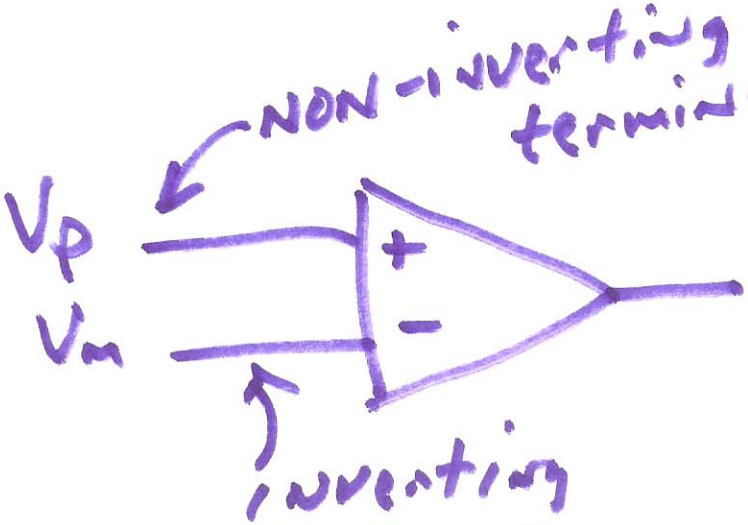
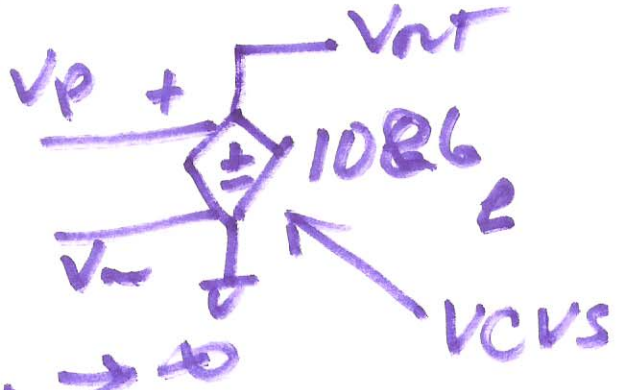
# Op-Amps I

