American University of Beirut
Department of Electrical and Computer Engineering
EECE 210 - Electric Circuits
Quiz 2
Closed Book - No Programmable Calculators - 90 minutes

April 8, 2016

Name: SOLUTION______

ID:______________________

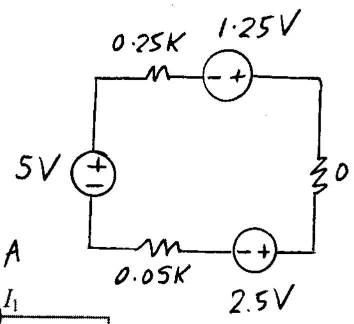
Solve the following problems;
Provide your answers on the attached Scantron card;
This question sheet must be returned with the Scantron card;
There is No penalty;
Mark with a *pencil* your LAST NAME, your First name Initial (FI) and your Middle name Initial (MI);
Mark your AUB ID Number in the box titled "ID NUMBER";
Write the name of your course instructor on the Scantron card;
Use a pencil for marking your answers ;
When using an eraser, make sure that you have erased well.

This exam has 9 pages.

Course Instructors: H. Akkary, L. Hamandi, K. Kabalan, and R. Jabr.

1. In the circuit shown in Fig. 1, $R_1 = 0.25\ \mathrm{k\Omega}$, $R_2 = 0.05\ \mathrm{k\Omega}$, $R_3 = 0.2\ \mathrm{k\Omega}$, $I_1 = 5$ mA, $I_2 = 50$ mA, and $V_S = 5$ V. Find v_o.

(a) 1.5 V
(b) 2.0 V
(c) 2.5 V
(d) 3.0 V
(e) None of the above



$$v_o = \frac{0.2}{0.5}(3.75) = 1.5\ \mathrm{V}$$

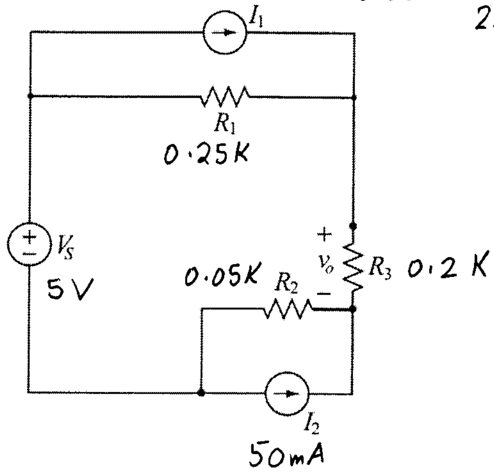


Fig. 1: Circuit for Problem 1

2. In the circuit shown in Fig. 2, R1 = 300 Ω, R2 = 600 Ω, and R3 = 200 Ω. Find the value of R_L that results in maximum power being transferred to R_L.

(a) 300 Ω
(b) 400 Ω
(c) 500 Ω
(d) 600 Ω
(e) None of the above

$$R_L = R_{Th} = 200 + 300 /\!/ 600 = 400\ \Omega$$

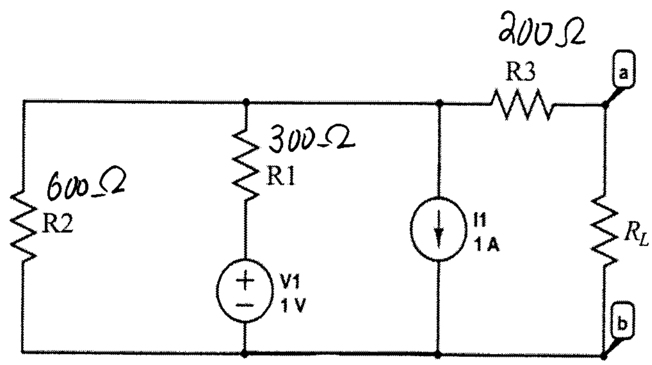


Fig. 2: Circuit for Problem 2

3. If $R = 8$ kΩ in the circuit shown in Fig. 3, find the Thévenin voltage (V_{Th}) between terminals a,b.

(a) 150 V
(b) 60 V
(c) 37.5 V
(d) 24 V
(e) None of the above

$$70 = 8(21 I_X) + 7 I_X$$
$$\Rightarrow I_X = 0.4 \text{ mA}$$
$$V_{Th} = 20 \times 0.4 \times 3 = 24 \text{ V}$$

