Solution Key

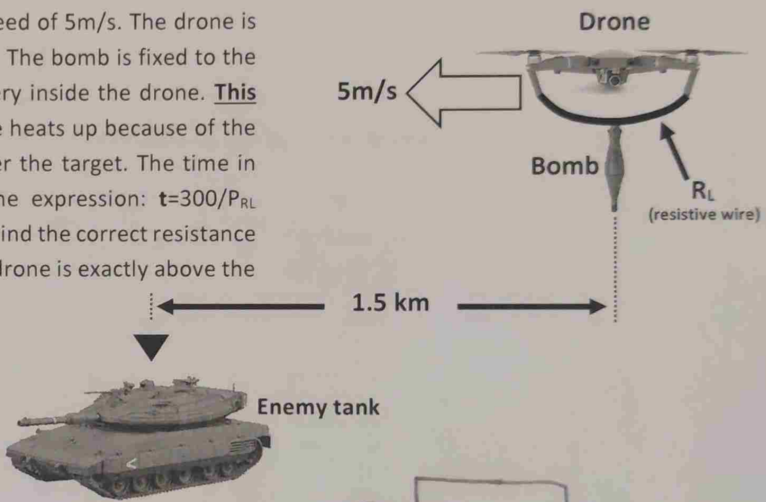
جـامـعـة الـشرق الأوسـط
MIDDLE EAST UNIVERSITY
Amman - Jordan
كلية الهندسة
Faculty of Engineering

Exam Sheet

Faculty: Engineering	Department: Renewable Energy Engineering
Academic Year: 2023/2024	Semester: 1st Semester
Course Name and Number: Electrical Circuits I (0952501)	
Instructor Name: A. Jayyousi	Midterm Exam ■
Exam Date: 5/12/2023	Exam Time:
Student Name:	Student ID:

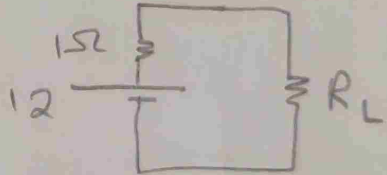
Problem 1 (CLO1) - Estimated Time: 20 min.	6 Points

A drone carries a bomb and moves at a horizontal fixed speed of 5m/s. The drone is to drop its bomb on a tank that is horizontally 1.5-km away. The bomb is fixed to the drone using a resistive wire (R_L) that is fed by a 12-V battery inside the drone. **This battery has an internal resistance of 1-Ω**. The resistive wire heats up because of the current and eventually melts allowing the bomb to fall over the target. The time in seconds needed for the wire to melt is described by the expression: **t**$=300/P_{RL}$ [seconds], where P_{RL} is the power consumed by R_L in Watts. Find the correct resistance of the resistive wire (R_L) to ensure the bomb falls when the drone is exactly above the tank and the enemy is destroyed.



(Note: Two answers are possible. Find both.)

$$\text{time needed} = \frac{\text{Distance}}{\text{velocity}} = \frac{1500\,m}{5\,m/s} = 300 \text{ sec.}$$



$$t = \frac{300}{P_{RL}} \Rightarrow 300 = \frac{300}{P_{RL}} \Rightarrow P_{RL} = 1W$$

$$P_{RL} = I^2 \cdot R_L = \left(\frac{12}{1+R_L}\right)^2 \cdot R_L \Rightarrow 1 = \frac{144 R_L}{R_L^2 + 2R_L + 1}$$

$$R_L^2 - 142 R_L + 1 = 0$$

$$R_{L_1} \simeq 141.99 \simeq 142\,\Omega$$

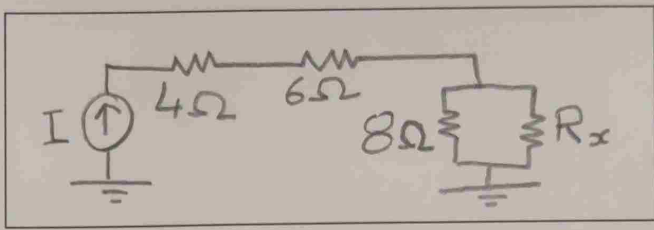
$$R_{L_2} \simeq 0.00704$$

R_L = 141.99 or 0.00704

Problem 2 (CLO1) - Estimated Time: 7 min.	5 Points

Look carefully at the shown circuit (the current source's value is unknown) and then answer the following:

a) Find the value of Rx that would maximise the amount of power produced by the source.



