$$v_{\mathrm{av},x} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$
$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$
$$a_{\mathrm{av},x} = \frac{v_{2,x} - v_{1,x}}{t_2 - t_1} = \frac{\Delta v_x}{\Delta t}$$
$$a_x = \lim_{\Delta t \to 0} \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt}$$
$$v_x = v_{0,x} + a_x t$$
$$x = x_0 + v_{0,x} t + \frac{1}{2} a_x t^2$$
$$v_x^2 = v_{0,x}^2 + 2a_x(x - x_0)$$
$$x - x_0 = \left(\frac{v_{0,x} + v_x}{2}\right) t$$

$$x = x_0 + v_{0,x} t$$
$$y = y_0 + v_{0,y} t - \frac{1}{2} g t^2$$
$$v_x = v_{0,x}$$
$$v_y = v_{0,y} - gt$$
$$\omega = \frac{v}{R}$$
$$a_{rad} = \frac{v^2}{R} = \omega^2 R = \frac{4\pi^2 R}{T^2}$$
$$\vec{\boldsymbol{v}}_{P,A} = \vec{\boldsymbol{v}}_{P,B} + \vec{\boldsymbol{v}}_{B,A}$$
$$\vec{\boldsymbol{v}}_{A,B} = -\vec{\boldsymbol{v}}_{B,A}$$

$$\vec{\boldsymbol{F}}_{\mathrm{Net}} = \sum_i \vec{\boldsymbol{F}}_i$$
$$\vec{\boldsymbol{F}}_{\mathrm{Net}} = m\vec{\boldsymbol{a}}$$
$$\vec{\boldsymbol{F}}_{A \text{ on } B} = -\vec{\boldsymbol{F}}_{B \text{ on } A}$$
$$F_W = mg$$
$$\vec{\boldsymbol{F}}_S = -k(\vec{\boldsymbol{x}} - \vec{\boldsymbol{x}}_0)$$
$$g = +9.8 \tfrac{m}{s^2}$$
$$F_{f_k} = \mu_k N$$
$$F_{f_s} \le \mu_s N$$
$$\vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{B}} = A_x B_x + A_y B_y + A_z B_z$$
$$\vec{\boldsymbol{A}} \cdot \vec{\boldsymbol{B}} = |\vec{\boldsymbol{A}}||\vec{\boldsymbol{B}}| \cos\phi$$

$$W_{1\to 2} = \int_{\vec{\boldsymbol{r}}_1}^{\vec{\boldsymbol{r}}_2} \vec{\boldsymbol{F}} \cdot d\vec{\boldsymbol{l}}$$
$$W = \vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{s}} = Fs\cos\phi$$
$$K = \frac{1}{2} m v^2$$
$$W_{\mathrm{Net}} = K_f - K_i = \Delta K$$

$$\Delta U = U_B - U_A = -W_{A\to B}$$
$$E_{\mathrm{Mechanical}} = K + U$$
$$\Delta E_{\mathrm{Mechanical}} = W_{\mathrm{NC}}$$
$$U_{\mathrm{grav}} = mgh$$
$$U_{\mathrm{spring}} = \frac{1}{2} k x^2$$
$$U = -W_{r\to r_0} + U_0$$
$$F_x(x) = -\frac{dU(x)}{dx}$$

$$\vec{\boldsymbol{R}}_{\mathrm{CM}} = \frac{1}{M_{\mathrm{Total}}} \sum_i m_i \vec{\boldsymbol{r}}_i$$
$$\vec{\boldsymbol{R}}_{\mathrm{CM}} = \frac{1}{M_{\mathrm{Total}}} \int \vec{\boldsymbol{r}} dm$$
$$\vec{\boldsymbol{R}}_{\mathrm{CM}} = \frac{1}{M_{\mathrm{Total}}} \sum_i M_i \vec{\boldsymbol{R}}_{\mathrm{CM},i}$$
$$\sum \vec{\boldsymbol{F}}_{\mathrm{ext}} = M \vec{\boldsymbol{A}}_{\mathrm{CM}}$$
$$\Delta K_{\mathrm{CM}} = W_{\text{Total, ext}}$$