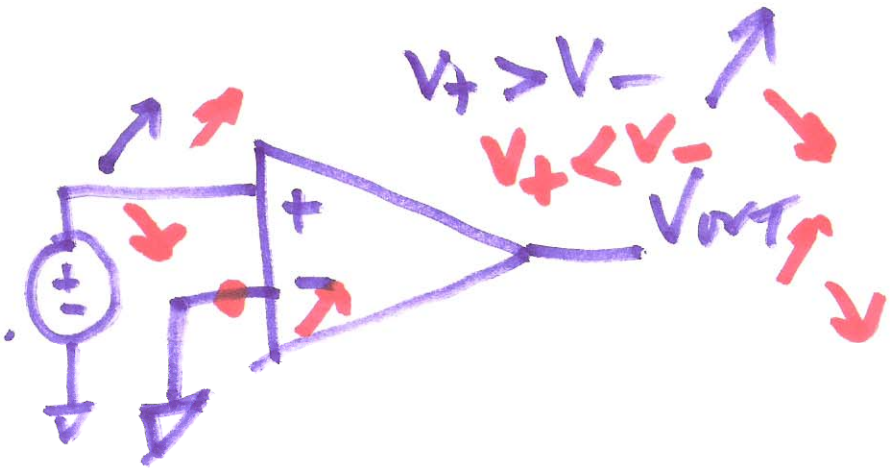



ideal op-Amp $A_{OL} \to \infty$

$V_p - V_m \to 0$

$V_p = V_m$

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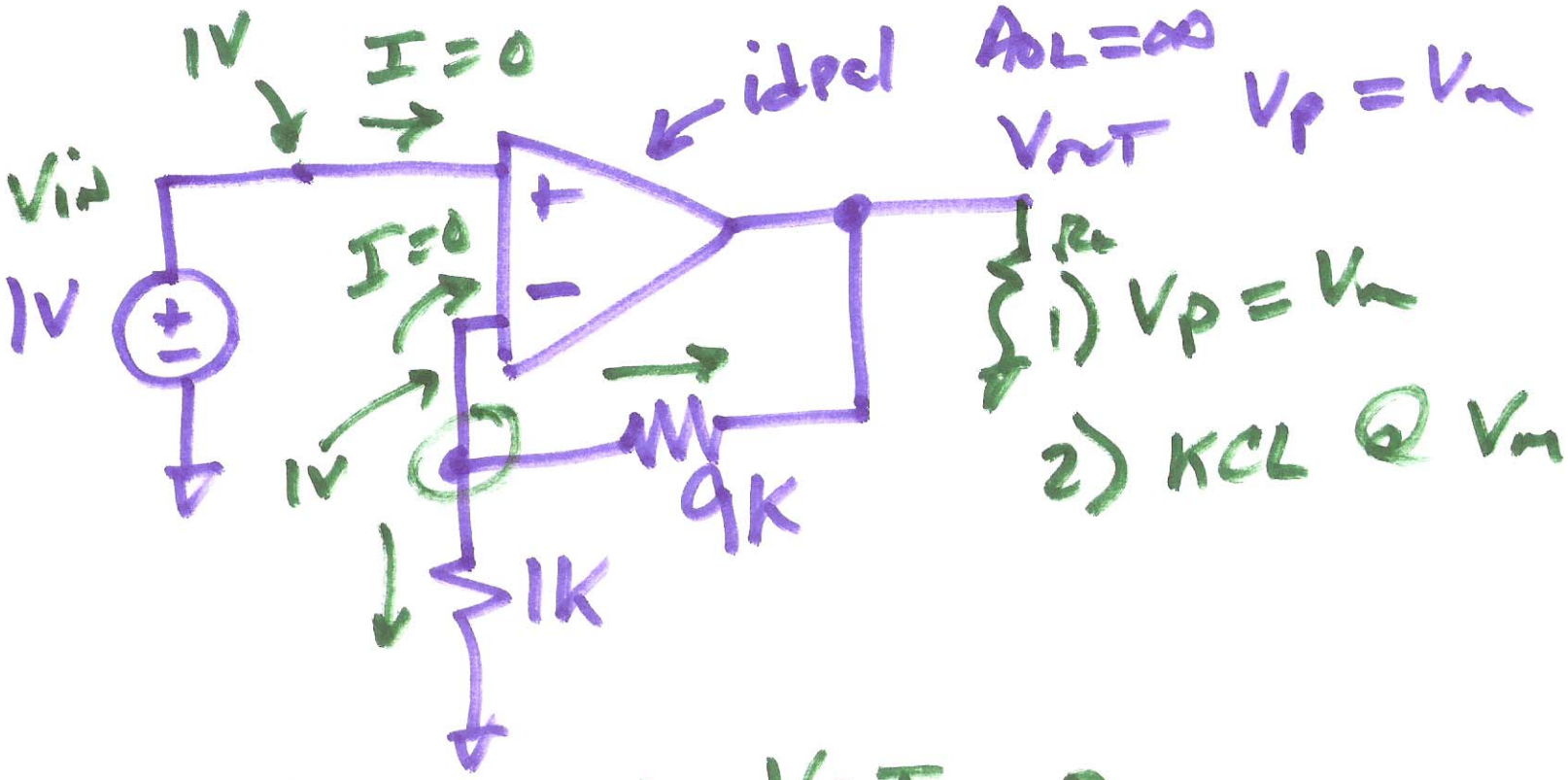


