Excel-Word Assignment

Using Office Tools in Engineering

APSC 101: Problem Solving and Modeling

Stephen J.R. Smith Faculty of Engineering and Applied Science

June 27th, 2025

Table of Contents

Table of Figures

Table of Tables

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 first-year courses (particularly APSC 101, 102, and 103 as your professional practice courses), and into your given discipline and career. Sections 1, 2, and 3 of this document outline the submission and formatting requirements for this assignment that you will need to maintain for APSC 101 and 103. Section 4 covers the background on turbidity, which will give you context for Question 1 as well as the concepts that will be used for your project in APSC 101. Section 5 covers Question 1 and asks you to do some formal research and analysis. And Section 6 covers Question 2 and has you implement excel functions and carry out an in-depth analysis.

1.1 Goals

In this assignment, you will use Microsoft Word and Microsoft Excel to learn various built-in tools to create detailed and professional reports, such as creating and linking tables/graphs, creating equations, using citations, and using proper formatting. 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 2nd, 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 the 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 Word and Excel 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 18th at 7:00pm EST. The meeting ID is 992 1261 3246 and the passcode is 048585. You can join the zoom call here.

If there are additional questions about the assignment, you may contact Sophia by email at sophia.thurston@queensu.ca for assistance until **August 25th**. If you email regarding issues with the software, you must have tried some troubleshooting on your own first. The internet is full of resources for Microsoft software. In your email, clearly describe what you have tried and what issues you are still having.

1.4 Required Software

This assignment can be completed on PCs, Macs, and online. The online version should be a last resort due to the errors in formatting mentioned above. You will need the following software and plug-ins:

1. Download and install “Microsoft 365 Apps for Enterprise” from Queen’s University.
    a. https://portal.office.com/account
2. From 365, you will be using
    a. 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 linked in the previous section.
    b. Microsoft Excel – Ensure the “Analysis ToolPak” plug-in is installed in your version. Instructions are included in the Microsoft Excel Tutorial.

Ensure that the version that you are using for Word and Excel is the **most recent version**. You may have to remove old copies to update properly.

1.4.1 Troubleshooting Download Issues

Microsoft hosts a support portal to troubleshoot various issues which can be found here. Look for issues with ‘Microsoft 365’ rather than ‘Office XXXX’ (ex. Office 2021). If you’re having issues, chances are that

it has been solved somewhere on that portal. Remember that troubleshooting depends on what type of device you have, so make sure that you're looking at the right steps. If it doesn't specify a Mac, it's most likely referring to Windows devices since that is the default for most software. Note that if you have a Mac, one of the more common issues is activation, so look at those pages first.

2. Instructions

This assignment contains data that you will need 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 and import them into a properly formatted Microsoft Word Document. Note that they need to be **imported and not** screenshoted. 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 and Uploading 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 – Excel-Word". 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"

Ex. "12345678_Doe_Jane_APSC101_ASSIGNMENT1.DOCX"

When you submit your work to OnQ, ensure you receive the confirmation email to validate that it was submitted correctly. Additionally, double check the file you submitted to be sure that it is the correct version and that it is a Word file.

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 NOT acceptable for this assignment and constitute a Departure from Academic Integrity. **Note that if material in a submission is found to be 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 requirements listed below to provide an example. They are listed in the approximate order that you will need them. This section is also the same as the formatting guide that will be given to you in APSC 101 and 103, so the expectations are consistent.

3.1 Filename

- In general, the file should be saved as per the naming convention in the assignment instruction document. If no naming convention is specified, follow the format:

  "STUDENT#_LASTNAME_FIRSTNAME_APSC###_ASSIGNMENT#.DOCX"

  (Ex. 12345678_Doe_Jane_APSC101_Assignment2.DOCX)

  Or

  "Team_TEAM#_APSC###_Phase#.DOCX"

  (Ex. Team_833B_APSC103_Phase3.DOCX)

- Depending on the course and whether it is a team or individual assignment.

3.2 Page Setup

The pages must have 1.0-inch margins ('Normal' setting) and 1.15 line spacing. All paragraphs, headers, text must be left justified, except for equations, and tables if necessary.

