EE2210 Electric circuits HW3 Ans.

1. Determine i and v for the circuit in Figure 1. (16%)

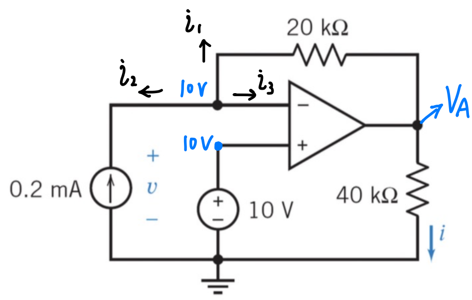


Figure 1.

The voltages at the input nodes of an ideal OP amplifier are equal!

$\therefore V = 10\ (V)$ #

Apply KCL at inverting input node of OP

$$i_1 + i_2 + i_3 = 0$$

$$\frac{10 - V_A}{20 \times 10^3} + (-0.2 \times 10^{-3}) + 0 = 0 \qquad \therefore V_A = 6\ (V)$$

$$i = \frac{V_A}{40k} = \frac{6}{40000} = 0.15\ (mA)$$ #

2.

② $\dfrac{0-V_a}{60k} + \dfrac{0-3.75}{30k} = 0$, $V_a = -7.5\,V$ #

$$\frac{V_a-0}{60k} + \frac{V_a-0}{15k} + \frac{V_a-V_o}{12k} = 0$$

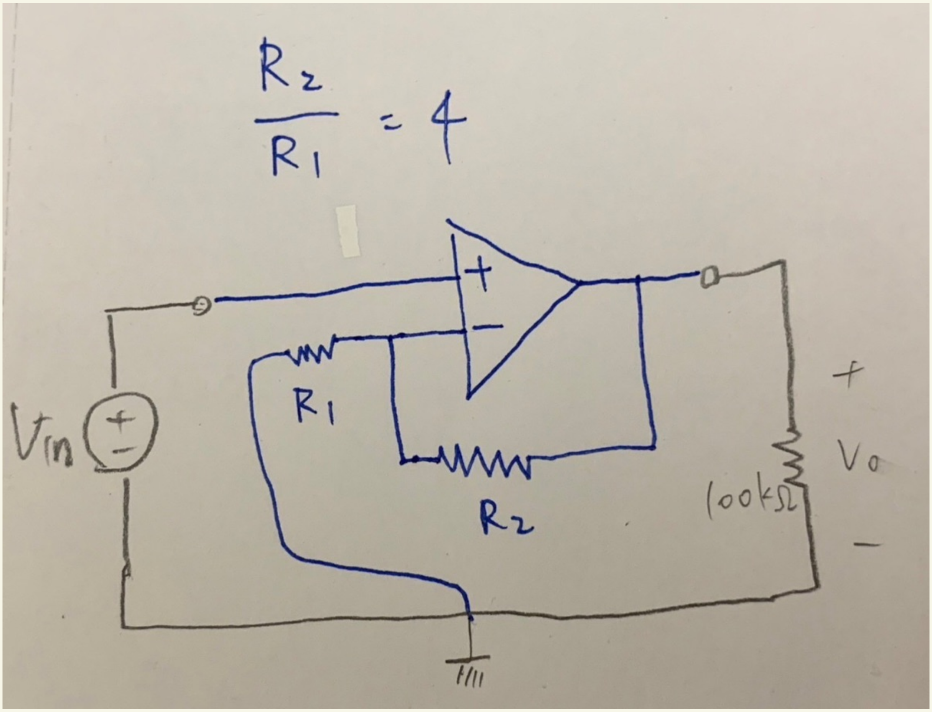
$\xrightarrow{\times 60k} V_a + 4V_a + 5V_a - 5V_o = 0$, $10V_a = 5V_o$, $V_o = 2V_a = -15\,V$ #

3. We want positive gain.

$\therefore$ Connect V_{in}^{+} to the positive side of the OP

V_{in}^{-} to the negative side

$$-\frac{V_{in}}{R_1} = \frac{V_{in}-V_o}{R_2} \Rightarrow \frac{V_o}{V_{in}} = 1+\frac{R_2}{R_1} = 5 \Rightarrow \frac{R_2}{R_1} = 4 \#$$



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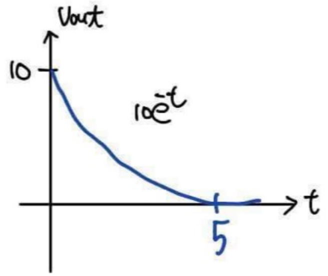
(a) $RC\dfrac{dV_c}{dt}+V_c=V_{in}=10$, $V_{in}=10u(t)$