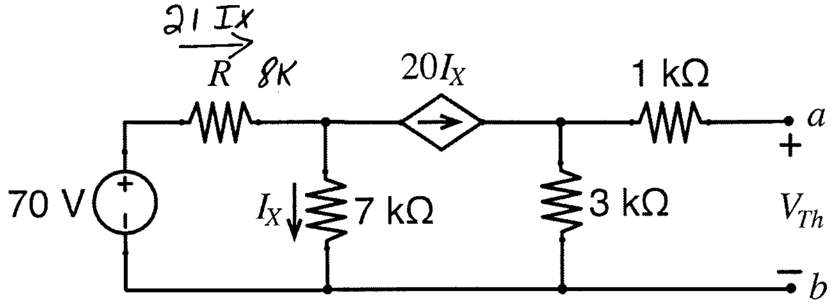


Fig. 3: Circuit of Problem 3

4. If $R = 8$ kΩ in the circuit shown in Fig. 4, find the short-circuit current (I_{SC}) directed from terminal a to terminal b.

(a) 6 mA
(b) 9.375 mA
(c) 15 mA
(d) 37.5 mA
(e) None of the above

$$70 = 8(21 I_X) + 7 I_X$$
$$\Rightarrow I_X = 0.4 \text{ mA}$$
$$I_{SC} = 20 \times 0.4 \times \frac{3}{4} = 6 \text{ mA}$$

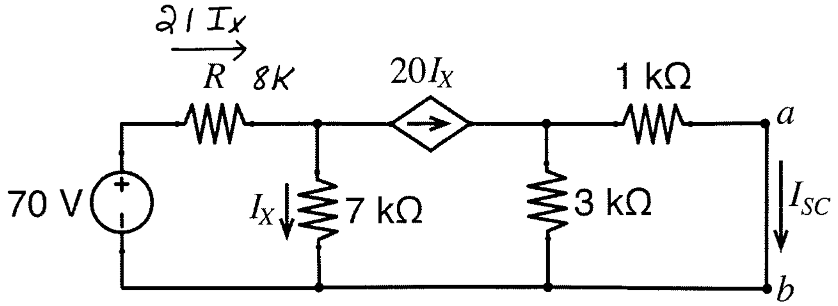


Fig. 4: Circuit of Problem 4

5. In the circuit shown in Fig. 5, Vs = 20 V, R1 = 1 kΩ, R2 = 3 kΩ, R3 = R4 = 4 kΩ, and R5 = 2 kΩ. Find the maximum power that can be delivered to R_L.

(a) 3.125 mW
(b) 2.5 mW
(c) 1.25 mW
(d) 1 mW
(e) None of the above

$$V_{Th} = \frac{4}{8} 20 = 10 V$$
$$R_{Th} = 4 + 2 + 4 \| 4 = 8 \, k\Omega$$
$$P_{L max} = \frac{10^2}{4 \times 8} = 3.125 \, mW$$

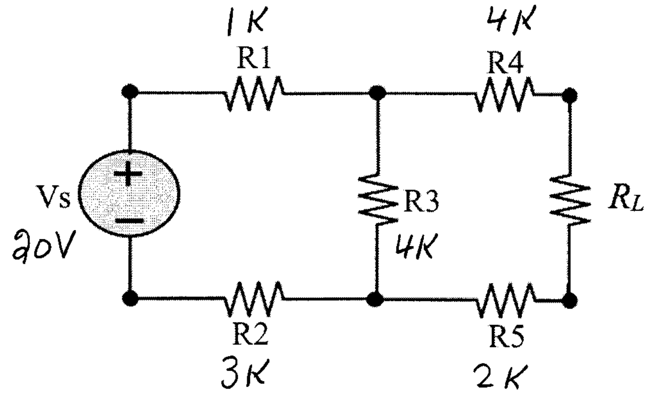
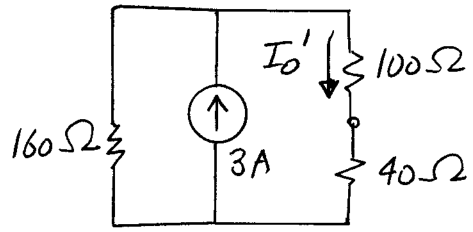


Fig. 5: Circuit of Problem 5

6. In the circuit shown in Fig. 6, $I_S = 3$ A. Find the component of I_O resulting from the I_S current source acting alone, with all the other voltage and current sources deactivated.