3.3 Text

- Paragraphs should not be indented
- Paragraphs should be separated by one line (1x 'enter')
- The end of a section should be separated by two lines (2x 'enter', so there is one empty line in between)
- Body text should be size 11 Calibri font
- Text should always be edited for spelling, grammar and concision

3.4 Title Page

- The title should contain:
  - Course name (APSC 101 or 103)
  - Report name
  - Team number
  - *Project Title (103 specific)*
  - Names and student numbers of all team members
  - Statement that all work in the report is written by the listed authors except for properly cited material
  - Name of Project Manager
  - *Name of Faculty Advisor (103 specific)*
  - *Name of Client (103 specific)*
  - Date submitted
- The title page should not have any embellishments or designs.
- See the practice solution example on the Excel Word Assignment website that can be found here.

3.5 Point of View

- Unless explicitly stated otherwise, all reports should be written in 3rd person (i.e. not using "I", "we", "our", "my") aside from reflections and descriptions of individual work.

3.6 Page Numbers

- Use Word's Header & Footer tool to insert page numbers at the top right side of the page
- There should be no page numbers on the title page
- Use Roman Numerals (i, ii, iii, etc.) for the page numbers for pages before the main body of the report (ie. Table of Contents, List of Figures, List of Tables)
- Use Arabic Numbers (1, 2, 3, etc.) beginning on the first page of the main body and for all subsequent pages (including appendices)
- To implement the different page numbers, you will need to use Section Breaks. Review the Microsoft Word Tutorial for how to do this.

3.7 Headings

- Use Word ***Styles*** to consistently format your headings for sections and subsections
- 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 and uses the next smallest Heading style (6. (Heading 1) into 6.1 (Heading 2) into 6.1.1 (Heading 3), etc.)
- Within the section, the subsections should be ordered chronologically

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.**

3.9 Table of Contents

- The Table of Contents is intended to give your reader a quick and easy way to find any element of your report. As such, it should be an accurate listing of all sections in your report. Each section should be listed with its relevant starting page number next to it.
- Use Word's ***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.

3.10 List of Figures/List of Tables

- The captions and page numbers of all figures and tables in your report should be listed in a table following the Table of Contents on the same page. If your Table of Contents is almost a page in

length, use the following page for the additional table.
- 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.

3.11 References

- Use Word's ***Citations and Bibliography*** tool to insert in-text citations and add a references list to the end of your document. Make sure that it is a references list and not a bibliography, as references are used for citing works used to support the ideas/claims of a paper, while a bibliography is for background works or further reading.
- It is not mandatory that you use the Microsoft Word citation management tool. You are free to use other citation management tools (Zotero is a great alternative).
- Reference **all** documents used (note that this is not a bibliography, but a list of the resources you directly cite in your work).
- Citations must be in IEEE style
- 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. You can find the guide here.**

3.12 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 before they are displayed.
- It is **not** expected that students use Word ***Captions*** to generate equation captions, cross-references, or a List of Equations.

3.13 Significant Figures

- Error should be reported to one OR two significant figures
- Quantities associated with error should be taken to the same digit as the significant error digit. Example: 654.9 ± 0.8 or 654.93 ± 0.80
- If there is no error, unless otherwise instructed, report all numerical values to 2 decimal places.

3.14 Sample Calculations

- 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. If permitted in a specific report, you may be able to put the full calculation in an appendix and just use the general equation in the body of the report (the first line of the sample calculation below) with the given equation number (represented below with # as a placeholder). Appendices are used to display content that is not essential to the understanding of your work but provides relevant supplementary information that aids reader comprehension.
- The slope, m, can be used along with the y-intercept, b and the independent variable, x, to calculate the response, y.

$$y = mx + b \qquad (\#)$$

$$y = 4 \times 5 - 5$$

$$y = 15\ units$$

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.

See the Microsoft Word Tutorial for instructions on how to properly implement all the above features into your reports. Review Section 8. Rubric to ensure you meet expectations.

3.16 Excel Formatting

Ensure that any tables and graphs that you are asked to include are linked to the Excel and are not screenshots. For formatting, follow the instructions that are laid out in the Microsoft Excel Tutorial, and adhere to the guidelines below.

For anything produced by Excel, you must use Calibri size 11 (unless individual data points are not visible, in which case you may set to a minimum size 9). Always use the correct significant figures as laid out in Section 3.13 Significant Figures. Tables and graphs should be scaled to not exceed the margins, and all attempts should be made to format them to be within that. If necessary, tables and graphs that are too large to be legible may be placed in an appendix and cross-referenced. An appendix can allow for different page layouts as it does not detract from the main body of the report (ex. see Section 8. Rubric, though that is not a formal appendix and is just an example of the different formatting). This can only be done if the instructions for the given assignment allow it.

