Excel-Word Assignment

Using Office Tools in Engineering

APSC 101: Problem Solving and Modeling

Smith Faculty of Engineering and Applied Science

Queen’s University

2024-06-24

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1. Overview

This assignment is designed to ease your transition into university by ensuring you have fundamental skills in using Microsoft Word and Microsoft Excel to create technical documents. For this assignment you are required to turn in one Microsoft Word document, formatted using the instructions, which includes calculations and graphs completed using Microsoft Excel. The formatting requirements of this document will be used throughout your professional practice courses in first year, APSC 101, 102, and 103, and prepare you for the requirements in Queen's Engineering and the engineering profession.

1.1 Goals

In this assignment you will use Microsoft Excel to create tables, scatter plots and complete data analysis, and use Microsoft Word to import tables/graphs, create equations, captions, and drawings. Built in tools in Microsoft Word will be used for heading styles, citations, cross-referencing, and creating a table of contents, list of figures and list of tables.

By completing this assignment successfully, students will be able to:

1. Input experimental data into Microsoft Excel
2. Perform calculations in Microsoft Excel using manually inputted formulae and built-in functions
3. Generate simple and effective tables and graphs to describe experimental data in Microsoft Excel
4. Perform basic data analysis in Microsoft Excel, specifically regression and residual analysis as a part of laboratory error analysis
5. Properly format and organize a formal report in Microsoft Word
6. Integrate both graphs and tables created in Microsoft Excel into a report in Microsoft Word
7. Generate equations and sample calculations in Microsoft Word
8. Correctly reference resources used in a formal laboratory report using IEEE formatting
9. Critically evaluate experimental results on a basic level

This assignment will also introduce you to the complex problem that you will be working on in APSC 101 this fall.

1.2 Deadline

This assignment, in the form of a single word document, is due by 9:00am EST on September 3rd, which is your first day of class. Instructions for submitting the assignment will be provided the week before it is due. Please note, this assignment requires use of Microsoft Word and Microsoft Excel, which is free for all students. Graders will be reading the document using the desktop application of Microsoft Word, which often displays formatting slightly differently from documents created using the online app. If you use the online app to create the document, ensure that your formatting is correct in the desktop app before you submit the document.

1.3 Relevant Resources

Microsoft Excel and Word tutorials have been designed to help you and are available in text and video form **here**. Sections of these tutorial documents will be referenced for specific tasks. It is expected that you will read these resources and refer to them when completing the assignment.

Join us for a **Q&A Webinar** about the Excel Word Assignment **on August 20th at 7:00pm EST**. The meeting ID is 958 9084 2572 and the passcode is 286451. You can join the zoom call HERE.

If there are additional questions about the assignment, you may contact Emily by email at emily.garvin@queensu.ca for assistance **until August 30th**.

1.4 Required Software

This assignment can be completed on PCs, Macs, and Online. The online version should be a last resort. You will need the following software and plug-ins:

1. Download and install “Microsoft 365 Apps for Enterprise” from Queen’s University.
    - https://portal.office.com/account
2. From 365, you will be using
    - Microsoft Excel – Ensure the “Analysis ToolPak” plug-in is installed in your version. Instructions are included in the **Microsoft Excel Tutorial** linked in the previous section.
    - Microsoft Word – Ensure you have the option to use the IEEE reference style in the Word citation tool. Information on the citation tool and IEEE reference style can be found in the Word Tutorial.

Ensure that the version of Microsoft Word/Excel that you are using is the most recent version. You may have to remove old copies of the program to update to the newest version.

1.4.1 Troubleshooting Mac Issues

If you are experiencing issues using Office for Mac, check that it is activated.

1. First ensure your MS Office is up to date and that all updates are applied to your Operating System.
   For Office: Open Word the click Help -> Check for Updates
   For the OS: Click on the Apple Menu -> System Preferences -> Software Update
2. Check if you can Activate Office from Within Word
   Open Word then click File -> Account 0 -> Log in to Queen’s Account

If still not activating, here are the instructions we follow to resolve activation issues with Office or Mac when updates are complete.

- Open KeyChain Access, search for “Microsoft” and delete all entries
- Open an Office app again try signing in and activating. Your exact experience may vary, and you may also have to sign out and back in again to make it work.

If that does not work, you can download the Office License Removal tool and it may work to help activate again: https://go.microsoft.com/fwlink/?linkid=849815

If you get Error 0xD000000C when activating Office for Mac then check out:
https://support.microsoft.com/en-us/office/error-0xd000000c-when-activating-office-for-mac-da865931-4658-4829-ba2d-8133390c6d25?ui=en-us&rs=en-us&ad=us

2. Instructions

This assignment contains data that you will have to analyze. The scenario is described in detail, starting in Section 5. Question One. To complete the question, you will need to create tables and graphs in Microsoft Excel, then import them into a properly formatted Microsoft Word Document. The only submission for this assignment will be one **Word Document***; Excel files and PDFs will* ***NOT BE GRADED****.* The specific formatting requirements are listed in Section 3. Formatting Requirements.