$$\sum \vec{\boldsymbol{F}} = \frac{d\vec{\boldsymbol{p}}}{dt}$$
$$\vec{\boldsymbol{p}} = m\vec{\boldsymbol{v}}$$
$$\vec{\boldsymbol{F}}_{\mathrm{Net,External}} = \frac{d\vec{\boldsymbol{P}}_{\mathrm{Total}}}{dt}$$
$$\omega = \frac{d\theta}{dt}$$
$$\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{d\theta^2}$$
$$\omega = \omega_0 + \alpha t$$
$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\vec{\boldsymbol{P}}_{\mathrm{Total}} = M_{\mathrm{Total}} \vec{\boldsymbol{V}}_{\mathrm{cm}}$$
$$|\vec{\boldsymbol{v}}_{2,f} - \vec{\boldsymbol{v}}_{1,f}| = |\vec{\boldsymbol{v}}_{2,i} - \vec{\boldsymbol{v}}_{1,i}| = |\vec{\boldsymbol{v}}^*_{2,i} - \vec{\boldsymbol{v}}^*_{1,i}| = |\vec{\boldsymbol{v}}^*_{2,f} - \vec{\boldsymbol{v}}^*_{1,f}|$$
$$K_{\mathrm{system,lab}} = \sum_i \frac{1}{2} m_i v_i^2 + \frac{1}{2} M_{\mathrm{Total}} v_{\mathrm{CM}}^2$$
$$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$
$$\theta - \theta_0 = \left(\frac{\omega_0 + \omega}{2}\right) t$$
$$v = r\omega$$
$$a_{\tan} = r\alpha$$

$$a_{\mathrm{rad}} = \frac{v^2}{r} = \omega^2 r$$
$$I = \sum_i m_i r_i^2$$
$$K = \frac{1}{2} I \omega^2$$

$$I_{\mathrm{Total}} = I_{\mathrm{CM}} + MD^2$$
$$K_{\mathrm{Total}} = \frac{1}{2} M v_{\mathrm{CM}}^2 + \frac{1}{2} I_{\mathrm{CM}} \omega^2$$
$$\tau = R_\perp F = (r\sin\theta) F$$
$$\vec{\boldsymbol{\tau}} = \vec{\boldsymbol{r}} \times \vec{\boldsymbol{F}}$$
$$\sum \vec{\boldsymbol{\tau}} = I\vec{\boldsymbol{\alpha}}$$
$$\vec{\boldsymbol{\tau}}_{\mathrm{grav}} = \vec{\boldsymbol{R}}_{\mathrm{CM}} \times M\vec{\boldsymbol{g}}$$
$$\vec{\boldsymbol{L}} = \vec{\boldsymbol{r}} \times \vec{\boldsymbol{p}}$$
$$\vec{\boldsymbol{L}} = I\vec{\boldsymbol{\omega}}$$

$$\sum \vec{\boldsymbol{\tau}} = \frac{d\vec{\boldsymbol{L}}}{dt}$$
$$U_{\mathrm{grav}} = MgY_{\mathrm{CM}}$$
$$F_x = -kx$$
$$\omega = \sqrt{\frac{k}{m}}$$
$$\frac{d^2x}{dt^2} = -\omega^2 x$$
$$T = \frac{2\pi}{\omega}$$

$$x(t) = A\cos(\omega t + \phi)$$
$$v(t) = -\omega A \sin(\omega t + \phi)$$
$$a(t) = -\omega^2 A\cos(\omega t + \phi) = -\omega^2 x(t)$$
$$\omega = \sqrt{\frac{g}{L}}$$
$$\omega = \sqrt{\frac{MgR_{\mathrm{CM}}}{I}}$$

hecto	h	10^2	kilo	k	10^3	mega	M	10^6	giga	G	10^9	tera	T	10^{12}	peta	P	10^{15}
centi	c	10^{-2}	milli	m	10^{-3}	micro	μ	10^{-6}	nano	n	10^{-9}	pico	p	10^{-12}	femto	f	10^{-15}