(a) 3.20 A
(b) 2.67 A
(c) 2.13 A
(d) 1.60 A
(e) None of the above



$$I_O' = \frac{160}{300} \times 3$$
$$= 1.6 \, A$$

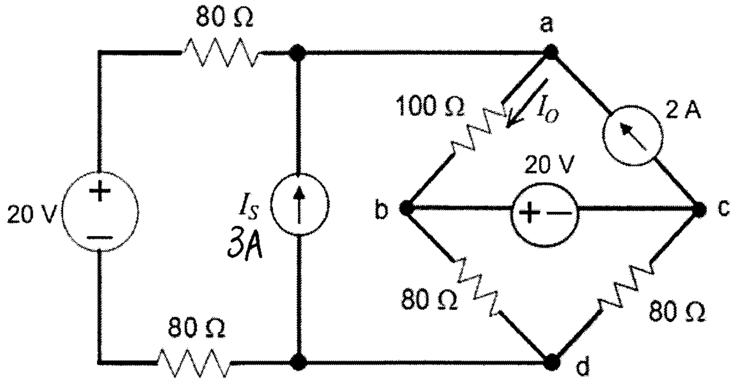


Fig. 6: Circuit of Problem 6

7. In the circuit shown in Fig. 7, Vs = 8 V and Vcc = 15 V. Find the minimum value of R that can be used such that the op-amp operates in its linear region.