R_x = ∞ (Open Circuit)

b) Find the value of Rx that would make the 8-Ω resistor take 80% of the current running in the 6-Ω resistor.

$I_{8\Omega} = 0.8 I_{6\Omega} = 0.8 I \Rightarrow I_x = I \frac{8}{R_x + 8} = 0.2 I$

$R_x + 8 = 40$

$R_x = 32$

R_x = 32

c) Find the value of Rx needed to make the total resistance of this circuit (as seen by the source) equal to 14-Ω.

Directly induced

R_x = 8Ω

Problem 3 (CLO1) - Estimated Time: 5 min.	**4 Points**

A heater (made of a simple resistor) consumes 80-Watts when connected across a 24-VDC source. How much will it consume when operated from a 240-VDC source (in Watts)?

$$R_{heater} = \frac{V^2}{P} \Rightarrow \frac{24^2}{80} = 7.2\ \Omega$$

$$P_{heater,240} = \frac{240^2}{7.2} = 8000\ W$$

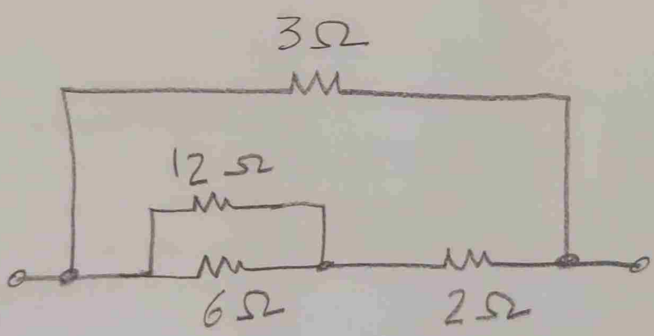
OR

10 times the voltage $\Rightarrow (10)^2$ times the power

P = 8000 W

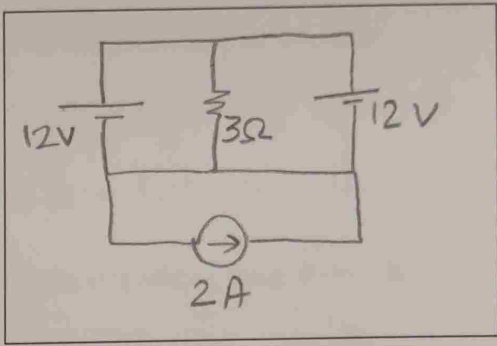
Problem 4 (CLO1) - Estimated Time: 7 min.	**4 Points**

You have four resistors with the following values: 2Ω, 3Ω, 6Ω and 12Ω. Show how you can connect these four resistors to achieve an equivalent resistance of 2Ω. (**Note**: You have to use all four resistors)



Problem 5 (CLO1) - **Estimated Time:** 5 min.	4 Points

In the shown circuit, find the following:



a) Find the power consumed by the 3-Ω resistor in the shown circuit.

$I_3 = \frac{12}{3} = 4A$

$P_3 = 12 * 4 = 48W$

$P_{3\Omega} =$ 48 W

b) Find the power generated by the 2A current source.

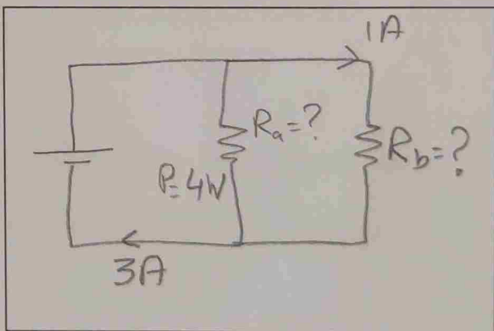
$V_{2A} = zero$

$P_{2A} = zero$

$P_{2A} =$ Zero

Problem 6 (CLO1) - **Estimated Time:** 5 min.	6 Points

In the shown circuit, an unknown voltage source feeds two resistors, Ra and Rb. Resistor Ra consumes 4-Watts, while a current of 1-A runs through Rb. A current of 3-A runs into the negative terminal of the unknown voltage source. Find R_a, R_b and E.



