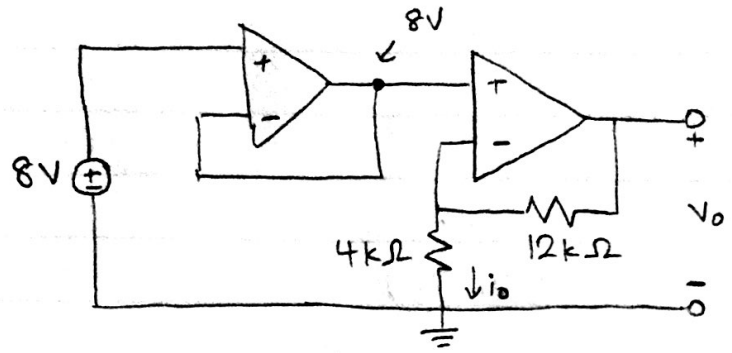
EE49 HW05

1.



$V_1 = 8V$

$V_2 = 4k\Omega \cdot i_o = 8V$

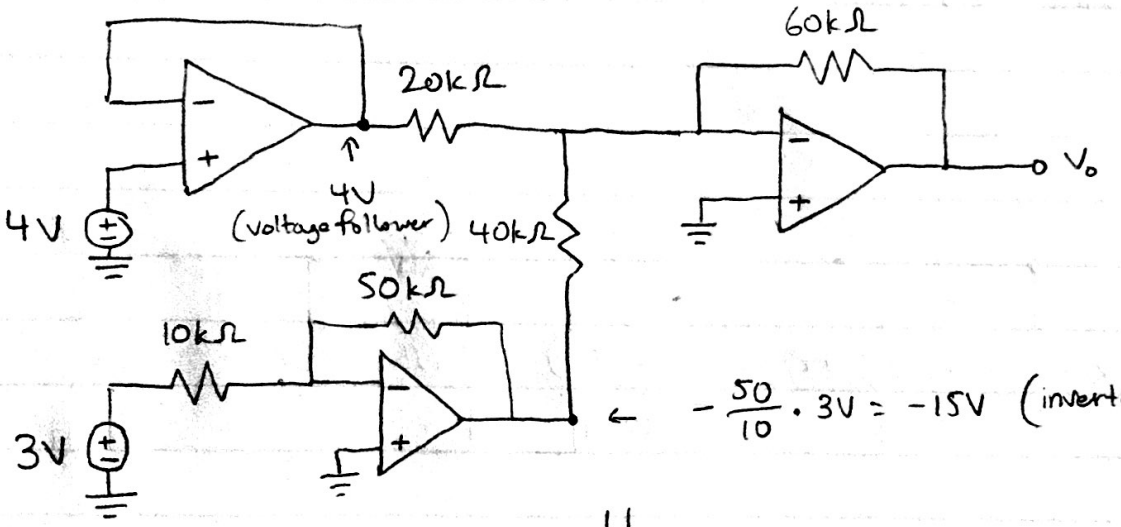
$\boxed{i_o = 2mA}$

$8V = \frac{4k\Omega}{4k\Omega + 12k\Omega} \cdot V_o$ (voltage divider)

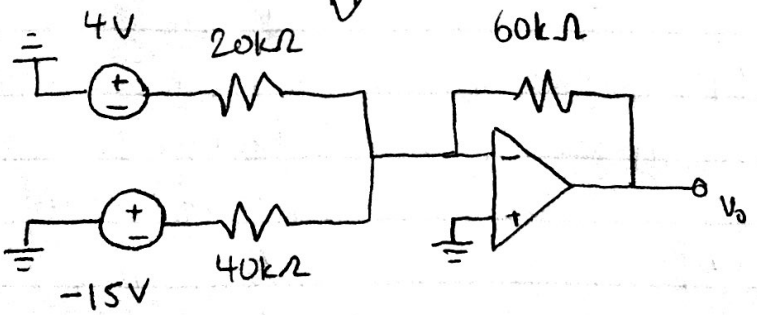
$8V = \frac{1}{4} \cdot V_o$

$\boxed{V_o = 32V}$

2.



