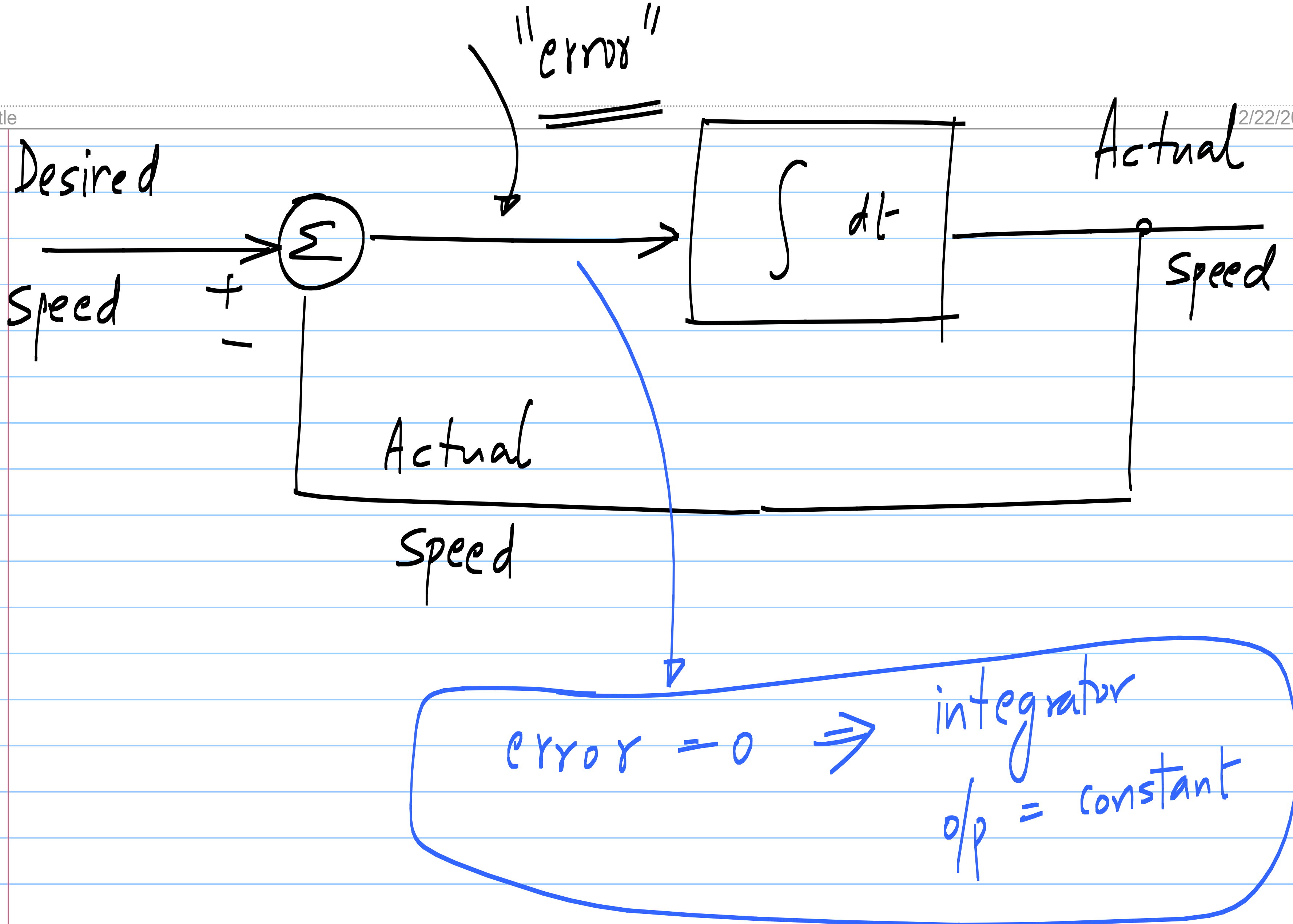
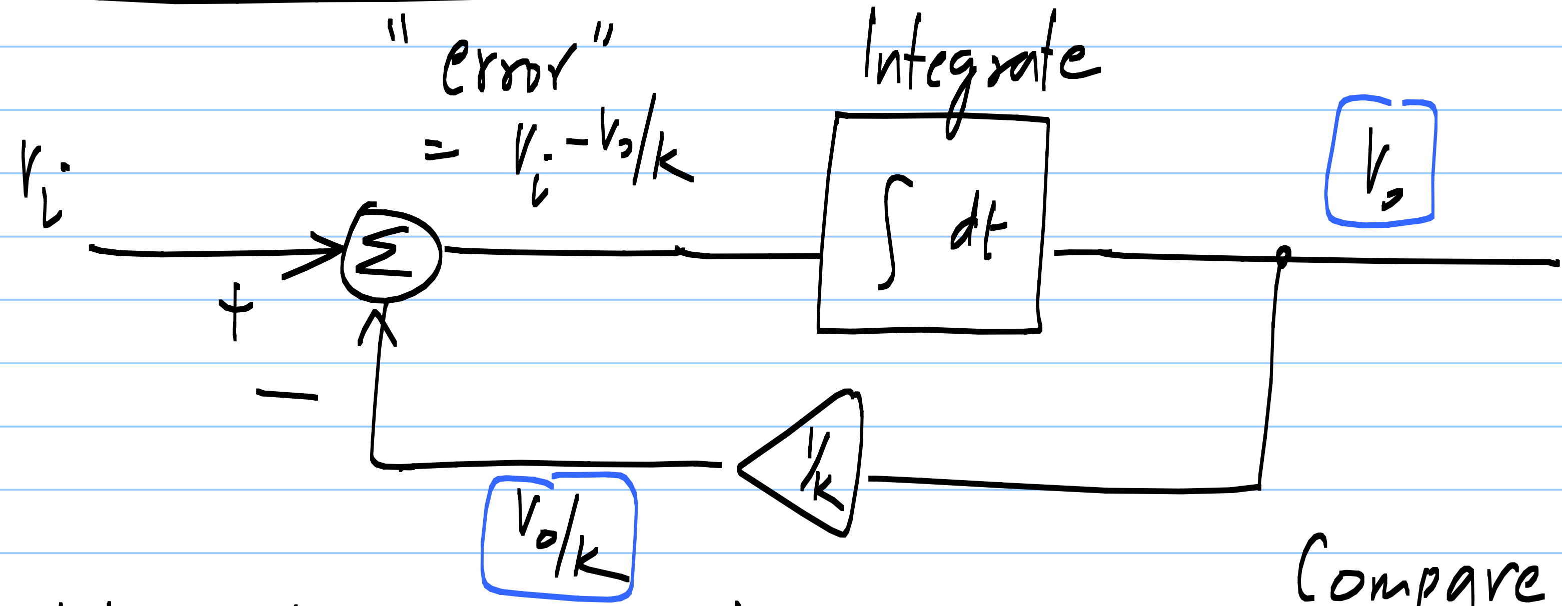
Note Title 2/22/2010