$$F_{12} = k\frac{|q_1 q_2|}{r_{12}^2} \quad \text{(2 point charges)}$$
$$\epsilon_0 = 8.85 \times 10^{-12}\text{F/m}$$
$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{N} \cdot \text{m}^2/\text{C}^2$$
$$\vec{\boldsymbol{E}} = \frac{\vec{\boldsymbol{F}}}{q} = \frac{kq}{r^2}\hat{\boldsymbol{r}} \quad \text{(point charge)}$$
$$\vec{\boldsymbol{E}} = k\sum_i \frac{q_i}{r_i^2}\hat{\boldsymbol{r}}_i \quad \text{(point charges)}$$
$$\vec{\boldsymbol{E}} = k\int \frac{dq}{r^2}\hat{\boldsymbol{r}} \quad \text{(continuous charge distribution)}$$
$$E = \frac{\lambda}{2\pi\epsilon_0 r} \quad \text{(infinite line)}$$
$$E = \frac{\sigma}{2\epsilon_0} \quad \text{(infinite sheet)}$$
$$\Phi = \int \vec{\boldsymbol{E}} \cdot \boldsymbol{d}\vec{\boldsymbol{A}}$$

$$\Phi_{\text{Net}} = \oint \vec{\boldsymbol{E}} \cdot \boldsymbol{d}\vec{\boldsymbol{A}} = \frac{Q_{\text{enc}}}{\epsilon_0}$$
$$\Delta U_{A\to B} = -W_{A\to B} = -\int_A^B \vec{\boldsymbol{F}}_{\text{E}} \cdot \boldsymbol{d}\vec{\boldsymbol{l}}$$
$$U = k\frac{q_1 q_2}{r} \quad \text{(2 point charges)}$$
$$U = k\sum_{\text{pairs}} \frac{q_i q_j}{r_{ij}} \quad \text{(pairs of point charges)}$$
$$V = \frac{U}{q} = \frac{kq}{r} \quad \text{(point charge)}$$
$$V = k\sum_i \frac{q_i}{r_i} \quad \text{(point charges)}$$
$$\Delta V_{A\to B} = -\int_A^B \vec{\boldsymbol{E}} \cdot d\vec{\boldsymbol{l}}$$
$$\vec{\boldsymbol{E}} = -(\hat{\boldsymbol{\imath}}\frac{\partial V}{\partial x} + \hat{\boldsymbol{\jmath}}\frac{\partial V}{\partial y} + \hat{\boldsymbol{k}}\frac{\partial V}{\partial z})$$

$$C = \frac{Q}{V} \qquad C_{\text{new}} = \kappa C_0$$
$$C = \epsilon_0\frac{A}{d}; \quad E = \frac{\sigma}{\epsilon_0} \quad \text{(parallel-plate)}$$
$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots \text{(series)}$$
$$C_{\text{eq}} = C_1 + C_2 + C_3 + \cdots \text{(parallel)}$$
$$U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

$$u = \frac{1}{2}\epsilon_0 E^2 \qquad I = \frac{dq}{dt} \qquad V = IR$$
$$P = VI = I^2 R = \frac{V^2}{R}$$
$$R = \rho\frac{L}{A} = \frac{1}{\sigma}\frac{L}{A}$$
$$R_{\text{eq}} = R_1 + R_2 + R_3 + \cdots \text{(series)}$$
$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots \text{(parallel)}$$

$$\sum I_{\text{in}} = \sum I_{\text{out}} \quad \text{(junction rule)}$$
$$\sum \Delta V_n = 0 \quad \text{(loop rule)}$$
$$\tau = RC$$
$$I(t) = I_0 e^{-t/RC}$$
$$q(t) = q_{\text{f}}(1 - e^{-t/RC}) \quad \text{(charging)}$$
$$q(t) = q_0 e^{-t/RC} \quad \text{(discharging)}$$

$$\mu_0 = 4\pi \times 10^{-7} T \cdot m/A$$
$$\vec{\boldsymbol{F}} = q\vec{\boldsymbol{v}} \times \vec{\boldsymbol{B}}$$
$$\vec{\boldsymbol{F}} = I\vec{\boldsymbol{L}} \times \vec{\boldsymbol{B}}$$
$$\vec{\boldsymbol{\mu}} = NI\vec{\boldsymbol{A}}$$
$$\vec{\boldsymbol{\tau}} = \vec{\boldsymbol{\mu}} \times \vec{\boldsymbol{B}}$$
$$U(\theta) = -\vec{\boldsymbol{\mu}} \cdot \vec{\boldsymbol{B}} = -\mu B\cos\theta$$

