Homework 3

Due date: Nov. 7^{th}, 2023

Turn in your hard-copy hand-writing homework in class

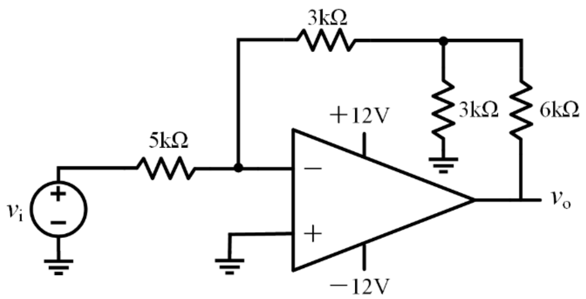
Rules:

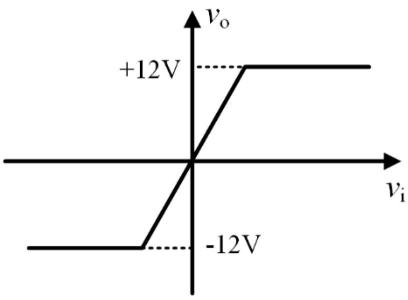
- Work on your own. Discussion is permissible, but extremely similar submissions will be judged as plagiarism.
- Please show all intermediate steps: a correct solution without an explanation will get zero credit.
- Please submit on time. No late submission will be accepted.
- Please prepare your submission in English only. No Chinese submission will be accepted.

1. The voltage output range of this ideal operational amplifier is [-12, 12]

a. assuming the figure shows an ideal operational amplifier, calculate v_o/v_i.

b. if the operational amplifier is operated in the linear region, determine the range of v_i





a. $$\begin{cases} \dfrac{V_i}{5} = \dfrac{0 - V_n}{3} \\ \dfrac{-V_m}{3} = \dfrac{V_m - V_o}{6} + \dfrac{V_m}{3} \end{cases} \Rightarrow V_o/V_i = -3$$

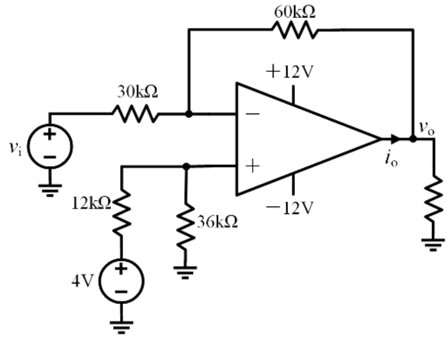
b. $\because -12 < V_o < 12$

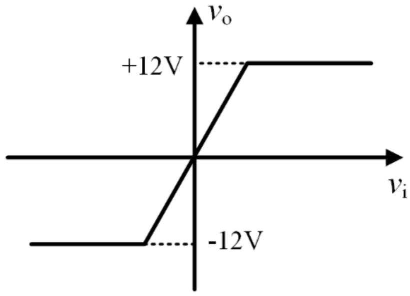
$\therefore -4 < V_i < 4$

2. The voltage output range of this ideal operational amplifier is [-12, 12]

a. Draw the curve of v_o changing with vi and write down the derivation process.

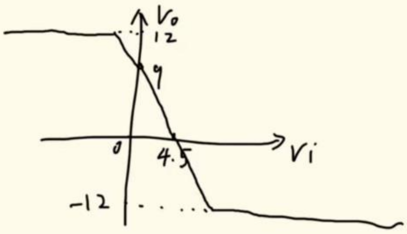
b. When v_i is 9 V, find i_o.





