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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 two 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 5th, which is your first day of class. Instructions for submitting the assignment will be provided two weeks before it is due. Please note, this assignment requires use of the Office 365 apps, which is free for all students. Graders will be reading the document using the desktop app, 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 14th at 7:00pm EST. The meeting ID is 972 4911 3488 and the passcode is 837900. You can join the zoom call HERE.
If there are additional questions about the assignment, you may contact Chloe by email at chloe.miklaucic@queensu.ca for assistance until August 20th.

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://queensu.ca/sharepoint/sites/software-centre/SitePages/Microsoft-Office.aspx](https://queensu.ca/sharepoint/sites/software-centre/SitePages/Microsoft-Office.aspx)
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.

If you encounter issues obtaining your own version of Office as described above, it can be accessed through Apps Anywhere. You’ll have to log in with your NetID and password, then install Apps Anywhere on your device. From there, you can launch Excel and Word from the list of Apps.

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 in order 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 for Mac when updates are complete.

- Open KeyChain Access, search for “Microsoft” and delete all entries
- Download script from Microsoft - [https://docs.microsoft.com/en-us/samples/browse/?redirectedfrom=TechNet-Gallery](https://docs.microsoft.com/en-us/samples/browse/?redirectedfrom=TechNet-Gallery)
- Run the script by right-clicking, choosing Open, then choose Open again or Press Control Key while running the App to be promoted whether you would like to open an app from an unidentified developer. The script runs quickly and usually opens Outlook.
- Restart the computer
- 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 script 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 on page 7. 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.

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://engineering.queensu.ca/policy/academic-integrity

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 10 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 10) and submission date

3.4 Point of View
- The report should be written in 3rd person. 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:
  o Eliminating vertical lines between cells
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.
- 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 in order 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: 654.89 ± 0.76 should be reported as 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](#).

- 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 #.

\[
y = mx + b
\]  
(1)

The slope, \(m\), can be used along with the \(y\)-intercept, \(b\) and the independent variable, \(x\), in order to calculate the response \(y\).

\[
y = mx + b
\]
\[
y = 4 \times 5 - 5
\]
\[
y = 15 \text{ units}
\]

### 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. Problem Scenario

In APSC 101 this fall you will work in teams to conceive, design, implement, test, and iterate an automated fluid dispenser (AFD) for lab and medical applications such as blood testing and water filtering. Your final deliverable will include instructions and design files that would allow anyone to build the AFD using commonly available electronic parts and a 3D printer. As part of the design, you will build a device that can deliver specific amounts of liquid and powder into test tubes that are held in a rotating turntable. *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 *DC motor and gearbox*. The DC motor and gearbox are similar to what we will give you in the fall term to rotate the turntable in your team’s design.

4.1 Background information about gearboxes

A gearbox is a mechanical system comprised of a series of interlocked gears, usually used to increase the output turning force (torque). This is done through a series of gear stages of gears with varying numbers of teeth. The ratio of teeth on the gears is equal to the gear ratio. For example, in the gear stage in Figure 1, a 10-tooth gear is powering a 50-tooth gear, which provides a gear ratio of 1:5. The 10-tooth gear will complete 5 revolutions for every revolution of the 50-tooth gear, but the 50-tooth gear will provide 5-times more turning force (torque) than the 10-tooth gear.

![Figure 1: A 10-tooth gear meshed with a 50-tooth gear](image)

Gear stages can be combined to create larger gear ratios by joining gear stages on a shared axle, as seen in Figure 2. The purple gears, with gear ratio 1:3, power the green gears, with ratio 1:4, and the overall gear ratio from left to right is the product of the ratios, which is 1:12.
If you’d like more information on how a gearbox works, check this out [1].