$\Rightarrow V_{c,p}=10$

$\Rightarrow V_{c,h}=Ae^{-t/RC}$

$\Rightarrow V_c(0)=0 \Rightarrow 10+A=0$, $A=-10 \Rightarrow V_c=10-10e^{-t}$

$\therefore V_{out}=10-(10-10e^{-t})=10e^{-t}$



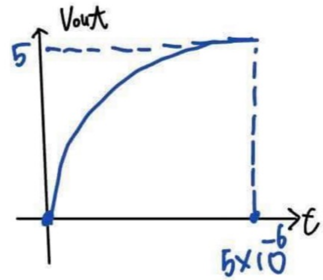
(b) $2Ri_L+L\cdot\dfrac{di_L}{dt}=V_{in}=10$, $V_{in}=10u(t)$

$\Rightarrow i_{L,p}=\dfrac{10}{2R}$, $i_{L,h}=Ae^{-t\,2R/L}$

$\Rightarrow i_L(0)=0=\dfrac{10}{2R}+A$, $A=\dfrac{-10}{2R}$

$\Rightarrow i_L=\dfrac{10}{2R}-\dfrac{10}{2R}e^{-t\,2R/L}$

$\Rightarrow V_{out}=i_L\cdot R=5-5e^{-10^6 t}$



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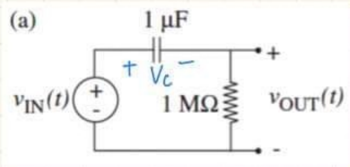


$$C\frac{dV_c}{dt} = \frac{V_{out}}{R} \Rightarrow 1\mu\frac{dV_c}{dt} = \frac{V_{out}}{1M} \Rightarrow \frac{dV_c}{dt} = V_{out}$$

$$\because V_c = V_{IN} - V_{out}$$

$$\frac{d(V_{IN} - V_{out})}{dt} = 10 - \frac{dV_{out}}{dt} = V_{out}$$

$$V_{out} = V_{outH} + V_{outp}$$

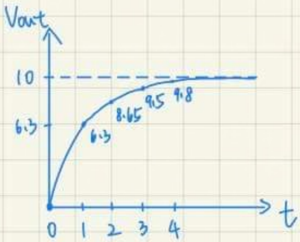
$$V_{outH} + \frac{dV_{outH}}{dt} = 0 \quad , \text{ if } V_{outH} = Ae^{st}$$

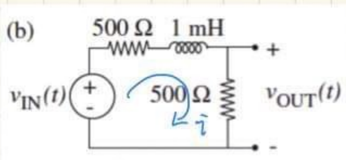
$$Ae^{st} + Ase^{st} = Ae^{st}(1+s) = 0 \quad \therefore s = -1$$

$$V_{outp} = 10$$

$$V_{out}(0) = 0 = A + 10 \quad , \therefore A = -10$$

$$\Rightarrow V_{out}(t) = -10e^{-t} + 10 \quad (t \geq 0)$$





$$i = \frac{V_{out}}{500}$$

$$V_{IN} - 500i - L\frac{di}{dt} = V_{out}$$

$$10t - 500 \cdot \frac{V_{out}}{500} - 1m \cdot \frac{1}{500} \cdot \frac{dV_{out}}{dt} = V_{out}$$

$$10t - 2V_{out} - 2\times10^{-6}\frac{dV_{out}}{dt} = 0$$

$$\frac{dV_{out}}{dt} + 10^6 V_{out} = 5\times10^6 t$$

$$V_{outn}(t) = Ae^{-10^6 t} \quad , V_{outf}(t) = B + Ct$$

$$\frac{dV_{outf}}{dt} + 10^6 \cdot V_{outf} = C + 10^6(B + Ct) = C + B\cdot10^6 + Ct\cdot10^6 = 5\times10^6 t$$

$$\therefore C = 5$$

$$5 + B\cdot10^6 = 0 \Rightarrow B = -5\times10^{-6}$$

$$V_{out}(t) = Ae^{-10^6 t} - 5\times10^{-6} + 5t$$

$$V_{out}(0) = A - 5\times10^{-6} = 0 \quad , A = 5\times10^{-6}$$

$$\therefore V_{out}(t) = 5\times10^{-6}e^{-10^6 t} - 5\times10^{-6} + 5t \quad (t \geq 0)$$