$$10^{-3}: \quad \frac{1V}{1K} + \frac{1 - V_{inT}}{9K} = 0$$

$$10^{-3}: \quad \frac{1 - V_{inT}}{9K} = -1m$$

$$\boxed{V_{inT} = 10}$$

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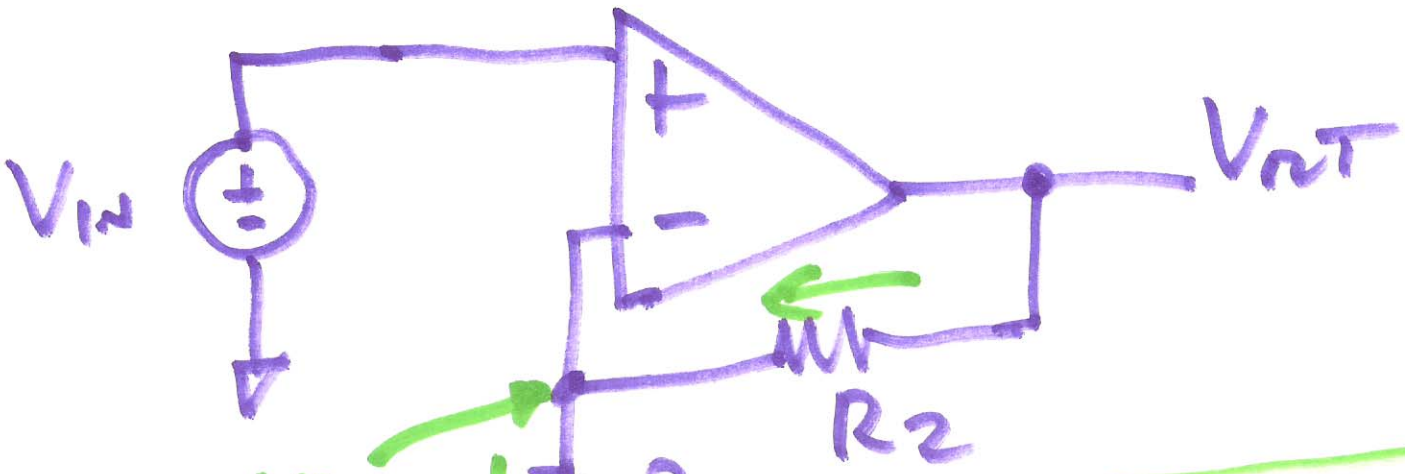
# NON-INVERTING Amplifier




$$\frac{V_{IN}}{R_1} = \frac{V_{OUT} - V_{in}}{R_2}$$

$$\frac{V_{OUT}}{V_{IN}} = 1 + \frac{R_2}{R_1}$$

$$V_{IN}\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{V_{OUT}}{R_2} \quad \nearrow \quad = \frac{R_1 + R_2}{R_1}$$