5. Assignment

In this assignment, you will analyze real data collected when a DC motor was connected to a gear box. You will analyze this data to make conclusions about the efficiency of the gearbox in Figure 3 with three different gear stages, each comprised of a pair of gears.
The motor powering the gearbox was supplied 6 volts and the gear ratios that were tested are 1:40, 1:160, and 1:800. These gear ratios were created by using just the first stage, the first two stages, or all three stages of the gear box in Figure 3. The three gear stages can be seen separated with the gears on a flat surface in Figure 4. The first stage of the gear train involves a worm gear (gear A), meshed with a 50-tooth gear (gear B), and has a gear ratio of 1:40. The second stage has a 10-tooth gear (gear C) meshing with a 40-tooth gear (gear D), giving it a gear ratio of 1:4. Similarly to joining the green and purple stages in Figure 2, the first two stages are combined by putting gear B and gear C both on axle 1, as labelled in Figure 3. The third stage has a 10-tooth gear (gear E) meshing with a 50-tooth gear (gear F), giving a gear ratio of 1:5. Gear D and gear E share axle 2, which connects the last two stages. In this experiment, a spool was attached to the axle with the desired gear ratio and used to lift a known mass. Two spools, which can be seen in Figure 5, were used throughout this experiment. Based on the labels in Figure 3, attaching the spool to axle 1 provides a gear ratio of 1:40, axle 2 provides a gear ratio of 1:160, and axle 3 provides a gear ratio of 1:800. An example of the mass lifted can be seen in Figure 6.

Don’t worry if you don’t follow all that detail – it’s not critical to analyzing the data but should be helpful when interpreting the results of the data at the end of this report.
The dependent variables measured were the amount of time that it took the gearbox to lift a known mass 10cm, measured in seconds, and the average current drawn by the motor during that time, measured in Amperes. There were three trials conducted with each mass ranging from 10g to 100g for each of the three gear ratios. This data can be seen in Table 1, Table 2, and Table 3 section 5.1 Data.

After conducting these trials, some improvements were made to improve the efficiency of the gearbox. The three improvements were using a spool with a radius 3 times as large as the original, replacing the worm gear in the gear train with a much smoother version, and adding lubricant to the gears. The original and replacement parts are shown in Figure 5 and Figure 7. The data collected with the improved method for the lowest gear ratio can be seen in Table 4, which can be found in section 5.1 Data.
With the raw data you will calculate the efficiency of the motor and gearbox assembly by determining the ratio of the output power to the input power in each trial. The input power will be calculated using Equation 1 where P is power (W), I is the current (A), and V is the voltage (V), which was always 6 volts.

\[ P = V \times I \]  

(1)

The output power can be calculated using Equation 2 where P is the power (W); m is the mass (kg), which was varied between 10 and 100 grams; g is the gravitational acceleration near earth’s surface, which is 9.81 m/s²; h is the vertical displacement (m), which was 10cm for all trials; and t is the change in time (s).

\[ P = \frac{m \times g \times h}{t} \]  

(2)

The efficiency (%) can be calculated using Equation 3. You will calculate the efficiency of the gear box in each trial and then calculate the average of the three trials where the same mass was used. The uncertainty of the average efficiency will be calculated as half of the largest difference between trials, as seen in Equation 4.

\[ Efficiency = \frac{Output \ Power}{Input \ Power} \times 100\% \]  

(3)

\[ Efficiency \ uncertainty = \frac{trial \ with \ largest \ efficiency - trial \ with \ smallest \ efficiency}{2} \]  

(4)

After calculating efficiency, you will graph your results and draw conclusions about the relationships between the load lifted or the number of gear stages and efficiency. In your analysis you will discuss why the adjustments to the method improved efficiency and which one you think had the biggest impact.

5.1 Data
The data that you will analyze in this assignment is shown in Table 1, Table 2, Table 3, and Table 4.

Table 1: The current and time required by a gearbox with one gear stage to lift varying masses 10cm

