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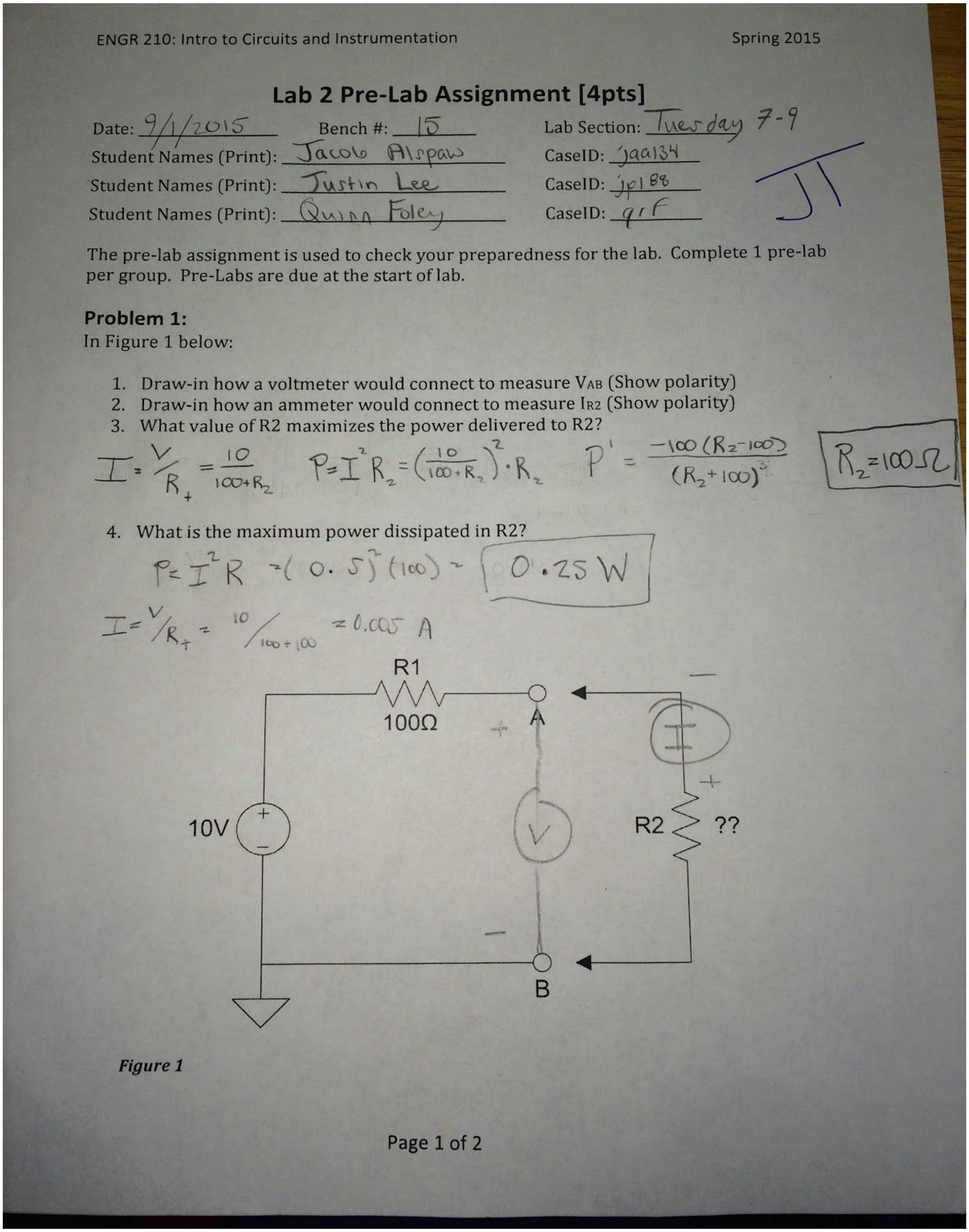
1)



ENGR 210: Intro to Circuits and Instrumentation — Spring 2015

Lab 2 Pre-Lab Assignment [4pts]

Date: 9/1/2015 Bench #: 15 Lab Section: Tuesday 7-9
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The pre-lab assignment is used to check your preparedness for the lab. Complete 1 pre-lab per group. Pre-Labs are due at the start of lab.

Problem 1:
In Figure 1 below:

1. Draw-in how a voltmeter would connect to measure V_{AB} (Show polarity)
2. Draw-in how an ammeter would connect to measure I_{R2} (Show polarity)
3. What value of R2 maximizes the power delivered to R2?

