APPLICATION OF OPAMPS AND PHOTORESISTORS

YOUR NAME______________________________________  LAB MEETING TIME________________


ANALYZING CIRCUIT ELEMENTS

List any references you may have used to answer questions in this PreLab

During Lab 7, you will be assembling and testing circuit shown below:

![Circuit Diagram]

List of supplies that will be provided during the lab (you will need to bring your own breadboard):

- \( V_{CC} = 4.5 \) V
- \( R_1 = R_2 = 1 \) kΩ
- \( R_3 = R_4 = 220 \) Ω
- \( R_5 = 100 \) kΩ
- \( R_6 = 15 \) kΩ
- \( R_7 = 47 \) kΩ
- \( PR_1 = PR_2 \) (photoresistor)
- \( C_1 = C_2 = C_3 = C_4 = 0.1 \) μF
- \( C_s = 47 \) μF
- \( P1 = P2 = P3 = 100 \) kΩ potentiometer
- \( TR_1 = TR_2 \): BS170
- \( OA_1 = OA_2 = OA_3 = OA_4 \): LF412CN
- \( M_1 \) = \( M_2 \): Velleman MOT1, 3V geared
- \( D_1, D_2 \)
- \( LED_1, LED_2 \)
- \( 4.5 \) V battery pack
- Batteries

1. As part of this PreLab, we will expect you to explore and learn on your own about different elements used. Provide some of your findings in the spaces below:

a) **Potentiometer**
   - What is a potentiometer and why is it useful in circuits? Explain on the example of potentiometers P1 and P3.
b) **Operational Amplifier:**
- What mathematical operations can be achieved using op-amps? Name at least 4-5 operations and provide simple schematics for two operations you have identified. At least one of the schematics should contain $L$ or $C$.

- What are min and max values of $v_{11}$ and $v_{12}$?

- What are min and max values of $v_3$ and $v_6$?

c) **Diode:**
- What is general purpose of a diode? Explore different types of diodes and list a few along with their applications (why would you use them?).

- Why is there a resistor in series with each LED (e.g. $R_3$ and LED1)?

- Diode has two terminals: anode and cathode. You will be using a “regular” diode and an LED in Lab 7. How will you recognize which wire leads to which of the terminals?
d) **Photoresistor:**
   - What is a photoresistor? Which of the two is usually smaller: $R_{\text{dark}}$ or $R_{\text{light}}$?
   - What is the purpose of the photo-resistor in this circuit? How does change in its resistance influence functioning of this circuit? Explain on the example of PR1.

e) **Transistor:**
   - Study transistors in brief and how they operate. What are the names of the three terminals?

f) **Motor:**
   We will be using a simple, hobby-type DC motor MOT1N by Velleman, [http://www.vellemanusa.com/products/view/?id=524516](http://www.vellemanusa.com/products/view/?id=524516)
   To benefit the most from this lab, we are asking you to explore some types of widely used motors and their most important characteristics (specs).
   - Voltage $v_{11}$ is PWM (pulse width modulated) signal. How does PWM affect motor speed (e.g. $v_{11}$)?

![Example of a PWM signal](https://example.com/pwm_signal.png)
Why does the motor have a capacitor and diode connected in parallel with it? Explain purpose for each of the two elements.

Explore brushed DC motors, AC motors, and stepper motors and the differences between them. When attempting to control the motor output speed (rpm) is it more important to vary the voltage or current supply to the motor? Explore some of the motor terms below and how they might be important when sizing a motor for a project:
- Stall current
- Max output current
- No load current

Also some other types of motors to explore:
- Servo motor
- Gear motor
- Brushless DC motor

Attach a separate sheet of paper with short description of most important findings about motors.

**Analyzing Different Parts of the Circuit**

2. There are two distinct parts of the circuit: top part (supply) and bottom part (left and right)

a) Top part of the circuit: OpAmp3 and OpAmp4:

- What is the value of \( v_1 \)?

- Why do we have \( C_3 \) in parallel with P3?
• If OpAmp3 is comparator, what values of voltage $v_3$ do you expect to get?

• What mathematical operation is OpAmp4 performing?

• If OpAmp4 is “picking-up” signal $v_3$ for further processing, what happens with $v_6$ when $v_3 > 0$ (“high”) and when $v_3 \leq 0$ (“low”)?

• As an engineer, you will often have to make an educated guess about the operation of a device or part of it. Can you guess the waveform of the signal $v_6$? Write your guess here before reading Lab file, and do not change your answer after you perform next steps (you will not lose credit if your answer for this part is wrong).

b) One half of the bottom part of the circuit: OpAmp1 and/or OpAmp2:

• OpAmp1 is used as comparator. Which two values are being compared?

• Why do you need potentiometer P1?
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- Given the shape of \( v_6 \) that you have guessed, explain how OpAmp1 generates PWM (pulse width modulated signal) at the output. If you cannot answer this part of the assignment since you are not sure about your guess for the waveform of the signal \( v_6 \), talk to the TA during office hours to get some help on this part.

![Example of a PWM signal](image)

- PWM signal switches between low and high values. What does this do to the transistor and motor following the transistor?

- For which resistance of the photo-resistor will motor spin, and for which will it stop (\( R_{\text{low}} \) or \( R_{\text{high}} \))? Correlate your answers to the amount of light (low or high light).