For tables, columns should have appropriate headers with units, and they should have professional presentation. This means maximizing whitespace, minimal colour, and minimal vertical and horizontal lines (borders). Any lines or colour added should purely benefit legibility.

For graphs, there are several components that must be included with professional presentation. Error bars must be calculated correctly (varying in length). Trendlines must be correct (particularly the correct relationship), and the equation must be displayed on the graph clearly. The x and y in the auto-generated equation must be changed to appropriate variables. Axes must have appropriate titles with units, scaling to show the data as clearly as possible (should be set to zero whenever possible), and appropriate major tick mark scaling. Gridlines should be minimal but present for better legibility. Legends should be included, and they should overlap the plot (i.e. do not cover any of the data but they are within the borders of the plot itself). Markers and fonts should be of an appropriately legible size, and colour usage should be minimized for a professional presentation. Chart titles should **not** be included as all necessary information should be included in the caption of the graph.

4. Background on Turbidity

Turbidity is a measure of the clarity of water due to the presence of suspended particles. These particles can include a mix of sediment, organic matter, plankton, and other microscopic organisms [1]. The particles will often make the water appear murky while they are suspended. 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 water by transmitting light through the water, 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 signals, and the measured light is output as voltage values which can be converted to Nephelometric Turbidity Units (NTU) [2].

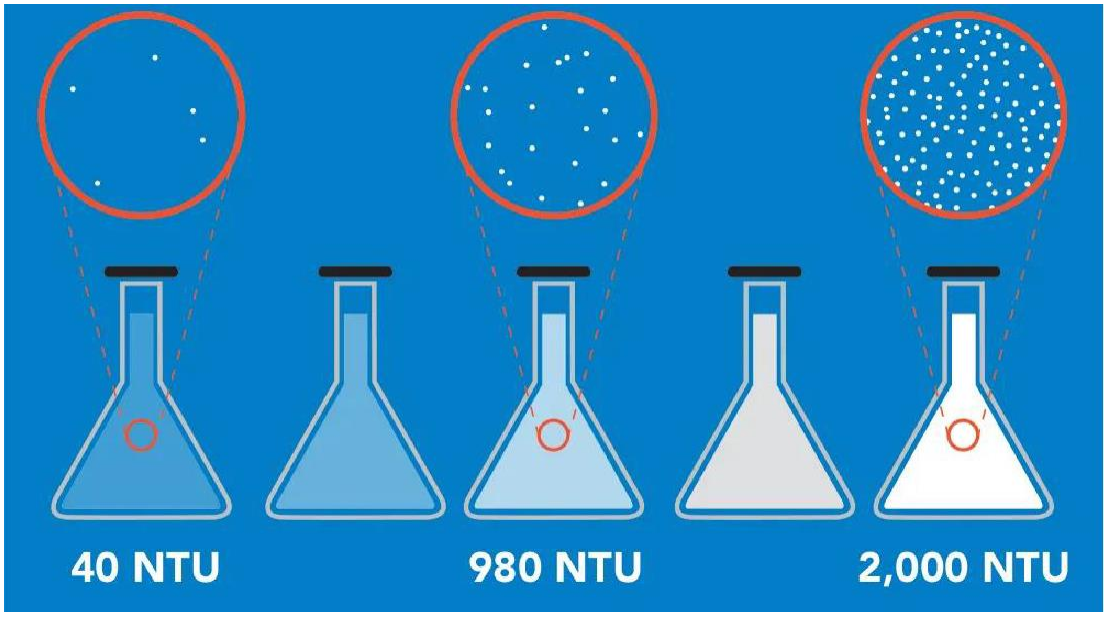

Figure 1: A series of water samples with increasing turbidity, indicated by the increasing NTU values, and the corresponding increasing particle concentration [3].

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 center of Cambridge Bay, Nunavut, as seen in Figure 2. Annual air temperatures in the community are -12^{o}C on average, with typical maximum highs in July of 11^{o}C and maximum lows in January of -32^{o}C.

Figure 2: Map of northern Canada depicting the fictional 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.

