CE 3348 Geotechnical Engineering Laboratory **Fall 2024**
Instructor: Ms. Sharon S Murillo
Office:
Office Hours: Students are always welcome
Text: Handouts

OBJECTIVES

The purpose of the laboratory is to acquaint you with various tests that are fundamental to the practice of Geotechnical Engineering. You will learn how to measure the properties of soil that control the classification, compressibility, and shear strength of soils. You will also learn about the limitations of the laboratory tests and gain insight into general problem of measuring soil properties. An additional objective of this lab is to teach you how to plot and present experimental data in a suitable way, how to prepare reports and how to present results to others. We will also use the laboratory period for review and problem solving in areas that are traditionally difficult for students to understand.

SCHEDULE

A schedule for the laboratory is presented on a separate sheet. As much as possible, the labs have been scheduled to coincide with the discussion in your lecture sections.

ATTENDANCE

Attendance in the lab is required. If you leave the lab before you have finished your experiment or before you have cleaned up your work area, your attendance will not be counted. We know that you have other constraints on your time, but we feel strongly that those students who make the effort to attend and to complete the lab should be rewarded, and those who do not should be penalized.

If you find you cannot attend your laboratory and have a valid excuse, it may be possible for you to attend the alternative lab session. We generally discourage the practice of attending make-up labs because it tends to lead to overcrowding and disorganization in the laboratory. However, we do try accommodating students with valid excuses. You must obtain permission in order to make up a laboratory. ***The attendance for the laboratory sessions will be taken toward the end of the class.***

LABORATORY REPORTS

You will be expected to present the results of your laboratory measurements in laboratory reports. Normally, one report is required for each laboratory period. Lab reports will be prepared by each individual student independently. A guideline is attached for your convenience.

***DUE DATE*: Please make sure that you follow the due dates on the lab reports.** *Due dates for lab reports are typically two weeks after the lab period that you conducted your experiments (see table on page 7)*. *However, unless otherwise noted in the lab session, the reduced data from your experiment is due on the day that you have conducted the test.* **Any person that would not hand in their reduced data on time will not be able to obtain a grade above 10 for that lab.**

You can improve your lab reports for a better grade (***up to 2 points***) if the due dates are met. Simply address the deficiencies of the reports and add the revised version and hand them to me at the end of the semester.

***GRADE*:** Your laboratory grade will be determined from the scores on the laboratory data reduction, laboratory reports and exercise problems during the lab. You will receive a grade of zero for any late lab report, for a report corresponding to any lab that you did not attend fully, or a lab exercise not handed in on time.

The laboratory reports will each be worth a maximum of 20 points, except for the report for the consolidation test, which will be worth 50 points. About 40% of your lab grade is assigned based on the data reduction activity that you hand in at the end of the lab. Deductions from your grade will automatically be made on each report as included in the checklist of pages 5 and 6. Each lab exercise will worth 10 points if they are handed

in by the end of the lab.

We do not want to harass you on the lab reports, but we also believe very strongly that it is in your best interest to learn to do work like that expected of college graduates, i.e., neat, concise, and accurate work. Previous graduates have told us that they were very appreciative after they left college of the efforts that had been made to make them better writers. We certainly hope that all of you will be better writers when you leave this course than when you entered.

COMMENTS BY STUDENTS

We are constantly trying to improve the laboratory to enhance the student's understanding of the course material and to make the best possible use of your limited time. We would appreciate any comments or suggestions for improvement that you might have.

POLICY ON CHEATING

Students are expected to be above reproach in all scholastic activities. Students who engage in scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and dismissal from the university. Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student, or the attempt to commit such acts (Regents' Rules and Regulations, Part One, Chapter VI, Section 3, Subsection 3.2, Subdivision 3.22). Scholastic dishonesty harms the individual, all students, and the integrity of the university. Policies on scholastic dishonesty will be strictly enforced.

All quizzes and data reduction results should be based on individual work. The lab reports should be written individually but based on the data from your effort and others. The lab exercises can be done in a group.

Laboratory Report Guidelines

The lab reports, excluding the appendices, should be ***less than 5 pages*** long. To save paper and space, submit all reports single-spaced. The laboratory report must consist of the following sections organized in the order listed below:

A) COVER PAGE with:
- Test Title
- Author's Name and Group Number
- Course Number and Semester
- Date of the Report
- Signature declaring that you have not deviated from the CE Department Honor Code.