(a) 10 Ω
(b) 8 Ω
(c) 4 Ω
(d) 2 Ω
(e) None of the above

$$V_o = \left(1 + \frac{8}{R}\right) 5$$

$$\left(1 + \frac{8}{R_{MIN}}\right) 5 = 15$$

$$\frac{8}{R_{MIN}} = 2$$

$$R_{MIN} = 4\Omega$$

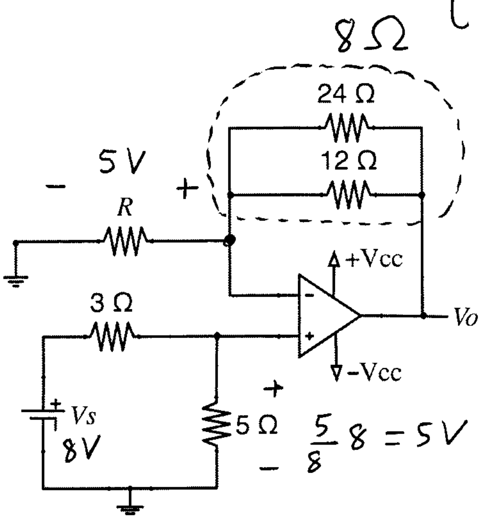


Fig. 7: Circuit of Problem 7

8. The op-amp shown in Fig. 8 is operating in the linear region and R = 4 kΩ. Find V_O.

(a) −13.5 V
(b) −10.8 V
(c) −9 V
(d) −6 V
(e) None of the above

$$V_O = -\frac{18}{4+2}(1+2)$$

$$= -9V$$

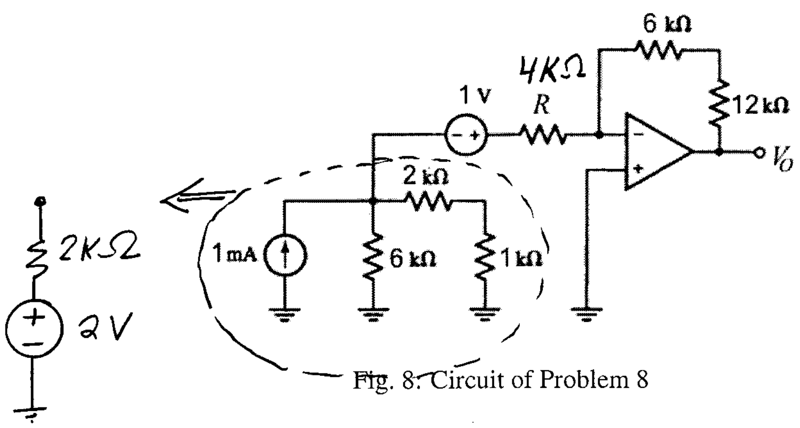


Fig. 8: Circuit of Problem 8

9. The op-amp shown in Fig. 9 is operating in the linear region. $V_S = 1$ V and $I_S = 0.03$ A. Find V_O.

(a) 2 V
(b) 3 V
(c) 4 V
(d) 5 V
(e) None of the above

$$V_p = \left(\frac{1}{100} + 0.03\right)50 = 2V$$

$$V_n = 2 = \frac{V_o}{2} \Rightarrow V_o = 4V$$

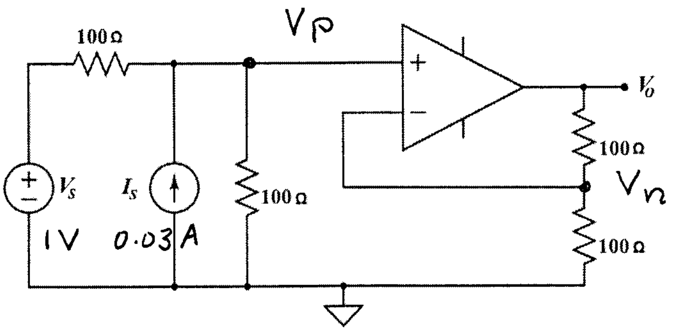
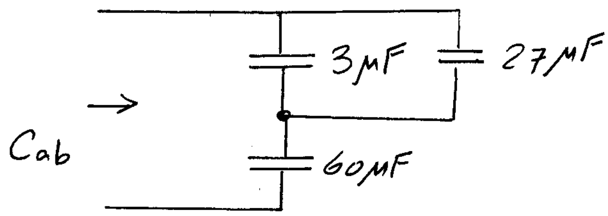


Fig. 9: Circuit of Problem 9

10. If C1 = 27 μF in the network shown in Fig. 10, find the equivalent capacitance with respect to the terminals a, b.

(a) 10 μF
(b) 12 μF
(c) 15 μF
(d) 20 μF
(e) None of the above



$$C_{ab} = \frac{30 \times 60}{30 + 60} = 20\ \mu F$$

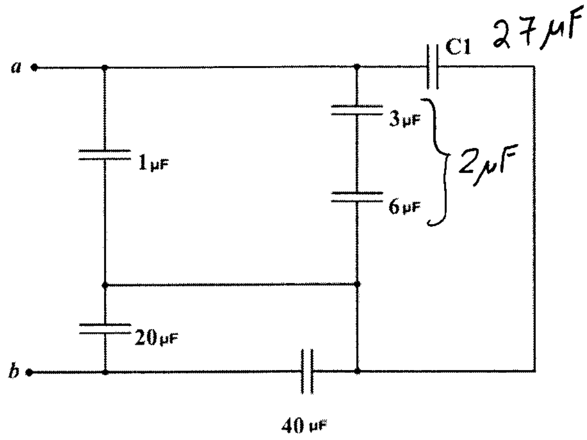


Fig. 10: Circuit of Problem 10

11. In the circuit shown in Fig. 11, $L = 5$ H. Write the mesh-current equation around mesh 1 (corresponding to mesh-current i_1).

$$-V_{SRC} + 10i_1 + 3\frac{di_1}{dt} - 2\frac{di_2}{dt} + 5(i_1 - i_2) + 5\frac{di_1}{dt} = 0$$

$$\Rightarrow V_{SRC} - 15i_1 + 5i_2 - 8\frac{di_1}{dt} + 2\frac{di_2}{dt} = 0$$

(a) $V_{SRC} - 15i_1 + 5i_2 - 3(di_1/dt) + 2(di_2/dt) = 0$
(b) $V_{SRC} - 15i_1 + 5i_2 - 8(di_1/dt) - 2(di_2/dt) = 0$
(c) $V_{SRC} - 15i_1 + 5i_2 - 3(di_1/dt) - 2(di_2/dt) = 0$
(d) $V_{SRC} - 15i_1 + 5i_2 - 8(di_1/dt) + 2(di_2/dt) = 0$
(e) None of the above