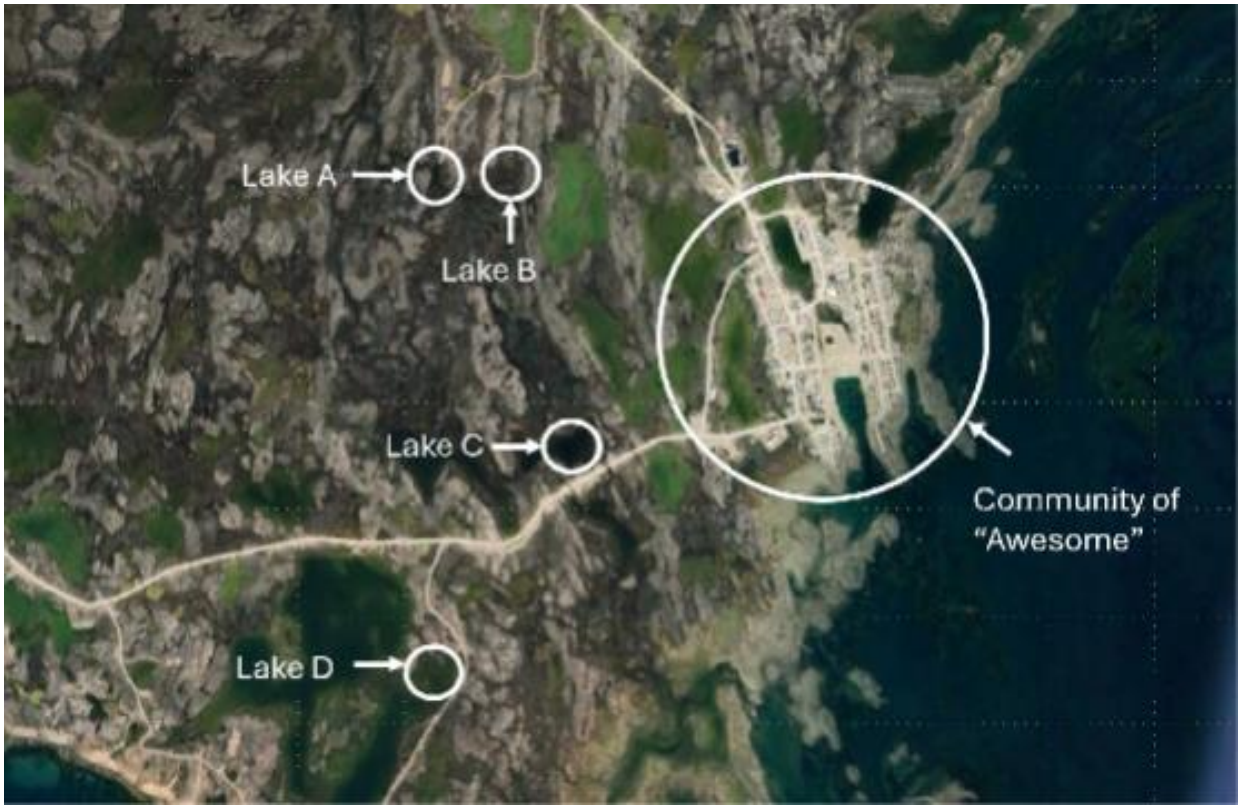

Figure 3: Map of current and optional drinking water source lakes for the community of "Awesome".

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 throughout the year.