# Amplifier using negative feedback




I'd like to make $V_o = kV_i$

≡ I'd like to make $\frac{V_o}{k} = V_i$

error: $\left(\frac{V_o}{k} - V_i\right)$

Compare actual o/p to the desired o/p.

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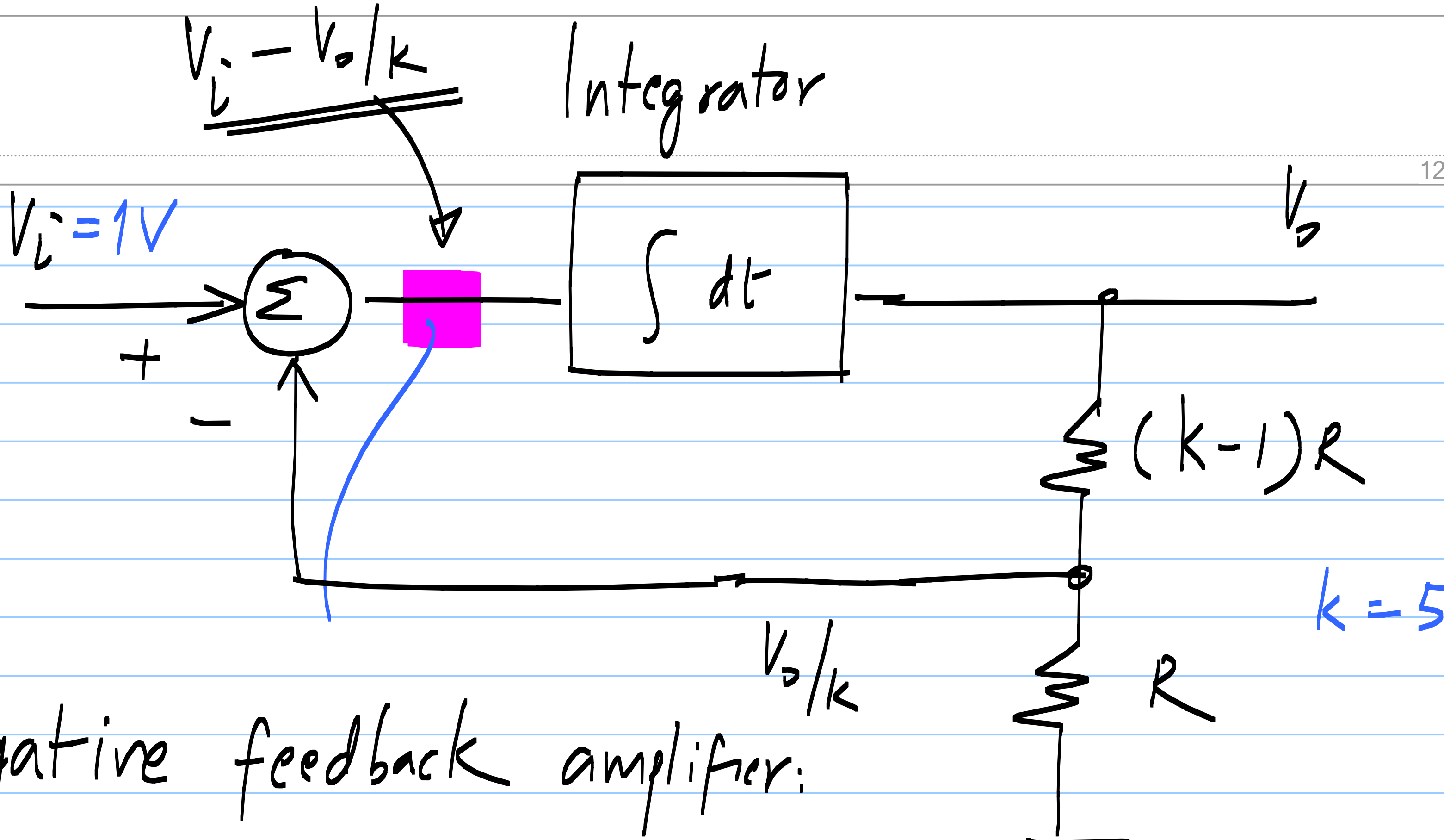
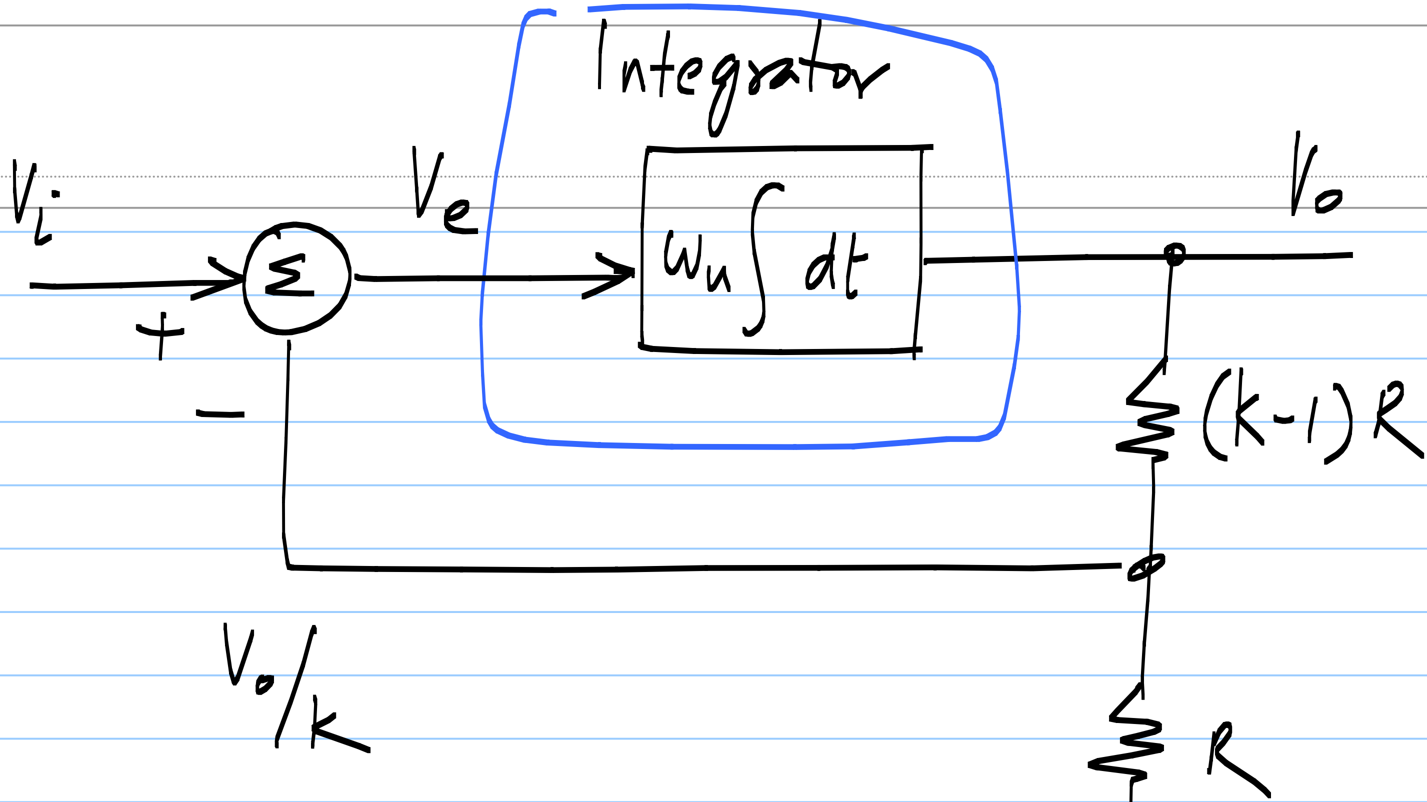
Note Title 12/22/2010