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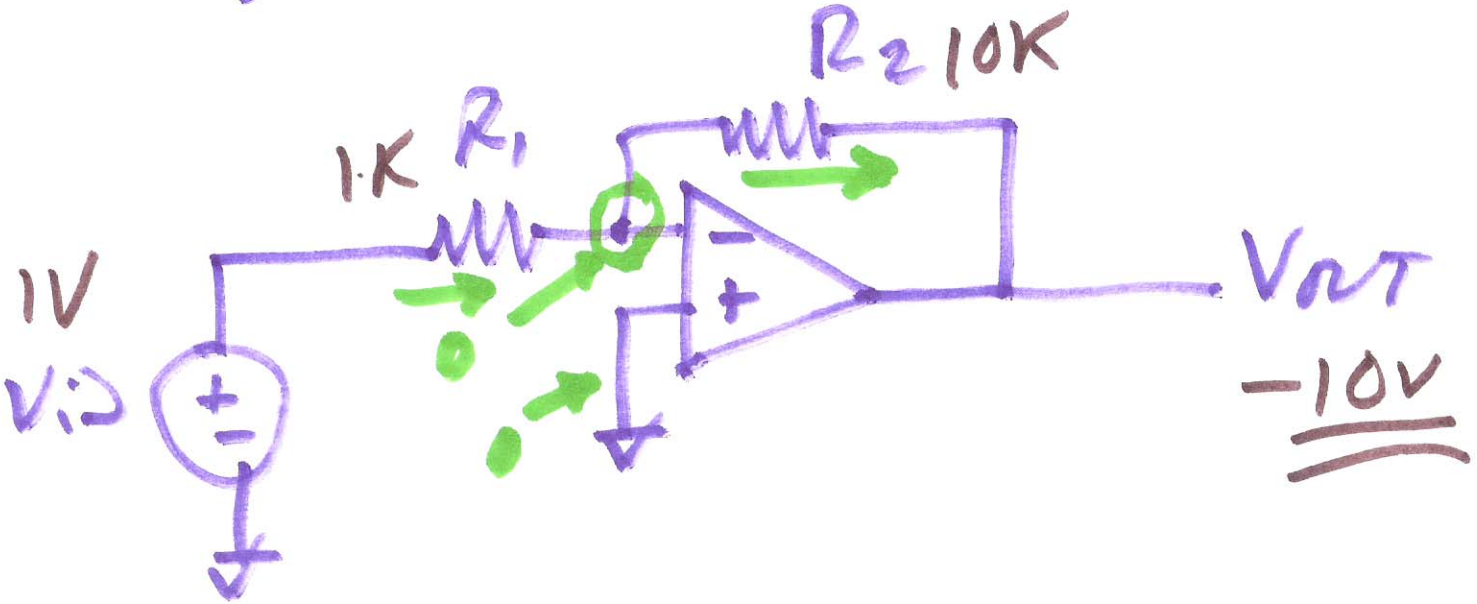
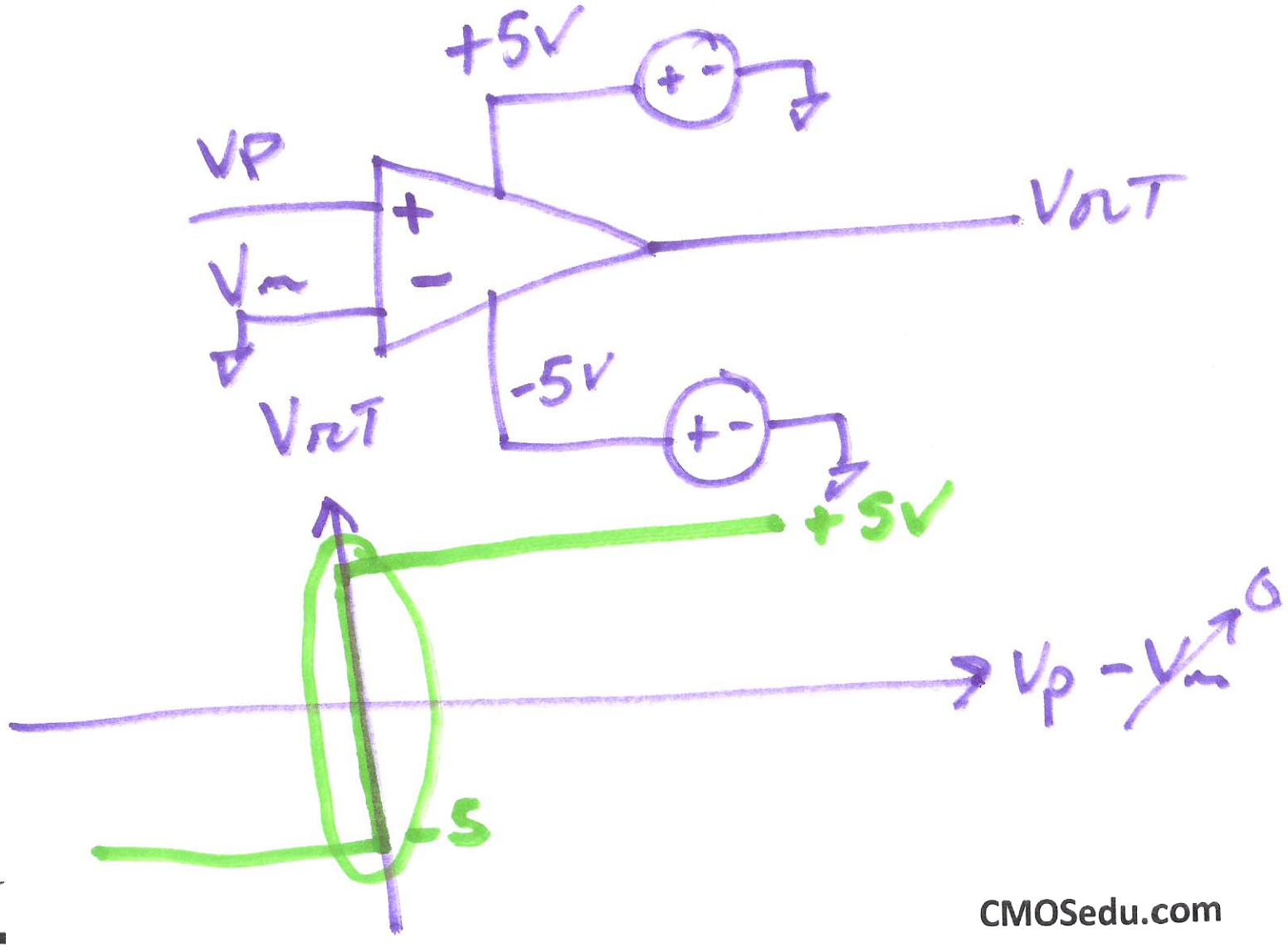
# Inverting Op-Amp