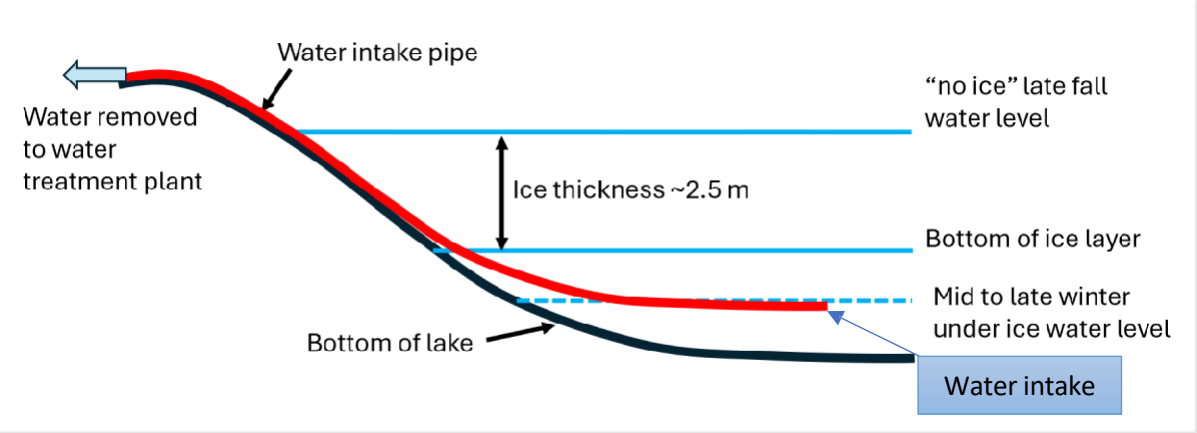

Figure 4: Schematic cross section of lake showing location of water intake pipe and water levels at different times throughout the year

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 having the highest level of concern and needs to be addressed as soon as possible with a long-term sustainable solution.

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 a permanent solution, so an interim solution is required. The community proposed the installation of 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, therefore containing sufficient water for 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 on their selection of 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’s quality and quantity. A summary of their metrics is provided in Table 1. Note, it is common in early stages of engineering designs for there to be missing or incomplete information from which to make decisions. These gaps are then addressed as the engineering design advances 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 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 is known to exist from previous testing.	One measurement in July of Turbidity = 10 NTU

Lake D	Yes	18 km	Sufficient quantity is 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 alternative source lakes.

Alternative Source Lake	**Community Input**
Lake B	This lake is deep based on the type of fish present. Deeper lakes may imply greater under-ice quantity than shallow lakes. The water is murky in early summer and clear at the end of summer.
Lake C	The community does not like the taste of the water. The 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	The community uses this lake for fishing and is near a culturally significant site. Disturbance in 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. Find at least two online sources detailing a water treatment technique of your choice (either physical water treatment or chemical water treatment). These sources must be reputable (i.e. not blog posts, instead try to find scientific papers or journals) and **cannot** be any of the sources included in this assignment. Information on these treatment techniques will be vital to know for your APSC 101 design course in the fall, for more information see Section 6. Question Two. Provide one to two (1-2) paragraphs summarizing 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 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 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 that 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 data collected from a turbidity sensor like the one your team will use in your prototype. For reference, pure water which has negligible suspended particles would produce a measure of 0 NTU. For more information on the turbidity sensors you will be using, check it out here [4].

6.1 Data

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

Voltage (V)	Calibration 1 (NTU)	Calibration 2 (NTU)	Calibration 3 (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 contains the first 10 rows of the data from settling tests using a mixture of bentonite clay and water 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 *flocs* and can then sink quickly to the bottom of the solution container [5]. The tests were conducted on three different sensors, all testing the same mixture meant to simulate the collected water from any of the potential alternate lakes for “Awesome”. The sensors were all set at different calibration levels. One was calibrated correctly, one was not recalibrated for this test (assume that it is only slightly uncalibrated), and one was distinctly uncalibrated (not necessarily in that order). As you are completing your analysis and discussion, think about how the data is impacted by these different levels of calibration, which sensor may correlate to which calibration level, and how to troubleshoot an issue such as this. Understand that data collection may need to be done with uncalibrated tools in your labs throughout your degree and understanding how to identify and fix these issues is an essential skill to have.

Table 4: The first 10 rows of the Sensor Data showing the voltage readings in 250 mL water with 0.8 g of bentonite clay and 0.5 g of alum. The mixture was stirred for 60 seconds, then settled for 140 seconds. The full table to be used is in the Provided Data Excel sheet

Time (s)	Sensor 1 (V)	Sensor 2 (V)	Sensor 3 (V)
1	2.52	2.62	2.41
2	2.56	2.56	2.33
3	2.56	2.59	2.31
4	2.57	2.67	2.34
5	2.61	2.54	2.41
6	2.57	2.56	2.35
7	2.52	2.56	2.34
8	2.50	2.57	2.29
9	2.52	2.56	2.30
10	2.47	2.54	2.33

6.2 Steps to Follow

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

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

2. Display the new information in your report in a table with Voltage, Average Turbidity, and Uncertainty columns, and ensure to record the average turbidity values to the decimal place that aligns with its uncertainty as explained in Section 3.13 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 (a polynomial relationship) and ensure that the trendline equation with specific variables (i.e. not the default x, y variables used by Excel), and correlation coefficient (R^2) are displayed on the plot. Excel Tutorial 3 Data Visualization of the Microsoft Excel Tutorials 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 the Sensor Data (example in Table 4, however use the full data set provided) into your Excel file. Using the formula of the trendline determined in **Step 3**, calculate the turbidity values

for each of the three sensors. Calculate the average turbidity measurement of the three sensors and the maximum uncertainty of each of the average turbidity values using **Equation 1**.