2.1 Saving your work

Make sure you have a good system for saving and organizing your university work. Ensure that your work is stored in a place with backups, like your Queen's Microsoft OneDrive folder. Without this system in place, it is very likely that work could be lost. Bad habits in saving files are not a valid excuse for late work.

Most students find that it is useful to have a single cloud folder for all academic work. It is highly suggested that you create a folder in your Microsoft OneDrive for each course, named with the course code, e.g. "APSC 101". In many cases it is helpful to have a subfolder within that folder if there are multiple files related to the same assignment, e.g., "Assignment 1 - Word-Excel". You should also get in the habit of naming each file something meaningful that you can search for and recognize. If there is a naming convention for an assignment, it is usually best to name the file in line with the convention right at the beginning, e.g. in this case the file you will have to submit will be named: "**STUDENT#_LASTNAME_FIRSTNAME_APSC101_Assignment1**.docx"

2.2 Important Academic Integrity Principles

DO NOT share your Word or Excel files with any other students. It is permitted to discuss and ask questions with other students, but ensure your work is all your own. If you share your work with other students, it may be considered an act of *facilitation* under the university's Academic Integrity policy. Every year there are students who start later and are tempted to use someone else's work. Remember for all university assignments: **discuss, question, talk, and help each other, but do not share.** For more on academic integrity, please review: https://smithengineering.queensu.ca/about/policies-and-governance/academic-integrity.html.

2.2.1 Generative Artificial Intelligence (AI) Tools

Students must submit their own work and cite the work that is not theirs. Generative AI writing tools such as ChatGPT are acceptable in this class, if you cite the material that they generate. Any other use constitutes a Departure from Academic Integrity. **Note that if substantial material in a submission is produced by generative AI, it will not be graded.**

3. Formatting Requirements

The following are the formatting requirements for the Word document that will be submitted. Ensure you read them carefully before starting the Word document, while working on it, and again before you submit. If you are ever in doubt of the formatting requirements, come back and check this section. This document was created using the same formatting requirements to provide an example.

3.1 Filename

- The assignment should be saved as a Word File named:
  STUDENT#_LASTNAME_FIRSTNAME_APSC101_Assignment1
  Most of your assignments in APSC 101 will use this kind of naming format.

3.2 Text

- Text should either be left or full justified. DO NOT use right or center justified.
- Paragraphs should not be indented
- Paragraphs should be separated by one line
- Use size 11 Calibri font, and 1.15 spacing
- Edit your writing for spelling, grammar and concision

3.3 Title Page

- Include a title page with your name, student number, course number (APSC 101) and submission date

3.4 Point of View

- The report should be written in **3rd person**. In general, do not use "I" or "we" aside from reflections and descriptions of individual work.

3.5 Headers and Page Numbers

- Use Word ***Header & Footer*** tool to insert a header, including your last name and the page number, positioned at the top right side of the page.
- Your name should be separated from the page number using a vertical line, like "Johnson | 1"
- There should be **no page numbers on the title page**
- Use Roman Numerals (i, ii, iii, etc.) for the page numbers for pages including the Table of Contents, List of Figures and List of Tables pages.
- Arabic Numbers (1, 2, 3, etc.) begin on the first page of the assignment and should be used for all subsequent pages (including appendices when applicable).

3.6 Headings

- Use Word ***Styles*** tool to consistently format your headings for sections and subsections.
- Use Heading 1 for Sections, Heading 2 for Subsections, Heading 3 for sections in subsections, etc.
- Each section should start with a number, ordered chronologically.
- Each subsection adds an extra decimal place to the section number that it is housed in.
- Within the section, the subsections should be ordered chronologically.
- At minimum, each section and the references should have its own heading.

3.7 Tables and Graphs

- Use **consistent formatting** for tables and graphs
- Consider the following guidelines for effective graphics in a formal report

3.7.1 Tables

- Maximize white space by:
    - Eliminating vertical lines between cells
    - Where possible, minimizing the number of horizontal lines between cells.
- Center the text in cells
- Limit the use of colour to cases where it is important to clearly describe information

3.7.2 Graphs

- DO NOT include chart titles. Your figure caption should sufficiently introduce the contents of your graph.
- Include axis titles, with appropriate units where applicable. You can use 'a.u.' for dimensionless quantities, standing for "arbitrary units".
- Include trendlines for the line of best fit. The equation of the trendline should be displayed on the graph, using appropriate variables and significant figures.
- Limit the use of colour where possible, except to differentiate between the series.
- Maximize white space and include your legend as part of the graph itself without covering data.
- Graphs included in the report should be copied from excel and pasted into the document using either option that links data, so that any changes made to the graph in excel are reflected in word.
- When inserting graphs into a report, ensure they are an appropriate size. Graphs/Figures should be as small as possible, while remaining clear and legible to the naked eye. The reader should not need to magnify the report to see the graph clearly. If the page were to be printed, the graph should still be legible. It is appropriate to conserve space and place figures side-by-side if they are clear, legible, and their content is related.