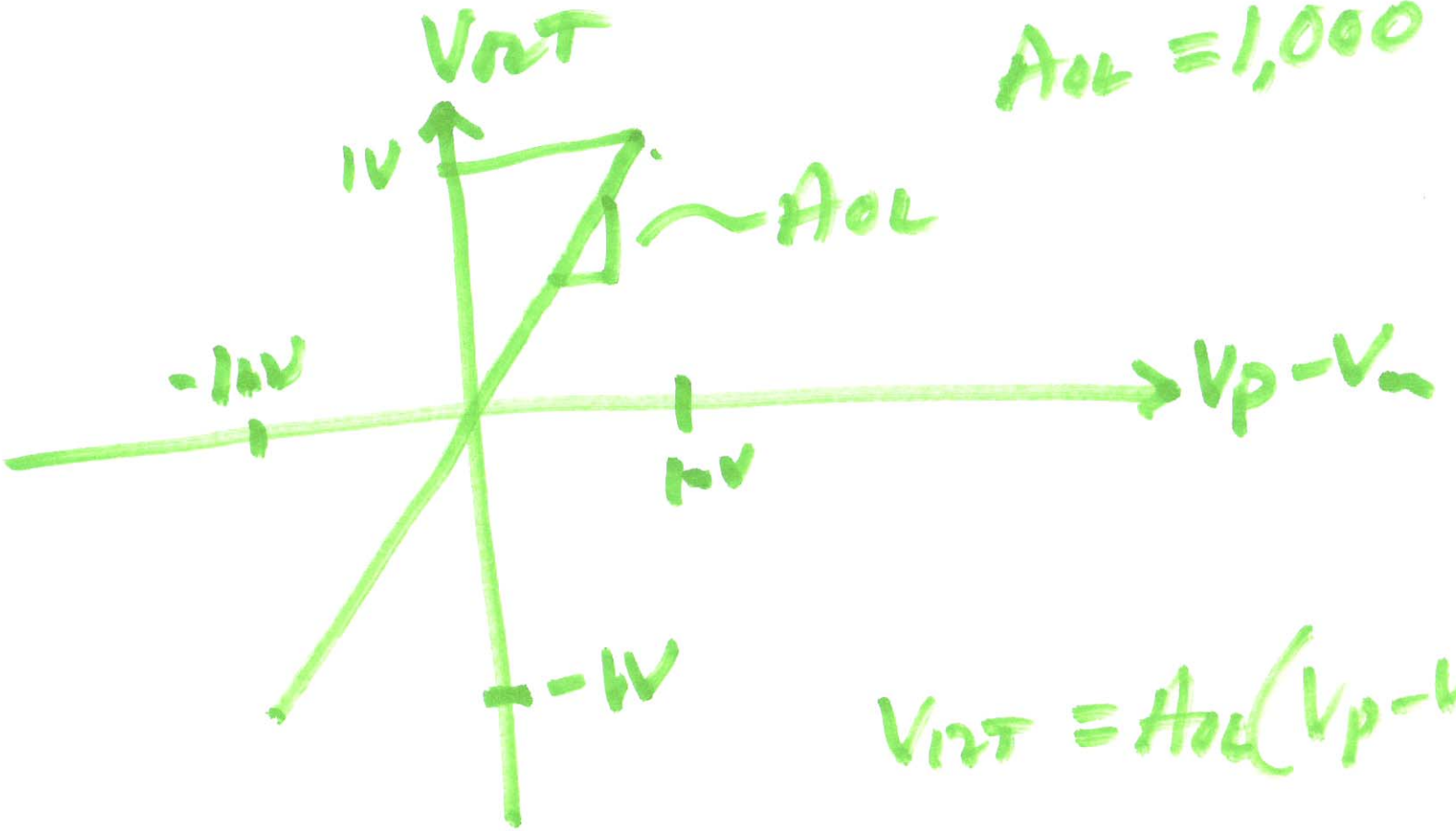



$$\frac{V_{in}}{R_1} = \frac{0 - V_{OUT}}{R_2}$$

$$\boxed{\frac{V_{OUT}}{V_{IN}} = -\frac{R_2}{R_1}}$$

Finite output swing