5. Construct a scatter plot from the table you created in **Step 4** with **Time [s]** on the x-axis and **Average Turbidity [NTU]** on the y-axis; only plot the data between the time period of 70 to 95 seconds. This time period covers the majority of the settling time and is the best representation of how quickly the flocs are able to settle. 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 is 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. the R^2 value is as close to 1 as possible (linear relationship) and ensure that the trendline equation with specific variables and correlation coefficients are displayed on the plot.
6. For the data graphed in **Step 5**, use **Regression** in excel to perform a regression analysis using columns from the table you created in **Step 4**. The use of a regression analysis can show whether a strong relationship between the dependent and independent variables exists and gives data on that relationship. For the linear regression performed here, this information includes slope and y-intercept. 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 you want to analyze. The graph from **Step 5** shows a linear relationship, therefore 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. 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** so that it will generate that plot.
7. Summarize your findings clearly with the data from the **Coefficients** and **Standard Error** columns from the regression analyses. Include the Residuals plot with error bars for the 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.
8. Based on your summary from **Step 7**, propose an equation to describe the relationship between time and turbidity for the graph. Use the **Equation** option in Word. Outline this equation using the Sample Calculation format outlined in Section 3.14 Sample Calculations.

*Hint: the regression analysis 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.*

$$y = m \times x + b \tag{2}$$

9. Construct a line plot showing each individual sensor from the data you pulled in **Step 4** (*not* the average turbidity) with **Time [s]** on the x-axis and **Turbidity [NTU]** on the y-axis. You should have three lines on one graph, and this will cover the full 1-200 data points. There should be no error bars on this graph.

6.3 Required Work for Submission

For your response to Question 2, 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 Section 8. Rubric to ensure that you have included everything required. Only refer to text, figures, and tables that are included in your report, with the exception of clearly cited material. By extension, you cannot refer to anything included 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 results and provide insight. Introduce and cross-reference graphs and tables before they appear in the report for better legibility. **Remember to review Section 8. Rubric before submission.** The results to be included are:

- 2 tables showing the provided data
- 1 table showing the calibration average and uncertainty, from **Step 2**
- 1 scatter plot showing the relationship between voltage and turbidity from **Step 3**
- 1 sample calculation, for turbidity from voltage, from **Step 4**
- 1 table with the mixture's converted turbidity values, average turbidity, and uncertainty from **Step 4**
- 1 scatter plot showing the relationship between time and turbidity from **Step 5**
- 1 residual plot from regression analyses from **Step 6**
- 1 summary table with the trend data from the regression analyses from **Step 7**
- 1 equation that describes the data from **Step 8**
- 1 line plot showing the converted turbidity values from all three sensors from **Step 9**

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

6.3.3 Conclusion

Your conclusion should wrap up the report and discuss the impacts of the Results & Analysis section. You should refrain from presenting new information in your 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:
    - Using your graph from **Step 5**, what is the relationship between time and the turbidity of the water? What can we learn from this?
    - Consider the trendline equation you obtained in **Step 3** and the data presented in Table 3. The table gives you the x-intercept of 0 NTU at 4.2 V, but when you plug 0 NTU into your trendline equation, it isn't perfectly 4.2 V. Calculate the voltage value given by the trendline equation and explain why it is different than the 4.2 V given by the data.
2. One paragraph analyzing the data in terms of its uncertainties and outliers. Address the following:
    - Examine the scatter plots and residual plots and identify whether they suggest that there was some experimental error in collecting data. How could these experimental errors be improved?
    - Were there any notable outliers? What might have caused them?
    - Examine the graph you made in **Step 9**. Recall the information provided above regarding the sensors that were used to test and their calibrations. Determine which line correlates to which sensor and discuss how you determined this. What are some reasons the sensors could have become uncalibrated (think about how the sensors are built)? How could these uncalibrated sensors be fixed?
    - Review the data collection process. How do the different steps of stirring versus settling correlate to the path of the turbidity graph from **Step 9**? What can we learn from this?

