

Math		
$(1 \pm x)^n = 1 \pm \frac{nx}{1!} + \frac{n(n-1)x^2}{2!} \pm \dots$ where $x^2 < 1$		
$(1 \pm x)^{-n} = 1 \mp \frac{nx}{1!} + \frac{n(n+1)x^2}{2!} \mp \dots$ where $x^2 < 1$		

Mechanics			
$G = 6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2 / \text{kg}^2$ $g = 9.81 \text{ m/sec}^2$	$x = x_0 + v_0 t + \frac{at^2}{2}$ $v = v_0 + at$ $x - x_0 = \frac{v^2 - v_0^2}{2a}$	$M \frac{d\vec{v}}{dt} = \vec{F}_{ext} + \vec{v}_{rel} \frac{dM}{dt}$	$\int F dt = F_{av} \Delta t = M(v_f - v_i)$ $\int \tau dt = F_{av} r \Delta t = I(\omega_f - \omega_i)$
$v_T = \omega r$ $a_r = \frac{v_T^2}{r} = \omega^2 r$ $a_T = \alpha r$	$\vec{v} = \vec{\omega} \times \vec{R}$ $\vec{a} = \frac{d\vec{\omega}}{dt} \times \vec{R} + \vec{\omega} \times \frac{d\vec{R}}{dt} = \vec{\alpha} \times \vec{R} + \vec{\omega} \times \vec{v}$	$I = \int r^2 dm = I_{CM} + Mh^2$ $\tau = I\alpha$	Hoop about cylinder axis: $I = MR^2$
Annular cylinder or ring about cylinder axis: $I = \frac{1}{2} M(R_1^2 + R_2^2)$	Annular cylinder or ring about diameter: $I = \frac{M}{4} (R_1^2 + R_2^2)$	Solid cylinder or disk about cylinder axis: $I = \frac{1}{2} MR^2$	Solid cylinder or disk about central diameter: $I = \frac{1}{4} MR^2 + \frac{1}{12} ML^2$
Thin rod about axis through center \perp to length: $I = \frac{1}{12} ML^2$	Thin rod about axis through one end \perp to length: $I = \frac{1}{3} ML^2$	Solid sphere about any diameter: $I = \frac{2}{5} MR^2$	Thin spherical shell about any diameter: $I = \frac{2}{3} MR^2$
Hoop about any diameter: $I = \frac{1}{2} MR^2$	Rectangular plate about \perp axis through center: $I = \frac{1}{12} M(a^2 + b^2)$	$L = I\omega$, $K = \frac{1}{2} I\omega^2$ $W = \int_{\theta_1}^{\theta_2} \tau_z d\theta$	$\vec{L} = \vec{r} \times \vec{p}$ $\frac{d\vec{L}}{dt} = \vec{r} \times \vec{F} = \vec{\tau}$
$\vec{\tau} = \vec{r} \times \vec{F}$ $\tau = rF \sin \theta = rF_{\perp} = r_{\perp} F$	$W = \int_i^f \vec{F} \cdot d\vec{s}$, $W_{net} = \Delta K = -\Delta U$ $P = \vec{F} \cdot \vec{v}$ COE: $\Delta K + \Delta U + \Delta E_{int} = W_{ext}$ COM: $F_{ext} s_{CM} = \Delta K_{CM}$	$\vec{F}_{12} = -\frac{Gm_1 m_2}{r_{12}^2} \hat{r}_{12}$ $\vec{F}_{21} = -\vec{F}_{12}$ $U(r) = -\frac{GMm}{r}$	$T^2 = \left(\frac{4\pi^2}{GM} \right) r^3$ $\frac{dA}{dt} = \frac{r^2 \omega}{2} = \frac{L_z}{2m}$

Relativity				
$\Delta t = \gamma \Delta t_0$, $L = \frac{L_0}{\gamma}$ $\gamma = \frac{1}{\sqrt{1 - u^2/c^2}}$ $v = \frac{v_0 + u}{1 + v_0 u/c^2}$	$x' = \gamma(x - ut)$ $y' = y$ $z' = z$ $t' = \gamma\left(t - \frac{ux}{c^2}\right)$	$x = \gamma(x' + ut')$ $y = y'$ $z = z'$ $t = \gamma\left(t' + \frac{ux'}{c^2}\right)$	$v'_x = \frac{\Delta x'}{\Delta t'} = \frac{v_x - u}{1 - uv_x/c^2}$ $v'_y = \frac{v_y}{\gamma(1 - uv_x/c^2)}$ $v'_z = \frac{v_z}{\gamma(1 - uv_x/c^2)}$	$v_x = \frac{\Delta x}{\Delta t} = \frac{v'_x + u}{1 + uv'_x/c^2}$ $v_y = \frac{v'_y}{\gamma(1 + uv'_x/c^2)}$ $v_z = \frac{v'_z}{\gamma(1 + uv'_x/c^2)}$
$K = mc^2(\gamma - 1) = E - E_0$ $E = \gamma mc^2$ $E_0 = mc^2$	$E = K + E_0 = \sqrt{(pc)^2 + (mc^2)^2}$ $\vec{p} = \frac{m\vec{v}}{\sqrt{1 - v^2/c^2}}$	$m_p = 1.67 \times 10^{-27} \text{ kg}$ $m_e = 9.11 \times 10^{-31} \text{ kg}$	$c = 3.00 \times 10^8 \text{ m/sec}$ $m_e c^2 = 0.511 \text{ MeV}$ $m_p c^2 = 938.3 \text{ MeV}$	
$(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2 - c^2(\Delta t)^2 = (\Delta x')^2 + (\Delta y')^2 + (\Delta z')^2 - c^2(\Delta t')^2$				

