Toronto Metropolitan University

**Department of Electrical, Computer, & Biomedical Engineering**
Faculty of Engineering
& Architectural Science

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| **Course Title:** | Electronic circuits |
| **Course Number:** | 404 |
| **Semester/Year (e.g.F2016)** | W2025 |

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| **Instructor:** | Md Sadid Haque Waselul |

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| *Assignment/Lab Number:* | 2 |
| *Assignment/Lab Title:* | Voltage regulators |

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| *Submission Date:* | 02-07-25 |
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# Introduction and Objective:

The purpose of this lab is to implement and analyze different types of voltage regulators while analyzing the efficiency of effectiveness of said regulators. The regulator circuits to be implemented in this experiment are a simple resistor voltage divider, a 1N4148 diode-based regulator, and a 1N4735 Zener diode-based regulator, whose circuit diagrams can be seen in Figures 1.0, 4.0, and 2.0 respectively. The variable load used with these regulators uses a potentiometer and a BJT to control the current supplied to the load, whose circuit diagram can be seen in Figure 3.0.

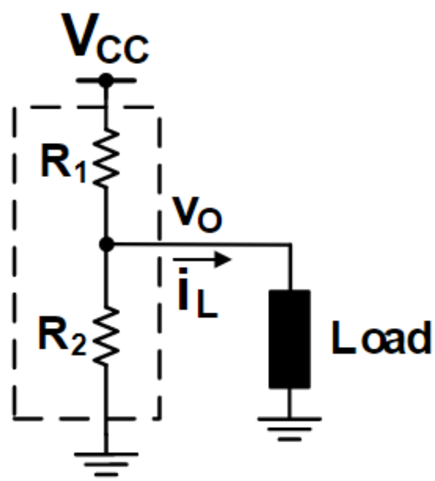



**Figure 1.0** Resistor based voltage divider regulator.

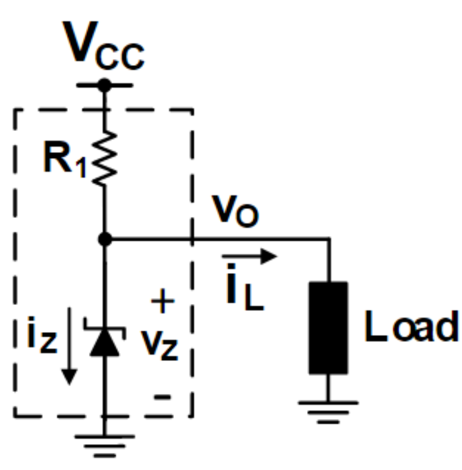



**Figure 2.0** Zener diode-based voltage regulator

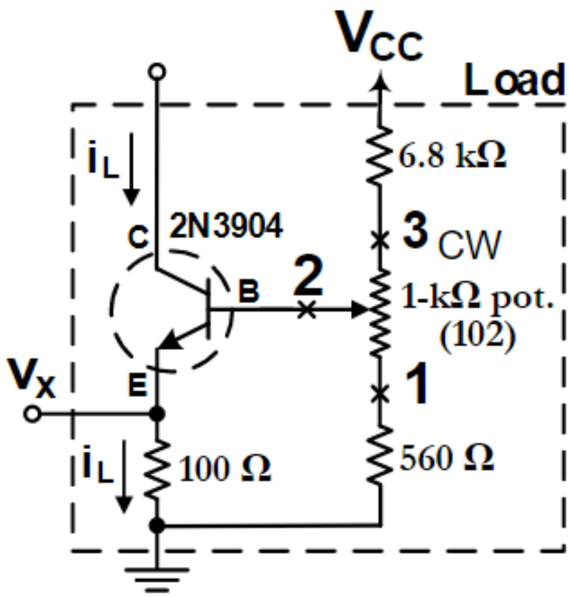



**Figure 3.0** Variable load circuit used for this experiment.

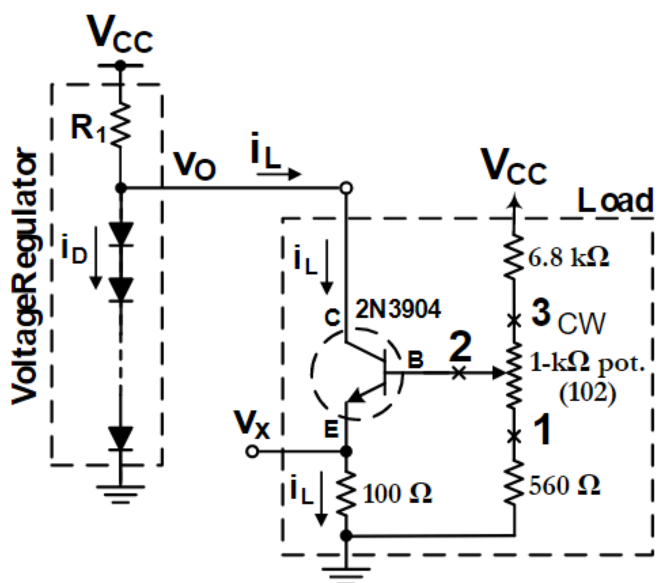



**Figure 4.0** regular diode regulator circulator connected with the variable load.

# Experiment and results:

The following experiments were conducted by measuring the output voltage of each regulator as a controlled amount of current is supplied to the variable load to measure the voltage regulation of each circuit:

| $i_L[mA]$ ($v_x[V]$) | 0 (0) | 1 (0.1) | 2 (0.2) | 3 (0.3) | 4 (0.4) | 5 (0.5) | 6 (0.6) | 7 (0.7) | 8 (0.8) |
|---|---|---|---|---|---|---|---|---|---|
| $v_O$ [V] | 6.24 | 5.96 | 5.63 | 5.27 | 4.91 | 4.59 | 4.20 | 3.89 | 3.50 |

**Table 1.0** Measured results for the circuit in Figure 1.0

| $i_L[mA]$ ($v_x[V]$) | 0 (0) | 1 (0.1) | 2 (0.2) | 3 (0.3) | 4 (0.4) | 5 (0.5) | 6 (0.6) | 7 (0.7) | 8 (0.8) |
|---|---|---|---|---|---|---|---|---|---|
| $v_O$ [V] | 6.290 | 6.180 | 6.180 | 6.173 | 6.163 | 6.157 | 6.148 | 6.027 | 5.490 |

**Table 2.0** Measured results for the circuit in Figure 2.0

| $i_L[mA]$ ($v_x[V]$) | 0 (0) | 1 (0.1) | 2 (0.2) | 3 (0.3) | 4 (0.4) | 5 (0.5) | 6 (0.6) | 7 (0.7) | 8 (0.8) |
|---|---|---|---|---|---|---|---|---|---|
| $v_O$ [V] | 6.343 | 6.302 | 6.217 | 6.127 | 6.016 | 5.889 | 5.722 | 5.512 | 5.290 |

**Table 3.0** Measured results for the circuit in Figure 4.0

# Conclusions and Remarks:

**C1:**

| $i_L[mA]$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| $v_O[V]$ (Table P1) | 6.19 | 5.84 | 5.50 | 5.15 | 4.80 | 4.46 | 4.11 | 3.76 | 3.42 |
| $R_L$ [$k\Omega$] | $\infty$ | 5.84 | 2.25 | 1.72 | 1.2 | 0.89 | 0.69 | 0.54 | 0.43 |

**Table C1.** Equivalent load resistance for the voltage divider of Figure

The load resistance $R_L$ should be very high in order for the output voltage to not deviate that much from the no-load output voltage.

**C2.**

$$e\% = \frac{\textit{calculated value} - \textit{measured value}}{\textit{measured value}} \times \mathbf{100}$$

| $i_L[mA]$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| $v_O[V]$ (Table P1) | 6.190 | 5.843 | 5.497 | 5.150 | 4.803 | 4.457 | 4.110 | 3.763 | 3.417 |
| $v_O[V]$ (Table E2) | 6.24 | 5.96 | 5.63 | 5.27 | 4.91 | 4.59 | 4.20 | 3.89 | 3.50 |
| $e\%$ | 0.80% | 1.96% | 2.63% | 2.28% | 2.18% | 2.90% | 2.14% | 3.26% | 2.37% |

**Table C2.**

The percent error for Table C2 is below 5%, making the values acceptable.