$\leftarrow -\frac{50}{10} \cdot 3V = -15V$ (inverting amplifier)



Summing amplifier

$$V_o = -\left(\frac{60k\Omega}{20k\Omega} \cdot 4V + \frac{60k\Omega}{40k\Omega} \cdot -15V\right)$$

$$= -(12V + -22.5V) = -(-10.5V) = \boxed{10.5V}$$

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3. $i(t) = 50 \sin 120\pi t \text{ mA}$

$$v = \frac{1}{C}\int_0^t i\,dt + v(0)$$

$$v(t) = \frac{1}{10^{-4}}\int_0^t 50 \sin 120\pi t \cdot 10^{-3}\,dt$$

$$v(t) = -\frac{500}{120\pi}(\cos 120\pi t - 1)$$

$$v(t) = -\frac{25}{6\pi}(\cos 120\pi t - 1)$$

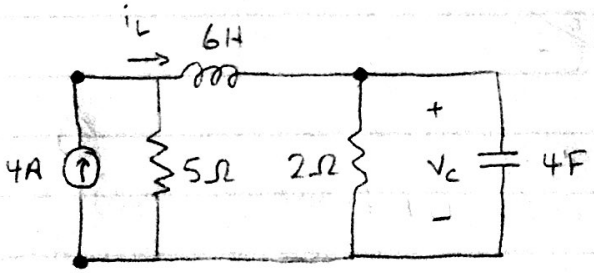
$v(0.002)$ (2ms)

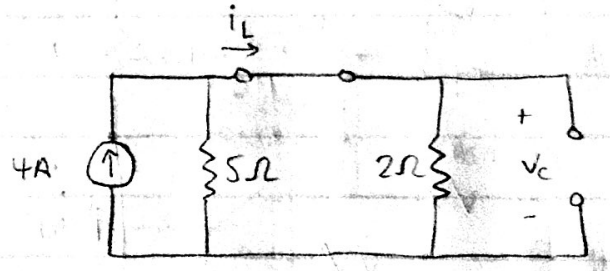
$$= -\frac{25}{6\pi}(0.7289 - 1)$$

$$= 0.3595 \text{ V}$$

$$= \boxed{359.5 \text{ mV}}$$

4.





$\boxed{i_L = 2.857 \text{ A}}$

$v_c = 2\Omega \cdot i_L = \boxed{5.714 \text{ V}}$

$w_c = \frac{1}{2} C v_c^2 = \frac{1}{2} \cdot 4 \cdot 5.714^2$

$= \boxed{65.306 \text{ J}}$

$w_L = \frac{1}{2} L i_L^2 = \frac{1}{2} \cdot 6 \cdot 2.857^2$

$= \boxed{24.490 \text{ J}}$

$i_L + i_{Rest} = 4\text{A}$

$5\Omega \cdot i_{Rest} = 2\Omega \cdot i_L$

$i_{Rest} = 2/5\, i_L$

$i_L + 2/5\, i_L = 4\text{A}$

$\frac{7}{5} i_L = 4\text{A}$

$i_L = 20/7 \text{ A}$

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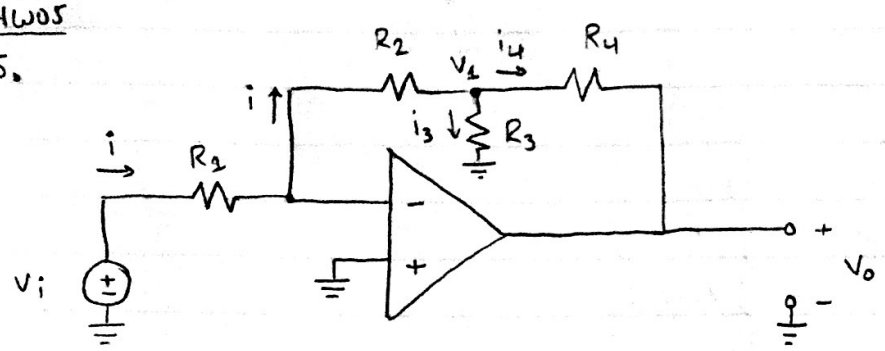
5.