Harmonic Oscillator, Wave Motion, Sound				
	$f = \frac{1}{T}, \quad \omega = \frac{2\pi}{T}, \quad v = \lambda f = \frac{\omega}{k} = \frac{2\pi f}{k}$		$\omega^2 = \frac{k}{m} = \frac{g}{l} = \frac{Mgd}{I} = \frac{\kappa}{I}$	
$m\ddot{x} + b\dot{x} + kx = 0$	$x = x_m \exp(-bt/2m) \cos(\omega't + \phi)$		$\omega' = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}$	
$m\ddot{x} + b\dot{x} + kx = F_m \cos(\omega''t)$	$x = \frac{F_m}{G} \cos(\omega''t - \beta)$	$G = \sqrt{m^2(\omega''^2 - \omega^2) + b^2\omega''^2}$		$\beta = \cos^{-1} \frac{b\omega''}{G}$
$y(x,t) = y_m \sin(kx - \omega t - \phi)$	$v = \sqrt{F/\mu}$	$v = \sqrt{\frac{B}{\rho_0}}$	$\lambda_n = \frac{2L}{n}$ (open pipe)	$\lambda_n = \frac{4L}{n}$ (closed pipe)
$\Delta\rho(x,t) = \Delta\rho_m \sin(kx - \omega t)$ $\Delta p(x,t) = \Delta p_m \sin(kx - \omega t)$ $s(x,t) = \frac{\Delta\rho_m}{k\rho_0} \cos(kx - \omega t)$	$\Delta\rho_m = \Delta p_m \frac{\rho_0}{B}$	$P_{av} = \frac{A(\Delta p_m)^2}{2\rho v}$ $I = \frac{P_{av}}{A}$	$SL = 10 \log \frac{I}{I_0}$ where $I_0 = 10^{-12} \text{ W/m}^2$	$f' = \frac{v \pm v_0}{v \mp v_s} f,$ $\sin \theta = \frac{v}{v_s}$

Fluids, Thermodynamics				
$B = -\frac{\Delta P}{\Delta V/V}$	$P + \frac{1}{2}\rho v^2 + \rho gh = \text{const}$ $\frac{dP}{dy} = -\rho g$	$Av = \frac{\Delta V}{\Delta t} = \text{const},$ $F_b = \rho Vg$	$\gamma = \frac{F}{L} = \frac{\Delta u}{\Delta A}$	$F = \eta A \frac{dv}{dy}, R = \frac{\rho Dv}{\eta}$
$\alpha = \frac{\Delta L/L}{\Delta T}$ $\beta = \frac{\Delta V}{V\Delta T}$	$PV = Nk_B T = nRT$ $(P + a\frac{n^2}{V^2})(V - nb) = nRT$	$N(v) = 4\pi N \left(\frac{m}{2\pi kT}\right)^{3/2} v^2 \exp(-mv^2/2kT)$ $N(E) = \frac{2N}{\sqrt{\pi}} \frac{1}{(kT)^{3/2}} E^{1/2} \exp(-E/kT)$		$R = 8.31 \text{ J/mol} \cdot \text{K}$ $k = 1.38 \times 10^{-23} \text{ J/K}$ $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
$v_p = \sqrt{\frac{2kT}{m}}, v_{av} = \sqrt{\frac{8kT}{\pi m}}, v_{rms} = \sqrt{\frac{3kT}{m}}$		$\frac{kT}{m} = \frac{RT}{M} = \frac{P}{\rho}, \lambda = \frac{kT}{\sqrt{2\pi} d^2 p}, \text{rate} = \frac{v_{rms}}{\lambda}$		$H = -kA \frac{dT}{dx}, R = \frac{L}{k}$
Process and Key Equation	Work: $\Delta W = -\int_{V_i}^{V_f} P dV$	Heat: $\Delta Q = nC_{V,p}T$		$\Delta E_{int} = \frac{3}{2}nR\Delta T$ (monatomic)
Constant Volume	0	$C_V = \frac{3}{2}R, \frac{5}{2}R, 3R$		ΔQ
Constant Pressure: $P = P_0$	$-P(V_f - V_i)$	$C_p = C_V + R$		$\Delta W + \Delta Q$
Constant Temperature: $P = \frac{nRT}{V}$	$-nRT \ln \frac{V_f}{V_i}$	$\Delta Q = -\Delta W$		0
Adiabatic: $PV^\gamma = \text{const}, \gamma = \frac{C_p}{C_V}$	$\frac{1}{\gamma-1}(P_f V_f - P_i V_i)$	0		ΔW
$C = \frac{Q}{\Delta T}, c = \frac{C}{m}, Q = Lm$	$dS = \frac{dQ}{T}$	$\frac{1}{2}k$ per degree of freedom		$B = \gamma P$
$\varepsilon = \frac{ W }{ Q_H }, e_C = 1 - \frac{T_L}{T_H}, K_C = \frac{ Q_L }{W} = \frac{T_L}{T_H - T_L}$		$S = nR \ln \frac{V_f}{V_i} + nC_V \ln \frac{T_f}{T_i}$		$\ln N! = N \ln N - N$ $S = k \ln w,$ $w = \frac{N!}{N_1! N_2!}$