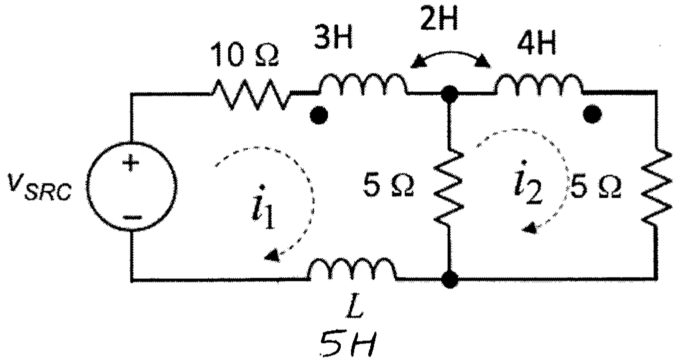


Fig. 11: Circuit of Problem 11

12. In the circuit shown in Fig. 12, $V_S = 30$ V and $C = 20$ μF. The switch has been in position x for a long time, and is moved to position y at $t = 0$. How much energy is delivered to the 40 Ω resistor in the time interval $0 \le t < \infty$?

$$v_C(0^-) = \frac{50}{60}(30) = 25\text{ V}$$

$$\tau = 20\times10^{-6} \times 50 = 10^{-3}\text{ s}$$

$$v_C(t) = 25e^{-1000t}\text{ V}$$

$$v_{40\Omega}(t) = \frac{40}{50}v_C(t) = 20e^{-1000t}\text{ V}$$

$$P_{40\Omega}(t) = \frac{1}{40}v_{40\Omega}^2 = 10e^{-2000t}\text{ W} \Rightarrow W_{40\Omega} = \int_0^\infty 10e^{-2000t}\,dt = \frac{10}{2000} = 5\text{ mJ}$$

(a) 5 mJ
(b) 11.25 mJ
(c) 20 mJ
(d) 31.25 mJ
(e) None of the above

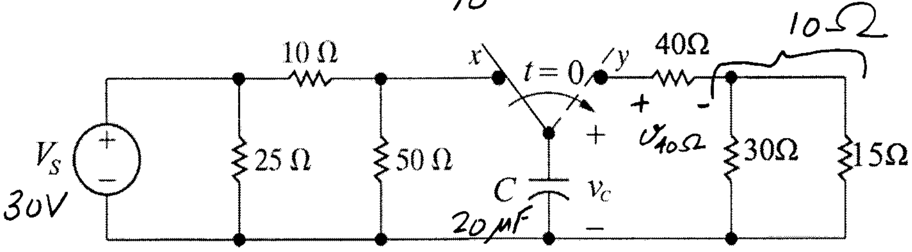


Fig. 12: Circuit of Problem 12

13. In the circuit shown in Fig. 13, the initial current in the inductor (I_O) is 10 A at $t = 0$. Find the value of the voltage $v_3(t)$ across resistor R3 at $t = 3$ s.

(a) 11.036 V

(b) 4.060 V

(c) 1.494 V

(d) 0.549 V

(e) None of the above

$T = \frac{5}{2+3} = 1\,s$

$i(t) = 10e^{-t}\,A$

$v(t) = 30e^{-t}\,V \Rightarrow v(3) = 30e^{-3} = 1.494\,V$

3Ω

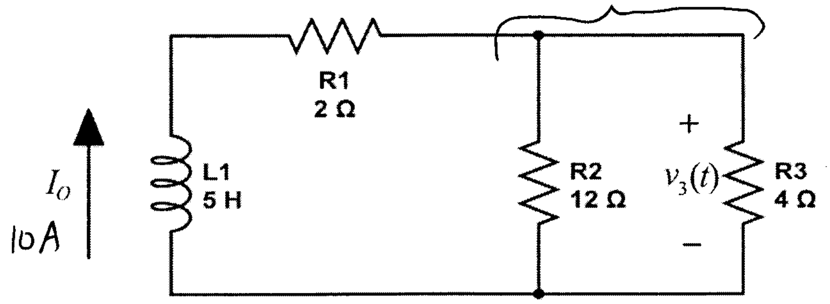


Fig. 13: Circuit of Problem 13

14. In the circuit shown in Fig. 14, Vs = 10 V, L = 0.2 H, and R = 5 Ω. The switch has been closed for a long time before it is opened at $t = 0$. The equation of $i(t)$ for $t \geq 0$ is: $i(t) = I_0 e^{-\alpha t}$ A. Find the value of α.