a. $\dfrac{V_i - 3}{30} = \dfrac{3 - V_o}{60}$ $\therefore$ $2V_i - 9 = -V_o$

$V_o = 9 - 2V_i$



b. $V_i = 9V$

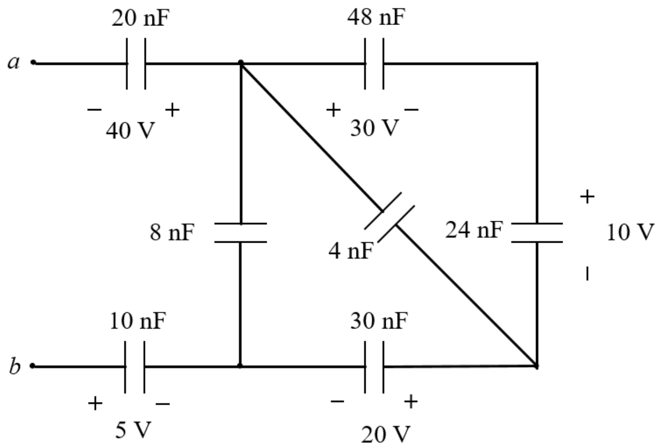
$V_o = -9V$

$i_o = \dfrac{-9}{10k} + \dfrac{-9-3}{60k}$

$= -11 \times 10^{-4}$

$= -1.1 \times 10^{-3} A$

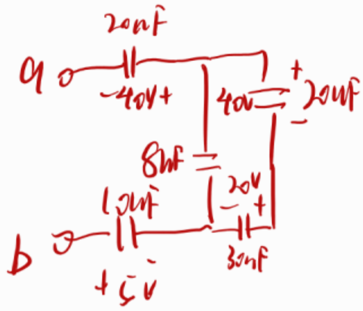
3. The capacitance and associated voltage for each capacitor is given. Find the equivalent capacitance C_{ab} and the voltage v_{ab} for the circuit below.



3. $\frac{1}{C_1} = \frac{1}{48} + \frac{1}{24} = \frac{1}{16}$ $\quad C_1 = 16\,nF$

$C_2 = 4 + 16 = 20\,nF$

=>

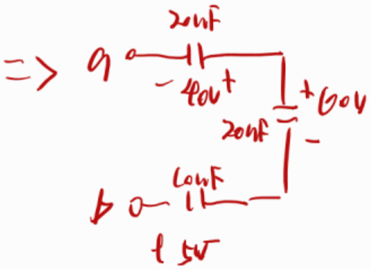


5'

$\frac{1}{C_3} = \frac{1}{30} + \frac{1}{20} = \frac{1}{12}$ $\quad C_3 = 12\,nF$

$C_4 = 8 + 12 = 20\,nF$

=>



5'

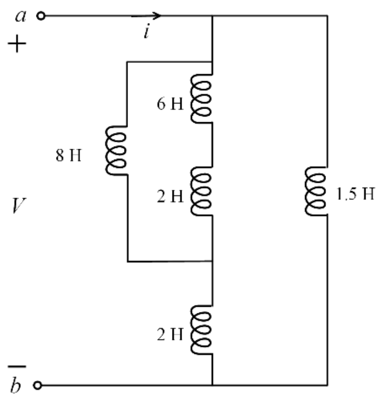
$\frac{1}{C_5} = \frac{1}{20} + \frac{1}{20} + \frac{1}{10} = \frac{1}{5}$ $\quad C_5 = 5\,nF$

$V_{ab} = 60 - 40 - 5 = 15V$ $\quad$ 5'

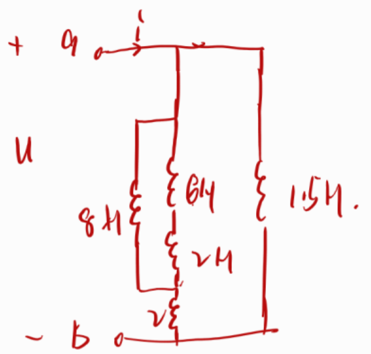
4. For the circuit below, $i(0)=0$ A, $v = 6e^{-2t}$ V. The initial energy of all inductance are all 0.

a. Calculate the equivalent inductance L_{ab}.

b. Find the i(t).



4.



