

# **BINDER FOR OUTCOME "6"**

*“an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions”*

**COLLEGE OF ENGINEERING  
CIVIL ENGINEERING DEPARTMENT  
PRAIRIE VIEW A&M UNIVERSITY**

**BINDER CONTAINING REPRESENTATIVE  
ASSIGNMENTS FROM ALL COURSES USED TO  
ASSESS OUTCOME “6”**

**Academic Years 2019-2020, 2020-2021, 2021-2022**

*05/30/2020 Revision*

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- 3. List of courses used to assess this outcome**
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  - CVEG 2061/2101 Materials & Dynamics Lab**
  - CVEG 2081/2102 Surveying & Geospatial Concepts**
  - CVEG 3031/3100 Steel & Concrete Lab**
  - CVEG 3043/3301 Environmental Engineering**

## 2. Description of Outcome "6" and its Performance Criteria

### Outcome 6:

*An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions*

### Sub-Outcomes and Performance Criteria

- 6.1: Conduct experimentation
- 6.2: Analyze and interpret data
- 6.3: Draw conclusions based on engineering judgment

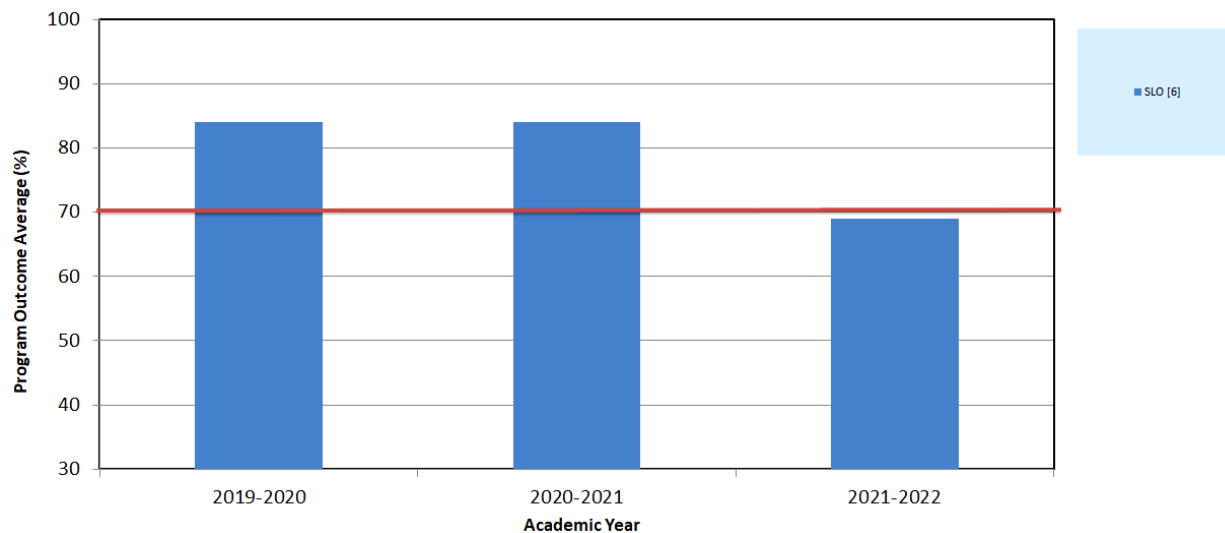
## 3. List of Courses Used to Assess the Outcome

Outcome 6 is assessed in the following courses:

- CVEG 2061/2101 Materials & Dynamics Lab
- CVEG 2081/2102 Surveying & Geospatial Concepts
- CVEG 3031/3100 Steel & Concrete Lab
- CVEG 3043/3301 Environmental Engineering

## 4. Summary Assessment Results and Continuous Improvements for Outcome "6" over the Assessment Years.

The direct average performance for all students in the 4 courses used to assess outcome 6 for the past three academic years are shown below



## 5. Problems identified and recommended actions to be taken to address problems

### 1. At the course level

| Problems Identified in the Various Courses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Recommended Actions Taken                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Basis for Action                                                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| <p>1. The major problem in CVEG 2061 has been the inability to identify the implication of experimental results.</p> <p>2. Some of the students in CVEG 2081 cannot follow all geometrical angular calculations and trigonometric calculations which are needed in surveying.</p> <p>3. In general, about 100% of the class was able to satisfy this outcome in CVEG 3031 in Fall 2019. Most of the equipment used for testing cement and concrete were not in good condition. So these need be maintained properly or repaired with the help of authorized personnel.</p> <p>4. Students coming into CVEG 3043 are not well prepared and comfortable to write reports that require critical thinking and data interpretation skills. They need practice with few initial lab reports before they are able to understand and show the improvements. Also, they don't seem to think it is worth their effort to spend lot of time in preparing these lab reports.</p> | <p>(1) Students in CVEG 2061 are encouraged to review basic Statics before attempting to interpret results.</p> <p>(2) Students should be encouraged to review the basics of physics, trigonometry and geometry. A prerequisite test may be conducted in CVEG 2081 to tap their knowledge of geometry and trigonometry.</p> <p>(3) Students should be encouraged in CVEG 3031 to participate equally among a group for writing reports. They should be instructed to use more references including the latest. The results obtained should be compared with the recommended values by the relevant code. A final comment about the result is needed after comparing with the standard coded value. Figure and table should be numbered in a systematic pattern.</p> <p>(4) In light of findings in CVEG 3043, Faculty should continue to stress the importance of technical reports starting with sophomore level courses in the civil engineering program. Students should continue to be encouraged to read technical papers and learn how reports are prepared. Include early feedback and additional practice.</p> | <p>To support continuous improvement and meet the Departmental target direct average of 70%</p> |

### 2. At Department Level

- (1) Faculty stressed the need to review pre-requisite materials in science and engineering
- (2) Faculty offered pre-test on pre-requisite materials to gauge the students' knowledge retention.
- (3) Faculty supports continued discussions on the importance of writing organized technical and lab reports beginning in sophomore classes.
- (4) Faculty encouraged students to follow appropriate references and codes in materials testing experiments.

#### Basis of Action:

To support continuous improvement and meet the Departmental target direct average of 70%



**6. Sample Assignments and Justification of suitability of assignment for measuring the outcome in the following courses:**

**CVEG 2061 Materials & Dynamics Lab**  
**CVEG 2081 Surveying & Geospatial Concepts**  
**CVEG 3031 Steel & Concrete Lab**  
**CVEG 3043 Environmental Engineering**

**OUTCOME “6” SPECIFIC ASSIGNMENTS  
USED TO ASSESS THE OUTCOME IN**

**CVEG 2061  
MATERIALS & DYNAMICS LAB**

**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING  
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET  
CVEG 2061 – Materials and Dynamics Lab  
FALL 2019**

**Instructor: Md. Jobair Bin Alam, Ph.D.**

**Title of Assignment**

**Stress-Strain Behavior of Steel**

**Outcome Measured Using this Assignment**

**Outcome 6**

An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions

**Check the engineering design characteristics related to this assignment**

|                                                           |                                                                                      |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Ability to develop experiment</b>                      |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Identify the appropriate parameters                                                  |
| ×                                                         | Identify and select appropriate equipment to determine the parameters experimentally |
| ×                                                         | Provide steps to set up and conduct the experiment                                   |
| ×                                                         | Identify data collection method to obtain the experiment results                     |
| <b>Ability to conduct experiment</b>                      |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Conduct experiment maintaining all safety precautions                                |
| ×                                                         | Safe and proper handling of equipment                                                |
| ×                                                         | Collect and record data using appropriate units of measurements and relevant figures |
| <b>Ability to analyze and interpret experimental data</b> |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Data presenting in tabular/graphical format to aid in interpretation                 |
| ×                                                         | Use appropriate statistical analysis (if required) to interpret data and results     |
| ×                                                         | Draw appropriate conclusions using engineering judgment based on experiment          |

**Brief justification of the suitability of assignment for the outcome**

**The lab experiment will increase the students' ability to identify the parameters to be measured and appropriate equipment to be used, along with conducting experiments and interpret data and results.**



Department of Civil & Environmental  
Engineering CVEG 2061 Materials and Dynamics  
Lab Report 1

A full set of data from a tensile test on 1018 steel stock sample are provided. The dimension of the sample tested is given in the following section. The test results are given in the next page.

**Sample Dimension:**

**Diameter of the steel: 0.41 mm**

**Length of the sample steel: 95 mm**

Prepare a report showing the mechanical properties of the material tested. The report should contain;

1. Detail sketch of the Stress-Strain curve
2. Detail sketch in the graph to find modulus of elasticity, yield stress, ultimate stress and fracture stress of the material tested
3. Different curve should be provided in the report showing different property of the material
4. Sample calculation
5. A professional report must be submitted (table of contents, abstract, introduction of stress-strain theory, test procedure, detail results, discussion of the test results, appendices etc. should be included in the report)

**NOTE: QUALITY OF YOUR WORK AND PRESENTATION WILL BE TAKEN INTO ACCOUNT FOR GRADING OF THIS REPORT**



Department of Civil & Environmental Engineering  
CVEG 2061 Materials and Dynamics Lab

| Force | Displacement | Force | Displacement |
|-------|--------------|-------|--------------|
| (N)   | (mm)         | (N)   | (mm)         |
| 0     | 0            | 9079  | 3.773        |
| 81    | 0.063        | 9229  | 4.173        |
| 142   | 0.113        | 9379  | 4.573        |
| 201   | 0.173        | 9479  | 4.973        |
| 263   | 0.233        | 9579  | 5.373        |
| 708   | 0.273        | 9679  | 5.773        |
| 1192  | 0.303        | 9729  | 6.173        |
| 1455  | 0.343        | 9779  | 6.573        |
| 2000  | 0.383        | 9879  | 6.973        |
| 2243  | 0.423        | 9879  | 7.373        |
| 2686  | 0.463        | 9779  | 7.773        |
| 3050  | 0.503        | 9779  | 8.173        |
| 3454  | 0.533        | 9779  | 8.573        |
| 3979  | 0.573        | 9779  | 8.973        |
| 4282  | 0.613        | 9779  | 9.373        |
| 4726  | 0.653        | 9779  | 9.773        |
| 5049  | 0.693        | 9779  | 10.173       |
| 5372  | 0.723        | 9729  | 10.573       |
| 5978  | 0.763        | 9679  | 10.973       |
| 6301  | 0.803        | 9629  | 11.373       |
| 6679  | 0.973        | 9579  | 11.773       |
| 7079  | 1.373        | 9479  | 12.173       |
| 7679  | 1.773        | 9279  | 12.573       |
| 7979  | 2.173        | 8879  | 12.973       |
| 8279  | 2.573        | 9579  | 13.373       |
| 8729  | 2.973        | 7379  | 13.773       |
| 8929  | 3.373        |       |              |

80

# Materials and Dynamics Lab

## Assignment 1: Stress-Strain

### Curve Graph

Due: September 27, 2019

Submitted by: Shadaria Lynch

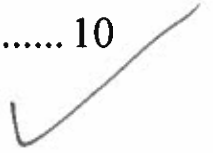
## Abstract

In this lab, the classroom's main objective was to create a stress-strain curve using Excel with the information that was provided to us. The classroom (made up of 8 students) were given the responsibility to handle this lab individually. The information provided to us included a set of data from tensile test on 1018 steel stock sample. Results from the tensile test gave us a set of numbers for force, displacement, diameter, and length of the steel. Given these results it is my responsibility to use this information to create a stress-strain graph and find the modulus of elasticity, yield stress, ultimate stress, and fracture stress.

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## Introduction

Stress is the strength of the material from which the body is made, and strength is the amount of deformation. The relationship between stress and strain of a material is known as the stress-strain curve. Stress-strain curves shows the many different properties of a material. In this lab, the material we were given to create a stress-strain curve for was a 1018 steel stock sample. Three fundamental properties of steel are the elastic modulus, the yield stress, and the ultimate strength. This report contains the results of an experiment to determine these properties of steel.

## Test Procedure

When forces are applied to materials, they deform in reaction to those forces. In order to describe the magnitude of this deformation you must define stress and strain. Stress is given by:

$$\sigma = \frac{P}{A}$$

Where  $P$  is the force applied and  $A$  is the cross-sectional area, which you could find by  $A = \pi r^2$ .

Strain is given by:

$$\epsilon = \frac{\Delta L}{L_0}$$

Here  $\Delta L$  represents the change in length which you could find by using  $L - L_0$ . The relationship between stress and strain is independent, it is given by Hooke's Law:

$$\sigma = E\epsilon$$

Where E represents the modulus of elasticity or Young's modulus. This is the mechanical property of linear elastic solid materials. It defines the relationship between stress and strain in a material. Young's modulus is given by:

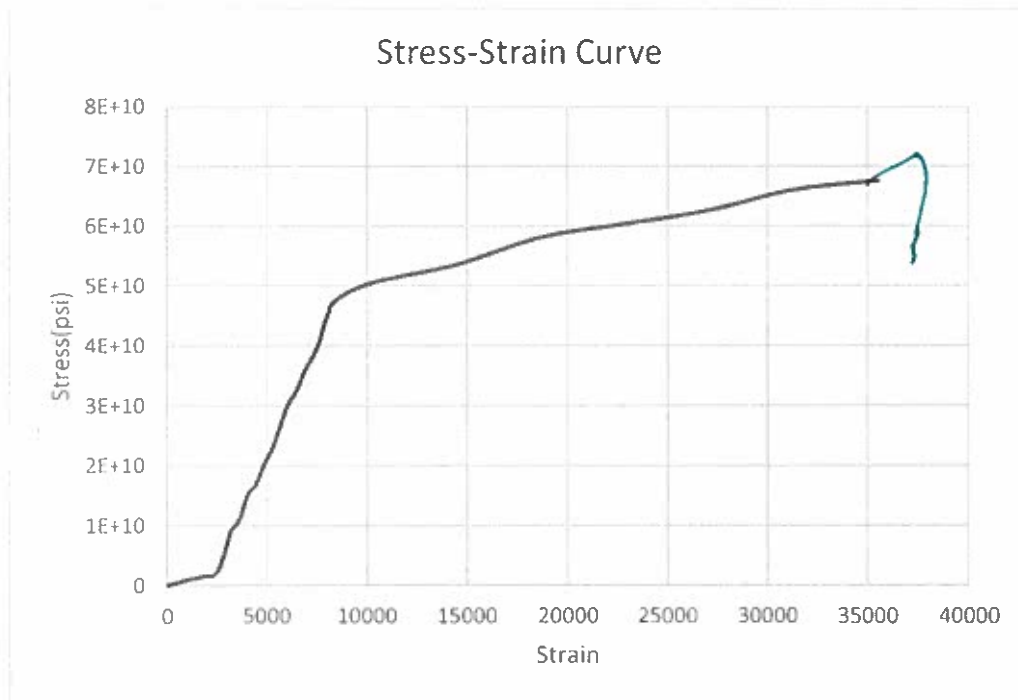
$$E = \frac{\sigma}{\epsilon}$$

## Detail Results

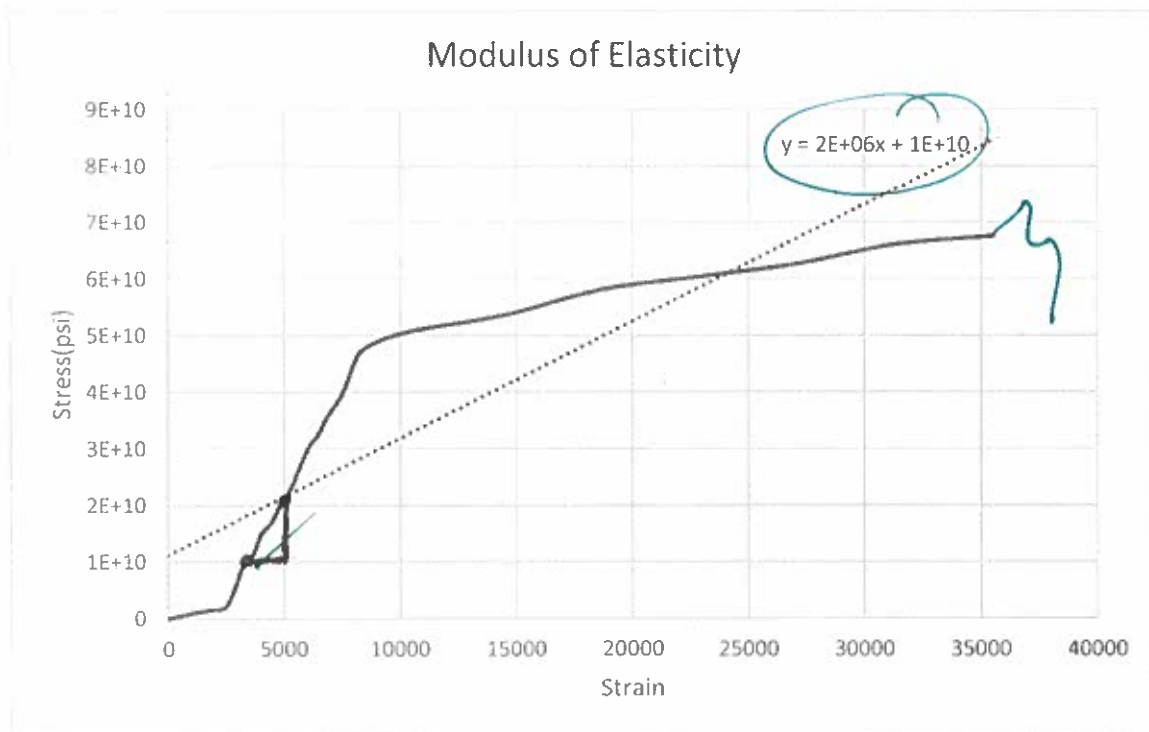
| Force | Displacement |
|-------|--------------|
| (N)   | (mm)         |
| 0     | 0            |
| 81    | 0.063        |
| 142   | 0.113        |
| 201   | 0.173        |
| 263   | 0.233        |
| 708   | 0.273        |
| 1192  | 0.303        |
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These were the results that were given from the tensile test on the 1018 steel stock. Additionally, the diameter was given as 0.41mm and the length of the steel was given as 95mm. With these results I converted the 'mm' units to 'm' and was able to find the data for stress, strain, modulus

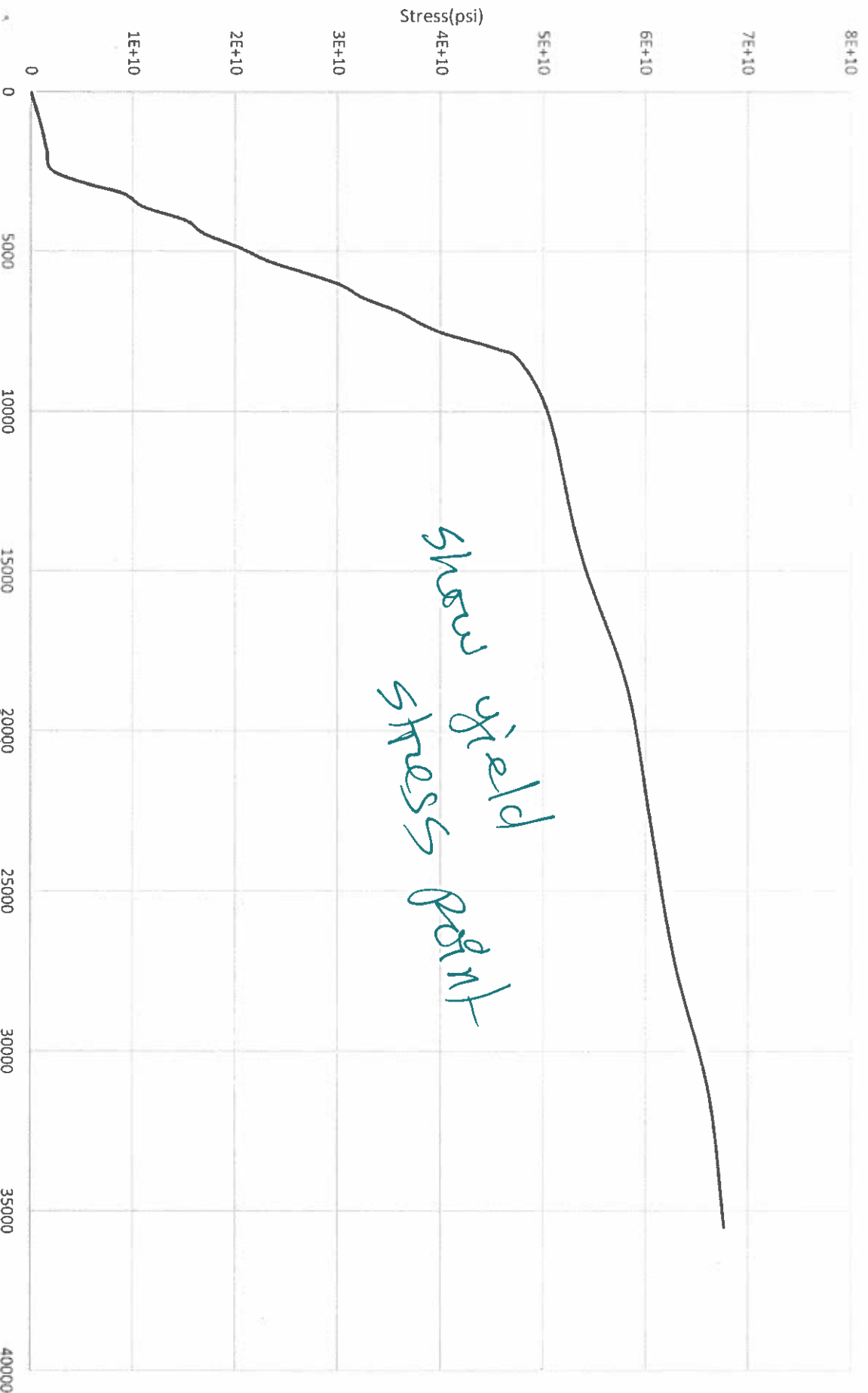
## Discussion

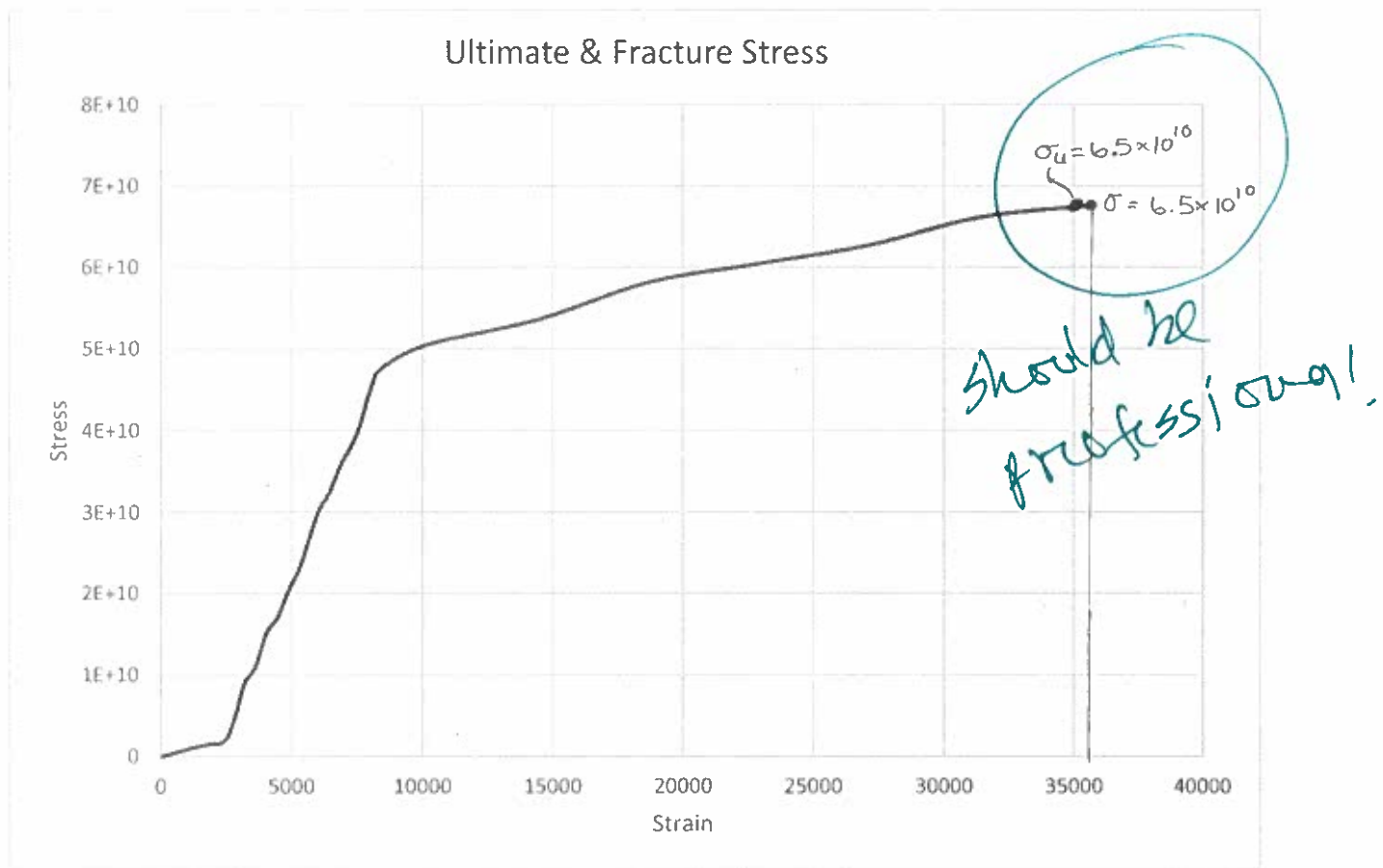


graph  
not exact  
perz data



## Yield Stress





Each of these graphs shows you the stress-strain curve. The dotted line on the second graph shows you the modulus of elasticity. The third graph represents the yield stress which the 0.2% offset of a material. Then the fourth graph shows the ultimate stress and fractured stress. Ultimate stress is the highest point on the curve and fractured stress is the point on the curve where the material stops its deformation.

ultimate stress = ?  
fracture " = ?

## Citation

- Hibbler, Russell C. *Mechanics of Materials*. 10th ed., Pearson, 2016.

**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING  
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CVEG 2061 Materials and Dynamics Lab

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**Maalvika Aggarwal**

Materials and Dynamics Lab

CVEG-2061

Prairie View A&M University

September 26<sup>th</sup>, 2020

**Lab 1: Tensile Test**

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## **OBJECTIVE:**

The objective of this lab is to determine the mechanical properties, like Young's Modulus, Yield stress, Ultimate stress, and fracture stress of a 1018 steel material provided and plot the Stress-Strain diagram of the material tested.

## **ABSTRACT:**

Tensile testing is one of the simplest and most widely used mechanical tests. By measuring the force required to elongate a specimen to breaking point, material properties can be determined that

will allow designers and quality managers to predict how materials and products will behave in application.

## **INTRODUCTION TO THE THEORY:**

### **I. Stress:**

Engineering Stress is determined by dividing the applied load 'P' by the specimen's original cross-sectional area  $A_0$ . This calculation assumes that the stress is constant over the cross section and throughout the gage length.

$$\sigma = \frac{P}{A_0}$$

Where,  $\sigma$  is engineering stress, P is the external axial tensile load, and  $A_0$  is the original cross-sectional area.

## II. Strain:

Likewise, Engineering Strain is obtained directly from the strain gage reading, or by dividing the change in the specimen's gage length,  $\delta$ , by the specimen's original gage length  $L_0$ .

$$\epsilon = \frac{\delta}{L_0}$$

Where,  $\epsilon$  is the engineering strain,  $L_0$  is the original length of the specimen, and  $\delta$  is the change in length.

## III. Stress-Strain Diagram:

When the values of stress,  $\sigma$ , and strain,  $\epsilon$ , are plotted, where the vertical axis is the stress and the horizontal axis is the strain, the resulting curve is called a conventional stress-strain diagram.

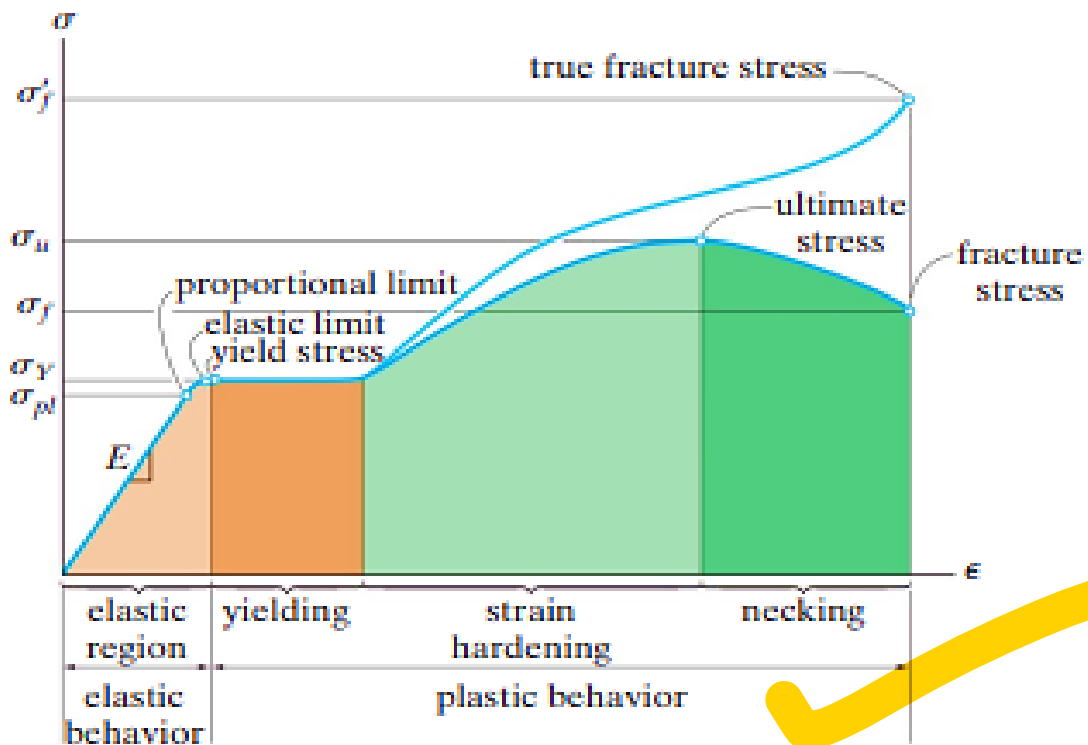


Figure 1: Stress-Strain diagram

### **A. Elastic Region:**

The initial region of the curve indicated in light orange is referred to as the elastic region. Here the curve is a straight line up to the point where the stress reaches the proportional limit,  $\sigma_{pl}$ . When the stress slightly exceeds this value, the curve bends until the stress reaches an elastic limit.

### **B. Young's Modulus:**

The modulus of elasticity or the Young's modulus ( $E$ ) represents the slope of the straight-line portion of the curve. It has the same units as the stress as strain is unitless.

### **C. Yielding:**

A slight increase in stress above the elastic limit will cause a breakdown of the material. This behavior is called yielding, and it is indicated by the rectangular dark orange region in Figure 1. The stress that causes yielding is called the yield stress,  $\sigma_Y$ .

### **D. Ultimate Stress:**

When yielding has ended, any load causing an increase in stress will be supported by the specimen, resulting in a curve that rises continuously but becomes flatter until it reaches a maximum stress (the peak in the graph) referred to as the ultimate stress,  $\sigma_u$ .

### **E. Fracture stress:**

After reaching the ultimate stress, the cross-sectional area will begin to decrease in a region of the specimen, and the stress begins to increase. This region of the curve due to necking is indicated in dark green in Figure 1. Here the stress-strain diagram tends to curve downward until the specimen breaks at the fracture stress,  $\sigma_f$ .

## PROCEDURE:

1. A material is gripped at both ends by an apparatus, which slowly pulls lengthwise on the piece until it fractures.
2. The pulling force is called a load, which is plotted against the material length change, or displacement.
3. The load is converted to a stress value and the displacement is converted to a strain value.
4. A stress-strain graph is plotted in excel.
5. The values of the different properties of materials are then calculated from the graph.

## TEST RESULTS:

Figure 2: Force vs. Elongation diagram generated by the experiment

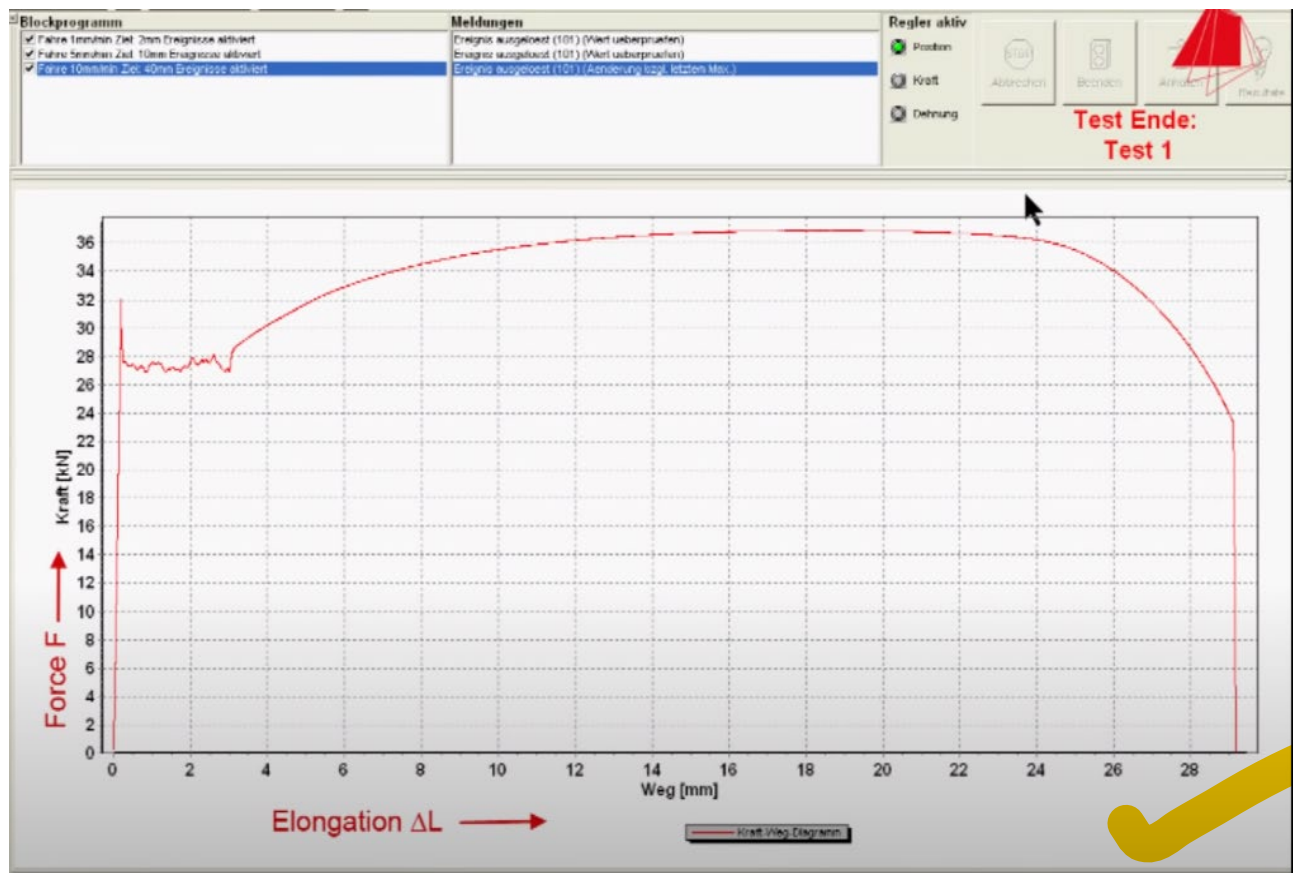




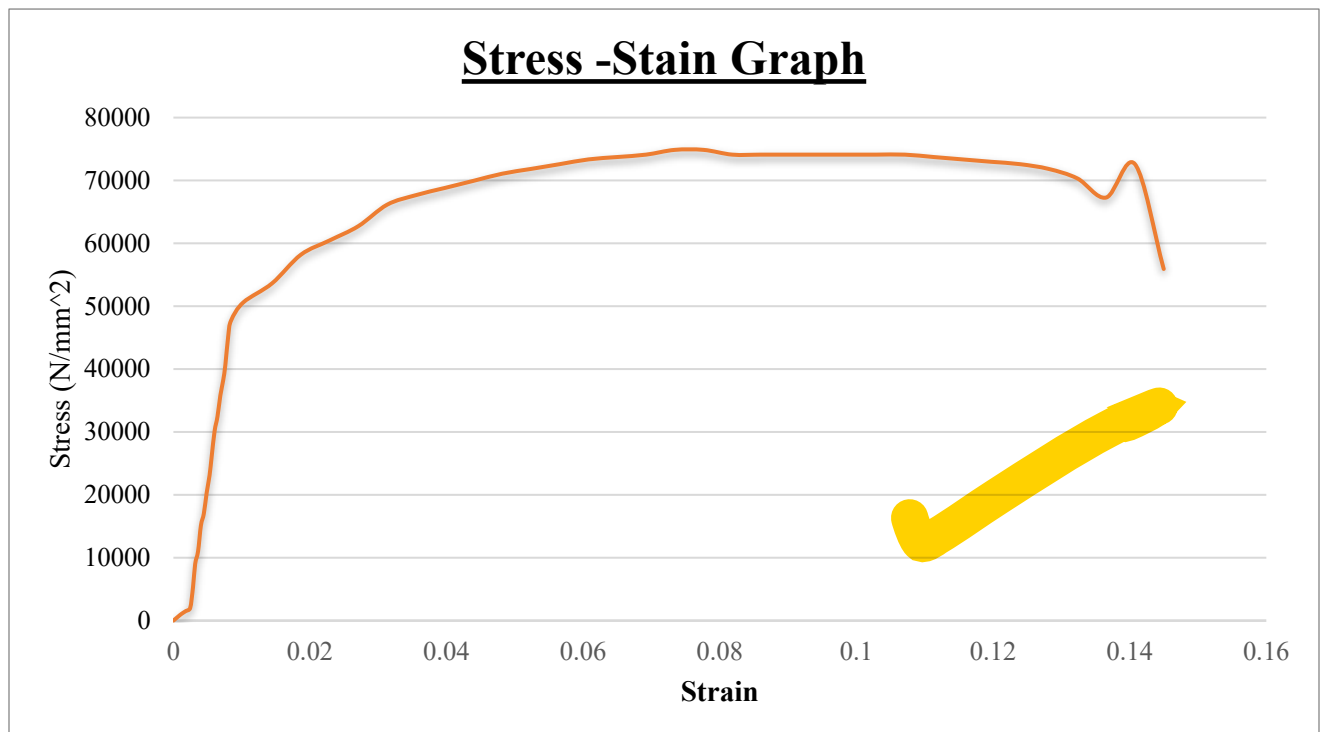
Table 1: Strain and Stress values calculated in Excel:

| <b>Force<br/>(N)</b> | <b>Displacement (mm)</b> | <b>Strain</b> | <b>Stress<br/>(N/mm<sup>2</sup>)</b> |
|----------------------|--------------------------|---------------|--------------------------------------|
| 0                    | 0                        | 0             | 0                                    |
| 81                   | 0.063                    | 0.000663158   | 613.829                              |
| 142                  | 0.113                    | 0.001189474   | 1076.096                             |
| 201                  | 0.173                    | 0.001821053   | 1523.206                             |
| 263                  | 0.233                    | 0.002452632   | 1993.051                             |
| 708                  | 0.273                    | 0.002873684   | 5365.323                             |
| 1192                 | 0.303                    | 0.003189474   | 9033.143                             |
| 1455                 | 0.343                    | 0.003610526   | 11026.194                            |
| 2000                 | 0.383                    | 0.004031579   | 15156.280                            |
| 2243                 | 0.423                    | 0.004452632   | 16997.768                            |
| 2686                 | 0.463                    | 0.004873684   | 20354.884                            |
| 3050                 | 0.503                    | 0.005294737   | 23113.327                            |
| 3454                 | 0.533                    | 0.005610526   | 26174.896                            |
| 3979                 | 0.573                    | 0.006031579   | 30153.419                            |
| 4282                 | 0.613                    | 0.006452632   | 32449.596                            |
| 4726                 | 0.653                    | 0.006873684   | 35814.290                            |
| 5049                 | 0.693                    | 0.007294737   | 38262.029                            |
| 5372                 | 0.723                    | 0.007610526   | 40709.769                            |
| 5978                 | 0.763                    | 0.008031579   | 45302.122                            |

|      |       |             |           |
|------|-------|-------------|-----------|
| 6301 | 0.803 | 0.008452632 | 47749.861 |
| 6679 | 0.973 | 0.010242105 | 50614.398 |
| 7079 | 1.373 | 0.014452632 | 53645.654 |
| 7679 | 1.773 | 0.018663158 | 58192.538 |
| 7979 | 2.173 | 0.022873684 | 60465.980 |
| 8279 | 2.573 | 0.027084211 | 62739.422 |
| 8729 | 2.973 | 0.031294737 | 66149.585 |
| 8929 | 3.373 | 0.035505263 | 67665.213 |
| 9079 | 3.773 | 0.039715789 | 68801.934 |
| 9229 | 4.173 | 0.043926316 | 69938.655 |
| 9379 | 4.573 | 0.048136842 | 71075.376 |
| 9479 | 4.973 | 0.052347368 | 71833.190 |
| 9579 | 5.373 | 0.056557895 | 72591.004 |
| 9679 | 5.773 | 0.060768421 | 73348.818 |
| 9729 | 6.173 | 0.064978947 | 73727.725 |
| 9779 | 6.573 | 0.069189474 | 74106.632 |
| 9879 | 6.973 | 0.0734      | 74864.446 |
| 9879 | 7.373 | 0.077610526 | 74864.446 |
| 9779 | 7.773 | 0.081821053 | 74106.632 |
| 9779 | 8.173 | 0.086031579 | 74106.632 |
| 9779 | 8.573 | 0.090242105 | 74106.632 |
| 9779 | 8.973 | 0.094452632 | 74106.632 |
| 9779 | 9.373 | 0.098663158 | 74106.632 |

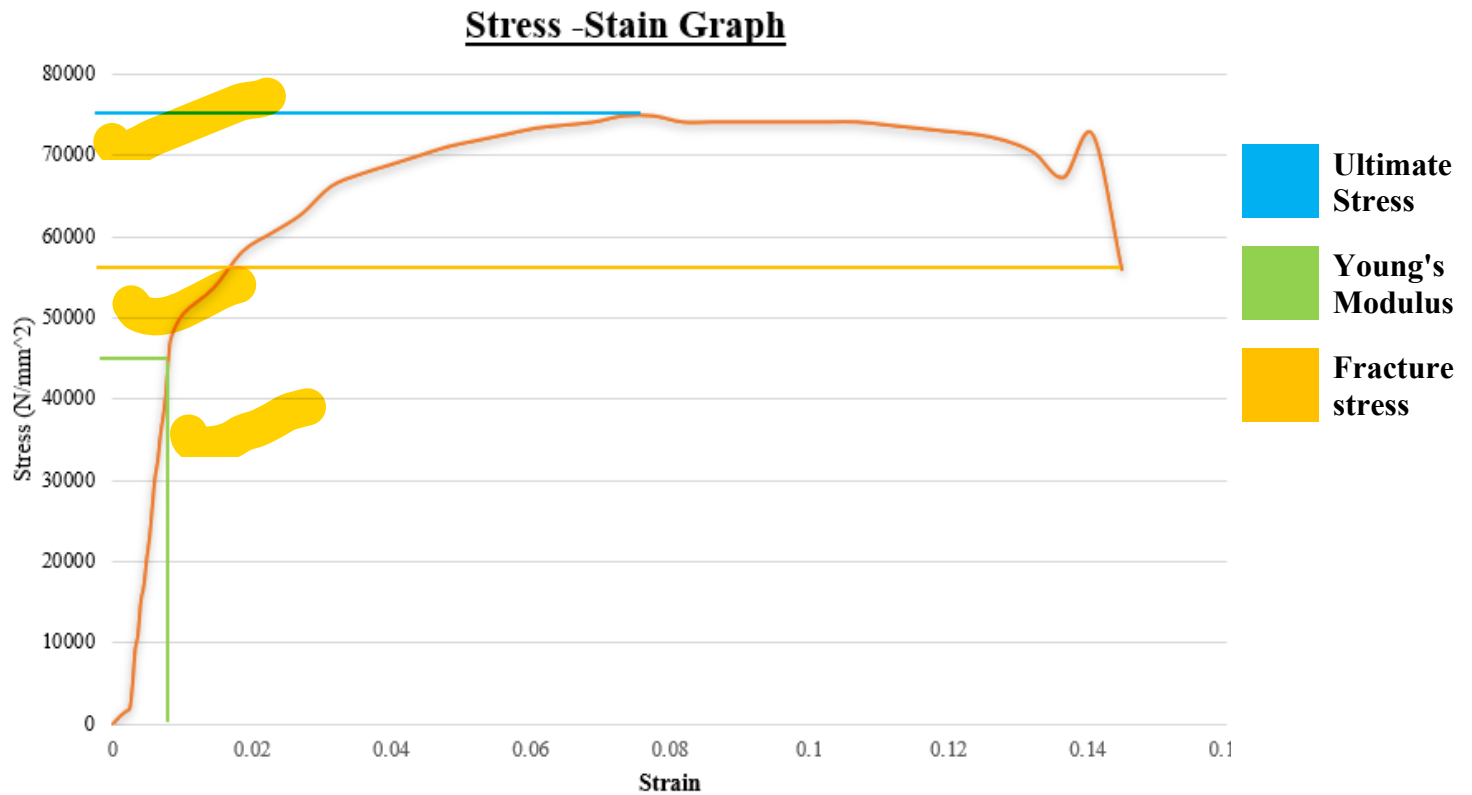
|      |        |             |           |
|------|--------|-------------|-----------|
| 9779 | 9.773  | 0.102873684 | 74106.632 |
| 9779 | 10.173 | 0.107084211 | 74106.632 |
| 9729 | 10.573 | 0.111294737 | 73727.725 |
| 9679 | 10.973 | 0.115505263 | 73348.818 |
| 9629 | 11.373 | 0.119715789 | 72969.911 |
| 9579 | 11.773 | 0.123926316 | 72591.004 |
| 9479 | 12.173 | 0.128136842 | 71833.190 |
| 9279 | 12.573 | 0.132347368 | 70317.562 |
| 8879 | 12.973 | 0.136557895 | 67286.306 |
| 9579 | 13.373 | 0.140768421 | 72591.004 |
| 7379 | 13.773 | 0.144978947 | 55919.096 |

Graph 1: Stress vs. Strain Graph



## CALCULATIONS:

Figure 3: The estimated values of Young's Modulus, Ultimate stress, and Fracture Stress



Modulus of Elasticity ( $E$ ) = Slope of straight line in the elastic region

$$Slope = \frac{y_2 - y_1}{x_2 - x_1}$$

From the graph,

$$E = \frac{45000 - 0}{0.01 - 0}$$

$$E = 4.5 \times 10^6 \text{ N/mm}^2$$

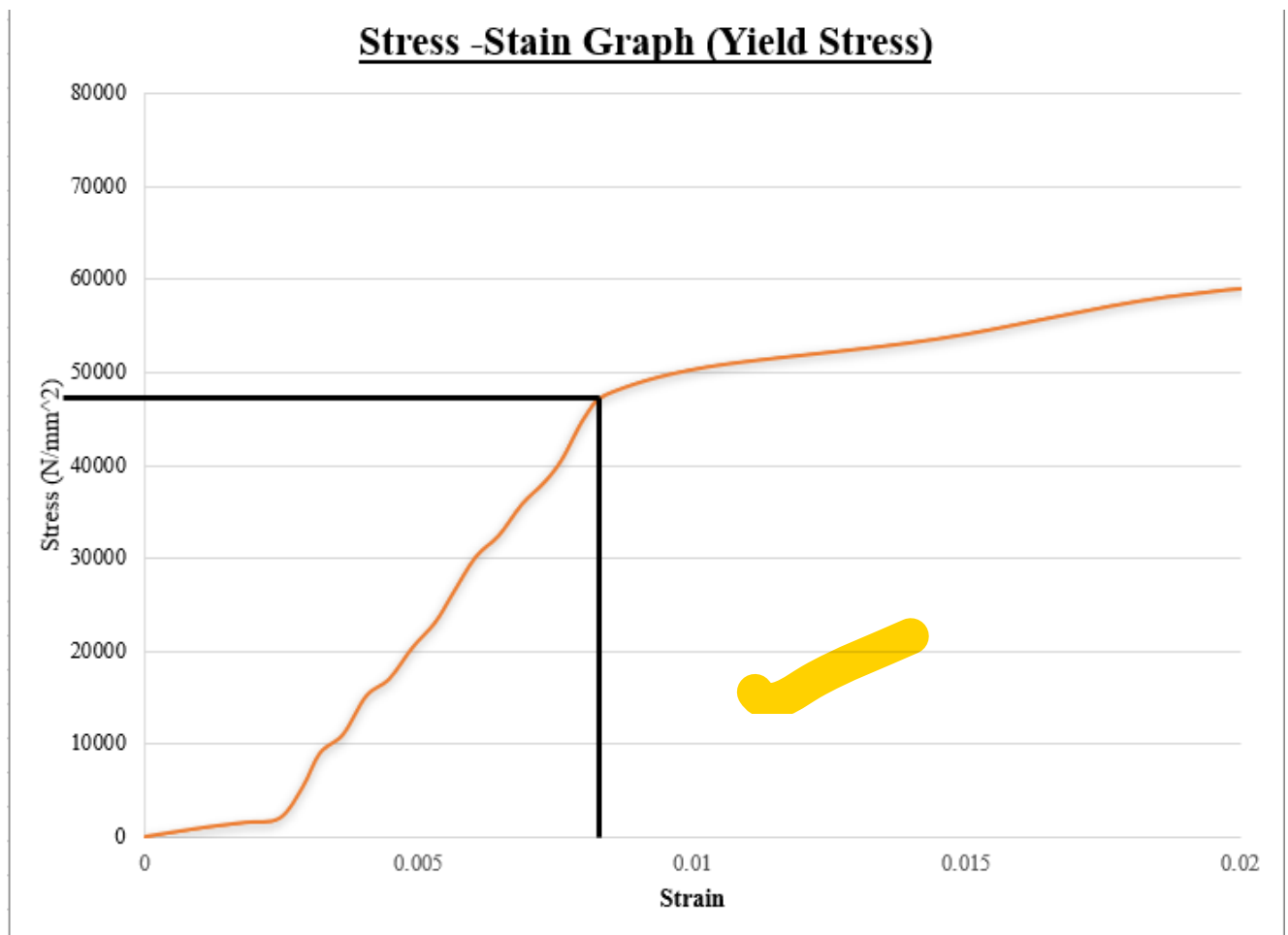
Ultimate stress  $\sigma_u$  = Maximum Stress

$$\sigma_u = 75000 \text{ N/mm}^2$$

Fracture stress  $\sigma_f$  = Causes the material to break

$$\sigma_f = 57000 \text{ N/mm}^2$$

Graph 2: The graph depicting estimated value of Yield Stress



Yield Stress,  $\sigma_Y$  = Causes Yielding

$$\sigma_Y = 48000 \text{ N/mm}^2$$

Table 2: Properties of the tested material:

| <b>Material: 1018 Steel Stock</b> |                                 |
|-----------------------------------|---------------------------------|
| <b>Material Properties</b>        | <b>Value (N/mm<sup>2</sup>)</b> |
| Modulus of Elasticity, $E$        | $4.5 \times 10^6$               |
| Yield Stress, $\sigma_Y$          | $4.8 \times 10^4$               |
| Ultimate stress, $\sigma_u$       | $7.5 \times 10^4$               |
| Fracture stress, $\sigma_f$       | $5.7 \times 10^4$               |

## **CONCLUSION:**

The tensile test is done to see how a material behaves, when under a tensile load. It tells how the different properties of materials are affected by a tensile load. The data achieved seemed a little bit off, mostly because of some technical errors. The stress-strain graph generated by the data provided resembled the actual stress-strain diagram in general, however, there were some abnormalities. For example, in the elastic region of the graph, the line was not 100% straight. There were some oscillations in the line, which could be due to some technical or mechanical errors that could have occurred while performing the experiment. Also, there was a sudden rise in the stress, just before the fracture stress was achieved.

The modulus of elasticity was calculated to be  $4.5 \times 10^6 \text{ N/mm}^2$ . The yield stress and fracture stress was estimated to be  $48,000 \text{ N/mm}^2$  and  $57,000 \text{ N/mm}^2$  respectively. The ultimate stress was achieved at  $75,000 \text{ N/mm}^2$ . Although, these values are pretty high compared to the values in real life, however, it could be due to some physical errors during the experiment.

Overall, it was a successful experiment. The tensile test made a relation from the conceptual theory studies in the classroom to the actual application of it.

## **APPENDIX:**

**Conventional Stress:** The nominal or engineering stress is determined by dividing the applied load  $P$  by the specimen's original cross-sectional area  $A_0$ . This calculation assumes that the stress is constant over the cross section and throughout the gage length.

**Engineering strain:** It is found directly from the strain gage reading, or by dividing the change in the specimen's gage length, by the specimen's original gage length  $L_0$ .

**Hooke's Law:** Makes the elastic region unique, however, is that after reaching  $\sigma_Y$ , if the load is removed, the specimen will recover its original shape. In other words, no damage will be done to the material. Conventional and true stress–strain diagram for ductile because the curve is a straight line up to  $\sigma_{pl}$ , any increase in stress will cause a proportional increase in strain. This fact was discovered in 1676 by Robert Hooke, using springs, and is known as Hooke's law.

**Yielding:** A slight increase in stress above the elastic limit will result the material to deform permanently. This behavior is called yielding and stress that causes yielding is called the yield point, and the deformation that occurs is called plastic deformation. The upper yield point occurs first, followed by a sudden decrease in load-carrying capacity to a lower yield point. Once the yield point is reached, then the specimen will continue to elongate (strain) without any increase in load.

**Necking:** Up to the ultimate stress, as the specimen elongates, its cross-sectional area will decrease in a fairly uniform manner over the specimen's entire gage length. However, just after reaching the ultimate stress, the cross-sectional area will then begin to decrease in a localized region of the specimen, and so it is here where the stress begins to increase. As a result, a constriction or “neck” tends to form with further elongation.

okay, good



## **REFERENCES**

“Mechanics of Materials.” *Pearson*, [www.pearson.com/store/p/mechanics-of-materials/P100000270525](http://www.pearson.com/store/p/mechanics-of-materials/P100000270525).

Good

# Prairie View A&M University

70



Department of Civil & Environmental Engineering CVEG 2061

Materials and Dynamics Lab Report #1

**Due:** September 25, 2020

**Submitted by:** Erik Smith

**Submitted to:** Dr. Jobair Alam

## Table of contents:

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Page 2: Table of contents

Page 3: List of figures

Page 4: List of figures continued and Abstract

Page 5: Introduction to Stress-Strain Theory

Page 6: Test procedure and Data & Observation

Page 7:

Page 8: Appendix

1. List of figures:

| Force(N) | Displacement(MM) | Stress  | Strain  |  |          |             |
|----------|------------------|---------|---------|--|----------|-------------|
| 0        | 0                | #VALUE! | #DIV/0! |  |          |             |
| 81       | 0.063            | #VALUE! | #DIV/0! |  | Diameter | 0.41 mm     |
| 142      | 0.113            | #DIV/0! | #DIV/0! |  | Area     | 149.48 mm^2 |
| 201      | 0.173            | #DIV/0! | #DIV/0! |  |          |             |
| 263      | 0.233            | #DIV/0! | #DIV/0! |  |          |             |
| 708      | 0.273            | #DIV/0! | #DIV/0! |  |          |             |
| 1192     | 0.303            | #DIV/0! | #DIV/0! |  |          |             |
| 1455     | 0.343            | #DIV/0! | #DIV/0! |  |          |             |
| 2000     | 0.383            | #DIV/0! | #DIV/0! |  |          |             |
| 2243     | 0.423            | #DIV/0! | #DIV/0! |  |          |             |
| 2686     | 0.463            | #DIV/0! | #DIV/0! |  |          |             |
| 3050     | 0.503            | #DIV/0! | #DIV/0! |  |          |             |
| 3454     | 0.533            | #DIV/0! | #DIV/0! |  |          |             |
| 3979     | 0.573            | #DIV/0! | #DIV/0! |  |          |             |
| 4282     | 0.613            | #DIV/0! | #DIV/0! |  |          |             |
| 4726     | 0.653            | #DIV/0! | #DIV/0! |  |          |             |
| 5049     | 0.693            | #DIV/0! | #DIV/0! |  |          |             |
| 5372     | 0.723            | #DIV/0! | #DIV/0! |  |          |             |
| 5978     | 0.763            | #DIV/0! | #DIV/0! |  |          |             |
| 6301     | 0.803            | #DIV/0! | #DIV/0! |  |          |             |
| 6679     | 0.973            | #DIV/0! | #DIV/0! |  |          |             |
| 7079     | 1.373            | #DIV/0! | #DIV/0! |  |          |             |
| 7679     | 1.773            | #DIV/0! | #DIV/0! |  |          |             |
| 7979     | 2.173            | #DIV/0! | #DIV/0! |  |          |             |
| 8279     | 2.573            | #DIV/0! | #DIV/0! |  |          |             |
| 8729     | 2.973            | #DIV/0! | #DIV/0! |  |          |             |
| 8929     | 3.373            | #DIV/0! | #DIV/0! |  |          |             |
| 9079     | 3.773            | #DIV/0! | #DIV/0! |  |          |             |
| 9229     | 4.173            | #DIV/0! | #DIV/0! |  |          |             |
| 9379     | 4.173            | #DIV/0! | #DIV/0! |  |          |             |
| 9379     | 4.573            | #DIV/0! | #DIV/0! |  |          |             |
| 9479     | 4.973            | #DIV/0! | #DIV/0! |  |          |             |
| 9579     | 5.373            | #DIV/0! | #DIV/0! |  |          |             |
| 9679     | 5.773            | #DIV/0! | #DIV/0! |  |          |             |
| 9729     | 6.173            | #DIV/0! | #DIV/0! |  |          |             |
| 9779     | 6.573            | #DIV/0! | #DIV/0! |  |          |             |

|      |        |         |         |
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| 9729 | 6.173  | #DIV/0! | #DIV/0! |
| 9779 | 6.573  | #DIV/0! | #DIV/0! |
| 9879 | 6.973  | #DIV/0! | #DIV/0! |
| 9879 | 7.373  | #DIV/0! | #DIV/0! |
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| 9779 | 8.173  | #DIV/0! | #DIV/0! |
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| 9779 | 10.173 | #DIV/0! | #DIV/0! |
| 9729 | 10.573 | #DIV/0! | #DIV/0! |
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| 9629 | 11.373 | #DIV/0! | #DIV/0! |
| 9629 | 11.773 | #DIV/0! | #DIV/0! |
| 9579 | 11.773 | #DIV/0! | #DIV/0! |
| 9479 | 12.173 | #DIV/0! | #DIV/0! |
| 9279 | 12.573 | #DIV/0! | #DIV/0! |
| 8879 | 12.973 | #DIV/0! | #DIV/0! |
| 9579 | 13.373 | #DIV/0! | #DIV/0! |
| 7379 | 13.773 | #DIV/0! | #DIV/0! |

## Abstract:

### 1. The Purpose of the Experiment:

- a. The purpose of this experiment was to use the set of data given to examine the mechanical properties of a 0.41mm thick piece of steel with a length of 95mm by calculating the stress-strain curve.