3.8 Captions

- Include captions **below figures** and **above tables** using the Word ***Captions*** tool.
- Refer to each figure and table in the body of your report using **cross-referencing**, also found under the Word ***Captions*** tool. Use the "Only Label and Number" option when inserting cross-references such that the references appear as "Table 1" or "Figure 1" in the body of the report.
- The first reference of a Table or Figure should occur before the first time the Figure or Table is presented. Every Table or Figure **must be cross-referenced.** This is true for every assignment that you will complete at Queen's.

3.9 List of Figures/List of Tables

- Use Word ***Captions*** to insert a List of Figures and List of Tables immediately after the Table of Contents, generated from the captions used in the report.
- The Table of Contents, List of Figures, and List of Tables should **not** be included in the Table of Contents.

3.10 Table of Contents

- Use Word ***Table of Contents*** tool to generate a Table of Contents page from the headings.

- Word will automatically do this provided that the ***Styles*** tool was used for section headings.

3.11 References

- Use Word ***Citations and Bibliography*** tool to insert in-text citations and add a references section to the end of your document.
- Reference **all** documents used
- Citations must be in IEEE style
- It is not mandatory that you use the Microsoft Word citation management tool. You are free to use other citations management tools.
- In-text citations are mandatory
- **No citation management tools are perfect. It is always expected that you manually check that your citations are generated in proper IEEE format and that you make all necessary adjustments.**
- Check your citations using the IEEE Citation resources found here.

3.12 Significant Figures

- Error should be reported to **one significant figure**
- Quantities associated with error should be taken to the same digit as the one significant error digit. *Example: 654.9 ± 0.8*
- If there is no error, unless otherwise instructed, report all numerical values to 2 decimal places.

3.13 Equations

- Number all equations used in the body of the report.
- Any equations included should be referenced at least once by number in the report body.
- It is **not** expected that students use Word ***Captions*** to generate equation captions, cross-references or a List of Equations.

3.14 Sample Calculations

Sample calculations are a special case, as the way that you will have to do them will change between first and second year. The criteria below are all that is required for a first-year report and should be okay for the purposes of first year, changing in second. You can find some shortcuts in the Microsoft Word Tutorial here.

- Include the generic form of the equation. Ensure the equation is numbered.
- Define all variables.
- Report the final answer **with units**

A proper sample calculation has been modelled below, depicting the equation separately first with equation number #.

$$y = mx + b \tag{\#}$$

The slope, *m*, can be used along with the y-intercept, *b* and the independent variable, *x*, to calculate the response *y*.

$$y = mx + b$$
$$y = 4 \times 5 - 5$$
$$y = 15\ units$$

3.15 Units

- Report units in axis titles and at the top of table columns
- When reporting units, ensure there is a space between the numerical value and the unit.
- A space **should not be left** if the unit is percentages or degrees.

4. Background on Turbidity

Turbidity is the clarity or cloudiness of water (or other materials) due to the presence of suspended particles [1]. These particles can include a mix of sediment, organic matter, plankton, and other microscopic organisms, which scatter and absorb light, making the water appear murky. Measuring turbidity is essential for various environmental and public health reasons, as high turbidity levels can indicate pollution, hinder aquatic life, and complicate water treatment processes [1].

Turbidity sensors measure the opaqueness of liquid by emitting light into the material, and capturing the reflected, scattered light with photodetectors [2]. The light is scattered by the particles found in the liquid, and as the amount of total suspended solids (TSS) increases the turbidity measurement increases, as shown in Figure 1 [2]. It is then converted to electrical signal, and the measured light is output as voltage values which can be converted to Nephelometric Turbidity Units (NTU) [2].