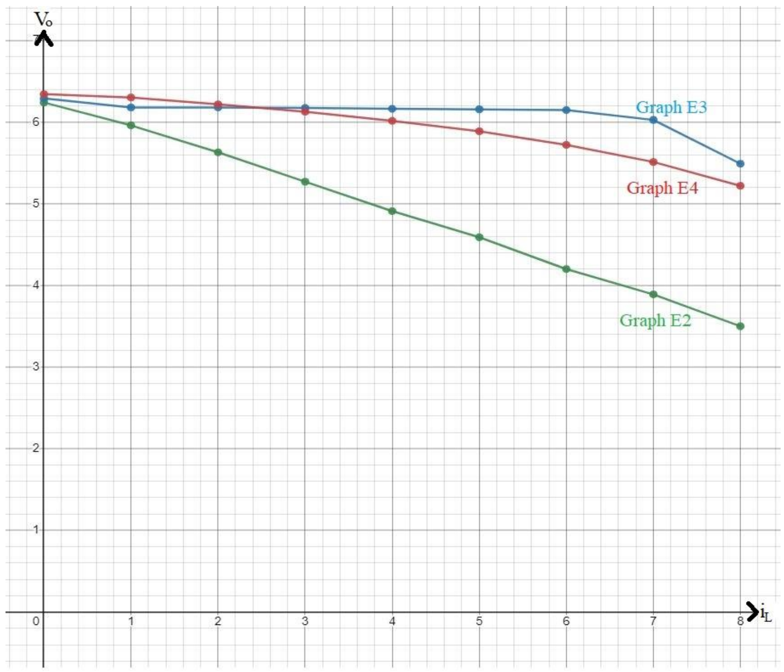
**C3.**

| $i_L[mA]$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| $v_O[V]$ (Table P2) | 6.1318 | 6.1298 | 6.1278 | 6.1258 | 6.1238 | 6.1218 | 6.1198 | 6.1178 | 6.1158 |
| $v_O[V]$ (Table E3) | 6.290 | 6.180 | 6.180 | 6.173 | 6.163 | 6.157 | 6.148 | 6.027 | 5.490 |
| $e\%$ | 2.52% | 0.81% | 0.84% | 0.76% | 0.64% | 0.57% | 0.46% | 1.51% | 11.40% |

**Table C3.**

The percent error for Table C3 is below 5% except for $i_L = 8mA$. There was a discrepancy due to human error during the experiment. Table C3 is still acceptable since the rest is below 5%.

**C4.**




**Graph C4.**

The voltage divider, whose behaviour is seen in Graph E2, does a very poor job in regulating the voltage supplied to the load, seen as the voltage across the load greatly decreases as the current supplied is increased. The diode-based regulator, whose behaviour is seen in Graph E4 does a far better job at regulating the voltage supplied to the load, only mildly decreasing as the current supplied is increased. The Zener diode-based regulator, whose behaviour is seen in Graph E3, is the best at regulating the voltage across the load, displaying an almost constant behaviour until the final point, which is most likely to be an anomaly in the data.

**C5:**

Aside from their better performance in voltage regulation, Zener diodes are also more efficient for regulation of higher voltages, seen as 9 1N4148 diodes were required to regulate a voltage of 6.2 V, while only one Zener diode was required, making Zener diode regulators cheaper and more space-efficient for higher voltage values.

**Ryerson University**

**Department of Electrical, Computer, & Biomedical Engineering**
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| **Course Title:** | Electronic Circuits I |
| **Course Number:** | ELE404 |
| **Semester/Year (e.g.F2016)** | W2025 |

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| **Instructor:** | Md Waselul Haque Sadid |

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| *Assignment/Lab Number:* | Pre-Lab #2 |
| *Assignment/Lab Title:* | Voltage Regulators |

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| *Submission Date:* | 02-06-25 |
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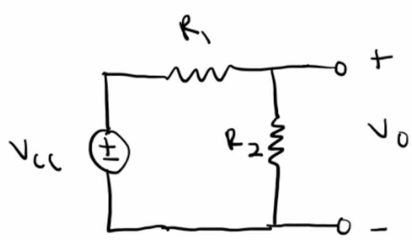
## Introduction

