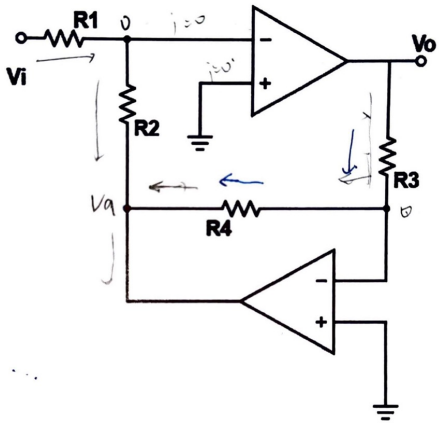
Quiz 3 solution

1. Show the relationship of the output voltage, v_O, to the input voltage, v_i, of the circuit in Figure 1. (15%)



$$V_a = -\frac{R_4}{R_3} V_o$$

$$V_a = \frac{-R_2}{R_1} V_i$$

$$V_o = \frac{R_2 R_3}{R_1 R_4} V_i$$

$$A_i: V_o = \frac{R_2 R_3}{R_1 R_4} V_i$$

Figure 1.

2. An ideal voltmeter (v_m) is used to measure the output voltage of the circuit in Figure 2. What is the reading of the voltmeter? (15%)

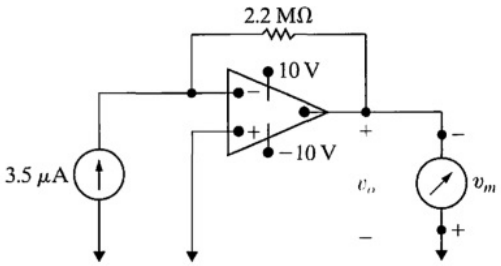


Figure 2.

There is virtual ground at OP input, then

$V_{op+} = V_{op-} = 0$

And there is no current entering OP input, so

$$\frac{0 - v_o}{2.2M} = 3.5u \rightarrow v_o = -7.7 \rightarrow v_m = -v_o = 7.7\,V$$

3.

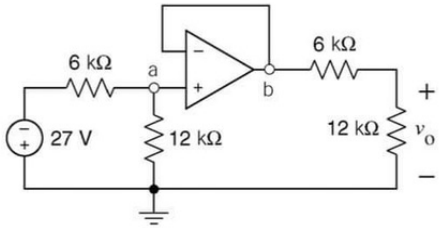
Solution:
Apply KCL at node a:

$$\frac{v_a-(-27)}{6000}+\frac{v_a}{12000}+0=0 \;\Rightarrow\; v_a=-18\text{ V}$$

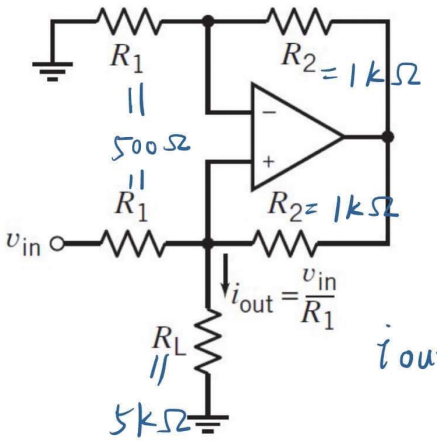
The node voltages at the input nodes of ideal op amps are equal, so $v_b = v_a$.

Using voltage division:

$$v_o=\frac{12000}{6000+12000}v_b=-12\text{ V}$$



4. Use voltage control current source



$i_{out} = \frac{v_{in}}{500} = 0.002\, v_{in}$

5.

$V_L = L\frac{di}{dt}$ for step response:

$V_i = 8i + 2i + L\frac{di}{dt} = 10i + L\frac{di}{dt}$

$\Rightarrow \frac{di}{dt} + \frac{10}{L}i = \frac{V_i}{L} \Rightarrow i_p = \frac{V_i}{L}\cdot\frac{L}{10} = 10$

for $i_h = Ae^{st}$

$\Rightarrow Ase^{st} + \frac{10}{L}Ae^{st} = 0 \Rightarrow (s + \frac{10}{L})Ae^{st} = 0$

$\Rightarrow s = -\frac{10}{L} = -25$

$i = i_p + i_h = 10 + Ae^{-25t}$

for $i(0) = 10 + A = 0 \rightarrow A = -10$

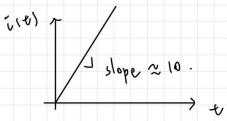
step response: $i(t) = 10 - 10e^{-25t}$.

ramp response: $i(t) = \int_{-\infty}^{t} 10 - 10e^{-25t}\,dt$

$= i(0^-) + \int_0^t 10 - 10e^{-25t}\,dt$

$= 0 + 10t + \frac{10}{25}e^{-25t}\Big|_0^t$

$= 10t + 0.4e^{-25t} - 0.4, \quad t = 0.$



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6. Consider the circuit in Figure 6 with the voltage source $v_i = 20*u(t-5)$ where u(t) represents a unit step function. Derive and plot v_o for $t \geq 0$. (20%)

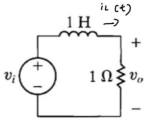
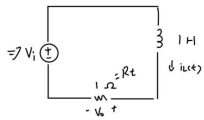


Figure 6.



$i_L(t) = A + Be^{-at}$ for $t > 5$

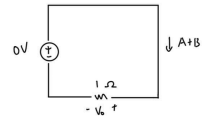
$i_L(0) = A + B$, $i_L(\infty) = A$

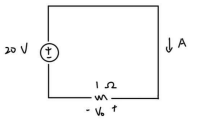
$A + B = 0$, $A = 20$ $B = -20$

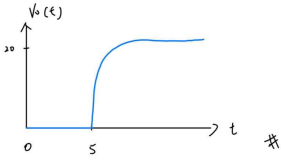
$\Rightarrow i_L(t) = 20 - 20e^{-at}$

$\frac{1}{a} = \tau = \frac{L}{Rt} = 1 \Rightarrow i_L(t) = 20 - 20e^{-t}$

$$\begin{cases} V_o(t) = 20 - 20e^{-(t-5)} \text{ V} & \text{for } t > 5 \\ V_o(t) = 0 & \text{for } t \leq 5 \end{cases}$$







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