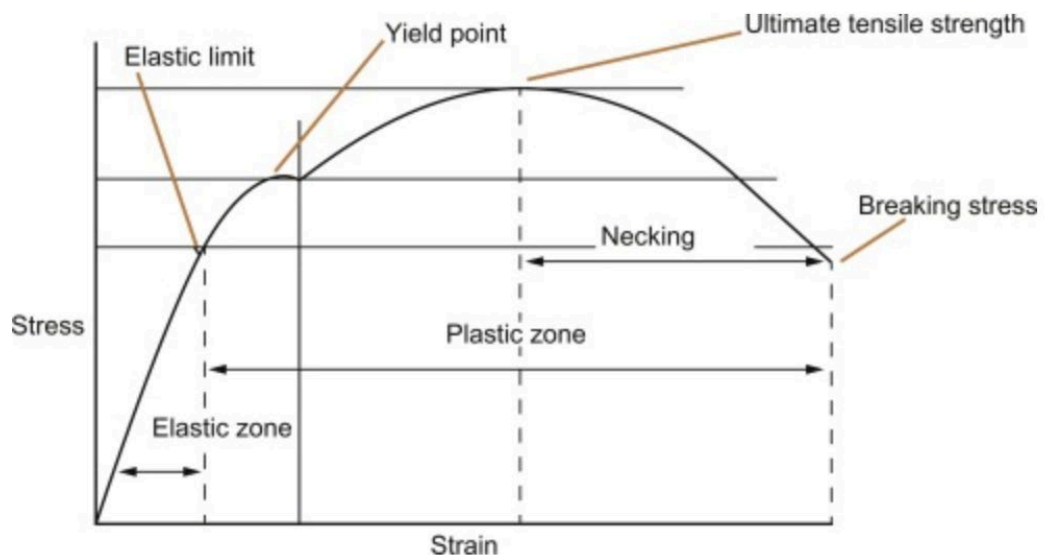
### 2. The Brief Description of the Method Used:

- a. The method used to determine the mechanical properties of this piece of steel is a tensile test. A tensile machine is needed to conduct this test because these machines provide uniformly increasing tension force on the material being tested.

3. **The Significant Results of the Test:**
4. **The Major Conclusions Drawn from the results:**

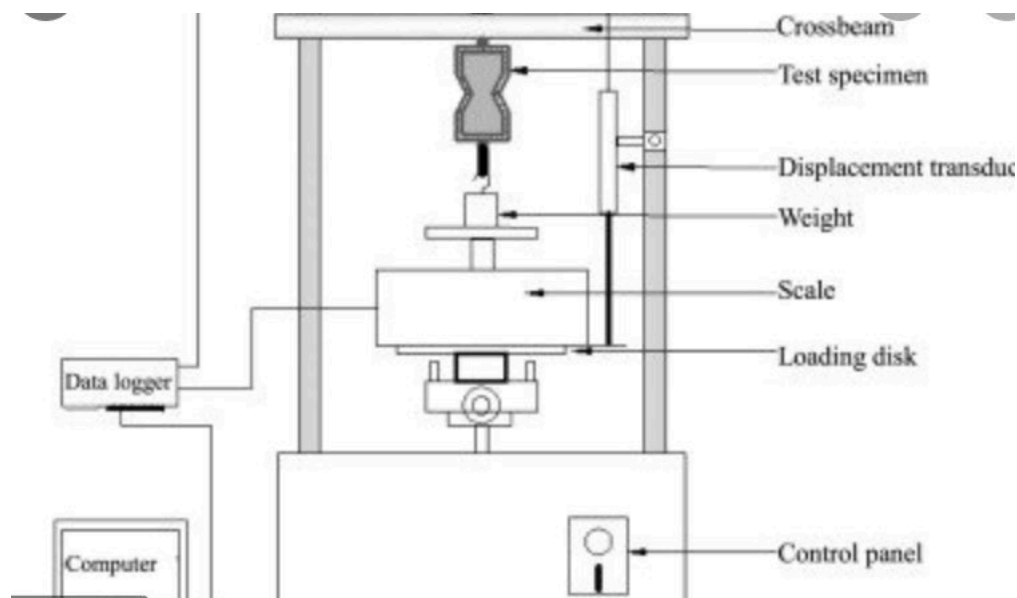
### Introduction of stress-strain theory:

The stress-strain curve expresses a relationship between a load applied to a material and the deformation of the material caused by the load. It is the most reliable and complete source for the evaluation of mechanical properties of any material. The curve is produced by plotting the applied stress on the material axis and the elongation produced due it. Different materials produce different stress-strain curves, this is influenced by the structure of the material. The material tenacity and the elongation at break are the two important properties that can be gathered from the stress-strain diagram. Attached below is an example of what a stress-strain diagram should look like.



### Test procedure:

The stress-strain diagram is determined by performing a tensile test. Tensile tests are conducted in tensile test machines which provide controlled uniformly increasing tension force, applied to the material. The materials ends are gripped by the machine and its gauge length is continuously measured until it breaks. The deformation of the material (strain) is the ratio of the increase of the specimen gauge length to its original gauge length. Seen below is a detailed drawing of a commonly used tensile test machine.



### Data and observation:

#### **1. Sample Dimensions:**

- Diameter of the steel: 0.41mm
- Length of sample steel: 95mm

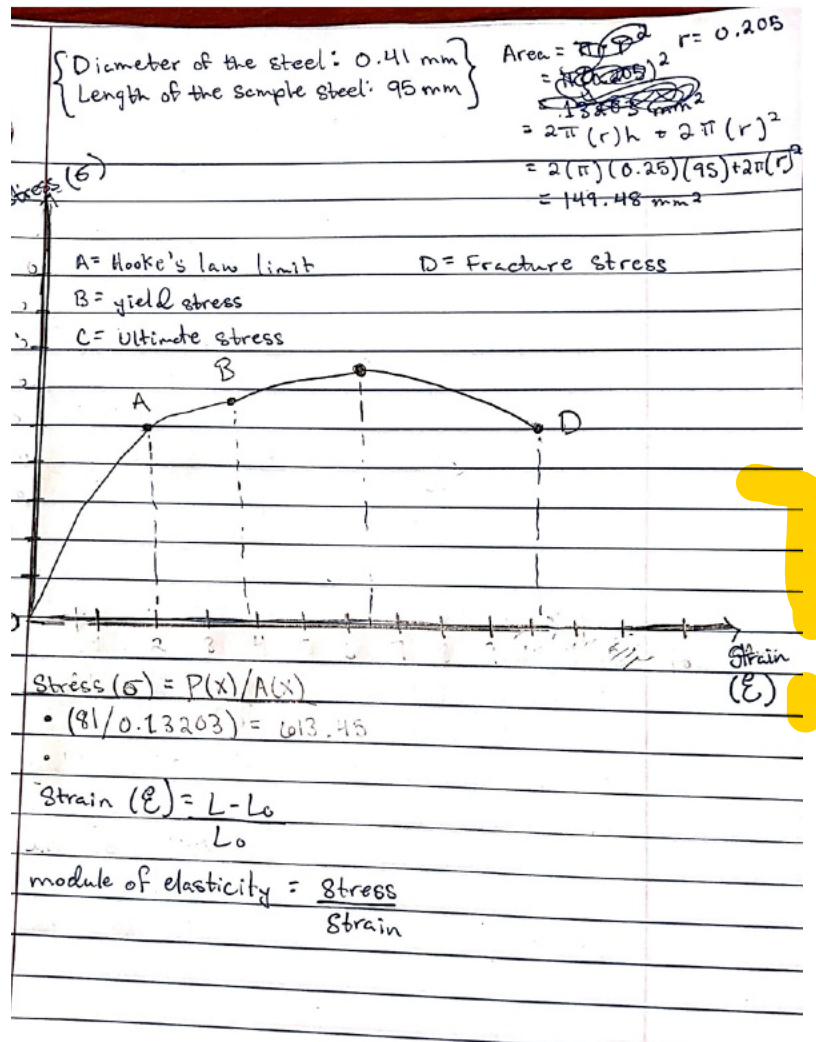
#### **2. Given Table:**

| Force<br>(N) | Displacement<br>(mm) | Force<br>(N) | Displacement<br>(mm) |
|--------------|----------------------|--------------|----------------------|
| 0            | 0                    | 9079         | 3.773                |
| 81           | 0.063                | 9229         | 4.173                |
| 142          | 0.113                | 9379         | 4.573                |
| 201          | 0.173                | 9479         | 4.973                |
| 263          | 0.233                | 9579         | 5.373                |
| 708          | 0.273                | 9679         | 5.773                |
| 1192         | 0.303                | 9729         | 6.173                |
| 1455         | 0.343                | 9779         | 6.573                |
| 2000         | 0.383                | 9879         | 6.973                |
| 2243         | 0.423                | 9879         | 7.373                |
| 2686         | 0.463                | 9779         | 7.773                |
| 3050         | 0.503                | 9779         | 8.173                |
| 3454         | 0.533                | 9779         | 8.573                |
| 3979         | 0.573                | 9779         | 8.973                |
| 4282         | 0.613                | 9779         | 9.373                |
| 4726         | 0.653                | 9779         | 9.773                |
| 5049         | 0.693                | 9779         | 10.173               |
| 5372         | 0.723                | 9729         | 10.573               |
| 5978         | 0.763                | 9679         | 10.973               |
| 6301         | 0.803                | 9629         | 11.373               |
| 6679         | 0.973                | 9579         | 11.773               |
| 7079         | 1.373                | 9479         | 12.173               |
| 7679         | 1.773                | 9279         | 12.573               |
| 7979         | 2.173                | 8879         | 12.973               |
| 8279         | 2.573                | 9579         | 13.373               |
| 8729         | 2.973                | 7379         | 13.773               |
| 8929         | 3.373                |              |                      |

3. From this data were tasked with preparing a report showing the mechanical properties of the material tested. The report should contain:
  - a. Detail sketch of the Stress-Strain curve.
  - b. Detail sketch in the graph to find modulus of elasticity, yield stress, ultimate stress, and fracture stress of the material tested.
  - c. Different curve should be provided in the report showing different property of the material.
  - d. Sample calculation.



## Calculations:



Scanned with CamScanner

You need to plot the test results using excel.

## Discussion of the test results:

## Appendix:

[http://www.substech.com/dokuwiki/doku.php?id=tensile test and stress-strain diagram](http://www.substech.com/dokuwiki/doku.php?id=tensile_test_and_stress-strain_diagram)

<https://www.khanacademy.org/science/in-in-class11th-physics/in-in-mechanical-properties-of-solids/in-in-stress-strain-and-modulus-of-elasticity/v/stress-vs-strain-curve>

**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING  
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET  
CVEG 2061 – Materials and Dynamics Lab  
SPRING 2021**

**Instructor: Md. Jobair Bin Alam, Ph.D.**

**Title of Assignment**

**Stress-Strain Behavior of Steel**

**Outcome Measured Using this Assignment**

**Outcome 6**

An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions

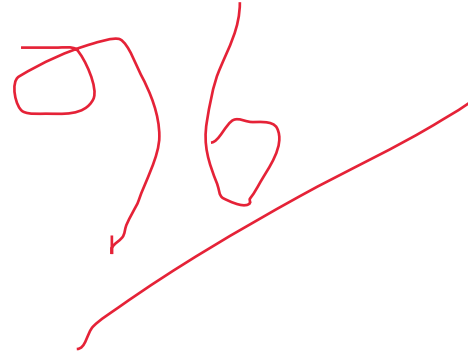
**Check the engineering design characteristics related to this assignment**

|                                                           |                                                                                      |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Ability to develop experiment</b>                      |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Identify the appropriate parameters                                                  |
| ×                                                         | Identify and select appropriate equipment to determine the parameters experimentally |
| ×                                                         | Provide steps to set up and conduct the experiment                                   |
| ×                                                         | Identify data collection method to obtain the experiment results                     |
| <b>Ability to conduct experiment</b>                      |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Conduct experiment maintaining all safety precautions                                |
| ×                                                         | Safe and proper handling of equipment                                                |
| ×                                                         | Collect and record data using appropriate units of measurements and relevant figures |
| <b>Ability to analyze and interpret experimental data</b> |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Data presenting in tabular/graphical format to aid in interpretation                 |
| ×                                                         | Use appropriate statistical analysis (if required) to interpret data and results     |
| ×                                                         | Draw appropriate conclusions using engineering judgment based on experiment          |

**Brief justification of the suitability of assignment for the outcome**

**The lab experiment will increase the students' ability to identify the parameters to be measured and appropriate equipment to be used, along with conducting experiments and interpret data and results.**

**Department of Civil & Environmental Engineering**  
**Prairie View A&M University**



**CVEG 2061 P81 Materials and Dynamics**  
**Laboratory**

Spring 2021

**Laboratory Report on**  
**“Stress-Strain Relationship”**

**Conducted on**  
February 12, 2021

**Submitted by**  
Sanjay Tillmutter

**On**  
February 26, 2021

To

**Dr. Md Jobair Bin Alam**  
*Materials and Dynamics Laboratory Instructor*  
CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT

# MATERIALS AND DYNAMICS LABORATORY

## LABORATORY GRADING SHEET

SPRING 2021

Title of Experiment: "Stress-Strain Relationship"

Name: Sanjay Tillmutter

Date Lab was Performed: Friday February 12, 2021 Report Due Date: Friday February 26, 2021

| <i>Ability to Conduct Experiments</i>                                                                                                             | MAX       | Your Score | Comments |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------|----------|
| Ability to demonstrate general lab safety (by your conduct and observations).                                                                     | 3         |            |          |
| Ability to follow and properly state the procedure used for the experiment, while maintaining all safety precautions.                             | 9         |            |          |
| Ability to demonstrate knowledge of how equipment function, their limitations, and the uncertainty associated with reading the instruments.       | 6         |            |          |
| Ability to collect and record data using appropriate units of measurement and identify the dependent and independent variables in the experiment. | 15        |            |          |
| <b>Total for Ability to Conduct Experiments</b>                                                                                                   | <b>33</b> |            |          |
| <b>Percentage for this Performance Criteria</b>                                                                                                   |           |            |          |
| <i>Ability to Analyze and Interpret experimental Data</i>                                                                                         |           |            |          |
| Provides appropriate abstracts for the experimental report                                                                                        | 5         |            |          |
| Ability to analyze the data using appropriate software to generate the required parameters using consistent units and significant figures.        | 22        |            |          |
| Use of statistical analysis as needed including uncertainty analysis                                                                              | 5         |            |          |
| Ability to present the data (raw /derived) in tabular and graphical form to meet the objectives and to aid in interpretation.                     | 14        |            |          |
| Ability to discuss the raw and derived data/graphs and assess the validity of the results in relation to the underlying theory.                   | 14        |            |          |
| Ability to draw appropriate and reasonable conclusions in relations to each of the experimental objectives.                                       | 7         |            |          |
| <b>Total for Ability to Analyze and Interpret experimental Data</b>                                                                               | <b>67</b> |            |          |
| <b>Percentage for this Performance Criteria</b>                                                                                                   |           |            |          |
| <b>TOTAL FOR THIS LAB</b>                                                                                                                         |           |            |          |

## LETTER OF TRANSMITTAL

February 26, 2021

Dr. Bin Alam  
Department of Civil & Environmental Engineering  
Prairie View A&M University

Dear Dr. Bin Alam:

The Technical Laboratory Report attached to this document contains the detailed results from the “Stress-Strain Relationship” Laboratory work conducted on the 12<sup>th</sup> of February. The Report contains the objective and theory of the Stress-Strain Relationship, along with any equations used in the analysis of data for the experiment. At the end of the report are the interpretations of the results, including the conclusion and any recommendations.

Please feel free to contact me by email at [stillmutt@pvamu.edu](mailto:stillmutt@pvamu.edu) if you have any questions on the report.

Sincerely,

*S. Tillmutt*



Sanjay Tillmutt.

## **ABSTRACT**

A laboratory experiment was conducted to use the data obtained from a tensile test to plot a Stress-Strain Diagram, and determine the Modulus of Elasticity, Yield Stress, Ultimate Stress, and the Fracture Stress. In this experiment, an unknown steel was tested using a tensile test machine. Data from the experiment was collected and shared. A Stress-Strain Diagram was generated using the data from the tensile test. Results of Modulus of Elasticity, Yield Stress, Ultimate Stress, and the Fracture Stress were computed, recorded, and discussed.



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## CHAPTER 1 – ABILITY TO CONDUCT EXPERIMENT

### 1.1 Objective:

The objective of this experiment was to evaluate the mechanical properties of the specimen through and understanding of curve results from the tensile test.

### 1.2 Theory:

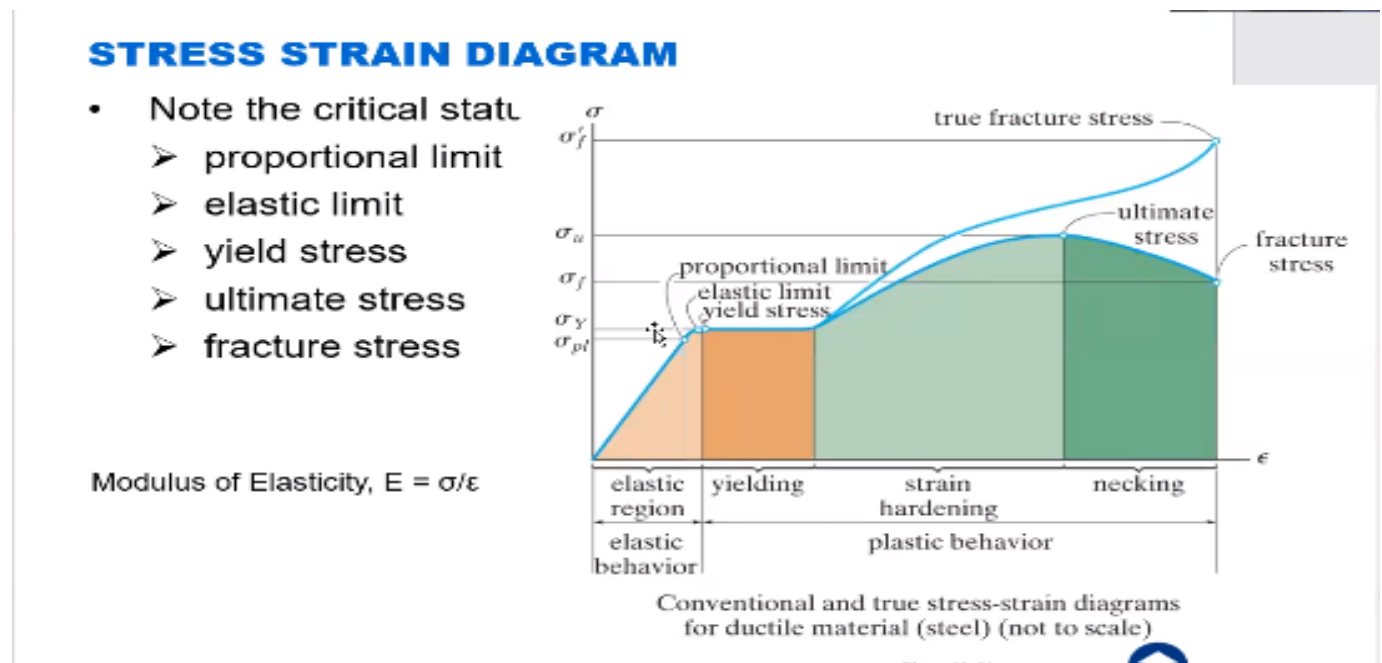


Figure 1 – Stress- Strain Diagram Showing Different Properties of Material

Metals have their own properties including physical, mechanical and thermal characteristics. The most important properties are the mechanical properties, which includes ductility, hardness, strength, and toughness. The mechanical properties are the measurements that are used as a reference for material selection. To know the mechanical properties of a metal, it needs material testing. One of the material tests is the tensile test.

Tensile test is a measurement that examines the strength of a material within applying loads in uniaxial direction to the specimen. The tested specimen is exposed by the increasing uniaxial force continuously while its change in elongation is being observed. The tensile test measures the resistance of a material to the given static load. The results that were obtained from the tensile test can be used to plot a curve and show the mechanical properties of the specimen. The mechanical properties of material that can be known from tensile test includes:- tensile strength, yield strength, modulus of elasticity, ductility, ultimate stress, etc.

Furthermore, the stress strain curve can be obtained from the measurement, which allows one to compute the mechanical properties above.

The stress-strain diagrams for most engineering materials exhibit a linear relationship between stress and strain within the elastic region. Consequently, an increase in stress causes a proportionate increase in strain. This fact was discovered by Robert Hooke in 1676 using springs and is known as Hooke's Law. It may be expressed mathematically as:

$$\sigma = E\epsilon \quad (1)$$

where,

$\sigma$  = Stress, MPa

$E$  = Modulus of Elasticity, MPa

$\epsilon$  = Strain, Unitless

Since the Modulus of Elasticity will be required for this experiment, Equation (1) can then be derived:

$$E = \frac{\sigma}{\epsilon} \quad (2)$$

Modulus of Elasticity is then obtained by dividing the stress by the strain in the material.

We can determine the nominal or engineering stress by dividing the applied load  $P$  by the specimen's original cross-sectional area,  $A$ . This calculation assumes that the stress is constant over the cross section and throughout the gauge length. We have:

$$\sigma = \frac{P}{A} \quad (3)$$

where,

$P$  = applied load, N

$A$  = cross sectional area,  $mm^2$

Likewise, the nominal or engineering strain is found directly from the strain gauge reading, or by the change in the specimen's gauge length,  $\delta$ , by the specimen's original gauge length  $L_0$ . Here the strain is assumed to be constant throughout the region between gauge points. Thus:

$$\epsilon = \frac{\delta}{L_0} \quad (4)$$

Where,  $\epsilon$  = strain, unitless

$\delta$  = change in length, mm

$L_0$  = original length, mm

### 1.3 Apparatus:

- Tensile Machine
- Vernier Caliper
- Stopwatch
- Steel Specimen

### 1.4 Experimental Safety:

The safety precautions followed during this experiment included wearing safety goggles, full sleeve shirts, and making sure not to inhale or ingest any of the test fluids. Due to the pandemic situation in this semester, social distancing, gloves, and masks were required.

### 1.5 Experimental Procedure:

#### Method

- The tensile test machine was prepared along with the specimen to be tested by the instructor.
- The length and diameter of the specimen was measured and recorded.
- The specimen was placed into the tensile test machine and tested. The specimen was tested until it failed
- The time taken for failure was recorded, and the final diameter and gauge length measured.

## **CHAPTER 2 – RAW EXPERIMENTAL DATA:**

### **2.1 Experimental Data:**

The data collection was conducted as a group effort for the reading and recording of Force and Displacement. The recorded data is shown in Table 1.

**Table 1 – Raw Experimental Data from Tensile Test**

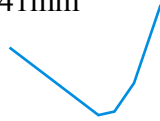
| Force | Displacement | Force | Displacement |
|-------|--------------|-------|--------------|
| (N)   | (mm)         | (N)   | (mm)         |
| 0     | 0            | 9079  | 3.773        |
| 81    | 0.063        | 9229  | 4.173        |
| 142   | 0.113        | 9379  | 4.573        |
| 201   | 0.173        | 9479  | 4.973        |
| 263   | 0.233        | 9579  | 5.373        |
| 708   | 0.273        | 9679  | 5.773        |
| 1192  | 0.303        | 9729  | 6.173        |
| 1455  | 0.343        | 9779  | 6.573        |
| 2000  | 0.383        | 9879  | 6.973        |
| 2243  | 0.423        | 9879  | 7.373        |
| 2686  | 0.463        | 9779  | 7.773        |
| 3050  | 0.503        | 9779  | 8.173        |
| 3454  | 0.533        | 9779  | 8.573        |
| 3979  | 0.573        | 9779  | 8.973        |
| 4282  | 0.613        | 9779  | 9.373        |
| 4726  | 0.653        | 9779  | 9.773        |
| 5049  | 0.693        | 9779  | 10.173       |
| 5372  | 0.723        | 9729  | 10.573       |
| 5978  | 0.763        | 9679  | 10.973       |
| 6301  | 0.803        | 9629  | 11.373       |
| 6679  | 0.973        | 9579  | 11.773       |
| 7079  | 1.373        | 9479  | 12.173       |
| 7679  | 1.773        | 9279  | 12.573       |
| 7979  | 2.173        | 8879  | 12.973       |

|      |       |      |        |
|------|-------|------|--------|
| 8279 | 2.573 | 9579 | 13.373 |
| 8729 | 2.973 | 7379 | 13.773 |
| 8929 | 3.373 |      |        |

By looking at Table 1 it can be seen that for force, the values rose to a peak and then dropped. It was also seen that the strain values rose exponentially despite the force being reduced after a maximum force was applied.

Length of specimen,  $L = 95\text{mm}$

Diameter of specimen's cross section =  $0.41\text{mm}$



### CHAPTER 3 – RESULTS AND DISCUSSION:

Information from Table 1 was used to help compute the stress and strain values seen in Table 2. Table 2 shows the values from Table 1 and those which were calculated from the information in it.

**Table 2 – Raw Experimental Data, Stress and Strain**

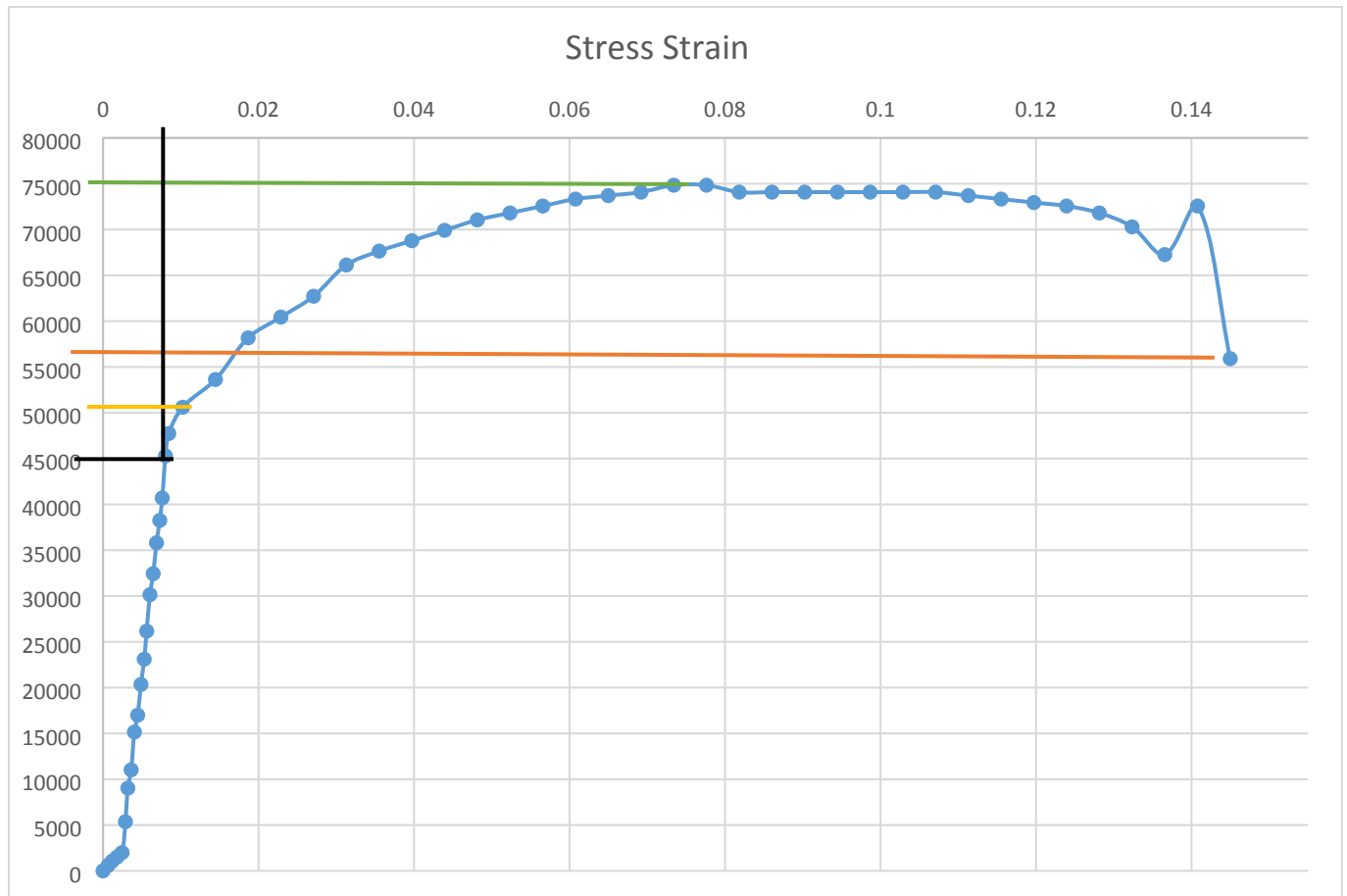
| Load | Elongation | Stress     | Strain     |
|------|------------|------------|------------|
| N    | mm         | MPa        |            |
| 0    | 0          | 0          | 0          |
| 81   | 0.063      | 613.636364 | 0.00066316 |
| 142  | 0.113      | 1075.75758 | 0.00118947 |
| 201  | 0.173      | 1522.72727 | 0.00182105 |
| 263  | 0.233      | 1992.42424 | 0.00245263 |
| 708  | 0.273      | 5363.63636 | 0.00287368 |
| 1192 | 0.303      | 9030.30303 | 0.00318947 |
| 1455 | 0.343      | 11022.7273 | 0.00361053 |
| 2000 | 0.383      | 15151.5152 | 0.00403158 |
| 2243 | 0.423      | 16992.4242 | 0.00445263 |
| 2686 | 0.463      | 20348.4848 | 0.00487368 |
| 3050 | 0.503      | 23106.0606 | 0.00529474 |
| 3454 | 0.533      | 26166.6667 | 0.00561053 |
| 3979 | 0.573      | 30143.9394 | 0.00603158 |
| 4282 | 0.613      | 32439.3939 | 0.00645263 |
| 4726 | 0.653      | 35803.0303 | 0.00687368 |
| 5049 | 0.693      | 38250      | 0.00729474 |
| 5372 | 0.723      | 40696.9697 | 0.00761053 |
| 5978 | 0.763      | 45287.8788 | 0.00803158 |
| 6301 | 0.803      | 47734.8485 | 0.00845263 |
| 6679 | 0.973      | 50598.4848 | 0.01024211 |
| 7079 | 1.373      | 53628.7879 | 0.01445263 |
| 7679 | 1.773      | 58174.2424 | 0.01866316 |
| 7979 | 2.173      | 60446.9697 | 0.02287368 |
| 8279 | 2.573      | 62719.697  | 0.02708421 |
| 8729 | 2.973      | 66128.7879 | 0.03129474 |

|      |        |            |            |
|------|--------|------------|------------|
| 8929 | 3.373  | 67643.9394 | 0.03550526 |
| 9079 | 3.773  | 68780.303  | 0.03971579 |
| 9229 | 4.173  | 69916.6667 | 0.04392632 |
| 9379 | 4.573  | 71053.0303 | 0.04813684 |
| 9479 | 4.973  | 71810.6061 | 0.05234737 |
| 9579 | 5.373  | 72568.1818 | 0.05655789 |
| 9679 | 5.773  | 73325.7576 | 0.06076842 |
| 9729 | 6.173  | 73704.5455 | 0.06497895 |
| 9779 | 6.573  | 74083.3333 | 0.06918947 |
| 9879 | 6.973  | 74840.9091 | 0.0734     |
| 9879 | 7.373  | 74840.9091 | 0.07761053 |
| 9779 | 7.773  | 74083.3333 | 0.08182105 |
| 9779 | 8.173  | 74083.3333 | 0.08603158 |
| 9779 | 8.573  | 74083.3333 | 0.09024211 |
| 9779 | 8.973  | 74083.3333 | 0.09445263 |
| 9779 | 9.373  | 74083.3333 | 0.09866316 |
| 9779 | 9.773  | 74083.3333 | 0.10287368 |
| 9779 | 10.173 | 74083.3333 | 0.10708421 |
| 9729 | 10.573 | 73704.5455 | 0.11129474 |
| 9679 | 10.973 | 73325.7576 | 0.11550526 |
| 9629 | 11.373 | 72946.9697 | 0.11971579 |
| 9579 | 11.773 | 72568.1818 | 0.12392632 |
| 9479 | 12.173 | 71810.6061 | 0.12813684 |
| 9279 | 12.573 | 70295.4545 | 0.13234737 |
| 8879 | 12.973 | 67265.1515 | 0.13655789 |
| 9579 | 13.373 | 72568.1818 | 0.14076842 |
| 7379 | 13.773 | 55901.5152 | 0.14497895 |



Table 2 shows the raw experimental data, the stress, and strain values that were computed using equations (3) and (4). The cross-sectional area of the steel specimen was computed and found to be  $0.1320 \text{ mm}^2$ . The loads from the raw data were then divided by the cross-sectional area to give the stress values in Table 2. The original length of the steel specimen was measured and given as 95mm. The elongation values in Table 1 were then divided by the original length to give the strain values in Table 2. A stress-strain curve was plotted using the values from Table 2, with Strain on X-axis and Stress on Y-axis. Figure 2 shows the curve which was plotted using the data from Table 2.





*Figure 2 – Stress-Strain Curve indicating where Modulus of Elasticity, Fracture Stress, Ultimate Stress, and Yield Stress will occur.*

From Figure 2 it can be seen that the Modulus of Elasticity will be equal to the stress at the proportional limit over the strain at the said point. This value worked out to be:

$$E = \frac{45287.87}{0.00803} = 5.56 \times 10^6 \text{ MPa}$$

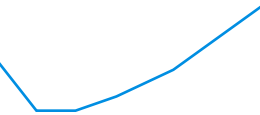
Figure 2 also graphically shows that the ultimate stress would be:

$$\sigma_u = 74840.91 \text{ MPa}$$



The yield stress was determined to be:

$$\sigma_Y = 50598.45 \text{ MPa}$$



The fracture stress was computed and found to be:

$$\sigma_f = 55901.52 \text{ MPa}$$



## **CHAPTER 4 – CONCLUSION**

### **4.1 Conclusion:**

A successful experiment was conducted to use the data obtained from a tensile test to plot a Stress-Strain Diagram, and determine the Modulus of Elasticity, Yield Stress, Ultimate Stress, and the Fracture Stress. The data obtained showed good consistency for the experiment. Results also showed that there was an exponential increase in elongation, even though the force applied increased to a peak magnitude, and then decreased. A graph was generated from the data which was obtained and computed. From this stress-strain graph, which was plotted, the ultimate stress, fracture stress, yield stress, and Modulus of Elasticity were determined graphically, and calculated. There was not information taken from the experiment to determine whether the steel specimen which was tested was either brittle or ductile, as no reduction in area was mentioned.



## Sample Calculations

For calculation of stress

$$\sigma = \frac{P}{A}$$

where,

P = applied load, N

A = cross sectional area,  $mm^2$

For P = 81 N

D = 0.41mm

$$A = \pi r^2$$

$$= \pi \times \left(\frac{0.41mm}{2}\right)^2 = 0.132 \text{ } mm^2$$

$$\sigma = \frac{P}{A}$$

$$= \frac{81 \text{ N}}{0.132 \text{ } mm^2}$$

$$= 613.64 \text{ MPa}$$

For calculation of strain

$$\epsilon = \frac{\delta}{L_0}$$

Where,  $\epsilon$  = strain, unitless

$\delta$  = change in length, mm

$L_0$  = original length, mm

For  $\delta = 0.063$  mm

$$\epsilon = \frac{\delta}{L_0}$$

$$= \frac{0.063 \text{ mm}}{95 \text{ mm}}$$

$$= 6.63 \times 10^{-4}$$

**Prairie View A&M University**  
**Roy G. Perry College of Engineering**  
**Civil & Environmental Engineering**



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**CVEG 2061 P81 - Materials and Dynamics**  
**Laboratory Report 1 -Stress Strain**  
**Trinity Scott**

## **Abstract**

The purpose of this experiment is to find the stress strain curve. For this experiment to be conducted we have to use a tensile test. This lab is used to attempt to gain a better understanding of the stress strain curve.



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## Introduction

This experiment was performed to determine five useful material properties, which can all be deduced on a stress/strain graph. The five properties include: Modulus of Elasticity, Ultimate Stress, Fracture Stress, Proportional Limit, and Yield Stress. Tensile test is one of the most fundamental types of mechanical tests someone can perform on a material. The tensile test measures the resistant of a material to the given static load.. This test is important because it tells the impact of the load given to the material mechanical properties of a material. ✓

### Elasticity Equation (1)

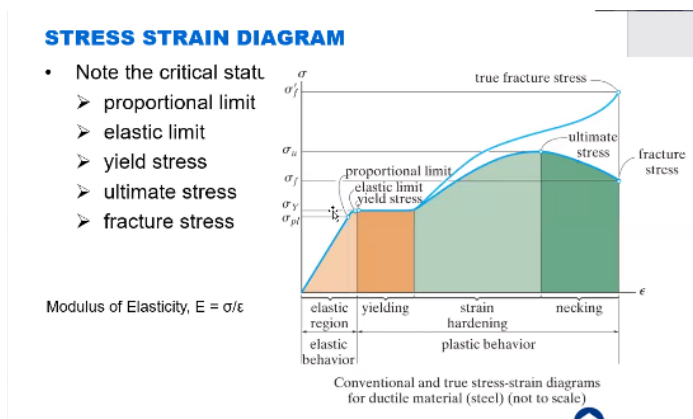
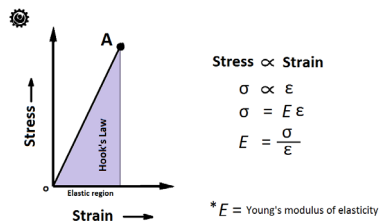


Figure 1 ← Fugure name

## Equipment and Apparatus

1. Tensile machine
2. Vernier caliper
3. Stopwatch



## Materials and Test Conditions

1. Notebook
2. Everyone completed the experiment separately.
3. Check for equipment conditions

## Test Results and Analysis

The following table shows a full data table from a tensile test on 1018 steel stock sample that is provided which is force and displacement.

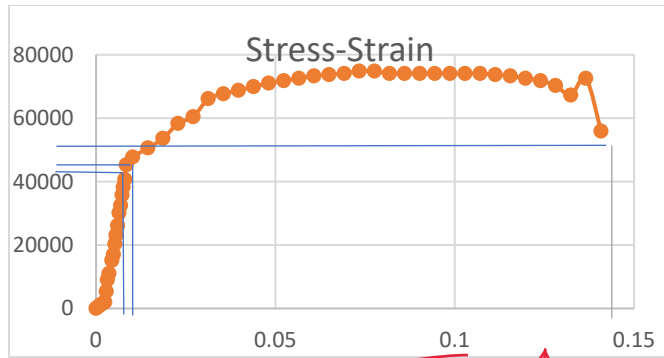
*Table 1 -Tensile Test*

| Force<br>(N) | Displacement<br>(mm) | Stress   | Strain   |
|--------------|----------------------|----------|----------|
| 0            | 0                    | 0        | 0        |
| 81           | 0.063                | 613.5182 | 0.000663 |
| 142          | 0.113                | 1075.55  | 0.001189 |
| 201          | 0.173                | 1522.434 | 0.001821 |
| 263          | 0.233                | 1992.04  | 0.002453 |
| 708          | 0.273                | 5362.603 | 0.002874 |
| 1192         | 0.303                | 9028.564 | 0.003189 |
| 1455         | 0.343                | 11020.6  | 0.003611 |
| 2000         | 0.423                | 15148.6  | 0.004453 |
| 2243         | 0.463                | 16989.15 | 0.004874 |
| 2686         | 0.503                | 20344.57 | 0.005295 |
| 3050         | 0.533                | 23101.61 | 0.005611 |
| 3454         | 0.573                | 26161.63 | 0.006032 |
| 3979         | 0.613                | 30138.13 | 0.006453 |

|      |        |          |          |
|------|--------|----------|----------|
| 4282 | 0.653  | 32433.15 | 0.006874 |
| 4726 | 0.693  | 35796.13 | 0.007295 |
| 5049 | 0.723  | 38242.63 | 0.007611 |
| 5372 | 0.763  | 40689.13 | 0.008032 |
| 5978 | 0.803  | 45279.16 | 0.008453 |
| 6301 | 0.973  | 47725.65 | 0.010242 |
| 6679 | 1.373  | 50588.74 | 0.014453 |
| 7079 | 1.773  | 53618.46 | 0.018663 |
| 7697 | 2.173  | 58299.37 | 0.022874 |
| 7979 | 2.573  | 60435.33 | 0.027084 |
| 8729 | 2.973  | 66116.05 | 0.031295 |
| 8929 | 3.373  | 67630.91 | 0.035505 |
| 9079 | 3.773  | 68767.05 | 0.039716 |
| 9229 | 4.173  | 69903.2  | 0.043926 |
| 9379 | 4.573  | 71039.34 | 0.048137 |
| 9479 | 4.973  | 71796.77 | 0.052347 |
| 9579 | 5.373  | 72554.2  | 0.056558 |
| 9679 | 5.773  | 73311.63 | 0.060768 |
| 9729 | 6.173  | 73690.35 | 0.064979 |
| 9779 | 6.573  | 74069.06 | 0.069189 |
| 9879 | 6.973  | 74826.49 | 0.0734   |
| 9879 | 7.373  | 74826.49 | 0.077611 |
| 9779 | 7.773  | 74069.06 | 0.081821 |
| 9779 | 8.173  | 74069.06 | 0.086032 |
| 9779 | 8.573  | 74069.06 | 0.090242 |
| 9779 | 8.973  | 74069.06 | 0.094453 |
| 9779 | 9.373  | 74069.06 | 0.098663 |
| 9779 | 9.773  | 74069.06 | 0.102874 |
| 9779 | 10.173 | 74069.06 | 0.107084 |
| 9729 | 10.573 | 73690.35 | 0.111295 |
| 9679 | 10.973 | 73311.63 | 0.115505 |
| 9579 | 11.373 | 72554.2  | 0.119716 |
| 9479 | 11.773 | 71796.77 | 0.123926 |
| 9279 | 12.173 | 70281.91 | 0.128137 |
| 8879 | 12.573 | 67252.19 | 0.132347 |
| 9579 | 12.973 | 72554.2  | 0.136558 |
| 7379 | 13.373 | 55890.75 | 0.140768 |
|      | 13.773 |          | 0.144979 |

*Graph 1-*

*Table 2 – Length and diameter given*



|   |       |    |
|---|-------|----|
| L | 95    | mm |
| d | 0.41  | mm |
| A | 0.132 |    |

E 5637346 Mpa  
 yield stress 47725.65 Mpa  
 ultimate stress 74069 Mpa  
 fracture stress 55890 Mpa

axis title?

In the stress strain graph you can see the sketched curve. If you look at the curve you can see the modulus of elasticity, yield stress, ultimate stress and fracture stress of material tested. A full set of data such as the diameter of 0.44mm, and length of 95mm from a tensile test on 1081 steel stock. To find stress force divided by area and for strain displacement divided by length of the steel. We found the radius in order to find the area which was 0.132

Sample Calculation:

**Stress = Force/ Area**

$$81/0.132 = 613.636 \text{ unit}$$

**Strain = displacement/ length**

$$0.113/95 = 0.1189$$

**Elasticity = Stress/ Strain**

$$40689.13/0.00803 = 4902304$$

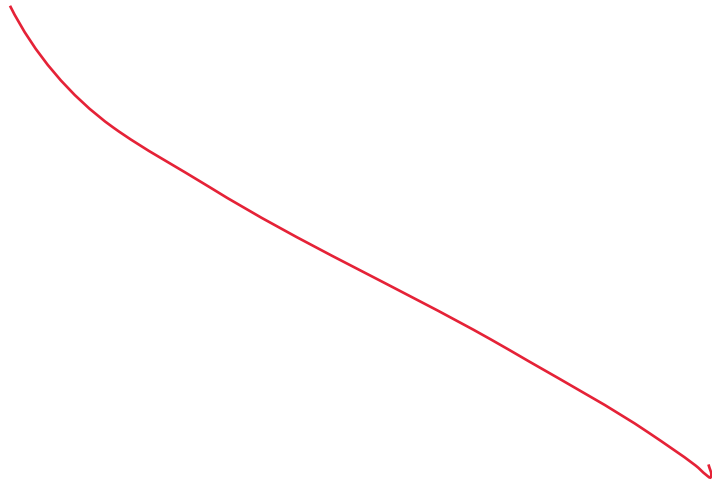
The yielded stress is 47,725.65 Mpa,. The ultimate stress is 7,4069 Mpa which was also found by using *figure 1*. Fracture stress was easily found by being the last point on the graph which was 55,890 Mpa.

## **Discussion Synthesis and Interpretation of Results and Findings**

In conclusion, with the data that was given we were able to complete a successful experiment. When you look at the stress strain graph you can see that the graph resembles what a real stress strain would look like. This experiment objective was successful by sketching the stress strain curve, finding the modulus of elasticity, yield stress, ultimate stress, and fracture stress of the material tested.



## **Appendices**



**CIVIL ENGINEERING DEPARTMENT**  
**PRAIRE VIEW A&M UNIVERSITY**



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**CVEG 2061 (P81): Materials and Dynamics LABORATORY**

**Spring 2021**

**LABORATORY REPORT ON**

**“Stress-Strain”  
Conducted on**

2/12/2021

**Submitted by**

Mouni Yamba

**On**

2/19/2020

**To**

**Md Jobair Bin Alam**

**CIVIL ENGINEERING DEPARTMENT**  
**HYDRAULICS LABORATORY GRADING SHEET**

**Spring 2021**

Title of Experiment: "Stress-Strain"

Name: Mouni Yamba

Date Lab was Performed: 2/12/2021

Report Due Date: 2/19/2021

| <b>Ability to conduct Experiments</b>                                                                                                                       | <b>Max</b> | <b>Your Score</b> | <b>Comments</b> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------------------|-----------------|
| Ability to demonstrate general lab safety (by your conduct And observations).                                                                               | 3          |                   |                 |
| Ability to follow and properly state the procedure used for the experiment, while maintaining all safety precautions.                                       | 9          |                   |                 |
| Ability to demonstrate knowledge of how equipment Function, their limitations, and the uncertainty associated With reading the instruments.                 | 6          |                   |                 |
| Ability to collect and record data using appropriate units of measurement and identify the dependent and independent Variables in the experiment.           | 15         |                   |                 |
| <b>Total for Ability to conduct Experiments</b>                                                                                                             | <b>33</b>  |                   |                 |
| <b>Percentage for this Performance Criteria</b>                                                                                                             |            |                   |                 |
| <b>Ability to analyze and Interpret experiment Data</b>                                                                                                     |            |                   |                 |
| Provides appropriate abstracts for the experimental report                                                                                                  | 5          |                   |                 |
| Ability to analyze the data using appropriate software to generate the required parameters using consistent units and significant figures.                  | 22         |                   |                 |
| Use of statistical analysis as needed including uncertainty Analysis.                                                                                       | 5          |                   |                 |
| Ability to present the data (raw/derived) in tabular and graphical form to meet the objectives and to aid in interpretation                                 | 14         |                   |                 |
| Ability to discuss the raw and derived data/graphs and Assess the validity of the results in relation of the results in relations to the underlying theory. | 14         |                   |                 |
| Ability to draw appropriate and reasonable conclusions in Relations to each of the experimental objectives.                                                 | 7          |                   |                 |
| <b>Total for Ability to analyze and Interpret experimental Data</b>                                                                                         | <b>67</b>  |                   |                 |

|                           |            |  |  |
|---------------------------|------------|--|--|
| <b>TOTAL FOR THIS LAB</b> | <b>100</b> |  |  |
|---------------------------|------------|--|--|

Letter of Transmittal

February 19, 2021

Md Jobair Bin Alam

Civil Engineering Department

Prairie View A&M University

Dear Md Jobair Bin Alam:

The attached technical laboratory report contains the detailed results of the “Stress-Strain” work done on February 12, 2021. The report contains the objectives of the experiment, the theory on Stress-strain, the equations used for analysis of the data, the procedure, results and discussions and interpretation of the results and recommendations.

Please contact me at 435-212-1079 or by email at [myamba@student.pvamu.edu](mailto:myamba@student.pvamu.edu) if you have any questions on the report.

Sincerely,

X

Mouni Yamba



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## LIST OF SYMBOLS

| <u>SYMBOL</u>                | <u>DEFINITION</u>                                            |
|------------------------------|--------------------------------------------------------------|
| $A$                          | Area over which force (F) acts ( $m^2$ )                     |
| $E$                          | Elastic modulus (GPa)                                        |
| $F$                          | Force (N)                                                    |
| $(l_o)_i$                    | Initial dimension in direction i (mm)                        |
| $t$                          | Specimen thickness (m)                                       |
| $V_{chart}$                  | Rate of chart displacement (mm/min)                          |
| $V_{displacement}$           | Rate of sample displacement (mm/min)                         |
| $w$                          | Specimen width (m)                                           |
| $\delta_{chart}$             | Displacement of chart (mm)                                   |
| $\delta_{sample}$            | Displacement of sample (mm)                                  |
| $\epsilon$                   | Strain                                                       |
| $\epsilon_{\sigma=0}$        | Predicted strain at zero stress                              |
| $\epsilon_i$                 | Normal strain in direction i                                 |
| $\Delta E$                   | Error in the predicted elastic modulus (GPa)                 |
| $\Delta F$                   | Error in the force (N)                                       |
| $\Delta l_i$                 | Change in dimension in direction i (mm)                      |
| $\Delta t$                   | Error in the specimen thickness (m)                          |
| $\Delta w$                   | Error in the width (m)                                       |
| $\Delta \epsilon_{\sigma=0}$ | Error in the predicted strain at zero stress                 |
| $\Delta \phi$                | Error in the predicted intercept of stress-strain data (MPa) |
| $\Delta \sigma$              | Error in the stress (MPa)                                    |
| $\phi$                       | Predicted intercept of stress-strain data (MPa)              |
| $\sigma$                     | Engineering stress (MPa)                                     |
| $\sigma_y$                   | Yield point (MPa)                                            |
| $\sigma_{ult}$               | Ultimate strength (MPa)                                      |

## **ABSTRACT**

The elastic modulus, yield point, and ultimate strength of 1018 steel were determined in uniaxial tension. The "dogbone" specimen geometry was used in a sample of 0.41 mm of diameter and 95 mm of length.

## **INTRODUCTION OF STRESS THEORY**

When forces are applied to materials, they deform in reaction to those forces. The magnitude of the deformation for a constant force depends on the geometry of the materials. Likewise, the magnitude of the force required to cause a given deformation, depends on the geometry of the material. For these reasons, engineers define stress and strain. Stress (engineering definition) is given by:

$$\sigma = \frac{F}{A} \quad (1)$$

Defined in this manner, the stress can be thought of as a normalized force. Strain (engineering definition) is given by:

$$\epsilon_i = \frac{\Delta l_i}{l_{0i}} \quad (2)$$

The strain can be thought of as a normalized deformation. While the relationship between the force and deformation depends on the geometry of the material, the relationship between the stress and strain is geometry independent. The relationship between stress and strain is given by a simplified form of Hooke's Law [1]:

$$\sigma = E\epsilon \quad (3)$$

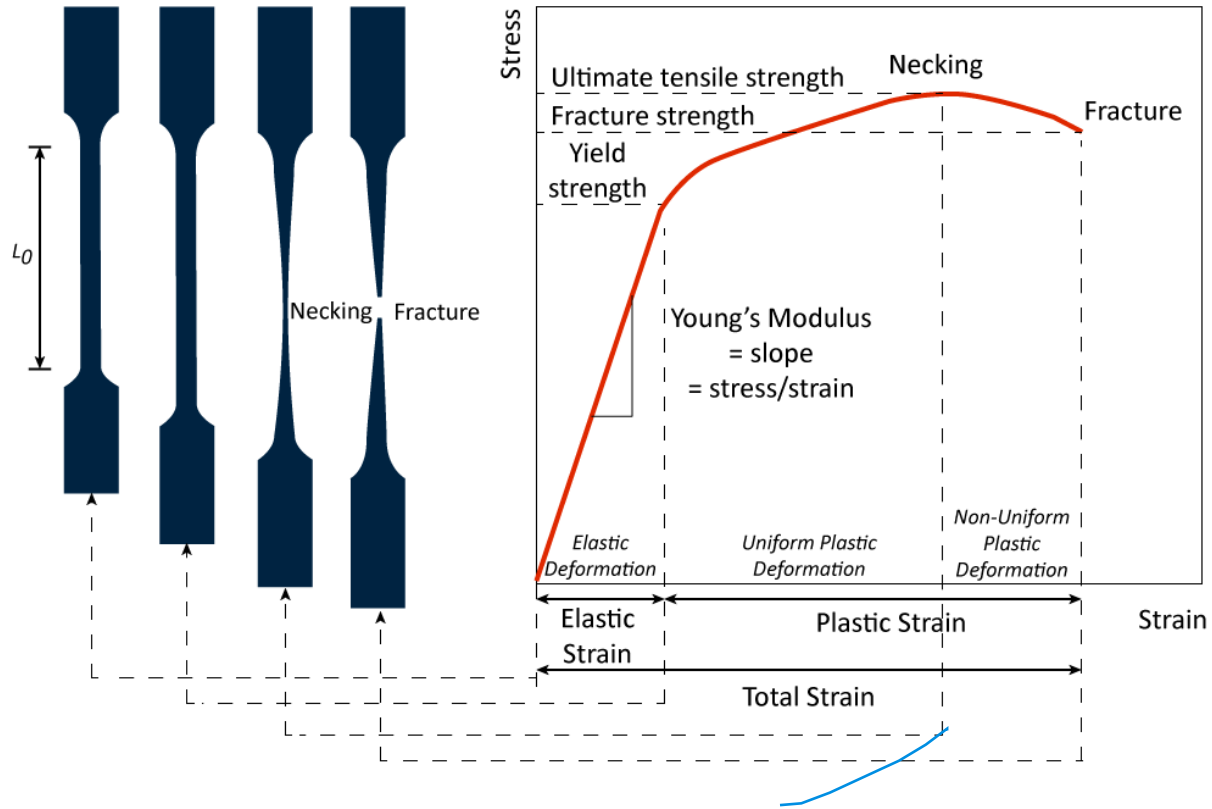
Since  $E$  is independent of geometry, it is often thought of as a material constant. However,  $E$  is known to depend on both the chemistry, structure, and temperature of a material. Change in any of these characteristics must be known before using a "handbook value" for the elastic modulus.

Hooke's Law (Equation 3) predicts a linear relationship between the strain and the stress and describes the elastic response of a material. In materials where Hooke's Law describes the stress-strain relationship, the elastic response is the dominant deformation mechanism. However, many materials exhibit nonlinear behavior at higher levels of stress. This nonlinear behavior occurs when plasticity becomes the dominant deformation mechanism. Metals are known to exhibit both elastic and plastic response regions [2]. The transition from an elastic response to a plastic response occurs at a critical point known as the yield point ( $\sigma_y$ ). Since a plastic response is characterized by permanent deformation (bending), the yield point is an important characteristic to know. In practice, the yield point is the stress where the stress-strain behavior transforms from a linear relationship to a non-linear relationship. The most used method to experimentally determine the yield point is the 0.2% offset method [3]. In this method, a line is drawn from the point ( $\sigma=0, \epsilon=0.2\%$ ) parallel to the linear region of the stress-strain graph. The slope of this line is equal to the elastic modulus. The yield point is then determined as the intersection of this line with the experimental data.

In materials that exhibit a large plastic response, the deformation tends to localize. Continued deformation occurs only in this local region and is known as necking [4]. Necking begins at a critical point known as the ultimate stress ( $\sigma_{ult}$ ). Since failure occurs soon after necking begins, the ultimate stress is an important characteristic to know.

While many experimental tests exist to determine the mechanical properties, the simplest is the tension test. A convenient sample geometry for the tensile test is the "dogbone" geometry (Figure 1). In this test geometry, one end the test specimen is held fixed while the other end is pulled in uniaxial tension collinear with the long axis of the sample. The forces throughout the sample and test machine are constant, but the stress varies with cross sectional area. The stress reaches critical values first in the region of the sample of minimum cross section, and the minimum cross section is in the sample. Therefore, the properties of the material are determined in this region.

