

# Excel-Word Assignment

Presented to the Class of Sci 26

APSC 101

1<sup>st</sup> Year Engineering

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Prepared by the Faculty of Engineering

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## 1. Overview

The Excel-Word assignment is designed to ease your transition into university by ensuring you have fundamental skills in using Microsoft Word and Microsoft Excel, and that you are able to format a technical document in a prescribed format. This skill is critical for many professions, including engineering.

For this assignment you are required to turn in one Microsoft Word document that includes, background research, discussion and sample calculations completed using Microsoft Excel. The formatting requirements of this document will hold throughout APSC 101 and 103 and generally align with the requirements in Queen's Engineering and the engineering profession

### 1.1 Purpose

This assignment will prepare you to analyze data and create technical reports using Microsoft Excel and Word. It will require the use of Microsoft Excel to create tables, scatter plots and complete data analysis, and the use of 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

### 1.2 Deadline

**This assignment is due by Tuesday September 6 at 9am EST.** This assignment is **worth 2%** of your final grade in APSC 101. 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 come free with your student ID. You may use the online version of these apps if you wish, however the formatting is often slightly different when generating using the online version compared to the desktop app. Be sure to ensure that your formatting appears correctly 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 [HERE](#). It is expected that you read these resources and refer to them when completing the assignment. If there are additional questions about the assignment, you may contact Connor by email at [cab26@queensu.ca](mailto:cab26@queensu.ca) for assistance until **August 31**.

## 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://queensuca.sharepoint.com/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**.
  - Microsoft Word – Ensure you have the option to use the IEEE reference style in the Word citation tool. Information on the citation tool and IEE 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 or 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>
- 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: <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 two questions:

### Question 1: Rollercoaster Maintenance

### Question 2: Fossil Dating

Both questions are described in detail, with question 1 starting on [page 7](#) and question 2 starting on [page 12](#). To complete the two questions, you will need to create tables and graphs in Microsoft Excel, then import them into a properly formatted Microsoft 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\_APSC100\_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. In terms of Academic Integrity, if you share your work with other students, it may be considered *facilitation*. 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\_APSC100\_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 100) and submission date

### 3.4 Point of View

- The report should be written in **3<sup>rd</sup> 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 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 question 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 where possible

### 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, units 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**.

### 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:  $654.89 \pm 0.76$  should be reported as  $654.9 \pm 0.8$*
- 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.

- 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 #.

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

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

$$\begin{aligned} y &= mx + b \\ y &= 4 \times 5 - 5 \\ y &= 15 \text{ units} \end{aligned}$$

### 3.15 Units

- Report units in axis titles, at the top of table columns, and in trendline equations.
- 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. Question 1: Rollercoaster Maintenance

Rollercoasters at amusement and theme parks around the world are a large draw for visitors from far and wide. Rollercoaster construction costs average around \$8 million USD, though themed roller coasters such as Expedition Everest at Disney's Animal Kingdom can cost close to \$100 million [1, 2]. In order to keep these attractions running safely for guests, rollercoasters must undergo periodic maintenance. In this question, you'll have to examine theoretical models to determine maintenance costs to allow the park executives to determine the best course of action to keep guests safe while ensuring the park is financially sustainable.



Figure 1: Expedition Everest at Disney's Animal Kingdom Theme Park in Orlando, FL [2]

**Disclaimer:** This scenario is entirely fictitious and the data has been designed solely for the purposes of this assignment. The data may not be an accurate representation of costs associated with maintaining a high thrill coaster and should not be used anywhere outside of the purposes of this assignment.

### 4.1 Problem Scenario

In this fictitious scenario, you have been hired by a new Canadian Theme Park that is open for their first season. Using data from analogous rides at other theme parks, expected maintenance costs of their three top attractions have been modelled against the number of rides that the coasters have performed before the maintenance begins. Since this is their first season of operation, they need you to predict trends in the data so they can account for maintenance in their park scheduling and profits. They have provided you the data in Table 1 below based on the computer simulations, where the data works from a base maintenance rate to maintain the ride in Canadian weather and increases with each successive ride. The data has also been provided in an excel file labelled "Rollercoaster Data.xlsx", which will help you directly work with the data. For this question, you have to prepare the data so the park executives have a better sense of how to handle important park decisions.

Table 1: Data for the top 3 rollercoasters at the new theme park as predicted by modelling software.