B) CHECK LIST OF EDITING

C) ABSTRACT (less than 150 words) with
- What you did (one or two sentences)
- Why you did it (one sentence)
- On what material (one sentence)
- What you found (one or two sentences)

The primary objectives and scope of the report should be stated; the techniques or approaches should be described only to the extent necessary for comprehension; and the findings and conclusions should be presented concisely. The abstract should not contain unfamiliar terms that are not defined, reference citations, or display equations or lists. The abstract should contain the answer to the parameter that you are measuring in the lab.

The abstract should contain all facts!! Do not say how the humanity will benefit from these tests!! Do not get poetic!! Evaluate every sentence!! Decide whether a given sentence is positively necessary or it is fluff!! Remove fluff!! If the goal of the lab is to measure the strength of a concrete, you should positively indicate in the abstract the strength that is appropriate for that concrete!!

D) INTRODUCTION with:
- General purpose of the test
- Intended use of the test results
- ***Do not describe test procedures.***

E) RESULTS and DISCUSSION:

The results and discussion section of your report is very important because it is an indication of your understanding of the purpose/meaning and procedure of the laboratory exercise. I have included a table (see pages 8 and 9) at the end of this syllabus that would guide you about the results and discussions that should be included in each report.

Write complete, clear, understandable and self-contained responses to each discussion question. Do not assume the reader knows the question asked in your laboratory exercise; in other words, make sure that the question you are answering is clear by your response

Tables: Data essential to the report (such as uncertainty estimates, results of key calculations-not lists of raw data) may best be presented for clarity in the form of tables. Tables should be numbered consecutively and should appear in the body of the report, or immediately following the references. Abbreviations and symbols may be used, if defined in the text or in a list of symbols. The tables should be complete in themselves; i.e., explanatory notes should be placed in footnotes rather than requiring the reader to refer to the report text for explanatory material.

Figures: Your lab report will undoubtedly contain several figures. Figures should be numbered consecutively, and all figures must be referenced from the written report. It is strongly recommended that you prepare all your figures electronically. Each figure must include an explanatory title positioned beneath the figure. Figures must be self-explanatory so, as far as possible, the reader can

understand the figure without referring to the text where you describe it (you still need the text though). Graphs can be drawn in Excel and copied into PowerPoint. However, note that the default form of graphs produced by Excel, while fine for the preliminary analysis of a logbook, is not suitable for reports. The file 'HowToPlot.xls' gives a specific example of how to turn a basic Excel plot into a report quality graph. The following requirements are illustrated in this example:

- Measured data should, in general be plotted as distinct points, with no lines, since it is the points that were measured. Lines should only be added if they represent something else, e.g. a regression fit or the result of a theoretical prediction.
- Color should be avoided unless necessary, as reports are almost always printed or copied in black and white. Colored background detracts from the clear presentation of the data.
- Gridlines should only be used if needed in which case they should be included for both axes and shown in gray or as dashed lines so as not to be confused with axis lines, or annotations on the plot.
- Axes should have proper scales and show major and minor divisions. A proper linear scale is one in which both major and minor divisions are in units of 1, 2 or 5 x 10^n, where n is an integer. Tick marks should point outwards and at least 5 major divisions should appear on each axis. In general, the axes should cross at zero. If not reasonable a note should be made in the figure or axis title (e.g. "note false origin on displacement axis").
- Axes titles should include the name and/or symbol of the plotted quantity and its unit, in a font consistent with the rest of the report.
- The legend should appear within the axes, if possible, without obscuring data. There should be no box drawn around graphs.
- **If estimates of the accuracy of the data are available and comparable in scale to the size of the quantity, the error magnitudes can be shown using error bars.**

F) APPENDIX A: DATA SHEETS AS RECORDED IN THE LAB:

- All data sheets should contain the names of all members of each group and the group number.
- Data sheet should be kept clean; no example calculations should be written on them. Write only comments about the experiment, where applicable (e.g., higher loading rate), or make note of any values you disregard.
- Before posting results, all members of each group should check their calculations.
- If any group does not post results in time, the rest of the groups should do their analysis by using results that are already posted.

G) APPENDIX B: SAMPLE CALCULATIONS:

An example of each of the types of calculations performed with the raw laboratory data to obtain the test results, and a reference to any formula that has been employed. This can be hand written, but it must be neatly done.

All these sections should be organized in the same exact order as shown above. The pages should be numbered in the bottom right hand corner and the set must be adequately bound. All graphs must be drawn with suitable drafting instruments. Curves and lines cannot be drawn free hand. A symbol template should be used to plot the data points and data points of different sets should be shown with different symbols.