**Figure 1. "Dogbone" specimen geometry used for tensile test.**



### EXPERIMENTAL PROCEDURE

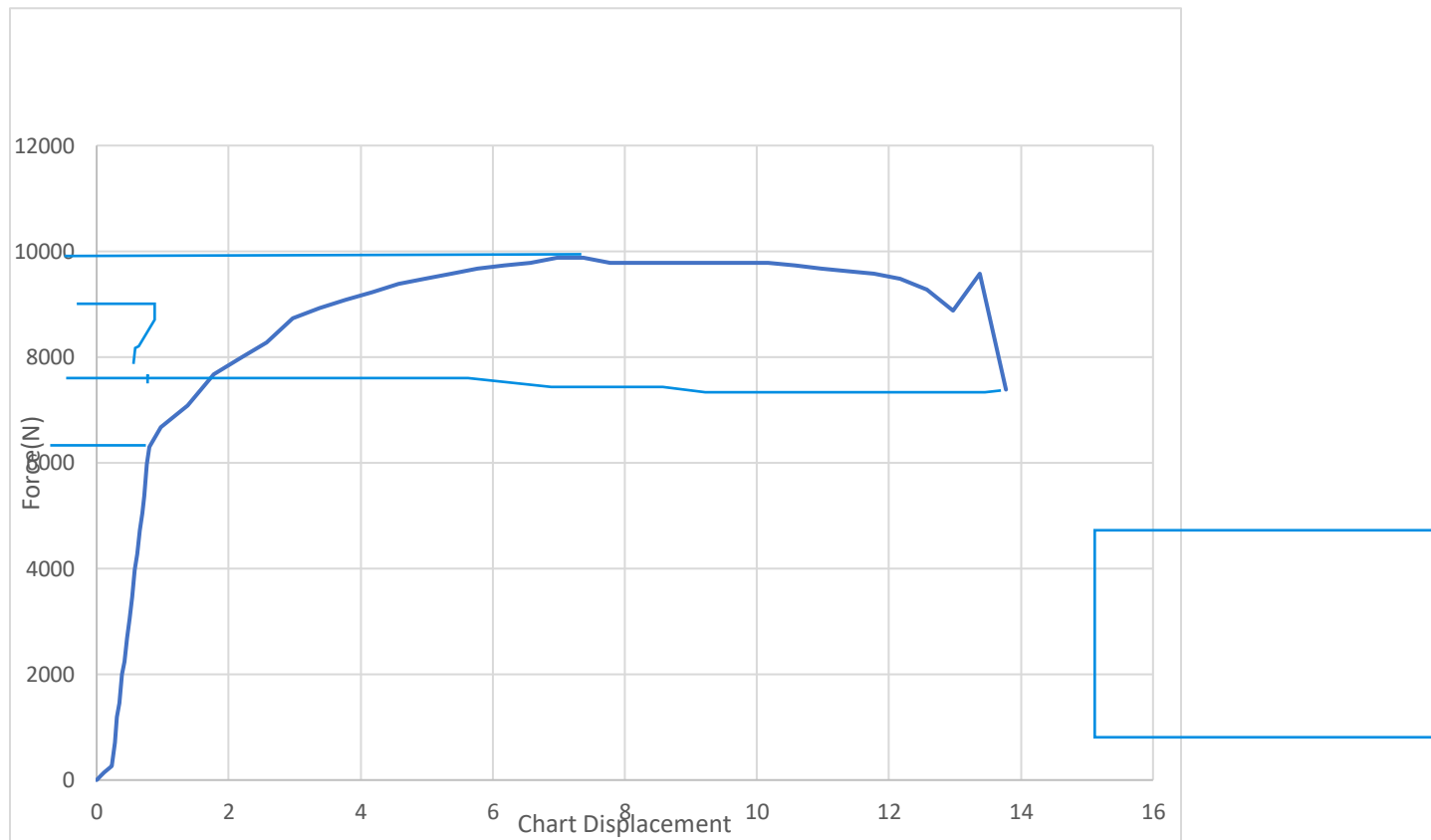
A sample with a diameter of steel 0.41mm and a length 95mm. This sample was clamped into an Instron Universal Test Machine (Model 1125). The Instron test machine is a displacement-controlled machine. One end of the sample was held at a fixed position with the other end was displaced at a constant rate. A load cell (Instron model 2511-319) was used to determine the force required to maintain a constant displacement rate. The accuracy of the load cell was  $\pm 1$  N. Data was collected on a strip chart (Instron model A1030) that monitored the force as a function of chart displacement. The stress in the sample at any force level can be determined from Equation 1. The calculation of strain requires the conversion of chart displacement ( $\delta_{\text{chart}}$ ) to sample displacement ( $\delta_{\text{sample}}$ ). The sample displacement can be calculated from:

$$\delta_{\text{sample}} = \frac{\delta_{\text{chart}} V_{\text{displacement}}}{V_{\text{chart}}} \quad (4)$$

The rate of sample displacement was  $1 \pm 0.01$  mm/min. The rate of chart displacement was  $10 \pm 0.1$  mm/min. The elastic modulus, yield point, and ultimate stress were determined from the stress-strain plot.

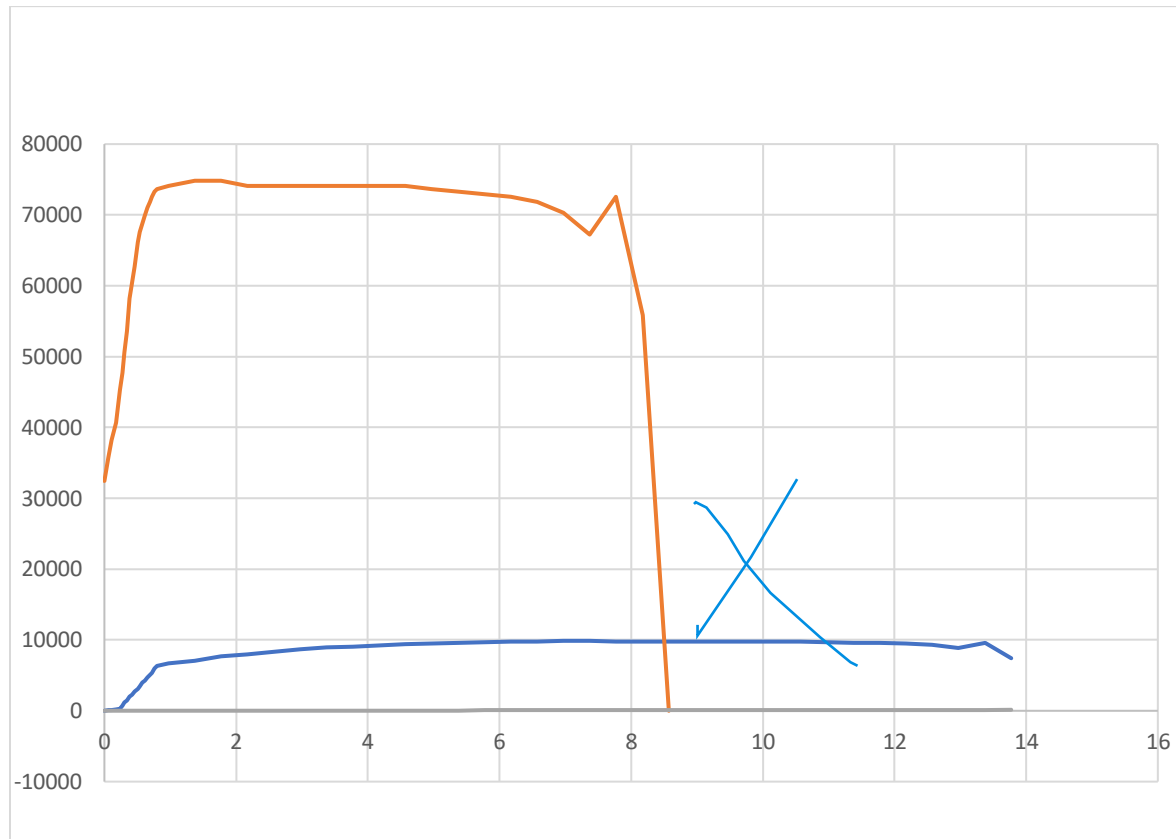
## RESULTS AND DISCUSSION

The force-chart displacement graph for the 1018 steel examined is shown in Figure 2. The data shown in Figure 2 were converted to a corresponding stress-strain graph, Figure 3. Figure 3 clearly indicates two regions of linear behavior in the low strain region of the stress-strain graph. This behavior suggests that the sample was very compliant at low stress levels, and very stiff at high stress levels. Unfortunately, there is no structural or chemical reason why steel should exhibit an increasing modulus with increasing stress. Therefore, a more probable explanation is realignment and rotation of the test fixture in the low stress (low force) region. Remember, that the test fixture and the sample are under the same applied force. Under these experimental conditions, the most compliant member will dominate the stress-strain behavior. While the fixture appears very compliant during realignment and rotation, the fixture appears very stiff due to its large cross section at higher force levels. In this second region, the stress-strain behavior is dominated by the sample.



**Figure 2.** Force as function of chart displacement for 1018 steel tested in tension.





**Figure 3.** Stress-Strain plot for 1018 steel tested in tension.

## **CONCLUSIONS**

The elastic modulus, yield point, and ultimate stress of 1018 steel were determined in uniaxial tension. The "dogbone" specimen geometry was used. At low forces, the dominant response was realignment and rotation of the test fixture. At high forces, deformation of the sample was the dominant response. The elastic modulus, yield point, and ultimate strength values determined are shown in Table I. The mean and standard deviation of the yield point were not calculated due to problems associated with realignment and rotation of the fixture.

## **REFERENCES**

1. Van Vlack, L.H., *Introduction to Materials Science and Engineering* - 6<sup>th</sup> Edition, Addison Wesley, 1989, p 8.
2. Smith, W.F., *Principles of Materials Science and Engineering* - 2<sup>nd</sup> Edition, McGraw Hill, 1990, p 255.

**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING  
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 2061 – Materials and Dynamics Lab**

**SPRING 2021**

**Instructor: Md. Jobair Bin Alam, Ph.D.**

**Title of Assignment**

**Pulley-Cable Mechanism**

**Outcome Measured Using this Assignment**

**Outcome 6**

An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions

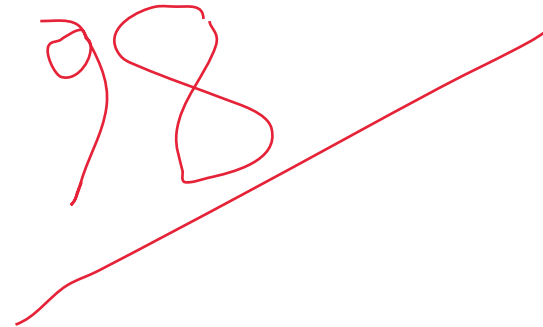
**Check the engineering design characteristics related to this assignment**

|                                                           |                                                                                      |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Ability to develop experiment</b>                      |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Identify the appropriate parameters                                                  |
| ×                                                         | Identify and select appropriate equipment to determine the parameters experimentally |
| ×                                                         | Provide steps to set up and conduct the experiment                                   |
| ×                                                         | Identify data collection method to obtain the experiment results                     |
| <b>Ability to conduct experiment</b>                      |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Conduct experiment maintaining all safety precautions                                |
| ×                                                         | Safe and proper handling of equipment                                                |
| ×                                                         | Collect and record data using appropriate units of measurements and relevant figures |
| <b>Ability to analyze and interpret experimental data</b> |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Data presenting in tabular/graphical format to aid in interpretation                 |
| ×                                                         | Use appropriate statistical analysis (if required) to interpret data and results     |
| ×                                                         | Draw appropriate conclusions using engineering judgment based on experiment          |

**Brief justification of the suitability of assignment for the outcome**

The lab experiment will increase the students' ability to identify the parameters to be measured and appropriate equipment to be used, along with conducting experiments and interpret data and results.

**Department of Civil & Environmental Engineering**  
**Prairie View A&M University**



**CVEG 2061 P81 Materials and Dynamics**  
**Laboratory**

Spring 2021

**Laboratory Report on**  
**“Determination of Acceleration in a Pulley Cable System”**

**Conducted on**  
April 2, 2021

**Submitted by**  
Sanjay Tillmutter

**On**  
April 9, 2021

To

**Dr. Md Jobair Bin Alam**  
*Materials and Dynamics Laboratory Instructor*  
CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT

MATERIALS AND DYNAMICS LABORATORY

LABORATORY GRADING SHEET

SPRING 2021

Title of Experiment:” Determination of Acceleration in a Pulley Cable System”

Name: Sanjay Tillmutter

Date Lab was Performed: Friday April 2, 2021 Report Due Date: Friday April 9, 2021

| <i>Ability to Conduct Experiments</i>                                                                                                             | MAX       | Your Score | Comments |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------|----------|
| Ability to demonstrate general lab safety (by your conduct and observations).                                                                     | 3         |            |          |
| Ability to follow and properly state the procedure used for the experiment, while maintaining all safety precautions.                             | 9         |            |          |
| Ability to demonstrate knowledge of how equipment function, their limitations, and the uncertainty associated with reading the instruments.       | 6         |            |          |
| Ability to collect and record data using appropriate units of measurement and identify the dependent and independent variables in the experiment. | 15        |            |          |
| <b>Total for Ability to Conduct Experiments</b>                                                                                                   | <b>33</b> |            |          |
| <b>Percentage for this Performance Criteria</b>                                                                                                   |           |            |          |
| <i>Ability to Analyze and Interpret experimental Data</i>                                                                                         |           |            |          |
| Provides appropriate abstracts for the experimental report                                                                                        | 5         |            |          |
| Ability to analyze the data using appropriate software to generate the required parameters using consistent units and significant figures.        | 22        |            |          |
| Use of statistical analysis as needed including uncertainty analysis                                                                              | 5         |            |          |
| Ability to present the data (raw /derived) in tabular and graphical form to meet the objectives and to aid in interpretation.                     | 14        |            |          |
| Ability to discuss the raw and derived data/graphs and assess the validity of the results in relation to the underlying theory.                   | 14        |            |          |
| Ability to draw appropriate and reasonable conclusions in relations to each of the experimental objectives.                                       | 7         |            |          |
| <b>Total for Ability to Analyze and Interpret experimental Data</b>                                                                               | <b>67</b> |            |          |
| <b>Percentage for this Performance Criteria</b>                                                                                                   |           |            |          |
| <b>TOTAL FOR THIS LAB</b>                                                                                                                         |           |            |          |

## LETTER OF TRANSMITTAL

April 9, 2021

Dr. Bin Alam  
Department of Civil & Environmental Engineering  
Prairie View A&M University

Dear Dr. Bin Alam:

The Technical Laboratory Report attached to this document contains the detailed results from the “Determination of Acceleration in a Pulley Cable System” Laboratory work conducted on the 2<sup>nd</sup> of April. The Report contains the objective and theory of the determination of the acceleration in a pulley cable system, along with any equations used in the analysis of data for the experiment. At the end of the report are the interpretations of the results, including the conclusion and any recommendations.

Please feel free to contact me by email at [stillmutt@pvamu.edu](mailto:stillmutt@pvamu.edu) if you have any questions on the report.

Sincerely,

*S.Tillmutt*

Sanjay Tillmutt.

## ABSTRACT

A laboratory experiment was conducted to use the data obtained from a pulley cable experiment to plot a diagram of velocity vs time and determine the acceleration of the masses in the pulley system experimentally and theoretically. In this experiment, two masses of known weight were placed in the pulley system, and the time and displacement recorded in order to determine velocity of the masses during the experiment. Data from the experiment was collected and shared. A graph of velocity vs time was plotted and generated using the data obtained from the experiment. Results of experimental and theoretical acceleration were computed, recorded, and discussed.



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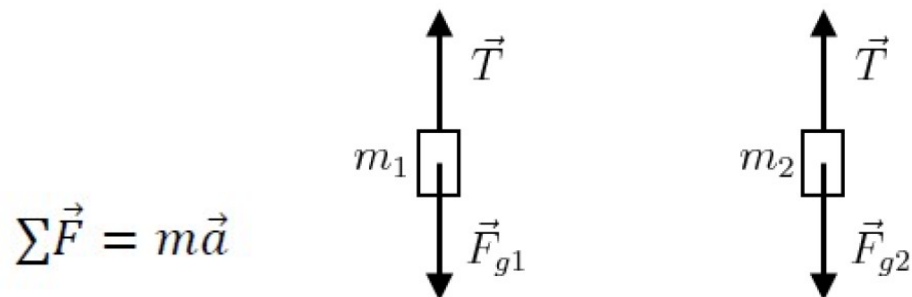
## CHAPTER 1 – ABILITY TO CONDUCT EXPERIMENT

### 1.1 Objective:

The objective of this experiment was to determine the acceleration, both experimental and theoretical, of the masses in a pulley system, and compare them to show the percentage yield. The objective was also to demonstrate the relationship between acceleration and the Velocity vs Time graph.

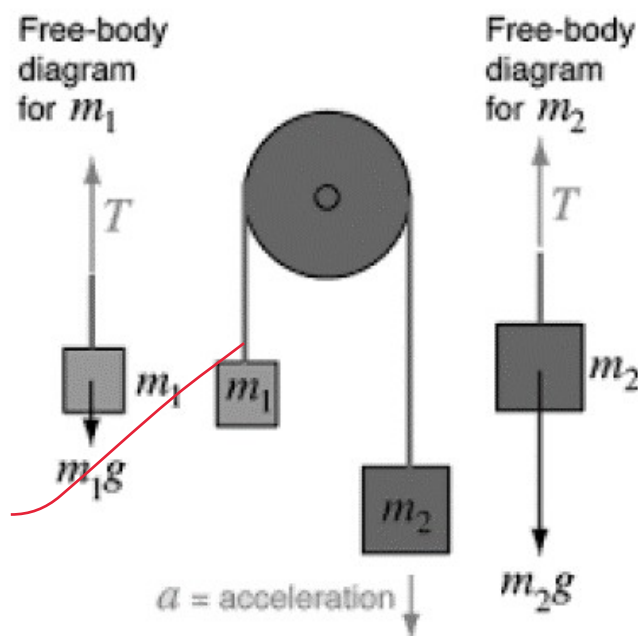
### 1.2 Theory:

According to Newton's 2nd Law the acceleration of an object depends on the net applied force and the object's mass. The string is hung over a pulley so that both masses are hanging. The weight of one mass pulls the system in one direction, while the weight of the other mass pulls in the other direction.



In the above free body diagrams,  $T$  is the tension in the string. Assuming that the pulley is massless and frictionless, and the string has no mass and does not stretch, the tension  $T$  will be the same throughout the string.

$$T = \frac{2g(m_1)(m_2)}{m_1 + m_2}$$



$$\sum F_{1y} = T - m_1g = m_1a_1$$

$$\sum F_{2y} = T - m_2g = m_2a_2$$

Considering the direction of movement

$$\sum F_{1y} = T - m_1g = m_1a$$

$$\sum F_{2y} = -T + m_2g = m_2a$$

Adding the above two equations we get:

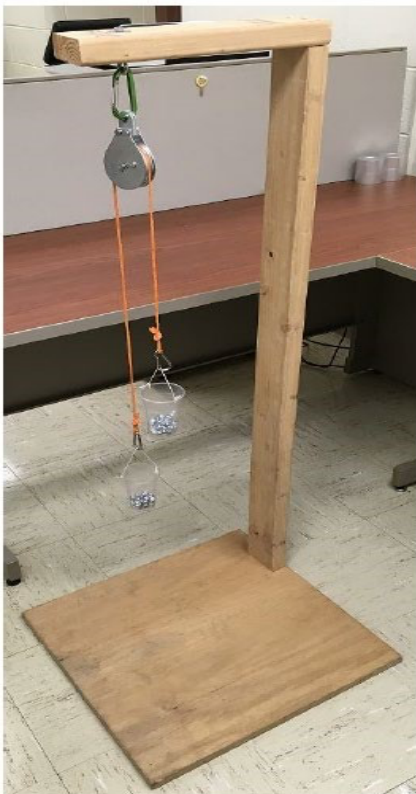
$$m_2g - m_1g = m_1a + m_2a$$

$$\Delta mg = m_{\text{tot}}a$$

$$a = g \left( \frac{\Delta m}{m_{\text{tot}}} \right)$$

### 1.3 Apparatus:

- Pulley System
- Masses
- Stopwatch



#### **1.4 Experimental Safety:**

The safety precautions followed during this experiment included wearing safety goggles, full sleeve shirts, and making sure not to inhale or ingest any of the test fluids. Due to the pandemic situation in this semester, social distancing, gloves, and masks were required.

#### **1.5 Experimental Procedure:**

##### **Method**

- The pulley system setup was prepared along with the masses by the instructor.
- The time and distance it took for the masses to move were recorded.
- The weights of the masses were recorded

## **CHAPTER 2 – RAW EXPERIMENTAL DATA:**

### **2.1 Experimental Data:**

The data collection was conducted as a group effort for the recording of the weight of the masses for each run. The recorded data is shown in Table 1.

**Table 1 – Raw Experimental Data – Mass Weights**

| <u>Run #</u> | <u>m<sub>1</sub> (g)</u> | <u>m<sub>2</sub> (g)</u> |
|--------------|--------------------------|--------------------------|
| <u>1</u>     | <u>370</u>               | <u>390</u>               |
| <u>2</u>     | <u>350</u>               | <u>410</u>               |
| <u>3</u>     | <u>330</u>               | <u>430</u>               |
| <u>4</u>     | <u>310</u>               | <u>450</u>               |

By looking at Table 1 it is seen that the initial masses used in the experiment ( $m_1$ ) were decreased for each run. Conversely, the final masses used in the experiment ( $m_2$ ) increased for each run.

Additional data was recorded during the experiment and is shown below in Table 2.

**Table 2 – Raw Experimental Data – Four Runs**

|            | Run 1          |  |            | Run 2          |  |            | Run 3          |  |            | Run 4          |
|------------|----------------|--|------------|----------------|--|------------|----------------|--|------------|----------------|
| Time (sec) | Velocity (m/s) |  | Time (sec) | Velocity (m/s) |  | Time (sec) | Velocity (m/s) |  | Time (sec) | Velocity (m/s) |
| 0          | 0              |  | 0          | 0              |  | 0          | 0              |  | 0          | 0              |
| 0.2        | 0.0614         |  | 0.2        | 0.151548       |  | 0.2        | 0.26847        |  | 0.2        | 0.37458        |
| 0.4        | 0.114535       |  | 0.4        | 0.31847        |  | 0.4        | 0.51245        |  | 0.4        | 0.76514        |
| 0.6        | 0.13954        |  | 0.6        | 0.42154        |  | 0.6        | 0.78954        |  | 0.6        | 1.18954        |
| 0.8        | 0.19578        |  | 0.8        | 0.63548        |  | 0.8        | 1.06245        |  | 0.8        | 1.498514       |
| 1          | 0.26147        |  | 1          | 0.80654        |  | 1          | 1.32155        |  | 1          | 1.78549        |
| 1.2        | 0.29478        |  | 1.2        | 1.05484        |  | 1.2        | 1.59254        |  | 1.2        | 2.28485        |
| 1.4        | 0.37451        |  | 1.4        | 1.098457       |  | 1.4        | 1.75145        |  | 1.4        | 2.33548        |
| 1.6        | 0.414521       |  | 1.6        | 1.31115        |  | 1.6        | 2.1215         |  | 1.6        | 3.154          |

From Table 2, it is seen that, for each run, as time went on velocity increased.

### **CHAPTER 3 – RESULTS AND DISCUSSION:**

Information from Table 1 and Table 2 was used to help compute the net force, net mass, total mass, theoretical and experimental accelerations, and percentage error values seen in Table 3. Table 3 shows the values from Table 1 and Table 2, and those which were calculated from the information in it.

**Table 3 – Raw Experimental Data, Net Force, Experimental and Theoretical Accel., and Percent Error**

| <b>Run #</b> | <b>m<sub>1</sub> (g)</b> | <b>m<sub>2</sub> (g)</b> | <b>m<sub>tot</sub> (g)</b> | <b>m<sub>tot</sub> (Kg)</b> | <b>dm (g)</b> | <b>dm (Kg)</b> | <b>F<sub>net</sub> (N)</b> | <b>a<sub>exp</sub> (m/s<sup>2</sup>)</b> | <b>a<sub>the</sub> (m/s<sup>2</sup>)</b> | <b>% error</b>   |
|--------------|--------------------------|--------------------------|----------------------------|-----------------------------|---------------|----------------|----------------------------|------------------------------------------|------------------------------------------|------------------|
| <b>1</b>     | <b>370</b>               | <b>390</b>               | <b>760</b>                 | <b>0.76</b>                 | <b>20</b>     | <b>0.02</b>    | <b>0.1962</b>              | <b>0.259</b>                             | <b>0.258157895</b>                       | <b>0.3261978</b> |
| <b>2</b>     | <b>350</b>               | <b>410</b>               | <b>760</b>                 | <b>0.76</b>                 | <b>60</b>     | <b>0.06</b>    | <b>0.5886</b>              | <b>0.785</b>                             | <b>0.774473684</b>                       | <b>1.3591573</b> |
| <b>3</b>     | <b>330</b>               | <b>430</b>               | <b>760</b>                 | <b>0.76</b>                 | <b>100</b>    | <b>0.1</b>     | <b>0.981</b>               | <b>1.25</b>                              | <b>1.290789474</b>                       | <b>3.1600408</b> |
| <b>4</b>     | <b>310</b>               | <b>450</b>               | <b>760</b>                 | <b>0.76</b>                 | <b>140</b>    | <b>0.14</b>    | <b>1.3734</b>              | <b>1.785</b>                             | <b>1.807105263</b>                       | <b>1.2232416</b> |

Table 2 shows all the data associated with each of the 4 trials/runs in the experiment. These values were calculated using the raw experimental data from tables 1 and 2. From the two given masses for the first run, m<sub>1</sub> and m<sub>2</sub>, the total mass and net mass was computed and tabulated. The net force for each run was then calculated by multiplying the net mass by gravitational acceleration. The theoretical acceleration for each run was then acquired by dividing the net mass by the total mass for each run, and multiplying the quotient by the gravitational acceleration. For the experimental acceleration, a velocity vs time graph was plotted using the data given in Table 2 and taking the slope of the straight line which was fitted to the data points. Since both the experimental and the theoretical acceleration were known, the percentage yield could be determined by simply subtracting the experimental yield from the theoretical yield and dividing the difference by the theoretical yield and multiplying by 100. An absolute value was to be achieved, meaning that the result could never be a negative number.

The results showed that the calculations associated with this experiment were reasonably accurate, as the experimental and theoretical acceleration values for each run were fairly close to each other. The percentage yield for the 4 runs ranged from 0.326% to 3.16%, with the 1<sup>st</sup> run giving the most accuracy and the 3<sup>rd</sup> run be the least accurate. Even though 3.16% was the greatest percentage error in calculation of experimental acceleration this was by no means an inaccurate calculation, as that means that the experimental acceleration value for that run was off by just 3%, which is very marginal in these kinds of experiments.

Such a small margin of error could have possibly stemmed from the number being read on the stopwatch being rounded up or down, or maybe the person recording time took a second late to stop the clock. Either way, such a small margin can be overlooked, especially given that it was the highest in the margin of error for this experiment.

Four charts were plotted from the data in Table 2 so that the experimental acceleration could be determined. In order to determine the acceleration from these velocity vs time charts, the graph had to be set up with time on X-axis and velocity on Y-axis. A straight line was then fitted to each of these plots, and the slope taken for each, yielding the experimental acceleration values for each of the four runs. Each of the charts are shown below. Figure 1 shows the velocity vs time graph for the first run, and so on (Figure 4 is v vs t graph for Run 4).

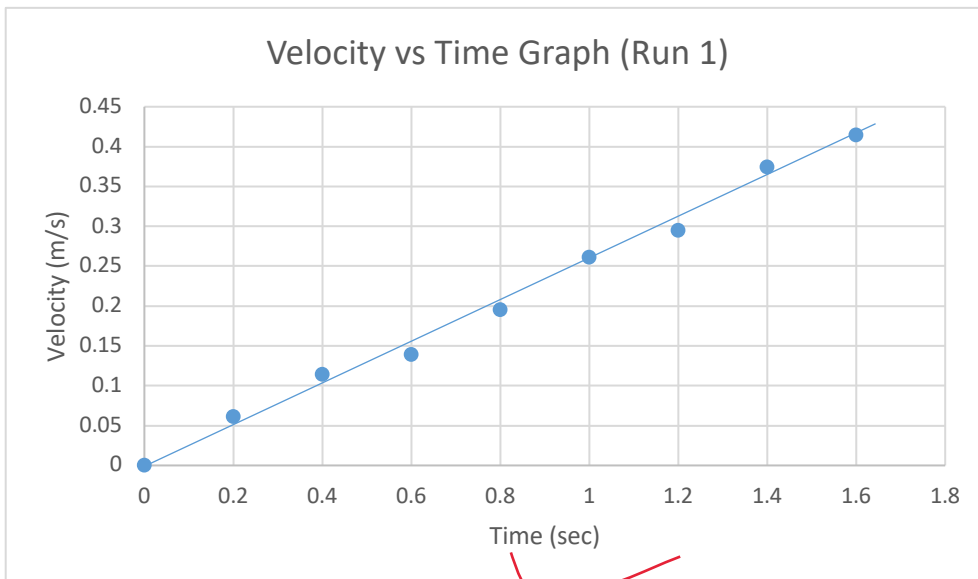


Figure 1

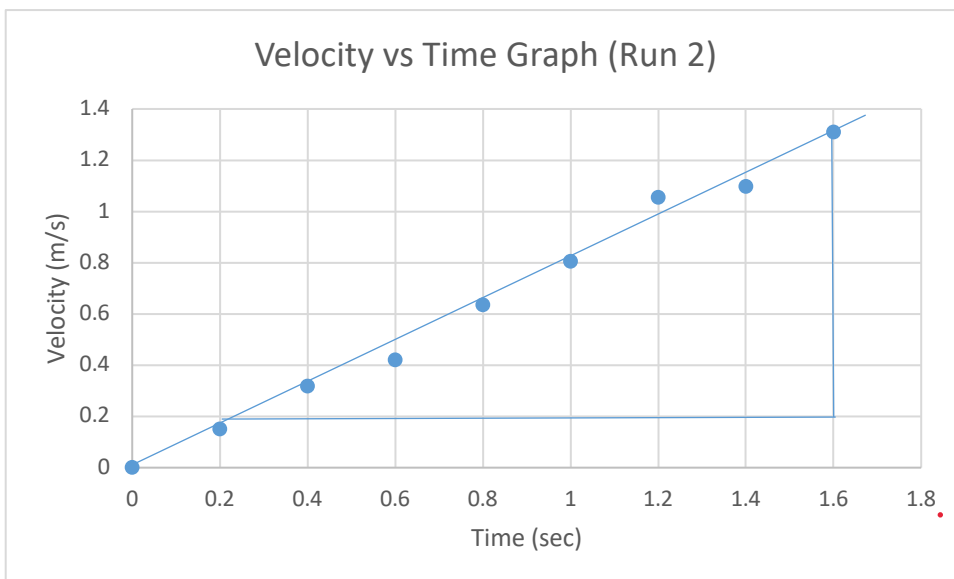


Figure 2

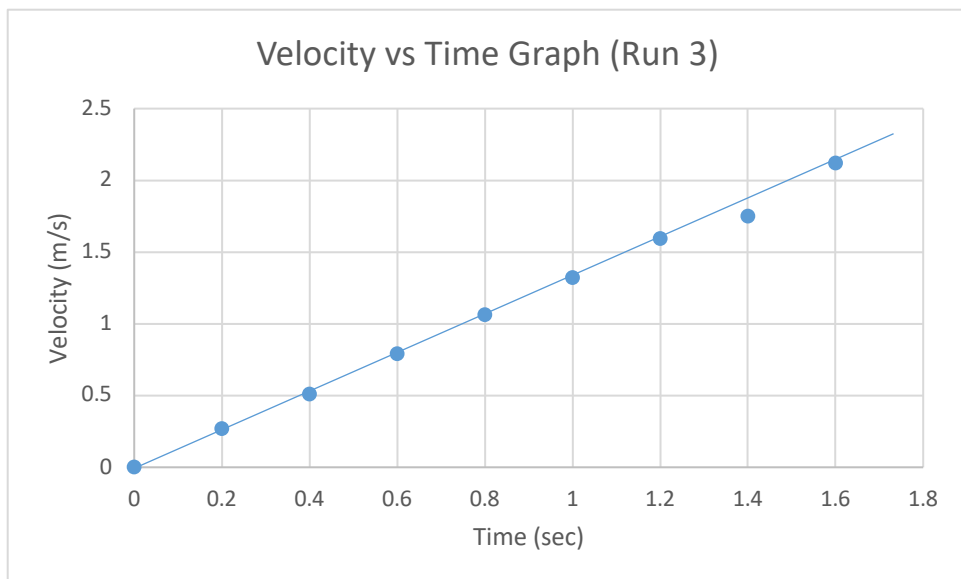


Figure 3

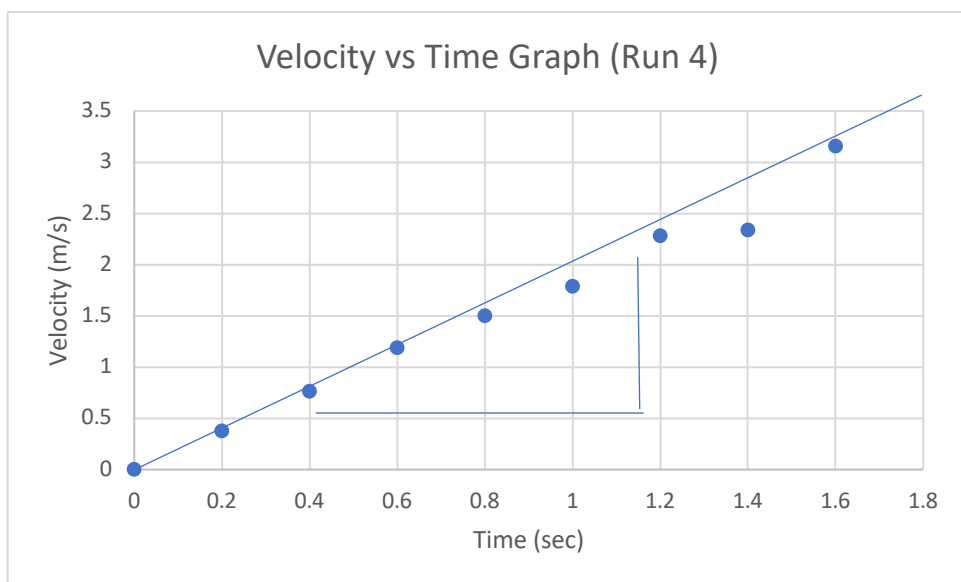


Figure 4



## **CHAPTER 4 – CONCLUSION**

### **4.1 Conclusion:**

A successful experiment was conducted to use the data obtained from a series of four experiments containing two masses in a pulley system, to plot a graph of velocity vs time in order to determine the experimental acceleration of the masses in the pulley system. The data obtained showed good consistency for the experiment. Results also showed that the calculated experimental and theoretical acceleration were consistently close to each other, meaning that there was confidence in the accuracy of the determination of the acceleration of the masses in the pulley system for each of the four runs. This is proven by the fact that the highest margin of error was 3.16%.

## Sample Calculations

**For calculation of total mass,  $m_{tot}$  (RUN 1)**

$$m_1 + m_2 = m_{tot}$$

$$\Rightarrow 370 + 390 = \frac{760g}{1000g} \times 1 Kg = 0.76 Kg$$

**Calculate  $\Delta m$**

$$m_2 - m_1 = \Delta m$$

$$\Rightarrow 390 - 370 = \frac{20g}{1000g} \times 1 Kg = 0.02 Kg$$

**Calculate  $F_{net}$**

$$F_{net} = \Delta m \times g$$

$$\Rightarrow 0.02 Kg \times 9.81 m/s^2$$

$$\Rightarrow 0.1962 Kgms^{-2} = 0.1962 N$$

**Calculate  $a_{the}$**

$$a_{the} = \frac{\Delta m}{m_{tot}} \times g$$

$$\Rightarrow \frac{0.02 Kg}{0.76 Kg} \times 9.81 m/s^2$$

$$= 0.258 m/s^2$$

**Calculate  $a_{exp}$**

Slope of Velocity vs Time graph =  $a_{exp}$

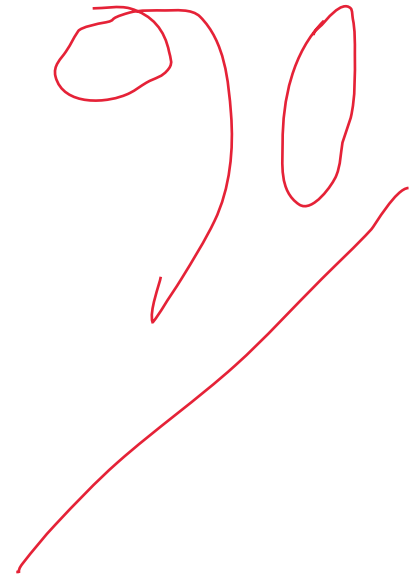
$$\Rightarrow \frac{Rise}{Run} = \frac{0.2 m/s}{0.77 s} = 0.259 m/s^2$$

**Calculate % error**

$$\% \text{ error} = \left| \frac{a_{the} - a_{exp}}{a_{the}} \times 100 \right|$$

$$\Rightarrow \left| \frac{0.258 - 0.259}{0.258} \times 100 \right| = 0.326 \%$$

**Prairie View A&M University**  
**Roy G. Perry College of Engineering**  
**Civil Engineering Department**



**CVEG 2061 P81- Materials and Dynamics**

**Lab Report 3- Pulley Cable**

**Nyja Kennedy**

**Given: 5 April 2021**

**Due: 9 April 2021**

## **Abstract**

**The purpose of this experiment** is for students to do the experiment and understand Newton's Second Law using the pulley cable.

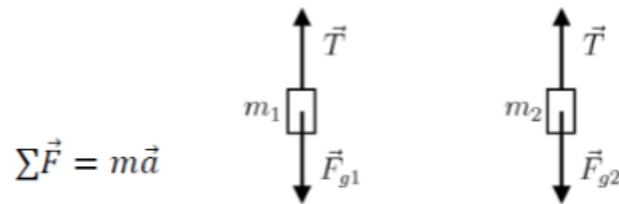


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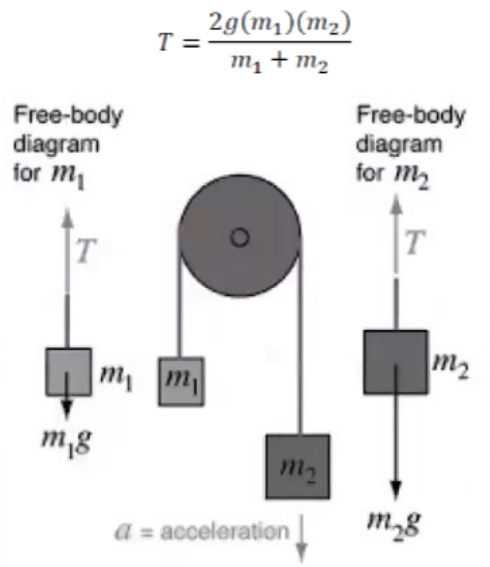
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## Introduction

According to Newton's 2nd Law the acceleration of an object depends on the net applied force and the object's mass. The string is hung over a pulley so that both masses are hanging. The weight of one mass pulls the system in one direction, while the weight of the other mass pulls in the other direction.



In the above free body diagrams,  $T$  is the tension in the string, assuming that the pulley is massless and frictionless, and the string has no mass and does not stretch, the tension  $T$  will be the same throughout the string.

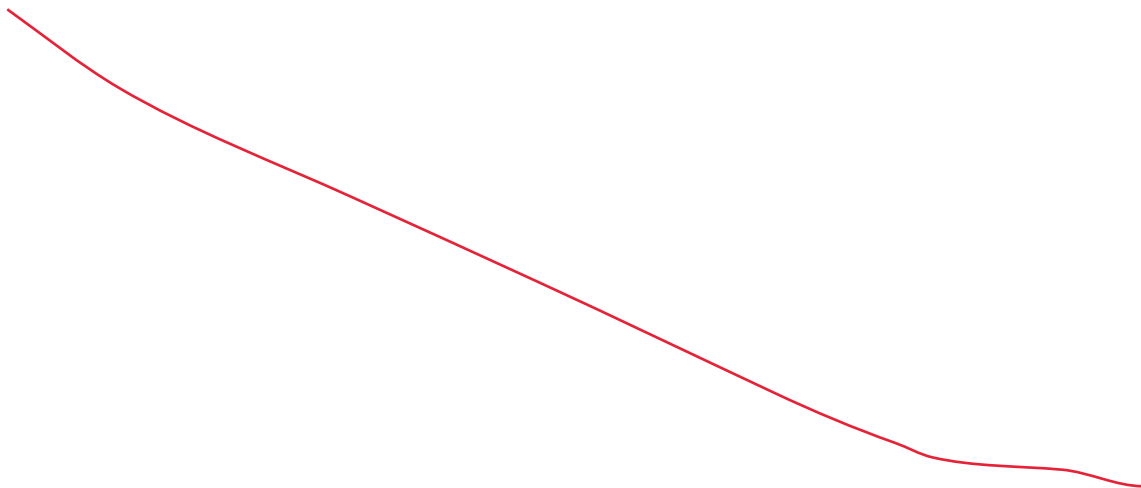


## Test Objectives

The test objective is to find the experimental acceleration from the results, theoretical acceleration, and percentage error from the experimental and theoretical acceleration.

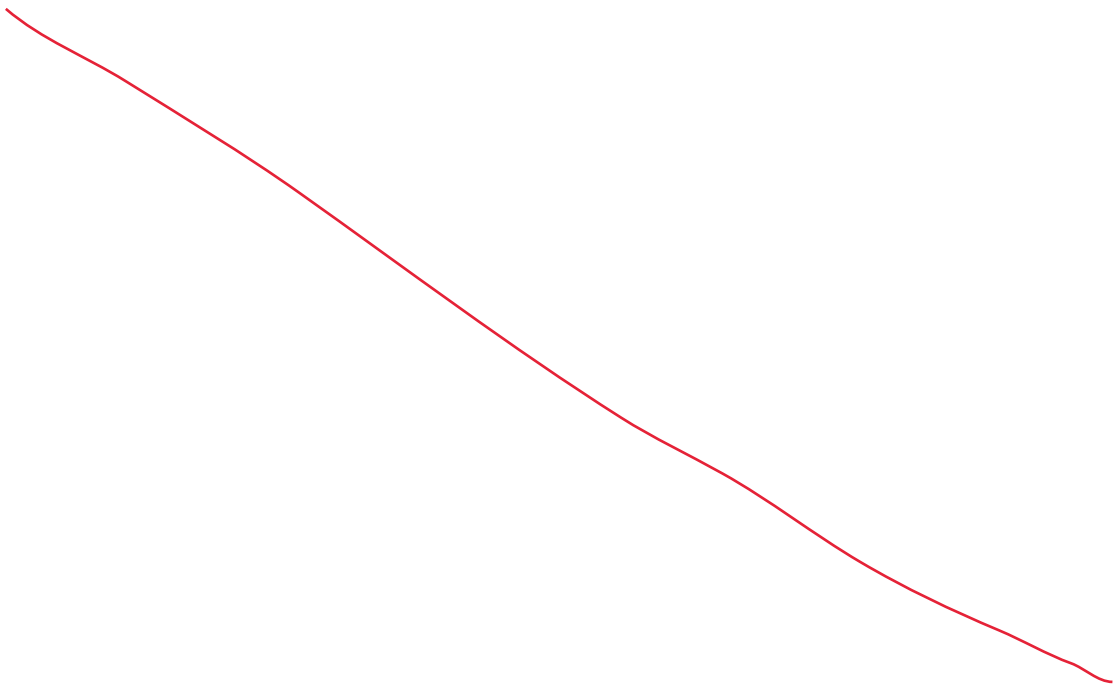
## Equipment and Apparatus

1. Weight hanger
2. Mass
3. Sting
4. Photogate
5. Pulley



## Material and Test Conditions

1. Notebook
2. Each group completed the experiment separately.
3. Check for equipment conditions
4. Start experiment



### **Data Analysis Methods and Model (Equations)**



Mass total is the sum of mass one and mass two(1)

Convert grams to kilograms by simply dividing the mass total by a thousand shown in the table.(2)

Delta mass is mass one subtracted by mass two which is converted from grams to kilograms by dividing by a thousand once mass one and mass two is subtracted.(3)

Net Force is in newtons is delta mass in kilograms multiplied by a thousand. (4)

Experimental acceleration is found by using time vs velocity. (5)

Once the scatter plot is made for each run, the slope is found which is the experimental acceleration.(6)

Theoretical acceleration delta mass divided by mass total multiplied by earths acceleration which is 9.81.(7)

Percent error is found by theoretical acceleration subtract divided by a theoretical multiplied by a hundred.(8)

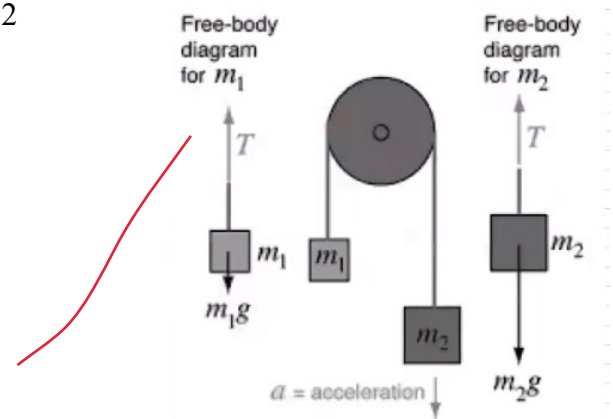
$$a = \frac{\Delta m}{m_{tot}} \times g$$

Equation 1

$F = ma$  Equation 2

Equation 3

$$T = \frac{2g(m_1)(m_2)}{m_1 + m_2}$$



## Suitable Statical Analysis Tools

For this experiment, there was no need for any statistical analysis tool as all the data obtained was able to process by using the machine and calculator.

## Test Results and Analysis

The following table shows a full set of experimental data from a Pulley-Cable test are provided. The test results are provided in the following tables.

Table 1

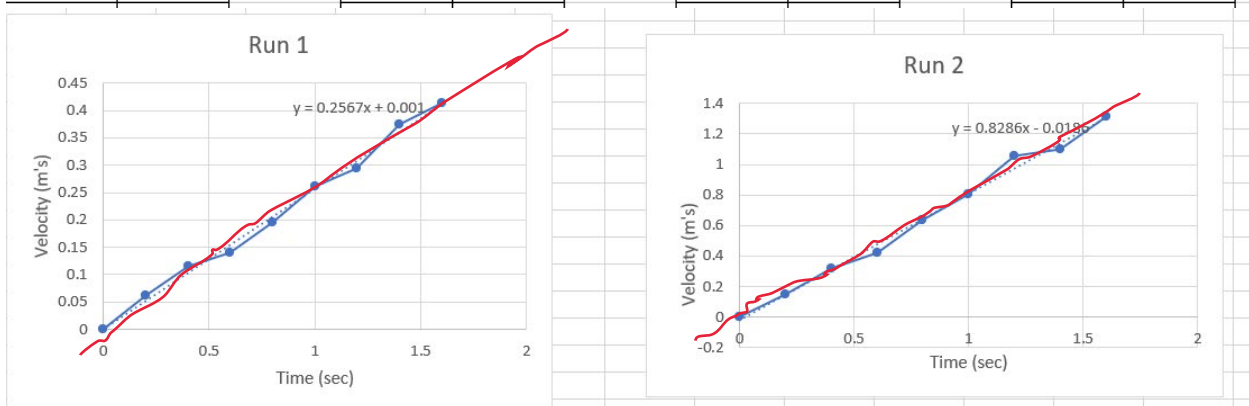
| Run # | m1  | m2  | mtot | mtot | $\Delta m$ | $\Delta m$ | Fnet   | aexp   | athe     | % error  |                |
|-------|-----|-----|------|------|------------|------------|--------|--------|----------|----------|----------------|
|       | g   | g   | g    | kg   | g          | kg         | N      | m/s^2  | m/s^2    |          |                |
| 1     | 370 | 390 | 760  | 0.76 | 20         | 0.02       | 0.1962 | 0.2567 | 0.258158 | 0.56473  |                |
| 2     | 350 | 410 | 760  | 0.76 | 60         | 0.06       | 0.5886 | 0.8286 | 0.774474 | -6.98879 | absolute value |
| 3     | 330 | 430 | 760  | 0.76 | 100        | 0.1        | 0.981  | 1.3023 | 1.290789 | -0.89174 |                |
| 4     | 310 | 450 | 760  | 0.76 | 140        | 0.14       | 1.3734 | 1.855  | 1.807105 | -2.65036 |                |

$$a = \frac{\Delta m}{m_{tot}} \times g$$

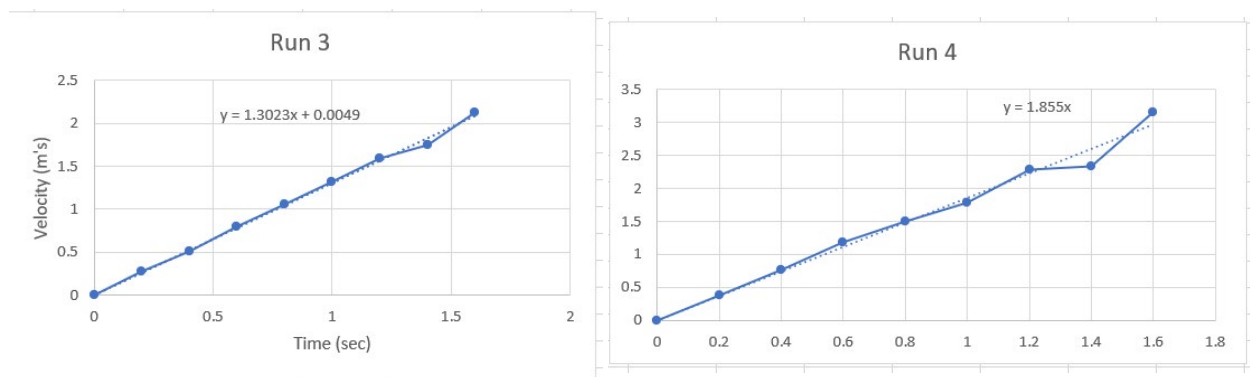
A full set of data such as mass one and mass two was given in the table shown as the pulley-cable test. Mass total is the sum of mass one and mass two, then we convert grams to kilograms by simply dividing the mass total by a thousand shown in the table. Delta mass is mass one subtracted by mass two which is converted from grams to kilograms by dividing by a thousand once mass one and mass two is subtracted. Net Force is in newtons is delta mass in kilograms multiplied by a thousand. Experimental acceleration is found by using time vs velocity shown in the table 2. Once the scatter plot is made for each run, the slope is found which is the experimental acceleration. Theoretical acceleration delta mass divided by mass total multiplied by earths acceleration which is 9.81. Percent error is found by theoretical acceleration subtract divided by a theoretical multiplied by a hundred.

Time vs Velocity Table 2

| Run 1 |          | Run 2 |          | Run3 |          | Run 4 |          |
|-------|----------|-------|----------|------|----------|-------|----------|
| Time  | Velocity | Time  | Velocity | Time | Velocity | Time  | Velocity |
| sec   | m's      | sec   | m's      | sec  | m's      | sec   | m's      |
| 0     | 0        | 0     | 0        | 0    | 0        | 0     | 0        |
| 0.2   | 0.0614   | 0.2   | 0.151548 | 0.2  | 0.26847  | 0.2   | 0.37458  |
| 0.4   | 0.114535 | 0.4   | 0.31847  | 0.4  | 0.51245  | 0.4   | 0.76514  |
| 0.6   | 0.13954  | 0.6   | 0.42154  | 0.6  | 0.78954  | 0.6   | 1.18954  |
| 0.8   | 0.19578  | 0.8   | 0.63548  | 0.8  | 1.06245  | 0.8   | 1.498514 |
| 1     | 0.26147  | 1     | 0.80654  | 1    | 1.32155  | 1     | 1.78549  |
| 1.2   | 0.29478  | 1.2   | 1.05484  | 1.2  | 1.59254  | 1.2   | 2.28485  |



→ should be straight line (best fit)



## Discussion Synthesis and Interpretation of Results and Findings

From this pulley text experiment using the physical pulley machine and the data given, the percent errors were found and were successful. Run one is 0.5%. Run two is 6.9%. Run three is 0.8 %. Run four is 2.5%. The percent value is not over 12% which means the experiment was successful. The experiment objective was successful by the experimental acceleration from the results, theoretical acceleration, and percentage error from the experimental and theoretical acceleration.

Concluding on the given data, graphs and calculations that were done for this experiment resembles on the percent error and the physical experiment show *in table 1 and table 2*.

## Summary

In conclusion this experiment was successful, and the objective was met due to finding the experimental acceleration from the results, theoretical acceleration, and percentage error from the experimental and theoretical acceleration. Time vs Velocity is important to finding theoretical acceleration for each run. The percent error displays the successful experiment that was conducted by students. Most information was found by using equations and simple calculations.

## Reference

Mechanics of materials 10th edition by R.C. Hibbeler

Zoom Recording Including slides shown Mr. Alam April 2, 2021

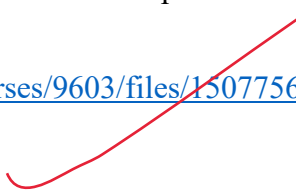
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Assignment Posted on Canvas by Mr. Alam

<https://ecourses.pvamu.edu/courses/9603/files/1507716?wrap=1>

Notes posted on canvas “ Pulley Cable Concpet Acceleration Determination” posted by Mr. Alam

[https://ecourses.pvamu.edu/courses/9603/files/1507756?module\\_item\\_id=397827](https://ecourses.pvamu.edu/courses/9603/files/1507756?module_item_id=397827)



Department of Civil & Environmental Engineering

CVEG 2061 Materials and Dynamics Lab

Assignment Report – 3

Noah Smith Jr.

75

Md Jobair Bin Alam

April 9, 2021

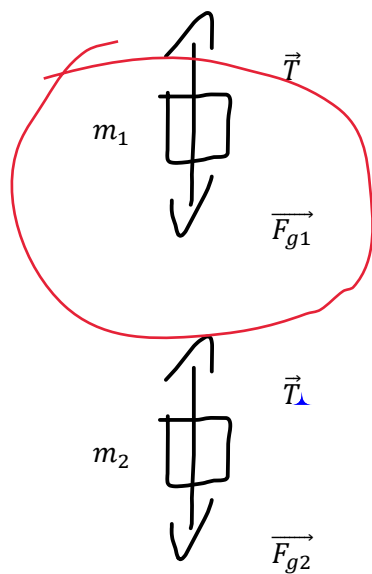
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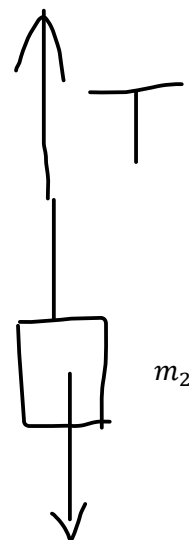
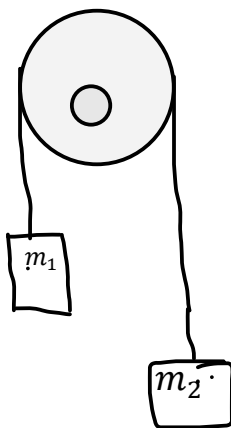
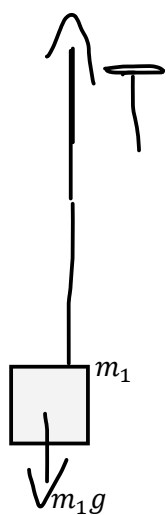
## Formula

$$\Sigma \vec{F} = m\vec{a}$$



you need to  
provide detail  
narrative!

$$T = \frac{2g(m_1)(m_2)}{m_1 + m_2}$$



a= acceleration

$m_2g$

$$\Sigma F_{1y} = T - m_1g = m_1a_1$$

$$\Sigma F_{2y} = T - m_2g = m_2a_2$$

Considering the direction of movement

$$\Sigma F_{1y} = T - m_1g = m_1a$$

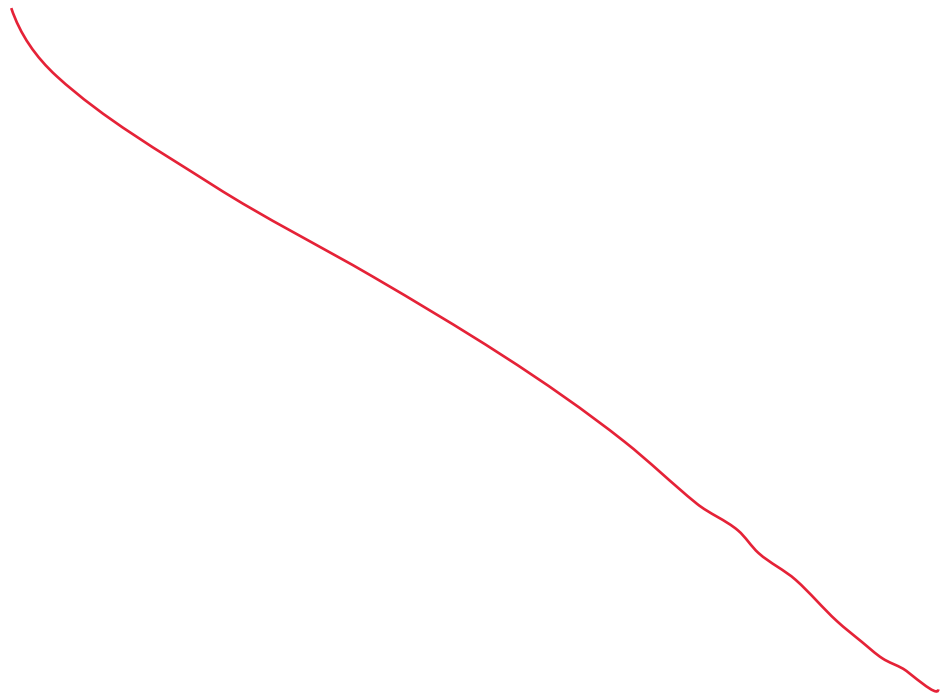
$$\Sigma F_{2y} = -T + m_2g = m_2a$$

Adding the above two equations we get:

$$m_2g - m_1g = m_1a + m_2a$$

$$\Delta mg = m_{tot}a$$

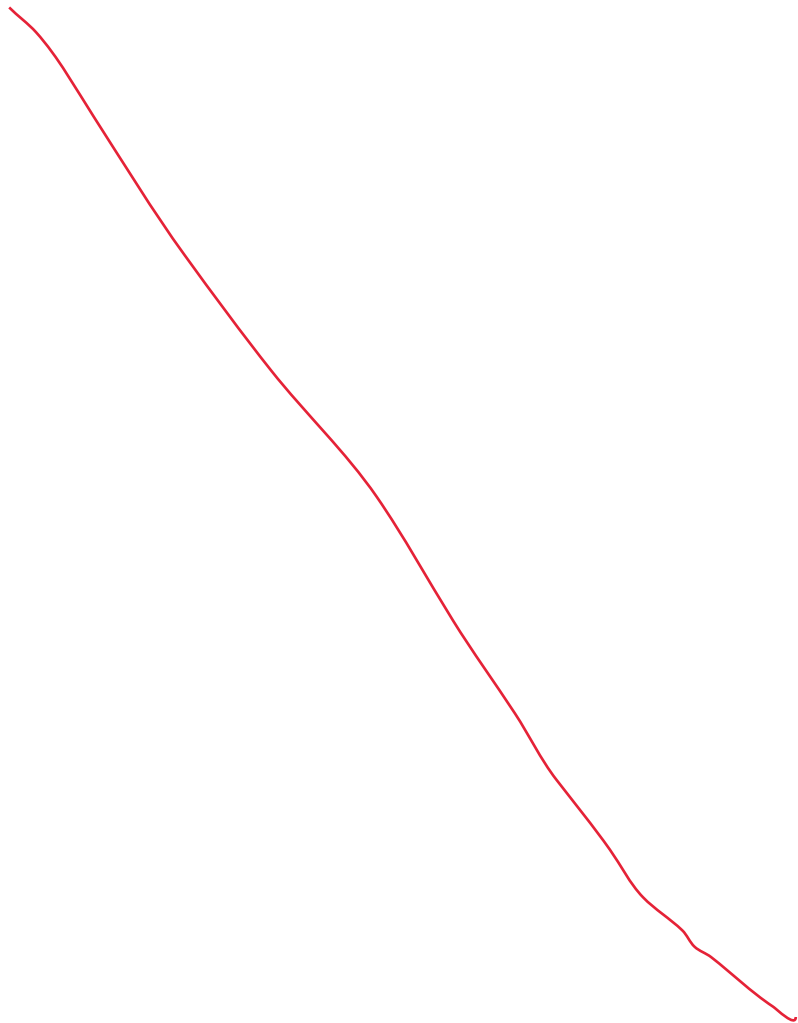
$$a = g\left(\frac{\Delta m}{m_{tot}}\right)$$





## Theory

According to Newton's 2nd Law the acceleration of an object depends on the net applied force and the object's mass. The string is hung over a pulley so that both masses are hanging. The weight of one mass pulls the system in one direction, while the weight of the other mass pulls in the other direction. In the above free body diagrams,  $T$  is the tension in the string, assuming that the pulley is massless and frictionless, and the string has no mass and does not stretch, the tension  $T$  will be the same throughout the string.