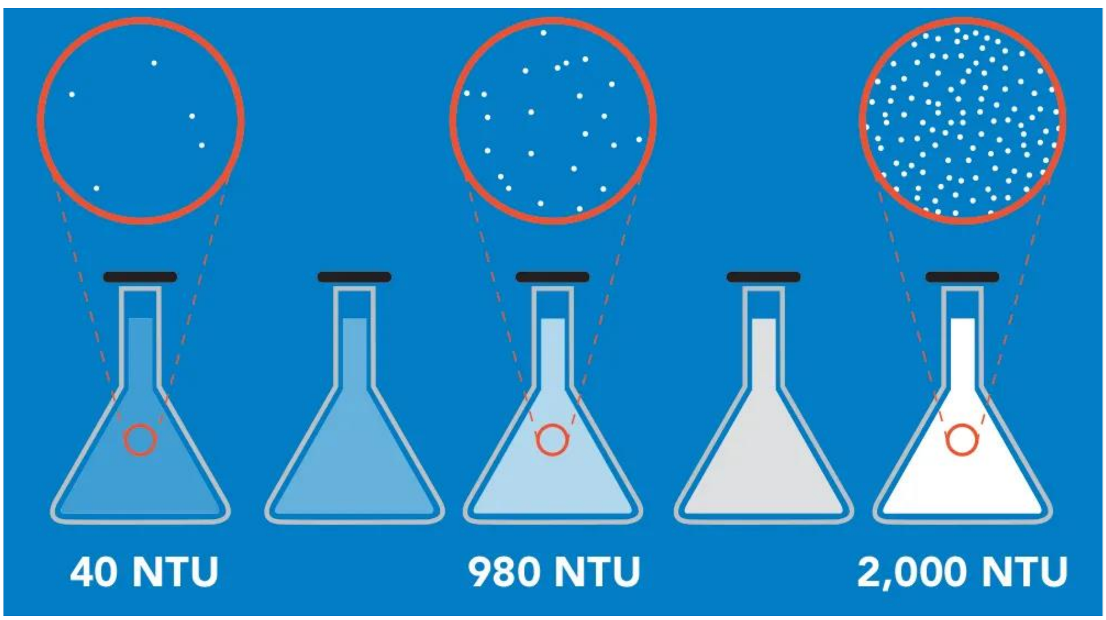

Figure 1: A series of water samples with increasing turbidity, indicated by the increasing NTU values, and the corresponding increasing particle concentration [3].

5. Question One

The completely made-up community called "Awesome", located in the Canadian territory of Nunavut, needs a solution to ensure a long-term supply of drinking water for use by the residents. The community has a small population (<1,500 people) and is only accessible by regularly scheduled flights from the regional centre of Cambridge Bay, Nunavut, as seen in Figure 2. Annual air temperatures in the community are -12°C, with typical maximum highs in July of 11°C and maximum lows in January of -32°C.

Figure 2: Map of northern Canada depicting the location of the Community of Awesome and Cambridge Bay in Nunavut.

For the past 70 years, the community has obtained its drinking water from a small lake, Lake A, as shown in Figure 3, that is fed by a river supplied from precipitation run off and glacial meltwater from an upland mountainous region. Lake A typically has had good water quality with turbidity values of <100 NTU. The community water treatment plant is designed to accept an average monthly turbidity of 200 NTU. In recent years, spikes in turbidity up to 275 NTU have been seen lasting up to two weeks in the spring. This water was successfully treated in the water treatment plant, suggesting that the existing treatment system can operate with intake higher than the designed turbidity level on a short-term basis.