$I_a = 2A$

$P_a = I_a^2 R_a \Rightarrow 4 = R_a * 4 \Rightarrow R_a = 1\Omega$

$V_a = V_b = E = 2 R_a = 2V$

$R_b = \frac{V_a}{I_a} = \frac{2}{1} = 2\Omega$

$R_a =$ 1 Ω

$R_b =$ 2 Ω

E = 2 V

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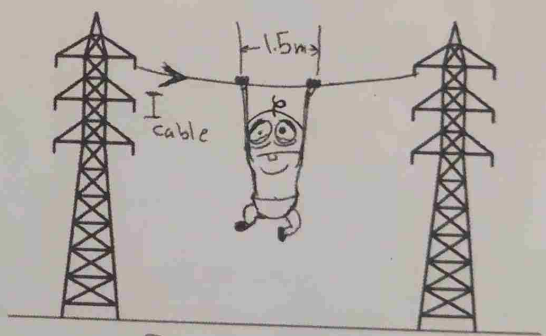
Academic Year: 2022/2023	Semester: 1^{st} Semester
Course Name and Number: Electrical Circuits I (0952501)	
Instructor Name: A. Jayyousi	
Midterm Exam ■	
Exam Date: 5/12/2022	Exam Time: 9:30 - 10:30
Exam Room Number:	
Student Name:	**Student ID:**

Problem No.	CLO	Full Points	Student's Point
Problem (1)+(2)	CLO (1)	10 Points	
Problem (3)+(4)	CLO (1)	8 Points	
Problem (5)+(6)	CLO (1)	8 Points	
Problem (7)	CLO (2)	5 Points	
Total		31 Points	

Problem 1 (CLO1) - Estimated Time: 10 min. **5 Points**

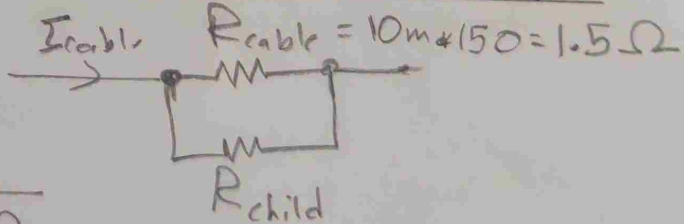
The minimum current needed to kill a child is 10**mA**. A little boy climbed up a power transmission line and is now hanging as shown in the figure using his two hands. The line in not insulated and has a resistance of **10mΩ/cm**. The distance between the child's two hands is 1.5-**meters**, and his body resistance across his arms (from hand to hand) is 10**kΩ** exactly. Find the minimum cable current (I_{cable}) in Amps that would be required to kill the child. Assume DC currents and voltages everywhere.



For the child to die:

$$I_{ch.} = 10mA$$

Current Division Rule:



$$I_{child} = I_{cable} * \frac{R_{cable}}{R_{cable} + R_{child}}$$

$$10m = I_{cable} * \frac{10m * 150}{1.5 + 10{,}000} \Rightarrow I_{cable} = \frac{0.01}{1.5} * 10{,}001.5$$