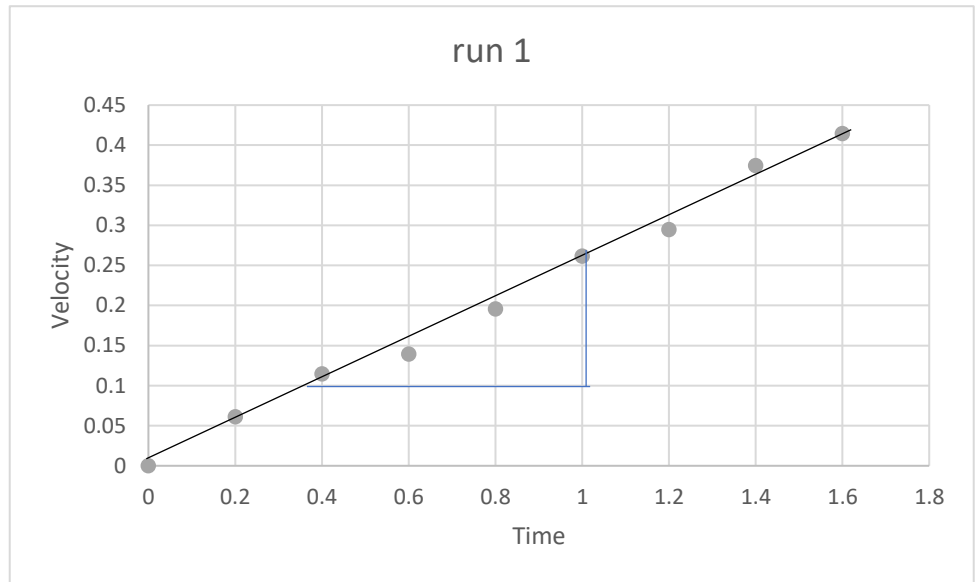


## Data

| Run # | m1       | m2  | mtot  | Mtot     | $\Delta m$ | $\Delta m$ | Fnet     | aexp             | athe             | % error  |
|-------|----------|-----|-------|----------|------------|------------|----------|------------------|------------------|----------|
|       | g        | g   | g     | Kg       | G          | kg         | N        | m/s <sup>2</sup> | m/s <sup>2</sup> |          |
|       |          |     |       |          |            |            |          |                  |                  |          |
| 1     | 370      | 390 | 760   | 0.76     | 20         | 0.02       | 0.1962   | 0.258065         | 2.578947         | 89.9934  |
| 2     | 350      | 410 | 760   | 0.76     | 60         | 0.06       | 0.5886   | 0.84507          | 7.736842         | 89.07733 |
| 3     | 330      | 430 | 760   | 0.76     | 100        | 0.1        | 0.981    | 1.25             | 12.89474         | 90.30612 |
| 4     | 310      | 450 | 760   | 0.76     | 140        | 0.14       | 1.3734   | 2                | 18.05263         | 88.92128 |
|       |          |     |       |          |            |            |          |                  |                  |          |
|       |          |     |       |          |            |            |          |                  |                  |          |
|       |          |     |       |          |            |            |          |                  |                  |          |
|       |          |     |       |          |            |            |          |                  |                  |          |
|       |          |     |       |          |            |            |          |                  |                  |          |
|       |          |     |       |          |            |            |          |                  |                  |          |
| Run 1 |          |     | Run 2 |          |            | Run 3      |          |                  | Run 4            |          |
| Time  | Velocity |     | Time  | Velocity |            | Time       | Velocity |                  | Time             | Velocity |
| Sec   | m/s      |     | sec   | m/s      |            | sec        | m/s      |                  | sec              | m/s      |
| 0     | 0        |     | 0     | 0        |            | 0          | 0        |                  | 0                | 0.37458  |
| 0.2   | 0.0614   |     | 0.2   | 0.151548 |            | 0.2        | 0.26847  |                  | 0.2              | 0.76514  |
| 0.4   | 0.114535 |     | 0.4   | 0.31847  |            | 0.4        | 0.51245  |                  | 0.4              | 0.76514  |
| 0.6   | 0.13954  |     | 0.6   | 0.42154  |            | 0.6        | 0.78954  |                  | 0.6              | 1.18954  |
| 0.8   | 0.19578  |     | 0.8   | 0.63548  |            | 0.8        | 1.06245  |                  | 0.8              | 1.498514 |
| 1     | 0.26147  |     | 1     | 0.80654  |            | 1          | 1.32155  |                  | 1                | 1.78549  |
| 1.2   | 0.29478  |     | 1.2   | 1.05484  |            | 1.2        | 1.59254  |                  | 1.2              | 2.28485  |
| 1.4   | 0.37451  |     | 1.4   | 1.098457 |            | 1.4        | 1.75145  |                  | 1.4              | 2.33548  |
| 1.6   | 0.414521 |     | 1.6   | 1.31115  |            | 1.6        | 2.1215   |                  | 1.6              | 3.154    |

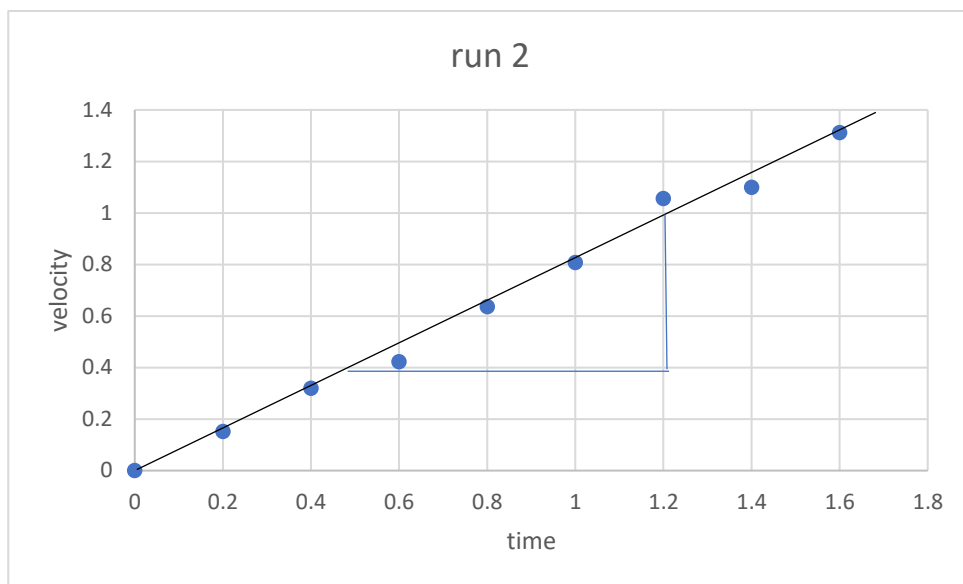
Graph of Run 1

| Run 1       |                 |
|-------------|-----------------|
| Time<br>sec | Velocity<br>m/s |
| 0           | 0               |
| 0.2         | 0.0614          |
| 0.4         | 0.114535        |
| 0.6         | 0.13954         |
| 0.8         | 0.19578         |
| 1           | 0.26147         |
| 1.2         | 0.29478         |
| 1.4         | 0.37451         |
| 1.6         | 0.414521        |



Graph of Run 2

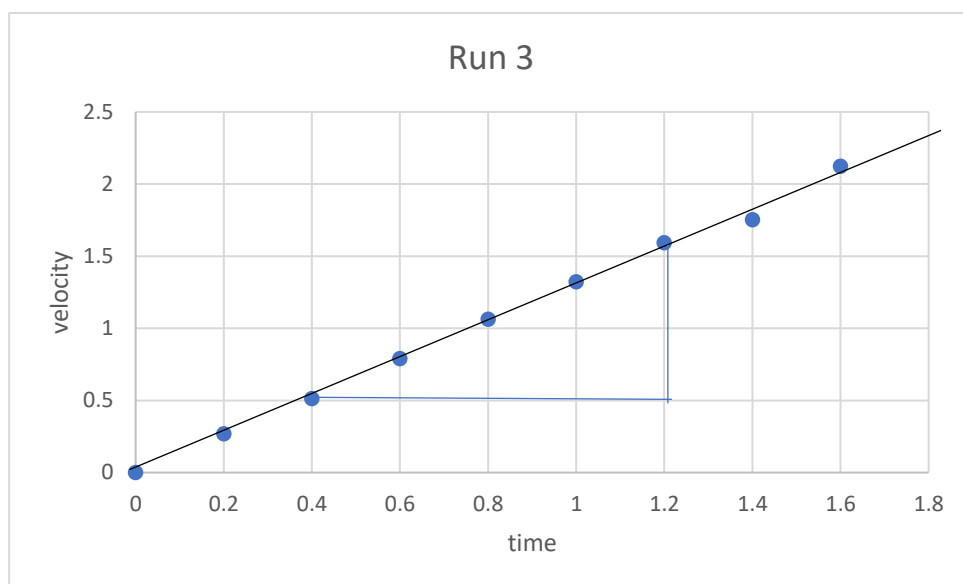
| Run 2       |                 |
|-------------|-----------------|
| Time<br>sec | Velocity<br>m/s |
| 0           | 0               |
| 0.2         | 0.151548        |
| 0.4         | 0.31847         |
| 0.6         | 0.42154         |
| 0.8         | 0.63548         |
| 1           | 0.80654         |
| 1.2         | 1.05484         |
| 1.4         | 1.098457        |
| 1.6         | 1.31115         |



|       |         |
|-------|---------|
| rise  | 0.6     |
| run   | 0.71    |
| slope | 0.84507 |

Graph of Run 3

| Run 3       |                 |
|-------------|-----------------|
| Time<br>sec | Velocity<br>m/s |
| 0           | 0               |
| 0.2         | 0.26847         |
| 0.4         | 0.51245         |
| 0.6         | 0.78954         |
| 0.8         | 1.06245         |
| 1           | 1.32155         |
| 1.2         | 1.59254         |
| 1.4         | 1.75145         |
| 1.6         | 2.1215          |

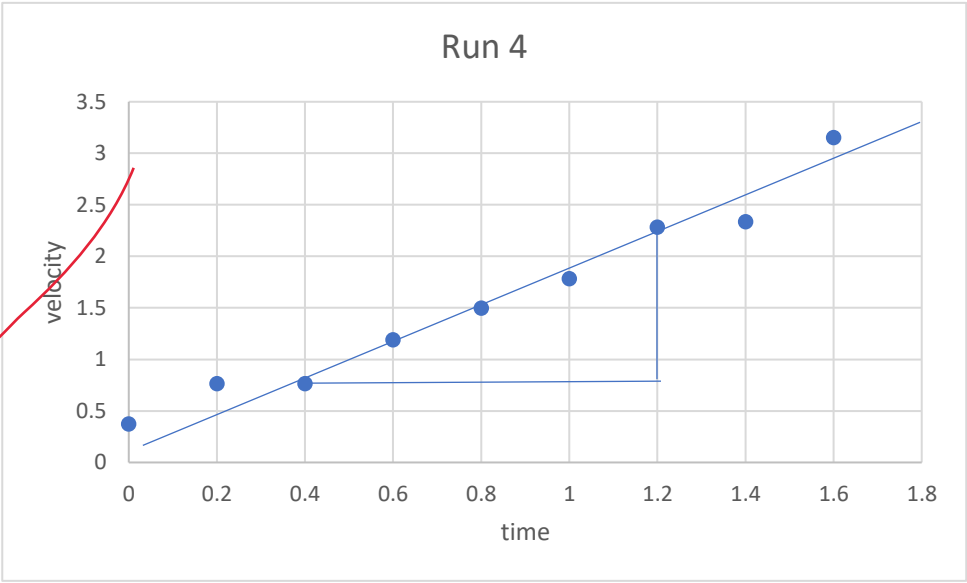


|       |      |
|-------|------|
| rise  | 1    |
| run   | 0.8  |
| slope | 1.25 |

Graph of Run 4

Run 4

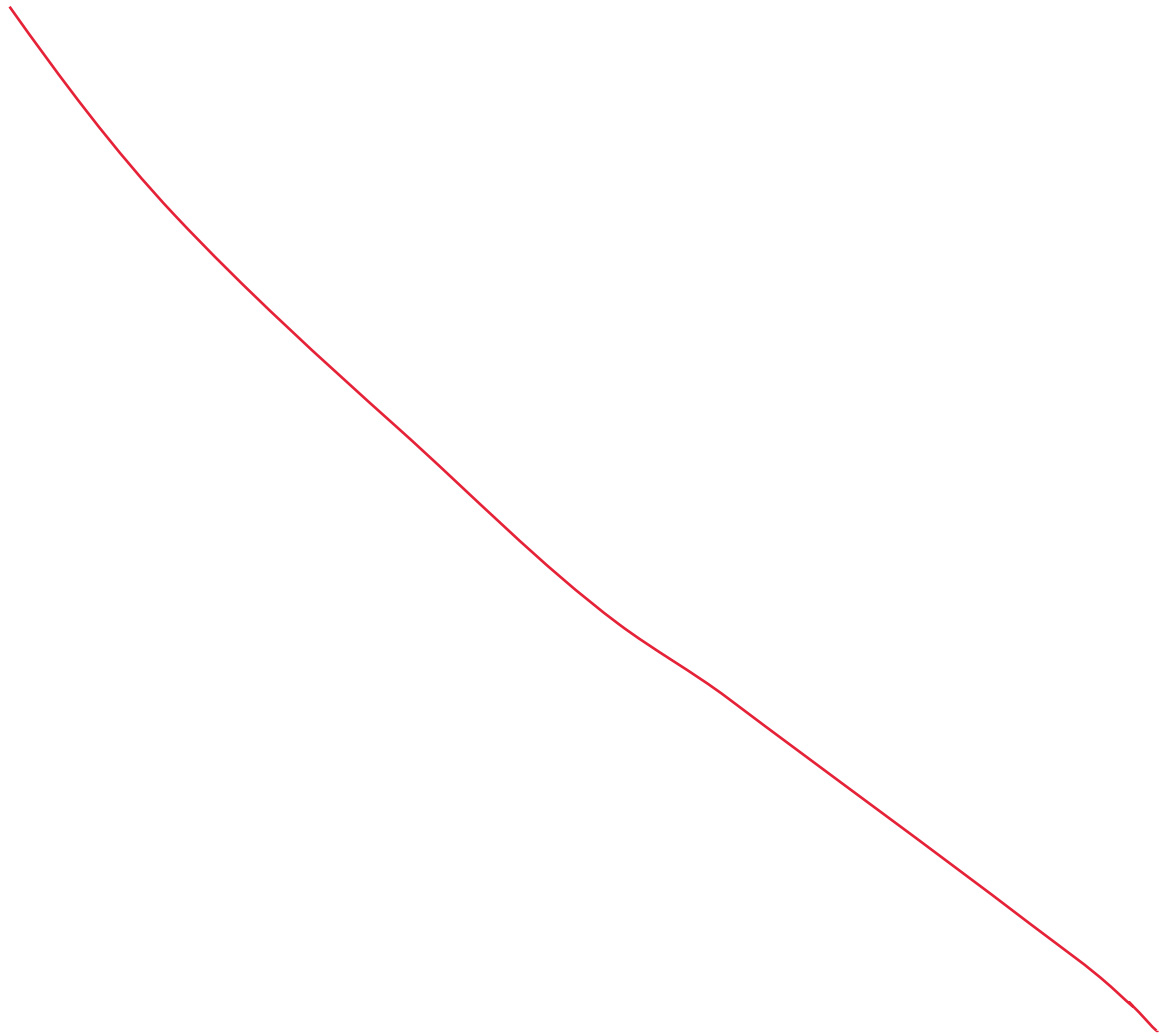
| Time<br>sec | Velocity<br>m/s |
|-------------|-----------------|
| 0           | 0.37458         |
| 0.2         | 0.76514         |
| 0.4         | 0.76514         |
| 0.6         | 1.18954         |
| 0.8         | 1.498514        |
| 1           | 1.78549         |
| 1.2         | 2.28485         |
| 1.4         | 2.33548         |
| 1.6         | 3.154           |



rise            1.6  
run            0.8  
slope           2

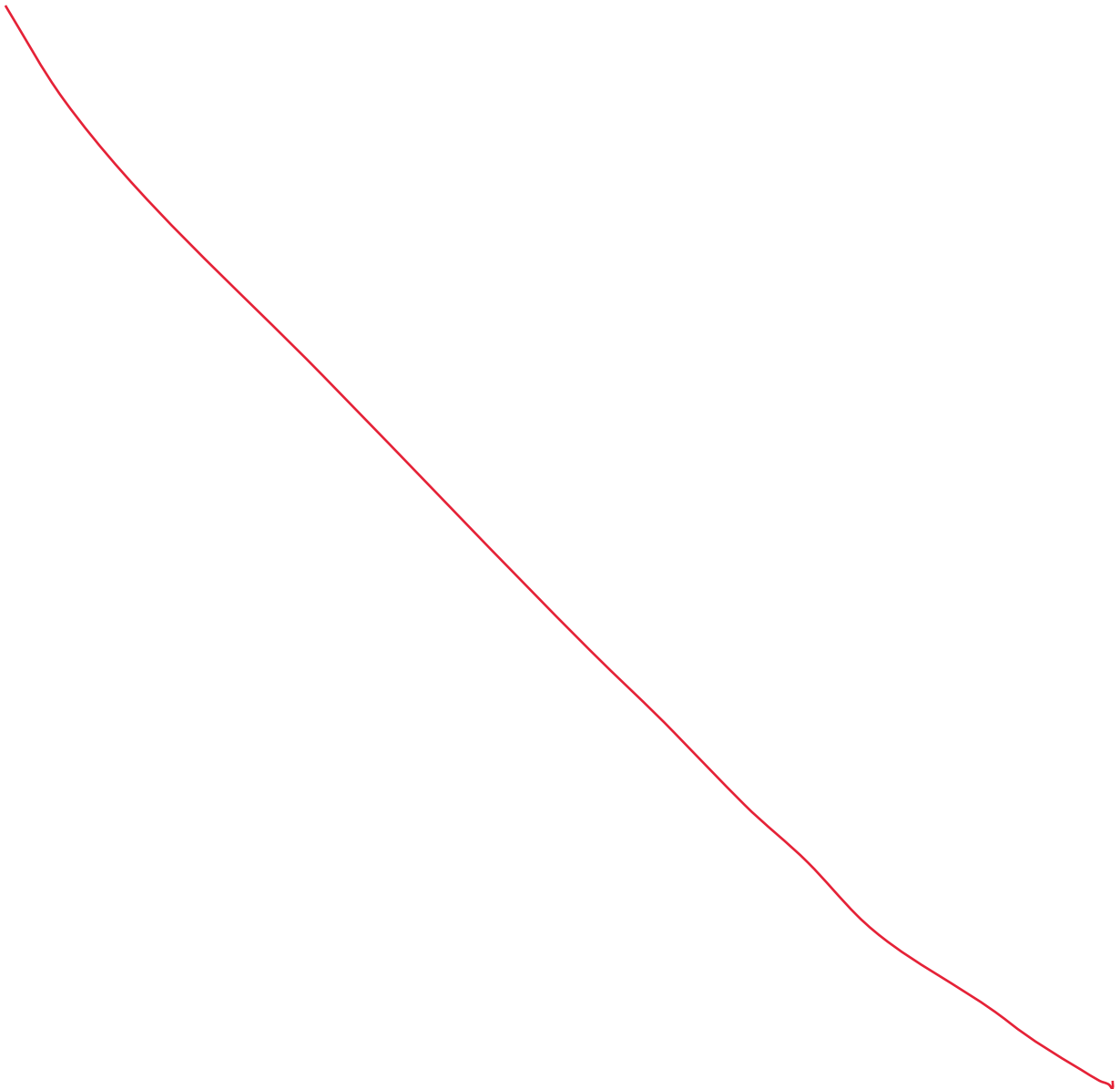
### Results

The slope and the  $\alpha$  differ significantly. This makes the experiment have a significantly large percent error. The percent error for this experiment is a constant between 88 and 90. With each run the slope grew larger and larger. Thus, why the experiment does not stay constant at 88.



Excel link

<https://d.docs.live.net/8fbeefc78cde0476/Documents/CVEG%202061%20Assignment%20Report%20-3.xlsx>





**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING  
OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 2061 – Materials and Dynamics Lab**

**SPRING 2021**

**Instructor: Md. Jobair Bin Alam, Ph.D.**

**Title of Assignment**

**Determination of Spring Constant**

**Outcome Measured Using this Assignment**

**Outcome 6**

An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions

**Check the engineering design characteristics related to this assignment**

|                                                           |                                                                                      |
|-----------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>Ability to develop experiment</b>                      |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Identify the appropriate parameters                                                  |
| ×                                                         | Identify and select appropriate equipment to determine the parameters experimentally |
| ×                                                         | Provide steps to set up and conduct the experiment                                   |
| ×                                                         | Identify data collection method to obtain the experiment results                     |
| <b>Ability to conduct experiment</b>                      |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Conduct experiment maintaining all safety precautions                                |
| ×                                                         | Safe and proper handling of equipment                                                |
| ×                                                         | Collect and record data using appropriate units of measurements and relevant figures |
| <b>Ability to analyze and interpret experimental data</b> |                                                                                      |
| Requires student to                                       |                                                                                      |
| ×                                                         | Data presenting in tabular/graphical format to aid in interpretation                 |
| ×                                                         | Use appropriate statistical analysis (if required) to interpret data and results     |
| ×                                                         | Draw appropriate conclusions using engineering judgment based on experiment          |

**Brief justification of the suitability of assignment for the outcome**

The lab experiment will increase the students' ability to identify the parameters to be measured and appropriate equipment to be used, along with conducting experiments and interpret data and results.

**Department of Civil & Environmental Engineering**  
**Prairie View A&M University**



**CVEG 2061 P81 Materials and Dynamics**  
**Laboratory**

Spring 2021

**Laboratory Report on**  
**“Determination of Spring Constant in a Steel Spring”**

**Conducted on**  
April 9, 2021

**Submitted by**  
Sanjay Tillmutter

**On**  
April 16, 2021

To

**Dr. Md Jobair Bin Alam**  
*Materials and Dynamics Laboratory Instructor*  
CIVIL & ENVIRONMENTAL ENGINEERING DEPARTMENT

**MATERIALS AND DYNAMICS LABORATORY**

**LABORATORY GRADING SHEET**

**SPRING 2021**

Title of Experiment: "Determination of Spring Constant in a Steel Spring"

Name: Sanjay Tillmutter

Date Lab was Performed: Friday April 9, 2021 Report Due Date: Friday April 16, 2021

| <i>Ability to Conduct Experiments</i>                                                                                                             | MAX       | Your Score | Comments |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------------|----------|
| Ability to demonstrate general lab safety (by your conduct and observations).                                                                     | 3         |            |          |
| Ability to follow and properly state the procedure used for the experiment, while maintaining all safety precautions.                             | 9         |            |          |
| Ability to demonstrate knowledge of how equipment function, their limitations, and the uncertainty associated with reading the instruments.       | 6         |            |          |
| Ability to collect and record data using appropriate units of measurement and identify the dependent and independent variables in the experiment. | 15        |            |          |
| <b>Total for Ability to Conduct Experiments</b>                                                                                                   | <b>33</b> |            |          |
| <b>Percentage for this Performance Criteria</b>                                                                                                   |           |            |          |
| <i>Ability to Analyze and Interpret experimental Data</i>                                                                                         |           |            |          |
| Provides appropriate abstracts for the experimental report                                                                                        | 5         |            |          |
| Ability to analyze the data using appropriate software to generate the required parameters using consistent units and significant figures.        | 22        |            |          |
| Use of statistical analysis as needed including uncertainty analysis                                                                              | 5         |            |          |
| Ability to present the data (raw /derived) in tabular and graphical form to meet the objectives and to aid in interpretation.                     | 14        |            |          |
| Ability to discuss the raw and derived data/graphs and assess the validity of the results in relation to the underlying theory.                   | 14        |            |          |
| Ability to draw appropriate and reasonable conclusions in relations to each of the experimental objectives.                                       | 7         |            |          |
| <b>Total for Ability to Analyze and Interpret experimental Data</b>                                                                               | <b>67</b> |            |          |
| <b>Percentage for this Performance Criteria</b>                                                                                                   |           |            |          |
| <b>TOTAL FOR THIS LAB</b>                                                                                                                         |           |            |          |

## LETTER OF TRANSMITTAL

April 16, 2021

Dr. Bin Alam  
Department of Civil & Environmental Engineering  
Prairie View A&M University

Dear Dr. Bin Alam:

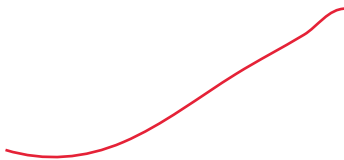
The Technical Laboratory Report attached to this document contains the detailed results from the “Determination of Spring Constant in a Steel Spring” Laboratory work conducted on the 9<sup>th</sup> of April. The Report contains the objective and theory of the determination of the spring constant in the steel spring, along with any equations used in the analysis of data for the experiment. At the end of the report are the interpretations of the results, including the conclusion and any recommendations.

Please feel free to contact me by email at [stillmutt@pvamu.edu](mailto:stillmutt@pvamu.edu) if you have any questions on the report.

Sincerely,

*S. Tillmutt*

Sanjay Tillmutt.



## ABSTRACT

A laboratory experiment was conducted to use the data obtained from a steel coil spring experiment to plot a diagram of Force vs Elongation to determine the spring constant of the steel coil spring experimentally and theoretically. In this experiment, several masses of known weight were applied to the steel spring, and the displacement of the spring recorded to determine elongation of the spring during the experiment. Data from the experiment was collected and shared. A graph of force vs elongation was plotted and generated using the data obtained from the experiment. Results of experimental and theoretical spring constant were computed, recorded, and discussed.

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## CHAPTER 1 – ABILITY TO CONDUCT EXPERIMENT

### 1.1 Objective:

The objective of this experiment was to determine the spring constant in the steel spring which was tested and compare them to show the percentage yield. The objective was also to demonstrate the relationship between spring constant and the Force vs Elongation graph.

### 1.2 Theory:

A spring constant is the measure of the stiffness of a spring. If a mass,  $m$  is attached to the lower end of the spring, the spring stretches a distance of  $d$  from its initial position under the influence of the “load” weight.

$$W = mg \quad (1)$$

The downward force,  $W$ , must be balanced by the upward restoring force of the spring when the system is at rest.

$$F = W = mg \quad (2)$$

According to Hooke's law the restoring force of the spring is directly proportional to the elongation within the elastic limit (the maximum a spring can stretch without being permanently deformed) and can be written as

$$F = k d \quad (3)$$

where  $F$  is the restoring force in Newtons (N),  $k$  is the spring constant in (N/m) and  $d$  is the elongation (the stretched amount) in Meters (m).

The restoring force is in the opposite direction to its elongation, as shown by the minus sign. When the applied force (the loaded weight) is used in calculation, the minus sign is not used, and the above equation can be written as

$$F = k d \text{ or } mg = k d \quad (4)$$

The spring constant,  $k$ , can therefore be calculated

$$k = F/d = mg/d \quad (5)$$

### 1.3 Apparatus:

- Pendulum clamp
- Aluminum pole
- Large clamp
- Assorted masses
- Mass hanger
- Steel spring
- Ruler
- 2-meter stick

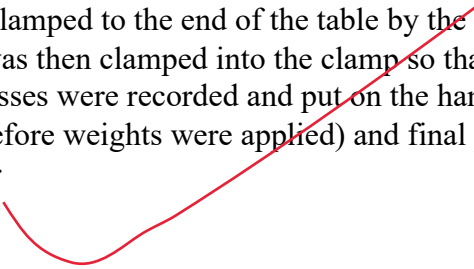


### 1.4 Experimental Safety:

The safety precautions followed during this experiment included wearing safety goggles, full sleeve shirts, and making sure not to inhale or ingest any of the test fluids. Due to the pandemic situation in this semester, social distancing, gloves, and masks were required.

### 1.5 Experimental Procedure:

#### Method

- The large clamp was clamped to the end of the table by the instructor.
  - The Aluminum pole was then clamped into the clamp so that the spring could hang from it
  - The weights of the masses were recorded and put on the hanger
  - The initial position (before weights were applied) and final position (after weights were applied) were measured using a ruler
- 

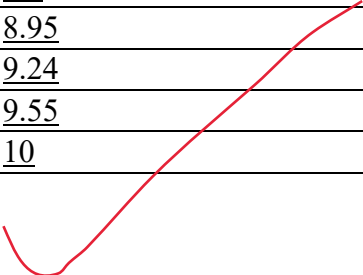
## **CHAPTER 2 – RAW EXPERIMENTAL DATA:**

### **2.1 Experimental Data:**

The data collection was conducted as a group effort for the recording of the weight of the masses and the initial and final position of the spring. The recorded data is shown in Table 1.

**Table 1 – Raw Experimental Data – Mass Weights, Initial, and Final Positions**

| Mass in Grams<br>g | Initial Position,<br>$X_i$ cm | Final Position, $X_f$<br>cm |
|--------------------|-------------------------------|-----------------------------|
| <u>0</u>           | <u>7.5</u>                    | <u>7.5</u>                  |
| <u>1500</u>        | <u>7.5</u>                    | <u>7.8</u>                  |
| <u>3000</u>        | <u>7.5</u>                    | <u>8</u>                    |
| <u>4500</u>        | <u>7.5</u>                    | <u>8.42</u>                 |
| <u>6000</u>        | <u>7.5</u>                    | <u>8.7</u>                  |
| <u>7500</u>        | <u>7.5</u>                    | <u>8.95</u>                 |
| <u>9000</u>        | <u>7.5</u>                    | <u>9.24</u>                 |
| <u>10000</u>       | <u>7.5</u>                    | <u>9.55</u>                 |
| <u>12000</u>       | <u>7.5</u>                    | <u>10</u>                   |



By looking at Table 1 it is seen that as the masses increased, so did the final position. The experiment was concluded with the maximum final position being at 10 cm on the ruler. The maximum weight that was put on the spring was 12000 grams, or 12 Kg.

### CHAPTER 3 – RESULTS AND DISCUSSION:

Information from Table 1 was used to help compute the values for net force, elongation, spring constant, and work done seen in Table 2. Table 2 shows the values from Table 1, and those which were calculated from the information in it.

**Table 2 – Raw Experimental Data, Force, Elongation, Spring Constant, and Work Done**

| Mass in grams | Mass in Kg | F (N)  | Initial Position, xi | Initial Position, xi | Final Position, xf | Final Position, xf | Elongation | Spring Constant, k | Work done by spring ( $0.5kx^2$ ) |
|---------------|------------|--------|----------------------|----------------------|--------------------|--------------------|------------|--------------------|-----------------------------------|
| g             | Kg         | N      | cm                   | m                    | cm                 | m                  | m          | N/m                | N-m                               |
| 0             | 0          | 0      | 7.5                  | 0.075                | 7.5                | 0.075              | 0          | 0                  | 0                                 |
| 1500          | 1.5        | 14.715 | 7.5                  | 0.075                | 7.8                | 0.078              | 0.003      | 4905               | 0.01903815                        |
| 3000          | 3          | 29.43  | 7.5                  | 0.075                | 8                  | 0.08               | 0.005      | 5886               | 0.05288375                        |
| 4500          | 4.5        | 44.145 | 7.5                  | 0.075                | 8.42               | 0.0842             | 0.0092     | 4798.369565        | 0.179043224                       |
| 6000          | 6          | 58.86  | 7.5                  | 0.075                | 8.7                | 0.087              | 0.012      | 4905               | 0.3046104                         |
| 7500          | 7.5        | 73.575 | 7.5                  | 0.075                | 8.95               | 0.0895             | 0.0145     | 5074.137931        | 0.444752338                       |
| 9000          | 9          | 88.29  | 7.5                  | 0.075                | 9.24               | 0.0924             | 0.0174     | 5074.137931        | 0.640443366                       |
| 10000         | 10         | 98.1   | 7.5                  | 0.075                | 9.55               | 0.0955             | 0.0205     | 4785.365854        | 0.888975838                       |
| 12000         | 12         | 117.72 | 7.5                  | 0.075                | 10                 | 0.1                | 0.025      | 4708.8             | 1.32209375                        |

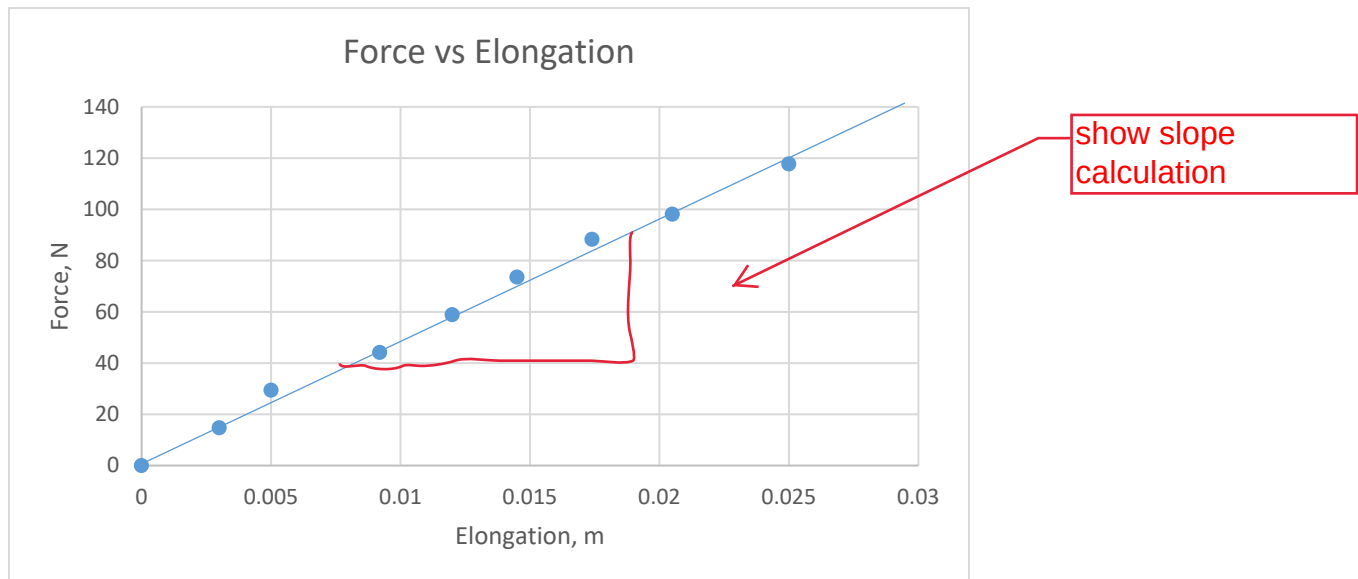
Table 2 shows all the data associated with the experiment. These values were calculated using the raw experimental data from Table 1. The first mass which was applied to the spring weighed 1.5 Kg. The net force was then calculated by multiplying that mass by gravitational acceleration. After this force was applied to the spring, an elongation was determined by subtracting the initial position of the spring from the final position of the spring after a mass was applied to it. The spring constant was then computed by using equation (3). This computation of spring constant using equation (3) yielded the theoretical value of k. For the experimental spring constant, k, a Force vs Elongation graph was plotted using the data given in Table 2 and taking the slope of the straight line which was fitted to the data points. Since both the experimental and the theoretical spring constant were known, the percentage yield could be determined by simply subtracting the experimental yield from the theoretical yield and dividing the difference by the theoretical yield and multiplying by 100. An absolute value was to be achieved, meaning that the result could never be a negative number.

The results showed that the calculations associated with this experiment were marginally acceptable, as the experimental and theoretical acceleration values were not so close to each other, but also not too far off either. The percentage error of the calculations for spring constant in this experiment was 13.75%. This value was said to be marginally acceptable because, generally, a 12.5% error is acceptable for most experiments.

Such a moderate margin of error could have possibly stemmed from several different factors, such as poor judgement in estimation of the slope of the Force vs Elongation graph, inaccurate ruler reading, or loss of track of how much weight was applied to the spring.

A chart was plotted from the data in Table 2 so that the experimental spring constant values could be determined. To determine the spring constant values from the Force vs Elongation graph, the graph had to be set up with elongation on X-axis and force on Y-axis. A straight line was then fitted to the plot, and the slope taken, yielding the experimental spring constant value for the experiment.

The chart is shown below. Figure 1 shows the Force vs Elongation graph that was set up using information from Table 2.

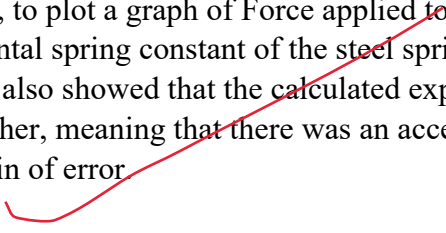


*Figure 1*

## **CHAPTER 4 – CONCLUSION**

### **4.1 Conclusion:**

A successful experiment was conducted to use the data obtained from an experiment containing several masses applied to a steel spring, to plot a graph of Force applied to the spring vs Elongation of the spring in order to determine the experimental spring constant of the steel spring. The data obtained showed good consistency for the experiment. Results also showed that the calculated experimental and theoretical spring constants were roughly close to each other, meaning that there was an acceptable gap between the two values. This is because there was 13.75% margin of error.



## Sample Calculations

**For calculation of total mass,  $m_{\text{tot}}$  (RUN 1)**

$$m_1 + m_2 = m_{\text{tot}}$$

$$\Rightarrow 370 + 390 = \frac{760g}{1000g} \times 1 \text{ Kg} = 0.76 \text{ Kg}$$

**Calculate  $\Delta m$**

$$m_2 - m_1 = \Delta m$$

$$\Rightarrow 390 - 370 = \frac{20g}{1000g} \times 1 \text{ Kg} = 0.02 \text{ Kg}$$

**Calculate  $F_{\text{net}}$**

$$F_{\text{net}} = \Delta m \times g$$

$$\Rightarrow 0.02 \text{ Kg} \times 9.81 \text{ m/s}^2$$

$$\Rightarrow 0.1962 \text{ Kgms}^{-2} = 0.1962 \text{ N}$$

**Calculate  $a_{\text{the}}$**

$$a_{\text{the}} = \frac{\Delta m}{m_{\text{tot}}} \times g$$

$$\Rightarrow \frac{0.02 \text{ Kg}}{0.76 \text{ Kg}} \times 9.81 \text{ m/s}^2$$

$$= 0.258 \text{ m/s}^2$$

**Calculate  $a_{\text{exp}}$**

Slope of Velocity vs Time graph =  $a_{\text{exp}}$

$$\Rightarrow \frac{\text{Rise}}{\text{Run}} = \frac{0.2 \text{ m/s}}{0.77 \text{ s}} = 0.259 \text{ m/s}^2$$

**Calculate % error**

$$\% \text{ error} = \left| \frac{a_{\text{the}} - a_{\text{exp}}}{a_{\text{the}}} \times 100 \right|$$

$$\Rightarrow \left| \frac{0.258 - 0.259}{0.258} \times 100 \right| = 0.326 \%$$

**Prairie View A&M University**  
**Roy G. Perry College of Engineering**  
**Civil Engineering**



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**CVEG 2061 P81- Materials and Dynamics**

**Laboratory Report 1- Torsion**

**Nyja Kennedy**

**Given:**

**Due: 15 April 2021**

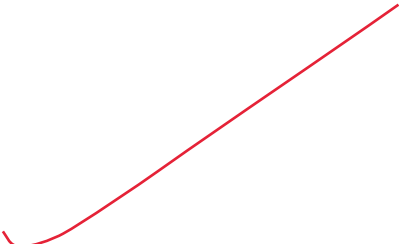
## Abstract

**The purpose of this experiment is** understanding the experiment data from a spring constant test of a steel spring. The data given gives a result of displaying force vs elongation. For this experiment conversion for mass, force, and initial and final positions are necessary to finding the most important information needed. Using Hooke's law is important to solving the calculations in this experiment to display the data table and graphs created.



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## Introduction

A spring constant is the measure of the stiffness of a spring. For instance, mass attached to a spring stretches the distance from the initial position. The downward force must be balanced by the upward restoring force of the spring when at rest. The spring's restoring force acts in the opposite direction to its elongation. , the spring's elongation, final position subtracted initial position, is dependent upon the spring constant,  $k$ , and the weight of a mass,  $mg$ , that hangs on the spring. Hooke's law states that, for small deformations of an object, the displacement of the deformation is directly proportional to the deforming force. Under these conditions the object returns to its original shape and size upon removal of the load. Hooke's law, the restoring force of the spring is proportional to elongation within the elastic limit. When forced is applied the equation written will be positive.

### Hooke's Law:

$$W = mg \quad F = k d$$

$$F = W = mg$$

Figure 1

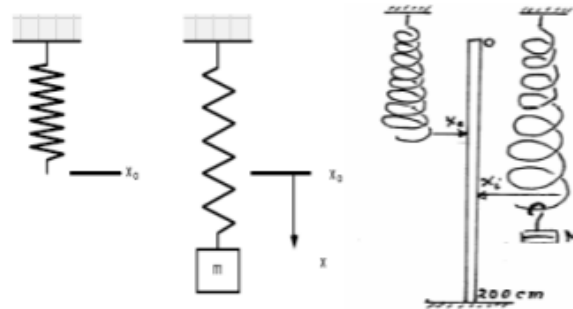


figure name?

## Test Objective

The object of the experiment is to determine the spring constant of the steel spring on given data, showing graphical representation on the data, and finding the work done by the spring at the different loading from graphical method and analytical method.

## Equipment and Apparatus

1. Large clamp
2. Pendulum clamp
3. Spring
4. Meter Stick
5. Mass Hanger

Figure 1

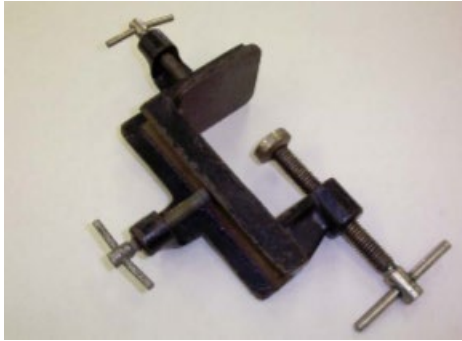


Figure 3



Figure 5



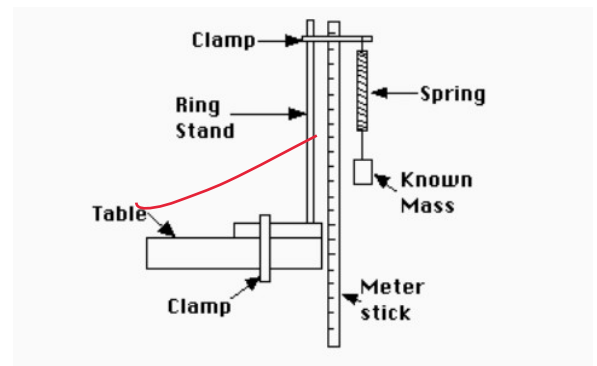
Figure 2



Figure 4



Figure 6 : Experiment put together



## **Materials and Test Conditions**

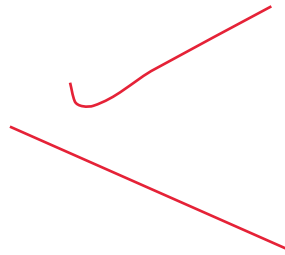
1. Notebook
2. Each group completed the experiment separately.
3. Check for equipment conditions
4. Start experiment.

## **Step by Step Description and Experimental Safety Issue**

Clamp the large clamp to the end of the table so that groove in the metal is vertical. (1) Place the aluminum pole in the groove and tighten up the screw. (2) Clamp the pendulum clamp to the top of the Aluminum pole. (3) Loosen the knob at the end of the clamp and place the loop of the end of the spring behind the two metal fingers (behind the knob). (4) Large diameter of the spring is facing downward, and small diameter is upward towards the knob. (5) record the initial position. (6) the difference between two number initial position subtracted by final position. (7) Hang the total mass given by instructor from the bottom loop of the spring. (8) Measure the bottom loop of spring where it is stretched. (9)

## Data Analysis Methods and Model (Equations)

1. Convert each mass in grams to kilograms (mass/1000)
2. Calculate force in Newton using  $F=W=mg$  (mass in kg \* 9.81)
3. Convert initial position centimeters to meters ( initial position/ 100)
4. Convert final position centimeters to meters ( Final position/ 100)
5. To determine elongation (Final position in meters – Initial position in meters)
6. Spring constant ( mass in kg / elongation)
7. Find k by using the graph that was created (rise/ run)
8. Work done by spring ( $0.5*k*x^2$ )



## Suitable Statical Analysis Tools

For this experiment, there was no need for any statistical analysis tool as all data is obtained by the process of using the experiment created and calculator.

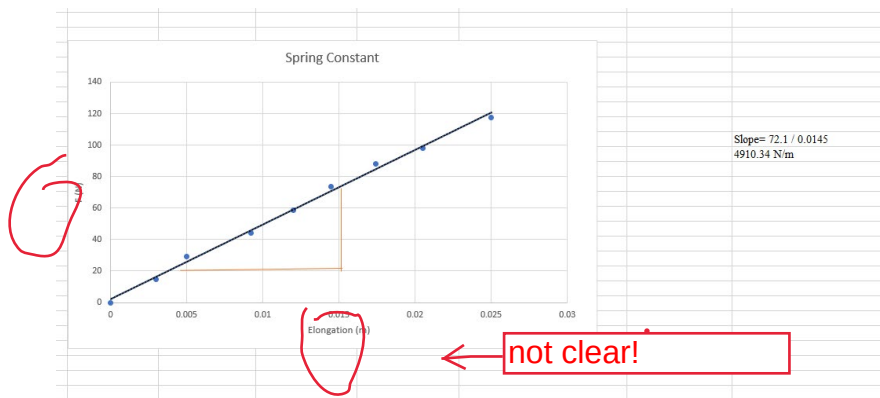
## Test Results and Analysis

This table displays the experimental data from a spring constant test of a steel spring.

Table 1

|                   |                   |                  |                       |                                 |                     | k                             |                          | 4910.34             |                                 | N/m |  |
|-------------------|-------------------|------------------|-----------------------|---------------------------------|---------------------|-------------------------------|--------------------------|---------------------|---------------------------------|-----|--|
| Mass in grams (m) | Mass in Kilo Gram | Force in Newtons | Initial Position (Xi) | Initial Position Xi centimeters | Final Position (Xf) | Final Position Xf Centimeters | Elongation in meters (d) | Spring Constant (k) | Work Done by Spring $0.5*k*x^2$ |     |  |
| g                 | kg                | F=W=mg           | cm                    | m                               | cm                  | m                             | m                        | (N/m)               | N-m                             |     |  |
| 0                 | 0                 | 0                | 7.5                   | 0.075                           | 7.5                 | 0.075                         | 0                        | 0                   | 0                               |     |  |
| 1500              | 1.5               | 14.715           | 7.5                   | 0.075                           | 7.8                 | 0.078                         | 0.003                    | 500                 | 0.02209653                      |     |  |
| 3000              | 3                 | 29.43            | 7.5                   | 0.075                           | 8                   | 0.08                          | 0.005                    | 600                 | 0.06137925                      |     |  |
| 4500              | 4.5               | 44.145           | 7.5                   | 0.075                           | 8.42                | 0.0842                        | 0.0092                   | 489.1304348         | 0.207805589                     |     |  |
| 6000              | 6                 | 58.86            | 7.5                   | 0.075                           | 8.7                 | 0.087                         | 0.012                    | 500                 | 0.35354448                      |     |  |
| 7500              | 7.5               | 73.575           | 7.5                   | 0.075                           | 8.95                | 0.0895                        | 0.0145                   | 517.2413793         | 0.516199493                     |     |  |
| 9000              | 9                 | 88.29            | 7.5                   | 0.075                           | 9.24                | 0.0924                        | 0.0174                   | 517.2413793         | 0.743327269                     |     |  |
| 10000             | 10                | 98.1             | 7.5                   | 0.075                           | 9.55                | 0.0955                        | 0.0205                   | 487.804878          | 1.031785193                     |     |  |
| 12000             | 12                | 117.72           | 7.5                   | 0.075                           | 10                  | 0.1                           | 0.025                    | 480                 | 1.53448125                      |     |  |

Graph 1 : Force in Newtons vs Elongation in meters



Graph 2 : Force vs Elongation



The full set of data such as the mass, initial position, and final position is given. Using the equations and calculations each column was found shown in *table 1*. *Graph 1 force vs elongation* and *table 1* highlighted in yellow shows the graphical representation on the data on finding  $k$  using the equation rise over run, which is equal to 4910.34 N/m. The value  $k$  is different value due to human error. In *table 1* I used the row highlighted in blue to analysis the graphical method and analytical method for *graph 2*. Work done by the spring at different loading from a graphical method shown in *graph 2* is equal to 0.3954 m<sup>2</sup> using the equation  $\text{area} = 0.5 \times \text{base} \times \text{height}$ . In *table 1* highlighted in orange shows the analytical method which is equal to 0.3535 N-m. The numbers 0.3954 and 0.3535 are significantly close to each other meaning the calculations are accurate. The table and two graphs are important in this experiment to show the graphical method and analytical method used.

## Discussion Synthesis and Interpretation of Results and Findings

This experiment, spring constant was successful done by the equations and the graphical method and analytical method used for the data that was given. The object was successfully found by determining the spring constant of the steel spring on given data, showing graphical representation on the data, and finding the work done by the spring at the different loading from graphical method and analytical method. Concluding on the given data, graphs and calculations that were done for the experiment shows accuracy between both methods that were found.

## Summary

In conclusion this experiment, spring constant was successful, and the objective was met due to finding what was given. The spring constant displays accurate information and data in a spring constant test. Such as the table 1, graph 1 and graph 2 displays the prove that this experiment is accurate although there is always going to be human errors in experiments. Most of the experiments data was found by using hook's law and simple conversion explained in data analysis methods and models.

## Reference

Mechanics of materials 10th edition by R.C. Hibbeler

Zoom Recording Including slides shown Mr. Alam April 9<sup>th</sup>, 2021

[https://pvpanther.zoom.us/rec/play/ckkA8p3B\\_j\\_nhatAdjIj8xJnF91rjLvngmBkhO4iwB3Mr5dP1ejzK137SDsuYmaCMPRvUip7j4C0l0kH.8CeKZ36bASTHLrBw](https://pvpanther.zoom.us/rec/play/ckkA8p3B_j_nhatAdjIj8xJnF91rjLvngmBkhO4iwB3Mr5dP1ejzK137SDsuYmaCMPRvUip7j4C0l0kH.8CeKZ36bASTHLrBw)

## Appendices



**OUTCOME “6” SPECIFIC ASSIGNMENTS  
USED TO ASSESS THE OUTCOME IN**

**CVEG 2081  
SURVEYING & GEOSPATIAL CONCEPTS**

# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 2081-Surveying and Geospatial Concepts**  
**Instructor: Dr. Abdul M Choudhury**

## **Title of Assignment**

**Lab Report #2**

## **Outcome Measured Using this Assignment**

### **Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

## **Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the lab report show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT  
CVEG 2081- SURVEYING AND GEOSPATIAL CONCEPTS  
COURSE ASSIGNMENT GRADING  
AND OUTCOME ASSESSMENT SHEET**

ASSIGNMENT TITLE:                      Lab Report #2

DUE DATE:                      10/28/2019\_\_\_\_\_                      DATE SUBMITTED: 10/28/2019

Name of Student: Felix Castilleja and Page Hines

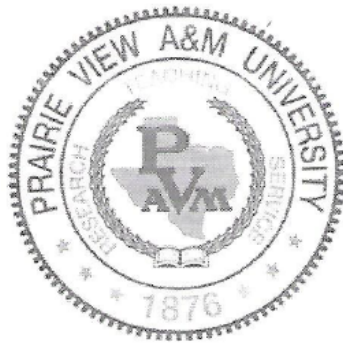
Title of Assignment:\_\_\_Differential Levelling

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                  | Max for this Assignment | Student's Score |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments all background calculations covering designing and conducting experiments have been included in this part. All relevant mathematical calculation and concepts relevant to the laboratory experiments have been covered .</i> | 100                     | 95              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                            | 100                     | 95              |

**CIVIL & ENVIRONMENTAL ENGINEERING**

**DEPARTMENT**

**PRAIRIE VIEW A&M UNIVERSITY**



**CVEG 2081**

**SURVEYING & GEOSPATIAL CONCEPTS**

**Lab Report 2 Differential Leveling**

**Submitted by:**

Felix Castilleja

Paige Hines

95  
TCW

**Submitted On :** October 28, 2019

**Submitted To :** Dr. Abdul Choudhury PE



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## Abstract

In this experiment, students will become familiar with modern leveling tools found in the field of surveying to determine the elevation around our benchmark civil.

The experiment was conducted using a digital leveling tool sitting on a tripod, and a leveling rod. We took foresight and backsight measurements of each point selected, with this we were able to calculate the new height and elevation of each point.

To conclude this experiment, the final elevation must match the starting elevation. If the numbers are off a correction must be made.

## Introduction

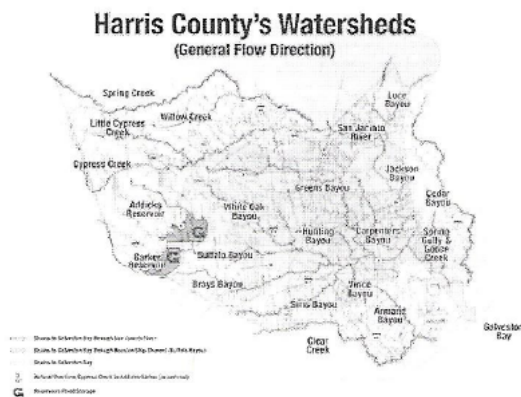
Leveling is the process by which elevations of points or differences in elevation are determined. Leveling is an important operation to acquiring the necessary data for mapping, engineering design, and construction. Leveling results are used for the following and as shown in figures 1.1 & 1.2 :

- (1) design highways, railroads, canals, sewers, water supply systems;
- (2) lay out construction projects according to planned elevations;
- (3) calculate volumes of earthwork and other materials;
- (4) investigate drainage characteristics of an area;
- (5) develop maps showing general ground configurations; and
- (6) study earth subsidence and crustal motion.

Elevation refers to the height above or below a fixed reference point and the elevation of a particular site can prevent disasters. Human beings become adapted to live in certain elevations, for example the elevation of Denver, Colorado is much higher than that of San Diego, California. The term leveling refers to the determining of elevation, and to do this we need a level which is a high powered telescope.

Starting out with our benchmark point, known as benchmark civil, we measured the backsight (+BS) and foresight (-FS) of each point. By adding the elevation to the backsight we can calculate the current height of the instrument (HI). We then subtract the foresight from the HI and this gives us our new elevation.

on a tripod, with a 13ft measuring rod. We did not have access to the laser measuring aspect of the leveling apparatus, so all measurements were calculated visual and double check by another person.





## List of Equipment & Materials

- (1) Topcon DL 503 Digital Level (fig 1.3)
- (1) Flat head levelling tripod (fig 1.4)
- (1) 13 ft Double sided Leveling Rod (fig 1.5)



Figure 1.3



Figure 1.4



Figure 1.5

## Experiment Description

### Pre-experiment

For this experiment, we were given information in regards to the known benchmark elevation of the Civil Engineering department side of the CL Wilson building which is 100 feet. Before any equipment is set up, we evaluated the field between the CL Wilson building and the chemical building to select possible turning points to evaluate and level. The first turning point can then be set by setting up the instrument at a location that is approximately half the distance between our known benchmark and the first turning point as shown in figure 1.6.

