BIRZEIT UNIVERSITY

Electrical and Computer Engineering Department

Circuits Analysis ENEE 2304

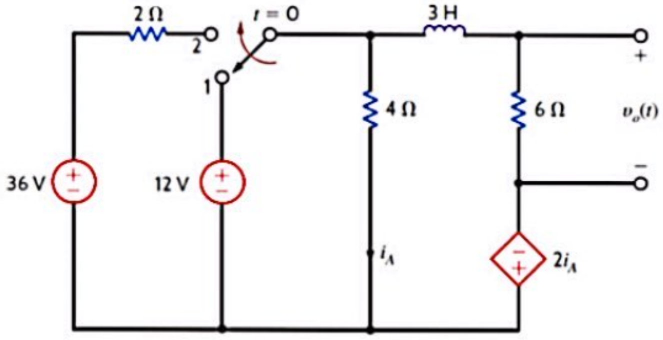
Short Exam # 3 (10 minutes)

Student Name: **ID:** **29th Oct, 2024**

Problem 1: For the circuit shown below, the switch has been in position "1" for a long time before being moved to position "2" at t=0s, then

A) Find $v_o(t)$ for $t \geq 0$

B) Sketch $v_o(t)$



Solution:

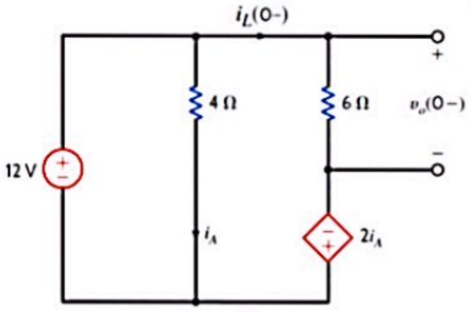
STEP 1 $v_o(t)$ is of the form $K_1 + K_2 e^{-t/\tau}$.

STEP 2 Using the circuit in **Figure (b)**, we can calculate $i_L(0-)$:

$$i_A = \frac{12}{4} = 3\text{ A}$$ 0.5

Then

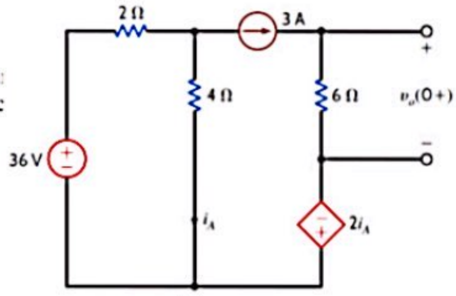
$$i_L(0-) = \frac{12 + 2i_A}{6} = \frac{18}{6} = 3\text{ A}$$ 0.5



(b) $t = 0-$

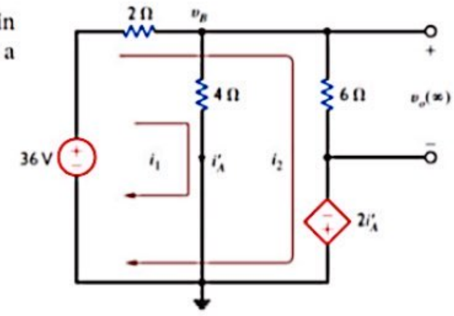
STEP 3 The new circuit, valid only for $t = 0+$, is shown in **Figure (c)**. The value of the cu: rent source that replaces the inductor is $i_L(0-) = i_L(0+) = 3$ A. Because of the current sourc

$$v_o(0+) = (3)(6) = 18\text{ V}$$ 1



(c)

STEP 4 The equivalent circuit, for the steady-state condition after switch closure, is given in Figure (d). Using the voltages and currents defined in the figure, we can compute $v_o(\infty)$ in a variety of ways. For example, using node equations, we can find $v_o(\infty)$ from



(d) $t = \infty$

$$\frac{v_B - 36}{2} + \frac{v_B}{4} + \frac{v_B + 2i'_A}{6} = 0$$

$$i'_A = \frac{v_B}{4}$$

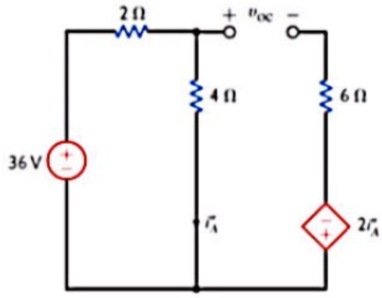
$$v_o(\infty) = v_B + 2i'_A$$

0.5

$$v_o(\infty) = 27 \text{ V.}$$

0.5

STEP 5 The Thévenin equivalent resistance can be obtained via v_{oc} and i_{sc} because of the presence of the dependent source. From Figure (e) we note that



(e)

$$i''_A = \frac{36}{2+4} = 6 \text{ A}$$

0.5

Therefore,

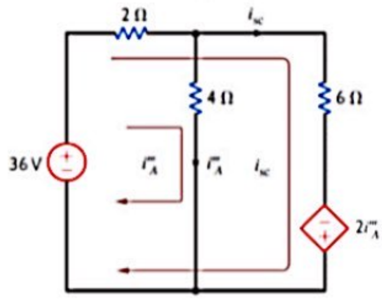
$$v_{oc} = (4)(6) + 2(6)$$
$$= 36 \text{ V}$$

0.5

From Figure (f), we can write the following loop equations (identical to those in step 4):

$$36 = 2(i'''_A + i_{sc}) + 4i'''_A$$
$$36 = 2(i'''_A + i_{sc}) + 6i_{sc} - 2i'''_A$$

0.5



(f)

Solving these equations for i_{sc} yields

$$i_{sc} = \frac{9}{2} \text{ A}$$

0.5

Therefore,

$$R_{Th} = \frac{v_{oc}}{i_{sc}} = \frac{36}{9/2} = 8\ \Omega$$

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Hence, the circuit time constant is

$$\tau = \frac{L}{R_{Th}} = \frac{3}{8} \text{ s}$$

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STEP 6 Using the information just computed, we can derive the final equation for $v_o(t)$:

$$K_1 = v_o(\infty) = 27$$
$$K_2 = v_o(0+) - v_o(\infty) = 18 - 27 = -9$$

Therefore,

$$v_o(t) = 27 - 9e^{-t/(3/8)} \text{ V}$$

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