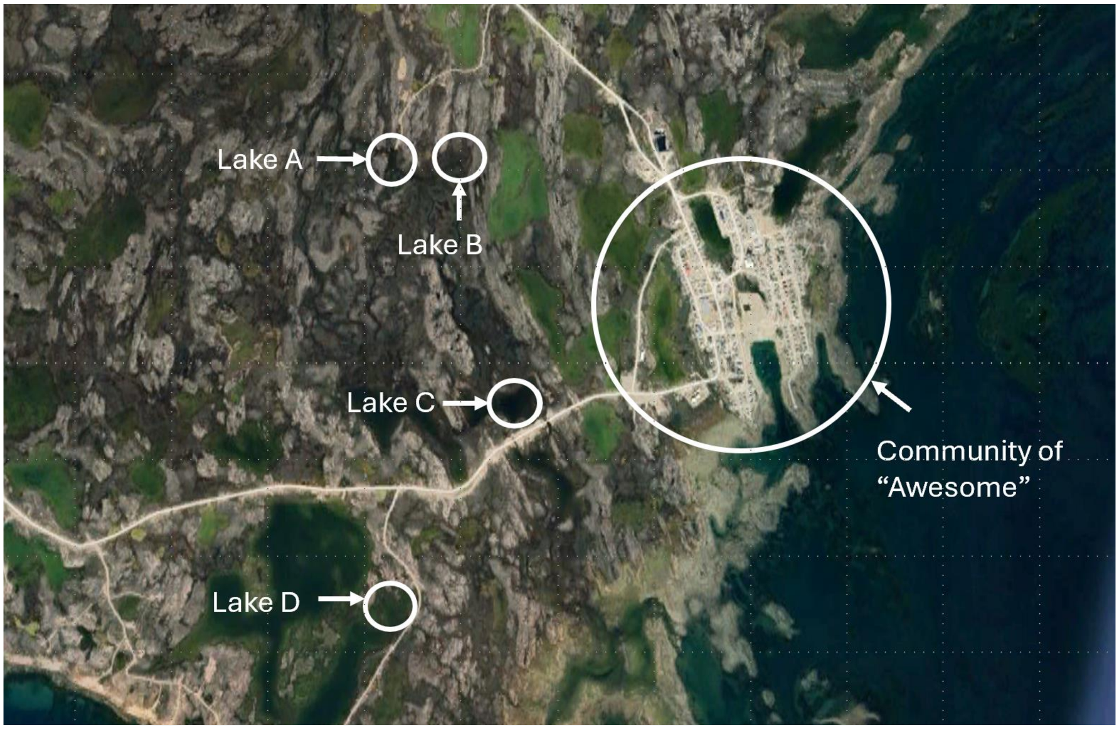

Figure 3: Map of current and optional drinking water source lakes for the community of “Awesome”.

Water is drawn from Lake A by a submerged pipeline connecting the water intake location from below the lake surface to the water treatment plant, as shown in Figure 4. The intake location is positioned above the lakebed sediments to avoid their transport into the water treatment plant, and below the maximum ice cover thickness to allow for uninterrupted water withdrawal through the year.

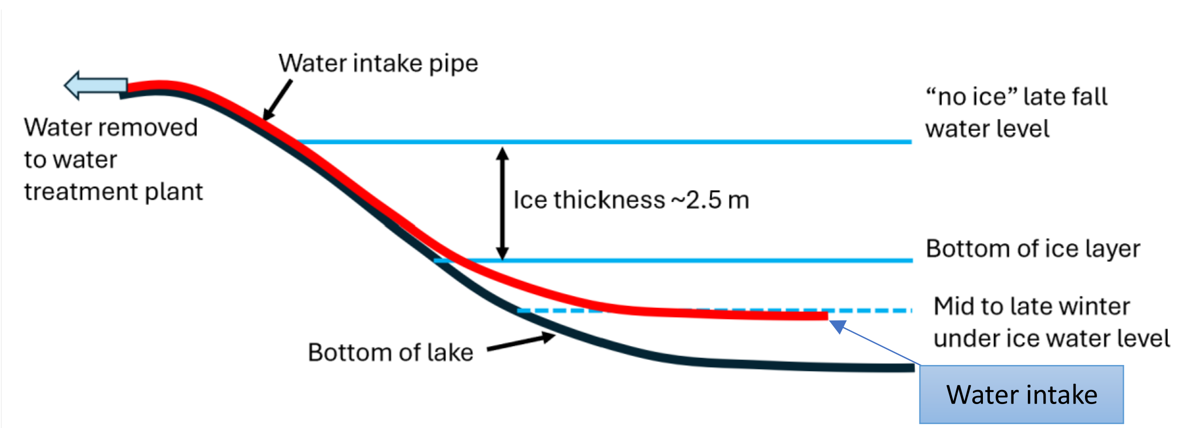

Figure 4: Schematic cross section of lake showing location of water intake pipe and water levels at different times throughout the year.

5.1 The Problem

In recent years, the water levels in Lake A have not been as high as historically observed, partly due to climate change. As a result, in the mid to late winter season (January to April), the “below ice” water levels, shown as the dashed line in Figure 4, are frequently at the same elevation as the pipeline intake which prevents withdrawing water. In response, the community has implemented water use restrictions to conserve water during that time, which has interfered with daily living for residences and businesses. Some community members have resorted to collecting their own water from unapproved surface water sources, which requires boiling before use to remove pathogens. This disruption in drinking water availability is identified by the community as the highest level of concern and top priority to be addressed. A long-term sustainable solution is required as soon as possible.

The funding to correct the water source issue in the community is supported through the territorial government, which historically has taken about 3-5 years to evaluate an issue and develop the engineering solution. An interim solution is required. The community proposed to install a temporary withdrawal location at an alternative lake during the summer months instead of removing water from Lake A. This would result in water levels in Lake A being higher prior to ice freeze and therefore Lake A would contain sufficient water over the winter. Water withdrawn from the alternate lake would be transported by truck to the existing water treatment plant. This temporary solution would be used until a more permanent engineering solution is complete.