CHECK LIST FOR EDITING

Item	Implication		Remark
Do You have all these items in your report?			
COVER PAGE	-10%		
CHECK LIST OF EDITING	-50%		
ABSTRACT	-35%		
INTRODUCTION	-25%		
RESULTS and DISCUSSION	-60%		
APPENDIX A	-15%		
APPENDIX B	-15%		
Report is single-spaced	-5%		
Font is 12 points Times New Roman	-5%		
Is Abstract Appropriate?			
What you did (one or two sentences)	-5%		
Why you did it (one sentence)	-5%		
On what material (one sentence)	-5%		
What you found (one or two sentences	-5%		
Contain answer to parameters measured	-10%		
Removed sentences that are not relevant	-5%		
Is Introduction Concise and Complete?			
General purpose of test (one paragraph)	-10%		
Intended use of test results (one paragraph)	-10%		
Removed sentences that are not relevant	-5%		
Are Results and discussion complete as per pages 9 and 10? **Cut and paste the bullets from tables on pages 9 and 10 for relevant lab report.**			
Gradation results and gradation curves from your group			
Index properties of the soils such as Coefficient of Curvature, Coefficient of Uniformity, Liquid Limit, Plastic Limit, Plasticity Index when appropriate for your group			
Use Items 1 and 2 to provide soil classification as per Unified Soil Classification System for your group.			
Compare your group's gradation curve with other groups and explain how close or how far the results from different groups are. If the results are different, explain why.			
Compare the index properties from your group with other groups and explain how close or how far the results from different groups are. If the results are different, explain why.			
Compare the soil classifications from your group with other groups and explain how close or how far the results from different groups are. If the results are different, explain why.			

CHECK LIST FOR EDITING

Do tables contain correct information and are in the right format? (-5% for each item and each figure)								
Item	**Table**							**Remark**
	1	**2**	**3**	**4**	**5**	**6**	**7**	
Table has a title that is descriptive								
Table title is **above** the table								
Table fits within margin								
Referred to table in text before including it								
Table is not split between two pages								
Tables are numbered consecutively as referred in text								
Have a few sentences in text describing the information from table								
All columns and Rows have descriptions								
All columns and rows have appropriate units								
The number of decimals same as precision of measurements								
Font type is same as report font type								
Abbreviated symbols defined under table								
Do figures contain correct information and are in the right format? (-5% for each item and each figure)								
Item	**Figure**							**Remark**
	1	**2**	**3**	**4**	**5**	**6**	**7**	
Figure has a title that is descriptive								
Figure title is **below** the figure								
Figure fits within margin								
Referred to figure in text before including it								
Figures are numbered consecutively as referred in text								
Figure is not split between two pages								
Have a few sentences in text describing the information from figure								
X and Y axes are labeled								
X and Y axes have appropriate units								
The number of decimals same as precision of measurements for X and Y axes								
Font type is same as report font type								
Measured data points are shown as symbols only (not connected by lines)								
Best fit curves and theoretical curves are shown as lines only								
If several data sets, are they distinguishable								
If several data points, a legend is included								
The legend is descriptive (no linear series 1)								

Item	**Implication**		**Remark**
Final Editing			
Everything except Appendices is typed	-10%		
Included page numbers	-5%		
Made sure tables not split b/w two pages	-5%		
Made sure figures not split b/w two pages	-5%		
Equations are on a separate line and numbered	-5% each		
All symbols and abbreviations are defined	-5% each		
Spell checked report/ read final time for completeness	-20%		

Tentative Lecture and Laboratory Schedule

Week	Laboratory	What is due?
8/26	Lab 0: Practice lab Report	All graphs and tables should be handed in by end of lab session
9/2	Lab 0: Practice lab Report	All graphs and tables should be handed in by end of lab session
9/9	Exercise 1: Wt./Vol. Relation Exercises	Report for Lab 0 by Friday Solutions to Exercise 1 at the end of lab
9/16	Lab 1: Soil Classification Demonstration	Data from Lab 1 at the end of lab
9/23	Exercise 2: Stress Calculation Exercises	Solutions to Exercise 2 at the end of lab
9/30	Lab 2: Compaction Demonstration	Report on Lab 1 by Friday Data from Lab 2 at the end of lab
10/7	Exercise 3: Permeability Exercises	Solutions to Exercise 3 at the end of lab
10/14	Lab 3a: Consolidation Set Up	Report on Lab 2 by Friday
10/21	Lab 3b: Consolidation Data Reduction	Data from Lab 3b at the end of lab
11/4	Exercise 4: Consolidation Exercises	Solutions to Exercise 4 at the end of lab
11/11	Lab 4a: Direct Shear Demonstration	Data from Lab 4a at the end of lab
11/18	Lab 4b: Unconfined Compression Demonstration	Data from Lab 4a at the end of lab
11/25	Exercise 5: Shear Strength Exercises	Solutions to Exercise 5 at the end of lab Report on Lab 4 by Friday

You need to complete four lab reports. What is expected from you in each lab report is as follows.