**Negative feedback amplifier:**

- Integrate the error to drive the output

Note Title 12/22/2010




error $V_e = \underline{V_i - V_o/k}$

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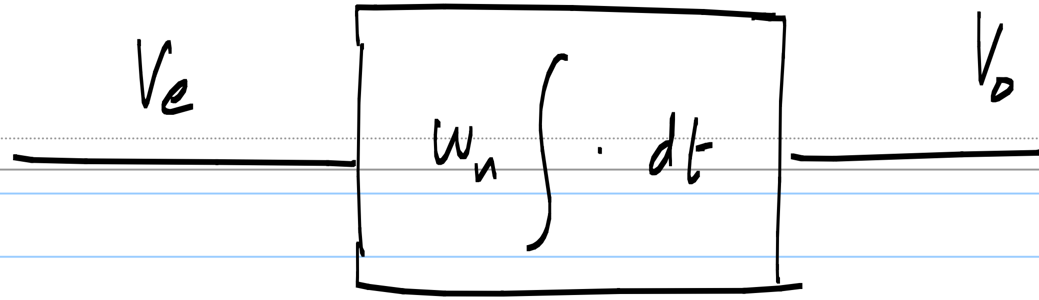
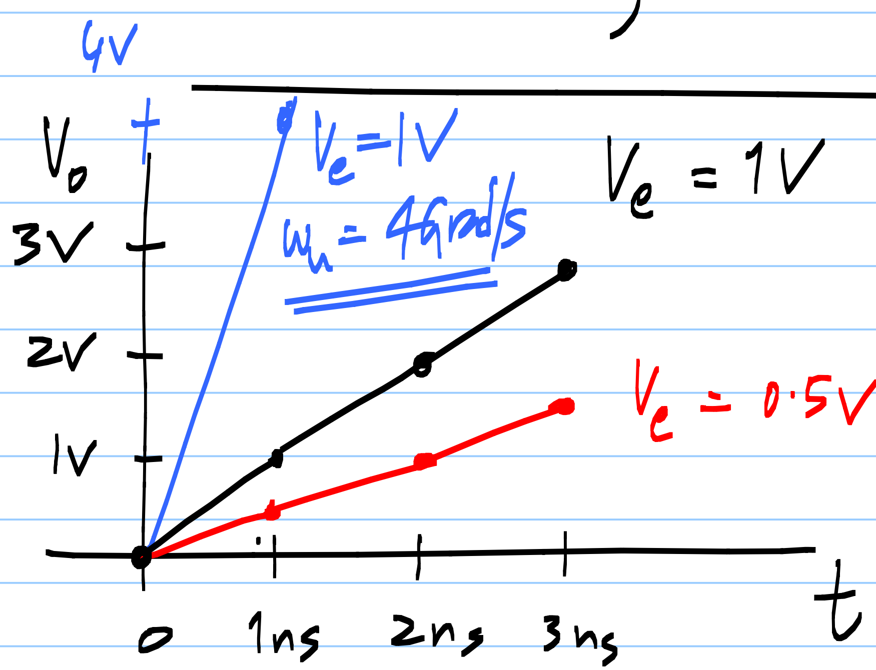