(a) 6 s^{-1}

(b) 30 s^{-1}

(c) 60 s^{-1}

(d) 120 s^{-1}

(e) None of the above

$\alpha = \frac{R_{EQ}}{L_{EQ}}$

$R_{EQ} = 0.5R + 2R // 6R = 2R = 10\Omega$

$L_{EQ} = L + 2L // L = \frac{5}{3}L = \frac{1}{3}H$

$\Longrightarrow \alpha = 30\,s^{-1}$

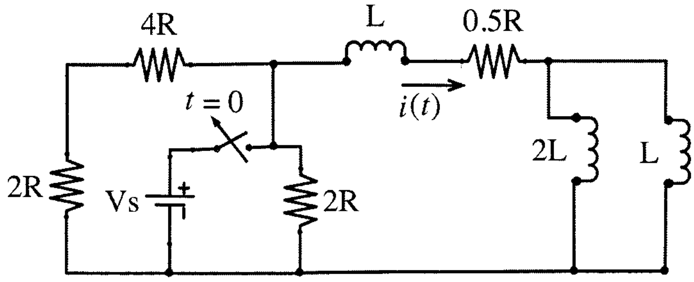


Fig. 14: Circuit of Problem 14

15. In the circuit shown in Fig. 15, $C_1 = 6\ \mu$F, $C_2 = 4\ \mu$F, and $R = 125$ kΩ. The initial voltages on capacitors C_1 and C_2 have been established by sources not shown: $v_1(0) = 20$ V and $v_2(0) = -10$ V. The switch is closed at t = 0. Determine how much energy is stored in capacitor C_1 as t$\rightarrow \infty$.

(a) 588 μJ
(b) 768 μJ
(c) 972 μJ
(d) 1452 μJ
(e) None of the above

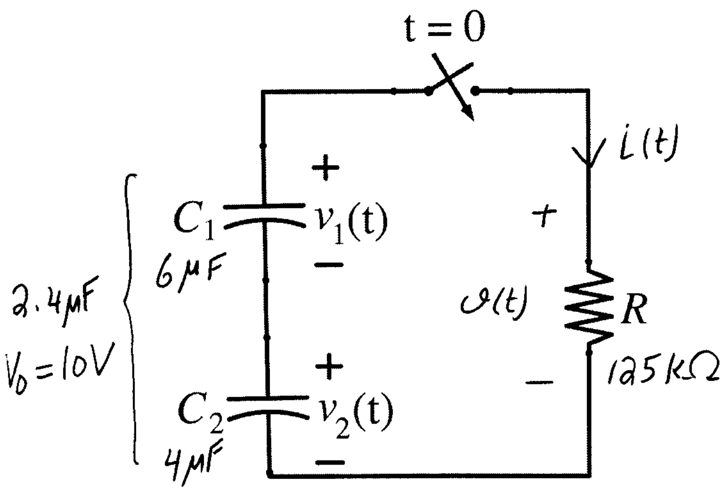


Fig. 15: Circuit of Problem 15

$$\tau = 2.4\times10^{-6}\times125\times10^{3} = 0.3\ s$$

$$v(t) = 10e^{-t/0.3}\ V$$

$$i(t) = 80e^{-t/0.3}\ \mu A$$

$$v_1(\infty) = -\frac{1}{6}\int_0^{\infty} 80e^{-t/0.3}dt + 20$$

$$= \frac{0.3\times80}{6}(0-1) + 20$$

$$= 16\ V$$

$$W_1(\infty) = \frac{1}{2}6(16)^2$$

$$= 768\ \mu J$$