7. References

[1] "Gravity: Analog Turbidity Sensor for Arduino," DFRobot, 17 December 2015. [Online]. Available: https://www.dfrobot.com/product-1394.html.

[2] D. O'Donnell, "Understanding the Science Behind Turbidity Sensors and How They Work," Sensorex, 13 September 2021. [Online]. Available: https://sensorex.com/understanding-the-science-behind-turbidity-sensors-and-how-they-work/.

[3] "What is a Turbidity Sensor," AtlasScientific, 2 August 2023. [Online]. Available: https://atlas-scientific.com/blog/what-is-a-turbidity-sensor/.

[4] "Turbidity Sensor SKU SEN0189," DFRobot, 15 December 2015. [Online]. Available: https://wiki.dfrobot.com/Turbidity_sensor_SKU__SEN0189.

[5] B. Campbell, "What is Coagulation for Water Treatment," Wastewater Digest, 8 March 2022. [Online]. Available: https://www.wwdmag.com/what-is-articles/article/10940184/what-is-coagulation-for-water-treatment.

[6] K. Wiginton, "Bentonite Clay," WebMD, 2 September 2022. [Online]. Available: https://www.webmd.com/a-to-z-guides/bentonite-clay-benefits.

8. Rubric

8.1 Weight

This assignment is **worth 2%** of your final grade in APSC 101.

8.2 Submission Instructions

This assignment is due by **Tuesday Sept. 2 at 9am EST.** Instructions for submission will be provided the week before it is due.

The submission made for this assignment *must* be a Word document; no other formats will be marked.

8.3 Late Penalty

10% will be deducted from your grade on this assignment for every day that it is late.

8.4 Marking

You must complete all of the assignment questions. Submitting an incomplete assignment will result in receiving a grade of zero.

There are two components to the total mark you will receive for this assignment.

1. The “Word” component, pertaining to the presentation of your Microsoft Word work, will be marked out of **16**.
2. The “Excel” component, pertaining to your data analysis in Microsoft Excel, will be marked out of **14**.

Please carefully review the marking rubrics for all sections.

8.5 Marking Rubric – Word

Please note that all of the assignment questions must be completed. An incomplete assignment will receive a zero.

	2 • **very clear** • **properly formatted using appropriate function in Word**	**1** • **understandable** • **properly formatted, but not with appropriate functions in Word**	**0** • **unclear** • **improperly formatted missing**	**Mark**
• **Title Page** • **Page Numbering**	• Page numbers present and correct, created using Word functions	• Page numbers are present, but have been created manually	• Page numbers are not present or formatting does not follow assignment instructions	**/2**
• **Section Headings** • **Table of Contents**	• Section headings specified in assignment instructions generated using Word Styles • Table of Contents generated automatically • Document structure follows assignment instructions	• Section headings and Table of Contents are present but have been generated manually • Document structure deviates from assignment instructions in a way that is difficult to follow	• No section headings or Table of Contents • Document structure is disorganized and is difficult to follow	**/2**
• **Figures** • **Tables**	• All Figures and Tables have thorough and well-written captions, generated using Word Captions • Automatic List of Figures & Tables • Figures are appropriately sized & legible • Figures and Tables are linked to Excel	• All Figures and Tables have descriptive, manually generated captions • Manual list of Figures & Tables • Most figures are appropriately sized & clear • Figures and Tables are linked to Excel	• Some Figures and Tables are missing captions or have unclear captions • List of Figures & Tables is incomplete or missing • Figures are illegible, unclear or inappropriately sized • Figures and Tables are screenshot from Excel	**/2**