$L_1 = 2 + \frac{8\times 8}{8+8} = 6H$ 5'

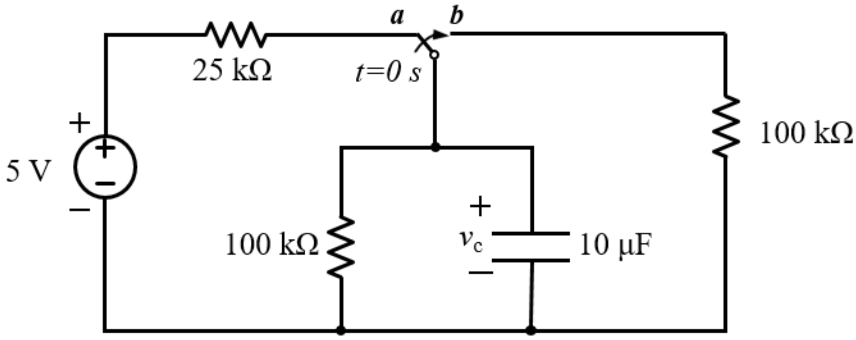
$L_{ab} = \frac{6\times 1.5}{6+1.5} = 1.2H$

$i(0) = 0A$ 5'

$i(t) = i(0) + \frac{1}{L}\int_0^t u(\xi)\,d\xi = 0 + \frac{1}{1.2}\int_0^t 6e^{-2\xi}\,d\xi$

$= -2.5(e^{-2t}-1)$ A 5'

5. For the circuit below, When t = 0s, the switch changes from node *a* to node *b* immediately. Assume that the circuit reaches steady state before $t = 0$. Determine the expression for $v_c(t)$ and $i_c(t)$ when t $\geqslant$ 0s.



5. $V_c(0_-) = \frac{5}{100+25} \times 100\,V = 4V$ $\quad V_c(0^+) = V_c(0^-) = 4V$ '5

When $t>0$, $R_{eq} = \frac{100 \times 100}{100+100}\, k\Omega = 50\, k\Omega$ '5

$\tau = RC = 50 \times 10^3 \times 10 \times 10^{-6}\, s = \frac{1}{2}\, s$

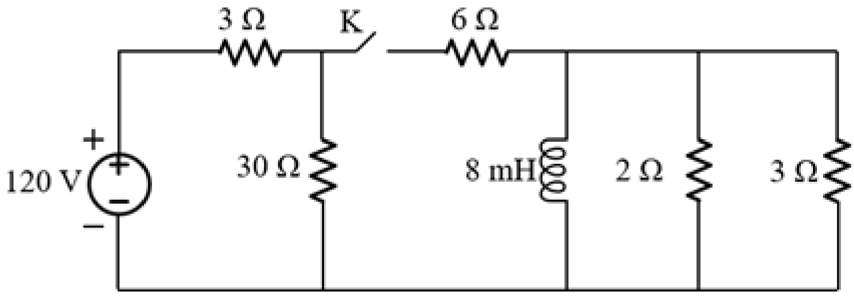
$V_c(t) = V_c(0^+)\, e^{-\frac{t}{\tau}} = 4e^{-2t}\, V$

$i(t) = \frac{V_c(t)}{50} = 0.08 e^{-2t}$ mA '10

6.

a. assuming that K have been closed for a long time, K opens at t=0, calculate the inductance currents for t > 0.

b. What is the percentage of energy stored in the inductor consumed on the resistor 2 Ω.



(a) $i = \frac{120}{3+(30//6)} \cdot \frac{30}{30+6} = 12.5A$ $\quad i_L = -i = -12.5A$

$\tau = \frac{L}{R} = \frac{8\times10^{-3}}{2//3}$ $\quad i_L(t) = -12.5e^{-\frac{t}{\tau}} = -12.5e^{-150t}$

(b) $W = \frac{1}{2}Li^2 = \frac{1}{2}\times\left(\frac{50}{4}\right)^2\times 8\times10^{-3} = 625mJ$

$P_L(t) = \left(\frac{i_L(t)R_3}{R_2+R_3}\right)^2 \cdot R_2 = 112.5e^{-300t}$

$W = \int_0^{+\infty} P_L(t)\,dt = \frac{112.5}{300} = 375mJ$

$\eta = \frac{375}{625}\times100 = 60\%$