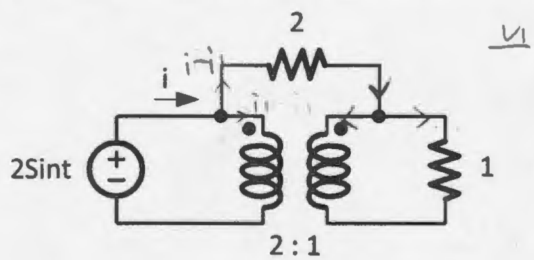
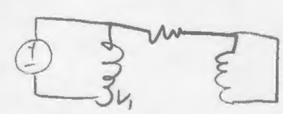
EE10 **Midterm Exam** **Fall 2016**

Total of 3 questions, 100 minutes.

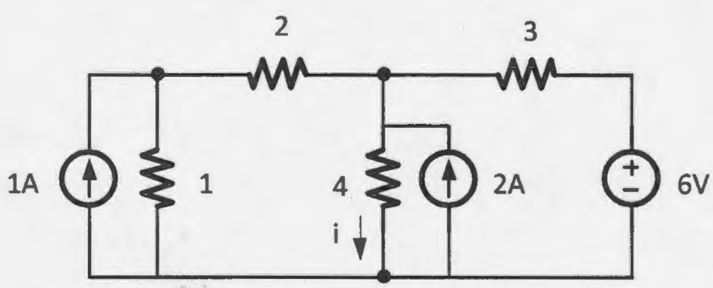
1. In the following circuit, the transformer is ideal. Find the current i (30 points).



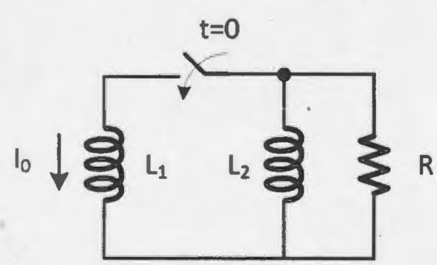
v_1



2. Find the current i in the circuit below by a) node analysis, b) superposition (40 points).



3. In the circuit below, inductor L_1 has an initial current of I_0 and the circuit has been idle for a long time. The switch is closed at $t = 0$. Plot and find the resistor voltage. What is the final current of the inductors at $t = \infty$ (40 points).



$$\frac{1}{L_1}+\frac{1}{L_2}=\frac{L_1+L_2}{L_1L_2}$$

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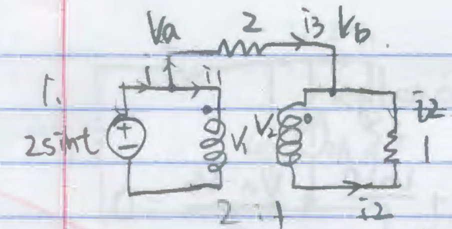

$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{2}{1}$

$V_1 = 2V_2$ ✓

8

$V_a - V_b = V_1 - V_2$

From KVL, $-2\sin t + V_1 = 0$ $\quad -V_2 + 1 \cdot i_2 = 0 \quad i_2 = V_2$

$V_1 = 2\sin t$

$V_2 = \frac{1}{2} V_1 = \sin t$ $\quad -\sin t$

$i_2 = \sin t \quad \frac{i_1}{i_2} = -\frac{N_2}{N_1} = -\frac{1}{2}$ ✓

$i_1 = -\frac{1}{2} i_2 = \cancel{-\frac{1}{2}\sin t}$ ~~(different direction)~~

current from Va to Vb is

$i_3 = \frac{V_a - V_b}{2} = \frac{2\sin t - \sin t}{2} = \frac{\sin t}{2}$

$i = i_3 + i_1 = \frac{\sin t}{2} + \frac{\sin t}{2} = \boxed{\sin t}$

X

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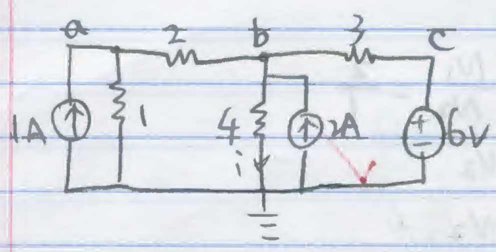
2



a) node analysis

for a

$$-1+\frac{V_a-0}{1}+\frac{V_a-V_b}{2}=0$$

$$V_a+\frac{V_a-V_b}{2}=1$$

$$3V_a-V_b=2$$

for b.

$$\frac{V_b-V_a}{2}+\frac{V_b}{4}+\frac{V_b-V_c}{3}-2=0$$

$$6(V_b-V_a)+3V_b+4(V_b-V_c)=24$$

$$-6V_a+13V_b-4V_c=24 \quad -6V_a+13V_b=48$$

for c $V_c=6V$.