Finite open-loop, $A_{OL}$, gain





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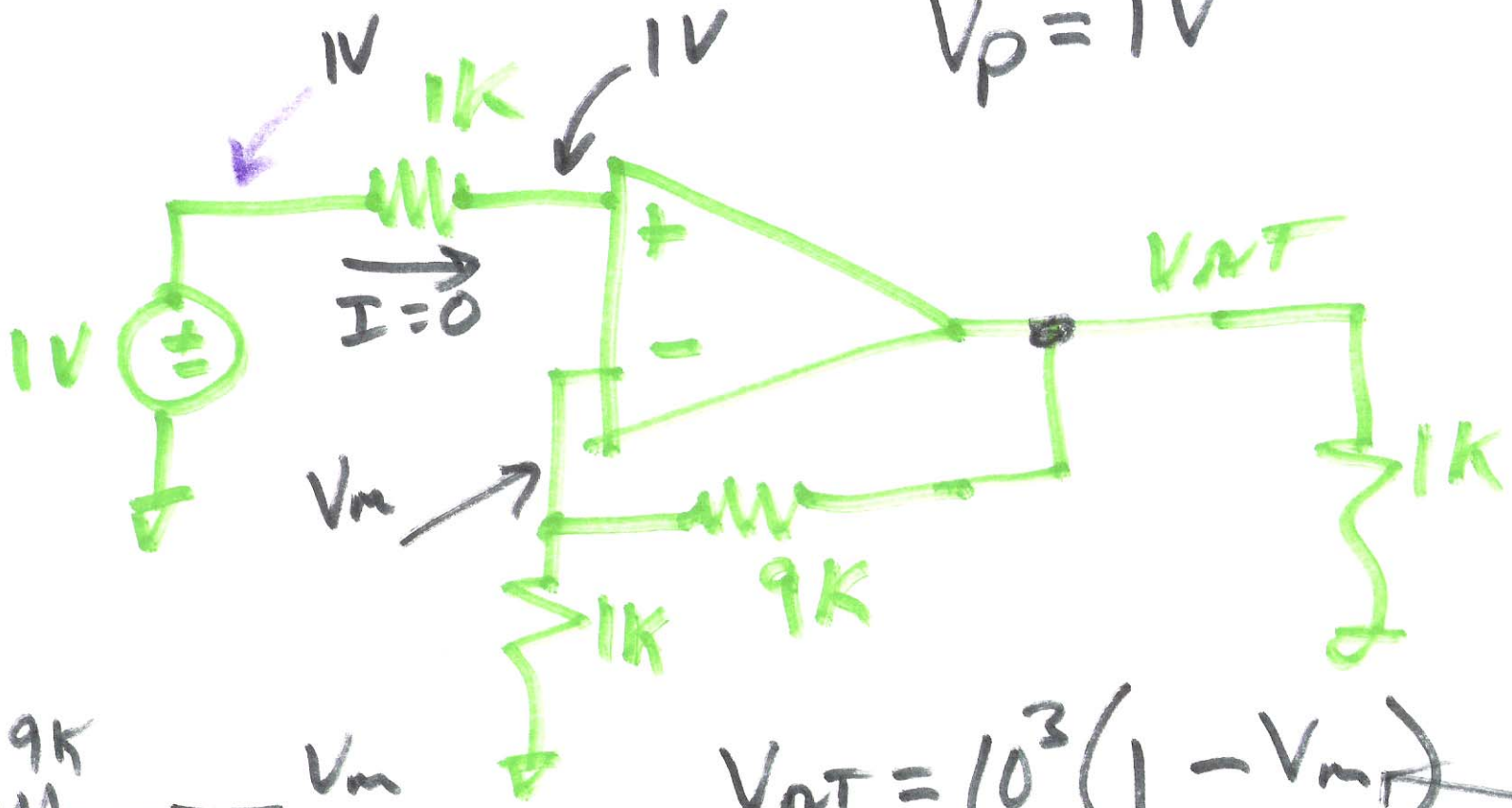
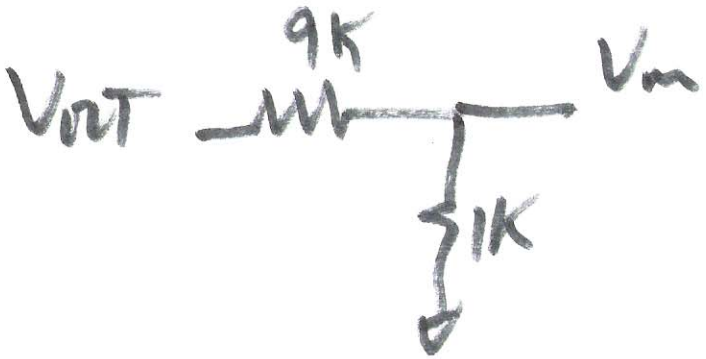
$A_{OL} = 1K$