Lake B, Lake C, and Lake D, as shown in Figure 3, have been identified as potential alternative source lakes by an engineering firm. This analysis did not consider input from the community. The engineering firm focused their selection of the alternative source lakes based on road accessibility, distance, challenges associated with travel between the source lake and the water treatment plant, and the source water quality and quantity. A summary of their metrics is provided in Table 1. Note, it is common for in early stages of engineering designs that there is missing or incomplete information from which to make decisions. These gaps are then addressed as the engineering design is advanced to a final stage. After the engineering firm completed their assessment, a community engagement session was completed, and the key community inputs have been summarized in Table 2.

Table 1: Summary of engineering determined characteristics of the alternative source lakes.

Alternative	Road Access	Distance	Water Quantity	Water Quality
Lake B	No	2 km new road would need to be constructed	Uncertain until testing is completed	Unknown
Lake C	Yes	4 km	Sufficient quantity known to exist from previous testing.	One measurement in July of Turbidity = 10 NTU
Lake D	Yes	18 km	Sufficient quantity known to exist from previous testing.	Daily average Turbidity between May to October = 150 NTU (maximum value 300 NTU, minimum value 80 NTU)

Table 2: Summary of community determined characteristics of the alternative source lakes.

Alternative Source Lake	Community Input
Lake B	Lake is deep based on the type of fish present. Deeper lakes may imply greater under-ice quantity than shallow lakes. Water is murky in early summer and clear at end of summer.
Lake C	Community does not like the taste of the water. Taste is subjective and therefore if the community does not like the taste in the source lake, they may have a biased opinion of its taste after water treatment.
Lake D	Community uses this lake for fishing and is near a culturally significant site. Disturbance to this area is not desired.

5.2 Required Work

Provide a written response for the following items:

1. You have been tasked with making a preliminary recommendation for which alternative source lake should be used for water withdrawal during the summer months. Consider this preliminary recommendation to be your best educated opinion based on very limited and incomplete information. This opinion may change as more information on this project becomes available. Provide two to three (2-3) paragraphs of text that outline the reasoning for the selection of the preferred source lake that addresses each of the following factors: accessibility, community input, and uncertainty in current knowledge regarding water quality and quantity.
2. Locate through internet search, a document detailing a water treatment technique (either **physical** water treatment or **chemical** water treatment). Information on these techniques will be vital to know for your APSC 101 design course in the fall, for more information see section 6. Question Two. Summarize the treatment process and be sure to cite the documentation you find and use in IEEE format and include it in the references section.

6. Question Two

In APSC 101 this Fall you will work in teams to conceive, design, implement, test, and iterate a tabletop water coagulation and filtration prototype for applications in water treatment facilities. Your final deliverable will include instructions and design files that would allow anyone to build the prototype the water treatment system using commonly available electronic parts and a 3D printer. As part of the design, you will build a device that can test the quality of the treated water. *Note that we do not expect you can already do this – we will teach you everything you need to know in the fall term!* For this assignment you are asked to analyze some data collected by running tests on a *turbidity sensor* similar to one your team will use in your prototype. For reference, pure water would produce a measure of 0 NTU which has negligible suspended particles. If you'd like more information on the turbidity sensors you will be using, check this out [4].

6.1 Data

The data that you will analyze in this assignment is shown in Table 3, Table 4, and Table 5. In Table 3, calibration was completed three times on a turbidity sensor, with known voltage readings producing measured turbidity values. The derived formula can be used to convert a sensor voltage reading to a corresponding turbidity value in NTU.

Table 3: The measured turbidity of water corresponding to turbidity sensor voltage readings

	Calibration 1	**Calibration 2**	**Calibration 3**
Voltage [V]	**Turbidity [NTU]**	**Turbidity [NTU]**	**Turbidity [NTU]**
4.20	0	0	0
4.00	700	800	650
3.50	2000	1700	2100
3.25	2500	2200	2800
3.00	2800	2700	2900
2.50	3100	2800	3000

Table 4 and Table 5 contain the data from settling tests to evaluate if and how quickly suspended particles in the water could fall by gravity and result in a clarified liquid. The tests were conducted on two different mixtures meant to simulate the collected water from any of the potential alternate lakes for "Awesome". Table 4 shows settling of bentonite clay in water, which is used to simulate the silt and mud of a lakebed.