In almost all electronic circuits, there is a need for one or more ***voltage regulators***. These are circuits that offer an ideally constant voltage, either as a reference or as the power supply for another part of the circuit. This lab examines the three simplest types of ***voltage regulator***, namely, a simple resistive voltage divider, a voltage regulator that capitalizes on the more-or-less constant and known on-state voltage drop of diodes, and a voltage regulator based on Zener diodes. This lab investigates the ***load regulation*** properties of the aforementioned three types of voltage regulator.

## Pre-lab Assignment

P1. Consider the voltage divider of **Figure 1**, whose purpose is to produce an output voltage of $v_O = 6.2\ V$ from a supply voltage of $V_{CC} = 10\ V$. Assuming that $R_1 = 560\ \Omega$ and $R_2 = 910\ \Omega$, calculate the output voltage $v_O$ for each of the load current values specified in **Table P1**. Then, based on the tabulated values, plot $v_O$ versus $i_L$, and present the curve as **Graph P1**.




$$R_{TH} = \frac{(R_1)(R_2)}{R_1 + R_2} = \frac{(560)(910)}{560 + 910} \Rightarrow 346.67\ \Omega$$

$$V_{TH} = \frac{R_2}{R_1 + R_2}(V_{CC}) = \frac{910}{560 + 910}(10) \Rightarrow 6.19\ V$$

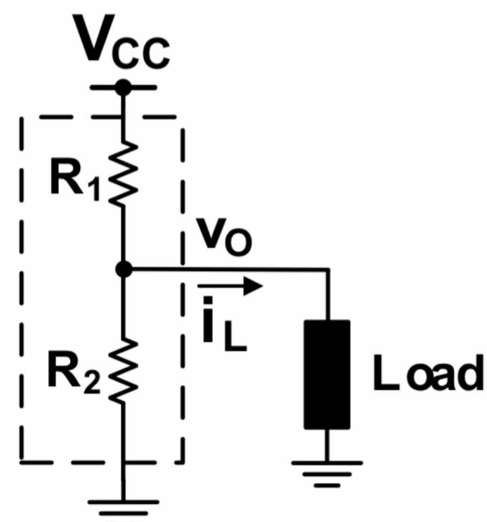
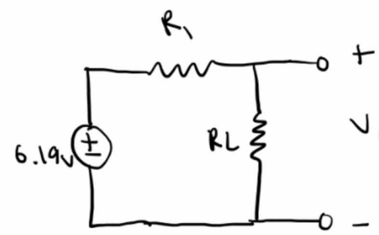