Expectations from Laboratory Reports

Report	Title	Synopsis
0	**Example Report**	In this lab you will practice proper format of a report. The goal is to prepare several tables and figures and complete the lab report. The following items are needed: • Complete all graphs • Complete all tables • Complete Introduction Section • Complete Results and Discussion Sections
1	**Soil Classification**	In this lab you will be classifying a coarse-grained and a fine-grained soil. Provide the following information for each soil. • Gradation results and gradation curves from your group • Index properties of the soils such as Coefficient of Curvature, Coefficient of Uniformity, Liquid Limit, Plastic Limit, Plasticity Index when appropriate for your group • Use Items 1 and 2 to provide the soil classification as per Unified Soil Classification System for your group. • Compare your group's gradation curve with other groups and explain how close or how far the results from different groups are. If the results are different, explain why. • Compare the index properties from your group with other groups and explain how close or how far the results from different groups are. If the results are different, explain why. • Compare the soil classifications from your group with other groups and explain how close or how far the results from different groups are. If the results are different, explain why.
2	**Compaction**	In this lab the compactive characteristics of one soil will be determined. Provide the following information for that soil. • Moisture-density curve from your group • Optimum Moisture content and Maximum Dry Unit Weight for your group • Compare your group's moisture density curves with other groups and explain how close or how far the results from different groups are. If the results are different, explain why. • Compare the optimum moisture content from your group with other groups and explain how close or how far the results from different groups are. If the results are different, explain why. • Compare the maximum dry density from your group with other groups and explain how close or how far the results from different groups are. If the results are different, explain why.
3	**Consolidation**	In this lab the consolidation characteristics of one soil will be determined. Provide the following information for that soil. Each group will be assigned raw data from one applied stress. Provide the following information for that stress. ***From your group raw data***: • Discuss how you got S_0, S_{100}, t_0, t_{100}, coefficient of consolidation, coefficient of secondary consolidation, etc. ***From class data from all groups*** • Plot void ratio vs. log of effective stress (e vs. logσ') and void ratio vs. effective stress (e vs. σ'); From those graphs find compression index, recompression index, maximum past pressure, compression strain index, recompression strain index, coefficient of compressibility, coefficient of volume compressibility and permeability. • Plot variation in coefficient of consolidation with log of effective stress (C_v vs. logσ') and comment on its characteristics • Plot coefficient of permeability vs. log of void ratio (k vs. log(e)) and comment on its characteristics • Plot coefficient of compressibility vs. loge and comment on its characteristics

Report	Title	Synopsis
4	**Shear Strength**	In this lab you will be determining the shear strength of a given soil using two test methods: Direct Shear Tests and Triaxial Tests. For each test method, three different tests will be carried out under different states of stress. Provide the following information in your report. ***<u>From Direct Shear Tests</u>***: • For each of the three tests, plot variation in shear stress with horizontal strain and determine the shear stress at failure. • From the three tests, graph the Mohr-Coulomb failure surface • Comment on the quality of the Mohr-Coulomb failure surface you obtained • From the Mohr-Coulomb failure surface, determine the angle of internal friction and the cohesion of the soil ***<u>From Triaxial Tests</u>***: • For each of the three tests, plot variation in axial stress with normal strain and determine the axial stress at failure. • From the three tests, graph three Mohr Circles • Superimpose the Mohr-Coulomb failure surface on the Mohr Circle graph • Comment on the quality of the Mohr-Coulomb failure surface you obtained • From the Mohr-Coulomb failure surface, determine the angle of internal friction and the cohesion of the soil • Compare the angles of internal friction obtained from direct shear and triaxial tests. Explain how close or how far the results from the two different tests are. If the results are different, explain why. • Compare the cohesion values obtained from direct shear and triaxial tests. Explain how close or how far the results from the two different tests are. If the results are different, explain why.

