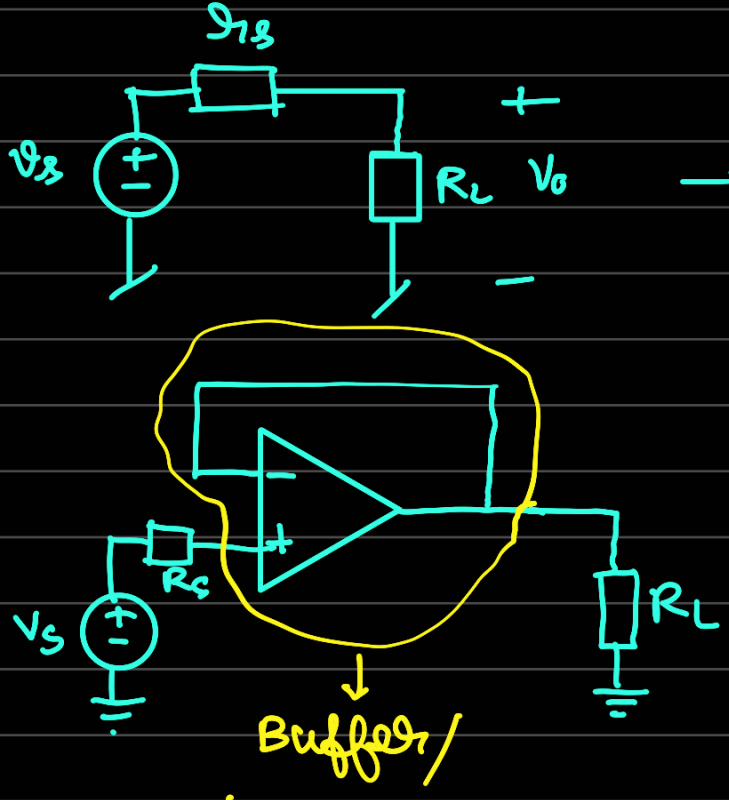
# Day-10

## → OpAmp – Loading effects :



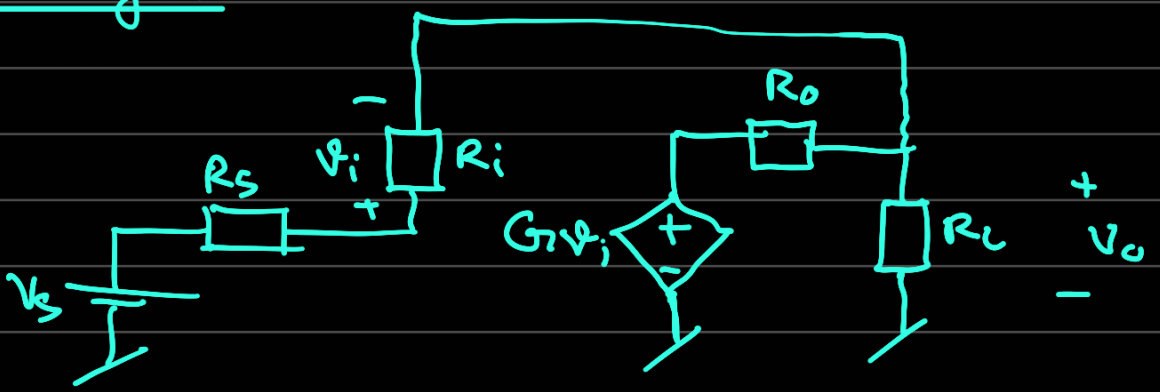

$$V_o = \frac{R_L}{R_L + R_s} V_s$$

→ No loading if $R_s \ll R_L$

↓

Buffer/
Unity gain amplifier/
Voltage follower

## Analysis –



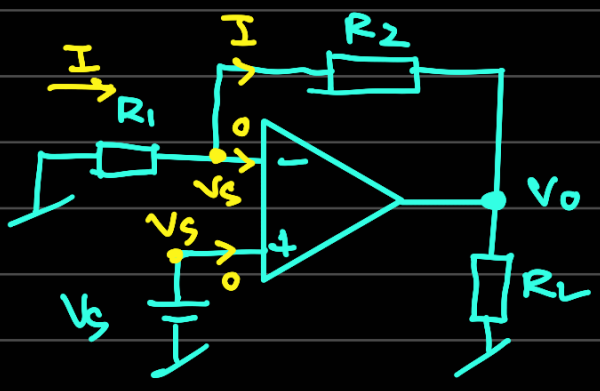

$$\frac{V_o}{V_s} = \frac{1}{1 + \frac{1}{G_1}\left(1 + \frac{R_s}{R_i}\right)}$$