### Methods used in the field

1. **Setting up the turning point** - A student holds the leveling rod at the turning point in front of the body holding it still and straight as possible to obtain an accurate reading. The leveling rod has two sides both measured in feet. One side has the feet divided into 10 sections with 5 sets of markers in between each section to obtain a decimal value as shown in figure 1.7. The more flat side of the rod displays feet and inches by dividing each foot into 12 sections. For a more accurate reading, the student will hold the leveling rod with the side displaying feet divided into 10 sections facing towards the location of the instrument.

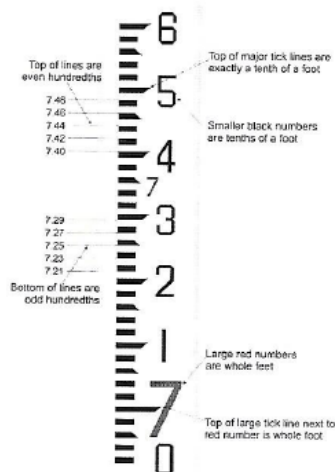


Figure 1.7

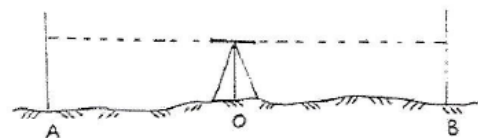
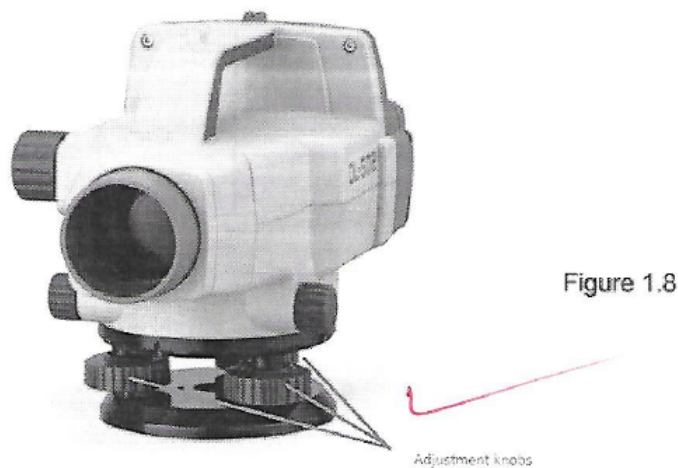


Figure 1.6

**2. Setting up the instrument** - After finding the approximate mean distance, the level tripod is first set up to place it firmly into the ground. The three legs are spread open with the turning locking screws loose. Each leg contains a sharper end with a flat peg projecting out to allow each leg to be driven into the ground. All three legs are driven into the ground to keep the tripod steady. The top of the stand is then lifted up to the appropriate level to where the eye lens will be approximately close to eye level. The leveling instrument is then placed on top of the stand with a single bolt in the center of the stand tightened to the bottom of the instrument. To obtain an accurate reading, the leveling instrument needs to be completely horizontal which is obtained by adjusting the three knobs at the bottom of the instrument that raises and lowers the horizontal sight of the instrument as shown in figure 1.8. The back end of the instrument contains a bubble level that indicates whether the instrument is completely leveled. The instrument is turned in 90 degree increments and to check if the bubble level is centered in a 360 degree rotation. With the bubble level centered in all four cases, the instrument is perfectly horizontal and ready for reading.



3. **Reading at benchmark Civil** - The leveling rod is placed at benchmark Civil with the same procedure described in step 1. The reading at benchmark Civil is then taken by looking through the focus lens of the instrument aiming at the leveling rod located at the benchmark. This reading will be measured as shown in figure 1.9 and will be recorded as the backsight reading of benchmark Civil which is 3.14.
4. **Reading at turning point 1** - The instrument is not moved from its location mentioned before. The student relocates the leveling rod to the location selected before the experiment began and sets up the leveling rod as described in step 1. The student at the instrument then points the instrument at the leveling rod and records the reading to be the foresight reading of turning point 1 which is 8.47. The instrument is then removed from the ground and is relocated to the mean distance between turning points 1 and 2 with the leveling rod still in the same location as shown in figure 1.7. The student sets up the instrument with the same procedure described in step 2 and aims the instrument towards the leveling rod at turning point 1 and records the reading as the backsight reading of turning point 1 which is 4.52.

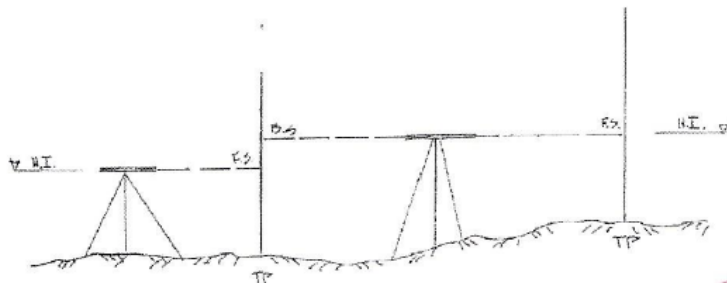


Figure 1.9

*Handwritten notes in red ink:*

- 3 civil* (with a checkmark)
- TP1*
- 4 general sketch*
- TP2*
- chem*
- TP3*
- TP4*

5. **Reading at turning point 2** - The leveling rod at turning point 1 is now relocated to the new turning point with the instrument remaining in the same location as left in step 4. Following the procedures to set up the leveling rod in step 1, the instrument is aimed towards the leveling rod located at turning point 2 and the reading is measured as the foresight of turning point 2 which is 3.27. The instrument is then removed from the ground and is relocated to the mean distance between turning point 2 and benchmark Chemical with the leveling rod still in the same location as shown in figure 1.9. The student sets up the instrument with the same procedure described in step 2 and aims the instrument towards the leveling rod at turning point 2 and records the reading as the backsight reading of turning point 2 which is 6.85.
6. **Reading at benchmark Chemical** - The instrument is not moved from its location mentioned before. The student relocates the leveling rod to the location of benchmark at the chemical building. The student at the instrument then points the instrument at the leveling rod and records the reading to be the foresight reading of benchmark Chemical which is 3.54. After this reading, we start the process of closing the "circuit" to remove the possibility of errors and obtain the most accurate data by recording the elevations of two more turning points towards the benchmark at the CL Wilson building (as shown in figure 1.10). The instrument is removed from the ground is relocated to a new location not too far from its previous location. The instrument is set up and aimed towards the leveling rod at benchmark chemical and the reading is measured as the backsight of benchmark Chemical which is 2.05.

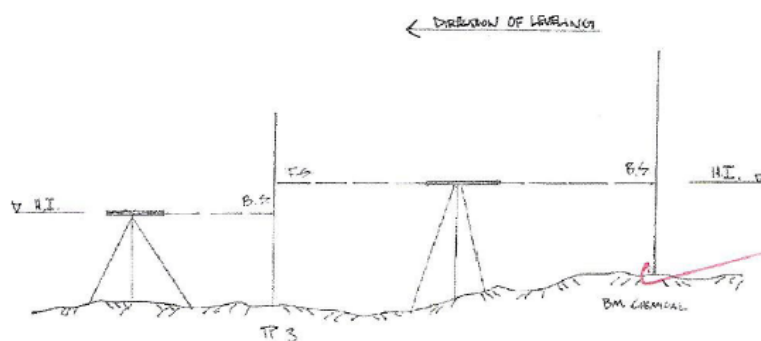
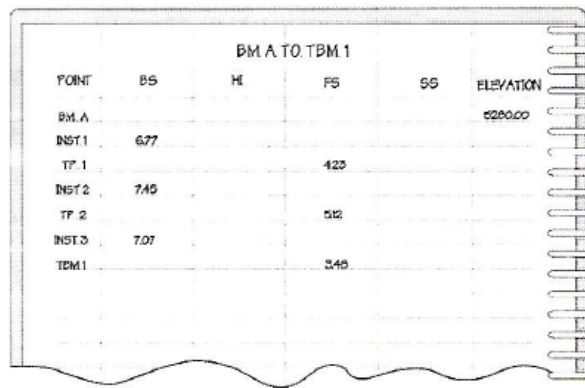


Figure 1.10

7. **Readings at TP3, TP4, & BM Civil** - The steps to measure the backsight and foresight readings at turning points 3, 4, and benchmark Civil are done by repeating procedures in steps 4-6. The measurements at each station were as the following: TP3 (+)6.22 & (-)8.53, TP4 (+)7.52 & (-)4.19, BM Civil (-)2.17.

## Results Analysis

After all field work is completed, the data obtained can be analyzed to calculate the different elevations at each turn point and benchmark at the chemical building. The backsights and foresights were recorded in a field journal similar to what is shown in figure 1.11.



| POINT  | BS   | BM A TO TBM 1 |      | SS | ELEVATION |
|--------|------|---------------|------|----|-----------|
|        |      | HI            | FS   |    |           |
| BM A   |      |               |      |    | 5280.00   |
| INST 1 | 6.77 |               |      |    |           |
| TP 1   |      |               | 4.23 |    |           |
| INST 2 | 7.49 |               |      |    |           |
| TP 2   |      |               | 5.02 |    |           |
| INST 3 | 7.07 |               |      |    |           |
| TBM 1  |      |               | 3.49 |    |           |

Figure 1.11

Each elevation at every turning point can be calculated starting from the known benchmark at the civil engineering department. To calculate the elevation at each turning point, the instrument height needs to be calculated by using equation 1.1.

$$\text{Height of Instrument (H.I.)} = \text{Elevation} + \text{backsight (B.S.)}$$

Equation 1.1

The backsight reading of benchmark Civil plus the known elevation of 100 feet will find the instrument between benchmark Civil and the first turning point which is calculated below.

$$H.I. = 100 \text{ ft} + 3.15 = 103.15 \text{ ft}$$

Elevation X at turning point one can now be calculated by using equation 1.2



$$\text{Elevation } X = H.I. - \text{foresight (F.S.)}$$

Equation 1.2

The calculated instrument height from using equation 1.1 minus the foresight reading of turning point one will find the elevation of turning point one.

$$\text{Elevation TP1} = 103.15 \text{ ft} - 8.47 = 94.68 \text{ ft}$$

The instrument heights between each station and the elevations at each turning point are calculated using equations 1.1 and 1.2. Calculating elevations at each turning point between BM Civil and BM Chemical will find our elevation at BM chemical.

$$H.I. \text{ TP1/TP2} = 94.68 \text{ ft} + 4.52 = 99.20 \text{ ft}$$

$$\text{Elevation TP2} = 99.20 \text{ ft} - 3.27 = 95.93 \text{ ft}$$

$$H.I. \text{ TP2/BM Chem} = 95.93 \text{ ft} + 6.85 = 102.78 \text{ ft}$$

$$\text{Elevation BM Chem} = 102.29 \text{ ft} - 3.54 = 99.24 \text{ ft}$$

As mentioned in step 6 in the experiment description, we will calculate elevations of the additional two turning points returning to BM Civil to close the "circuit" by using equations 1.1 and 1.2 like before. The elevation of BM Civil should be the same as the known elevation if no errors in recording the data in the field. Elevations of TP3, TP4, & BM Civil are calculated as shown below.

$$H.I. \text{ BM Chem/TP3} = 99.24 \text{ ft} + 2.05 = 101.29 \text{ ft}$$

$$\text{Elevation TP3} = 101.29 \text{ ft} - 8.53 = 92.76 \text{ ft}$$

$$H.I. \text{ TP3/TP4} = 92.76 \text{ ft} + 6.22 = 98.98 \text{ ft}$$

$$\text{Elevation TP4} = 98.98 \text{ ft} - 4.19 = 94.79 \text{ ft}$$

$$H.I. \text{ TP4/BM Civil} = 94.79 \text{ ft} + 7.52 = 102.31 \text{ ft}$$

$$\text{Elevation BM Civil} = 102.31 \text{ ft} - 2.19 = 100.12 \text{ ft}$$

To ensure we calculated correctly, a page check is completed to ensure our elevations are calculated correctly with our backsights and foresights by using equation 1.3

$$\text{Known Benchmark Elv.} + \sum B.S. - \sum F.S. = \text{Calculated Benchmark Elv.}$$

Equation 1.3

Once the page check is performed, we calculate the misclosure and determine the error at each station. The misclosure is the difference between the benchmark elevation calculated at the end of the closed circuit and the original known benchmark elevation due to field errors. Our misclosure is calculated as follows:

$$100.12 \text{ ft} - 100 \text{ ft} = 0.12 \text{ ft}$$

We calculated a positive error which means we will adjust our elevations with a negative value to obtain the same original known benchmark. With the misclosure, we can now calculate the error at each station to adjust our elevations on our field notes.

$$\frac{-0.12 \text{ ft}}{6 \text{ Stations}} = -0.02 \text{ ft}$$

The adjusted field notes can be found on page 14 with all data collected from the field and calculated misclosure.





## Summary

Leveling is a crucial process in the design and construction of infrastructure. Differential leveling is only one of many processes of leveling. With today's modern surveying tools, we can evaluate the elevation at many different points from one known elevation with the smallest error. In this experiment, we evaluated the elevation of the chemical building in reference to our known elevation at the CL Wilson building. In the leveling process we also evaluated the elevations at different points between the chemical and CL Wilson building. With this data, we can analyze the drainage characteristics of the area, develop maps showing general ground configurations, etc.



## References

Ghilani, Charles D. *Elementary Surveying: an Introduction to Geomatics*. Pearson, 2017.

→ 1 use more ref?

# RAIRIE VIEW A+M UNIVERSITY: FROM BM CIVIL TO BM CHEM

| STATION  | B.S. (+) | H.I. (+) | F.S. (-) | ELEVATION (+) | CORR  | ADJ ELEVATION |
|----------|----------|----------|----------|---------------|-------|---------------|
| BM CIVIL | 3.15     |          |          | 100           | —     |               |
|          |          | 103.15   |          |               |       |               |
| TP1      | 4.52     |          | 8.47     | 94.68         | -0.02 | 94.66         |
|          |          | 99.20    |          |               |       |               |
| TP2      | 6.85     |          | 3.27     | 95.43         | -0.04 | 95.89         |
|          |          | 102.78   |          |               |       |               |
| BM CHEM  | 2.05     |          | 3.54     | 99.24         | -0.06 | 99.18         |
|          |          | 101.29   |          |               |       |               |
| TP3      | 6.22     |          | 8.53     | 92.76         | -0.08 | 92.68         |
|          |          | 98.98    |          |               |       |               |
| TP4      | 7.52     |          | 4.19     | 94.79         | -0.10 | 94.69         |
|          |          | 102.31   |          |               |       |               |
| BM CIVIL |          |          | 2.19     | 100.12        | -0.12 | 100           |

$$+\sum = 30.31 \quad -\sum = 30.19$$

## PAGE CHECK

$$100 + 30.31 - 30.19 = 100.12$$

## MISCLOSURE

$$100.12 - 100 = 0.12 \text{ (POSITIVE ERROR)}$$

## ERROR AT EA. STATION

$$\frac{-0.12}{6 \text{ STATIONS}} = -0.02$$

what is the limit

# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 2081-Surveying and Geospatial Concepts**  
**Instructor: Dr. Abdul M Choudhury**

**Title of Assignment**

Lab Report #3

**Outcome Measured Using this Assignment**

**Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the homework show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT  
CVEG 2081- SURVEYING AND GEOSPATIAL CONCEPTS  
COURSE ASSIGNMENT GRADING  
AND OUTCOME ASSESSMENT SHEET**

ASSIGNMENT TITLE:    DIFFERENTIAL LEVELLING

DUE DATE:            11/11/2019\_\_\_\_\_      DATE SUBMITTED: 11/11/2019

Name of Student: Jonathan M Chevalier

Title of Assignment:\_\_\_ Profile Levelling of an existing road.

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                  | Max for this Assignment | Student's Score |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments all background calculations covering designing and conducting experiments have been included in this part. All relevant mathematical calculation and concepts relevant to the laboratory experiments have been covered .</i> | 100                     | 93              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                            | 100                     | 93              |

**CIVIL ENGINEERING DEPARTMENT  
Prairie View A&M UNIVERSITY**



**CVEG 2081 SURVEYING AND GEOSPATIAL  
LABORATORY  
FALL 2019**

**LABORATORY REPORT ON:**

**“Profile Leveling of an Existing Road”**

**Conducted on:**

~~October 28<sup>th</sup>, 2019~~

October 28<sup>th</sup>, 2019

**Submitted by**

**Johnathon M. Chevalier**

93  
ATC

**On:**

~~November 4<sup>th</sup>, 2019~~

November 11<sup>th</sup>, 2019

**To:**

**Dr. Abdul M. Choudhury**

## LETTER OF TRANSMITTAL

November 4<sup>th</sup>, 2019

Dr. Abdul M. Choudhury

Civil Engineering Department

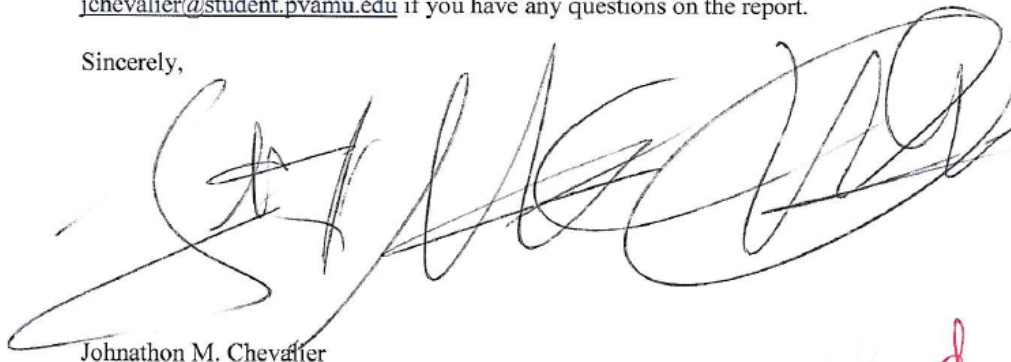
Prairie View A&M University

Dear Dr. Choudhury,

The lab report that is attached is a lab that includes detailed calculations and results from a lab that involved the "Profile Leveling of an Existing Road". The work of this lab occurred on October 28<sup>th</sup>, 2019 and will contain the abstract, an introduction of the lab, the inclusion of the equipment used and a description of the lab along with an analysis section of the data collected. This lab is conducted to configure the results of the profile leveling and the elevations here at Prairie View A&M University on a road between the New Electrical Engineering Building and the John B. Coleman Library.

Please contact me at 832-270-3467 or by e-mail at [jaychevy1998@gmail.com](mailto:jaychevy1998@gmail.com) or [jchevalier@student.pvamu.edu](mailto:jchevalier@student.pvamu.edu) if you have any questions on the report.

Sincerely,

A large, stylized handwritten signature in black ink, appearing to read "Johnathon M. Chevalier".

Johnathon M. Chevalier

good

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### **ABSTRACT**

*leveling*  
In this experiment, students will become familiar with modern tools found in the field of ~~surveying~~ to record and plot landmarks in order to effectively calculate the differential leveling on the campus. Students were sent to the field and decide the points to determine exactly where a Benchmark point would be, and where the beginning of calculations would begin. This will provide hands-on experience with the use of modern tools that surveyor's use on an everyday basis to measure and record the necessary data to be able to determine the certain leveling of landscape. Students will become familiar with measurement techniques to obtain the necessary data to plot and determine points of profile leveling, intermediate sight points for chosen stations and create a chart that helps them differentiate between the final and beginning points. *one of target was to plot the existing profile of road at different sections.*

## ***INTRODUCTION***

Surveying, or geomatics, is the science, art, and technology of determining the relative position of different points on, above, or below the Earth's surface. The practice of surveying is nothing new and evidence of the use of surveying can be traced back to about 1400 B.C. in Egypt. The lands of Egypt were divided into plots for taxation purposes by "rope-stretchers". These surveyor's or "rope-stretchers" would make their measurements with ropes having marks at a certain unit difference.

*Discuss about  
Leveling*



### ***TEST OBJECTIVE***

The objective of this experiment is to become familiar with various measurement techniques and the use of measurement equipment allows us to correctly assign each value to each station point. After assignments and the proper calculations calculated we can assess and begin to conduct profile leveling using the founded intermediate sight, and also the elevation of each station point. This will then allow us to determine if we can level out the ground in order for a structure or if we can effectively build a structure on the uneven levelled surface, excluding the sediments and other aspects like that. *Discuss about inter sight*

---

*1*

## ***LIST OF EQUIPMENT OF MATERIALS***

### Measuring Devices

- (1) Total Station Instrument- fig 1.1
- (1) Long open Reel Measuring Tape (100 feet)- fig 1.2

### Markers

- Surveying Measuring Stick- fig 1.3



Figure 1.1



Figure 1.2

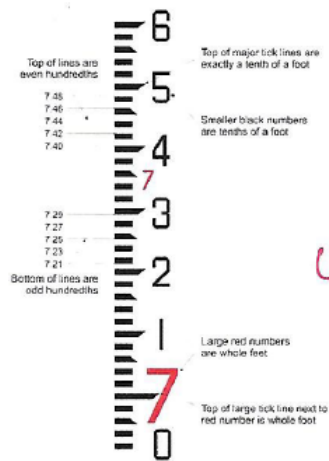


Figure 1.3

## EXPERIMENT DESCRIPTION

### Pre-experiment

For this experiment, an existing section of land containing different elevations was required. The experiment could not have been performed as efficiently a section of land selected different contained different levels of elevation due to the fact of calculating profile leveling.

### Methods used in the field & Pre-calculations

1. Students came together and selected a section of land that contained different levels of elevation and picked seven different station points to collect data
2. Starting at the first station point students figured out the reference elevation point and the balance sight by utilizing the measurements tools provided to us.
3. Moving on to the next station, students have to once configure a way to collect not only the intermediate sight but also the fall sight by using the measurement tools from the previous station point.
4. Due to interfering objects move the total instrument station in position to get the intermediate sight readings at the final 3 stations?
5. At station 3-6 (step 4 if necessary), the same process is repeated as stated in step 2.
6. Moving on to the final station, a student only has to measure the intermediate sight of the station point from the previous station point
7. Record all data collected

**Table 1: Raw Experimental Data**

| Station Point      | B.S.<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|--------------------|---------------------------|------------------------------------|---------------------------|----------------|---------------------|
| BM <sub>road</sub> | 4.90                      |                                    |                           |                | 100                 |
|                    |                           | 104.90                             |                           |                |                     |
| TP <sub>1-1</sub>  |                           |                                    |                           | 6.72           |                     |
| TP <sub>1-2</sub>  |                           |                                    |                           | 6.20           |                     |
| TP <sub>1-3</sub>  |                           |                                    |                           | 5.98           |                     |
| TP <sub>1-4</sub>  |                           |                                    |                           | 6.16           |                     |
| TP <sub>1-5</sub>  |                           |                                    |                           | 6.54           |                     |
| Total              |                           |                                    |                           |                |                     |

The table presented above is the beginning of data collected solely from the experiment. No calculations have been made yet but this table shows us the necessary information to determine the elevation of each station point.

**Table 1.2: Raw Experimental Data**

| Station Point     | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|-------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| TP <sub>2-1</sub> |                          |                                    |                           | 6.26           |                     |
| TP <sub>2-2</sub> |                          |                                    |                           | 5.88           |                     |
| TP <sub>2-3</sub> |                          |                                    |                           | 5.65           |                     |
| TP <sub>2-4</sub> |                          |                                    |                           | 5.80           |                     |
| BM <sub>2-5</sub> | 7.83                     |                                    | 6.15                      |                |                     |
| Total             |                          |                                    |                           |                |                     |

The table presented above is the beginning of data collected solely from the experiment. No calculations have been made yet but this table shows us the necessary information to determine the elevation of each station point.

**Table 1.3: Raw Experimental Data**

| Station Point     | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|-------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| TP <sub>3-1</sub> |                          |                                    |                           | 7.58           |                     |
| TP <sub>3-2</sub> |                          |                                    |                           | 7.20           |                     |
| TP <sub>3-3</sub> |                          |                                    |                           | 6.92           |                     |
| TP <sub>3-4</sub> |                          |                                    |                           | 7.08           |                     |
| TP <sub>3-5</sub> |                          |                                    |                           | 7.44           |                     |
| Total             |                          |                                    |                           |                |                     |

The table presented above is the beginning of data collected solely from the experiment. No calculations have been made yet but this table shows us the necessary information to determine the elevation of each station point.

**Table 1.4: Raw Experimental Data**

| Station Point     | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|-------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| TP <sub>4-1</sub> |                          |                                    |                           | 7.02           |                     |
| TP <sub>4-2</sub> |                          |                                    |                           | 6.76           |                     |
| TP <sub>4-3</sub> |                          |                                    |                           | 6.51           |                     |
| TP <sub>4-4</sub> |                          |                                    |                           | 6.72           |                     |
| TP <sub>4-5</sub> |                          |                                    |                           | 7.11           |                     |
| Total             |                          |                                    |                           |                |                     |

The table presented above is the beginning of data collected solely from the experiment. No calculations have been made yet but this table shows us the necessary information to determine the elevation of each station point.

**Table 1.5: Raw Experimental Data**

| Station Point     | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|-------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| TP <sub>5-1</sub> |                          |                                    |                           | 6.63           |                     |
| TP <sub>5-2</sub> |                          |                                    |                           | 6.30           |                     |
| TP <sub>5-3</sub> |                          |                                    |                           | 6.11           |                     |
| TP <sub>5-4</sub> |                          |                                    |                           | 6.37           |                     |
| TP <sub>5-5</sub> |                          |                                    |                           | 6.60           |                     |
| Total             |                          |                                    |                           |                |                     |

The table presented above is the beginning of data collected solely from the experiment. No calculations have been made yet but this table shows us the necessary information to determine the elevation of each station point.

**Key Note:** The above tables are too configured into one table and was separated for easier purpose understandings.

**Post-experiment**

All data collected from the field can be used to determine the elevation point of each station point. After calculating the total between the 'B.S., + sight' and 'F.S., - sight' and the elevation using 'I.S.', we can double check the elevation between the first station point and the last station point.

**Equations to be used:**

- *Elevation + 'B.S., + sight' = Height of Instrument*
- *Height of Instrument - 'F.S., - sight' = Elevation of station point*
- *Elevation of station point = Elevation of previous station point + (previous 'I.S.' + current 'I.S.')*



## RESULT ANALYSIS

### Calculations:

1.  $100 \text{ feet} + 4.90 \text{ feet} = 104.90 \text{ feet}$
2.  $104.90 \text{ feet} + 6.72 \text{ feet} = 98.18 \text{ feet}$
3.  $98.18 \text{ feet} + (6.72 - 6.20) \text{ feet} = 98.70 \text{ feet}$
4.  $98.70 \text{ feet} + (6.20 - 5.98) \text{ feet} = 98.92 \text{ feet}$
5.  $98.92 \text{ feet} + (5.98 - 6.16) \text{ feet} = 98.74 \text{ feet}$
6.  $98.74 \text{ feet} + (6.16 - 6.54) \text{ feet} = 98.36 \text{ feet}$
7.  $98.36 \text{ feet} + (6.54 - 6.26) \text{ feet} = 98.64 \text{ feet}$
8.  $98.64 \text{ feet} + (6.26 - 5.88) \text{ feet} = 99.02 \text{ feet}$
9.  $99.02 \text{ feet} + (5.88 - 5.65) \text{ feet} = 99.25 \text{ feet}$
10.  $99.25 \text{ feet} + (5.65 - 5.80) \text{ feet} = 99.10 \text{ feet}$
11.  $99.10 \text{ feet} + (30.31 - 30.18) \text{ feet} = 98.75 \text{ feet}$
12.  $98.75 \text{ feet} + (7.83 - 7.58) \text{ feet} = 99 \text{ feet}$
13.  $99 \text{ feet} + (7.58 - 7.20) \text{ feet} = 99.38 \text{ feet}$
14.  $99.38 \text{ feet} + (7.20 - 6.92) \text{ feet} = 99.66 \text{ feet}$
15.  $99.66 \text{ feet} + (6.92 - 7.08) \text{ feet} = 99.50 \text{ feet}$
16.  $99.50 \text{ feet} + (7.08 - 7.44) \text{ feet} = 99.14 \text{ feet}$
17.  $99.14 \text{ feet} + (7.44 - 7.02) \text{ feet} = 99.56 \text{ feet}$
18.  $99.56 \text{ feet} + (7.02 - 6.76) \text{ feet} = 99.82 \text{ feet}$
19.  $99.82 \text{ feet} + (6.76 - 6.51) \text{ feet} = 100.07 \text{ feet}$
20.  $100.07 \text{ feet} + (6.51 - 6.72) \text{ feet} = 99.86 \text{ feet}$
21.  $99.86 \text{ feet} + (6.72 - 7.11) \text{ feet} = 99.47 \text{ feet}$
22.  $99.47 \text{ feet} + (7.11 - 6.63) \text{ feet} = 99.95 \text{ feet}$
23.  $99.95 \text{ feet} + (6.63 - 6.30) \text{ feet} = 100.28 \text{ feet}$
24.  $100.28 \text{ feet} + (6.30 - 6.11) \text{ feet} = 100.47 \text{ feet}$
25.  $100.47 \text{ feet} + (6.11 - 6.37) \text{ feet} = 100.21 \text{ feet}$
26.  $100.21 \text{ feet} + (6.37 - 6.60) \text{ feet} = 99.98 \text{ feet}$

→ 2 should be in the table

**Table 2.1: Raw Experimental Data**

| Station Point      | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|--------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| BM <sub>road</sub> | 4.90                     |                                    |                           |                | 100                 |
|                    |                          | 104.90                             |                           |                |                     |
| TP <sub>1-1</sub>  |                          |                                    |                           | 6.72           | 98.18               |
| TP <sub>1-2</sub>  |                          |                                    |                           | 6.20           | 98.70               |
| TP <sub>1-3</sub>  |                          |                                    |                           | 5.98           | 98.92               |
| TP <sub>1-4</sub>  |                          |                                    |                           | 6.16           | 98.74               |
| TP <sub>1-5</sub>  |                          |                                    |                           | 6.54           | 98.36               |
| Total              |                          |                                    |                           |                |                     |

**Table 2.2: Raw Experimental Data**

| Station Point     | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|-------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| TP <sub>2-1</sub> |                          |                                    |                           | 6.26           | 98.64               |
| TP <sub>2-2</sub> |                          |                                    |                           | 5.88           | 99.02               |
| TP <sub>2-3</sub> |                          |                                    |                           | 5.65           | 99.25               |
| TP <sub>2-4</sub> |                          |                                    |                           | 5.80           | 99.1                |
| BM <sub>2-5</sub> | 7.83                     | 106.93                             | 6.15                      |                | 98.75               |
| Total             |                          |                                    |                           |                |                     |

**Table 2.3: Raw Experimental Data**

| Station Point     | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|-------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| TP <sub>3-1</sub> |                          |                                    |                           | 7.58           | 99                  |
| TP <sub>3-2</sub> |                          |                                    |                           | 7.20           | 99.38               |
| TP <sub>3-3</sub> |                          |                                    |                           | 6.92           | 99.66               |
| TP <sub>3-4</sub> |                          |                                    |                           | 7.08           | 99.50               |
| TP <sub>3-5</sub> |                          |                                    |                           | 7.44           | 99.14               |
| Total             |                          |                                    |                           |                |                     |

**Table 2.4: Raw Experimental Data**

| Station Point     | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|-------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| TP <sub>4-1</sub> |                          |                                    |                           | 7.02           | 99.56               |
| TP <sub>4-2</sub> |                          |                                    |                           | 6.76           | 99.82               |
| TP <sub>4-3</sub> |                          |                                    |                           | 6.51           | 100.07              |
| TP <sub>4-4</sub> |                          |                                    |                           | 6.72           | 99.86               |
| TP <sub>4-5</sub> |                          |                                    |                           | 7.11           | 99.47               |
| Total             |                          |                                    |                           |                |                     |

**Table 2.5: Raw Experimental Data**

| Station Point     | B.S<br>+ Sight<br>(feet) | Height of<br>Instruments<br>(feet) | F.S.<br>- Sight<br>(feet) | I.S.<br>(feet) | Elevation<br>(feet) |
|-------------------|--------------------------|------------------------------------|---------------------------|----------------|---------------------|
| TP <sub>5-1</sub> |                          |                                    |                           | 6.63           | 99.95               |
| TP <sub>5-2</sub> |                          |                                    |                           | 6.30           | 100.28              |
| TP <sub>5-3</sub> |                          |                                    |                           | 6.11           | 100.47              |
| TP <sub>5-4</sub> |                          |                                    |                           | 6.37           | 100.21              |
| TP <sub>5-5</sub> |                          |                                    |                           | 6.60           | 99.98               |
| Total             |                          |                                    |                           |                |                     |

### ***CLOSING STATEMENT***

#### **Summary:**

In this experiment, our objective was to use the modern tools found in the field of surveying to record and plot the dimensions of elevation and leveling of a section of unlevelled land at Prairie View A&M University. By choosing this road between the library and the New Electrical Engineering Building, we are able to select five section points and find out the elevations of each point. After finding the appropriate values we can conclude that the road that was tested is not only in the of a negative parabola but as the road goes along it begins to dip and rise. This can indicate that the foundation under the road was not evenly leveled which cause such a significant raise and decrease in the values of elevation.



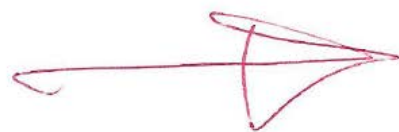
### **REFERENCES**

1. Ghilani, Charles D. *Elementary Surveying: an Introduction to Geomatics*. Pearson, 2017.
2. Association by Milton Cruz's group data collection

Add more

-1  
→

## Appendix

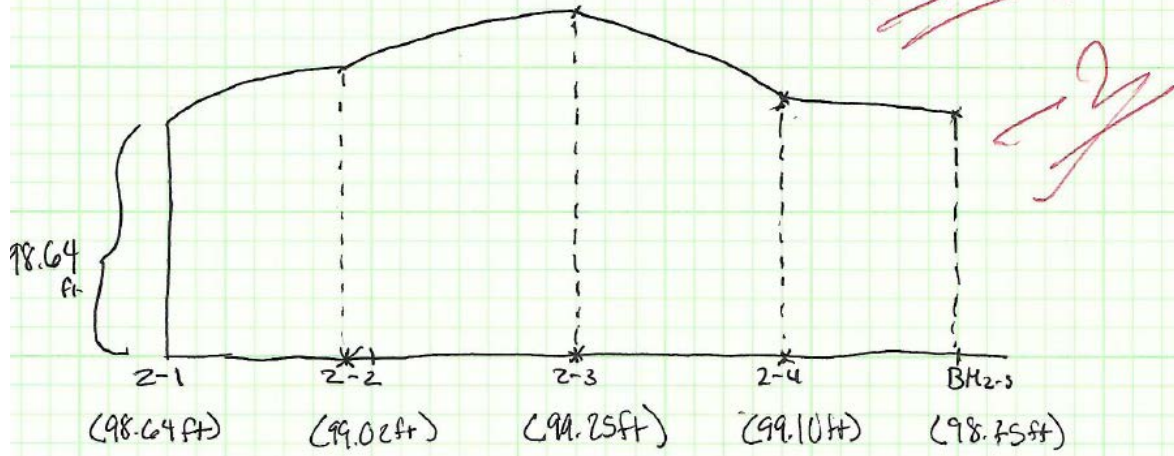


## Section 2

Figure 2.2

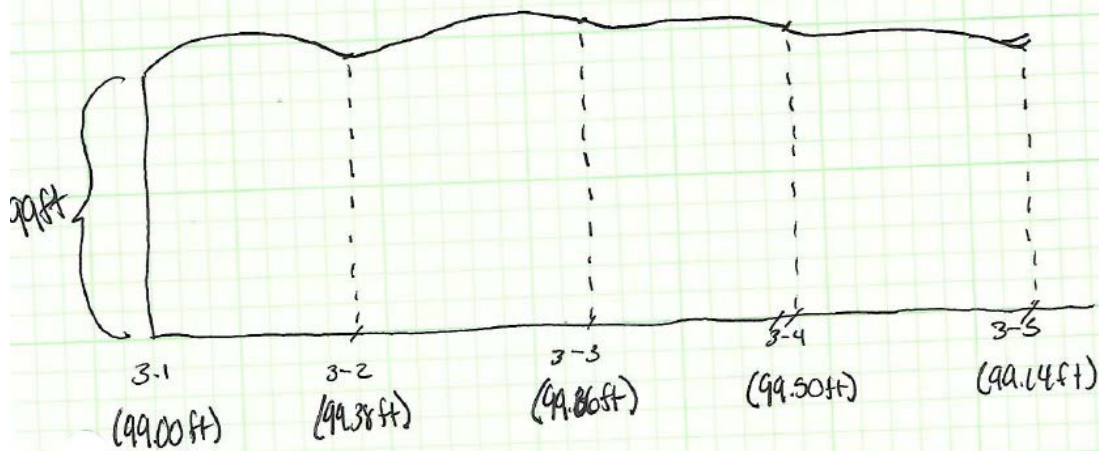
*Section 1 missing*

*Scale?*



## Section 3

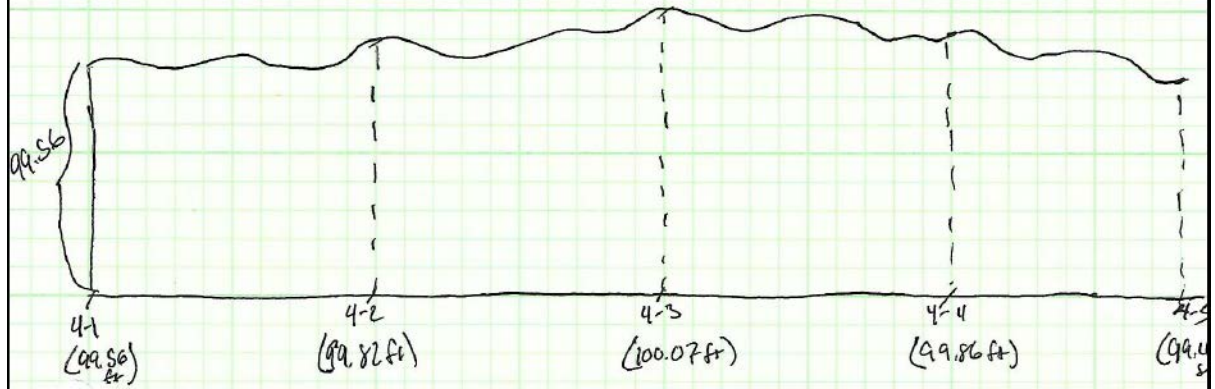
Figure 2.3





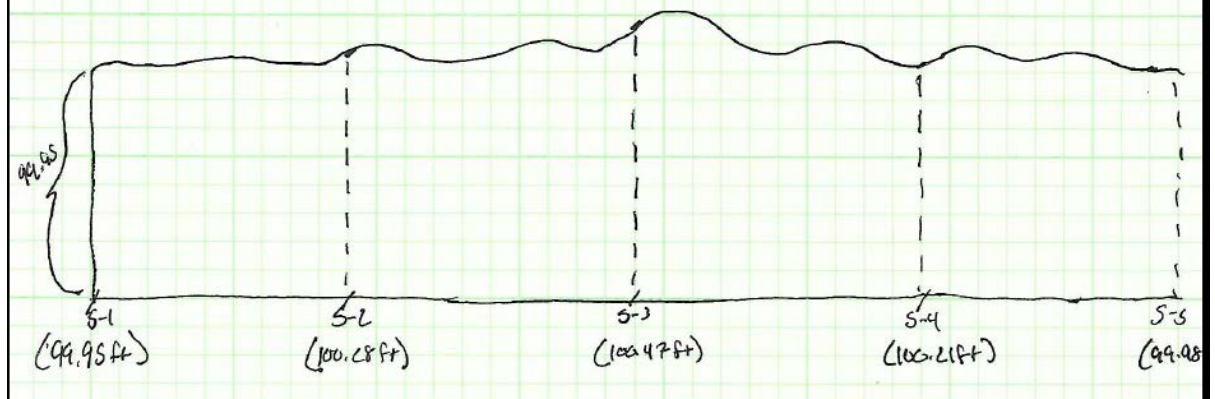
# Section 4

Figure 2.4



# Section 5

Figure 2.5





# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 2081-Surveying and Geospatial Concepts**  
**Instructor: Dr. Abdul M Choudhury**

## **Title of Assignment**

**Lab Report #1**

## **Outcome Measured Using this Assignment**

### **Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

## **Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the lab report show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT  
CVEG 2081- SURVEYING AND GEOSPATIAL CONCEPTS  
COURSE ASSIGNMENT GRADING  
AND OUTCOME ASSESSMENT SHEET**

ASSIGNMENT TITLE:                      Lab Report #1

DUE DATE:                      10/24/2020\_\_\_\_\_                      DATE SUBMITTED: 10/14/2020

Name of Student: Nija Kennedy, Omar Rafey and Abdul Alshammari

Title of Assignment:\_\_\_Tape surveying

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                  | Max for this Assignment | Student's Score |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments all background calculations covering designing and conducting experiments have been included in this part. All relevant mathematical calculation and concepts relevant to the laboratory experiments have been covered .</i> | 100                     | 91              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                            | 100                     | 91              |

**SCORE 91/100**

CIVIL ENGINEERING DEPARTMENT

**PRAIRIE VIEW A&M UNIVERSITY**



**CVEG 2081 Surveying and Geospatial Concepts**

**LABORATORY REPORT 1 ON**

**Plotting the Plan of the Old Chemical Engineering Building  
by Tape Surveying**

**Submitted by Group 2**

**Nyja Kennedy**

**Omar Rafey**

**Abdul Alshammari**

**On**

**October 14, 2020**

**To**

**Dr. Choudhury**

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### **Abstract**

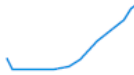
**The purpose of this experiment** was to plot the plan of the old chemical engineering building by measuring the distance between four points via tape measuring.

The experiment was conducted by using two tape measurers of 100 ft and 30 ft. The 100 ft surveyor tape was used to measure the distance between the ranging poles and the 30 ft tape measure was used to measure the offset of the building and some landmarks.

The significant results of the experiment were for the students to be able to draw a plan of a building using numbers obtained from tape surveying.

### Equipment and Apparatus

Field notebook  
30 ft tape measure  
100 ft surveyor tape  
Four ranging poles



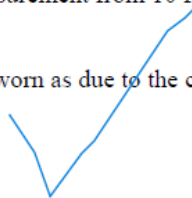
### Materials and Test Conditions

Two dimensional positions of points  
Ranging poles  
Tape measure  
Sunny weather  
Four people involved to complete experiment

### Step by Step Description and Experimental Safety Issue

1. Plant ranging poles around building so that the previous ranging pole is withing line of sight
2. Starting pole is labeled A, second pole is B, third pole is C, and fourth pole is D
3. 100 ft surveyor tape is used to measure the distance between ranging poles
4. Offsets from the surveyor tape are measured with the 30 ft tape measure
5. Measurements are written down in field notebook according to instructions laid out by instructor
6. In order to measure the angle between the lines of sights, a measurement of 10 ft is taken from the pole in the two directions and a third measurement from 10 ft on one line of sight to 10 ft on the other line of sight is taken

For the experiment, proper safety equipment had to be worn as due to the current COVID-19 pandemic. The safety equipment includes face masks.



### **Introduction**

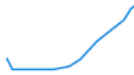
— 1 Surveying is the technique and science of determining the three-dimensional positions of points and the distances and angles between them. There are various ways to take measurements in surveying and one of these methods is chaining which is taking the linear measurements of the horizontal distance between two or more fixed points.

### **Test Objective**

The objective of this experiment is for the students to be able to plot the plan for the old chemical engineering building using the two-dimensional measurements obtained from tape surveying as well as identifying data inaccuracies due to human error.

### Equipment and Apparatus

Field notebook  
30 ft tape measure  
100 ft surveyor tape  
Four ranging poles



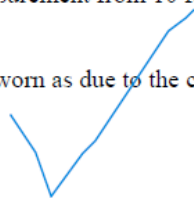
### Materials and Test Conditions

Two dimensional positions of points  
Ranging poles  
Tape measure  
Sunny weather  
Four people involved to complete experiment

### Step by Step Description and Experimental Safety Issue

1. Plant ranging poles around building so that the previous ranging pole is withing line of sight
2. Starting pole is labeled A, second pole is B, third pole is C, and fourth pole is D
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5. Measurements are written down in field notebook according to instructions laid out by instructor
6. In order to measure the angle between the lines of sights, a measurement of 10 ft is taken from the pole in the two directions and a third measurement from 10 ft on one line of sight to 10 ft on the other line of sight is taken

For the experiment, proper safety equipment had to be worn as due to the current COVID-19 pandemic. The safety equipment includes face masks.





### Data Analysis Methods and Models (Equations)

In order to find the angle at each marker, we need to use the Law of Cosines

$$c = \sqrt{a^2 + b^2 - 2ab \cos(\gamma)}$$

Manipulating the formula to solve for the angle  $\gamma$  gives us

$$\gamma = \cos^{-1}\left(\frac{a^2 + b^2 - c^2}{2ab}\right)$$

In order to write the angle in the proper format, we need to convert the numbers after the decimal point to minutes and seconds. The conversion is simple as

$$1^\circ = 60'$$

And

$$1' = 60''$$

From the equations above, we can derive all we need from the measurements obtained.

### Suitable Statistical Analysis Tools

For this experiment, there was no need for any statistical analysis tool as all the data obtained was able to be processed using just a calculator.

## Test Results and Analysis

The following figure provides an overview of the scope of the experiment (not to scale).



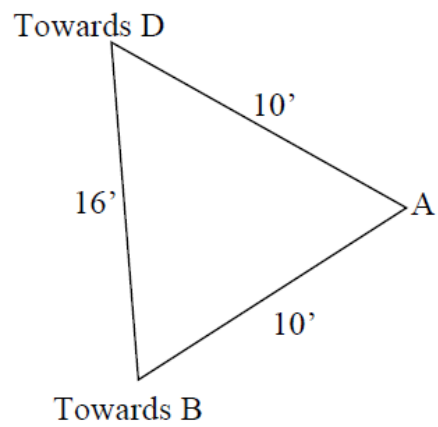
Figure 1 Overview of Experiment

The following four tables contain the measurements obtained from the tape survey. The measurements for the corners of the building have been labeled, and the unlabeled measurements are of various landmarks such as trees or poles.

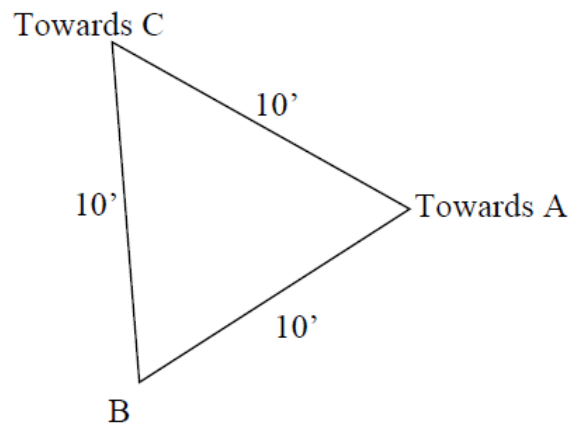
*Table 4 Measurements from D to A*

|  |                |                    |
|--|----------------|--------------------|
|  | Line DA starts |                    |
|  | 47'5"          | 10'6"              |
|  |                | Corner of Building |
|  | 77'2"          | 12'                |
|  | 109'5"         | 9'11"              |
|  |                | Corner of Building |
|  | End: 115'2"    |                    |

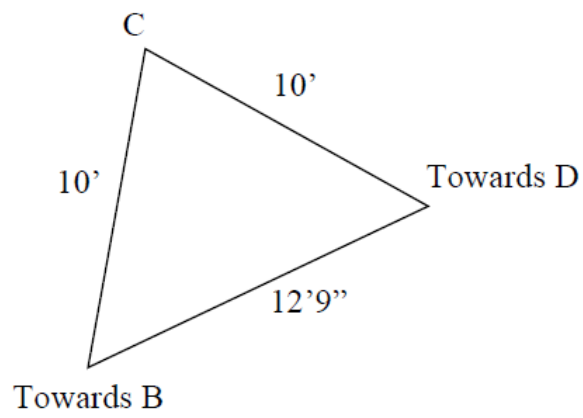
From the tables above, we have the points needed to draw the outline of the building. In order to put together lines AB, BC, CD, and DA, the angle at each ranging pole is required. The following four figures show the measurements obtained at each of the markers.



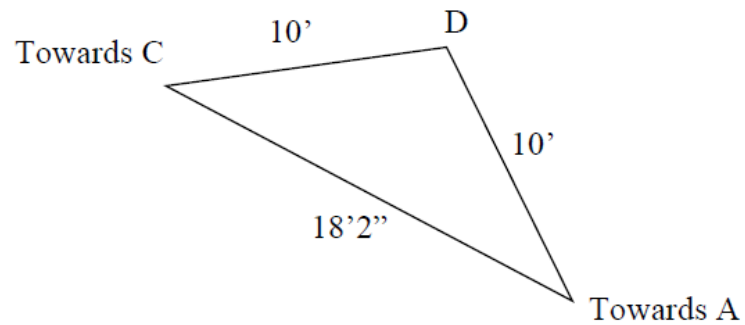
*Figure 2 Angle Measurements for Marker A*



*Figure 3 Angle Measurements for Marker B*



*Figure 4 Angle Measurements for Marker C*



*Figure 5 Angle Measurements for Marker D*

Using the measurements shown in the figures, we can use the manipulated version of the Law of Cosines and angle conversions written on page 6 to obtain the following values for the angles at each marker.

*Table 5 Angles Calculated at the Markers*

| Marker | Angle (Decimal) | Angle      |
|--------|-----------------|------------|
| A      | 106.26°         | 106°15'36" |
| B      | 60°             | 60°        |
| C      | 79.21°          | 79°12'36"  |
| D      | 130.55°         | 130°33'    |
| Sum    | 376.02°         | 376°1'12"  |

We can see that sum of the angles obtained is greater than 360°. This tells us that the data is not entirely accurate.

### Discussion, Synthesis and Interpretation of the Results and Findings

The purpose of this experiment is to plot a two-dimension plan for the old chemical engineering building by measuring the distance between the ranging poles via tape measuring. As we seen from the data in the previous section, we have four markers A, B, C and D. To measure the angle between the lines we use law of cosines, in which we have three known distances and one unknown angle to be measured. So, if we have three lines, we can easily derive the unknown angle and also convert it the proper format with minutes and seconds.

$$1^{\circ} = 60'$$

$$1' = 60''$$

To measure the angle at marker A, we take a measure of 10' in two directions from pole A and a third measurement from the 10' on one line of sight and 10' from the other line of sight. The distance between the two 10' measurements at marker A is 16'. By using the law of cosines, we calculate the angle at A to be  $106.26^{\circ}$  or  $106^{\circ}15'26''$ .

We repeat this process at markers B, C, and D.

The distance between the 10' measurements at marker B is 10'. By using the law of cosines, we calculate the angle at B to be  $60^{\circ}$  or  $60^{\circ}0'0''$ .

The distance between the 10' measurements at marker C is 12'9". By using the law of cosines, we calculate the angle at B to be  $79.21^{\circ}$  or  $79^{\circ}12'36''$ .

The distance between the 10' measurements at marker D is 18'2". By using the law of cosines, we calculate the angle at B to be  $130.55^{\circ}$  or  $130^{\circ}33'$ .

The sum of angle of four marker for a close four-sided polygon is

$$\angle A + \angle B + \angle C + \angle D = 106.26^{\circ} + 60^{\circ} + 79.21^{\circ} + 130.55^{\circ} = 376.02^{\circ}$$

This value is the interior angle of the measured quadrilateral surrounding the chemical engineering building and was found using simple trigonometry and without the use of any statistical analysis tool.

The error in the angle calculation is 4.2% since

$$\begin{aligned}\% \text{ Error} &= \frac{(\text{Measured Angle} - \text{Actual Angle})}{\text{Measured Angle}} * 100 \\ &= \frac{(376.02 - 360)}{376.02} * 100 = 4.2\%\end{aligned}$$

### **Summary- Conclusion and Recommendations**

The purpose of surveying is to find the elevation or depression of the land from surface. For this reason, different techniques are used to measure the distances such as pacing, taping, chain or GPS system. In our experiment we choose the taping method to measure the distance between four markers and then using trigonometry to find the angle at each marker. The distance between markers is measured by 100 ft tape and the perpendicular offset from the tape with the 30 ft tape. Then by using law of cosines with three known sides we found the unknown angle at each marker.

We know that the sum of the interior angle of a closed quadrilateral is  $360^\circ$ , but in our measurements, the sum of the interior angles ended up being more than  $360^\circ$ . The percentage error in measuring angle is about 4.2%. We learned that measuring distances and angles with taping is a less accurate method and does not give satisfying results. The accuracy of the angles calculated depends upon the accuracy of distances measured between the markers. The learning objectives we covered in this experiment are the use of tapes to measures distances, to draw 2D plan of any building using tape measurements, to measure angle at markers, to understand the practical application of the law of cosines, and to measure percentage errors in measuring angles.

It is recommended that we should use more accurate equipment to measures distance between two points and for this purpose we have to use advanced leveling instrument. The error can be minimized by using mathematical techniques. The most accurate instrument used nowadays for measuring distances is the GPS. We can also improve the results by minimizing the human error occurring during the measurements and it being recorded in the field notebook.

## References

1. [https://en.wikipedia.org/wiki/Distance\\_measuring\\_equipment](https://en.wikipedia.org/wiki/Distance_measuring_equipment)
2. <https://www.icsm.gov.au/education/fundamentals-mapping/surveying-mapping/surveying-methods>
3. <https://www.tpub.com/engbas/12-18.htm>
4. <https://geog.sfsu.edu/field-equipment-category/gps>
5. <https://theconstructor.org/surveying/surveying-equipment-angle-elevation-measurement/17021/>
6. <http://www.fao.org/3/W8297E/w8297e05.htm>

## Appendices

Surveying by S.K Duggal

Chapter- 01

Chapter- 02



# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 2081-Surveying and Geospatial Concepts**  
**Instructor: Dr. Abdul M Choudhury**

**Title of Assignment**

**Lab Report #3**

**Outcome Measured Using this Assignment**

**Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the homework show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT  
CVEG 2081- SURVEYING AND GEOSPATIAL CONCEPTS  
COURSE ASSIGNMENT GRADING  
AND OUTCOME ASSESSMENT SHEET**

ASSIGNMENT TITLE:    DIFFERENTIAL LEVELLING

DUE DATE:            11/04/2020\_\_\_\_\_      DATE SUBMITTED: 11/04/2019

Name of Student: Caleb Ross and Allyssa Reynolds

Title of Assignment:\_\_\_ Differential Levelling

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                  | Max for this Assignment | Student's Score |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments all background calculations covering designing and conducting experiments have been included in this part. All relevant mathematical calculation and concepts relevant to the laboratory experiments have been covered .</i> | 100                     | 95              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                            | 100                     | 95              |

Prairie View A&M University Civil Engineering  
Department



CVEG 2081(P81): Surveying & Geospatial Laboratory  
Fall 2020

Laboratory Report 2 on  
“Finding the Elevation of Chemical Engineering  
Building by Differential Levelling”

Conducted on  
October 26, 2020

Submitted by:  
Caleb Ross, Allyssa Reynolds

On  
November 4, 2020

To  
Dr. Choudhury

**SCORE 95/100**

### Abstract:

- The purpose of this experiment was to find the elevation of a point by using differential leveling, understanding the concept of leveling on a practical level, and applying the theory to real-world optics. In this lab, we applied what we learned within class regarding surveying, often taking elevations of different locations using a tripod, scope, and grade rod. During this experiment, it was found that there were errors created throughout the experiment. These errors were adjusted by utilizing the Field Notebook and finding the misclosure within the experiment.

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### Figure 1.0

| LAB 2                     |         |                                     |      |         |      |          |
|---------------------------|---------|-------------------------------------|------|---------|------|----------|
| Station                   | B.S.    | H.I.                                | I.S. | F.S.    | Elev | Adj Elev |
| CIVIL DEPARTMENT (B.M. 1) | 0.38 ft | $(100 + 0.38) = 100.038 \text{ ft}$ |      |         |      | 100 ft   |
| TP1                       | 4.86 ft |                                     |      | 6.12 ft |      |          |
| Chemical Building         |         |                                     |      | 0.38 ft |      |          |
| TP2                       | 2.85 ft |                                     |      | 5.7 ft  |      |          |
| CIVIL DEPARTMENT (B.M. 2) |         |                                     |      | 7.2 ft  |      | 100 ft   |

Figure 1.0 represents the "Field Notebook." a layout that is used throughout the leveling lab. This figure reflects the data collected throughout the lab procedure.