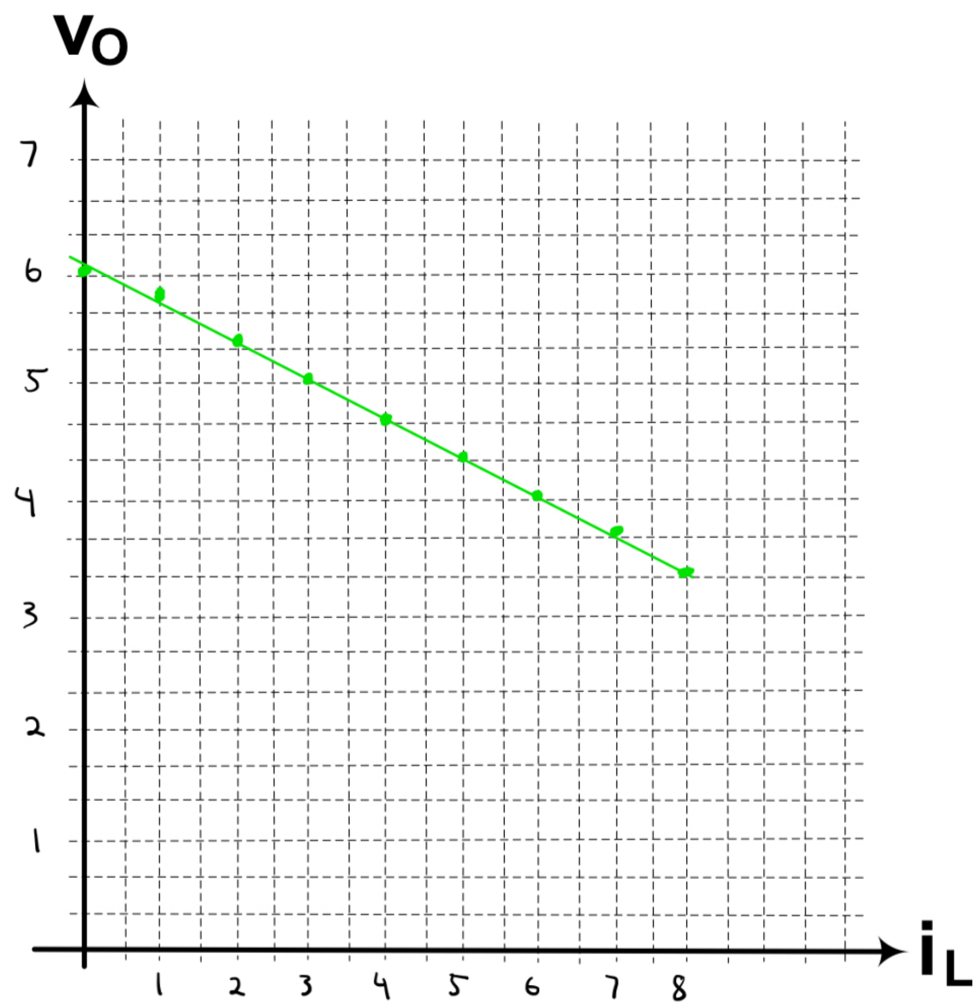

**Figure 1. A resistive voltage divider supplying a load.**




$$V_O = 6.19 - 346.67(i_L)$$

**Table P1.** Output voltage as a function of load current in the voltage divider of **Figure 1**.

| $i_L[mA]$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| $v_O\ [V]$ | 6.190 | 5.843 | 5.497 | 5.150 | 4.803 | 4.457 | 4.110 | 3.763 | 3.417 |




**Graph P1. Output voltage versus load current in the resistive voltage divider of Figure 1.**

P2. Consider the circuit of **Figure 2**, which is the circuit of **Figure 1** in which $R_2$ is replaced by a **1N4735 6.2-V Zener diode.** According to its datasheet, **1N4735** produces $v_Z = 6.2\ V$ at a current of $i_Z = 41\ mA$, and its series resistance is $r_Z = 2\ \Omega$, as long as its current is larger than $I_{ZK} = 1\ mA$. Assuming that $R_1 = 560\ \Omega$ and $V_{CC} = 10\ V$, calculate the output voltage $v_O$ for each of the load current values specified in **Table P2**. Then, based on the tabulated values, plot $v_O$ versus $i_L$ and present the curve as **Graph P2**.