$$V_o = \omega_n \int V_e \cdot dt$$

$\omega_n$: dimensions of frequency

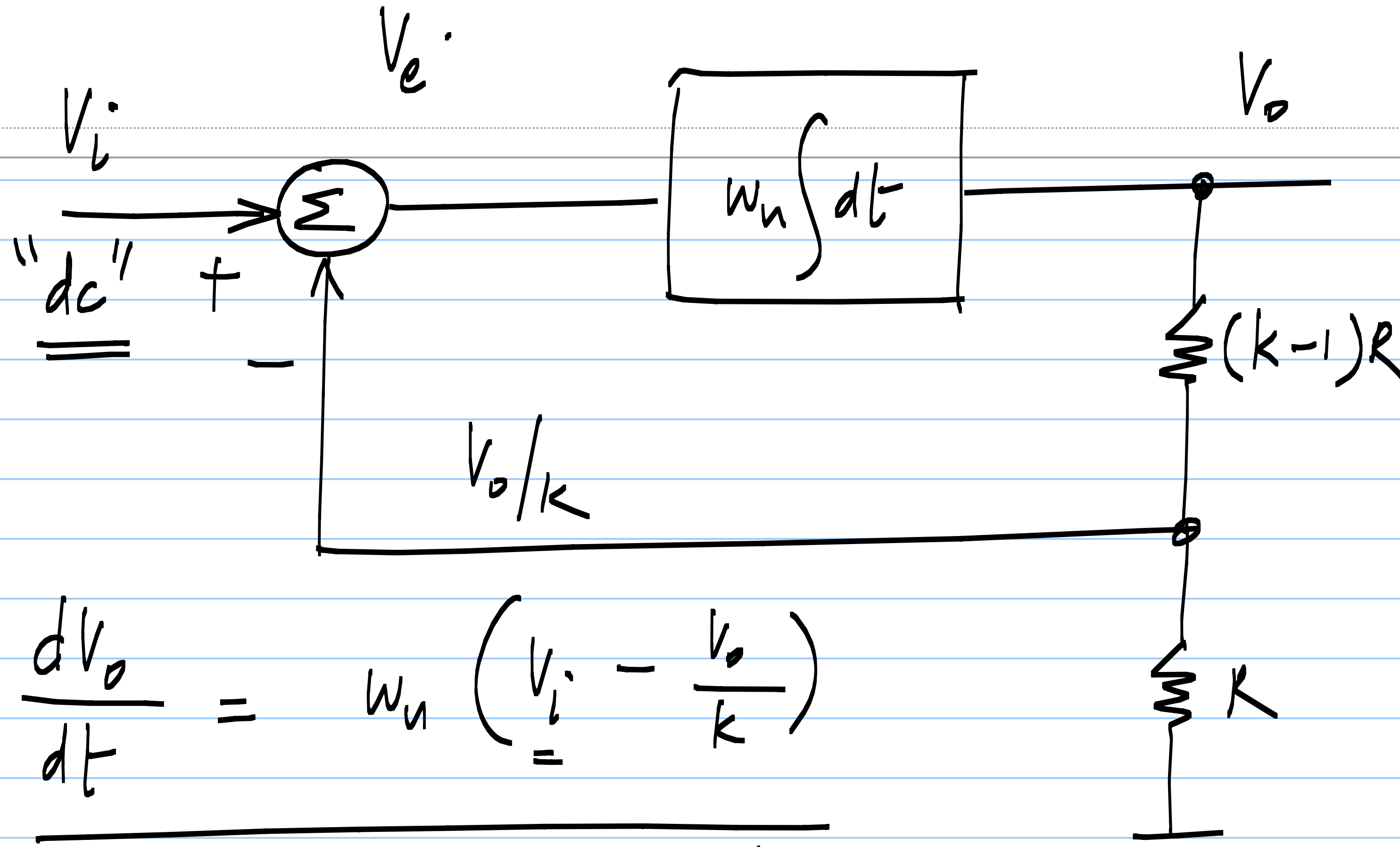



$\omega_n = 1 \, Grad/s$

$= 10^9 \cdot rad/s$

$\omega_n = 4 \, Grad/s$

$= 4 \times 10^9 \, rad/s$




$$\frac{dV_o}{dt} = w_n \left( V_i - \frac{V_o}{k} \right)$$

$$\frac{dV_o}{V_i - \frac{V_o}{K}} = w_n \cdot dt \xrightarrow[V_i : \text{const}]{\text{Integrate}} : \; \frac{dV_o}{k \cdot V_i - V_o} = \frac{w_n \cdot dt}{k}$$