$$\begin{cases} 3V_a-V_b=2 & ① \\ -6V_a+13V_b=48 & ② \end{cases}$$

① × 13 $\quad 39V_a-13V_b=26 \quad ③$

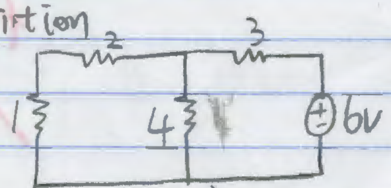
③ + ② $\quad 33V_a=74 \quad V_a=\frac{74}{33}=2.24V. \quad V_b=\frac{52}{11}=4.72V$

$$\frac{74}{11}-2=\frac{52}{11}$$

$$i=\frac{V_b}{4}=\frac{52}{11}\div 4=\boxed{\frac{13}{11}}=\boxed{1.18A}$$

② superposition

close 1A, 2A

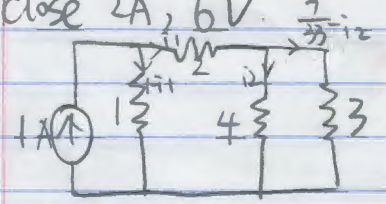


$$R_{eq}=\frac{(1+2)\times 4}{1+2+4}=\frac{12}{7}$$

$$I=6\div\left(3+\frac{12}{7}\right)=\frac{14}{11}A$$

$$i_{①}=\frac{14}{11}\cdot\frac{3}{3+4}=\frac{6}{11}A$$

close 2A, 6V.



$$\frac{3\times 4}{3+4}=\frac{12}{7}\Omega$$

$$i_1\left(2+\frac{12}{7}\right)=1(1-i_1)$$

$$\frac{26}{7}i_1=1-i_1$$

$$\frac{33}{7}i_1=1 \quad i_1=\frac{7}{33}$$

$$4i_2=3\left(\frac{7}{33}-i_2\right) \quad 4i_2=\frac{7}{11}-3i_2$$

$$i_2=\frac{1}{11}A.$$

$$i_{②}=\frac{1}{11}A$$

close 1A, 6V.

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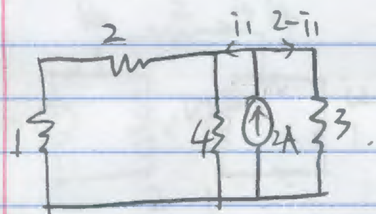


$\frac{3\times4}{3+4} = \frac{12}{7}\Omega$

$\frac{12}{7} i_1 = 3(2-i_1)$

$\frac{12}{7} i_1 = 6 - 3i_1 \quad \frac{33}{7} i_1 = 6$

$i_1 = \frac{14}{11}A$

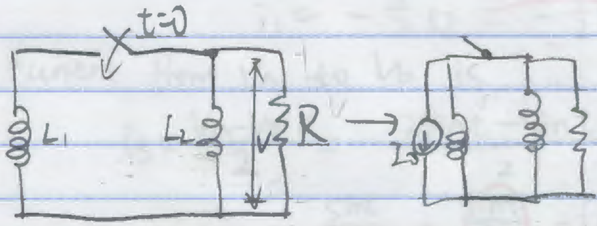
$\frac{14}{11}A \cdot \frac{3}{3+4} = \frac{6}{11}A$

$i_3 = \frac{6}{11}A$

So $i = \frac{6}{11} + \frac{6}{11} + \frac{1}{11} = \boxed{\frac{13}{11}A} = \boxed{1.18A}$

40

3



$V = L\frac{di}{dt}$

25

$V_R(0^-) = 0$

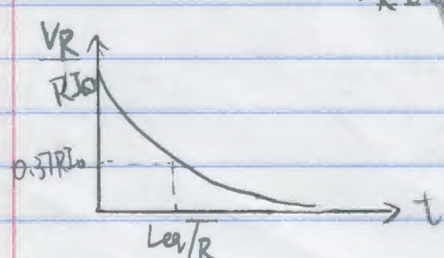
$V_R(0^+) = I_0 R$

$V_R(\infty) = 0$ as all energy is dissipated by resistor

$L_{eq} = \frac{L_1 L_2}{L_1+L_2}$

$V_R(t) = 0 + (RI_0 - 0)e^{-\frac{t}{\tau}}$ $\quad \tau = \frac{L}{R} = \frac{L_1L_2}{(L_1+L_2)R}$

$= \boxed{RI_0 e^{-\frac{(L_1+L_2)Rt}{L_1L_2}}}$



Because of flux conservation

$L_1 I_0 = L_{eq} I$

$L_1 I_0 = \frac{L_1 L_2}{L_1+L_2} I \qquad I = L_1 I_0 \frac{L_1+L_2}{L_1L_2} = \boxed{\frac{I_0(L_1+L_2)}{L_2}}$