# Overview of Labs

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Speed sensor circuit: Electronic prototype construction
Lab Overview

In today’s lab we will:

i. Learn about and use basic electronic components used in lab

ii. Understand the principle of operation of a speed sensor

iii. Build a prototype speed sensor using a Light emitting diode (LED) and a phototransistor
**Electronic components used**

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<th>Component</th>
<th>Operation</th>
<th>Schematic symbol</th>
<th>Actual snapshot</th>
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| Resistor                 | • Resists the flow of electrical current  
                           | • Non-polarized                                                        | ![Resistor Symbol] | ![Resistor Actual] |
| Light Emitting Diode (LED)| • Emits light when current flows through it  
                           | • Polarized                                                            | ![LED Symbol]      | ![LED Actual]      |
| Photo-transistor (diode) | • Allows current to flow, from top leg (collector) to bottom leg (emitter) when light falls on it base | ![Photo-transistor Symbol] | ![Photo-transistor Actual] |

*Only component not used in Eng 181 circuits lab*
Transistors

- Can act like a “switch”
- Can act as an amplifier
- Current limited
- Phototransistor is a special type of transistor
Other Equipment: Prototype board and DMM

Examples of electrically connected holes

5 V DC Power Supply

Digital Multimeter - DMM
(used for measuring voltage and resistance)
Principle of operation: Speed Sensor

Why do we need to study a speed sensor?

- To measure speed of the ball at different points in the roller coaster project

BASIC PRINCIPLE:

- Measure time between when the leading and trailing edges of the ball pass a given point. Given the diameter of the ball, an estimate of the speed that the ball is traveling can be found.
When the ball passes between an LED and a phototransistor, the light is blocked.

Diagram:
- **R1**: 100 Ω
- **D1**: High intensity red LED
- **Q1**: Phototransistor
- **D2**: Green LED
- **R2**: 1K Ω
- **D3**: OR output
- **1N4148**
THE SPEED SENSOR CIRCUIT

Let's see how it works

Output Signal
The clear plastic around the LED is a lens that focuses the light into a beam. The beam has a spread of about 6 degrees. Because of this and because the edges of the ball are not flat, the measured time is shorter than the actual time.
The correction factor for the LED/Phototransistor pair and the 1” Dia. coaster ball was measured to be 8.3%. So the speed can be calculated using:

\[ s = \frac{D}{1.083 \times (t_2 - t_1)} \]
Task 1: Review of KVL (different schematic representations)
Correspondence between circuit board and schematic connections

This connection is made by the vertical bars on the backplane.
Recording Voltages $V_{R1}$ and $V_{R2}$

Record measurements/questions associated with task #1
Task 2: Construction and analysis of Green LED circuit

Switch is off/open

Current Flow

Green LED glows

Switch is on/closed

Current Flow

Green LED does not glow
Task 2: Direction of Current flow when switch is off or open

At node a, total current $i$ breaks into $i_1$ and $i_2$; i.e. $i = i_1 + i_2$

Since open switch provides infinite resistance, no current flows through it; therefore $i_1 = 0$ and $i = i_2$
Task 2: LED circuit when switch is open/off
Task 2: Direction of Current flow when switch is on or closed

At node a, total current i breaks into i₁ and i₂; i.e. i = i₁ + i₂
Since closed switch provides zero resistance, all current flows through it therefore i₁ = i and i₂ = 0
Task 2: LED circuit when switch is closed/on
Applying of what we learned to RC speed sensor

<table>
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<tr>
<th>Ball position</th>
<th>In between the transistor and LED</th>
<th>Not in between the transistor and LED</th>
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<tr>
<td>Transistor (modeled by a switch in task#2)</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>LED</td>
<td>ON</td>
<td>OFF</td>
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Task 3: Construction and analysis of phototransistor circuit

- Visually distinguishing between a Red LED and a phototransistor

Red LED (labeled “LED” on the lens side) has a flatter lens

Phototransistor’s lens has a more bullet-like shape (labeled “Photo-diode” on the front)
Task 3: Construction of speed sensor circuit (part 1)

Follow the Lab Procedure given in your lab procedure for TASK#3 and TASK#4

• Construct Phototransistor circuit through schematic

• Possible approach
  From task 2 circuit:
  i. Switch off power supply
  ii. Replace 100 Ω resistance with 1000 Ω resistance
  iii. Replace switch with phototransistor
Task 3 : Construction of speed sensor circuit (part 2)

Complete the circuit by hooking up a Red LED in front of the photo transistor while making sure there is enough space for the given piece of track to fit in the space, in between the Red LED and the photo transistor.
Task 3: Verification

• Ensure that the Red Led and phototransistor are aligned such that Red LED beam is centered on the phototransistor lens.

• Verify that the phototransistor circuit works by placing an opaque object between Red LED and the phototransistor.

• Circuit works properly if the green LED turns “ON” when the light beam is interrupted.
Task 3: Measurements

Measure:

- $V_{\text{phototransistor (Beam ON)}} = \underline{\text{Volts}}$
- $V_{\text{phototransistor (Beam OFF)}} = \underline{\text{Volts}}$
Task 4: Using speed sensor circuit for velocity measurements (connections)

Connect the “BNC Connector” to the matching BNC connector labeled “Channel 0” on the rear panel of the PC.

Connect the “Ground Clip” to any ground point in the circuit.

Connect the “Signal Clip” to the output of the Phototransistor (non-black side)

If signal clip is connected to the black/ground end of the phototransistor you will not get any lab view plots
Task 4

- The output of each speed sensor will consist of a pulse, where the output voltage goes from low to high to low as the ball passes (like a square wave).

- We're interested in the time ($\Delta t$) between when the leading and trailing edges of the ball pass the sensor.
Task 4

- Follow instructions given in your lab manual to finish task 4

- Use Alt+PrintScrn to copy your Lab view plot with speed sensor data (i.e. coaster ball velocities) in a word document

You need to attach this screen capture in your lab memos

- Answer all the measurement/discussion questions in the lab procedure
• Record the results on your worksheets

• This lab will be performed in teams of 2 students (or 3 if only 3 team members)

If you come across a faulty electronic component, do not replace it with a neighboring team, instead bring it to the instructional staff’s attention
Memo due next Lab

• Only one set of data per team should be selected for the single team memo.