$G_1 = 2 \times 10^5$, $R_s = 500\ \Omega$ (741)
$R_i = 2 \times 10^6$, $(R_o \approx 75\ \Omega)$

Open loop gain = $\frac{V_o}{V_+ - V_-}$

Close loop gain = $\frac{V_o}{V_s}$

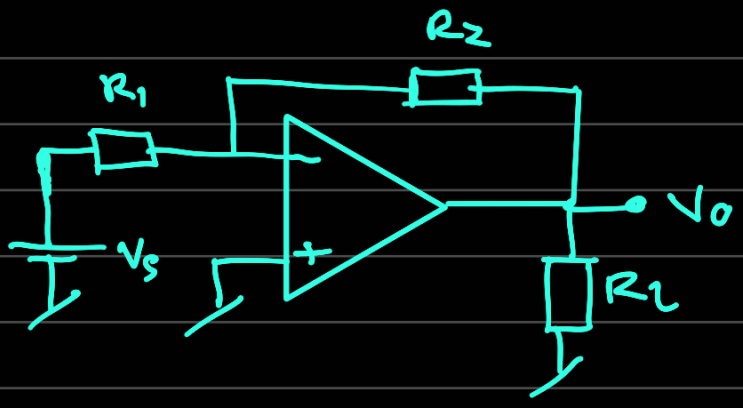
→




$$\frac{-V_s}{R_1} = \frac{V_s - V_o}{R_2}$$

$$\Rightarrow \frac{V_o}{V_s} = 1 + \frac{R_2}{R_1}$$

(Non-inverting amplifier)

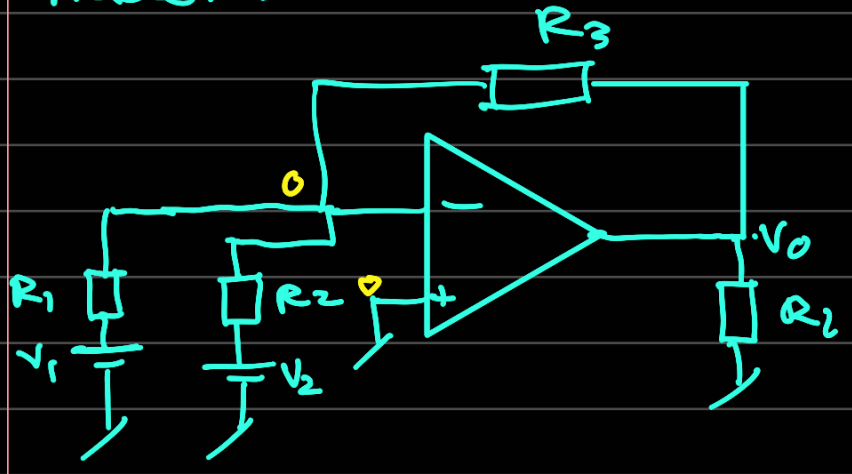



$$\frac{V_s - 0}{R_1} = \frac{0 - V_o}{R_2}$$

$$\Rightarrow \frac{V_o}{V_s} = -\frac{R_2}{R_1}$$

(Inverting)