$$I_{cable} \simeq 66.67A$$

I_{cable} = 66.67

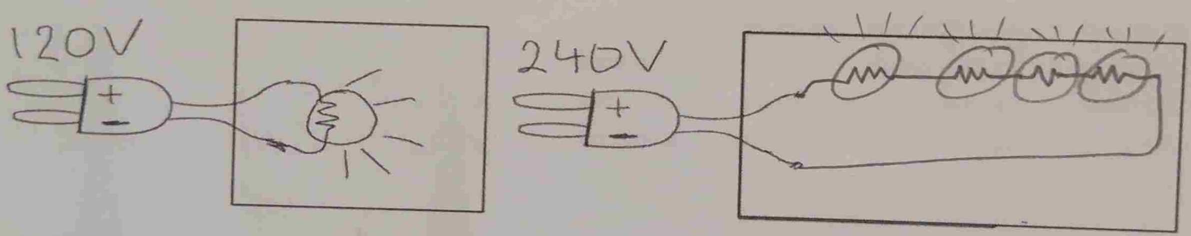
Problem 2 (CLO1) - **Estimated Time:** 10 min.	**5 Points**

A certain type of japanese light bulbs is manufactured for the japanese market where the voltage supplied to users is 120V. The bulb consumes a certain amount of power. Someone in Jordan imports a large number of these japanese bulbs (all identical). Since the voltage available in Jordan is 240V, he cannot connect the bulb directly to the electrical socket (it would explode). How can he connect **a number** of these japanese bulbs together in order to make them work from a 240-VDC source **such that their total power is exactly equal to the power which the single bulb achieves in Japan**? Draw a diagram in the box below to illustrate your answer. You can use as many bulbs as you want; just make sure that their total power in Jordan(240V) will be exactly equal to the power of a single one of them in Japan(120V).

$P_{Japan} = P_{Jordan}$

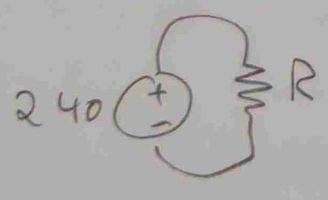
$$\frac{120^2}{R} = \frac{240^2}{R'} \Rightarrow R' = \frac{240^2}{120^2} \cdot R = 4R$$

$R' = 4R \Rightarrow$ 4 resistors (bulbs) in series



Problem 3 (CLO1) - **Estimated Time:** 10 min.	**4 Points**

A heater (made of a simple resistor) consumes 400-Watts when connected across a 240VDC source. How much will it consume when operated from a 120V source (in Watts)?



$\Rightarrow P_{240} = 400W.$ $\quad R = \frac{V^2}{P} = \frac{240^2}{400} = 144\Omega$

$$P_{120} = \frac{V^2}{R} = \frac{120^2}{144} = 100W$$

P = 100 Watts

Problem 4 (CLO1) - **Estimated Time:** 5 min. **4 Points**

You have **ten million** resistors. Each resistor has a resistance of 15-Ω. They are all identical. You divide the resistors into separate groups; each group has 1000 resistors exactly. You connect the resistors in each group in series to form a string. All the strings are then connected in parallel. What is the total resistance of this huge combination in ohms?

No. of R = 10,000,000

No. of strings = $\frac{\text{No. of R}}{1000}$ = 10,000

R_{string} = 15,000

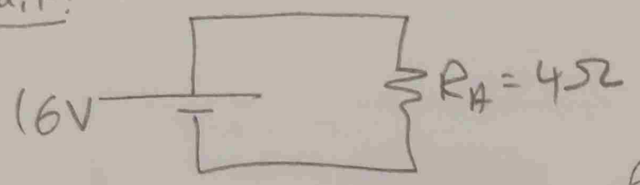
$R_{total} = \frac{R_{string}}{10,000} = 1.5\,\Omega$

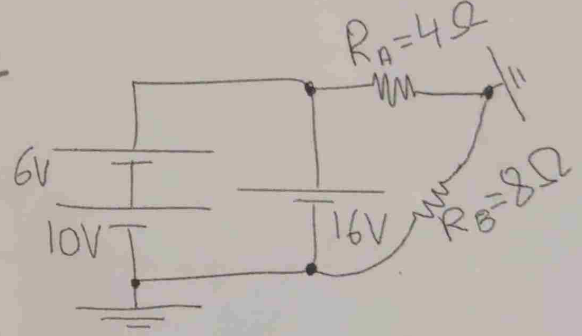
R_{total}= 1.5 Ω

Problem 5 (CLO1) - **Estimated Time:** 5 min. **4 Points**

Study the circuit below. Note that it includes two ground points. Find the power consumed by R_A and R_B in Watts.