$I = V/R_T = \frac{10}{100+R_2}$ $P = I^2 R_2 = \left(\frac{10}{100+R_2}\right)^2 \cdot R_2$ $P' = \frac{-100(R_2-100)}{(R_2+100)^3}$ $\boxed{R_2 = 100\Omega}$

4. What is the maximum power dissipated in R2?

$P = I^2 R = (0.5)^2(100) = \boxed{0.25\text{ W}}$

$I = V/R_T = 10/(100+100) = 0.005\text{ A}$

Figure 1

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Problem 2:

In Figure 2 below:

1. Find V_{AB}

$R_T = 1000 + 1000 = 2000\,\Omega$

$I = V/R_T = 10/2000 = 0.005\ A$

$\boxed{V_{AB} = 5V}$

$V_{AB} = 0.005(1000) = 5V$

2. Find I_{R1} if A and B are **shorted** together.

$V = IR$

$I_{R_1} = \frac{V}{R} = \frac{10}{1000} = \boxed{0.01\ A}$

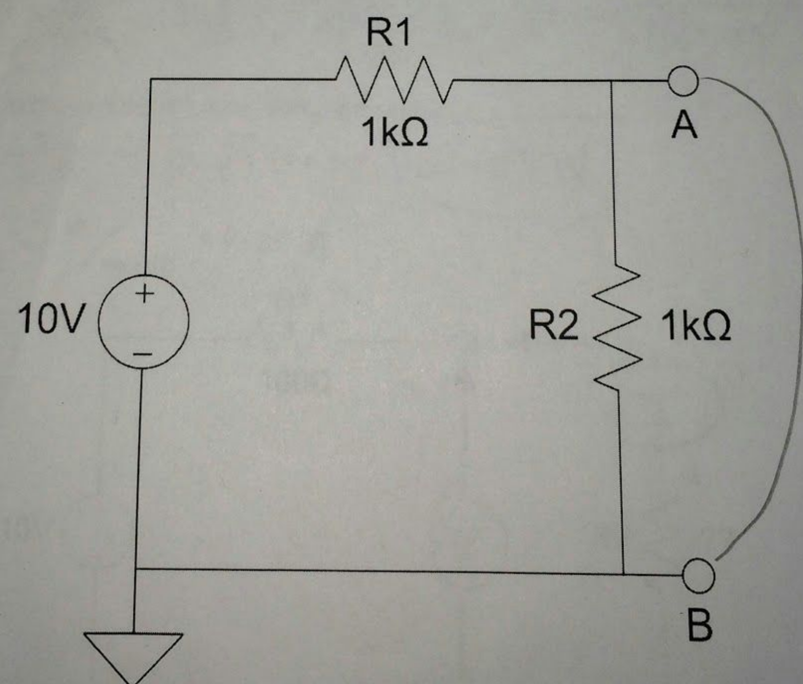


Figure 2

2a) $V_{AB} = V_T - V_I$, $V_I = I * R_1$

I = $V_T/R_T = V_T/R_1 + R_2 = 1/(10 + R_2)$

$V_2 = I * R_2 = R_2/(10 + R_2)$

To maximize the voltage between A and B, the resistance of R_2 should be as close to infinite resistance as possible because the current is the same throughout a series circuit which would make the resistance in R_1 insignificant, causing nearly all the voltage in the circuit to go through R_2 .

2b) In order to maximize the current in the circuit, the voltage in R_2 should be 0 Ω. If R_2 has a resistance of 0 Ω, then the total resistance would be minimized in the circuit which increases the current with a constant voltage source.

3a) $I = V_t/R_2 = 1/(10 + R_2)$

$P = I^2R = (1/(10 + R_2))^2 * R_2$

$dP/dR_2 = (10 - R_2)/(R_2 + 10)^3$

The derivative of the power function yields a maximum value for power output for a value of R_2. When $R_2 = 10\ \Omega$, the power in R_2 is maximized.

3b) $P = I^2R = (1/(10 + R_2))^2 * 10$

$P' = -20/(R_2 + 10)^3$

We can see that P and R_2 are inversely proportional. Less R_2 results in more P dissipated in R_1, This in conjunction with the derivative of the power functioning always decreasing shows that R_2 needs to be 0 Ω for P dissipated in R_1 to be reach a maximum.