$$d\vec{\boldsymbol{B}} = \frac{\mu_0 I}{4\pi}\frac{d\vec{\boldsymbol{s}} \times \hat{\boldsymbol{r}}}{r^2}$$
$$B = \frac{\mu_0 I}{2\pi R} \quad \text{(long wire)}$$
$$B = \mu_0 nI \quad \text{(inside solenoid)}$$
$$B = \frac{1}{2}\mu_0 nI \quad \text{(infinite sheet)}$$
$$F_1 = F_2 = \frac{\mu_0}{2\pi d}I_1 I_2 L \quad \text{(parallel wires)}$$

$$\oint \vec{\boldsymbol{B}} \cdot d\vec{\boldsymbol{l}} = \mu_0 I + \mu_0\epsilon_0\frac{d}{dt}\int \vec{\boldsymbol{E}} \cdot d\vec{\boldsymbol{A}}$$
$$\Phi_B = \int \vec{\boldsymbol{B}} \cdot \vec{\boldsymbol{A}}$$
$$\mathcal{E}_{\text{ind}} = -\frac{d}{dt}\Phi_B$$
$$\oint \vec{\boldsymbol{E}} \cdot d\vec{\boldsymbol{l}} = -\frac{d}{dt}\int \vec{\boldsymbol{B}} \cdot d\vec{\boldsymbol{A}}$$

$$L = \frac{\Phi_B}{I}; \quad \mathcal{E}_L = -L\frac{dI}{dt}$$
$$U_L = \frac{1}{2}LI^2; \quad u_B = \frac{B^2}{2\mu_0}$$
$$\omega_0 = \frac{1}{\sqrt{LC}}$$
$$I(t) = I_m\sin(\omega t + \phi)$$
$$\mathcal{E}(t) = \mathcal{E}_m\sin(\omega t)$$

$$\mathcal{E}_m = I_m Z; \quad V_{R_{max}} = I_m R$$
$$V_{L_{max}} = I_m X_L; \quad X_L = \omega L$$
$$V_{C_{max}} = I_m X_C; \quad X_C = \frac{1}{\omega C}$$
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$
$$\tan\phi = \frac{X_L - X_C}{R}$$

$$\frac{V_S}{V_P} = \frac{I_P}{I_S} = \frac{N_S}{N_P}$$
$$I_D = \epsilon_0\frac{d}{dt}\int \vec{\boldsymbol{E}} \cdot d\vec{\boldsymbol{A}}$$
$$E_0 = cB_0; c = \frac{1}{\sqrt{\epsilon_0\mu_0}}$$
$$\vec{\boldsymbol{S}} = \frac{\vec{\boldsymbol{E}} \times \vec{\boldsymbol{B}}}{\mu_0}; I = c\epsilon_0 E_0^2$$

$$I_{\text{final}} = I_0\cos^2\theta$$
$$\theta_I = \theta_R$$
$$v = \frac{c}{n}$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$
$$\theta_c = \sin^{-1}\frac{n_2}{n_1}$$

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$
$$M = \frac{h'}{h}$$

	SI Units			Base units:	m, kg, s, A	
Hz	s^{-1}	1/s	F	$kg^{-1}\cdot m^{-2}\cdot s^4\cdot A^2$	C/V	
N	$kg\cdot m\cdot s^{-2}$	$kg\cdot m/s^2$	Ω	$kg\cdot m^2\cdot s^{-3}\cdot A^{-2}$	V/A	Prof. Vadas Gintautas
J	$kg\cdot m^2\cdot s^{-2}$	N·m=C·V=W·s	Wb	$kg\cdot m^2\cdot s^{-2}\cdot A^{-1}$	J/A	PHY251/PHY252
W	$kg\cdot m^2\cdot s^{-3}$	J/s=V·A	H	$kg\cdot m^2\cdot s^{-2}\cdot A^{-2}$	V·s/A=Wb/A	Chatham University
C	s·A	s·A	T	$kg\cdot s^{-2}\cdot A^{-1}$	$V\cdot s/m^2=Wb/m^2$=N/(A·m)	Fall 2013 – Spring 2014
V	$kg\cdot m^2\cdot s^{-3}\cdot A^{-1}$	W/A=J/C				