Figure 2.0

| LAB 2                                                                                                                                                                                                                                                                                                                  |         |                                      |      |         |                                        |                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------|------|---------|----------------------------------------|------------------------------------------|
| Station                                                                                                                                                                                                                                                                                                                | B.S.    | H.I.                                 | I.S. | F.S.    | Elev                                   | Adj Elev                                 |
| CIVIL DEPARTMENT (B.M. 1)                                                                                                                                                                                                                                                                                              | 0.38 ft | $(100 + 0.38) = 100.038 \text{ ft}$  |      |         |                                        | 100 ft                                   |
| TP1                                                                                                                                                                                                                                                                                                                    | 4.86 ft | $(94.26 + 4.86) = 99.12 \text{ ft}$  |      | 6.12 ft | $(100.038 - 6.12) = 93.918 \text{ ft}$ | $(94.26 + 2.155) = 96.415 \text{ ft}$    |
| Chemical Building                                                                                                                                                                                                                                                                                                      | 2.78 ft | $(98.74 + 2.78) = 101.52 \text{ ft}$ |      | 0.38 ft | $(99.12 - 0.38) = 98.74 \text{ ft}$    | $(98.74 + 273.155) = 108.095 \text{ ft}$ |
| TP2                                                                                                                                                                                                                                                                                                                    | 2.85 ft | $(96.35 + 2.85) = 99.2 \text{ ft}$   |      | 5.7 ft  | $(101.52 - 5.7) = 95.82 \text{ ft}$    | $(95.75 + 13) = 108.75 \text{ ft}$       |
| CIVIL DEPARTMENT (B.M. 2)                                                                                                                                                                                                                                                                                              |         |                                      |      | 7.2 ft  | $(99.2 - 7.2) = 92 \text{ ft}$         | $(91.88 + 14) = 105.88 \text{ ft}$       |
| $\sum = 10.87$ $\sum = 19.49$<br>A) $100 \text{ ft} + 10.87 - 19.49 = 91.38$ ✓ Page Closure<br>B) $91.38 - 100 = -8.62 \text{ ft}$ misclosure<br>C) $\frac{-(-8.62)}{4} = +2.155$ correction per setup<br>SAMPLE CALCULATION<br>$H.I. = ELEV + B.S. \Rightarrow 100 \text{ ft} + 0.38 \text{ ft} = 100.038 \text{ ft}$ |         |                                      |      |         |                                        |                                          |

Figure 2.0 represents the completed Field Notebook, with calculations to show the misclosure found. All adjustments have been made to find the correct elevation of Benchmark 2.

Figure 3.0

**SAMPLE CALCULATION**

$$H.I. = C.I.C.V. + B.S. \Rightarrow 100.4 + 0.284 = 100.684$$

$$\Rightarrow 94.26 + 4.86 = 99.124$$

$$C.I.C.V. = H.I. - F.S. \Rightarrow 99.124 - 38 = 98.744$$

$$\Rightarrow 78.584 - 7.24 = 91.384$$

$$Adj. C.I.C.V. = C.I.C.V. + (ADJUSTURE) \Rightarrow 94.26 + (1)(2.155) = 96.4154$$

$$\Rightarrow 98.74 + (2)(2.155) = 103.054$$

$$\Rightarrow 98.78 + (3)(2.155) = 107.4454$$

Figure 3.0 represents the sample calculations, showing the equations used, and applying real data to find specific answers. This data is collected from the Field Notebook shown in Figure 2.0.

Figure 4.0

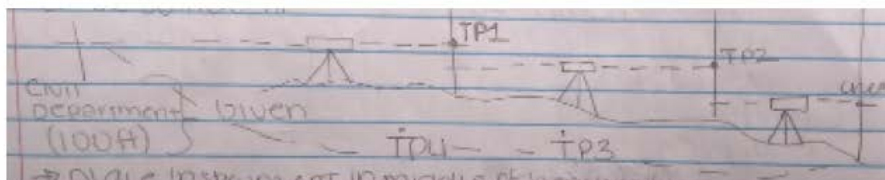


Figure 4.0 represents the drawing of the procedure to use the leveling instrument to find various elevations. This drawing was completed during the class period before the lab.

Figure 5.0



Figure 4.9

Parts of an automatic level.

(Courtesy Leica Geosystems.)

Figure 5.0 reflects the different parts of the leveling instrument, the telescope. This figure was given from the textbook Elementary Surveying: An Introduction to Geomatics.

### Introduction:

- The objective of this exercise is to determine the elevation at different points using methods learned in class. The lab involved measuring the forward and back side elevation from the given benchmark, the Civil Engineering building, of 100 feet. From the benchmark, we measured different elevations at various points.

### Test Objective:

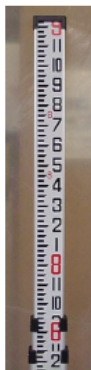
- The objective is to use the skills we learned in class to take elevations in the field. We were given a benchmark elevation of 100 feet. We were supposed to measure the different elevations in the field from the Civil Engineering building to the Chemical Engineering building on Prairie View A & M University's campus using two turning points in each direction.

### Description of Equipment



#### Leveling Instrument

- With a tripod, the telescope is used as a leveling instrument to find a specific point through its magnifying lens. This instrument's parts include bubble, objective lens focus, eyepiece focus, capstan screws, leveling screws, and horizontal motion screws.



#### Grade Rod

- A grade rod is a measuring rod that can be used to find distances up to 13 feet. This rod can be extended from 7 to 13 feet and gives readings up to four decimal places.



### Tripod

- A tripod is an instrument where the telescope is mounted upon. Its three legs provide stability so that the telescope can be used for its purpose in various topographical conditions.

### Levels and Transit Levels (Telescope)



- The telescope defines the line of sight and magnifies the view of the grade rod. This procedure allows surveyors to observe and obtain accurate sight readings.

#### **Materials:**

- Tripod: 3-legged instrument
- Grade Rod: 7ft to 3ft long
- Levels and Transit levels (Telescope): instrument used to find specific points within various positions, obtaining elevations at those particular points
- Test Conditions: Dry and humid, partly cloudy, and windy (moderate)
- Temperature: Between 72°F - 76°F/about 30% humidity

#### **Procedure:**

##### Set up:



- Before measuring can be done, the tripod has to be set. To set up the tripod, the leg and screw on the scope must be adjusted by manipulating the screws attached to the legs.

#### Level:

- When the tripod is set up, the scope has to be leveled. To scope is leveled by adjusting the leveling knobs until the bubble on the scope is inside the circle. Once the bubble is inside the circle, the scope is leveled.

#### Spot:

- When the tripod is set up and is leveled, a spot for the individual holding the grade rod must be found to start measuring specific elevations.

#### Measure:

- Once the point for grade rod is established, the procedure for obtaining measurements can begin. Using the eyepiece focus, the surveyor looks through the lens, observing the measurement from the rod at the given point.

#### Record:

- Once measurements are obtained, record data onto the pad/notebook.

### **Data Analysis Methods:**

- The elevations were found by looking through our scope and reading the grade rod. In the exercise, we were required to two benchmarks with a starting benchmark at an elevation of 100 feet. The benchmarks were both supposed to have two turning points each, leaving us with four turning points in total. The elevations that were measured were supposed to all be recorded as BS, backside or FS, forward side, and the height of the instrument, and the new elevation is all supposed to be calculated using the formulas below.

- **Formulas:**

1.  $HI = BM + BS$  (Height of Instrument = elevation + back sight)
2.  $EL = HI - FS$  (Elevation = Height of Instrument - foresight)
3. Adjusted Elevation = elevation  $\pm (x) \times$  misclosure
4. Page Check = Known elevation + sum of backsight - sum of foresight = last elevation  
calculated
5. Misclosure = Page check - last known elevation
6. Correction per setup =  $-(\text{misclosure})/\text{Number of positions}$

### Test Results and Analysis:

- The measurements are not 100% accurate due to human error. The human error would be the reading of the grade rod due to it not being leveled or held perfectly.
- The measurements and calculations are all shown in the table below. **Figure 2.0** reflects a handwritten drawing of the data table presented below. **Figure 3.0** shows the sample calculations.

| Sta. | BS +sight | HI | FS -sight | Ele | Adj. Ele |
|------|-----------|----|-----------|-----|----------|
|------|-----------|----|-----------|-----|----------|

|      |         |              |         |                |                    |
|------|---------|--------------|---------|----------------|--------------------|
| BMC  | 0.38 ft | 100 + 0.38   |         |                | 100 ft             |
|      |         | = 100.038 ft |         |                |                    |
| TP1  | 4.86 ft | 94.26 + 4.86 | 6.12 ft | 100.038 - 6.12 | 94.26 + 2.155      |
|      |         | = 99.12 ft   |         | = 94.26 ft     | = 96.415 ft        |
| BMC+ | 2.78 ft | 98.74 + 2.85 | 0.38 ft | 99.12 - 0.38   | 98.74 + (2)(2.155) |
|      |         | = 101.52 ft  |         | = 98.74 ft     | = 103.05 ft        |

|     |         |                   |         |                   |                      |
|-----|---------|-------------------|---------|-------------------|----------------------|
| TP2 | 2.85 ft | $95.73 + 2.85$    | 5.79 ft | $101.52 + 5.79$   | $97.73 + (3)(2.155)$ |
|     |         | <b>= 98.58 ft</b> |         | <b>= 97.73 ft</b> | <b>= 102.195 ft</b>  |
| BMC |         |                   | 7.2 ft  | $98.58 - 7.2$     | $91.38 + (4)(2.155)$ |
|     |         |                   |         | <b>= 91.38 ft</b> | <b>100 ft</b>        |

**Table 1.1**

**Sample Calculations:**

- Equation 1:  $100\text{ft} + 0.38\text{ft} = 100.038\text{ ft}$
- Equation 2:  $99.12\text{ ft} - .038\text{ft} = 98.74\text{ ft}$
- Equation 3:  $94.26 + (1)(2.155) = 96.415\text{ ft}$
- Equation 4:  $100\text{ft} + 10.87 - 19.49 = 91.38$
- Equation 5:  $91.38 - 100 = -8.62$  (Misclosure)
- Equation 6:  $-(-8.62)/4 = 2.155$  (positive, so add to correct)

## Discussion and Interpretation of the Results and Findings

- Although the initial elevations were incorrect at each point, we were able to find the misclosure and provide the correction to adjust the elevations. This error could be due to numerous factors, the main factor being personal error. Using the instrument was a new experience for many of us who conducted this lab, so our experience was very limited. This means the readings called out could've been inaccurate, the bubble wasn't centered, and the rod wasn't adjusted correctly.

## Summary:

- During the field exercise, we were split up into two groups and were tasked to take elevations using our knowledge from class and surveying tools. We started from the benchmark with an elevation of 100 feet and began taking the F.S. (forward side) and B.S. (backside) of the different points in the field. We had two benchmarks and four turning points giving us a total of six points to measure F.S. and B.S. for. When all of the points had measurements we then were required to calculate the H.I. (height of instrument) and the new elevations using formulas learned in class.

## References:

Antique, Surveying. *Leveling Rods and Accessories*.

[www.antiquesurveying.com/leveling\\_rods\\_and\\_accessories.htm](http://www.antiquesurveying.com/leveling_rods_and_accessories.htm).

Ghilani, Charles D. Elementary Surveying: An Introduction to Geomatics, 15/e. Pearson,

<https://platform.yirdocs.com/r/s/0/doc/256234/sp/15675496/mi/52460380?cfi=%2F4%2F2%5BP70010127910000000000000000000000F45%5D%2F20%5BP70010127910000000000000000000000F59%5D&fi=P70010127910000000000000000000000F59&menu=index>.

“[Hot Item] Famous Brand Topcon Tripod Surveying Instrument Accessories.”

Made-in-China.Com,

[haodiok.en.made-in-china.com/product/sycQjEPUASWV/China-Famous-Brand-Topcon-Tripod-Surveying-Instrument-Accessories.html](http://haodiok.en.made-in-china.com/product/sycQjEPUASWV/China-Famous-Brand-Topcon-Tripod-Surveying-Instrument-Accessories.html).

Tool, Northern. *Sight + Automatic Transit Levels*.

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**OUTCOME “6” SPECIFIC ASSIGNMENTS  
USED TO ASSESS THE OUTCOME IN**

**CVEG 3031  
STEEL & CONCRETE LAB**

# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 3031-Steel & Concrete Lab**  
**Instructor: Dr. Abdul M Choudhury**

## **Title of Assignment**

**Lab Report # 1**

## **Outcome Measured Using this Assignment**

### **Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

## **Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the Lab Experiment show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT**  
**CVEG 3031- STEEL & CONCRETE LAB**  
**COURSE ASSIGNMENT GRADING**  
**AND OUTCOME ASSESSMENT SHEET**

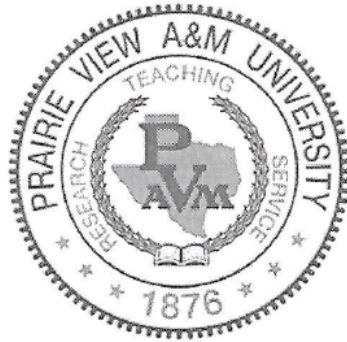
ASSIGNMENT TITLE:                      Lab Report # 1

DUE DATE:                      10/30/2019                      DATE SUBMITTED: 10/30/2019  
 Name of Student: Randle Jones

Title of Assignment: \_\_\_\_Sieve Analysis of Aggregates\_\_\_\_

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Max for this Assignment | Student's Score |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments covering designing and conducting experiments have been included in part. The laboratory data has been plotted graphically and necessary statistical calculation was carried out to arrive at the conclusion. Another main emphasize was also given on writing the laboratory reports properly.</i> | 100                     | 98              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100                     | 98              |





**CVEG 3031**

**Concrete & Steel Lab**

**Report #1**

**Lab Title: Sieve Analysis of Aggregates**

**Submitted by: Randelle Jones**

**Date Assigned: September 23, 2019**

**Due Date: September 30, 2019**

**Submitted to Dr. A. M. Choudhury**

98  
100

Sample

### **Abstract:**

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. In the lab we conducted an experiment in which we tested the retention rate of a sieve set, standardized by the ASTM Gradation Specifications for fine aggregates, versus fine aggregates passage through them. The collection of different sized particles left over on various sieves allows us to calculate passing percentage, percent retained, and the total weight.



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## **Introduction**

Sieve analysis consists of shaking the soil sample through a stack of sieves with openings of decreasing size from top to bottom. The mass of soil retained on each sieve is then determined, and a size-particle distribution curve can be produced by using experimental data. The purpose of this experiment is to take a uniform mixture and determine the percentage of retention for each sieve size.

## **Test objective**

The sieve analysis is performed to:

- 1) determine the distribution per sieve for the aggregate
- 2) display a graphical representation of your results
- 3) summarize the calculations and interpret the logic ✓

## **Apparatus**

Balance

Set of sieves

Pan

Sieve shaker

## **Material**

Fine aggregate – sand ✓

### **Procedures**

1. Record the weight of each sieve as well as the bottom pan to be used in the analysis
2. Record weight of the give dry soil sample
3. Assemble the sieves in ascending order. Place the pan at the bottom
4. Carefully pour the sand sample into the top sieve and place the lid over it
5. Place the sieve set into the mechanical shaker and shake for 5 minutes
6. Remove the stack from the shaker and weigh and record the weight of each sieve with its retained sand amount.
7. Return material and clean equipment

### Data Analysis

| Sieve Size (mm) | ES - Weight of Empty Sieve (grams) | AS - Weight of sieve with aggregate (grams) |
|-----------------|------------------------------------|---------------------------------------------|
| 9.5             | 764.7                              | 764.7                                       |
| 4.75            | 763.6                              | 763.8                                       |
| 2               | 676.5                              | 698.4                                       |
| .6              | 400.2                              | 879.3                                       |
| .425            | 563.3                              | 774                                         |
| .15             | 509.2                              | 766.8                                       |
| .075            | 501.9                              | 525.8                                       |
| pan             | 502.5                              | 508.1                                       |

**Table 1. Sieve Analysis Data**

### Test Results

**Table 2. Retained Calculations**

| Sieve size, mm | Amount Retained (AS – ES) , grams | Percent Retained, % |
|----------------|-----------------------------------|---------------------|
| 9.5            | 0                                 | 0                   |
| 4.75           | 0.2                               | .02                 |
| 2              | 21.9                              | 2                   |
| .6             | 479.1                             | 48                  |
| .425           | 210.7                             | 21                  |
| .15            | 257.6                             | 26                  |

|       |      |     |
|-------|------|-----|
| .075  | 23.9 | 2.5 |
| pan   | 5.6  | .6  |
| total | 999  |     |

**Table 3. Cumulative Calculations**

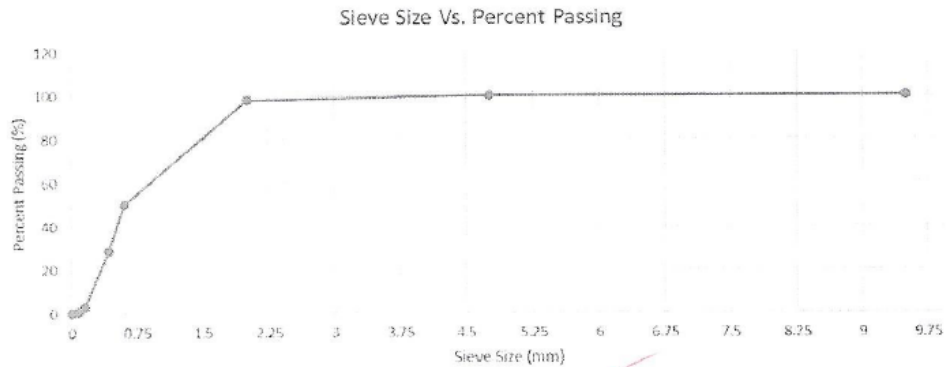
| Cumulative Amt. Retained ,grams | Cumulative Percent Retained ,% | Percent Passing,% |
|---------------------------------|--------------------------------|-------------------|
| 0                               | 0                              | 100               |
| .2                              | .02                            | 100               |
| 22.1                            | 2.02                           | 98                |
| 501.2                           | 50.02                          | 50                |
| 711.9                           | 71.02                          | 29                |
| 969.5                           | 97.02                          | 3                 |
| 993.4                           | 99.52                          | 1                 |
| 999                             | 100.02                         | 0                 |

*Present in  
one table*

### Interpretation of Results

Using the data collected, by subtracting the final weight of the sieve with the aggregate minus the empty weight of the sieve will give the amount of aggregate obtained by level. The cumulative of the masses were calculated to get the percentage of the total passing or retained. It is obvious that a fine aggregate was used because the lower sieves held a higher percent retained and the larger sieves have a higher percent passing. The total amount of aggregate retained varies from the actual amount used, which means some aggregate was lost during the transition of weighing the aggregate and loading the mechanical shaker.

**Figure 1. Sieve vs. Percent Passing**



$$FM = (0 + 0.1 + 50.17 + 97.05) / 100$$

$$FM = 1.47$$

*check the value  
too low*

The fineness modulus for fine aggregates, ranges from 2.3 to 3.1. Since we did not have the specific sieves for the experiment, we used sieves that were close in range to the required sieves. The material that we tested, was found to be fine aggregate.



## Summary & Conclusion

In conclusion, a sieve analysis of aggregates was conducted to determine the grading of the given materials by using a Sieve. With the analysis of the sand in the sieve shaker, we were able to determine the multiple sizes that were present in the sand mixture. The fineness of the aggregate was measured similarly.

Con

### References

Zaniewski, John P., Mamlouk, S. Micheal; **Materials for Civil and Construction Engineers**, Fouth Edition, Hoboken: Pearson Education Inc., [2016]

Add more

# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 3031-Steel & Concrete Lab**  
**Instructor: Dr. Abdul M Choudhury**

**Title of Assignment**

**Lab Report # 2**

**Outcome Measured Using this Assignment**

**Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the Lab Experiment show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT  
CVEG 3031- STEEL & CONCRETE LAB  
COURSE ASSIGNMENT GRADING  
AND OUTCOME ASSESSMENT SHEET**

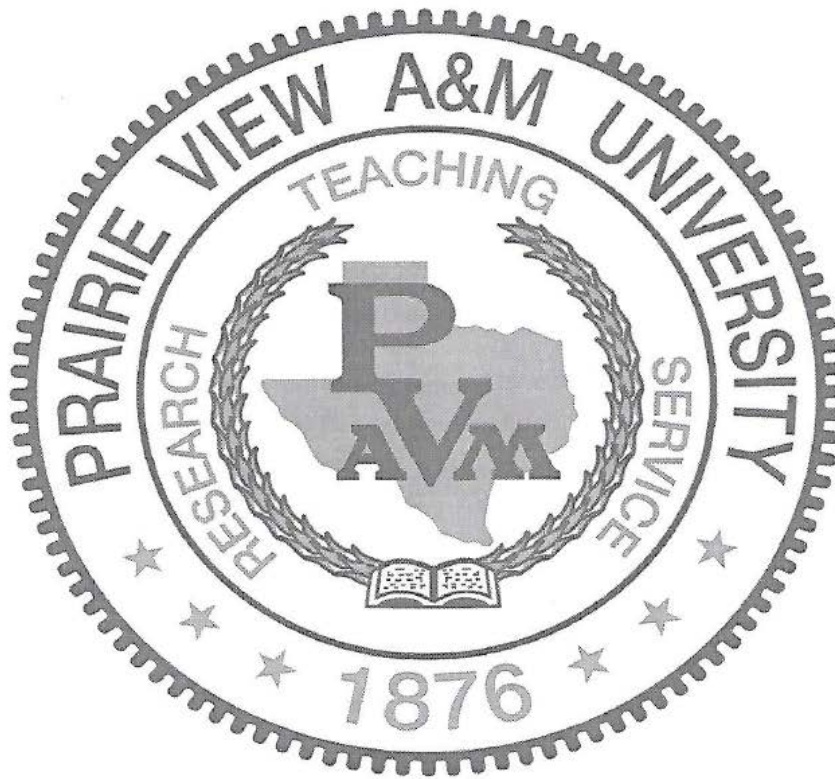
ASSIGNMENT TITLE:                      Lab Report #2

DUE DATE:            10/08/2019\_\_\_\_\_            DATE SUBMITTED: 10/08/2019\_\_\_\_\_

Name of Student: Milton Cruz and Nykea Keitt

Title of Assignment:\_\_\_Specific gravity and absorption

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Max for this Assignment | Student's Score |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments covering designing and conducting experiments have been included in part. The laboratory data has been plotted graphically and necessary statistical calculation was carried out to arrive at the conclusion. Another main emphasize was also given on writing the laboratory reports properly.</i> | 100                     | 96              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100                     | 96              |



CVEG 3031: Concrete and Steel Laboratory

Report #2: Specific Gravity and Absorption

Milton Cruz and Nykea Keitt

Due: 10/8/19

Submitted to: Dr. A. M. Choudhury

96/100

Sample

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## **Abstract**

The purpose of this experiment is to determine the specific gravity and absorption of sand. Another purpose of this experiment is to analyze sand and its properties. This lab also helps with knowing how to test and analyze a fine aggregate. Sand is an example of a fine aggregate. Specific gravity is the ratio of the density of a component to the density of water. A pycnometer is used to determine the specific gravity. By taking the weight of the pycnometer, the pycnometer with water, the pycnometer with sand, and the pycnometer with sand and water, it will help us determine the specific gravity. Absorption is the percentage is the dry weight subtracted from the saturated weight, divided by the dry weight, and multiplied by 100. Three jars were filled with sand and water. The jars sat for 24 hours. The sand was now saturated and weighed. The results for specific gravity and absorption are small numbers.

## Introduction

In this laboratory experiment, an aggregate was taken under analysis to identify two of its properties. The two properties were specific gravity and absorption. These are taken into consideration to better understand the application of sand within the use of construction. The use of water helps identify the density of sand in reference to water. In order to calculate the absorption, the saturated dry weight is needed.

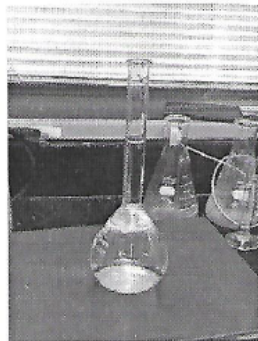
*How it effect mixed design? -2*

## Test Objective

The purpose of this laboratory experiment was to determine the dry specific gravity and absorption of the fine aggregate sand.

## Description of Equipment

- ❖ Pycnometer - to get an accurate reading since it is control volume.
- ❖ Scale - to weigh the various components need to compute the specific gravity and absorption
- ❖ Three jars - to hold the sand and water to calculate the absorption
- ❖ Sand - what is being tested
- ❖ Water - necessary for the absorption test



Pycnometer



Jars



### Step-by-step Description and Safety Issues

1. Weigh the pycnometer.
2. Weigh the pycnometer with water.
3. Weigh the pycnometer with sand.
4. Weigh the pycnometer with water and sand.
5. Repeat steps 1-4 three times.
6. Weigh each of the three jars.
7. Pour sand into each of the jars halfway.
8. Weigh each jar with sand.
9. Pour water in the jars.
10. Weigh each jar with sand and water.
11. Let the samples sit for 24 hours.
12. After 24 hours, drain the water out.
13. Weight the jar with the saturated sand.

Proper lab procedures and techniques must be followed.

### Data Analysis, Methods, Models

The lab data was collected throughout the lab procedure with the intent of following the similar steps that are shown in the textbook; to combine put understanding from the theoretical calculations to the realistic results that were presented in the lab. There were some distinct changes that were made in order to make the lab analysis of the fine aggregate possible. There was no use of the over or desiccator to remove the excess moisture that remained when taking the results of the saturated aggregate resulting in some of the values to be higher than average.

**Test Results and Analysis**  
**Absorption**

| Sample  | Jar    | Aggregate/<br>Jar | Aggregate/<br>Water/Jar | Wet<br>Aggregate/<br>Jar |
|---------|--------|-------------------|-------------------------|--------------------------|
| Jar 5-1 | 14.2 g | 40.5 g            | 76 g                    | 46.5 g                   |
| Jar 1   | 14.4 g | 45 g              | 83 g                    | 52.3 g                   |
| Jar 3   | 14.5 g | 52 g              | 86 g                    | 60.8 g                   |

| Object                                    | Jar 5-1 | Jar 1  | Jar 3  |
|-------------------------------------------|---------|--------|--------|
| Dry Weight                                | 26.3 g  | 30.6 g | 37.5 g |
| SSD Weight<br>(Saturated<br>Surface-Dry)  | 32.3 g  | 37.9 g | 46.3 g |
| Submerged<br>Weight (Water/<br>Aggregate) | 61.8 g  | 68.6 g | 71.5 g |

$$Absorption = \frac{SSD\ Weight - Dry\ Weight}{Dry\ weight} * 100$$

$$Abs. Jar\ 5-1 = \frac{32.3 - 26.3}{26.3} * 100 = 22.81\%$$

$$Abs. Jar\ 1 = \frac{37.9 - 30.6}{30.6} * 100 = 23.85\%$$

$$Abs. Jar\ 3 = \frac{46.3 - 37.5}{37.5} * 100 = 23.46\%$$

### Specific Gravity

| Object                         | T1      | T2      | T3      |
|--------------------------------|---------|---------|---------|
| Pycnometer                     | 91 g    | 90.5 g  | 91 g    |
| Pycnometer/<br>Water           | 338.8 g | 338 g   | 338 g   |
| Pycnometer/<br>Aggregate       | 138.9 g | 134.5 g | 159 g   |
| Pycnometer/<br>Water/Aggregate | 367.4 g | 365 g   | 380.5 g |

| Object          | T1     | T2   | T3   |
|-----------------|--------|------|------|
| Dry W Aggregate | 47.9 g | 44 g | 68 g |

$$\text{Apparent Sp. Gr.} = \frac{\text{Dry Weight}}{(\text{Pycnometer/Water}) + (\text{Dry Weight}) - (\text{Pycnometer/Water/Aggregate})}$$

$$Sp 1 = \frac{47.9}{338.8 + 47.9 - 367.4} = 2.482$$

$$Sp 2 = \frac{44}{338 + 44 - 365} = 2.5882$$

$$Sp 3 = \frac{68}{338 + 68 - 380.5} = 2.667$$

*Handwritten note:*  $AV = ? - 1$

### Discussion, Synthesis, and Interpretation

The values of all of the samples taken throughout the lab experiment came to be very similar. There were some slight variations in the numbers potentially due to the human error that is presented when removing the water and measuring with the naked eye. Some of the values that were produced by the experiment may be slightly different from what may be used in the field because of the change in the lab procedure to not use the oven to dry the aggregate. The use of the oven could've helped produce better results. Without the oven there were some residual water left over that allowed for the saturation to be much higher than was expected with both the specific gravity and absorption, but more noticeable in the absorption part of the lab.

### **Summary-Conclusions and Recommendations**

The importance of the absorption of an aggregate can lead to the success of a material to meet its structural capabilities or can lead to the failure of its strength and its composition. The lab accurately measured the specific gravity of the fine aggregate that was tested. The results of the specific gravity for fine aggregate are in the range of 2.5 to 2.7. Our lab results taken from three different tests taken came very close from the range and two of the three samples met the specifications of the fine aggregate meaning there was little to no error. Furthermore, the results for the fine aggregate in the absorption portion of the lab experiment came out very high from the normal range. The normal range can be from zero to eight (0 to 8) percent for fine aggregate and can reach low as three (3) percent when introduced with concrete wormand applications. The range that our was roughly four to five times larger than the expected values. The reason why there was a large discrepancy was due to the time the aggregate had to dry. Once the water was removed from the submerged aggregate there was not enough time or heat applied to allow for the aggregate to dry well leading to the excess remainder of water present. The use of an over would decrease the difference in the values giving use accurate data.

### Works Cited

Mamlouk, Michael S., and John P. Zaniewski. *Materials for Civil and Construction Engineers*.  
Pearson Education Limited, 2016.

Add more? - 1

# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 3031-Steel & Concrete Lab**  
**Instructor: Dr. Abdul M Choudhury**

## **Title of Assignment**

**Lab Report # 1**

## **Outcome Measured Using this Assignment**

### **Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

## **Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the Lab Experiment show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT  
CVEG 3031- STEEL & CONCRETE LAB  
COURSE ASSIGNMENT GRADING  
AND OUTCOME ASSESSMENT SHEET**

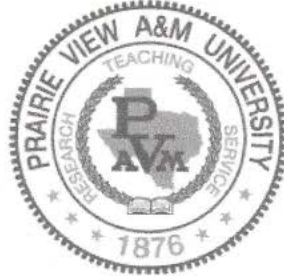
ASSIGNMENT TITLE:                      Lab Report # 1

DUE DATE:                      10/05/2020                      DATE SUBMITTED: 10/05/2020  
Name of Student: Nathaniel Smith, Brennen wright, Perla Zaldavier

Title of Assignment: \_\_\_\_Sieve Analysis of Aggregates\_\_\_\_

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Max for this Assignment | Student's Score |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments covering designing and conducting experiments have been included in part. The laboratory data has been plotted graphically and necessary statistical calculation was carried out to arrive at the conclusion. Another main emphasize was also given on writing the laboratory reports properly.</i> | 100                     | 94              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100                     | 94              |

**Department of Civil and Environmental Engineering  
Prairie View A&M University**



**CVEG 3031: Concrete & Steel Lab**

**Laboratory Report On:  
Sieve Analysis**

**Conducted On: September 28, 2020**

**Submitted By:  
Group 4  
Nathaniel Smith  
Brennen Wright  
Perla Zaldivar**

**Date Submitted: October 5, 2020**

**Submitted To: Dr. Choudhurry**

94  
100



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### Abstract

The purpose of this experiment was to understand how aggregates pass through a series of sieve films of different sizes. To fulfil this, experiment a sieve shaker was used in order to ensure the aggregates passed through the sieve. Fine aggregates are less than 4.75 mm while coarse aggregates are more than 4.75 mm or are retained by 4.75 mm. The experiment showed how different size aggregates go through different sieve, which is beneficial for companies, as large aggregates are cost efficient.

This test is used to determine the nature of gradation like well graded, poor graded etc. This test also gives the indication about whether blending is required or not.



Sieve Shaker: The sieve shaker is able to effectively gradate the aggregates through the series of sieves for a desired time.



### Materials and Test Conditions

The materials used in this lab consisted sieve, sieve shaker, scale, aggregate of different size, s scoop and notepad. All materials were used in a laboratory setting with the appropriate safety measures and PPE. Usage of the sieve shaker was used to analyze the sample to determine the particle size of the sample. The different size sieve either allowed the sample to pass through or retained the sample in the corresponding sieve.

### Procedure

1. Using clean sieve ranging from 9.5 mm to 0.075mm, weigh each sieve on the scale including the pan and record the weights.

## Introduction

Aggregates are placed on a sieve in order to determine the gradation of the aggregate. The test determines the distribution of the aggregates throughout the sieves. The purpose of the lab is to determine how the sample of the aggregate is retained on each sieve.

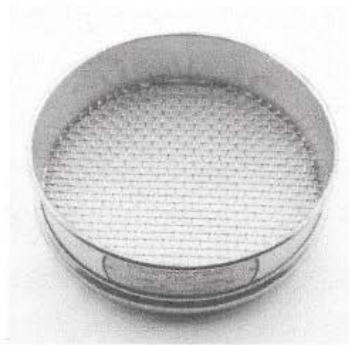
## Objective

The objective of the experiment was to determine how different size aggregates are distributed in the sieve. Determine the relationship between sieve size and percent passing of aggregate gradation. Find the fineness modulus which is the measure of fine aggregate gradation of the sieve from 9.5 mm to 0.150 mm.

*what is the use of sieve analysis and FM for mixed design?*

## Apparatus

Sieve: Composed of metal wire around the circumference of the sieve which come in different sizes.



Scale: Used to measure the weight of the respective sieve and aggregate retained in the sieve.

2. Stack the sieve ensuring the largest sieve is on top with the pan at the bottom.
3. Add 6 scoops of the aggregate sample to the stack of sieves. Place the cover plate to the sieve.
4. Place the stack of sieve on the sieve shaker, allow the machine to shake for 5 minutes.
5. Carefully remove the stack of sieve from the sieve shaker.
6. Remove the cover plate of the sieve stack, weigh each sieve on scale including the pan and record the data on a notepad.
7. The weight retained is found by subtracting the weight from Step 2 from weight obtained in Step 6.

#### Data Analysis Method

The methods used to analyze the data collected was found using the appropriate equations given in Materials for Civil and Construction Engineers textbook. Once the weight retained is found as explained in Step 7 of the procedure, the percent retained is found by

$$\frac{a}{\text{Total Weight Retained}} \times 100$$

Where a is the corresponding weight retained for the specific sieve. The Cumulative percent retained is computed as,

$$\text{Cumulative Percent Passing} = \sum \text{Percent Retained} \text{ upto the current sieve}$$

The Percent passing are computed as,

$$\text{Percent Passing} = 100\% - \% \text{ Cumulative Weight Retained}$$

The fineness modules are computed as,

$$\frac{\sum \text{Cumulative Percent Retained}}{100}$$

However, any sieve below 0.150mm isn't computed in the fineness modules equation.

### **Suitable Statistical Analysis Tools**

The tools used to suitably analyze our statistics include but are not limited to samples given in the pre laboratory assessment. Additionally, another tool includes formulas, examples and information provided in the Materials for Civil and Construction Engineers textbook.

### **Test Results and Analysis**

The data in Table 1 shows the weight of each clean sieve prior to adding the sample.

**Table 1 Mass of Sieve**

| <b>Sieve Size</b> | <b>Weight (g)</b> |
|-------------------|-------------------|
| 9.5 mm            | 842.4             |
| 4.75 mm           | 760.1             |
| 2.36 mm           | 696.3             |
| 1.18 mm           | 651.2             |
| 0.600 mm          | 612.6             |
| 0.300 mm          | 548.4             |
| 0.150 mm          | 513.8             |
| 0.075 mm          | 503.4             |
| Pan               | 488.3             |

The data in Table 2 shows the weight retained for each corresponding sieve as well as the percent retained, cumulative weight retained and percent passing.

## Discussion

Based on the data acquired through the experiment the weight retained wasn't linear as the sieve got smaller. From Table 2 the sieve that retained the most weight was the sieve size of 0.600 mm. The table also demonstrates the percent retained for each sieve size.

## Conclusion and Recommendations

In conclusion the experiment demonstrated how different size aggregates are separated in the sieve. The size and texture of the aggregate affect how concrete or asphalt will bond with the binder material. The size also impacts the cost for cement and asphalt companies. The lab demonstrated how aggregates are effectively separated in a short period of time by using a sieve and sieve shaker.

## References

Mamlouk, Michael S., and John P. Zaniewski. *Materials for Civil and Construction Engineers*. Pearson Education, Inc., 2017.

-3  
-1 Add more Ref. from internet, ASTM, etc.

What should be the  
standard value of FM?  
Is your finding a reasonable  
value?

Over all good



**Table 2 Aggregate Retained**

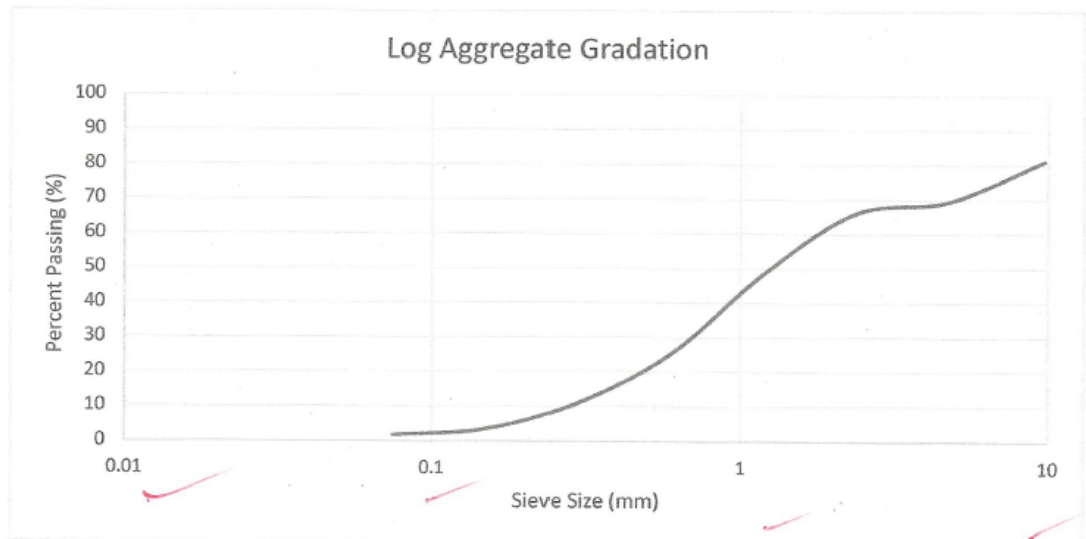
| Sieve Size   | Weight Retained (g) | Percent Retained (%) | Cumulative Percent Retained (%) | Percent Passing (%) |
|--------------|---------------------|----------------------|---------------------------------|---------------------|
| 9.5 mm       | 182.60              | 18.83                | 18.83                           | 81.17               |
| 4.75 mm      | 114.40              | 11.80                | 30.63                           | 69.37               |
| 2.36 mm      | 33.70               | 3.47                 | 34.10                           | 65.90               |
| 1.18 mm      | 170.80              | 17.61                | 51.71                           | 48.29               |
| 0.600 mm     | 220.90              | 22.78                | 74.49                           | 25.51               |
| 0.300 mm     | 138.60              | 14.29                | 88.78                           | 11.22               |
| 0.150 mm     | 74.10               | 7.64                 | 96.42                           | 3.58                |
| 0.075 mm     | 17.60               | 1.81                 | 98.23                           | 1.77                |
| Pan          | 16.70               | 1.17                 | 99.40                           |                     |
| <b>Total</b> | 969.40              |                      |                                 |                     |

The fineness modules was found to be,

$$\frac{18.83+30.63+34.10+51.71+74.49+88.78+96.42}{100} = 3.94$$

Figure 1 shows the relationship between the sieve size and the percent passing of the sample used in the experiment.

**Figure 1 Log Aggregate Gradation**





## Discussion

Based on the data acquired through the experiment the weight retained wasn't linear as the sieve got smaller. From Table 2 the sieve that retained the most weight was the sieve size of 0.600 mm. The table also demonstrates the percent retained for each sieve size.

## Conclusion and Recommendations

In conclusion the experiment demonstrated how different size aggregates are separated in the sieve. The size and texture of the aggregate affect how concrete or asphalt will bond with the binder material. The size also impacts the cost for cement and asphalt companies. The lab demonstrated how aggregates are effectively separated in a short period of time by using a sieve and sieve shaker.

## References

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-3  
-1 Add more Ref. from internet, ASTM, etc.

What should be the  
standard value of FM?  
Is your finding a value  
reasonable

over all good

# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 3031-Steel & Concrete Lab**  
**Instructor: Dr. Abdul M Choudhury**

**Title of Assignment**

**Lab Report # 3**

**Outcome Measured Using this Assignment**

**Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the Lab Experiment show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT  
CVEG 3031- STEEL & CONCRETE LAB  
COURSE ASSIGNMENT GRADING  
AND OUTCOME ASSESSMENT SHEET**

ASSIGNMENT TITLE:                      Lab Report #3

DUE DATE:            11/16/2020\_\_\_\_\_            DATE SUBMITTED: 11/16/2020\_\_\_\_\_

Name of Student: Abram Augute, Autumn Carter and Paige Hines

Title of Assignment:\_\_\_Compressive strength of Portland cement

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Max for this Assignment | Student's Score |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments covering designing and conducting experiments have been included in part. The laboratory data has been plotted graphically and necessary statistical calculation was carried out to arrive at the conclusion. Another main emphasize was also given on writing the laboratory reports properly.</i> | 100                     | 92              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100                     | 92              |

**CIVIL ENGINEERING DEPARTMENT  
PRAIRIE VIEW A&M UNIVERSITY**



**CVEG 3031 CONCRETE AND STEEL LAB**

**FALL 2020**

**LABORATORY REPORT ON**

**"Compressive Strength Test"**

**Conducted on**

**October 26, 2020**

**Submitted by**

**Abram Auguste, Autumn Carter, Paige Hines, Johnathan Chevalier**

**On**

**November 16, 2020**

**To**

**Dr. A. Choudhury**

**SCORE 92/100**

**CIVIL ENGINEERING DEPARTMENT  
CONCRETE AND STEEL LABORATORY GRADING SHEET  
FALL 2020**

Title of Experiment: **Compressive Strength Test**  
Name: Paige Hines

Date Lab was Performed: October 26, 2020

Report Due Date: November 16, 2020

| <i>Ability to Conduct Experiments</i>                                                                                                             | MAX        | Your Score | Comments |
|---------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|----------|
| Ability to demonstrate general lab safety (by your conduct and observations).                                                                     | 3          |            |          |
| Ability to follow and properly state the procedure used for the experiment, while maintaining all safety precautions.                             | 9          |            |          |
| Ability to demonstrate knowledge of how equipment function, their limitations, and the uncertainty associated with reading the instruments.       | 6          |            |          |
| Ability to collect and record data using appropriate units of measurement and identify the dependent and independent variables in the experiment. | 15         |            |          |
| <b>Total for Ability to Conduct Experiments</b>                                                                                                   | <b>33</b>  |            |          |
| <b>Percentage for this Performance Criteria</b>                                                                                                   |            |            |          |
| <i>Ability to Analyze and Interpret experimental Data</i>                                                                                         |            |            |          |
| Provides appropriate abstracts for the experimental report                                                                                        | 5          |            |          |
| Ability to analyze the data using appropriate software to generate the required parameters using consistent units and significant figures.        | 22         |            |          |
| Use of statistical analysis as needed including uncertainty analysis                                                                              | 5          |            |          |
| Ability to present the data (raw /derived) in tabular and graphical form to meet the objectives and to aid in interpretation.                     | 14         |            |          |
| Ability to discuss the raw and derived data/graphs and assess the validity of the results in relation to the underlying theory.                   | 14         |            |          |
| Ability to draw appropriate and reasonable conclusions in relations to each of the experimental objectives.                                       | 7          |            |          |
| <b>Total for Ability to Analyze and Interpret experimental Data</b>                                                                               | <b>67</b>  |            |          |
| <b>TOTAL FOR THIS LAB</b>                                                                                                                         | <b>100</b> |            |          |

### Letter of Transmittal

November 9 2020

Dr. A. Choudhury

Civil Engineering Department

Prairie View A&M University

Dear Dr. Choudhury:

The attached technical laboratory report contains the detailed results of the Compressive strength test laboratory work done on October 26, 2020. The report contains the objectives of the experiment, the equations used for analysis of the data, the raw experimental data, tabulated presentation of the important results, discussion and interpretation of the results and recommendations.

Please contact me at 346-757-5960 or by e-mail at [phines1@student.pvamu.edu](mailto:phines1@student.pvamu.edu) if you have any Questions on the report.

Sincerely,

Paige Hines

Paige Hines

## ABSTRACT

**The purpose of the lab experiment** was completed to test the compressive strength of concrete mortar cubes. The compressive strength of concrete is determined by the proportion of ingredients used in concrete. To in this lab, we are using mortar cube molds, concrete mix, sand and water. The molds will be left to dry for two weeks, afterwards we will return to the experiment to do the compressive test.

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## CHAPTER 1: ABILITY TO CONDUCT EXPERIMENT

### 1.1 OBJECTIVE

The objective of this experiment is to determine the Compressive Strength of Concrete following a two-week period.

### 1.2 THEORY:

According to ASTM 109 the concrete ratio is, 1:0.485:2.75. Where, 1 represents cement, 0.485 represents water, and 2.75 represents sand. These molds typically come in multiples of three and we will be making 3 mortar cubes.

The ratio that we will be using is 250g:121ml:687g, this ratio is based on the ASTM 109 ratio.

$$\text{Cement amount} = 250g$$

$$\text{Water amount} = 250 * 0.485 = 121ml$$

$$\text{Sand amount} = 250 * 2.75 = 687g$$



*Figure 2: Cube Mold for Cement.*

### **1.3 APPARATUS**

1. Mortar cube mold
2. Cement mix
4. Mixing bowl
5. Standard Water
6. Sand
7. Sand Scooper
8. Compression Testing Machine

### **1.4 EXPERIMENTAL SAFETY**

The experiment was conducted using equipment in the engineering lab under the supervision of the professor. The instructor observed as the students filled the containers with sand/aggregate and mixed with water. Students maintained a safety protocols as the weight of sand was collected for each container. At the closing of the experiment the students were required to clean up and dispose of any wasteful material.

### **1.5 EXPERIMENTAL PROCEDURE II**

Equipment: Mortar cube mold, mixing bowl

- a) Weigh 250g of cement and place into mixing bowl
- b) Weigh 687g of sand and place into mixing bowl
- c) Measure out 121ml of water and place into mixing bowl
- d) Thoroughly mix all ingredients together
- e) Tightly pack concrete mix into cube mold.
- f) Clean of excess concrete
- g) Label molds
- h) After 24 hours remove mortar from mold.
- i) Keep the test specimens submerged underwater for stipulated time.
- j) Ensure that concrete specimen must be well dried before placing it on the UTM.
- k) Testing specimens are placed in the space between bearing surfaces.
- l) The concrete cubes are placed on bearing plate and aligned properly with the center of thrust in the testing machine plates.
- m) The loading must be applied axially, till the specimen collapse.
- n) Final breakdown of the specimen must be noted.

## CHAPTER 2: RAW EXPERIMENT DATA SECTION

2.1: The following data is based on what was collected during our compressive strength lab.

| Compressive Strength Test | (lb) | (psi) |
|---------------------------|------|-------|
| 1st Cube                  | 1130 | 282.5 |
| 2nd Cube                  | 1014 | 253.5 |
| 3rd Cube                  | 1412 | 353   |

*Table 1: Raw Experimental Data – Compressive Strength*

The Compressive strength of specimen can be calculated by dividing maximum load carried by the specimen by cross-sectional area of the specimen cubes.

$$\frac{\text{Max Load}}{\text{Cross – Sectional Area}} = \text{Compressive Strength of Concrete}$$

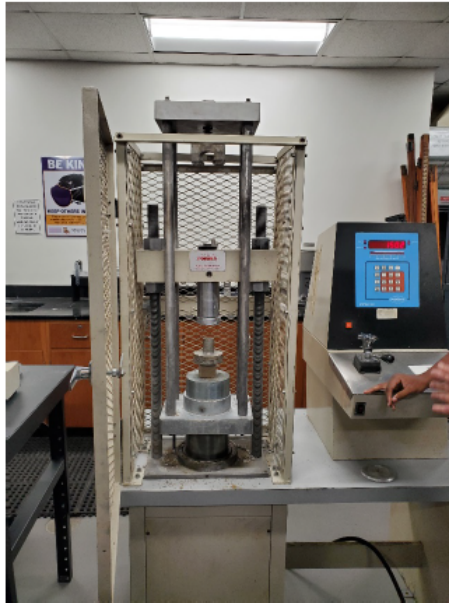
Where the cross-sectional area is:  $2 \text{ in.} \times 2 \text{ in.} = 4 \text{ in.}^2$

## CHAPTER 3: DISCUSSION

Compressive strength is the material or structure's ability to resist or withstand compression. A material's compressive strength is determined by the material's capacity to withstand failure in the form of cracks and fissures.

Concrete testing enables us to concentrate mainly on concrete's compressive strength because it encourages us to measure concrete's ability to withstand compressive stresses between structures where other stresses such as axial stresses and tensile stresses are handled by reinforcement and other means.

The cube test for Compressive strength can be done on 1,3, 7, 14 and 28 days. In our case, the test was done after 14 day. As one can see, the max load that was placed on these cement cubes varies greatly. I believe it was due to the fact that there were pieces of our apparatus were not able to properly fashioned and this could have cause devastating changes in experiment data.



*Figure 2: Compression Testing Machine.*

#### **CHAPTER 4: CONCLUSION**

An experiment was conducted to measure the compressive strength of cement. While this experiment was not conducted with 100% accuracy the main objective of this experiment was completed. As we all know, a combination of sand, cement, and aggregate is concrete. The strength of the concrete depends on many variables, such as the individual compressive strength of its components (cement, sand, aggregate), the consistency of the materials used the proportions of the air entrainment mix, the water-cement ratio, the methods of curing and the effects of temperature.

Compressive strength provides an interpretation of the total strength and the variables above. By performing this test, the concrete strength psi and consistency of concrete produced can be easily evaluated.

The results for the lab experiment were not consistent, giving evidence that the test was likely flawed.

## **ASSIGNMENTS FOR OUTCOME “6”**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**(As it relates to Steel & Concrete lab)**

# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 3100-Steel & Concrete Lab**  
**Instructor: Dr. Abdul M Choudhury**

**Title of Assignment**

**Lab Report # 1**

**Outcome Measured Using this Assignment**

**Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the Lab Experiment show the students ability to design and conduct experiments, as well as to analyze and interpret data**



**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT**  
**CVEG 3100- STEEL & CONCRETE LAB**  
**COURSE ASSIGNMENT GRADING**  
**AND OUTCOME ASSESSMENT SHEET**

ASSIGNMENT TITLE:                      Lab Report # 1

DUE DATE:                      10/04/2021                      DATE SUBMITTED: 10/04/2021  
 Name of Student: Allyssa Reynolds

Title of Assignment: \_\_\_\_Sieve Analysis of Aggregates\_\_\_\_

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Max for this Assignment | Student's Score |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments covering designing and conducting experiments have been included in part. The laboratory data has been plotted graphically and necessary statistical calculation was carried out to arrive at the conclusion. Another main emphasize was also given on writing the laboratory reports properly.</i> | 100                     | 91              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100                     | 91              |

**Prairie View A&M University**



**Civil Engineering Department**

---

**CVEG 3100 (P81): Concrete & Steel Laboratory**

**Fall 2021**

---

**Group No. 2**

**Laboratory Report No. 1**

**Laboratory Name:**

**“Sieve Analysis”**

**Conducted on**

**September 27, 2021**

**Submitted by**

**Allyssa Reynolds**

**Due**

**October 4, 2021**

**To**

**Dr. Choudhury**

91  
/ 100

## Abstract

This experiment aims to understand the concept of using the sieve analysis test to understand the properties of coarse and fine aggregates, including their gradation. A very prominent hard material used within Civil Engineering is concrete, as concrete can be used to construct roads, bridges, and structures.

Concrete mainly consists of cement, aggregates, and water. To understand the strength of concrete, engineers must understand how aggregates are used, thus the importance of using the sieve analysis.

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*index page  
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## Introduction

**This exercise aims to determine the gradation of materials, including the fineness modulus, by properly conducting the sieve analysis test.**

The sieve analysis is used to test the gradation of fine and coarse materials. Within this process, sieves of various sizes are used to separate aggregate sizes. Particularly, engineers need to understand if the material is coarse or fine. To understand this difference, fine materials pass through a sieve size of 4.75 mm, while coarse materials do not pass this sieve. ✓

After the engineer can determine which material is coarse or fine, appropriate tests can be conducted to determine various characteristics of the materials, such as the bucket immersion test and pycnometer test. The first test is used for coarse materials, while the latter is used for fine materials.

*- 2 significance & blending  
FM & Blending*

### **Test objectives**

The main objective is to determine the fineness modulus of material by conducting the sieve analysis test.

### **Description of Equipment**

**Sieves and Aggregates:** Used to separate various aggregate sizes.

**Measuring Scale:** Used to find the mass of material.

**Sifter Testing Machine:** Used to separate aggregate within their appropriate sieves.

### Materials and Test conditions

Sieve

Sifter Testing Machine

Measuring Scale

Aggregate of Various Sizes

Empty Bowl

### Procedure: Sieve Analysis Test

- I. Obtain appropriate sieve sizes, and weigh each **empty** sieve. Record data properly.
  - A. Sieve sizes used include 19mm, 9.5mm, 4.75mm, 2.3mm, 1.19mm, 0.600mm, 0.300mm, 0.150mm, 0.075mm, and the pan.
- II. Weigh empty bowl. Record weight properly.
- III. Place 2 kilograms of the aggregate of various materials within the empty bowl.
  - A. The weight of the bowl with aggregate should be the weight of the bowl + 2 kilograms.
- IV. Place appropriate aggregate into sieves.
  - A. Sieves should be increasing order of sieve size, with 9.5mm being the sieve size at the top and 0.075mm being the sieve size directly above the pan.
- V. Place sieves in the sifter machine.
  - A. Let the machine run for 4 minutes.
- VI. After the sifter machine is done, take sieves out without losing any aggregate.
- VII. Weigh each sieve with aggregate. Record the weight appropriately.
- VIII. Empty materials in respective bins.

**No experimental safety issues were present** as no hazardous materials were used. Standard safety protocol, such as wearing appropriate personal protective equipment, including closed-toe shoes and pants, was followed throughout experiments.

### Data Analysis Methods

(Eq. 1) Amount Aggregate Retained: *Sieve w/Aggregate – Empty Sieve Size*

(Eq. 2) Cumulative Retained Aggregate:

*Summation of Each Aggregate Size per Respective Sieve*

(Eq. 3) Cumulative Percent Retained:

*(Cumulative Retained  $\cdot$  100)  $\div$  Total Amount of Aggregate*

(Eq. 4) Percent Passing:  $100 - \text{Cumulative Percent Retained}$

(Eq. 5) Fineness Modulus:  $\frac{\Sigma \text{Cumulative Percent Retained}}{100}$

Max Aggregate Size: 19mm

Nominal Aggregate Size: 19mm

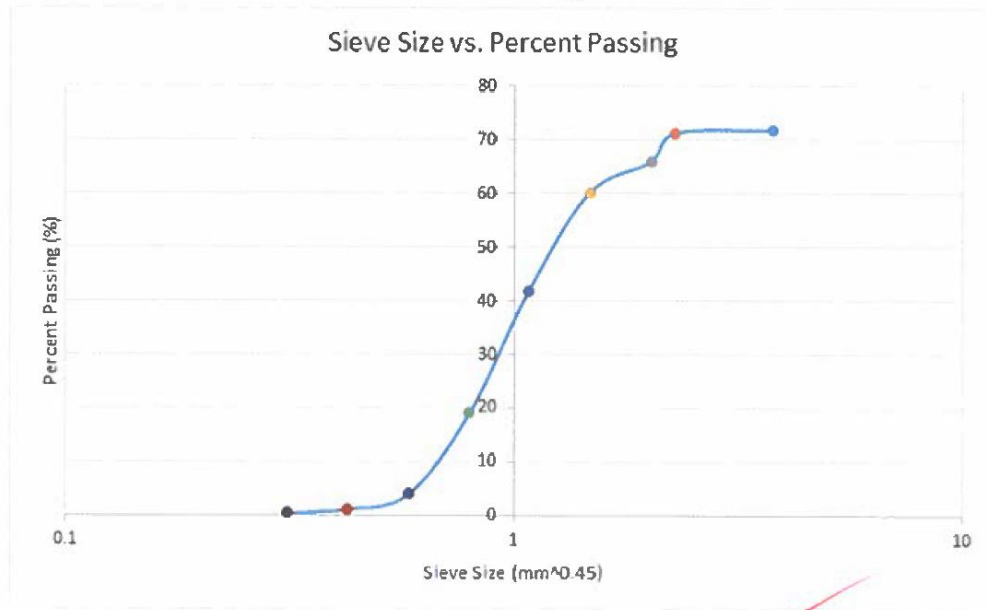
## List of Figures/Calculations

Sieve Analysis Table 1.0

| Sieve Size (mm) | Amount of Aggregate Retained (g) | Cumulative Retained Aggregate (g) | Cumulative Percent Retained (%) | Percent Passing (%) |
|-----------------|----------------------------------|-----------------------------------|---------------------------------|---------------------|
| 19              | 450.5                            | 450.5                             | 28.165                          | 71.84               |
| 6.3             | 25                               | 475.5                             | 28.728                          | 71.27               |
| 4.75            | 70                               | 545.5                             | 34.10                           | 65.9                |
| 2.36            | 92.5                             | 638                               | 39.887                          | 60.11               |
| 1.18            | 293.5                            | 931.5                             | 58.24                           | 41.76               |
| 0.600           | 363.5                            | 1295                              | 80.96                           | 19.04               |
| 0.300           | 240.5                            | 1535.5                            | 95.99                           | 4.01                |
| 0.150           | 44.5                             | 1580                              | 98.78                           | 1.22                |
| 0.075           | 11                               | 1591                              | 99.47                           | 0.53                |
| Pan             | 8.5                              | 0                                 | 100                             | 0                   |
| Total           | 1599.5                           | 564.32                            |                                 |                     |

Fineness Modulus:  $\frac{34.10+39.9+58.24+80.96+95.99+98.78}{100} = \frac{407.97}{100} = 4.0797$

Graph 1.0: Reflects the Sieve Size vs. Percent Passing





### Test Results and Analysis

It was found that our fineness modulus was 4.0797. We found this number by finding the sum of the cumulative percent retained and dividing the sum by 100. Sieves accounted for within this calculation include sizes 4.75mm, 2.36mm, 1.18mm, 0.6mm, 0.3mm, and 0.015mm.

To find the cumulative percent retained, we needed to find the amount of aggregate retained first. In doing so, equation one was utilized by subtracting the weight of the aggregate in the sieve and subtracting that value by the empty sieve. Next, equation two was used to find the cumulative retained aggregate by adding each value of the recorded amount retained. Lastly, equation three was utilized to find the percent cumulative retained by multiplying the cumulative retained value by 100 and dividing that value by the total amount of aggregate obtained.