$V_o = -693 V_i$ (Let $V_i = 1V$)

$V_1 = V_i - iR_1 - iR_2$ — ohm's law

$V_1 = i_3 R_3$ — ohm's law

$V_1 = i_4 R_4 + V_o$ — ohm's law

$V_1 = \frac{R_3}{R_3 + R_4} \cdot V_o$ — voltage divider

$i = i_3 + i_4$ — KCL

$i_3 = \frac{V_1}{R_3} = \frac{1}{5} V_1$

$i_4 = \frac{V_1 - V_o}{R_4} = \frac{1}{R_2}(V_1 - V_o)$

$i = \frac{1}{5} V_1 - \frac{1}{R_2}(V_1 - V_o)$

$$V_1 = V_i - 5\left(\frac{1}{5} V_1 - \frac{1}{R_2}(V_1 - V_o)\right) - R_2\left(\frac{1}{5} V_1 - \frac{1}{R_2}(V_1 - V_o)\right)$$

$$= 1 - V_1 + \frac{5}{R_2}(V_1 - V_o) - \frac{R_2}{5} V_1 + (V_1 - V_o)$$

$$= 694 - \frac{R_2}{5} V_1 + \frac{5}{R_2}(V_1 - 693)$$

$$V_1 R_2 = -\tfrac{1}{5} V_1 R_2^2 + 694 R_2 + 5V_1 - 3465$$

From voltage divider

$$V_1 = \frac{5}{5 + R_2} \cdot -693 = \frac{-3465}{5 + R_2}$$

$$\frac{-3465}{5+R_2} \cdot R_2 = -\frac{1}{5} \cdot \frac{-3465}{5+R_2} \cdot R_2^2 + 694 R_2 + 5 \cdot \frac{-3465}{5+R_2} - 3465$$

$$-3465 R_2 = 693 R_2^2 + 694 R_2 (5 + R_2) - 17325 - 3465(5 + R_2)$$

$$693 R_2^2 + 3470 R_2 + 694 R_2^2 - 17325 - 17325 - 3465 R_2 + 3465 R_2 = 0$$

$$1387 R_2^2 + 3470 R_2 - 34650 = 0$$

$$R_2 = \frac{5(\sqrt{2042791} - 347)}{1387} = 3.9\,\Omega$$

$$\frac{R_2}{R_1} = \frac{3.9}{5} = \boxed{0.78}$$

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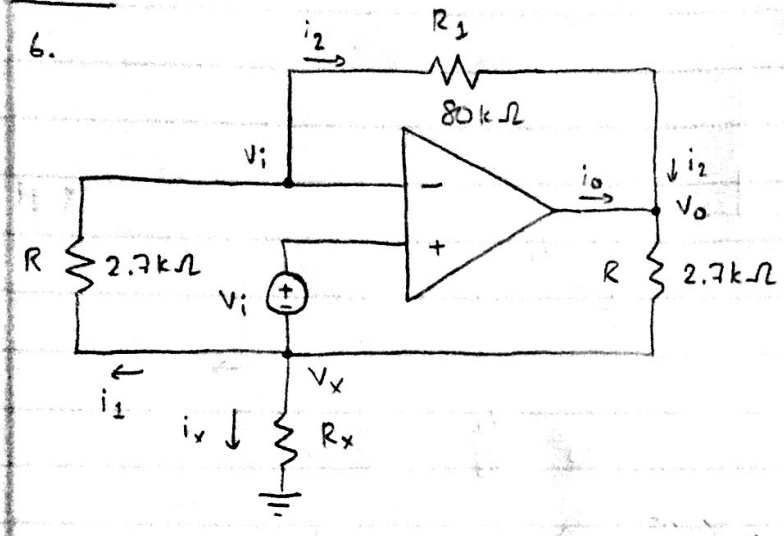
6.

