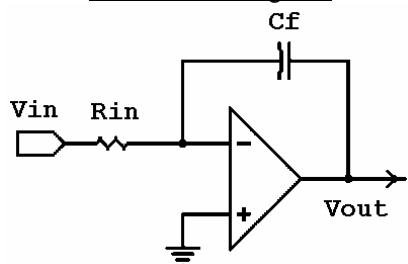


Thevenin Voltage Sources		
Find Vth	Set load between A and B to open and find $V_A - V_B$	$V_L = \frac{R_L}{R_{th} + R_L} V_{th}$
Find Rth	Set voltage sources to shorts and find combined resistance between A and B.	

Harmonic Oscillation		
UnDamped	Damped	Cantilever Beam
$\frac{d^2V}{dt^2} + \omega_0^2 V = 0$ $v(t) = A \cos(\omega_0 t + \phi)$ $\omega_0 = \frac{1}{\sqrt{LC}}$	$\frac{d^2V}{dt^2} + 2\alpha \frac{dV}{dt} + \omega_0^2 V = 0$ $v(t) = A e^{-\alpha t} \cos(\omega_0 t + \phi)$ $V_1 = V_0 e^{-\alpha(t_1 - t_0)}$ $\alpha = \frac{R}{2L}$	$\frac{Ewt^3}{4l^3} = (m + m_n)(2\pi f_n)^2$ $m = 0.23m_{beam}$

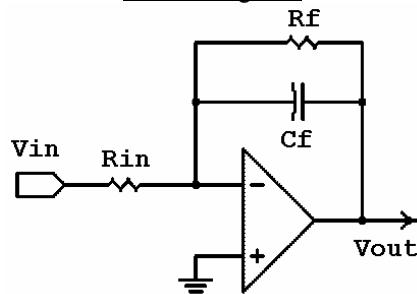
Op-Amp Circuits		
<u>Op Amp Analysis Rules</u> <ol style="list-style-type: none"> 1. $V_+ = V_-$ 2. $I_+ = I_- = 0$ <u>Op-Amp Analysis</u> <ol style="list-style-type: none"> 1. Remove Op-Amp 2. Draw a circuit at each input to the op-amp 3. Solve for Vout in terms of the input voltage(s). 	<u>Voltage Follower</u> $A_V = \frac{V_{out}}{V_{in}} = 1$	
<u>Inverting Amplifier</u> $A_V = \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$	<u>Non-Inverting Amplifier</u> $A_V = \frac{V_{out}}{V_{in}} = 1 + \frac{R_f}{R_g}$	
<u>Differential Amplifier</u> $V_{out} = \frac{R_f}{R_{in}}(V_2 - V_1)$	<u>Adder</u> $V_{out} = -\frac{R_f}{R_1}V_1 - \frac{R_f}{R_2}V_2$	

Ideal Active Integrator

$$H(j\omega) = \frac{V_{out}}{V_{in}} = -\frac{1}{j\omega R_{in} C_f}$$

$$v_{out}(t) = -\frac{1}{R_{in} C_f} \int v_{in}(t) dt$$

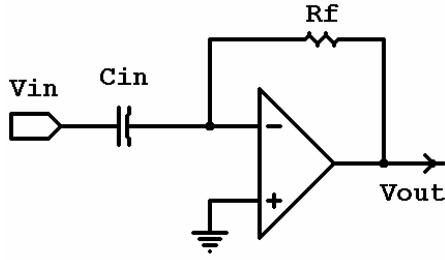
$$\int \sin(\omega t) dt = \frac{-1}{\omega} \cos(\omega t) + K$$

Miller Integrator

$$H(j\omega) = \frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}(1 + j\omega R_f C_f)}$$

$$\omega \gg \frac{1}{R_f C_f} \Rightarrow H(j\omega) \approx -\frac{1}{j\omega R_{in} C_f}$$

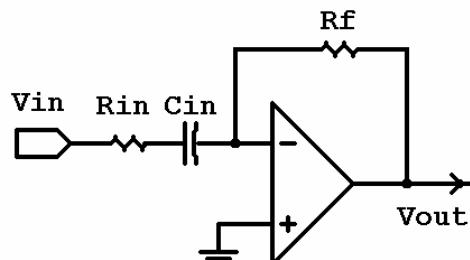
$$\omega \gg \frac{1}{R_f C_f} \Rightarrow v_{out}(t) \approx -\frac{1}{R_{in} C_f} \int v_{in}(t) dt$$

Ideal Active Differentiator

$$H(j\omega) = \frac{V_{out}}{V_{in}} = -j\omega R_f C_{in}$$

$$v_{out}(t) = -R_f C_{in} \frac{dv_{in}(t)}{dt}$$

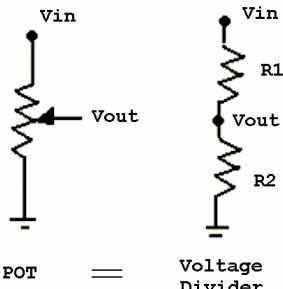
$$\frac{d \sin(\omega t)}{dt} = \omega \cos(\omega t)$$

Practical Active Differentiator

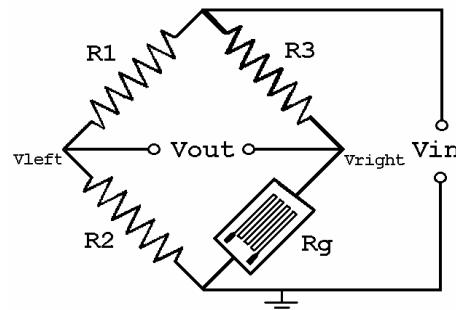
$$H(j\omega) = \frac{V_{out}}{V_{in}} = -\frac{j\omega R_f C_{in}}{1 + j\omega R_{in} C_{in}}$$

$$\omega \ll \frac{1}{R_{in} C_{in}} \Rightarrow H(j\omega) \approx -j\omega R_f C_{in}$$

$$\omega \ll \frac{1}{R_{in} C_{in}} \Rightarrow v_{out}(t) = -R_f C_{in} \frac{dv_{in}(t)}{dt}$$

Potentiometers

$$RT = R1 + R2 \quad Vout = \frac{R2}{RT} Vin$$

Strain Gauge Bridge

$$Vout = dV = V_{left} - V_{right} = Vin \left[\frac{R2}{R1 + R2} - \frac{Rg}{R3 + Rg} \right]$$