### Discussion and Interpretation of the Results & Findings

All objectives of the experiment have been met, as the fineness modulus of the aggregates was found. Additionally, the Semi Log Graph of Percent Passing vs. Sieve Size was able to be obtained.

### Summary

During this experiment, we were tasked with finding the fineness modulus of given fine and coarse aggregates. After conducting the sieve analysis test, we were able to determine the fineness modulus successfully. We were also able to find other aggregate characteristics, including the percent passing of the materials and the cumulative percent passing of the aggregate.

## References

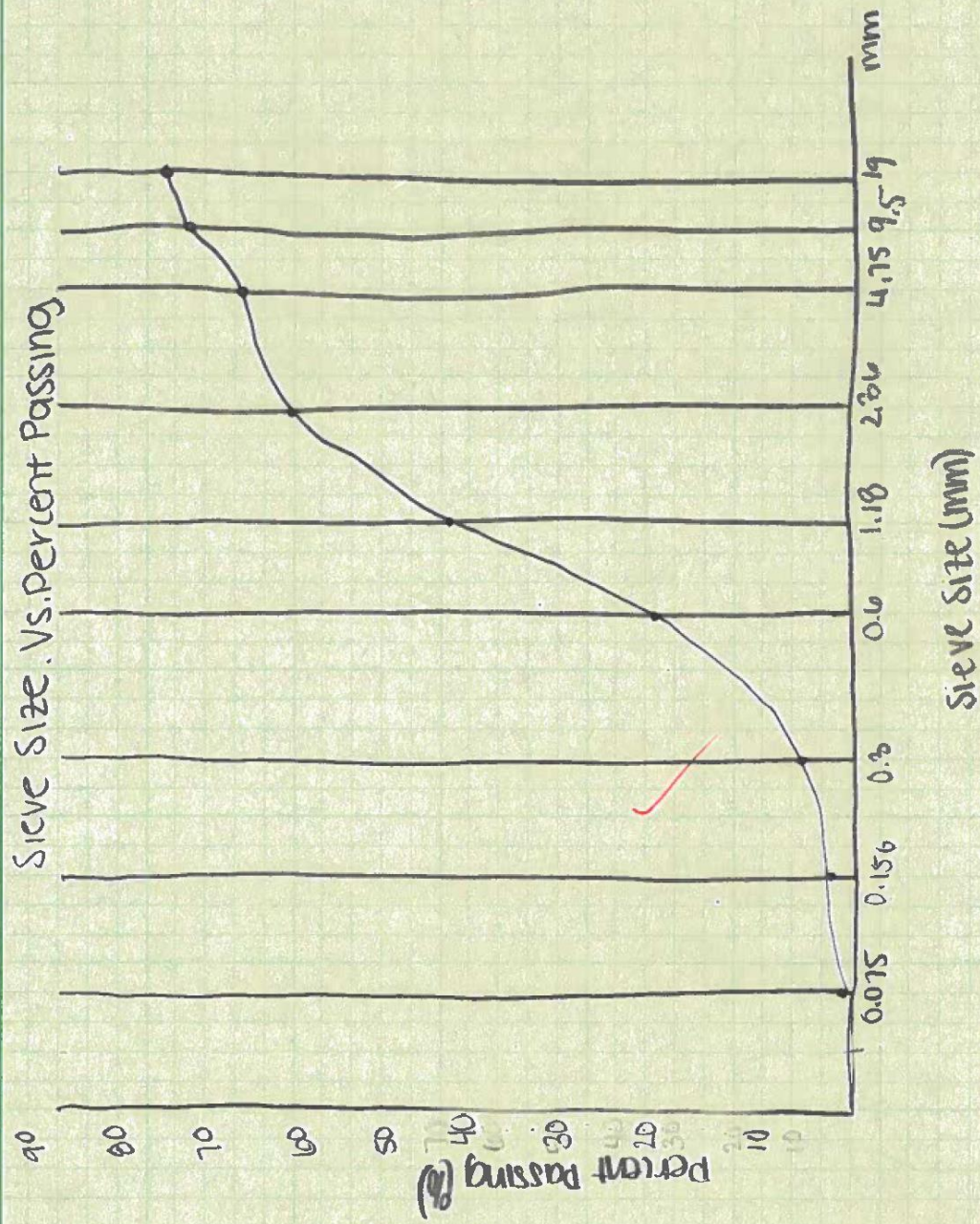
Mamlouk, Michael S, and John P. Zaniewski. *Materials for Civil and Construction Engineers*. , 2017. Digital.

Mishra, Gopal. "Grain Size Analysis of Fine Aggregates - Particle Size Distribution Test." *The Constructor*, 10 Nov. 2017, [theconstructor.org/practical-guide/grain-size-analysis/2261/](https://theconstructor.org/practical-guide/grain-size-analysis/2261/).

*Sample Container for Coarse Aggregates.*  
[humboldtinfog.com/sample-container-coarse-aggregates.html](https://humboldtinfog.com/sample-container-coarse-aggregates.html).

W.S. Tyler Sound Enclosure for Ro-Tap II Sieve Shaker, 34"W x 31"H x 33" D from Cole-Parmer.  
[coileparmer.com/i/w-s-tyler-sound-enclosure-for-ro-tap-ii-sieve-shaker-34-w-x-31-h-x-33-d/5998655?PubID=UX&persist=true&ip=no&gclid=Cj0KCQjwwNWKBhDAARIsAJ8HkheSRQb7In6Kjde5L-YQYzSHNPXmKCD5oTRAIH\\_loMRChMN2YZRye8aAgZwEALw\\_wcB](https://coileparmer.com/i/w-s-tyler-sound-enclosure-for-ro-tap-ii-sieve-shaker-34-w-x-31-h-x-33-d/5998655?PubID=UX&persist=true&ip=no&gclid=Cj0KCQjwwNWKBhDAARIsAJ8HkheSRQb7In6Kjde5L-YQYzSHNPXmKCD5oTRAIH_loMRChMN2YZRye8aAgZwEALw_wcB).

ASTM code no ?



# **OUTCOMES SPECIFIC ASSIGNMENT COVER SHEET**

**CVEG 3100-Steel & Concrete Lab**  
**Instructor: Dr. Abdul M Choudhury**

**Title of Assignment**

**Lab Report # 2**

**Outcome Measured Using this Assignment**

**Outcome 6**

**An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief justification of the suitability of this assignment for the outcome**

**The questions on this section of the Lab Experiment show the students ability to design and conduct experiments, as well as to analyze and interpret data**

**CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT  
CVEG 3100- STEEL & CONCRETE LAB  
COURSE ASSIGNMENT GRADING  
AND OUTCOME ASSESSMENT SHEET**

ASSIGNMENT TITLE:                      Lab Report #2

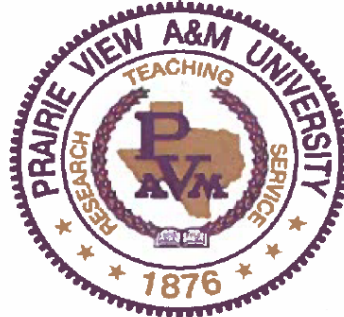
DUE DATE:              10/04/2021\_\_\_\_\_              DATE SUBMITTED: 10/04/2021\_\_\_\_\_

Name of Student: Maalvika Aggarwal

Title of Assignment:\_\_\_Specific gravity and absorption of aggregates

| Competency Area                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Max for this Assignment | Student's Score |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------|
| <b>(6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions</b><br><i>Laboratory experiments covering designing and conducting experiments have been included in part. The laboratory data has been plotted graphically and necessary statistical calculation was carried out to arrive at the conclusion. Another main emphasize was also given on writing the laboratory reports properly.</i> | 100                     | 98              |
| TOTAL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100                     | 98              |

**Prairie View A&M University**  
**Roy G. Perry College of Engineering**  
**Civil & Environmental Engineering Department**



**CVEG 3100 P81 – Concrete and Steel Laboratory**  
**Fall 2021**

**Maalvika Aggarwal**

**Lab 2: Specific gravity and Absorption of Fine Aggregate**  
**and Coarse Aggregate**

98  
100

**Due Date: October 4<sup>th</sup>, 2021**

**Submitted to: Dr. Choudhury**

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#### **EQUIPMENT AND ANALYSIS TOOLS:**

- Fine Aggregate
- Coarse Aggregate
- Water
- Pycnometer
- Measuring scale- to measure the mass of materials.
- A scoop- to pour the aggregate.
- Metal tins
- A steel bucket- used for bucket-immersion test.
- A large plastic bucket- used for bucket-immersion test.
- Spring balance- used for bucket-immersion test. ✓

#### **EXPERIMENTAL SAFETY ISSUE:**

- No hazardous materials or chemicals used in the experiment.
- Appropriate clothing should be worn, i.e., closed toe shoes, pants, and blouses. Standard laboratory protocols must be followed.
- Aggregates may contain dust and bacteria/germs, which can be harmful to one's health. Wearing of masks and gloves is recommended. ✓

#### **DESCRIPTION OF PROCEDURE:**

##### **PYCNOMETER TEST-FOR FINE AGGREGATE**

1. Take an empty pycnometer and measure its mass, using a measuring scale. Record the mass.



2. Add water to the pycnometer, roughly to the 500-ml mark, and measure the mass. Record the mass of the pycnometer with water.
3. Discard the water and add an amount of fine aggregate (sand) to the pycnometer, roughly to the 200-ml mark. Measure the mass of pycnometer with sand and record it.
4. Again, add water to the pycnometer with the aggregate and measure the mass of the pycnometer with water and aggregate, and record it. Repeat the process two more times.
5. Safely discard all the aggregate as per the instructions and clean up.

#### ABSORPTION TEST-FOR FINE AGGREGATE

1. Take an empty metal tin and measure its mass, using a measuring scale. Record the result.
2. Using a scoop, pour some amount of coarse aggregate and add it to the metal tin.
3. Record the mass of the metal tin with aggregate, using a measuring scale.
4. Add some amount of water to the aggregate in the metal tin and let it sit for a period of twenty-four hours, during which the absorption will occur.
5. After 24-hours, measure the mass of the metal tin with the wet aggregate using a measuring scale and record the result. Repeat the process twice more, to get 3 trials.
6. Safely discard all the aggregate and clean-up.

#### BUCKET-IMMERSION TEST-FOR COARSE AGGREGATE

1. Take an empty steel-mesh bucket and place it on a measuring scale. Record its empty mass.
  2. Manually take some amount of coarse aggregate and add it to the steel-mesh bucket. Record the mass of the bucket with aggregate.
- 

3. Take another big plastic bucket filled with water.
4. Immerse the steel-mesh bucket with aggregate into the plastic bucket, with the help of a spring balance suspended upon the handle of the steel-mesh bucket. Make sure the steel bucket does not touch the bottom of the plastic bucket.
5. Record the mass of the steel-mesh bucket from the digital spring balance in pounds.
6. Repeat the process three times, in total.
7. Safely discard all the aggregate and clean-up.

**DATA AND TEST RESULTS:**

Table 1: Data collected from the Pycnometer test for Fine Aggregate:

| TRIAL # | Weight of empty pycnometer (g) | Weight of pycnometer with water (g) | Weight of pycnometer with fine aggregate (g) | Weight of pycnometer with fine aggregate and water (g) |
|---------|--------------------------------|-------------------------------------|----------------------------------------------|--------------------------------------------------------|
| 1       | 167.88                         | 662.24                              | 474.68                                       | 850.00                                                 |
| 2       | 174.55                         | 665.29                              | 461.58                                       | 835.50                                                 |
| 3       | 169.31                         | 662.91                              | 511.94                                       | 870.50                                                 |

*2 Add some practical figures* ✓

Table 2: Data collected from the Bucket-Immersion test for Coarse Aggregate:

| <b>TRIAL #</b> | <b>Weight of empty steel bucket (Kg)</b> | <b>Weight of steel bucket with coarse aggregate in Air (Kg)</b> | <b>Submerged weight of steel bucket with coarse aggregate (Lb)</b> | <b>Submerged weight of steel bucket with coarse aggregate (Kg) (Weight in lb*0.453)</b> |
|----------------|------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| 1              | 1.974                                    | 2.4195                                                          | 4.60                                                               | 2.0838                                                                                  |
| 2              | 1.996                                    | 2.4435                                                          | 4.70                                                               | 2.1291                                                                                  |
| 3              | 1.992                                    | 2.4405                                                          | 4.70                                                               | 2.1291                                                                                  |

Table 3: Data collected from Absorption test for Fine Aggregate:

| <b>TRIAL #</b> | <b>Weight of empty metal tin (g)</b> | <b>Weight of metal tin and fine aggregate (g)</b> | <b>Weight of metal tin and wet aggregate (g)</b> |
|----------------|--------------------------------------|---------------------------------------------------|--------------------------------------------------|
| 1              | 25.50                                | 70.20                                             | 91.50                                            |
| 2              | 24.90                                | 68.40                                             | 89.30                                            |
| 3              | 25.40                                | 62.50                                             | 82.00                                            |

### CALCULATIONS:

Table 4: Calculations for the Pycnometer test for Fine Aggregate:

| Trial # | Weight of pycnometer (g) | Weight of pycnometer with water (g)<br><u>B</u> | Weight of pycnometer with fine aggregate (g) | Dry weight of aggregate (g)<br>(Weight of pycnometer and aggregate – weight of pycnometer)<br><u>A</u> | Weight of pycnometer with fine aggregate and water (g)<br><u>C</u> |
|---------|--------------------------|-------------------------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| 1       | 167.88                   | 662.24                                          | 474.68                                       | 306.8                                                                                                  | 850.00                                                             |
| 2       | 174.55                   | 665.29                                          | 461.58                                       | 287.03                                                                                                 | 835.50                                                             |
| 3       | 169.31                   | 662.91                                          | 511.94                                       | 342.63                                                                                                 | 870.50                                                             |

$$\text{Specific Gravity for Fine Aggregate (SG)} = \frac{A}{B + A - C}$$

$$SG \text{ for trial 1} = \frac{306.8}{662.24 + 306.8 - 850} = 2.577$$

$$SG \text{ for trial 2} = \frac{287.03}{665.29 + 287.03 - 835.5} = 2.457$$

$$SG \text{ for trial 3} = \frac{342.63}{662.91 + 342.63 - 870.5} = 2.537$$

**Average Specific gravity for fine aggregate (sand) = 2.524**

Standard Value of Specific Gravity of Sand = 2.65

Percentage of Error =  $\frac{2.524 - 2.65}{2.65} \times 100 = 4.76\%$

*Range*

Table 5: Calculations for Bucket-Immersion test for Coarse Aggregate:

| Trial # | Weight of empty steel bucket (Kg) | Weight of steel bucket with coarse aggregate in air (Kg) | Dry weight of coarse aggregate in air (Kg)<br>(Weight of bucket with aggregate – empty weight of bucket)<br><u>A</u> | Submerged weight of steel bucket with coarse aggregate (Kg) | Weight of coarse aggregate in water (Kg)<br>(Submerged weight of bucket with aggregate – empty weight of bucket)<br><u>B</u> |
|---------|-----------------------------------|----------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| 1       | 1.974                             | 2.4195                                                   | 0.445                                                                                                                | 2.0838                                                      | 0.109                                                                                                                        |
| 2       | 1.996                             | 2.4435                                                   | 0.447                                                                                                                | 2.1291                                                      | 0.133                                                                                                                        |
| 3       | 1.992                             | 2.4405                                                   | 0.448                                                                                                                | 2.1291                                                      | 0.137                                                                                                                        |

Specific Gravity for Coarse Aggregate ( $SG_c$ ) =  $\frac{A}{A-B}$

$$SG \text{ for trial 1} = \frac{0.445}{0.445 - 0.109} = 1.327$$

$$SG \text{ for trial 2} = \frac{0.447}{0.447 - 0.133} = 1.423$$

$$SG \text{ for trial 3} = \frac{0.448}{0.448 - 0.137} = 1.440$$

Average Specific gravity for coarse aggregate = 1.396

Standard Value of Specific Gravity of Coarse Aggregate = 2.6

$$\text{Percentage of Error} = \frac{1.440 - 2.6}{2.6} * 100 = 46.2\%$$

*Range*

Table 6: Calculations for Absorption test for Fine Aggregate:

| Trial # | Weight of empty metal tin (g) | Weight of metal tin and fine aggregate (g) | Dry weight of Fine Aggregate (g)<br>(Weight of metal tin and fine aggregate - Weight of empty metal tin)<br><u>A</u> | Weight of metal tin and wet aggregate (g) | Weight of Wet Aggregate (g)<br>(Weight of metal tin and wet aggregate - Weight of empty metal tin)<br><u>C</u> |
|---------|-------------------------------|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| 1       | 25.50                         | 70.20                                      | 44.7                                                                                                                 | 91.50                                     | 66                                                                                                             |
| 2       | 24.90                         | 68.40                                      | 43.5                                                                                                                 | 89.30                                     | 64.4                                                                                                           |
| 3       | 25.40                         | 62.50                                      | 37.1                                                                                                                 | 82.00                                     | 56.6                                                                                                           |

$$\text{Absorption for Fine Aggregate} = \frac{C-A}{A} \times 100$$

$$\text{Absorption for trial 1} = \frac{66 - 44.7}{44.7} \times 100 = 47.651\%$$

$$\text{Absorption for trial 2} = \frac{64.4 - 43.5}{43.5} \times 100 = 48.046\%$$

$$\text{Absorption for trial 3} = \frac{56.6 - 37.1}{37.1} \times 100 = 52.561\%$$

**Average Absorption for fine aggregate = 49.419%**

#### **DISCUSSION AND ANALYSIS:**

Table 7: Reflects the Test results for all the Three tests:

| PROPERTY | Average Specific Gravity of Fine Aggregate | Average Specific Gravity of Coarse Aggregate | Average Absorption of Fine Aggregate |
|----------|--------------------------------------------|----------------------------------------------|--------------------------------------|
|          | 2.524                                      | 1.396                                        | 49.419 %                             |

### Discussion:

As it can be seen, the average specific gravity for the fine aggregate was found to be 2.524, through the pycnometer test. The standard value of specific gravity for sand is 2.65. Thus, the experiment had a percent error of 4.76%. This error is not huge and is within the parameters. Therefore, the result shall be accepted.

The specific gravity of coarse aggregate was calculated to be 1.396. This was done through a technique of bucket-immersion test. Since, the standard value of specific gravity for coarse aggregate is 2.6, this gave a percent error of 46.2%. This error is considerably large and does not fall within the parameters to be accepted. This means that the experiment had major possible errors.

Absorption of fine aggregate was found to be 49.419%, through a test of absorption performed with a period of twenty-four hours. The standard value of absorption falls within the range of 2.5- 3%. Since, the calculated absorption exceeds that threshold, it cannot be accepted, and it shows that the experiment performed had quite a lot of errors.





### **CONCLUSION:**

It is evident that both coarse and fine aggregate have separate methods/tests to determine their specific gravity and absorption. The experiment started with the pycnometer test for finding the specific gravity of fine aggregate. Further, an absorption test was performed to calculate the absorption (percentage) of fine aggregate. Lastly, the experiment was concluded with a bucket-immersion test to determine the specific gravity of coarse aggregate. After recording all the data, calculations were performed to determine the specific gravity for both coarse and fine aggregate and absorption for the latter. An average specific gravity of 2.524 was found for fine aggregate and 1.396 for coarse aggregate. The absorption came out to be 49.419%.

In order to maintain accuracy and precision, there were a total of 3 trials performed in each test. An average of all three was taken as the final result. The specific gravity of fine aggregate had a percent error of 4.76%, which is acceptable. However, unfortunately, the other two tests performed were for the specific gravity of coarse aggregate, which had a percent error of 46.2%, and absorption of fine aggregate that was way above the acceptable threshold. These results cannot be accepted as they show a high percentage of error in the experiment.

There can be many possible sources of error in the experiment. Human error is the most common error as there was a lot of aggregate/water that gets lost in the transferring phase of one equipment to another. Other errors could be misinterpreting the measuring scale or spring balance, error while recording. Also, it is possible that since the test was performed first time by inexperienced students, it could have affected the accuracy of results.

Overall, taking into account all the test results, the experiment was somewhat successful and further strengthened the knowledge of classroom theory.

## **APPENDIX:**

**Absorption-** The increase in mass of aggregate due to water penetrating into the pores of the particles, during a prescribed period of time, but not including water adhering to the outside surface of the particles, expressed as percentage of the dry mass.

**Specific gravity-** Also known as relative density, it is the ratio of the density of a material to the density of water at a stated temperature. It is unitless.

**Archimedes' principle-** It states that the buoyant force on an object equals the weight of the fluid it displaces. Specific gravity is the ratio of the density of an object to a fluid, usually water.

**Coarse aggregates:** Aggregate particles that are retained on a 4.75 mm sieve, i.e., Sieve No. 4.

**Fine aggregates:** Aggregate particles that pass a 4.75 mm sieve, i.e., Sieve No. 4.



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**OUTCOME “6” SPECIFIC ASSIGNMENTS  
USED TO ASSESS THE OUTCOME IN**

**CVEG 3043  
ENVIRONMENTAL ENGINEERING**

**CVEG 3043 sec P01 – Environmental Engineering**  
**Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE, Professor**

**Spring 2020**

**Title of Assignment**

Laboratory Report on Determination of Acidity, Alkalinity  
and Hardness of Selected Water Samples

**Outcome Measured Using this Assignment**

**Outcome #6**

**an ability to develop and conduct appropriate  
experimentation, analyze and interpret data, and use  
engineering judgment to draw conclusions**

**Brief Description of the suitability of this assignment for the  
outcome**

This Laboratory report shows the procedure students used to conduct the experiment, the raw data recorded, the analysis and presentation of the derived results, and interpretation of the results in the discussions and conclusions.

Determination of Alkalinity, Hardness, and Acidity of River Water,  
Lake Water, Groundwater samples

CVEG 3043: Environmental Engineering Spring 2020

ABET Criteria 3(6)

pH data missing for the  
lab report.

Submitted by

Zain Qureshi

Other Group Members: Layla Ogletree, Chika Okwor, Mohammad  
Mohammad, Omar Rafey

Submitted to

Dr. Raghava Kommalapati, PE, BCEE, F. ASCE

Department of Civil and Environmental Engineering

Prairie View A&M University

03/31/2020

## 1) Abstract

Alkalinity is defined as water trying to resist changes in pH to become more acidic, hardness is defined as the amount of calcium and magnesium that is dissolved into the water and acidity defined as a measure of the concentration of hydrogen ions in water. In this laboratory experiment we measured all the defined terms above on four different water samples, which were ground water, Mayde Creek, Lake Conroe, and PV wastewater. The procedures for all three tests were kindred and consisted of the use of titrant reagents and buffering solutions. In terms of data, alkalinity was shown to be highest in PV Wastewater with an average of 342 mg/L as  $\text{CaCO}_3$  which can be considered high and have adverse health effects on humans and aquatic life as well and the results indicate that PV Wastewater and Pattison Groundwater are more effective at neutralizing acids compared to the Mayde Creek and Lake Conroe samples. In regard to hardness, Pattison Groundwater had the high value with an average of 205.2 mg/L as  $\text{CaCO}_3$  which can be because it is underground and passes over rocks with minerals that raise alkalinity. Then PV Wastewater and Pattison Groundwater both had the highest levels of acidity with 60 mg/L as  $\text{CaCO}_3$ . When looking at the results of the experiment the water samples with the best balance of all three characteristics of water seems to be the Lake Conroe and Mayde Creek samples in terms of consumption while Pattison Groundwater and PV Wastewater are not due to the higher levels of alkalinity, hardness, and acidity but can be treated using different softening methods and methods to lower alkalinity.

## 2) Introduction

Alkalinity plays an important role for aquatic life because it can buffer acid rain and other acids that may come in contact with surface water which can prevent harmful pH changes, and that same idea is also applied to our drinking water. This happens because as water passes over rocks, it picks up minerals such as Potassium, Magnesium, Bicarbonate and other trace elements (*What is Alkaline Water and Why do I need it?*, April 2017) which will increase the alkaline level. Though hardness of water does not carry many natural dangers to living organisms, it can affect pipes. Water hardness occurs when water is traveling through deposits of limestone, chalk, or gypsum which in general are mostly made up calcium and magnesium carbonates, bicarbonates and sulfates (*Hard Water*, May 2015). Acidity of water cannot only affect the health of humans but aquatic life as well as such that water which becomes more acidic will stress or kill them. The measurements levels of these three characteristics (Alkalinity, Hardness, and Acidity respectively) are done by the use of titration methods to determine which water sample will be optimal for any use or for consumption.

### **3) Objectives**

To measure the Alkalinity, Hardness, and Acidity of four different samples of water; ground water, Mayde Creek, Lake Conroe, and PV wastewater in three different experiments. Once this analysis is completed, we will use some basic calculations to find specifically what we need.

## **4) Experimental Methods**

### **4.1) Materials**

#### **4.1.1) Alkalinity**

- Water samples
- Plastic measuring tube
- Square mixing bottle
- Phenolphthalein indicator powder pillow
- Bromocresol Green-Methyl Red indicator powder pillow
- Sulfuric acid standard solution

#### **4.1.2) Hardness**

- Plastic tube
- Water samples
- Square mixing bottle
- Buffer solution (Hardness 1)
- Hardness 2 indicator
- Hardness 3 Titrant Reagent

#### **4.1.3) Acidity**

- Water samples
- Plastic measuring tube
- Square mixing bottle
- Bromocresol Green-Methyl red powder pillow
- Sodium Hydroxide standard solution



## **4.2) Procedure**

### **4.2.1) Alkalinity**

- 1) Fill the plastic tube with the water sample until it reaches the top, then proceed to pour it into the square mixing bottle.
- 2) Add the contents of one Phenolphthalein indicator powder pillow and swirl it to mix.
- 3) If the water remains colorless, phenolphthalein alkalinity is zero.
- 4) Add the contents of one Bromocresol Green-Methyl red indicator powder pillow to the square mixing bottle and swirl it.
- 5) Now add one drop of Sulfuric acid standard solution and swirl the square mixing bottle, repeat this until the sample turns pink, record the number of drops.

### **4.2.2) Hardness**

- 1) Fill the plastic tube with the water sample until it reaches the top, then proceed to pour it into the square mixing bottle.
- 2) Add three drops of buffer solution (Hardness 1) to the square mixing bottle and swirl it to mix.
- 3) Add one drop of Hardness 2 indicator to the square mixing bottle and then swirl it again. A blue color indicates soft water while if a red color appears then proceed to the next step.
- 4) Add Hardness 3 Titrant Reagent one drop at a time, swirl after every drop and repeat until the water turns blue and record the number of drops.
- 5) Each drop of Hardness 3 Titrant is equivalent to 1 grain per gallon hardness as 17.1 mg/L calcium carbonate.

### **4.2.3) Acidity**

- 1) Fill the plastic tube with the water sample until it reaches the top, then proceed to pour it into the square mixing bottle.
- 2) Add one drop of Phenolphthalein indicator solution to the square mixing bottle swirl it.
- 3) If the water changes in color and becomes pink, then the total acidity is zero.
- 4) If the water remains colorless then proceed to add Sodium Hydroxide standard solution one drop at a time until the water turns pink, record the number of drops.

## 5) Figures



**Figure 5.1)** Alkalinity test kit



**Figure 5.2)** Hardness test kit



**Figure 5.3)** Acidity test kit

pH data missing.

## 6) Results and Discussion

After completion of all three of the experiments, a table with the results of the different water samples test was compiled. The calculations were down as follows; One drop of NaOH solution multiplied by 20 will give you the total acidity in mg/L as  $\text{CaCO}_3$  of the sample and then divide the number by 17.1 mg/L as  $\text{CaCO}_3$  if wanted in grains per gallon as  $\text{CaCO}_3$ , the number of titrant drops multiplied by 17.1 mg/L as  $\text{CaCO}_3$  to determine the alkalinity, and hardness is determined by multiplying the number of hardness 3 titrate reagent drops by 17.1 mg/L as  $\text{CaCO}_3$ .

**Table 6.1)** Water sample experimental results

| Sample Name                           | Pattison Groundwater             | Mayde Creek                    | Lake Conroe                     | PV Wastewater                    |
|---------------------------------------|----------------------------------|--------------------------------|---------------------------------|----------------------------------|
| Alkalinity (mg/L as $\text{CaCO}_3$ ) | Trail 1) 188.1<br>Trail 2) 205.2 | Trail 1) 68.4<br>Trail 2) 51.3 | Trail 1) 85.5<br>Trail 2) 102.6 | Trail 1) 342<br>Trail 2) 342     |
| Average                               | 196.65                           | 59.85                          | 94.05                           | 342                              |
| Hardness (mg/L as $\text{CaCO}_3$ )   | Trail 1) 188.1<br>Trail 2) 222.3 | Trail 1) 51.3<br>Trail 2) 51.3 | Trail 1) 85.5<br>Trail 2) 85.5  | Trail 1) 102.6<br>Trail 2) 102.6 |
| Average                               | 205.2                            | 51.3                           | 85.5                            | 102.6                            |
| Acidity (mg/L as $\text{CaCO}_3$ )    | Trail 1) 60<br>Trail 2) 60       | Trail 1) 20<br>Trail 2) 20     | Trail 1) 40<br>Trail 2) 40      | Trail 1) 60<br>Trail 2) 60       |
| Average                               | 60                               | 20                             | 40                              | 60                               |

Looking over the results, it is recommended to consume Mayde Creek or Lake Conroe water since based on these characteristics those are the most balanced of the water samples. While the Pattison Groundwater is very high in hardness but can be reduced using a simple water softener to remove the minerals (*Basic Water Chemistry Part 1: Water Hardness*, 2018) and the PV Wastewater is very high in Alkalinity, which can be reduced using a pH reducer or muriatic acid (*What is Alkaline Water and Why do I need it?*, April 2017).

After reviewing the data above, it is made evident that the water with the highest Alkalinity is PV Wastewater with a value of 342 mg/L as  $\text{CaCO}_3$ . Pattison Groundwater has an average alkalinity of 196.65 mg/L as  $\text{CaCO}_3$  and following those are Lake Conroe and Mayde Creek which both have averages of 94.05 and 59.85 mg/L as  $\text{CaCO}_3$ . All the samples besides PV Wastewater are within the ranges of acceptable for drinking water with Pattison Groundwater being a little bit on the higher end while Lake Conroe and Mayde Creek being in the lower end. The range for acceptable alkalinity in water ranger from 20 to 200 mg/L as  $\text{CaCO}_3$  (*What is Alkaline Water and Why do I need it?*, April 2017). Pattison Groundwater and PV wastewater being high do mean that they carry more minerals in them compared to the Mayde Creek and Lake Conroe samples and this could be due to the fact that the Pattison Sample was taken from a groundwater revisor and PV Wastewater contains minerals, specifically most alkalinity comes from calcium carbonate that comes from rock and soil (*Alkalinity: Is it Healthy or Harmful*, 2015), that could have been added to it by humans.

As for the Hardness of the samples, being below 60 mg/L as  $\text{CaCO}_3$  is considered soft water, between 60-120 mg/L as  $\text{CaCO}_3$  is considered moderately hard, 120-180 mg/L as  $\text{CaCO}_3$  is considered hard and greater than 180 mg/L as  $\text{CaCO}_3$  is very hard (McGowan, 2000). On average the Pattison Groundwater had a higher average, 205.2 mg/L as  $\text{CaCO}_3$ , than the other samples which means that the water though not necessarily bad for human consumptions can cause other problems such as limescale starting to coat the inside of pipes and other apparatuses since it is considered very hard. Lake Conroe and PV wastewater are considered moderately hard, 85.5 and 102.6 mg/L as  $\text{CaCO}_3$  respectively, so they can cause the same problems as the Pattison Groundwater sample but to a lesser degree and the Mayde Creek sample is considered soft with an average of 51.3 mg/L as  $\text{CaCO}_3$ .

When comparing the average values of acidity that were tabulated, it can be seen that the acidity for all of the sample were relatively within in the same range, with PV Wastewater and Pattison Groundwater both having averages of 60 mg/L as  $\text{CaCO}_3$  while Lake Conroe had an average of 40 mg/L as  $\text{CaCO}_3$  and Mayde Creek having an average of 20 mg/L as  $\text{CaCO}_3$ . The difference in acidity can be due to higher contents of mineral acids that may have been present, high levels of carbon dioxide, or pollution (*pH, Alkalinity, Hardness*, 2004).

## 7) Conclusion

Good analysis.

Once completion of this laboratory experiment and analysis of all the data, the alkalinity, hardness, and acidity of each water sample was able to be determined. When comparing the average values of alkalinity there was a range with PV Wastewater being the highest and Pattison Groundwater being second. The high alkalinity could be due to the high amount of minerals that were dumped into the water or that were accumulated naturally. Though the averages do shows that all these water samples except PV Wastewater would be ideal to drink and even good for aquatic life. Using a treatment such as a pH reducer or muriatic acid can help lower the alkalinity in the PV Wastewater sample though. Then looking at the hardness of each water sample they were all spread out with Mayde Creek being consider soft and the rest being considered some level of hard. Pattison Groundwater was the highest in this regard and with this sample being groundwater, it makes the most sense since it would pick up more minerals from being in an environment to do so but it can be reduced using a water softener to remove those minerals and make it better for human consumption. Then regarding acidity, the ranges were all relatively close to one another with Pattison Groundwater and Mayde Creek both having the same acidity and the highest which could be because the amount of acidic minerals or both having higher concentrations of carbon dioxide.

## 8) References

“*Hard Water*”. URL: <https://wellowner.org/water-quality/ground-water-quality-basics/>. Web. March 14, 2020.

“*Alkalinity: Is it Healthy or Harmful?*”. 2005. URL: <https://www.thirteen.org/edonline/studentstake/water/schoolwater/alkalinity/alkalinity.htm>. Web. March 14, 2020.

“*pH, Alkalinity, Hardness*”. 2004. URL: <https://dnr.wi.gov/regulations/labcert/documents/training/basics-genchem.pdf>. Web. March 14, 2020.

“*What is Alkaline Water and Why do I need it?*”. April, 2017. URL: <https://www.mineralpro.com/blog/alkaline-water-health-benefits/>. Web. March 14, 2020.

“*Basic Water Chemistry Part 1: Water Hardness*”. 2018. URL: <https://www.liveaquaria.com/article/60/?aid=60>. Web. March 14, 2020.

## 9) Appendix

Averages were determine using this formula,

$$Average = \frac{x_1 + x_2}{2}$$

Note: Laboratory Raw Data is shown on the next page, along with sample calculations

All High range

| Sample:    | Pattison Groundwater |          | Maple Creek |         | Lake Conroe |         | PI Wastewater |          |
|------------|----------------------|----------|-------------|---------|-------------|---------|---------------|----------|
| Acidity    | 3 drops              | 3 drops  | 1 drop      | 1 drop  | 2 drops     | 2 drops | 3 drops       | 3 drops  |
| Alkalinity | 11 drops             | 12 drops | 14 drops    | 3 drops | 5 drops     | 6 drops | 20 drops      | 20 drops |
| Hardness   | 11 drops             | 13 drops | 3 drops     | 3 drops | 5 drops     | 3 drops | 6 drops       | 6 drops  |
|            | Trial 1              | Trial 2  | Trial 1     | Trial 2 | Trial 1     | Trial 2 | Trial 1       | Trial 2  |

Sample Calc.

Pattison Groundwater  
as mg/L of  $\text{CaCO}_3$   
For Trial 1

$$\text{Acidity: } 3 \text{ drops} \times 20 \text{ mg/L} = 60 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Alkalinity: } 11 \text{ drops} \times 17.1 \text{ mg/L} = 188.1 \text{ mg/L as } \text{CaCO}_3$$

$$\text{Hardness: } 11 \text{ drops} \times 17.1 \text{ mg/L} = 188.1 \text{ mg/L as } \text{CaCO}_3$$

Average of  
Alkalinity as  
mg/L of  $\text{CaCO}_3$   
For Pattison  
Groundwater

$$\text{Avg} = \frac{188.1 + 205.2}{2} = 196.65 \text{ mg/L as } \text{CaCO}_3$$

**CVEG 3043 sec P01 – Environmental Engineering**  
**Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE, Professor**

**Spring 2020**

**Title of Assignment**

Laboratory Report on Determination of Chemical Oxygen Demand for Selected Water and Wastewater Samples

**Outcome Measured Using this Assignment**

**Outcome #6**

**an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief Description of the suitability of this assignment for the outcome**

This Laboratory report shows the procedure students used to conduct the experiment, the raw data recorded, the analysis and presentation of the derived results, and interpretation of the results in the discussions and conclusions.

# **Determination of Chemical Oxygen Demand of Selected Water and Wastewater Samples**

**CVEG 3043: Environmental Engineering Spring 2020**



More detail should go into the analysis of the water samples and how they can be improved. Use the references in the text.

## **ABET Criteria 3 (6)**

### **Submitted by:**

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Marshall Green, Merchae Dargins, Jamal Baker, Devan Addison-Turner

### **Submitted to:**

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March 28<sup>th</sup>, 2020



## **Abstract**

The presence of chemical oxygen demand in water samples plays a crucial role in the amount of organic matter and the amount of oxygen need for that organic matter to survive. Raw and effluent wastewater may come from the same water source in this lab but one undergoes a treatment that involves using a chemical agent to eliminate organic matter and produce a different concentration amount of chemical oxygen demand. It is said that chemical oxygen demand is a measure of organic matter so with this being said we can determine the amount of organic matter that is present in the water sample due to the amount of organic matter that is decreased by the chemical agent. It seems to be knowledgeable to say that when water is treated it would be best to put the waste water through a chemical acid in demand process then determine how drinkable it truly is and if it still is not drinkable enough to then put it to a bio chemical accident man that is another part of waste water treatment.

### **1. Introduction**

To introduce this lab, you must introduce the main component which is wastewater and the chemicals being experimented on. The wastewater being dealt with is raw and effluent water, which both contains an amount of organic matter that significantly impacts the oxygen demand. Later in the discussion section, the true difference between raw and effluent wastewater will be discussed but for now just acknowledge that they possess different components but share the same similarities.

### **2. Objectives**

This laboratory is based on the analysis of two different wastewater samples that were provided. This is designed to find out the chemical oxygen demand in the water sample and which chemical could be considered most effective when it comes to the breaking down of organic matter.

### **3. Experimental Methods**

#### **3.1. Materials**

- 3.1.1. Beaker, 250-mL
- 3.1.2. Blender
- 3.1.3. COD Digestion Reagent vials
- 3.1.4. DRB200 Reactor
- 3.1.5. Adapter
- 3.1.6. Magnetic stirrer and stir bar
- 3.1.7. Opaque shipping container for storage

3.1.8. Pipet, .1 – 1.0-mL (Tensette)

3.1.9. Pipet, 2.0-mL (volumetric)

3.1.10. Test Tube Rack

### 3.2. Procedures

#### 3.2.1. Reactor Digestion Procedure

3.2.1.1. Put 100 mL in a blender and allow blend for 30 seconds

3.2.1.2. Pour the sample into a 250-mL beaker and gently stir with a magnetic stir plate.

3.2.1.3. Set the DRB200 Reactor power to on. Preheat to 150 °C

3.2.1.4. Hold the vial at an angle of 45 degrees, use a clean pipet to add 2.00 mL of sample to the vial.

#### 3.2.2. Reactor Blank Preparation

3.2.2.1. Hold the vial at an angle of 45 degrees, use a clean pipet to add 2.00 mL of deionized water to the vial.

3.2.2.2. Close and seal the vials by the cap and rotate gently to mix well

3.2.2.3. Insert vial in the preheated DRB200 reactor and heat for 2 hours

3.2.2.4. Allow vials to cool for 20 minutes and rotate gently again and allow vials to cool to room temperature.

#### 3.2.3. Colorimetric Procedure

3.2.3.1. Start the 431 COD ULR & 430 COD LR program and Clean a blank sample cell.

3.2.3.2. Insert Blank Cell into cell holder and ensure display shows 0.

3.2.3.3. Clean the prepared sample cell and insert into the cell holder and select READ.

#### 3.2.4. Blank Colorimetric Procedure

3.2.4.1. Put the instrument in absorbance mode

3.2.4.2. Add 5 mL of deionized water into an empty vial and zero the tool

3.2.4.3. Test the blank vial using proper test procedures and after recording date allow the vial to sit in the dark

3.2.4.4. Put the instrument in a different absorbance mode.

3.2.4.5. Repeat steps 2 & 3

#### 4. Figures

##### 4.1. Beaker



##### 4.2. Blender



##### 4.3. COD Digestion Reagent Vials



#### 4.4. DRB200 Reactor



#### 4.5. Magnetic stir bar



#### 4.6. Opaque shipping container



**4.7. Pipets**



**4.8. Test tube rack**



For every experiment done, there were a set of tools and equipment that we used in order to determine the weight of the bowl, filtration paper and matter in the water samples.

## 5. Results & Discussion

### *Results*

*Table 6.1 – COD Presence*

| Sample                | Sample 1 (mg/L) | Sample 2 (mg/L) |
|-----------------------|-----------------|-----------------|
| Blank *               | 0               | 0               |
| Standard (300 mg/L)** | 297             | 299             |
| Raw Wastewater        | 225             | 237             |
| Effluent Wastewater   | 12              | 15              |

\*Blank is used to zero the reading on the Photometer

\*\* Standard is supposed to show 300 mg/L but it is showing pretty close to the value expected and thus no adjustment is needed.

### *Discussion*

#### Quick Definition to know:

- Raw Wastewater: Wastewater that is untreated wastewater. This is considered flow in water or influent.
- Effluent Wastewater: Wastewater that is treated wastewater. This is considered flow in.

In the provided data above, it is visible to the fact that the raw water contained more organic matter than the effluent wastewater. It would make clear sense as to why this would be the case due to the fact that the effluent water undergoes a chemical cleansing. The chart shows us the COD amount present in the water, and we see the major difference between treated and untreated water.

References ?

## 7. Conclusions

In conclusion, this lab helped us determine the amount of chemical oxygen demand between the two different water sources. We can see the concentration amount of the COD and with that we can attempt to determine the amount of organic matter that has been decreased. The effluent water solidifies that there was a drastic loss in the amount of organic matter present within the water samples.

## 8. References

Company, HACH. "Oxygen Demand, Chemical." *Oxygen Demand, Chemical*, 2014, [ecourses.pvamu.edu/pluginfile.php/2369548/mod\\_resource/content/0/Oxygen%20Demand%20Chemical%208000%20%20Hach%20Method.pdf](https://ecourses.pvamu.edu/pluginfile.php/2369548/mod_resource/content/0/Oxygen%20Demand%20Chemical%208000%20%20Hach%20Method.pdf).

Kommalapati, Raghava. "COD Lab Data." *CVEG 3043: Environmental Engineering*, 2020, [ecourses.pvamu.edu/pluginfile.php/2369542/mod\\_resource/content/0/COD%20Lab%20Data%200320.pdf](https://ecourses.pvamu.edu/pluginfile.php/2369542/mod_resource/content/0/COD%20Lab%20Data%200320.pdf).

"Wastewater Characteristics and Effluent Quality Parameters." *1. Wastewater Characteristics and Effluent Quality Parameters*, [www.fao.org/3/t0551e/t0551e03.htm](http://www.fao.org/3/t0551e/t0551e03.htm).

## 9. Appendix

**CVEG 3043 sec P01 – Environmental Engineering**  
**Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE, Professor**

**Spring 2021**

**Title of Assignment**

Laboratory Report on Determination of pH, Acidity, Alkalinity and Hardness of Selected Water Samples

**Outcome Measured Using this Assignment**

**Outcome #6**

**an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief Description of the suitability of this assignment for the outcome**

This Laboratory report shows the procedure students used to conduct the experiment, the raw data recorded, the analysis and presentation of the derived results, and interpretation of the results in the discussions and conclusions.



# **Determination of Acidity, Alkalinity, pH, and Hardness for Brazos River Water Samples**

**CVEG 3043: Environmental Engineering Spring 2021**

**I. ABET Criteria SLO 6 85/100**

**II. Submitted by**

**Paige Hines**

**III. Submitted to**

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Conducted on: 03/30/21  
Due: 04/06/21**

# Table of Content

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Abstract is missing:

- What you did in the experiment. Briefly explain how the experiment was carried out (alkalinity and acidity)
- What results you got
- What you concluded from the results
- Any recommendations

## **Abstract**

The acidity of a water sample may be used to classify the various minerals and acids present. The basic substance of carbonate, bicarbonate, and hydroxide in water is measured as alkalinity. The term "hardness" refers to the sum of calcium and magnesium ions in precipitating soap. The sum of hydrogen ions and hydroxide ions in a solution is calculated by the pH. The aim of this experiment is to determine the acidity, alkalinity, pH, and hardness of the water samples that were used (Brazos River, Lady Bird Lake, and Groundwater). After all of the procedures have been finished and recorded, the four water samples can be compared. Drops of Phenolphthalein and Bromcresol were applied to a water sample until it turned pink to determine the acidity and alkalinity. Using a buffer and titrant, the hardness of the water was measured until it turned blue. Using a pH meter, the pH levels were determined. Water from lady bird lake had the highest acidity, hardness and pH. While PV groundwater had the highest alkalinity. Due to some possible error occurrences the hardness for lake water had to be redone and the average of all the values was taken for the results of this experiment.

## **Introduction**

The tendency of a solid base to react to the pH value of water is known as acidity. Acidity is a measurement of the water's overall composition, and it can only be specified after the contaminants in the water have been identified. The color shift of the phenolphthalein indicator is similar to pH 8.3, which is considered a normal endpoint for total acidity titration. At 3.7, Bromcresol blue undergoes a dramatic color transition. Regardless of the system of calculation, the titrations are historically referred to as "methyl orange acidity"(pH 3.7) and "phenolphthalein"(pH 8.3) or total acidity. Alkalinity is a pH-dependent property that determines how easily a material can neutralize acid. When determining alkalinity, the amounts of carbonate, bicarbonate, and hydroxide are considered. Hardness is described as the ability of certain ions to precipitate soap. The calcium and magnesium concentrations in a water sample determine the hardness of the water. Alkalinity and acidity in water are measured using the pH meter. The hydrogen ions and hydroxide ions can be measured by pH, and such reactions can occur based on the concentration. The chemical characteristics of water such as acidity, alkalinity, hardness, and pH can be used to determine the state of a sample.

## **Objectives**

The goals of this experiment are to assess the acidity, alkalinity, pH, and hardness values of the water samples used (Brazos River, Lady Bird Lake, and Groundwater). The four water samples will then be compared after all of the protocols have been completed and registered.

## **Experimental Methods**

Water samples:

- 1) Brazos River
- 2) Lady Bird Lake
- 3) Groundwater

### **Acidity Procedures (Total Acidity)**

- 1) Fill the measuring tube brim full of the sample water and Pour the contents into the square-mixing bottle.
- 2) Add one drop of Phenolphthalein Indicator Solution to the mixing bottle and swirl to mix.
- 3) If the water turns pink, the total acidity is zero.

- 4) If the water remains colorless, add the Sodium Hydroxide Standard Solution drop by drop and count each drop. Swirl to mix. Continue adding drops until the sample turns slightly pink.
- 5) The total acidity is expressed in mg/L as calcium carbonate, multiply number of drop by 20.

#### **Alkalinity Procedures (High Range)**

- 1) Fill the measuring tube brim full of the sample water and Pour the contents into the square-mixing bottle.
- 2) Add one Phenolphthalein Indicator Powder Pillow to the mixing bottle. Swirl to mix. If the sample remains colorless the Phenolphthalein alkalinity is 0 so go to step 5.
- 3) If sample turns pink, add Sulfuric Acid Standard Solution to the mixing bottle one drop at a time and Count each drop. Swirl to mix after each drop. When the sample becomes colorless, record the number of drops added.
- 4) Calculate the Result – Multiply by 20 the number of drops of titrant used. This is the mg/L of phenolphthalein alkalinity as  $\text{CaCO}_3$ .
- 5) Add the contents of one Bromcresol Green-Methyl Red Indicator Powder Pillow to the mixing bottle and swirl to mix.
- 6) Add Sulfuric Acid Standard Solution one drop at a time and count each drop. Swirl the mixing bottle after each drop is added. Add drops until the sample turns pink.
- 7) Multiply by 20 the total number of drops, This is total mg/L of methyl orange alkalinity as  $\text{CaCO}_3$ .

#### **pH**

- 1) Calibrate the pH meter
- 2) Pour water sample on to a test tube
- 3) Submerge the probe on the test tube
- 4) Read the pH and temperature from the pH meter and record data
- 5) Repeat for sample 2 for the same water sample

#### **Hardness Procedures (High Range)**

- 1) Fill the measuring tube brim full of the sample water and Pour the contents into the square-mixing bottle.
- 2) Add three drops of the Buffer Solution, Hardness 1 to the mixing bottle. Swirl to mix.
- 3) Add one drop of Hardness 2 indicator to the mixing bottle. Swirl to mix. (\*A blue color indicates soft water. If a red color develops, proceed to step 4)
- 4) Add Hardness 3 Titrant Reagent by drops. Count the drops until the color changes from red to blue. Swirl to mix after each drop is added.
- 5) Calculate the Results- Each drop of Hardness 3 Titrant Reagent equals 1 grain hardness as  $\text{CaCO}_3$ . One grain per gallon equals 17.1 mg/L.

## Results

The following table are the results from the Acidity, Alkalinity, Hardness, and pH experiment. The test samples were of water from Lady Bird Lake, Bravos River, and PV Groundwater.

|            |                                        | Lake Water                                                      |                              |                              | River Water                      |                                | Groundwater                    |                                |
|------------|----------------------------------------|-----------------------------------------------------------------|------------------------------|------------------------------|----------------------------------|--------------------------------|--------------------------------|--------------------------------|
|            |                                        | 1 - SM, MY                                                      | 2 - ST, AA                   | 3 - LO                       | 1 - NK, NS                       | 2 - BW, DG                     | 1 - ML, PH                     | 2 - DP, DS                     |
| Acidity    |                                        | 0 mg/L CaCO <sub>3</sub>                                        | 0 mg/L CaCO <sub>3</sub>     |                              | 0 mg/L CaCO <sub>3</sub>         | 0 mg/L CaCO <sub>3</sub>       | 0 mg/L CaCO <sub>3</sub>       | 0 mg/L CaCO <sub>3</sub>       |
|            |                                        | 60 mg/L CaCO <sub>3</sub>                                       | 60 mg/L CaCO <sub>3</sub>    | 60 mg/L CaCO <sub>3</sub>    | 20 mg/L CaCO <sub>3</sub>        | 20 mg/L CaCO <sub>3</sub>      | 40 mg/L CaCO <sub>3</sub>      | 40 mg/L CaCO <sub>3</sub>      |
| Alkalinity |                                        | 170 mg/L CaCO <sub>3</sub>                                      | 187 mg/L CaCO <sub>3</sub>   | -                            | HR: 187 mg/L CaCO <sub>3</sub>   | LR: 170 mg/L CaCO <sub>3</sub> | HR: 280 mg/L CaCO <sub>3</sub> | HR: 280 mg/L CaCO <sub>3</sub> |
| Hardness   | Average: 264.95 mg/L CaCO <sub>3</sub> | 205.2 mg/L as CaCO <sub>3</sub><br>273.6 mg/L CaCO <sub>3</sub> | 324.9 mg/L CaCO <sub>3</sub> | 256.1 mg/L CaCO <sub>3</sub> | HR: 153.9 mg/L CaCO <sub>3</sub> | HR: 171 mg/L CaCO <sub>3</sub> | 171 mg/L CaCO <sub>3</sub>     | 153 mg/L CaCO <sub>3</sub>     |
| pH         |                                        | 6.85<br>15.1 <sup>o</sup> C                                     | 7.09<br>15.2 <sup>o</sup> C  | -                            | 6.42<br>18 <sup>o</sup> C        | 6.99<br>17.4 <sup>o</sup> C    | 6.51<br>17.7 <sup>o</sup> C    | 7.02<br>18.8 <sup>o</sup> C    |

Table. 1 Acidity, Alkalinity, Hardness, and pH results

## Discussion

The lake water came from Lady Bird Lake in Austin, TX. It has the highest total acidity out of the three water samples, measuring at  $60 \frac{mg}{L}$  as CaCO<sub>3</sub> with an alkalinity that was significantly higher, averaging at  $178.5 \frac{mg}{L}$  as CaCO<sub>3</sub>. Acidity and alkalinity directly coincide with pH, as pH measures waters acidity and alkalinity on a 14 point scale. According to the Lady Bird Lake Watershed Data Report, in 2019 the pH came in at a high of 9.0 and a low of 6.5 (TST, 12). Even on a low scale the pH of Lady Bird Lake simply went from base to alkalinity. This is reflected in our report, since the pH calculated in the lab measured at a high of 7.09 and a low of 6.85 never fully making it out of the base range. The lake water also had the highest hardness, indicating that it has a heavy presence of Calcium and Magnesium. Hardness is typically measured in parts per million (ppm) or milligrams per liter (mg/L). The hardness measured for lake water came out to be an average of  $264.95 \frac{mg}{L}$  as CaCO<sub>3</sub> which put it in a range of being classified as very hard water (Water hardness and pH, 67).

Groundwater is reported having the largest measurements for alkalinity. The alkalinity was the highest but the pH was the highest for the lake water. It was expected that since the

acidity was not as high as the lake water, and the alkalinity was the highest for the groundwater, that the pH might be the highest, but that was not the case. The pH for the groundwater was slightly less than that of the lake water. This is likely just due to location. The groundwater sample was collected in Prairie View A&M University and the lake water was collected in Austin, TX. Water softening is widely used to reduce the harmful effects of hard water in any situation where it is a concern. There are many methods for removing calcium, magnesium, and other metal cations from water, but lime softening is the most common.

## Conclusion

In this lab, we did four simple tests to measure the acidity, alkalinity, pH, and hardness of 3 samples of water, lake water from lady bird lake, river water from bravos river, and groundwater from Prairie View. The most common method used was the titration method where we mixed certain chemicals, such as Phenolphthalein and Bromphenol, with our water samples approximated the concentration of acidity, alkalinity, and hardness. Each chemical had a certain pH associated with it, the Phenolphthalein typically had a higher pH and was associated with alkalinity while the bromphenol had a low pH and was associated with acidity. The pH was measured using a pH meter. The hardness of water is determined by the calcium and magnesium concentrations in a sample. Noncarbonate hardness is described as the amount of hardness that exceeds the sum of carbonate and bicarbonate alkalinity numerically. There was some slight errors when it came to the hardness of lake water. The original values that were collected for sample one and two very different and so the lab was reconducted and a new value was recorded. We were then instructed to add all the collected values for the hardness of lake water and take the average which is how I got the value of  $264.95 \frac{mg}{L}$  as  $CaCO_3$ . In the future, paying more attention to the number of drops for each sample and making sure that one doesn't put unnecessary drop into a solution could possibly help this lab avoid those kinds of mistakes in the future.

Cite your sources in the report

Number your references

## References

Committee, T. (2015, October 24). Water hardness and ph. Retrieved April 07, 2021, from <https://opentextbc.ca/ingredients/chapter/water-hardness-and-ph/>

*Lady Bird Lake Watershed Data Report* (p. 19, Rep.). (2019). TX: TCEQ. doi:[https://gato-docs.its.txstate.edu/jcr:375d9d74-fb78-47ce-b4bd-5918eaa3cb2c/Lady%20Bird%20Lake%20Watershed%20Data%20Report\\_190925.pdf](https://gato-docs.its.txstate.edu/jcr:375d9d74-fb78-47ce-b4bd-5918eaa3cb2c/Lady%20Bird%20Lake%20Watershed%20Data%20Report_190925.pdf)

Kommalapati, R. Dr. Handout for Determination of Acidity, Alkalinity, and Hardness for Selected Water Samples

**CVEG 3043 sec P01 – Environmental Engineering**  
**Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE, Professor**

**Spring 2021**

**Title of Assignment**

Laboratory Report on Determination of Biochemical  
Oxygen Demand for Selected Wastewater Samples

**Outcome Measured Using this Assignment**

**Outcome #6**

**an ability to develop and conduct appropriate  
experimentation, analyze and interpret data, and use  
engineering judgment to draw conclusions**

**Brief Description of the suitability of this assignment for the  
outcome**

This Laboratory report shows the procedure students used to conduct the experiment, the raw data recorded, the analysis and presentation of the derived results, and interpretation of the results in the discussions and conclusions.



**Determination of Biochemical Oxygen Demand of Selected Influent  
Wastewater and Effluent Wastewater**

**CVEG 3043: Environmental Engineering  
Spring 2021**

**ABET Criteria SLO 6 100/100**

**Submitted by**

**Abram Auguste (Identification: #P22028029)**

**Submitted to**

**Dr. Raghava R. Kommalapati, PE, BCEE**

**Department of Civil and Environmental Engineering  
Prairie View A&M University  
May 3, 2021**

## ABSTRACT

**The purpose of the Biochemical Oxygen Demand lab experiment** was to measure Effluent wastewater and Influent wastewater samples for their biochemical oxygen demand levels. The BOD measurement quantifies the dissolved oxygen in a testing sample immediately after it is procured, known as DO initial, and after a five (5) day period, known as DO final. The quantified BOD values allows environmental engineers to understand the activity and amount of organic matter as well as bacteria present in the water analyzed. The ultimate biochemical oxygen demand and  $k$  constant was measure from diluted influent and effluent water samples by 10 mL and 125 mL, respectively. The DO values were then documented each passing day (24 hour period) using a dissolved oxygen meter. The final ultimate BOD results were as follows: For the **Influent Water**: Least Squares Method  $BOD_u = 438.335 \text{ g/m}^3$ , Thomas Method  $BOD_u = 715.06 \text{ g/m}^3$ , and Fujimoto Method  $BOD_u = 525 \text{ g/m}^3$ . The **Effluent Wastewater**: Least Squares Method  $BOD_u = 41.648 \text{ g/m}^3$  Thomas Method  $BOD_u = 54.856 \text{ g/m}^3$ , and Fujimoto Method  $BOD_u = 43 \text{ g/m}^3$ . The  $BOD_u$  values all seemed to be consistent in value for each of the three methods applied. The range of the samples were in close proximity. The value amount appeared accurate with the  $BOD_u$  for the effluent being much lower than the  $BOD_u$  for the Influent. It was determined that the Influent contained the highest value of biochemical oxygen demand followed by the effluent waste water sample with the lowest value of oxygen demand. The difference in values between the Influent and Effluent water samples are a result of the effluent water being treated by the waste water treatment plant. Any discrepancies are discussed in the discussion section of this report. Recommendations include performing additional trials to reduce errors in our calculations. Other recommendations include performing the labs as a collective group to help monitor performance and avoid inconsistencies. Also, including clear explanations in the lab trials can assist in further understanding of the lab process. Lastly, communication and listed instructions between lab supervisors and students can help reduce inconsistent steps in the lab process.