$I_Z = I_Z - I_L$

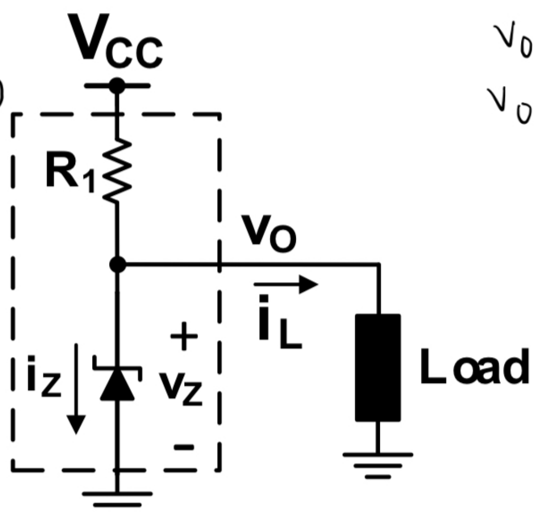
$V_O = V_{Z0} + I_Z \cdot r_Z$

$V_O = 6.118V + [I_Z - I_L] \cdot 2$

$V_{Z0} = V_Z - (i_Z \cdot r_Z)$

$= 6.2 - (41 \times 10^{-3} A \cdot 2\Omega)$

$= 6.118 V$




$I_Z = \frac{V_{CC} - V_{Z0}}{R_1 + R_2}$

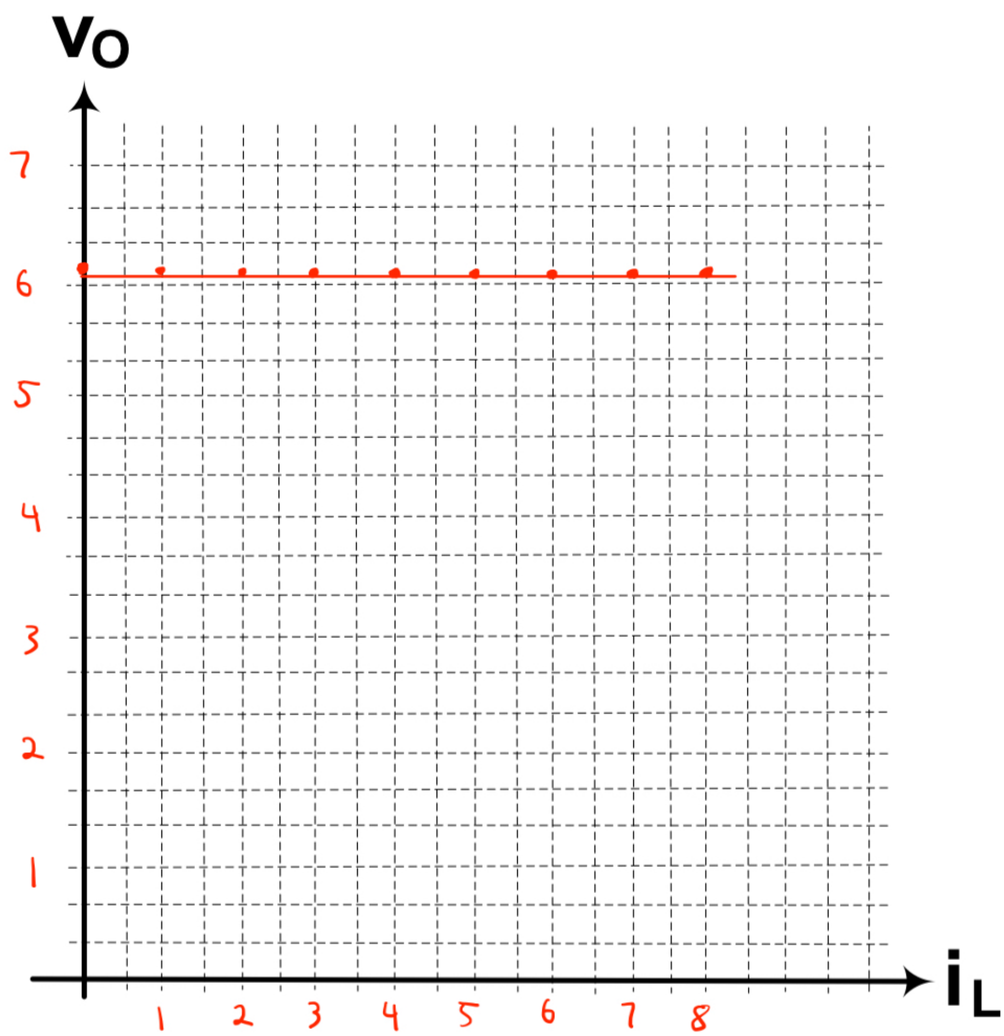
$= \frac{10 - 6.118}{560 + 2}$

$= 6.91\ mA$

**Figure 2. A Zener-diode-based voltage regulator.**

**Table P2.** Output voltage as a function of load current in the Zener-diode-based voltage regulator of **Figure 2**.

| $i_L[mA]$ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| $v_O\ [V]$ | 6.1318 | 6.1298 | 6.1278 | 6.1258 | 6.1238 | 6.1218 | 6.1198 | 6.1178 | 6.1158 |




**Graph P2. Output voltage versus load current in the Zener-diode-based voltage regulator of Figure 2.**