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$$\frac{dV_o}{kV_i - V_o} = \frac{\omega_u \cdot dt}{k}$$

Integrating

$$-\ln\left(kV_i - V_o\right)\Big|_{V_o(0)}^{V_o(t)} = \frac{\omega_u}{k} \cdot t\Big|_0^t$$

$$\ln \frac{kV_i - V_o(t)}{kV_i - V_o(0)} = -\frac{\omega_u}{k} \cdot t$$

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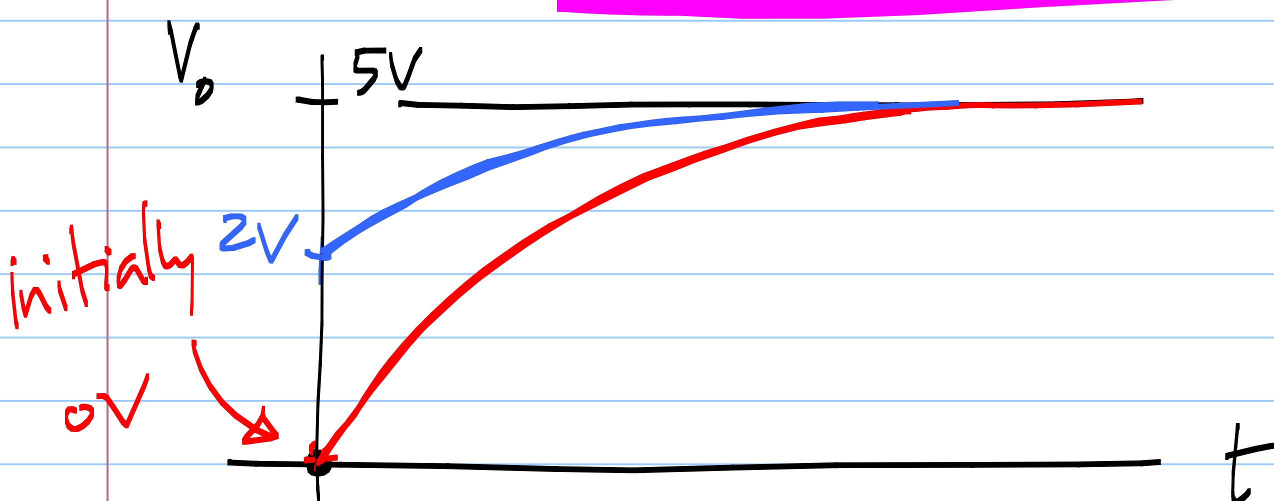
$$V_o(t) = V_o(0)\cdot \exp\left(-\frac{\omega_n}{k}\cdot t\right)$$
$$+\ k\cdot V_i \cdot \left(1 - \exp\left(-\frac{\omega_n}{k}\cdot t\right)\right)$$