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.132</td>
<td>1.70</td>
<td>0.148</td>
<td>1.84</td>
<td>0.129</td>
<td>1.57</td>
</tr>
<tr>
<td>20</td>
<td>0.132</td>
<td>1.78</td>
<td>0.134</td>
<td>1.75</td>
<td>0.128</td>
<td>1.78</td>
</tr>
<tr>
<td>30</td>
<td>0.129</td>
<td>1.62</td>
<td>0.132</td>
<td>1.76</td>
<td>0.128</td>
<td>1.71</td>
</tr>
<tr>
<td>40</td>
<td>0.145</td>
<td>1.83</td>
<td>0.150</td>
<td>1.82</td>
<td>0.149</td>
<td>1.92</td>
</tr>
<tr>
<td>50</td>
<td>0.165</td>
<td>2.08</td>
<td>0.158</td>
<td>1.93</td>
<td>0.158</td>
<td>1.90</td>
</tr>
<tr>
<td>60</td>
<td>0.162</td>
<td>1.95</td>
<td>0.169</td>
<td>1.88</td>
<td>0.165</td>
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</tr>
<tr>
<td>70</td>
<td>0.171</td>
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<td>0.179</td>
<td>2.20</td>
<td>0.169</td>
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</tr>
<tr>
<td>100</td>
<td>0.175</td>
<td>1.97</td>
<td>0.200</td>
<td>2.19</td>
<td>0.228</td>
<td>2.61</td>
</tr>
</tbody>
</table>
**Table 2:** The current and time required by a gearbox with two gear stages to lift varying masses 10cm

<table>
<thead>
<tr>
<th>Mass [g]</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.114</td>
<td>6.26</td>
<td>0.110</td>
</tr>
<tr>
<td>20</td>
<td>0.084</td>
<td>5.54</td>
<td>0.082</td>
</tr>
<tr>
<td>30</td>
<td>0.079</td>
<td>5.19</td>
<td>0.083</td>
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<td>70</td>
<td>0.102</td>
<td>5.82</td>
<td>0.098</td>
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<tr>
<td>80</td>
<td>0.098</td>
<td>5.84</td>
<td>0.119</td>
</tr>
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<td>90</td>
<td>0.142</td>
<td>7.12</td>
<td>0.133</td>
</tr>
<tr>
<td>100</td>
<td>0.139</td>
<td>6.36</td>
<td>0.172</td>
</tr>
</tbody>
</table>

**Table 3:** The current and time required by a gearbox with three gear stages to lift varying masses 10cm

<table>
<thead>
<tr>
<th>Mass [g]</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.117</td>
<td>30.73</td>
<td>0.114</td>
</tr>
<tr>
<td>20</td>
<td>0.107</td>
<td>30.13</td>
<td>0.104</td>
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<tr>
<td>30</td>
<td>0.109</td>
<td>31.01</td>
<td>0.111</td>
</tr>
<tr>
<td>40</td>
<td>0.110</td>
<td>30.49</td>
<td>0.113</td>
</tr>
<tr>
<td>50</td>
<td>0.130</td>
<td>31.83</td>
<td>0.123</td>
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<td>60</td>
<td>0.116</td>
<td>30.22</td>
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</tr>
<tr>
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<tr>
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<td>0.106</td>
<td>29.42</td>
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<tr>
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<td>0.099</td>
<td>28.62</td>
<td>0.109</td>
</tr>
</tbody>
</table>
Table 4: The current and time required by a gearbox with one gear stage to lift varying masses 10cm with an improved method

<table>
<thead>
<tr>
<th></th>
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</tr>
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<td>0.55</td>
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</tr>
</tbody>
</table>

5.2 Steps to Follow

1. Transfer Tables 1-4 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 input and output power for each trial using Equations 1 and 2. To save time, use the strategies for processing data presented in Video 2.2. Using Formulas and Functions. Make sure that you are converting everything to the proper units. Display the information in your report in four tables with the same headings as Table 5 below with the values rounded to three decimal places. In your report, show the steps for the two calculations for one trial using the Equation option in Word. In your steps, display the numbers up to two significant figures.

Table 5: Template for the input and output power table

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
</tr>
</thead>
</table>

2. Calculate the efficiency for each trial using Equation 3 then calculate the average efficiency of the three trials using the built-in AVERAGE() function in Excel. Calculate the maximum uncertainty of this average efficiency using Equation 4. Also, calculate the Natural Logarithm of the mass using the built-in LN() function. This will be used in step 4. Watch Video 2.2. Using Formulas and Functions to learn about implementing equations in Excel. Display the data in your report in four tables with the same headings as Table 6 below. Ensure to record the average efficiency values to the decimal place that aligns with its uncertainty as explained in section 3.12 Significant Figures above. For your reference, there is an example of a properly formatted table in the PDF version of the Microsoft Excel Tutorial.