Table 4: The voltage readings in 300 mL water with 0.8 g of bentonite clay as it settled over 10 minutes

	Sensor 1	**Sensor 2**	**Sensor 3**
Time [s]	**Voltage [V]**	**Voltage [V]**	**Voltage [V]**
50	2.90	2.80	2.91
70	2.96	2.85	3.02
90	3.05	2.93	3.10
110	3.10	3.00	3.17
130	3.13	3.06	3.22
150	3.17	3.10	3.27
170	3.19	3.14	3.31
190	3.21	3.18	3.34
210	3.25	3.21	3.35
230	3.27	3.23	3.37
250	3.28	3.25	3.39
270	3.30	3.28	3.42
290	3.31	3.30	3.43
310	3.33	3.29	3.44
330	3.35	3.31	3.47
350	3.36	3.32	3.48
370	3.37	3.33	3.50
390	3.38	3.34	3.50
410	3.40	3.36	3.51
430	3.40	3.37	3.54
450	3.42	3.39	3.55
470	3.42	3.38	3.56
490	3.43	3.42	3.57
510	3.45	3.43	3.58
530	3.45	3.45	3.58
550	3.45	3.46	3.61
570	3.47	3.46	3.61
590	3.47	3.46	3.61

Table 5 shows settling using the same concentration of bentonite clay after *alum* (aluminum sulphate) is added. Alum is a *coagulant,* which are materials made up of positively charged particles [5] that attract and form compounds with negatively charged material like bentonite clay [6]. These new compounds clump together as larger material "flocs" and can then sink quickly to the bottom of the solution container [5].

Table 5: The voltage readings in 600 mL water with 1.6 g of bentonite and 0.2 g of alum as it settled over 10 minutes

	Sensor 1	**Sensor 2**	**Sensor 2**
Time [s]	**Voltage [V]**	**Voltage [V]**	**Voltage [V]**
20	2.76	2.75	2.70
40	2.89	2.86	2.84
60	2.92	2.87	2.86
80	2.92	2.88	2.94
100	2.97	2.94	2.95
120	3.00	3.00	2.97
140	3.05	3.02	2.99
160	3.09	3.05	3.02
180	3.11	3.08	3.07
200	3.13	3.10	3.08
220	3.15	3.13	3.12
240	3.18	3.16	3.17
260	3.20	3.17	3.15
280	3.21	3.19	3.15
300	3.23	3.23	3.20
320	3.23	3.25	3.22
340	3.24	3.28	3.25
360	3.25	3.27	3.23
380	3.29	3.28	3.23
400	3.32	3.31	3.29
420	3.33	3.32	3.29
440	3.34	3.33	3.30
460	3.34	3.33	3.31
480	3.36	3.35	3.32
500	3.36	3.36	3.33
520	3.39	3.38	3.35
540	3.40	3.40	3.38
560	3.42	3.41	3.42
580	3.42	3.42	3.40
600	3.44	3.43	3.40

6.2 Steps to Follow

1. Transfer Table 3 into an Excel spreadsheet by copying from this document and pasting into Excel. Alternatively, you can download the Excel file titled “Provided Data" from the website. Calculate the average turbidity of the three calibrations using the built-in AVERAGE() function in excel. Calculate the maximum uncertainty of this average turbidity using **Equation 1**.

$$Turbidity\ uncertainty = \frac{sensor\ with\ largest\ turbidity - sensor\ with\ smallest\ turbidity}{2} \quad (1)$$

2. Display the new information in your report in a table and ensure to record the average turbidity values to the decimal place that aligns with its uncertainty as explained in section 3.12 Significant Figures above.
3. Construct a scatter plot for the table you created in **step 2** with **Voltage [V]** on the x-axis and **Turbidity [NTU]** on the y-axis. Only the average turbidity values need to be displayed on the graph. Include vertical error bars for the data points corresponding to the average calibration values with the uncertainty that you calculated in **step 1**. Add a trendline that fits the average calibration data (polynomial) and ensure that the trendline equation with specific variables (i.e. not the default x, y variables used by Excel), and correlation coefficient are displayed on the plot. Excel Tutorial 3 Data Visualization of the Microsoft Excel Tutorial walks through this process and there is an example of a properly formatted scatter plot in the PDF version of the Microsoft Excel Tutorial. The trendline equation is important for further analysis, as it allows for any voltage value to be converted to its corresponding turbidity value, so be sure to include it in the results section of your report.
4. Transfer Table 4 and Table 5 into your excel file. Using the formula of the trendline from **step 3**, calculate the turbidity values for each table for each of the three sensors. Calculate the average turbidity measurement of the three sensors and the maximum uncertainty of the turbidity using **Equation 1** for both tables.
5. Construct a scatter plot from each of the tables you created in **step 4** with Time [s] on the x-axis and Average Turbidity [NTU] on the y-axis. Include vertical error bars for the uncertainty that you calculated in **step 4**. Error bars on a graph show the accuracy of measurements visually, as well as determining if a trendline has a good fit. If all the data points have error bars that cross the trendline path, then the trendline is a good representation of the data. Add a trendline that fits the data well, i.e. has the highest possible R^2 value (either linear or logarithmic) and ensure that the trendline equation with specific variables and correlation coefficient are displayed on the plot. If the trendline is logarithmic, calculate the Natural Logarithm of the time using the built-in LN() function. This will be used in **step 6** when the data is required to be linearized.
6. For the sets of data graphed in **step 5**, use **Regression** in excel to perform a regression analysis using columns from the tables you created in **step 4**. The use of a regression analysis can show whether a strong relationship between the dependent and independent variables exist and gives data on that relationship. For the linear regression preformed here, this information includes slope and y-intercept. Do not complete a regression analysis for the data presented in Table 1. Please refer to Excel Tutorial 4 Data Analysis, which describes how to conduct a regression analysis and analyze the residual plots. To complete your regression analysis, you must first select the set of data. If you believe that either of the graphs from **step 5** show a linear relationship, then the input X range for the regression analysis should be the **Time [s]** column and the input Y range should be the **Average Turbidity [NTU]** column. If you believe that either of the graphs from **step 5** show a logarithmic relationship, then the data needs to be linearized since a regression analysis only evaluates a linear relationship. To do this the input X range should be the **LN Time [s]** column and the input Y range should be the **Average Turbidity [NTU]** column. After selecting your data, ensure you check the summary statistics box and use a **68% confidence level,** where the value 68 comes from 68% of a normal data point density being within ± one standard deviation (variation or uncertainty) of the mean. Be sure to check the box for **Residual Plots**.