$V_o(t) = kV_i$

when $t=\infty$

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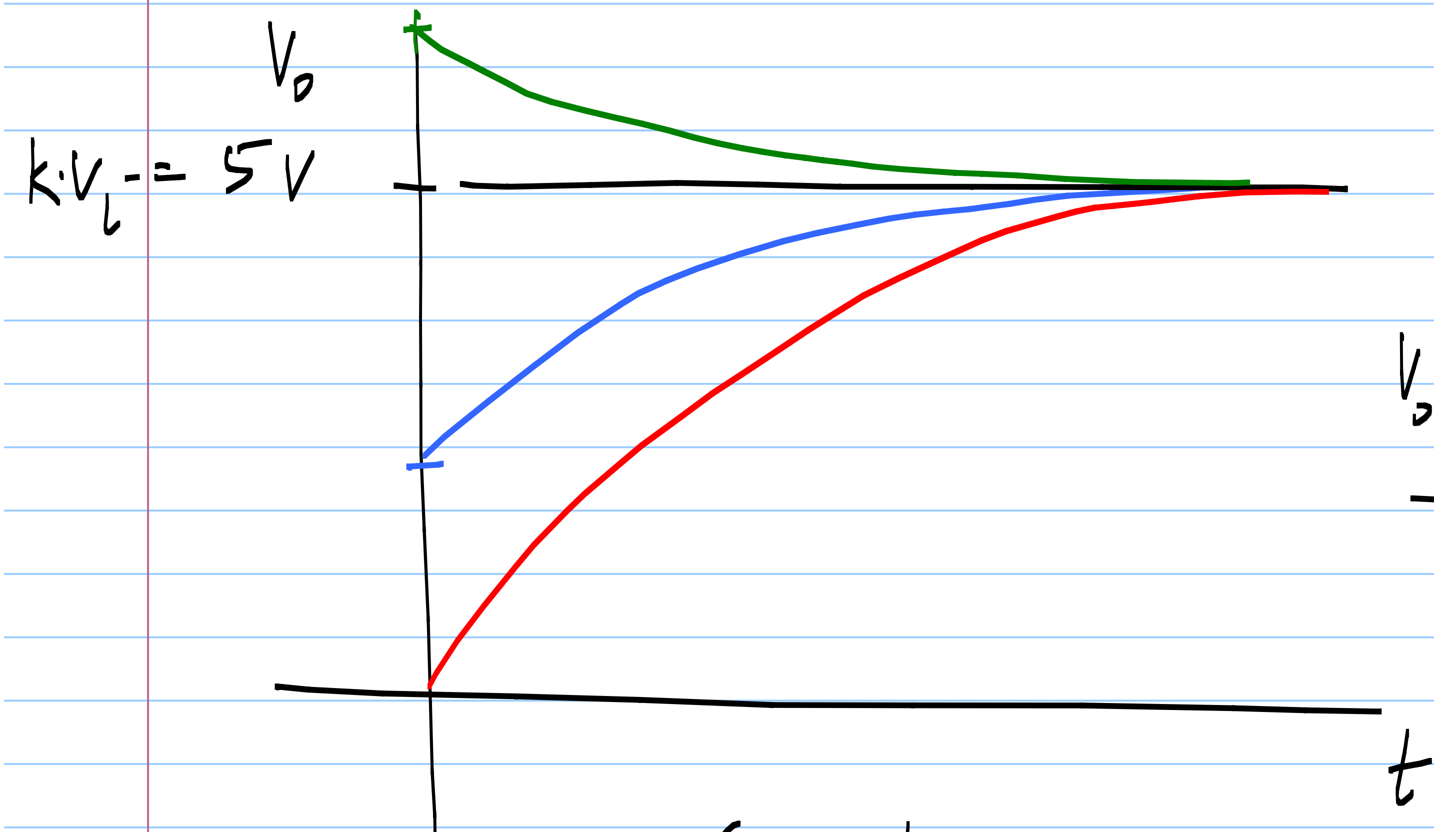
Note Title 12/22/2010

$$V_o(t) = V_o(0)\exp\left(-\frac{\omega_n t}{k}\right) + kV_i\left(1 - \exp\left(-\frac{\omega_n t}{k}\right)\right)$$