Eq. Circuit:





$P_{RA} = \frac{16^2}{4} = 64W$

P_{RA} = 64 W

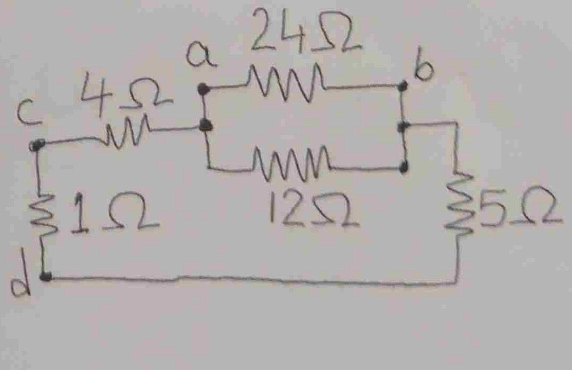
P_{RB} = Zero [Parallel with S.C.]

Problem 6 (CLO1) - **Estimated Time:** 5 min. **4 Points**

Find R_{bc} in ohms.

$\{[24 // 12] + 4\} // (5+1)$

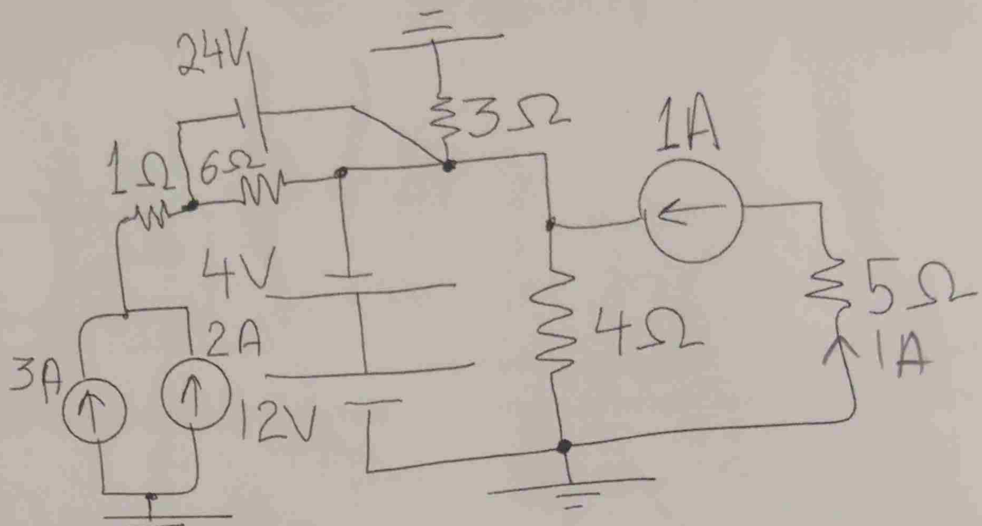
$12 // 6 = 4\Omega$



R_{bc} = 4 Ω

Problem 7 (CLO2) - **Estimated Time:** 5 min.	**5 Points**

Study the circuit below then find the power (in Watts) consumed by the 1Ω, 3Ω, 4Ω, 5Ω and 6Ω resistors.



$$P_{5\Omega} = 1^2 \times 5 = 5W$$

$$P_{4\Omega} = \frac{(12-4)^2}{4} = 16W$$

$$P_{6\Omega} = \frac{24^2}{6} = 96W$$

$$P_{1\Omega} = (3+2)^2 \times 1 = 25W$$

$$P_{3\Omega} = \frac{(12-4)^2}{3} = 21.\bar{3}W$$

$P_{1\Omega}$ = 25W	$P_{3\Omega}$ = 21.3W	$P_{4\Omega}$ = 16W	$P_{5\Omega}$ = 5 W	$P_{6\Omega}$ = 96W