esc} = \sqrt{\frac{2GM_E}{R_E}}$

$F = G\frac{m_1m_2}{r^2}$ $G = 6.673 \times 10^{-11}\ N\,m^2/kg^2$ $PE = -G\frac{M_Em}{r}$ $g = G\frac{M_E}{r^2}$ $x_{cg} = \frac{\Sigma m_i x_i}{\Sigma m_i}$ and $y_{cg} = \frac{\Sigma m_i y_i}{\Sigma m_i}$

$\omega_{av} = \frac{\theta_f - \theta_i}{t_f - t_i} = \frac{\Delta\theta}{\Delta t}$ $\alpha_{av} = \frac{\omega_f - \omega_i}{t_f - t_i} = \frac{\Delta\omega}{\Delta t}$ $a_c = \frac{v^2}{r} = \omega^2 r$ $v_{max} = A\omega$ $a_{max} = A\omega^2$ $KE_{rot} = ½I\omega^2$

$\tau = r\,F\sin\theta$ $\Sigma\tau = I\alpha$ $\Sigma\tau = \frac{\Delta L}{\Delta t}$ $L = I\,\omega$ $I \equiv \Sigma mr^2$ $a_t = \alpha r$ $s = \theta r$ $v_t = \omega r$ $F_C = ma_C$

$v_t = \frac{m\omega^2 r}{k}\left(1 - \frac{\rho_f}{\rho}\right)$ $v_t = \frac{mg}{k}\left(1 - \frac{\rho_f}{\rho}\right)$ $v_t = \frac{2r^2g}{9\eta}(\rho - \rho_f)$ $\frac{F}{A} = Y\frac{\Delta L}{L_o}$ $F = \eta\frac{Av}{d}$ *Rate of flow* $= \frac{\Delta V}{\Delta t} = \frac{\pi R^4(P_1 - P_2)}{8\eta L}$

Density of water = 1 g/cm³ = 1000 kg/m³ $B = \rho_{fluid}gV_{obj}$ $P = P_o + \rho gh$ $P + \frac{1}{2}\rho v^2 + \rho gy = \text{constant}$ $h = \frac{2\gamma}{\rho gr}\cos\phi$ $\gamma = \frac{F}{L}$ $I = \frac{\wp_{av}}{A} = \frac{\wp_{av}}{4\pi r^2}$

$v = \sqrt{\frac{F}{\mu}}$ *where* $\mu = \frac{m}{L}$ $T = 2\pi\sqrt{\frac{I}{mgL}}$ $v = f\lambda$

$x = A\cos(2\pi ft) = A\cos\omega t$
$v = -2\pi fA\sin(2\pi ft) = -A\,\omega\sin\omega t$
$a = -4\pi^2f^2A\cos(2\pi ft) = -A\omega^2\cos\omega t$

$\omega = 2\pi f = \sqrt{\frac{k}{m}}$ $f = 1/T$ $f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ $v = \pm\sqrt{\frac{k}{m}(A^2 - x^2)}$ $T = 2\pi\sqrt{\frac{L}{g}}$ $T = 2\pi\sqrt{\frac{m}{k}}$

$\beta = 10\log\frac{I}{I_o}$ $v = \sqrt{\frac{B}{\rho}}$ $f_n = (2n-1)\frac{v}{4L} = (2n-1)f_1$ $n = 1, 2, 3, \ldots$ $f_n = \frac{n}{2L}c_s = \frac{n}{2L}\sqrt{\frac{F}{\mu}}$ $f_n = n\frac{v}{2L} = nf_1$ $n = 1, 2, 3\ldots$ $f_o = f_s\left(\frac{v + v_o}{v - v_s}\right)$ $c_s = v = \left(331\frac{m}{s}\right)\sqrt{\frac{T}{273\,K}}$ $R \equiv \frac{\Delta V}{I}$

$f_b = |f_2 - f_1|$

$\Delta PE = -W$
$= -qE_x(x_f - x_i)$ $F = k_e\frac{|q_1||q_2|}{r^2}$

TABLE 15.1

Charge and Mass of the Electron, Proton, and Neutron

Particle	Charge (C)	Mass (kg)
Electron	-1.60×10^{-19}	9.11×10^{-31}
Proton	$+1.60 \times 10^{-19}$	1.67×10^{-27}
Neutron	0	1.67×10^{-27}

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$I = \frac{1}{A}\frac{\Delta E}{\Delta t} = \frac{\wp}{A}$ $W = -q(V_B - V_A)$ $v_d = \frac{eE}{m_e}\tau$

$V = k_e\frac{q}{r}$ $k_e = 8.9875 \times 10^9\ N\,m^2/C^2$ $\Delta V = V_B - V_A = \Delta PE / q$ $PE = q_2V_1 = k_e\frac{q_1q_2}{r}$

$r_1 - r_2 = (n + \frac{1}{2})\lambda$ $r_1 - r_2 = n\lambda$ $R = \rho\frac{L}{A}$ $1\ \Omega = 1\ V / A$

ε_o is the *permittivity of free space* $= 8.85 \times 10^{-12}\ C^2/Nm^2$ $1\ A = 1\ C/s$ $I \equiv \frac{\Delta Q}{\Delta t}$

Capacitors in series: $1/C_{eq} = 1/C_1 + 1/C_2 + \ldots$
Capacitors in parallel: $C_{eq} = C_1 + C_2 + \ldots$

Resistors in Series: $R_{eq} = R_1 + R_2 + R_3 + \ldots$
Resistors in Parallel: $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

$1\ F = 1\ C / V$ $C = \kappa C_o = \kappa\varepsilon_o(A/d)$

$\Phi_E = EA\cos(\theta)$ $R = R_o[1 + \alpha(T - T_o)]$ $T^2 = Kr^3$ $C = \varepsilon_o\frac{A}{d}$ $C \equiv \frac{Q}{\Delta V}$

$q = Qe^{-t/RC}$ $\tau = RC$ $e = 2.718\ldots$

$q = Q(1 - e^{-t/RC})$ In a discharging RC circuit, at $t = \tau = RC$, the charge decreases to (1/e) * Q_{max}

$\wp = I^2R = \frac{\Delta V^2}{R}$ $\Delta V = B\,\ell\,v$

$\text{Energy} = \frac{1}{2}Q\Delta V = \frac{1}{2}C\Delta V^2 = \frac{Q^2}{2C}$ $\wp = \frac{\Delta Q}{\Delta t}\Delta V = I\Delta V$ $F = qvB = \frac{mv^2}{r}$ $B = \frac{\mu_o I}{2\pi r}$ $r = \frac{mv}{qB}$ $\varepsilon_L = -L\frac{\Delta I}{\Delta t}$ $L_{sol} = \frac{\mu_0 N^2 A}{l}$

$B \equiv \frac{F}{qv\sin\theta}$ $\Delta P = -B\frac{\Delta V}{V}$ μ_o is called the *permeability of free space;* $\mu_o = 1.26X10^{-6}\ Tm/A$ $\Phi_B = B_\perp A = B\,A\cos\theta$

$\tau = NBIA\sin\theta$

$B = N\frac{\mu_o I}{2R}$ $B = \mu_o\,(N/\ell)\,I$ $F_B = B\,I\,\ell\sin\theta$ $\varepsilon = NAB\omega\sin(\omega t)$ $\varepsilon = -N\frac{\Delta\Phi_B}{\Delta t}$