## I. Introduction

The experiment was conducted using equipment in the engineering lab under the supervision of the professor. The instructor explained to students the BOD testing procedure as students took notes. “The biochemical oxygen demand (BOD) is a test performed to measure the potential of wastewater and other waters to deplete the oxygen level of receiving waters” <sup>[1]</sup>. The BOD testing assist environmental engineers in finding the strength of the wastewater based on the amount of oxygen consumed. Understanding BOD levels help regulate the

oxygen in water sources that is crucial for ecosystem. If too much oxygen is consumed then living organism would perish from too little oxygen available. Once the lab was discussed by the instructor the data was collected after a 5 day period and shared with students to analyze the outcome of the experiment.

## **II. Objectives**

The objective for the Biochemical Oxygen Demand (BOD) experiment was to find the BOD levels and determine the values for the ultimate BOD,  $k$  constant, and  $BOD_5$  using the Linear Least Square method, Thomas Method, and Fujimoto method for both Effluent Wastewater and Influent Wastewater, and Blank Water Sample. These values were tabulated and reported. An overview of BOD's influence on the water was discussed. The results helped identify amounts of organic matter from the biochemical oxygen demand in water.

## **III. Experimental Methods**

### **APPARATUS BOD**

1. Disposable Wipes
2. Pipette
3. Water Samples (1 Liter Samples): Effluent Waster Water, Influent Waster Water, and Blank Water Sample
4. Disposable BOD Bottles, 300 mL
5. Bottle wash
6. Dissolved Oxygen Sensor
7. BOD Bottle Cap

### **PROCEDURES**

#### **BIOCHEMICAL OXYGEN DEMAND PROCEDURE**

1. Insert 10 mL of the influent wastewater sample into standard BOD bottle.

2. Insert 290mL of distilled water (the blank) into the same standard BOD bottle with the influent water to reach a max volume of 300mL. The distilled water consist of a seed to eliminate any bacteria that would require an oxygen demand.
3. Insert 125 mL of the effluent wastewater sample into a standard BOD bottle.
4. Insert 175 mL of distilled water into the same bottle that consist of the effluent water to reach a maximum volume of 300mL.
5. Insert 300mL of distilled water into a standard BOD bottle that will be used as the blank for experiment.
6. Tightly seal each BOD bottle with a stopper and prepare for titration.
7. Measure and record the dissolved oxygen (DO) for the two water samples by inserting the three BOD bottles filled with solutions in a Dissolved Oxygen Meter.
8. Place all three bottles in an incubator at 20° for 5 days. After 5 days measure the DO again. At least 1.0 mg/L DO should be left in each BOD bottle.
9. Then calculate the BOD ultimate ( $BOD_u$ ).
  - a. To calculate the BOD ultimate ( $BOD_u$ ) use either the Least-Squares Method, Thomas Method, or the Fujimoto Method.

#### IV. Results & Discussion

The final results of the BOD experiment were reasonable resulting from the state of treatment for each sample. The untreated Influent water sample had a high **715.06 g/m<sup>3</sup>** after applying the Thomas method and the Effluent water sample had a value of **54.856 g/m<sup>3</sup>**. The Thomas method provided the highest values likely resulting from the tabulation data manipulation. The Least square method provided the lowest values of the BOD<sub>u</sub> which is the most accurate method. All three methods provided data in the same range. When free oxygen is available the aerobic bacteria will use the organic matter in wastewater as a food source. The BOD test the amount of such organic matter in the wastewater. Typical sources of BOD are readily biodegradable organic carbon.<sup>3</sup> The greater the value of dissolved oxygen in the waste water the more organic matter found. In testing the BOD helps determine the strength of the wastewater by quantifying the oxygen used by bacteria.<sup>2</sup> The waste water influent is untreated water and is expected to contain high levels of BOD unlike the blank and Influent water samples. The Effluent water data indicates that it is safe water to drink under United States Federal guidelines. It is important to note that public water spaces are more inclined for contamination and pollution since easily accessible by the general public and easily susceptible to contamination by the general public.

## V. Conclusion & Recommendation

The experiment was conducted to find the values for biochemical oxygen demand (BOD) levels in both Influent and Effluent wastewater samples. The BOD<sub>u</sub> value for the Influent wastewater was much greater than the effluent wastewater likely as a result of the water being treated with various chemicals to eliminate the organic matter in the water and assist with human consumption of the water. The values were consistent with the fact that the wastewater influent had not yet been treated and likely contained high amounts of organic matter. The wastewater effluent went through a treatment and the BOD<sub>u</sub> should reasonably be much lower. The topics discussed in class and instructions given the Instructor helped guide the methods used. Final numerical data from the experiment were obtained and analyzed. As a result, the influent water would be fit for human consumption. Some key recommendations proposed would be to gather several water samples sourced from different areas to get better insight on area BOD ranges and understand the source of organic matter in the water. Also, performing several trials per water sample would help eliminate human error and deviations from expected values. Lastly, conducting the experiments in a collective group setting and without the working of the teacher assistance would help with group management and execution errors. The following recommendations would result in best lab practices and results in a better understanding of the material.

## VI. REFERENCES

- [1] "What Is Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)?" Mantech. N.p., n.d. Web. 12 Apr. 2016. [http://www.mantech-inc.com/products/why\\_bod\\_cod/](http://www.mantech-inc.com/products/why_bod_cod/).
- [2] "Product - Biochemical Oxygen Demand (BOD)." Biochemical Oxygen Demand (BOD) Testing – Hach. N.p., n.d. Web. 13 Apr. 2016. <<http://www.hach.com/bodguide>>.
- [3] "Biochemical Oxygen Demand." *Hawley's Condensed Chemical Dictionary* (2007): n. pag. EOLSS. Web. <<http://www.eolss.net/Sample-Chapters/C06/E6-13-04-03.pdf>>.
- [4] <https://www.mathsisfun.com/data/grapher-equation.html>

## VII. APPENDIX

**Table 1-1**

Influent Sample

| Time (d) | DO mg/l |                        |
|----------|---------|------------------------|
|          | Sample  | Dilution Water (Blank) |
| 0        | 8.65    | 8.75                   |
| 1        | 7.21    | 8.64                   |
| 2        | 5.56    | 8.52                   |
| 3        | 4.12    | 8.4                    |
| 4        | 2.96    | 8.31                   |
| 5        | 1.99    | 8.22                   |
| 6        | 0.87    | 8.16                   |

**Table 1-2**

Effluent Sample

| Time (d) | DO mg/l |                        |
|----------|---------|------------------------|
|          | Sample  | Dilution Water (Blank) |
| 0        | 8.71    | 8.75                   |
| 1        | 7.52    | 8.64                   |
| 2        | 6.43    | 8.52                   |
| 3        | 5.22    | 8.4                    |
| 4        | 4.16    | 8.31                   |
| 5        | 3.32    | 8.22                   |
| 6        | 2.46    | 8.16                   |

### Sample Calculations

#### INFLUENT

Given:

$$V_s = 10 \text{ mL}$$

$$P = \frac{10 \text{ mL}}{300} = 0.0333333333$$

$$f = 1 - P = 0.9666666667$$

$$BOD_1 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.65 - 7.21) - (8.75 - 8.64) \times (0.97)}{0.03333333333 \text{ mL}} = 40.01 \text{ mg/L}$$

$$BOD_2 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.65 - 5.56) - (8.75 - 8.52) \times (0.97)}{0.03333333333 \text{ mL}} = 86.03 \text{ mg/L}$$

$$BOD_3 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.65 - 4.12) - (8.75 - 8.40) \times (0.97)}{0.03333333333 \text{ mL}} = 125.75 \text{ mg/L}$$

$$BOD_4 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.65 - 2.96) - (8.75 - 8.31) \times (0.97)}{0.03333333333 \text{ mL}} = 157.94 \text{ mg/L}$$

$$BOD_5 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.65 - 1.99) - (8.75 - 8.22) \times (0.97)}{0.03333333333 \text{ mL}} = 184.43 \text{ mg/L}$$

$$BOD_6 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.65 - 2.46) - (8.75 - 8.16) \times (0.97)}{0.03333333333 \text{ mL}} = 216.29 \text{ mg/L}$$

### LINEAR LEAST SQUARE METHOD

| Influent |        |                |         |              |
|----------|--------|----------------|---------|--------------|
|          | y      | y <sup>2</sup> | y'      | y*y'         |
| 0        | 0      | -              | -       | -            |
| 1        | 40.01  | 1600.8         | 43.015  | 1721.03      |
| 2        | 86.03  | 7401.16<br>1   | 42.87   | 3688.10<br>6 |
| 3        | 125.75 | 15813.0<br>6   | 35.955  | 4521.34<br>1 |
| 4        | 157.94 | 24945.0<br>4   | 29.34   | 4633.96      |
| 5        | 184.43 | 34014.4<br>2   | 29.175  | 5380.74<br>5 |
| 6        | 216.29 | 46781.3<br>6   | -       | -            |
| Sum      | 594.16 | 83774.4<br>9   | 180.355 | 19945.1<br>8 |

\*The sum of values are from n=1 to 5

$$n(a) + b \sum y - \sum y' = 0 \quad (1)$$

$$(a) \sum y + (b) \sum y^2 - \sum y' \cdot y = 0 \quad (2)$$

From Equation (1)

$$5(a) + 594.16(b) - 180.355 = 0$$

From Equation (2)

$$594.16(a) + 83,774.49(b) - 19,945.18 = 0 \quad (2)$$

Applying algebraic expression and substituting (1) into (2), a and b yields

$$a = 49.4867$$

$$b = -0.112897$$

Next,  $BOD_{ultimate}$  is given by

$$BOD_u = \frac{-a}{b} = \frac{-49.4867}{(-0.112897)} = 438.335 \text{ mg/L}$$

And the constant k is given by

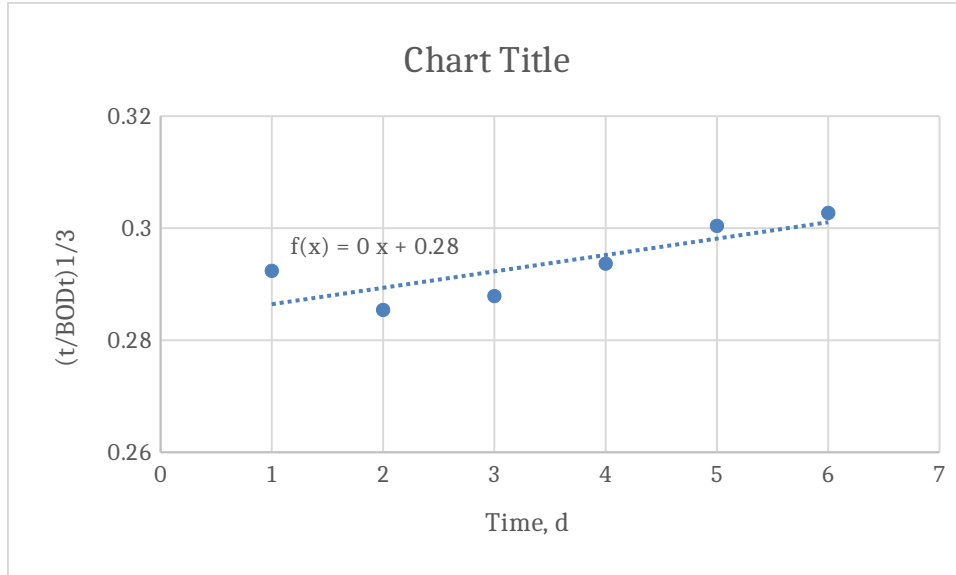
$$k = -b = -0.112897$$

### **THOMAS METHOD**

Thoma    Metho  
s        d  
Influen  
t

| Time, d | BOD <sub>t</sub> | (t/<br>BOD <sub>t</sub> ) <sup>1/3</sup> |
|---------|------------------|------------------------------------------|
| 0       | 0                | -                                        |
| 1       | 40.01            | 0.292377<br>4                            |
| 2       | 86.03            | 0.285404                                 |
| 3       | 125.75           | 0.287875<br>3                            |
| 4       | 157.94           | 0.293667<br>5                            |
| 5       | 184.43           | 0.300408<br>9                            |
| 6       | 216.29           | 0.302718                                 |





The Thomas Method equation is given by

$$\left(\frac{t}{BOD_t}\right)^{1/3} = \frac{1}{k BOD_u^{-1/3}} + \frac{(k)^{2/3}}{6(BOD_u)^{1/3}} t \quad (1)$$

Where slope and intercept is defined by,

$$Slope = \frac{(k)^{2/3}}{6(BOD_u)^{1/3}} t = 0.0029 = b$$

$$Intercept = \frac{1}{k BOD_u^{-1/3}} = 0.2835 = a$$

By direct substitution of the above variables,

$$k = 6 \times \frac{b}{a} = 6 \times \frac{0.0029}{0.2835} = 0.01023 d^{-1}$$

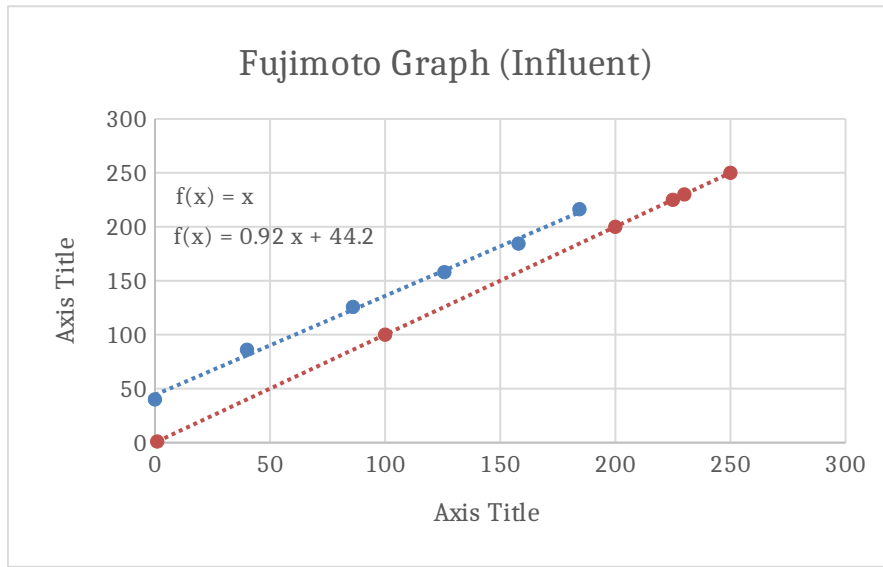
Finally the ultimate biochemical oxygen demand is given by

$$BOD_u = \frac{1}{6(a)^2(b)} = \frac{1}{6(0.2835)^2(0.0029)} = 715.06 mg/L$$

## **FUJIMOTO METHOD**

Fujimoto Table

| Time, d | BOD <sub>t</sub> | BOD <sub>t+1</sub> |
|---------|------------------|--------------------|
| 0       | 0                | 40.01              |
| 1       | 40.01            | 86.03              |
| 2       | 86.03            | 125.75             |
| 3       | 125.75           | 157.94             |
| 4       | 157.94           | 184.43             |
| 5       | 184.43           | 216.29             |



**Note: The Intersecting points of the above graph given by the below graph fit for the intersecting point.**



To find the Intersecting line, set the two equations equal then solve

$$y = .9177 x + 44.199 \text{ and } y = x$$

Such that the intersecting BOD value is  $BOD_u = 525 \text{ mg/L}$

Next, substituting into the below equation gives

$$y_t = BOD_u (1 - e^{-t \cdot k})$$

Where at  $t = 5$

$$y_5 = 525 (1 - e^{-5 \cdot k}) = 184.43$$

Where

$$k = 0.08655 \text{ d}^{-1}$$

## EFFLUENT

**Given:**

$$V_s = 125 \text{ mL}$$

$$P = \frac{125 \text{ mL}}{300} = 0.4166666667$$

$$f = 1 - P = 0.5833333333$$

$$BOD_1 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.71 - 7.52) - (8.75 - 8.64) \times (0.58)}{0.4166666667 \text{ mL}} = 2.702 \text{ mg/L}$$

$$BOD_2 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.71 - 6.43) - (8.75 - 8.52) \times (0.58)}{0.4166666667 \text{ mL}} = 5.15 \text{ mg/L}$$

$$BOD_3 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.71 - 5.22) - (8.75 - 8.40) \times (0.58)}{0.4166666667 \text{ mL}} = 7.886 \text{ mg/L}$$

$$BOD_4 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.71 - 4.16) - (8.75 - 8.31) \times (0.58)}{0.4166666667 \text{ mL}} = 10.304 \text{ mg/L}$$

$$BOD_5 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.71 - 3.32) - (8.75 - 8.22) \times (0.58)}{0.4166666667 \text{ mL}} = 12.194 \text{ mg/L}$$

$$BOD_6 = \frac{(DO_0 - DO_1) - (B_0 - B_1) \times f}{P} = \frac{(8.71 - 2.46) - (8.75 - 8.16) \times (0.58)}{0.4166666667 \text{ mL}} = 14.174 \text{ mg/L}$$

**LINEAR LEAST SQUARE METHOD**

Effluent

|     | y      | y <sup>2</sup> | y'     | y*y'    |
|-----|--------|----------------|--------|---------|
| 0   | 0      | -              | -      | -       |
| 1   | 2.702  | 7.300804       | 2.575  | 6.95765 |
| 2   | 5.15   | 26.5225        | 2.592  | 13.3488 |
| 3   | 7.886  | 62.189         | 2.577  | 20.3222 |
| 4   | 10.304 | 106.172        | 2.154  | 22.1948 |
| 5   | 12.194 | 148.693        | 1.935  | 23.5953 |
| 6   | 14.174 | 200.902        | -      | -       |
| Sum | 38.236 | 350.878        | 11.833 | 86.4188 |

|  |  |   |  |   |
|--|--|---|--|---|
|  |  | 4 |  | 8 |
|--|--|---|--|---|

\*The sum of values are from n=1 to 5

$$n(a) + b \sum y - \sum y' = 0 \quad (1)$$

$$(a) \sum y + (b) \sum y^2 - \sum y' \cdot y = 0 \quad (2)$$

From Equation (1)

$$5(a) + 38.236(b) - 11.833 = 0$$

From Equation (2)

$$38.236(a) + 350.8784(b) - 86.4188 = 0 \quad (2)$$

Applying algebraic expression and substituting (1) into (2), a and b yields

$$a = 2.89889$$

$$b = -0.0696052$$

Next,  $BOD_{ultimate}$  is given by

$$BOD_u = \frac{-a}{b} = \frac{-2.89889}{(-0.0696052)} = 41.648 \text{ mg/L}$$

And the constant k is given by

$$k = -b = 0.0696052$$

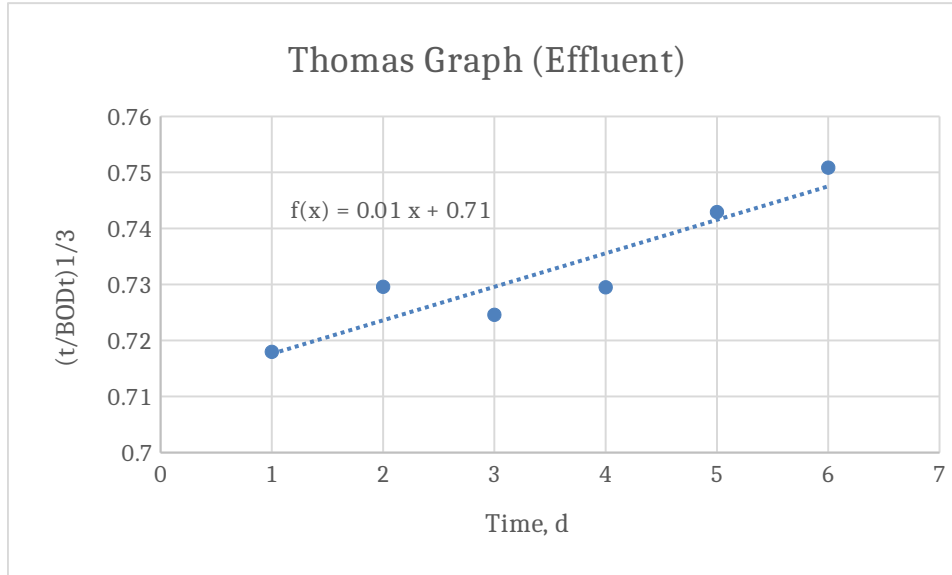
## **THOMAS METHOD**

Effluen

t

| Time, d | BOD <sub>t</sub> | (t/<br>BOD <sub>t</sub> ) <sup>1/3</sup> |
|---------|------------------|------------------------------------------|
| 0       | 0                | -                                        |
| 1       | 2.702            | 0.717967<br>7                            |
| 2       | 5.15             | 0.729582<br>2                            |
| 3       | 7.886            | 0.724583                                 |
| 4       | 10.304           | 0.729487<br>8                            |

|   |        |               |
|---|--------|---------------|
| 5 | 12.194 | 0.742918<br>7 |
| 6 | 14.174 | 0.750849<br>6 |



The Thomas Method equation is given by

$$\left(\frac{t}{BOD_t}\right)^{1/3} = \frac{1}{k BOD_u^{-1/3}} + \frac{(k)^{2/3}}{6(BOD_u)^{1/3}} t \quad (1)$$

Where slope and intercept is defined by,

$$Slope = \frac{(k)^{2/3}}{6(BOD_u)^{1/3}} t = 0.006 = b$$

$$Intercept = \frac{1}{k BOD_u^{-1/3}} = 0.7116 = a$$

By direct substitution of the above variables,

$$k = 6 \times \frac{b}{a} = 6 \times \frac{0.006}{0.7116} = 0.00843 d^{-1}$$

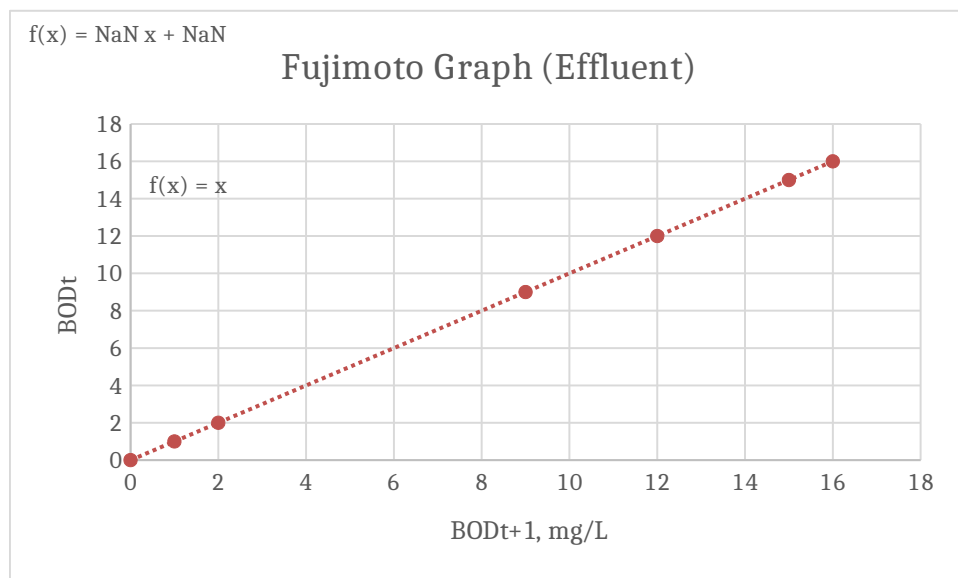
Finally the ultimate biochemical oxygen demand is given by

$$BOD_u = \frac{1}{6(a)^2(b)} = \frac{1}{6(0.7116)^2(0.006)} = 54.856 mg/L$$

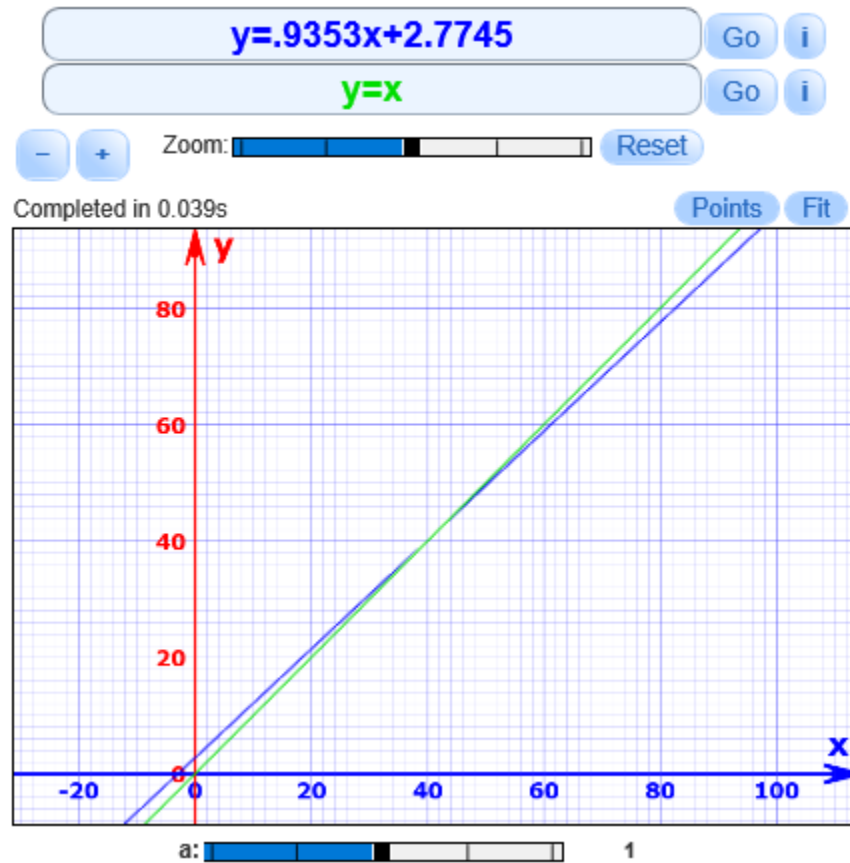
## FUJIMOTO METHOD

Fujimoto Table

| Time,<br>d | BOD <sub>t</sub> | BOD <sub>t+1</sub> |
|------------|------------------|--------------------|
| 0          | 0                | 2.702              |
| 1          | 2.702            | 5.15               |
| 2          | 5.15             | 7.886              |
| 3          | 7.886            | 10.304             |
| 4          | 10.304           | 12.194             |
| 5          | 12.194           | 14.174             |



**Note: The Intersecting points of the above graph given by the below graph fit for the intersecting point.**



To find the Intersecting line set the two equations equal then solve

$$y = .9353x + 2.7745 \text{ and } y = x$$

**Where**  $BOD_u = 43 \text{ mg/L}$

Next, substituting into the below equation gives

$$y_t = BOD_u(1 - e^{-5 \cdot k})$$

Where at  $t = 5$

$$y_5 = 43(1 - e^{-5 \cdot k}) = 12.194$$

Where

$$k = 0.06669 \text{ d}^{-1}$$



**CVEG 3301 sec P01 – Environmental Engineering**  
**Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE, Professor**

**Spring 2022**

**ASSIGNMENTS FOR OUTCOME “6”**

**an ability to develop and conduct appropriate experimentation,  
analyze and interpret data, and use engineering judgment to  
draw conclusions**

**CVEG 3301 sec P01 – Environmental Engineering**  
**Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE, Professor**

**Spring 2022**

**Title of Assignment**

Laboratory Report on Determination of pH, Acidity, Alkalinity and Hardness of Selected Water Samples

**Outcome Measured Using this Assignment**

**Outcome #6**

**an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions**

**Brief Description of the suitability of this assignment for the outcome**

This Laboratory report shows the procedure students used to conduct the experiment, the raw data recorded, the analysis and presentation of the derived results, and interpretation of the results in the discussions and conclusions.

**Determination of Acidity, Alkalinity, PH, and Hardness for River  
water, Lake water, Wastewater, and Groundwater**

**CVEG 3301: Environmental Engineering  
Spring 2022**

**ABET Criteria    SLO 6 92**

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**ABSTRACT:**

Water has three distinct types of characteristics- physical, chemical, and biological. The focus of this particular experiment is the chemical characteristics of water like pH, acidity, alkalinity, and hardness. The main objective of the experiment is to determine all these characteristics for four different samples of water that include river water, lake water, groundwater from two separate locations. All these characteristics are related to each other. The pH of a water sample signifies the concentration of hydrogen ions, which if less, it means that water is alkaline and if the concentration is high, the water is acidic. Both acidity and alkalinity are pH dependent. Also, the part of hardness that is associate with alkalinity is called carbonate hardness. The alkalinity of water cannot be higher than the total hardness. These characteristics are mainly determined to see their effect on water and the to see if water is suitable for drinking, which is the primary purpose of water.

A pH and conductivity meter is used to determine the pH of the water sample. The probe, which is attached to the meter is immersed in the sample water to take the reading for pH. The other three characteristics are determined utilizing the titration technique. To determine hardness, water sample is titrated with ethylenediaminetetraacetic acid (EDTA,) to determine alkalinity, the water sample is titrated with a strong acid, and to determine the acidity, the water sample is titrated with a standard base. The unit for concentration of acidity, alkalinity, and hardness is mg/L as  $\text{CaCO}_3$ .

It was found that the river, lake water, PVAMU groundwater, and groundwater from Millican water have a pH value of 6.985, 7.565, 7.655, and 6.37, respectively. Similarly, the total hardness for river water, lake water, PVAMU groundwater, and groundwater from Milican are 247.95 mg/L as  $\text{CaCO}_3$ , 188.1 mg/L as  $\text{CaCO}_3$ , 153.9 mg/L as  $\text{CaCO}_3$ , and 62.85 mg/L as  $\text{CaCO}_3$ , respectively. The higher the pH, the higher the alkalinity and the lower the pH, the lower the acidity of the water gets. It was concluded that if, just the pH characteristic of the water

was taken into account, then from that perspective, all the water sample qualifies as drinking sources. Also, it was established that the hardness of the water should not be a health concern for people, but more of an inconvenience.

Include recommendations

## I. Introduction

People generally expect water to be both safe to drink and esthetically pleasing. They expect water to be both palatable and potable. Palatable water is water that doesn't have any taste or any odor. It is also pleasant to drink. Water which is essentially free of chemicals, microorganisms, and other contaminants, and is safe to drink is called potable.<sup>[1]</sup> Chemical characteristics of water includes determine parameters such as pH, alkalinity, hardness, and acidity of water.

pH is the negative log of hydrogen ion concentration. In layman terms, if the concentration of hydrogen ion is high, the pH value will be low, however if the concentration of hydrogen ion is low, the pH will be high. In this experiment, pH is measure using a pH meter. However, here are other ways to determine pH values, like with the help of indicators and colors. The pH is measure on a scale of 0 to 14, with 14 being the most basic and 0 being the most acidic. A value of 7 denotes neutral. So, for example, if a water sample has a value of pH that is less than 7, that water will be acidic and if it has a pH value of more than 7, the water will be alkaline.

This tells how pH is related to both acidity and alkalinity, which means both these characteristics are pH dependent. Acidity is the capacity of water to neutralize a base. A base is the one that releases  $\text{OH}^+$  and accepts  $\text{H}^+$  ions. Acidity for most waters is usually zero. It is measured by titrating water with a standard base, like NaOH, to raise the pH. On the other hand, alkalinity is defined as the capacity of water to neutralize an acid. An acid is the one that releases  $\text{H}^+$  ions. Alkalinity is measured by titrating the water sample with a strong acid to lower pH. Its

main constituents are hydroxyl, carbonate, and bicarbonate. However, bicarbonate generally accounts for most of the alkalinity. Alkalinity is also related to hardness.

There are two types of hardness- carbonate and non-carbonate hardness. The former is called temporary hardness and is the portion of hardness that is associated with alkalinity, which is carbonate and bicarbonate. Temporary hardness can be removed by heating too. The remaining is called permanent or non-carbonate hardness. It is associated with other ions like  $\text{Cl}^-$  and  $\text{SO}_4^{2-}$ . It is also measured by titrating it with EDTA, Ethylenediaminetetraacetic acid. Hardness is mainly due to calcium ( $\text{Ca}^{2+}$ ) and magnesium ( $\text{Mg}^{2+}$ ), but all ions a charge of 2 or higher contribute to hardness.

In this experiment, of 4 different samples of water will be tested and determined. These 4 different samples of water include a sample of river water, a sample of lake water, a sample of PVAMU tap water (groundwater,) and one sample of groundwater. The river water sample was collected from the Brazos River in Houston, Texas; the lake water was collected from the Joe pool lake in Arlington, Texas; the tap water was from Prairie View A&M University; and the groundwater was from Millican, Texas. The water samples were collected in big, one-gallon bottles. It was made sure that while collecting the river and lake samples, the cap on the bottles is replaced while the mouth of the bottle is still underwater. This measure was taken to protect the samples from contamination as if it comes out, they will get in contact with the air and get contaminated.

To be safe and suitable for use, water should be free from all impurities and must meet all parameters set by the Environmental protection agency. Therefore, in this experiment, the chemical characteristics of water will be determined for the above-mentioned water samples.

## **II. Objectives**

The purpose is to determine the chemical properties of water, which include pH, alkalinity, hardness, and acidity of four different samples of water, which include river water, lake water, Prairie View A&M groundwater, and groundwater from Millican, Texas to check the suitability of water as a drinking source. A pH & conductivity meter was used, and the technique of titration was utilized.

### **III. Experimental Methods**

#### **EQUIPMENT REQUIRED:**

- pH meter
- Water samples
- Graduated cylinder
- Test tubes
- Beakers
- Burette
- Titrants for Acidity, Alkalinity, and Hardness
- Phenolphthalein indicator

#### **DESCRIPTION OF PROCEDURE (The laboratory handouts were referred)**

##### **PH TEST FOR WATER SAMPLES**

1. Rinse a beaker with distilled water and repeat the process for the pH probe.
2. Take a decent amount of water sample in the beaker
3. Using a pH and conductivity meter, immerse the probe into the beaker. Make sure to not touch the bottom nor the walls of the beaker.

4. Repeat the process one more time.
5. Safely discard all the water as per the instructions and clean up.

### **HARDNESS TEST FOR WATER SAMPLES**

1. Take a beaker and rinse with distilled water.
2. Take some amount of water sample in a beaker.
3. To determine hardness, it must be titrated with Ethylenediaminetetraacetic acid
4. So, add the EDTA titrant to the solution, using a burette. A few drops of this will turn the solution from wine red to blue.
5. Count these number of drops and note it as first reading of hardness. Repeat the process twice.
6. Safely discard all the water as per the instructions and clean up.

### **ALKALINITY TEST FOR WATER SAMPLES**

1. To calculate alkalinity, the water sample must be titrated with an acid and an indicator must be used.
2. Rinse a beaker with distilled water and pour some amount of water sample into it.
3. In this case, the indicator is phenolphthalein. Add the indicator to the beaker.
4. Titrate the water sample till the last drop of titrant causes the solution to change color to light pink.
5. Observe the number of drops and record it.
6. Safely discard all the water as per the instructions and clean up.

### **ACIDITY TEST FOR WATER SAMPLES**

1. Prepare NaOH titrant.



2. Rinse a beaker with distilled water and take some water sample in it. Add the indicator to the sample.
3. Titrate it with NaOH till it changes color to light pink.
4. Observe and number of drops of titrant used to change the color.
5. Safely discard all the water as per the instructions and clean up.

## IV. Results &amp; Discussion

## RESULTS:

Tables are not needed on the results. Discuss results and provide table in appendix

Table 1: Reflects the pH Test Results:

| Water Sample      | Average<br>pH |
|-------------------|---------------|
| River Water       | 6.985         |
| Lake Water        | 7.565         |
| PVAMU Groundwater | 7.655         |
| Groundwater       | 6.37          |

Table 2: Reflects Hardness Test Results:

| Water Sample      | Average<br>Hardness<br>(mg/L as CaCO <sub>3</sub> ) |
|-------------------|-----------------------------------------------------|
| River Water       | 247.95                                              |
| Lake Water        | 188.1                                               |
| PVAMU Groundwater | 153.9                                               |
| Groundwater       | 62.85                                               |

Table 3: Reflects the Alkalinity Test Results:

| Water Sample      | Average Alkalinity           |
|-------------------|------------------------------|
|                   | (mg/L as CaCO <sub>3</sub> ) |
| River Water       | 1155                         |
| Lake Water        | 385                          |
| PVAMU Groundwater | 962.5                        |
| Groundwater       | 385                          |

Table 4: Reflects the Acidity Test Results:

| Water Sample      | Average<br>Acidity<br>(mg/L as CaCO <sub>3</sub> ) |
|-------------------|----------------------------------------------------|
| River Water       | 0.0337                                             |
| Lake Water        | 0.1641                                             |
| PVAMU Groundwater | 0.0550                                             |
| Groundwater       | 0.0456                                             |

## DISCUSSION:

Tables 1, 2, 3, and 4 depict the results for pH, hardness, Alkalinity, and Acidity of water. As it can be seen that the pH for river water and lake water is 6.985 and 7.655. for both are groundwater samples, the pH values were 7.655 and 6.37. Usually, the pH for natural waters in United States is between the range of 6.5 to 8.5, with around 7.4 being the optimum value for pH.<sup>[2]</sup> In addition, pure water must have a pH value of 7 and neutral because it has neither acidic, nor basic qualities, and the pH of groundwater normally ranges from around 6 to 8.5. Over the few years, people have started following the trend of drinking alkaline water, which has pH of around 7 to 9, and so, drinking water with a pH slightly greater than 7, is not unsafe, rather has shown to improve overall health and slow ageing.<sup>[3]</sup> The alkalinity of river water, lake water, PVAMU groundwater and groundwater is 1155, 385, 962.5, 385 mg/L as CaCO<sub>3</sub> and acidity is 0.0337, 0.1641, 0.0550, and 0.0456 mg/L as CaCO<sub>3</sub>.

Nonetheless, the pH levels that are not neutral, meaning are either less or more than 7 can cause high concentrations of metals for which there are specific standards/parameters set by the EPA. And so, to control that there is SMCL, Secondary Maximum Contaminant level, according to which, the pH of drinking water must be between 6.5 to 8.5.<sup>[4]</sup>

The hardness for river water, lake water, PVAMU groundwater and groundwater is 247.95 mg/L as CaCO<sub>3</sub>, 188.1 mg/L as CaCO<sub>3</sub>, 153.9 mg/L as CaCO<sub>3</sub>, and 62.85 mg/L as CaCO<sub>3</sub>. This characteristic of water does not necessarily be a concern for health and may not have a particular health standard, but it can be inconvenience. Hard water contains mainly calcium and magnesium, which easily precipitate and interact with soap to become scum, which is quite difficult to remove and is bothersome. Hard water can also lead to formation of scales in pipes, heaters, etc. Hardness value of than 1 gpg is considered soft and around 7 to 10.5 gpg is regarded as hard. Hardness value of 10.5 gpg and higher is considered very hard So, it can be seen that the river water had the most amount hardness, almost 14.5 gpg, which indicates that the water is

very hard. Groundwater from Milican had the least amount of hardness, around 3.5 gpg, but it is still considered slightly hard.

## V. Conclusion & Recommendation

The experiment was to determine the pH, acidity, hardness, and alkalinity of river water, lake water, and groundwater from Prairie View and Melian, to check the quality of water source and to determine the suitability of water as a drinking water source. It was found that the river, lake water, PVAMU groundwater, and groundwater water have a pH of 6.985, 7.655, 7.655, and 6.37, respectively. According to Secondary Maximum Contaminant level, the pH of drinking water must be between 6.5 to 8.5.<sup>[4]</sup> Since the pH values of all these sample are in range according to the standards set by EPA, all these are presumably safe to drink, but only from the pH point of view. The alkalinity of river water, lake water, PVAMU groundwater and groundwater is 1155, 385, 962.5, 385 mg/L as  $\text{CaCO}_3$  and acidity is 0.0337, 0.1641, 0.0550, and 0.0456 mg/L as  $\text{CaCO}_3$ . It was determined that the river water had the most amount of hardness present and the groundwater from Melian had the least amount of hardness. It was also established that hardness does not have a health safety standard, but it can affect people in other troublesome ways. Overall, the experiment was successful, and all the objectives of the experiment were met.

## VI. References

1. Masten, Susan J., and Mackenzie Leo Davis. “*Chemical Characteristics.*” Principles of Environmental Engineering and Science, McGraw-Hill Education, New York, NY, 2020.
2. “Water Quality.” NASA, NASA, 2022, <https://www.grc.nasa.gov/www/k-12/fenlewis/Waterquality.html#:~:text=The%20pH%20of%20river%20water,river%20water%20is%20around%207.4>.
3. Cirino, Erica. “Ph of Drinking Water: Acceptable Levels.” *Healthline*, Healthline Media, 30 Mar. 2019, <https://www.healthline.com/health/ph-of-drinking-water#unsafe-ph-for-water>.
4. “Groundwater-Quality Analyte Descriptions.” *Groundwater-Quality Analyte Descriptions*, <https://kgs.uky.edu/kgsweb/datasearching/water/analyteDescr.asp#:~:text=In%20the%20absence%20of%20coal,of%20soil%20and%20rock%20contacted>.

## VII. Appendix

### **LABORATORY DATA:**

Table 5: Reflects the pH Test Data collected in the Laboratory:

| Water Sample      | Trial 1<br>pH | Trial 2<br>pH | <b>Average<br/>pH</b> |
|-------------------|---------------|---------------|-----------------------|
| River Water       | 6.97          | 7.00          | 6.985                 |
| Lake Water        | 7.52          | 7.61          | 7.565                 |
| PVAMU Groundwater | 7.74          | 7.57          | 7.655                 |
| Groundwater       | 6.23          | 6.51          | 6.37                  |

### **SAMPLE CALCULATION FOR pH (RIVER WATER):**

$$\text{Average pH} = \frac{\text{Trial 1 pH} + \text{Trial 2 pH}}{2} = \frac{6.97 + 7}{2} = \mathbf{6.985}$$

Table 6: Reflects the Hardness Test Data Calculations:

| Water Sample      | Trial 1<br>Hardness<br>(gpg) | Trial 1<br>Hardness<br>(mg/L as<br>CaCO <sub>3</sub> ) | Trial 2<br>Hardness<br>(gpg) | Trial 2<br>Hardness<br>(mg/L as<br>CaCO <sub>3</sub> ) | <b>Average<br/>Hardness<br/>(mg/L as<br/>CaCO<sub>3</sub>)</b> |
|-------------------|------------------------------|--------------------------------------------------------|------------------------------|--------------------------------------------------------|----------------------------------------------------------------|
| River Water       | 15                           | 256.5                                                  | 14                           | 239.4                                                  | 247.95                                                         |
| Lake Water        | 12                           | 205.2                                                  | 10                           | 171                                                    | 188.1                                                          |
| PVAMU Groundwater | 8                            | 136.8                                                  | 10                           | 171                                                    | 153.9                                                          |
| Groundwater       | 3                            | 57.3                                                   | 4                            | 68.4                                                   | 62.85                                                          |

### **SAMPLE CALCULATION FOR HARDNESS (RIVER WATER):**

$$\text{Hardness in mg/L} = \text{Hardness in grains per gallon (gpg)} \times 17.1 = 256.5 \frac{\text{mg}}{\text{L}} \text{ as } \text{CaCO}_3$$

$$\text{Average Hardness} = \frac{\text{Trial 1 hardness} + \text{Trial 2 hardness}}{2} = \frac{256.5 + 239.4}{2} = 247.95 \frac{\text{mg}}{\text{L}} \text{ as } \text{CaCO}_3$$

Table 7: Reflects the Alkalinity Test Data collected in the Laboratory:

| Water Sample      | Trial 1 Alkalinity |                        |                         | Trial 2 Alkalinity |                        |                         | Average Alkalinity         |
|-------------------|--------------------|------------------------|-------------------------|--------------------|------------------------|-------------------------|----------------------------|
|                   | Drops              | gpg as $\text{CaCO}_3$ | mg/L as $\text{CaCO}_3$ | Drops              | gpg as $\text{CaCO}_3$ | mg/L as $\text{CaCO}_3$ | (mg/L as $\text{CaCO}_3$ ) |
| River Water       | 3                  | 68                     | 1155                    | 3                  | 68                     | 1155                    | 1155                       |
| Lake Water        | 1                  | 23                     | 385                     | 1                  | 23                     | 385                     | 385                        |
| PVAMU Groundwater | 3                  | 68                     | 1155                    | 2                  | 45                     | 770                     | 962.5                      |
| Groundwater       | 1                  | 23                     | 385                     | 1                  | 23                     | 385                     | 385                        |

**SAMPLE CALCULATION FOR SUSPENDED SOLIDS (RIVER WATER):**



The following table 7.1, form the handout provided in the laboratory was referred for Alkalinity values in gpg and mg/L as  $\text{CaCO}_3$

No images only  
typed table

Table 7.1: Reflects the concentration in gpg and mg/L:

| Number of drops | Total Alkalinity as $\text{CaCO}_3$ (gpg) | Total Alkalinity as $\text{CaCO}_3$ (mg/L) |
|-----------------|-------------------------------------------|--------------------------------------------|
| 1               | 23                                        | 385                                        |
| 2               | 45                                        | 770                                        |
| 3               | 68                                        | 1155                                       |
| 4               | 90                                        | 1540                                       |
| 5               | 113                                       | 1925                                       |
| 6               | 135                                       | 2310                                       |
| 7               | 158                                       | 2695                                       |
| 8               | 180                                       | 3080                                       |
| 9               | 203                                       | 3465                                       |
| 10              | 225                                       | 3850                                       |
| 11              | 250                                       | 4235                                       |
| 12              | 270                                       | 4620                                       |
| 13              | 293                                       | 5005                                       |
| 14              | 315                                       | 5390                                       |
| 15              | 338                                       | 5775                                       |
| 16              | 360                                       | 6160                                       |
| 17              | 383                                       | 6545                                       |
| 18              | 405                                       | 6930                                       |
| 19              | 428                                       | 7315                                       |
| 20              | 450                                       | 7700                                       |
| 21              | 473                                       | 8085                                       |
| 22              | 495                                       | 8470                                       |

-1

$$\text{Average Alkalinity} = \frac{\text{Trial 1 Alkalinity} + \text{Trial 2 Alkalinity}}{2} = \frac{1155 + 1155}{2} = 1155 \frac{\text{mg}}{\text{L}} \text{ as } \text{CaCO}_3$$

Table 8: Reflects the Acidity Test Data Calculations:

| Water Sample      | Trial 1<br>Acidity<br>(mg/L as CaCO <sub>3</sub> ) | Trial 2<br>Acidity<br>(mg/L as CaCO <sub>3</sub> ) | Average<br>Acidity<br>(mg/L as CaCO <sub>3</sub> ) |
|-------------------|----------------------------------------------------|----------------------------------------------------|----------------------------------------------------|
| River Water       | 0                                                  | 0.0675                                             | 0.0337                                             |
| Lake Water        | 0                                                  | 0.32815                                            | 0.1641                                             |
| PVAMU Groundwater | 0                                                  | 0.11                                               | 0.0550                                             |
| Groundwater       | 0                                                  | 0.09125                                            | 0.0456                                             |

**SAMPLE CALCULATION FOR DISSOLVED SOLIDS (RIVER WATER):**

$$\text{Average Acidity} = \frac{\text{Trial 1 acidity} + \text{Trial 2 acidity}}{2} = \frac{0 + 0.0675}{2} = \mathbf{0.0337 \frac{mg}{L} \text{ as } CaCO_3}$$

**CVEG 3301 sec P01 – Environmental Engineering**  
**Raghava R. Kommalapati, Ph.D., P.E., BCEE, F. ASCE, Professor**

**Spring 2022**

**Title of Assignment**

Laboratory Report on Determination of Chemical Oxygen  
Demand for Selected Water/Wastewater Samples

**Outcome Measured Using this Assignment**

**Outcome #6**

**an ability to develop and conduct appropriate  
experimentation, analyze and interpret data, and use  
engineering judgment to draw conclusions**

**Brief Description of the suitability of this assignment for the  
outcome**

This Laboratory report shows the procedure students used to conduct the experiment, the raw data recorded, the analysis and presentation of the derived results, and interpretation of the results in the discussions and conclusions.

**Determination of Chemical Oxygen Demand (COD) for River Water,  
Lake Water, Wastewater, and Standard Solution Water/Wastewater  
Samples**

**CVEG 3301-Z81: Environmental Engineering  
Spring 2022**

90

**ABET Criterion**

**SLO 6 \_\_\_\_**

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## **Abstract**

The Chemical Oxygen Demand (COD) experiment aimed to determine the chemical oxygen demand of three different water samples, river water, lake water, wastewater effluent, and a standard solution, and to determine if the samples were suitable for drinking water purposes. Within Environmental Engineering, it is necessary to understand and determine the quality of representative water and wastewater samples. This is essential as water and wastewater quality can negatively impact a community and environment if toxins or pathogenic microorganisms are present (Davis et al., 2004). One characteristic used to determine quality is biological characteristics. This experiment was completed by utilizing a standard testing procedure provided by HACH. The results for chemical oxygen demand were as follows: 797.5 mg/L, 23 mg/L, 32 mg/L, and 13 mg/L for the standard solution, lake water, river water, and wastewater effluent, respectively. The expected COD value for unpolluted waters is 20 mg/L or less (S.K. Jain et al., 2003). River water and lake water were deemed inadequate drinking water sources and would require the proper removal of microbes to reach acceptable COD values. Wastewater effluent was deemed an acceptable drinking water source as it held COD readings under 20 mg/L. The percentage error for the standard solution was 0.3125% when compared to the expected value. This percentage reflected that the experiment was ultimately conducted correctly, and theoretically, the results obtained were accurate. Recommendations include conducting the experiment in triplicates instead of duplicates and utilizing a separate method to determine water quality due to the limitations of the COD method.

**Keywords:** Chemical oxygen demand, wastewater, water quality

## **1. Introduction**

Within Environmental Engineering, it is necessary to understand and determine the quality of representative water and wastewater samples. This is essential as water and wastewater quality can impact a community and environment either negatively or positively. Civil Engineers who work to clean and distribute water for consumption are tasked with purifying the water and distributing the water into designated communities. Engineers who work with wastewater are tasked with cleansing water and redistributing the water into the designated water body. Although both water samples have different purposes, they are distinguished by their quality.

Since both water and wastewater are made of organic and inorganic compounds, engineers cannot distinguish each component in the required time. Thus the sample is analyzed to determine the toxic elements present—this aids in understanding how each water sample should be treated to remove the component(s). Given that the purification process is essential, engineers use physical, chemical, and biological characteristics to determine the quality of a water sample. Biological characteristics were observed in this laboratory: Chemical oxygen demand (COD).

Chemical oxygen demand is an indirect measurement of organic matter, as COD measures the quantity of dissolved oxygen within the water sample (S.K. Jain et al., 2003). As the engineers process various water samples, organic matter contents are present within each sample. This organic matter is made of multiple components, including many microbes. Microbes consume the organic matter and oxygen within the water sample to produce cells or energy. Too many microbes will cause the oxygen content in the water to deplete. This can cause aquatic life that requires oxygen to survive to suffer and eventually die off. COD is also an adequate method of measuring dissolved oxygen in the absence of oxygen. This is completed as an oxidizing chemical, potassium dichromate, is consumed by the sample in place of the oxygen.

Chemical oxygen demand was chosen to determine the quality of the water/wastewater samples. This method can provide an accurate and quick means to determine the water quality in the absence and presence of oxygen. Thus, this study aimed to determine the chemical oxygen demand of three different water samples, river water, lake water, wastewater, and a standard solution, and to determine the suitability of each sample as a potential drinking water source.

### **1.1 Objective**

The primary objective of the chemical oxygen demand experiment was to determine the chemical oxygen demand of three different water samples, river water, lake water, wastewater, and a standard solution. The secondary objective was to determine the suitability of each water sample as a potential drinking water source from the experimental data.

## **2. Materials and Methods**

### **2.1 Materials/Apparatus:**

1. Dissolved Oxygen, DO, Meter
2. HACH COD Standard Solution
3. DRB 3900 Spectrometer Machine
4. HACH COD Reactor
5. 200 mL Beaker
6. Deionized Water
7. Pipette

### **2.2 Experimental Procedure**

Materials were initially prepared by cleaning and rinsing with distilled water. The river water was obtained from the Brazos River in Navasota, Texas. The lake water sample was obtained from Joe Pool Lake in Arlington, Texas. The wastewater effluent sample was obtained from the Prairie View A&M University wastewater treatment plant. The standard solution was obtained from HACH COD standard testing kit. All samples were transferred to a clean, gallon container from the water body. Each water sample was prepared by inversely shaking the sample container

to encourage uniformity before conducting each test. All materials and water samples were disposed of as directed.

### 3. Results and Discussion

| Chemical Oxygen Demand Test |              |
|-----------------------------|--------------|
| Water Sample                | Sample, mg/L |
| Standard                    | 797.5        |
| Lake Water                  | 23           |
| River Water                 | 32           |
| Wastewater Effluent         | 13           |

Table 1.1: **Chemical Oxygen Demand results** is the tabular representation of experimental data showing the COD results obtained from experimental data.

The chemical oxygen demand readings were as follows: 797.5 mg/L, 23 mg/L, 32 mg/L, and 13 mg/L for the standard solution, lake water, river water, and wastewater effluent. The standard solution readings provided from the HACH COD testing kit were 800 mg/L.

A study conducted by S.K. Jain and V.P. Singh analyzed various ways to quantify and model water quality. It was determined that a COD reading of 20 mg/L or less was a standard value for unpolluted waters (S.K. Jain et al., 2003). The river water and lake water both held readings over 20 mg/L. Initially, the wastewater effluent readings were negative, reflecting an error conducted in the experiment. Thus, the quality of lake water was unable to be determined at first. After repeating the experiment, the wastewater effluent readings were under 20 mg/L. The standard solution reading was close to the expected value provided from the HACH testing kit of 800 mg/L.

Both lake water and river water samples were deemed unacceptable for consumption purposes based on the standard COD values from the previously discussed research article. Wastewater effluent was deemed acceptable as its COD reading was under the COD value of unpolluted waters. It can be hypothesized that the low COD reading for the wastewater effluent sample is because the liquid was treated correctly in the wastewater treatment plant. This means the treatment used is adequate in removing organic matter. The standard solution reading held a percentage error of 0.3125%. As this error was within the acceptable range of  $\pm 5\%$ , it was determined that the overall experiment was conducted correctly.

### 4. Sources of Error

There were numerous errors presented throughout the experiment. One primary error analyzed was a personal error. As each experiment was conducted, results may not have been very

accurate, even though duplicates were performed. This could be due to inexperience within the laboratory. This error is reflected within the initial lake water sample readings, as the readings were negative. This reflected that the experiment was conducted incorrectly for this water sample.

## **5. Conclusion and Recommendation**

The Chemical Oxygen Demand, COD, experiment was conducted to determine the chemical oxygen demand of three different water samples, river water, lake water, wastewater effluent, and a standard solution. River water and wastewater were deemed inadequate drinking water sources and would require the proper removal of microbes to reach acceptable COD values. Initially, the analysis of the lake water sample was inconclusive due to its negative readings. These readings reflected the errors conducted in the experiment. After repeating this experiment, wastewater effluent was deemed acceptable as its COD reading was under the COD value of unpolluted waters. The percentage error for the standard solution was within the acceptable range, indicating that the experiment was ultimately conducted correctly. Recommendations include completing the experiment in triplicates, as this is the standard method when completing experiments. Recommendations also include considering a separate test to identify the quality of water samples as COD is limited to only determining the material present. This method cannot determine the organic and inorganic content separately and cannot be used to determine the total organic carbon (S.K. Jain et al., 2003).



## 5. References

1. Davis, Mackenzie L, and Susan J. Masten. Principles of Environmental Engineering and Science. New York, NY: McGraw-Hill, 2004. Print.
2. S.K. Jain, V.P. Singh, Chapter 13 - Water Quality Modeling, Editor(s): S.K. Jain, V.P. Singh, Developments in Water Science, Elsevier, Volume 51, 2003, Pages 743-786, ISSN 0167-5648, ISBN 9780444514295, [https://doi.org/10.1016/S0167-5648\(03\)80067-9](https://doi.org/10.1016/S0167-5648(03)80067-9).  
(<https://www.sciencedirect.com/science/article/pii/S0167564803800679>)

## Appendix A:

| Chemical Oxygen Demand Test |             |                |                |
|-----------------------------|-------------|----------------|----------------|
| Water Sample                | Blank, mg/L | Sample 1, mg/L | Sample 2, mg/L |
| Standard                    | 0           | 804            | 791            |
| Lake Water                  | 0           | 19             | 27             |
| River Water                 | 0           | 31             | 33             |
| Wastewater Effluent         | 0           | 11             | 15             |

Table 1.1: **Complete COD Results** is the tabular representation of experimental data showing all of the COD results obtained from experimental data.

| Percentage Error, % |
|---------------------|
| 0.3125              |

Table 2.1: **Percentage Error** is the tabular representation of percentage error calculation obtained by utilizing the COD reading obtained from the standard solution and the standard COD reading provided from HACH.

## Appendix B:

### Sample Calculation 1: Finding the Average

Given: X = 1, Y = 2

Average of X and Y is:

$$Average = \frac{X+Y}{\Sigma values\ used} = \frac{1+2}{2} = 1.5$$

### Sample Calculation 1: Finding the Percentage Error

$$Percentage\ Error,\ \% = \frac{|real\ value - expected\ value|}{expected\ value} \cdot 100 = \frac{|797.5 - 800|}{800} \cdot 100 = 0.3125\%$$