Table 6: Template of efficiency table

| Mass [g] | LN Mass [g] | Average Efficiency [%] | Uncertainty [± %] |
3. Construct a scatter plot for each of the four tables you created in step 2 with Mass [g] on the x-axis and Average Efficiency [%] on the y-axis. Include vertical error bars for the uncertainty that you calculated in step 2. Add a trendline that fits the data (either linear or logarithmic) and ensure that the trendline equation with specific variables and correlation coefficient are displayed on the plot. Video 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 the Microsoft Excel Tutorial.

4. For three sets of data that were graphed in step 3, use Regression in excel to perform a regression analysis using columns from the tables you created in step 2. You do not have to complete a regression analysis for the data presented in Table 4. Please refer to Video 4 of the Microsoft Excel Tutorial, 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 the graph from step 3 shows a linear relationship, then the input X range for the regression analysis should be the Mass [g] column and the input Y range should be the Average Efficiency [%] column. If you believe that the graph from step 3 shows 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 Mass [g] column and the input Y range should be the Average Efficiency [%] column. After selecting your data, ensure you check the summary statistics box and use a 68% confidence level and check the box for Residual Plots. Summarize your findings in a table with the same headers as Table 7 with the data from the Coefficients and Standard Error columns from the regression analyses. Include a row in the table for each gear setup 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.

Table 7: Template of final summary table

<table>
<thead>
<tr>
<th>Gear Ratio</th>
<th>Relationship</th>
<th>Y-Intercept</th>
<th>Y-Intercept Error</th>
<th>Slope</th>
<th>Slope Error</th>
</tr>
</thead>
</table>

5. Based on your summary table from step 4, propose equations to describe the relationship between mass and efficiency for each of the three data sets. 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 c is the y-intercept.

\[ y = m \times x + c \]  

(5)

5.3 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 are permitted to include figures or equations from this document without a formal citation, but you cannot refer to something that is not included in your report.

5.3.1 Introduction
Your introduction for this question should have two to three (2-3) short paragraphs. The purpose of an introduction is to prepare the reader for the report and make them care about the data. The paragraphs are:

1. An introduction to the scenario you will be working on in APSC 101 in the form of a Problem Definition (1-2 paragraphs). Cite any sources you use in IEEE format. Your problem definition should include:
   a. Describe the overall goals of the design project.
   b. Identify groups or individuals (“stakeholders”) who could use or be impacted by a potential prototype. Try to identify stakeholders beyond the obvious ones.
   c. Identify societal benefits; any potential benefits experienced by any stakeholders as a result of your prototype. You can also consider multiple applications of your prototype.
   d. Identify safety considerations that should be considered in the design, manufacturing, or use of a potential prototype.
   e. A description of how the analysis conducted in this assignment will help you complete the design challenge in the fall.
2. A brief introduction paragraph 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.

5.3.2 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. 4 tables showing the provided data
2. 2 sample calculations, one for input power and one for output power. From Steps to Follow 1
3. 4 tables with the input and output power. From Steps to Follow 1
4. 4 tables with the efficiency of the gearbox in each trial. From Steps to Follow 2
5. 4 scatter plots showing the relationship between mass and efficiency. From Steps to Follow 3
6. 3 residual plots from regression analyses. From Steps to Follow 4
7. 1 summary table with the trend data from the regression analyses. From Steps to Follow 4
8. 3 equations that describe the data. From Steps to Follow 5

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.
5.3.3 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:
   a. What is the relationship between the mass lifted and the efficiency of the gearbox?
   b. What is the relationship between the number of gear stages and the efficiency?
   c. Examine the scatter plots and residual plots and identify whether they suggest that there was some experimental error in collecting data.

2. Three modifications were made to the system between the measurements shown in Table 1 and Table 4. Explain in one paragraph how you would determine which of the factors had the most significant impact on efficiency? Which of the three do you think is most likely to have had the biggest impact? Compare the values you presented as a product of Steps to Follow 2 and graphed in Steps to Follow 3 for the data provided in Table 1 and Table 4.
References