• **Cross-referencing**	• All Tables & Figures are cross-referenced in text using Word Captions	• All Figures & Tables are cross-referenced in text manually	• Some Figures & Tables are not referenced in text	**/2**
• **Sample Calculation** • **Equations**	• Thorough and descriptive sample calculations are included, following recommended format • All equations are numbered and manually referred to in text • Equations are generated using equation editor in Word Symbols	• Sample calculations are presented but do not follow recommended format • Equations are numbered and manually referred to in text • Equations are not generated using the equation editor in Word Symbols	• Sample calculations are missing steps or missing completely. • Some equations are missing numbers • Some equations are not referenced in text	**/2**
• **Citations**	• All sources are cited using IEEE style • Citations & bibliography generated using Word Citations (or Zotero or equivalent citation software) Note that no citation management tool is perfect, you may need to manually correct citations that are generated.	• All sources are cited using IEEE style • Citations are manually formatted	• Incorrect or inconsistent citation formatting • Some resources used are not cited	**/2**
• **Descriptive text at the beginning and end** • **Critical Evaluation of Results**	• Appropriate descriptive text has been included to introduce the scenario and summarize the results. • The text is clear, concise and thorough • The required conclusions are all present and well-argued	• Marginal descriptive text has been included to introduce the scenario and summarize the results • Text is not concise, partially incomplete or somewhat unclear	• Minimal descriptive text has been included to introduce the scenario or summarize the results • The text is largely incomplete or unclear • The required conclusions are missing or poorly argued	**/2**

		• Required conclusions are mostly present or argued with some flaws		
• **General Formatting**	• All of the following has been used: - Size 11 Calibri font - 3rd person point of view - Left justification - Spaces separate paragraphs (not indented)	• Most of the following has been used: - Size 11 Calibri font - 3rd person point of view - Left justification - Spaces separate paragraphs (not indented)	• None or little of the following has been used: - Size 11 Calibri font - 3rd person point of view - Left justification - Spaces separate paragraphs (not indented)	**/2**
TOTAL				**/16**

8.6 Marking Rubric – Excel

Please note that all of the assignment questions must be completed. An incomplete assignment will receive a zero.

	2 • ***complete with no errors*** • ***consistent, professional formatting***	1 • ***complete with some errors*** • ***inconsistent formatting***	0 • ***incomplete or largely incorrect*** • ***improper formatting***	Mark
• **Tables (Data Entry & Formulas)**	• Data is accurate • Data is presented with significant figures consistent with questions • Formulas have been used properly	• Data has some errors • Significant figures are consistent in most numbers • Some formulas have been used properly	• Data is largely inaccurate • Significant figures are inconsistent • Formulas used improperly	**/2**
• **Tables (Formatting)**	• Columns are presented with appropriate headers and units • Professional presentation of information such as: - Minimal Colour - Minimal vertical lines between cells - Minimal horizontal lines between cells • White space has been maximized	• Columns are presented with mostly appropriate headers and units • Poor presentation of information such as: - Unnecessary Colour - Many vertical lines between cells - Unnecessary horizontal lines between cells	• Tables are presented with extra unwanted columns or missing columns • Headers are not included or are a misrepresentation of data • Units are missing or incorrect	**/2**
• **Figures (Error Bars)**	• Error bars are made with the correct equation, varying in length	• Error bars are present, but do not reflect the values from the error equation	• Error bars are not present	**/2**

• **Figures (Trendlines)**	• All trendlines are present and correct • Equations of all trendlines are present	• Trendlines are present • Equations are present, but are partially incorrect	• Trendlines are missing • Equations are missing or entirely incorrect	**/2**
• **Figures (Regression Analysis)**	• Regression analysis is complete, reporting correct values for slope and intercept with their standard errors	• Regression analysis is complete, but reported values of slope or intercept are partially incorrect	• Regression analysis has not been completed/reported	**/2**
• **Figures (Residual plot)**	• Residual plot has been produced, and is used to discuss accuracy in conclusion	• Residual plot has minor errors in labeling or interpretation in conclusion	• Residual plot is missing, incorrect or misinterpreted	**/2**
• **Figures (Formatting)**	• Figures include all of the following: - Descriptive axis titles with units - Appropriate Scales - Professional Legends (Overlap Plot) - Appropriate Marker and font sizes • Figures avoid all of the following - Excessive use of horizontal & vertical gridlines - Chart Titles - Unnecessary Colour	• Figures include most of the following: - Descriptive axis titles with units - Appropriate Scales - Professional Legends (Overlap Plot) - Appropriate Marker and font sizes • Figures avoid most of the following - Excessive use of horizontal & vertical gridlines - Chart Titles - Unnecessary Colour	• Figures include most of the following: - Descriptive axis titles with units - Appropriate Scales - Professional Legends (Overlap Plot) - Appropriate Marker & font sizes • Figures avoid most of the following - Excessive use of horizontal & vertical gridlines - Chart Titles - Unnecessary Colour	**/2**
TOTAL				**/14**