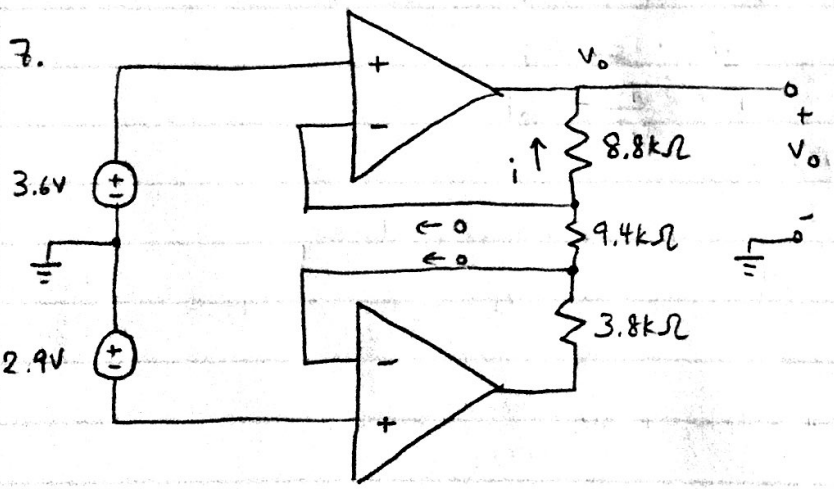


$i_2 + i_o = i_x + i_1$ $\qquad$ $v_x = -i_x R_x$

$i_1 = i_2$

$i_o = i_x$

7.



$$i = \frac{2.9V - 3.6V}{9.4k\Omega} =$$

$$v_o = 8.8k\Omega \cdot i = \boxed{-0.66V}$$

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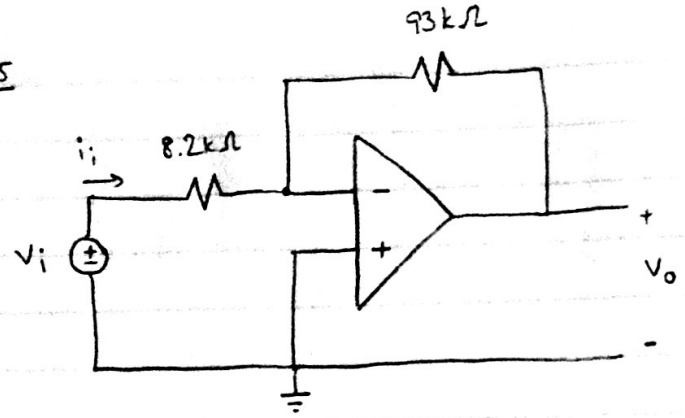
8]



$$v_o = -\frac{93}{8.2} v_i$$

$$v_i - i_i \cdot (8.2 + 93) - v_o = 0$$

$$v_i - 101.2\, i_i + \frac{93}{8.2} v_i = 0$$

$$12.34\, v_i = 101.2\, i_i \rightarrow \frac{v_i}{i_i} = \frac{101.2}{12.34} = 8.2$$

$\boxed{R_i = 8.2\,\Omega}$

9]

$$E_{init} = \frac{1}{2} C \cdot V^2$$

$E_{remaining} / E_{init} = 9/16$

$$E_{remaining} = \frac{1}{2} C \cdot \left(\frac{3}{4} V\right)^2$$

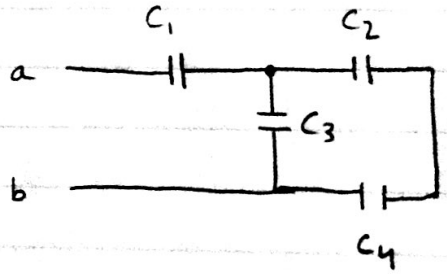
$\boxed{r = \frac{9}{16}}$

10] $F = qE = q\frac{V}{d}$

$= 6.6\,nF \cdot \frac{74V}{83\,\mu m}$

$= \boxed{5.88 \cdot 10^{-3}\ N}$

11.



$$\frac{1}{\frac{1}{C_1} + \frac{1}{C_3 + \frac{1}{\frac{1}{C_2} + \frac{1}{C_4}}}}$$

$\boxed{C_{eq} = 1.244}$