4a) I=0.1 A

$R_t = (1/R_1 + 1/R_2)^{-1}$

R_1 =10Ω

V=I*R

$V = 0.1 * (1/R_1 + 1/R_2)^{-1}$

$P = V^2/R = (0.1 * (1/R_1 + 1/R_2)^{-1})^2/R_2$ = $R_2/(10+R_2)^2$

P'= $(10 - R_2)/(R_2 + 10)^3$

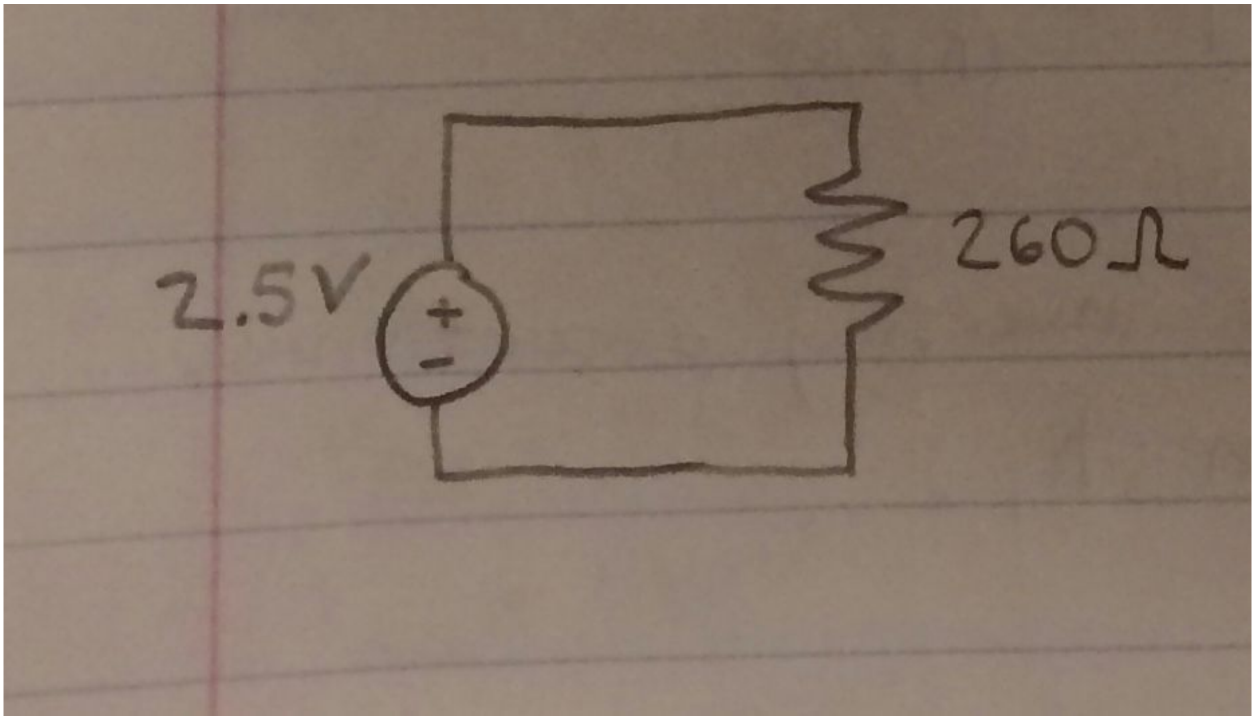
The derivative of the power function yields a maximum value for power output for a value of R_2. When $R_2 = 10\ \Omega$, the power in R_2 is maximized.

4b) $P = (0.1 * (1/R_1 + 1/R_2)^{-1})^2/R_1 = 0.1(R_2)^2/(10 + R_2)^2$

P' = $2R_2$ / $(10+R_2)$

The derivative of the power function yields a maximum value for power output for a value of R_2. When $R_2 = 0\ \Omega$, the power in R_2 is maximized.

5) Voltage = 2.51 V I= 9.76 mA R=V/I=260 Ω



6) If the voltage supply was turned off, then we could measure the resistance because it will be different. Another way to distinguish the circuits is to short the terminals over the above resistor or between A and B by measuring the current. Then the current flowing through this short would be different because the above circuit would have no external resistance and the current would be “infinite.” The source in figure 3 will have a current of about 10 mA shorting over terminals A and B.

7) Slope = Internal Resistance

V	I	R
1.25	.317	3.3
1.35	.129	10

Given that the slope is equal to $\Delta V/\Delta I$, the value of the slope is equal to (1.25-1.35)/(.317-.129)=-.531, so internal resistance due to the battery is 0.531 Ω.

Voltage drop from the internal resistance is equal to $I(R_{internal})$ = 0.317 * 0.531 = 0.168 V
Voltage produced is equal to voltage drop over the resistor plus the voltage drop from the internal resistance: V_{total}=1.25 + 0.168 = 1.42 V produced by the battery. However, 0.168 V are dropped from the internal resistance.

8) P=I*V=$I^2R = V^2/R$

$V_{battery}$ = 1.42 V

With the load as the sole external resistance, $V_{Load} = V_{battery}(R_{Load}/(R_{Load}+R_{internal})$ which leads to
$P_{Load} = V_{battery}^2(R_{Load}/(R_{internal}+R_{Load})^2) = 2.02(R_{Load}/(0.531+R_{Load})^2)$
$P_{Load}' = (1.07 - 2.02*R_{Load})/(R_{Load} + 0.531)^3$
The derivative of the power function yields a maximum value for power output for a value of R_2.
When $R_{Load} = 0.531\ \Omega$, the power in R_{Load} is maximized. Using our power function, defining the amount of power through the load, this maximum power is 0.95 W.

9) P=I*V=$I^2R = V^2/R$

As R decreases, V is constant, so I increases. $V_{battery}$ = 1.42 V
With no external resistance, P=$(V_{battery})^2 / R_{internal}$, $(1.42)^2 / 0.531 =$ 3.80 W