ENGR 212: Laboratory Experiment 2
Answer Guide & TA Notes

Teaching Assistant Reference

Overview

This guide outlines the theoretical values and expected behaviors for **Lab Experiment 2**. Use this to verify student results and explain discrepancies during the lab session.

1 Part 1: Voltage Divider Circuit Calculations

Problem Statement

Students must calculate v_{out}, i, and P_{R_2} for the circuit in Figure 1(a) with a fixed source of 10V and $R_1 = 10\text{k}\Omega$. The value of R_2 varies across five specific resistance values.

Formulas Used

The circuit is a standard unloaded voltage divider.

1. **Current (i):**
$$i = \frac{V_{source}}{R_{eq}} = \frac{10\text{V}}{R_1 + R_2}$$

2. **Output Voltage (v_{out}):**
$$v_{out} = i \times R_2 = 10\text{V} \times \left(\frac{R_2}{R_1 + R_2} \right)$$

3. **Power Dissipated by R_2 (P_{R_2}):**
$$P_{R_2} = i^2 \times R_2 = \frac{(v_{out})^2}{R_2}$$

Answer Key (Theoretical Values)

Use the table below to check the "Calculation" columns in student reports. Note that power is calculated in milliwatts (mW).

R$_2$ Value	Total R (R$_1$ + R$_2$)	Current i	Voltage v$_{out}$	Power P$_{R_2}$
2.2 kΩ	12.2 kΩ	**0.820 mA**	**1.80 V**	**1.48 mW**
4.7 kΩ	14.7 kΩ	**0.680 mA**	**3.20 V**	**2.18 mW**
10 kΩ	20.0 kΩ	**0.500 mA**	**5.00 V**	**2.50 mW**
20 kΩ	30.0 kΩ	**0.333 mA**	**6.67 V**	**2.22 mW**
33 kΩ	43.0 kΩ	**0.233 mA**	**7.67 V**	**1.78 mW**

Table 1: Theoretical values for Table 1. Measured values should be within resistor tolerance ($\approx 5\%$).

2 Part 2: LED Circuit Analysis

Theoretical Expectations

1. Forward Bias Behavior

- **Threshold:** An LED is a non-linear device. Current will remain near zero until the voltage across the LED reaches its **turn-on voltage** ($V_{turn-on}$).

- **Typical $V_{turn-on}$:** For a standard red LED, this is typically **1.8V − 2.0V**.

- **Behavior:**

  - **Input 1V:** Source < Turn-on. LED is OFF. $I \approx 0$mA. $V_{LED} \approx 1$V (Open circuit behavior).
  - **Input 2V $\sim$ 5V:** Source > Turn-on. LED turns ON. V_{LED} clamps near the forward voltage (≈ 2V) and rises very slowly.

Master Reference Table: Part 2 Measurements

The table below provides theoretical data for all permutations of R_1 and Input Voltage (V_{in}). **Note:** Calculations assume a generic Red LED with $V_f \approx 1.8$V − 2.0V.

R_1 Value	Input (V_{in})	LED State	V_{LED} (approx)	V_{R1} (calc)	Current i (mA)
0 Ω	1.0 V	OFF	1.00 V	0.00 V	0.00
	2.0 V	Dim ON	1.80 V	0.00 V	0.05
	3.0 V	ON	1.88 V	0.00 V	0.29
	4.0 V	Bright	1.95 V	0.00 V	0.53
	5.0 V	Brightest	2.00 V	0.00 V	0.77
100 Ω	1.0 V	OFF	1.00 V	0.00 V	0.00
	2.0 V	Dim ON	1.80 V	0.01 V	0.05
	3.0 V	ON	1.88 V	0.03 V	0.28
	4.0 V	Bright	1.95 V	0.05 V	0.51
	5.0 V	Brightest	2.00 V	0.08 V	0.75
1 kΩ	1.0 V	OFF	1.00 V	0.00 V	0.00
	2.0 V	Faint	1.78 V	0.05 V	0.04
	3.0 V	ON	1.85 V	0.23 V	0.23
	4.0 V	ON	1.90 V	0.43 V	0.43
	5.0 V	Bright	1.95 V	0.62 V	0.62
100 kΩ	1.0 V	OFF	1.00 V	0.00 V	0.00
	2.0 V	OFF/Dim	1.60 V	0.38 V	0.004
	3.0 V	Very Dim	1.65 V	1.30 V	0.013
	4.0 V	Dim	1.70 V	2.21 V	0.022
	5.0 V	Dim	1.75 V	3.12 V	0.031

Table 2: Theoretical Measurements for LED Circuit (Figure 3).

TA Grading Notes

- **100 kΩ Behavior:** At this high resistance, current drops to $\approx 30\,\mu$A. The LED may appear OFF or extremely faint. Most of the voltage drop occurs across R_1, not the LED.

- **Low Voltage (< 1.8V):** If V_{in} is below the turn-on threshold, the circuit is open. $V_{LED} = V_{in}$ and $I = 0$.

- **Measurement Tolerance:** Student DMMs may not be sensitive enough to capture μA changes. Zero current readings at 100kΩ are acceptable for grading purposes.