$$V_{OUT} = 10^3 (1 - V_m)$$

$$V_m = V_{OUT} \cdot \frac{1K}{1K+9K} = \frac{V_{OUT}}{10}$$

$$V_{OUT} = 10^3 - \frac{10^3}{10} \cdot V_{OUT}$$

$$V_{OUT}(1+100) = 1{,}000$$

$$V_{OUT} = \frac{1{,}000}{101}$$

$$= \underline{9.9V}$$

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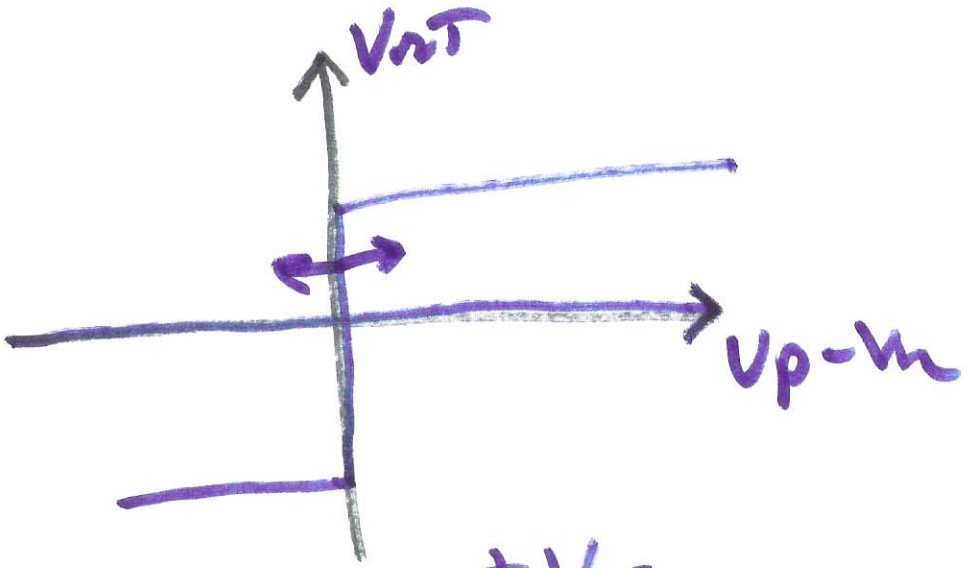
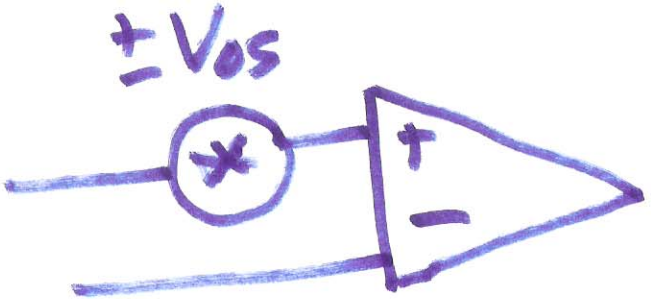
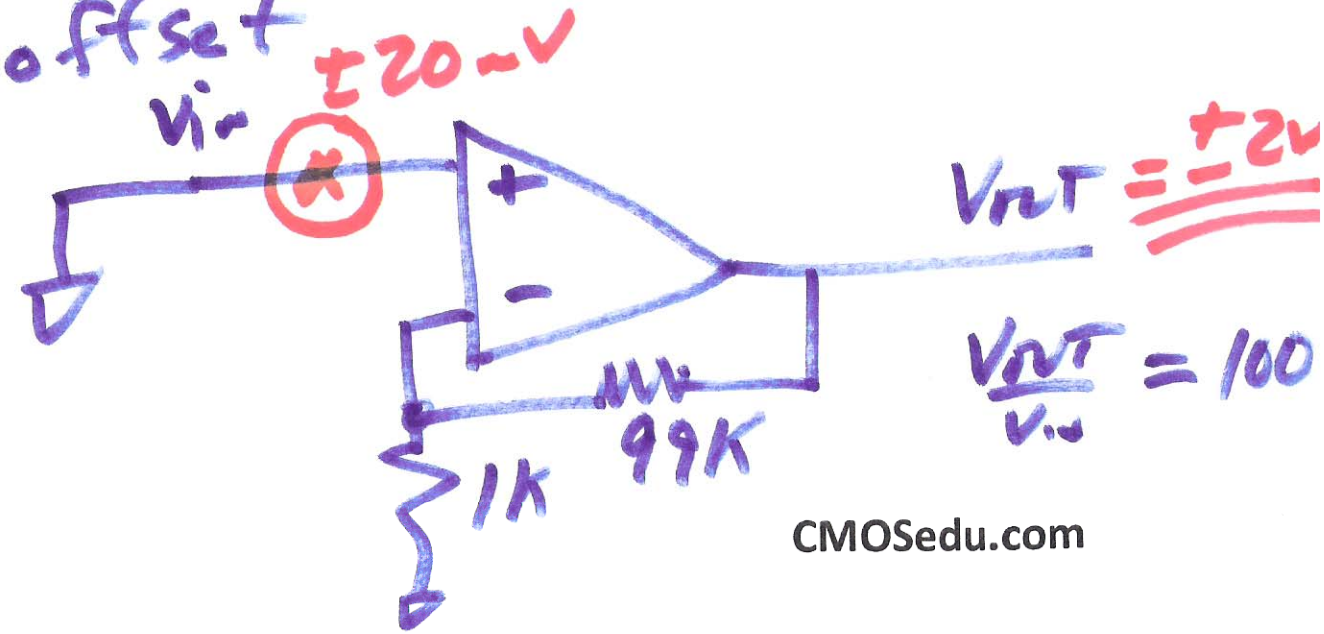