Example Report

Laboratory 0

How to Prepare a Laboratory Report

Soheil Nazarian

Group 4

CE 3348
Spring 2020

January 28, 2020

Participation

Data Collection (Extensive Collaboration)	Data Analysis (Limited Collaboration)	Graphs & Tables (Limited Collaboration)	Report (No Collaboration)
5%	**0%**	**100%**	**100%**

I have neither given nor received unauthorized aid on this report, nor have I concealed any violations of the Honor Code. I have not included materials derived from the efforts of another student or non-student in this semester or the past semesters.

Signature: _____ *Date:* _____

CHECK LIST FOR EDITING

Item	Implication		Remark
Do You have all these items in your report?			
COVER PAGE	-10%		
CHECK LIST OF EDITING	-50%		
ABSTRACT	-35%		
INTRODUCTION	-25%		
RESULTS and DISCUSSION	-60%		
APPENDIX A	-15%		
APPENDIX B	-15%		
Report is single-spaced	-5%		
Font is 12 points Times New Roman	-5%		
Is Abstract Appropriate?			
What you did (one or two sentences)	-5%		
Why you did it (one sentence)	-5%		
On what material (one sentence)	-5%		
What you found (one or two sentences	-5%		
Contain answer to parameters measured	-10%		
Removed sentences that are not relevant	-5%		
Is Introduction Concise and Complete?			
General purpose of test (one paragraph)	-10%		
Intended use of test results (one paragraph)	-10%		
Removed sentences that are not relevant	-5%		
Are Results and discussion complete as per pages 9 and 10? **Cut and paste the bullets from tables on pages 9 and 10 for relevant lab report.**			
Complete all graphs			
Complete all tables			
Complete Introduction Section			
Complete Results and Discussion Sections			

CHECK LIST FOR EDITING

Do tables contain correct information and are in the right format? (-5% for each item and each figure)

Item	Table							Remark
	1	2	3	4	5	6	7	
Table has a title that is descriptive								
Table title is **above** the table								
Table fits within margin								
Referred to table in text before including it								
Table is not split between two pages								
Tables are numbered consecutively as referred in text								
Have a few sentences in text describing the information from table								
All columns and Rows have descriptions								
All columns and rows have appropriate units								
The number of decimals same as precision of measurements								
Font type is same as report font type								
Abbreviated symbols defined under table								

Do figures contain correct information and are in the right format? (-5% for each item and each figure)

Item	Figure							Remark
	1	2	3	4	5	6	7	
Figure has a title that is descriptive								
Figure title is **below** the figure								
Figure fits within margin								
Referred to figure in text before including it								
Figures are numbered consecutively as referred in text								
Figure is not split between two pages								
Have a few sentences in text describing the information from figure								
X and Y axes are labeled								
X and Y axes have appropriate units								
The number of decimals same as precision of measurements for X and Y axes								
Font type is same as report font type								
Measured data points are shown as symbols only (not connected by lines)								
Best fit curves and theoretical curves are shown as lines only								
If several data sets, are they distinguishable								
If several data points, a legend is included								
Legend is descriptive (no linear series 1)								

Item	Implication		Remark
Final Editing			
Everything except Appendices is typed	-10%		
Included page numbers	-5%		
Made sure tables not split b/w two pages	-5%		
Made sure figures not split b/w two pages	-5%		
Equations are on a separate line and numbered	-5% each		
All symbols and abbreviations are defined	-5% each		
Spell checked report/ read final time for completeness	-20%		

How to Prepare a Laboratory Report

Abstract

Through several case studies, we reviewed the process of presenting and analyzing laboratory results. The focus was on the use of computer software such as Excel and Word.

Introduction

One of the major complaints of the potential employers of UTEP students is that their communication skills are not well-developed. To address this problem, we attended a laboratory session on how to prepare tables and figures and how to incorporate them in our reports.

Four case studies were presented and analyzed in the laboratory session. The major points and lesson learned from each case are summarized below. The first case study was related to incorporating statistical analysis in interpreting results. The goal of the second case study was to extract results from experimental data using a curve-fitting algorithm.

(Complete this section to include all case studies)

Results and Discussions

Data from a test carried out to determine the water content of a soil sample was used in the first case study. The raw data provided are included in Table 1. The experiment was repeated ten times. The basic statistical information from the ten experiments is also included in the table. The average water content is about 7.1% with a standard deviation of about 1.5%. Judging from the coefficient of variation of about 22%, the test results do not seem to be precise. Inspecting Table 1, an outlier is observed under experiment 5. Ignoring this point, the average water content increased to 7.6%. The coefficient of variation decreased to about 6%, indicating a reasonably precise test result.