7. Summarize your findings in a table with the same headers as Table 6 with the data from the **Coefficients** and **Standard Error** columns from the regression analyses. Include a row in the table for each settling test (with and without alum) and indicate what relationship was suspected (linear or logarithmic). Include the Residuals plot for each set of data in your report and comment on whether you believe the plot supports the relationship that you suspected. Guidelines for this analysis are found in the video Excel Tutorial 4 Data Analysis.

Table 6: Template of final summary table

Alum Prescence	Relationship	Y-Intercept	Y-Intercept Error	Slope	Slope Error

8. Based on your summary table from **step 7**, propose equations to describe the relationship between time and turbidity for each of the two graphs. You do not have to include errors in your equations. Use the **Equation** option in Word.

*Hint: the regression analyses that you did in **step 4** provided results to describe a linear relationship in the form of Equation 5 where x is the input X range, y is the input Y range, m is the slope, and b is the y-intercept.*

$$y = m \times x + b \quad (5)$$

6.3 Required Work for Submission

For this question, you will have to develop 3 sections in your document: an introduction, results and analysis, and a conclusion. They should include everything listed in this section, plus any additional information that you feel may enhance the reader's understanding of your analysis or the topic. Once you have finished your assignment you are encouraged to read the rubric to ensure that you have included everything. You cannot refer to text, figures, or tables that are not included in your report, including, but not limited to, any information in this document.

6.3.1 Introduction

A brief introduction to describe the tables, graphs and equations that will be presented in your report (1 paragraph). Make sure you use **Word Captions** to add captions and cross-references when you are referring to the graphs and tables in your report. Your equations should also be numbered and referred to by their number in the body of your report.

6.3.2 Results and Analysis

Results and analysis sections will change based on the style of report that you are doing, between the different disciplines and even sometimes within the same discipline. For the purposes of this report, this section should include all elements listed below, with short paragraphs in between where necessary to introduce the result and provide insight where necessary. The results to be included are:

1. 3 tables showing the provided data
2. 1 table showing the calibration average and uncertainty, from **step 2**
3. 1 scatter plot showing the relationship between voltage and turbidity from **step 3**
4. 1 sample calculation, for turbidity from voltage, from **step 4**
5. 2 tables with the settling liquids' average turbidity and uncertainty from **step 4**
6. 2 scatter plots showing the relationship between settling time and turbidity from **step 5**

7. 2 residual plots from regression analyses. From **step 6**
8. 1 summary table with the trend data from the regression analyses from **step 7**
9. 2 equations that describe the data from **step 8**

The order of the results above is the recommended order for your report, however other orders are acceptable provided that all the information has been presented and the report still flows logically.

6.3.3 Conclusion

Your conclusion should wrap up the report and discuss impacts of the results & analysis section. You should refrain from presenting new information in a conclusion; rather, use it as an opportunity to discuss future implications and close the research on the topic for now. If the implications require new information to be presented, this information should only provide clarity or enhance what has already been presented. Your conclusion should include two paragraphs:

1. One paragraph analyzing the relationships presented in your data. Address the following questions and statement:
   - What is the relationship between the time and the turbidity of the water?
   - What is the relationship between the presence of alum and the water settling rate?
   - Examine the scatter plots and residual plots and identify whether they suggest that there was some experimental error in collecting data.
2. Explain whether you believe the presence of alum changed the effectiveness with which you could filter the water, using the data and tables/figures created and the regression analysis you preformed to provide support for your findings.

References

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