$V_{os} = \pm 20mV$
$V_{out}$ due to offset



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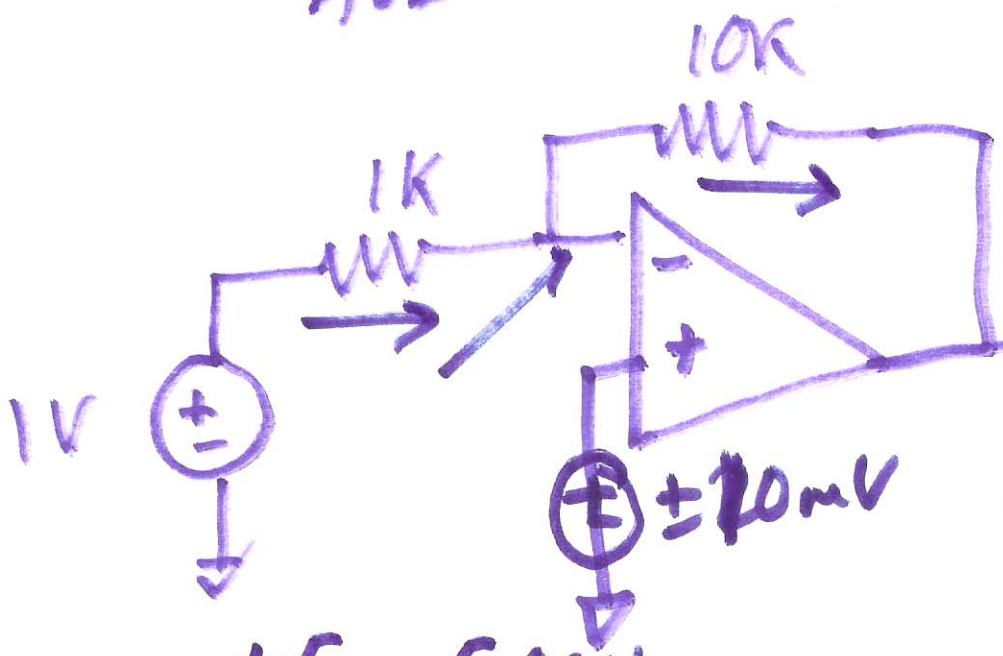
$V_{OS} = \pm 10mV$

$A_{OL} = 500 V/V$




$V_{out} = 11(.0294) - 10$

$= 11(.009785) - 10$

$= -9.676, -9.892$

$V_p = \pm 10mV$

$V_m = ?$

$11V_m - 10 = \pm 5 - 500V_m$

$511V_m = 15$

$5$

$V_m = \frac{15}{511}, \frac{5}{511}$

$.0294 \quad .009785$

$V_{out} = 500(\pm 10mV - V_m)$

$\frac{1 - V_m}{1K} = \frac{V_m - V_{out}}{10K}$

$10 - 10V_m = V_m - V_{out}$

$V_{out} = 11V_m - 10$

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