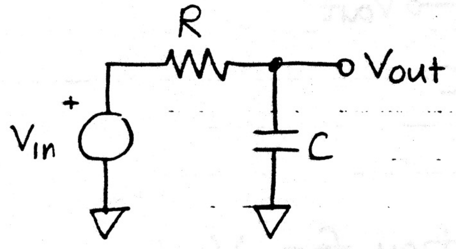
# BANDWIDTH AND RISETIME

Consider the single pole network



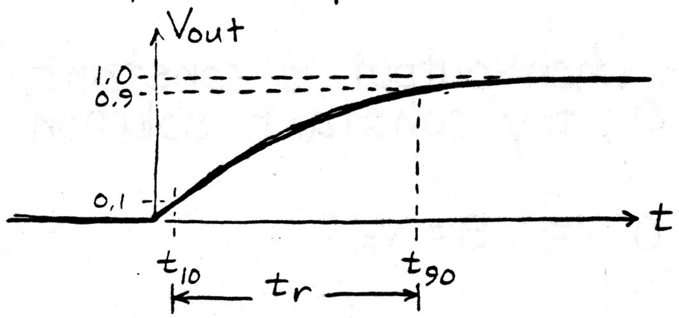

$$\frac{V_{out}}{V_{in}} = H(s) = \frac{1}{1+sRC} = \frac{1}{1+s\tau}$$

Letting $s=j\omega$, we have

$$H(j\omega) = \frac{1}{1+j\omega\tau} = \frac{1}{1+j\left(\frac{\omega}{\omega_o}\right)}$$

where $\omega_o = 1/\tau$ is the 3dB bandwidth, in radians/sec

The "rise time" $t_r$ is defined as the time required for the output to rise from 10% to 90% of the output step:




From general step response

$$0.1 = 1.0 - e^{-t_{10}/\tau} \Rightarrow t_{10} = -\tau \ln(0.9)$$

$$0.9 = 1.0 - e^{-t_{90}/\tau} \Rightarrow t_{90} = -\tau \ln(0.1)$$

$$t_r = t_{90} - t_{10} = \tau \ln(9)$$

Or, $\boxed{t_r = 2.2\,\tau}$

Since $\tau = 1/\omega_o$, and $f_o = \omega_o/2\pi = BW$ (3dB bandwidth in Hz)

$$t_r = 2.2\frac{1}{\omega_o} = \frac{1}{BW}\,\frac{2.2}{2\pi} \Rightarrow \boxed{BW \cdot t_r = 0.35}$$

Approximately valid for any linear system with poles near real axis (little overshoot in step response)