$k = 5$

$V_i = 1V$

$$V_o = kV_i\left(1 - \exp\left(-\frac{\omega_n t}{k}\right)\right)$$

$$= (0.99)\,kV_i$$

$$\exp\left(-\frac{\omega_n t}{k}\right) = 0.01 \Rightarrow t = \underbrace{2\ln(10)}_{4.6}\left(\frac{k}{\omega_n}\right)$$

Note Title 12/22/2010

$$\exp\left(-\frac{\omega_n}{k}\cdot t\right) = 0.01$$

$$\Rightarrow \quad t = \frac{2\ln(10)}{4.6}\cdot\left(\frac{k}{\omega_n}\right)$$

$$\frac{k}{\omega_n} = \frac{5}{10^9\,\text{rad/s}} = 5\,\text{ns}$$

$$t = 23\,\text{ns} \longrightarrow 4.6\,\text{ns}$$

reaches 99% of the steady state value $kV_i$ (zero initial condition)

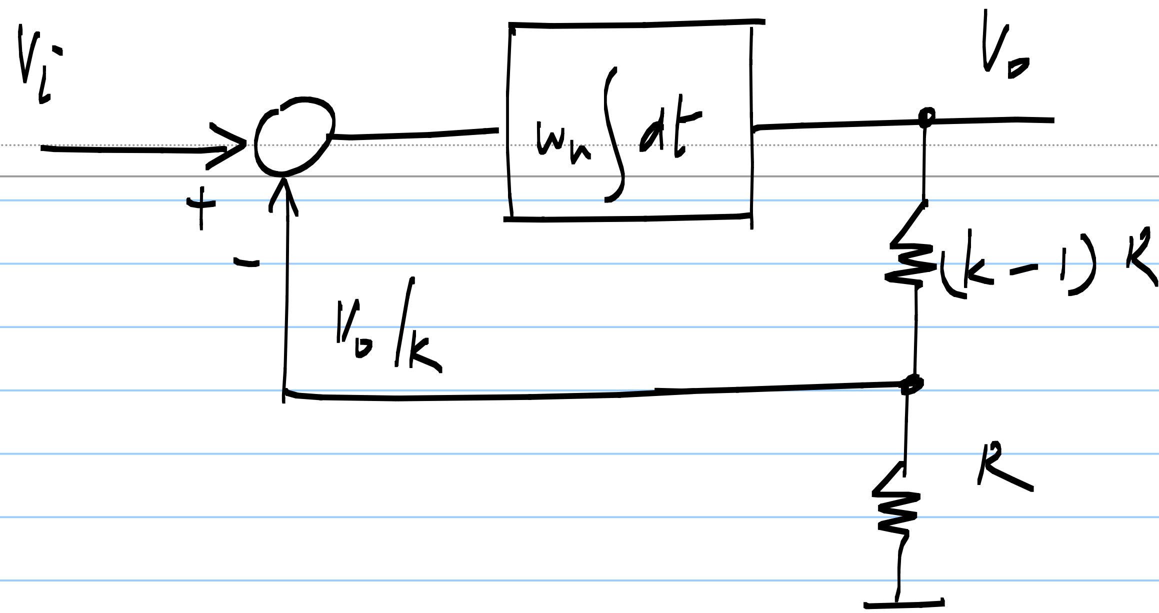
$$\omega_n = 10^9\,\text{rad/s}$$

$$k = 5$$

$$\omega_n = 5\times 10^9\,\text{rad/s}$$

$$\frac{k}{\omega_n} = \frac{5}{5\cdot 10^9\,\text{rad/s}} = 1\,\text{ns}$$

Note Title




$\frac{k}{w_n}$ : time constant

- Compare divided output to the input & integrate the difference to drive the output
- Integrator: - $w_n$ - speed of integration
- $V_o(t)$ < First order DE, $\exp(-w_n t/k)$

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