Table 1 – Results from Water Content Tests on a Soil Sample

Experiment	Water Content
1	7.3
2	7.7
3	7.9
4	8.1
5	2.9
6	7.1
7	7.6
8	6.9
9	7.4
10	8.3
Average, %	7.1
Standard Deviation, %	1.5
Coefficient of Variation, %	22.1

The goal of the second case study was to extract results from experimental data using a curve-fitting algorithm. As shown in Table 2, the discharge velocity, V, of a material was measured as a function of hydraulic gradient, i. According to Darcy's law, these two parameters are related through:

$$V = K\, i \tag{1}$$

where K is the hydraulic conductivity. The variation in discharge velocity with hydraulic gradient is also depicted in Figure 1. To obtain the hydraulic conductivity, a line is fitted to the measured data. The line describes the trend of the data in a fair manner since the R^2 value is about 0.83. The hydraulic conductivity of this material is about 0.036 cm/sec.

Table 2 – Variation in Discharge Velocity with Hydraulic Gradient from a Permeability Test

Hydraulic Gradient, cm/cm	4.7	3.4	2.0
Discharge Velocity, cm/sec	0.16	0.12	0.09

(Find any possible error in this section in graphs etc. and complete this section as well)

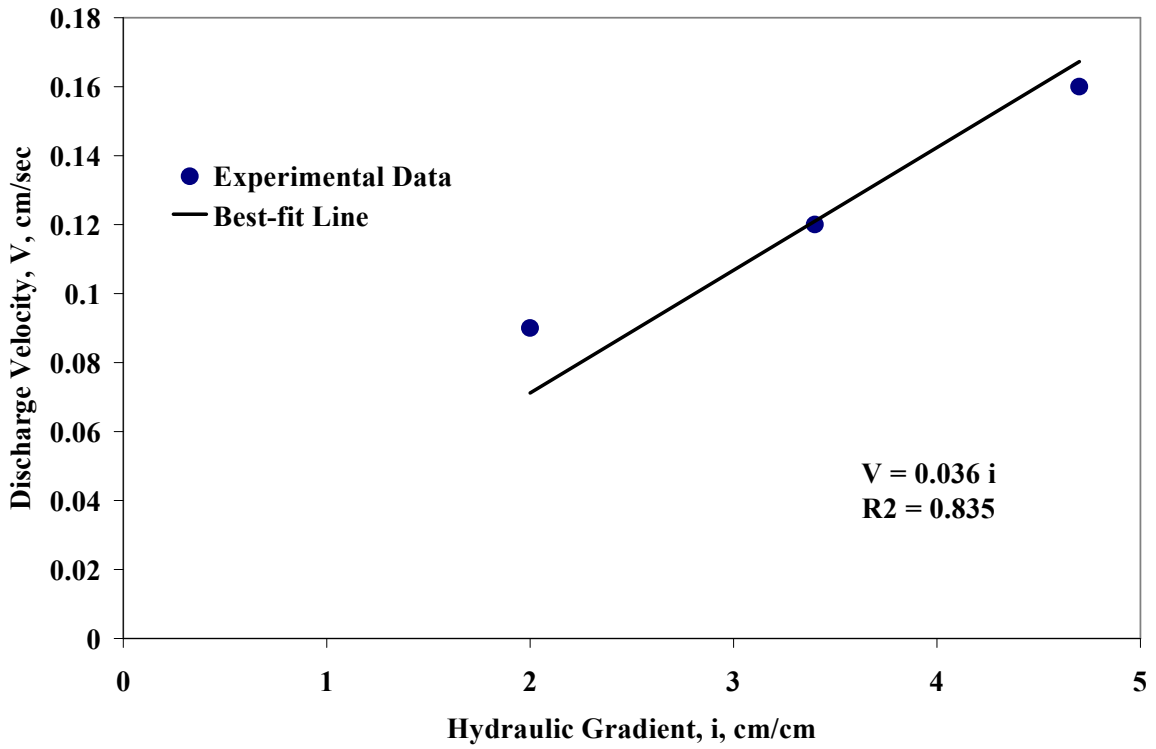

Figure 1 – Variation in Discharge Velocity with Hydraulic Gradient from a Permeability Test

(Make all the graphs, tables necessary for other case studies and write them up)

APPENDIX A: DATA SHEETS AS RECORDED IN THE LAB

(place all the forms you used in this lab)

APPENDIX B: SAMPLE CALCULATIONS

(Place sample hand calculation or excel sheet etc. here)