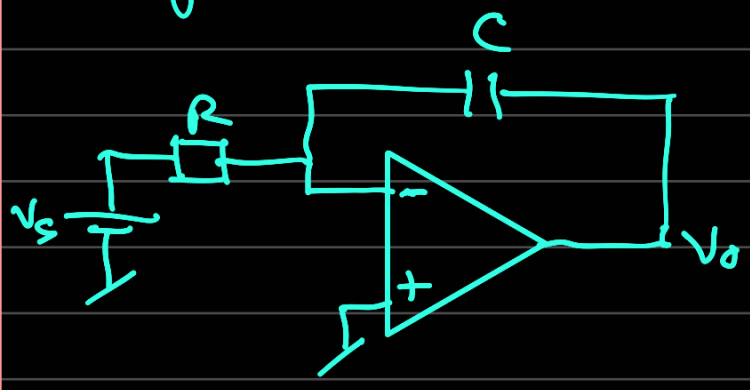
→ Adder :



$$\frac{V_1}{R_1} + \frac{V_2}{R_2} = -\frac{V_0}{R_3}$$

$$\Rightarrow V_0 = -\left[\left(\frac{R_3}{R_1}\right)V_1 + \left(\frac{R_3}{R_2}\right)V_2\right]$$

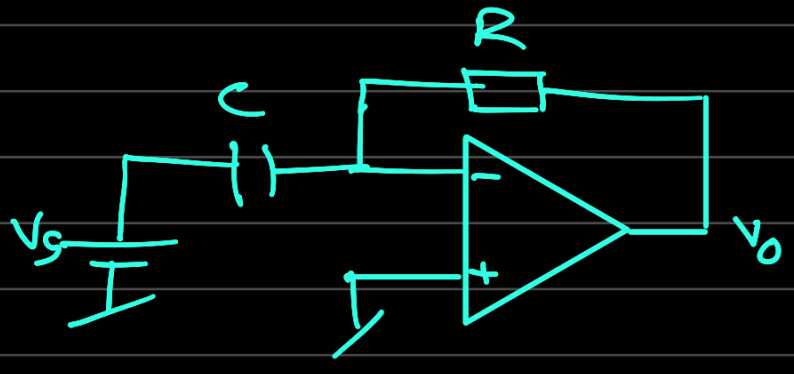
→ Integrator -




$$\frac{V_s - 0}{R} = -C\frac{dV_0}{dt}$$

$$\Rightarrow V_0 = -\frac{1}{RC}\int V_s\, dt$$

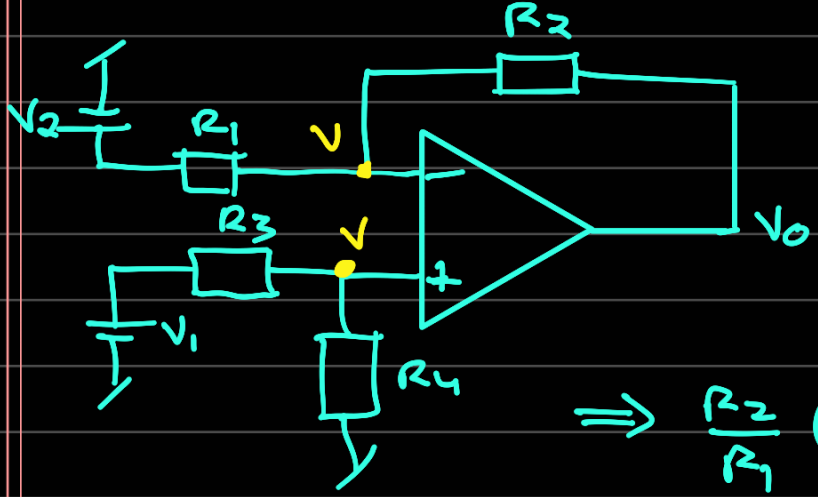
→ Differentiator -




$$C\frac{dV_s}{dt} = -\frac{V_0}{R}$$

$$\Rightarrow V_0 = -RC\frac{dV_s}{dt}$$

→ Difference amplifier -




$$V = \frac{V_1 R_4}{R_3 + R_4}$$

$$\frac{V_2 - V}{R_1} = \frac{V - V_0}{R_2}$$

$$\Rightarrow \frac{R_2}{R_1}(V_2 - V) = V - V_0$$

$$\Rightarrow V_0 = V + R_2/R_1\,(V - V_2)$$

$$= \frac{V_1 R_4}{R_3 + R_4}\left(1 + \frac{R_2}{R_1}\right) - V_2\left(\frac{R_2}{R_1}\right)$$