Rides (1000s)	Projected Maintenance Cost (\$)			Average	Uncertainty for Average [ $\pm$ \$]
	Ride 1	Ride 2	Ride 3		
0	491.17	480.63	525.20		
5	9534.03	7169.78	10140.66		
10	18201.08	18548.60	24827.60		
15	39508.82	31051.51	30001.60		
20	42339.78	28759.56	35857.18		
25	62746.83	54591.14	60017.32		
30	58146.52	61235.22	62645.08		
35	90481.07	94655.42	62424.60		
40	126468.27	101246.88	92410.95		
45	102520.76	90117.83	65021.51		
50	72896.83	96612.12	88309.51		
55	83710.46	98538.05	124458.19		
60	92206.05	116188.37	107619.46		

65	201440.96	168043.50	143974.43
70	126752.04	106697.55	136722.47
75	197664.27	164751.37	170710.54
80	218596.17	206180.40	241060.90
85	157654.18	132921.00	180384.35
90	223128.73	213673.70	355026.80
95	271719.01	213270.02	237832.97
100	1018819.87	1231921.58	1094466.72
105	1282768.16	1244943.41	688960.61
110	1300019.95	1045126.62	961060.37
115	1025760.79	1311712.36	1351102.84
120	1383563.72	1063405.87	1254725.52
125	1258600.83	1349345.97	974965.52
130	1901665.35	1642138.59	1571833.49
135	1686274.09	1263258.19	1654657.80
140	1213346.77	1274081.81	2044418.19
145	2299931.10	2263791.43	1475656.63
150	1845204.85	1414341.14	1411456.55
155	1636673.09	1480756.75	1409918.94
160	2104633.51	2157696.80	3380690.95
165	3065802.01	2970983.63	2184265.82
170	1882676.69	2319676.24	1993065.48
175	2645731.22	2136558.07	2113564.75
180	1830905.77	2271655.99	1871128.04
185	3941842.34	3606738.76	2401735.88
190	2006659.05	2613659.02	2093565.81
195	3012890.39	3035187.02	2368838.34
200	3928456.09	3246543.15	4580755.50

Due to the fact that these are the top three rides at the park, the average of the rides will need to be calculated to allow for maintenance cost prediction of future rollercoaster additions to the park. Since rollercoasters of different natures may attract different crowds, have different operating capacities and require differing styles of maintenance than other coasters, there is an uncertainty value associated with the average maintenance cost. The uncertainty has been defined as equation 1 below.

$$Uncertainty = \pm Average^{\frac{2}{3}} \quad (1)$$

Examining the data set, you may also notice that there is a point where the cost of maintenance has a large jump, then exponential growth. At that point, the ride has passed the window for a short maintenance and will need to go down for an extensive amount of time in order to ensure that all safety systems on the ride are also maintained due to the high number of rides. This jump is accompanied by an exponential increase in maintenance costs.

Once you have properly analyzed the rides to keep the park safe and operating for the current season, the park executives want your input to help determine which new ride in Table 2 they should invest in for next season. They have recommended using “maintenance correction factors” to account for

maintenance needs for attractions of different intensities, where a correction factor of 1 refers to a high thrill ride like those in Table 1 and a factor of 0 corresponds to a new show that can undergo nightly stage maintenance at negligible costs. This correction factor, denoted  $f$ , is applied to the slope of the **Average** trendline that will be determined from data in Table 1. Defining  $r$  for number of rides, in thousands,  $C_{avg}$  for average maintenance costs in \$, and  $m$  &  $b$  for the slope & intercept, the correction factor can be applied using equation 2 below.

$$C_{avg} = m(f)(r) + b \quad (2)$$

It can be assumed that each ride will be taken down for maintenance after 78 500 rides, and each ride system will require the same maintenance time at that point. Highly themed family rides can cost even more to build than some thrill rides, meaning you will have to use the data in Table 2 below to determine which ride would be the best for the park.

Table 2: Options of new rides for next season, including construction costs and the maintenance correction factor

Option	Ride Name	Type of Ride	Cost to build (\$)	Maintenance Correction Factor
A	Splashdown	Family Water Ride	7 050 000	0.49
B	Journey to the Enchanted Forest	Themed Dark Ride	11 760 000	0.56
C	Sabretooth	Moderate Thrill Ride	7 000 000	0.91

## 4.2 Steps to Follow

1. Transfer **Table 1** into an Excel spreadsheet. Calculate the average of all three rides using the AVERAGE() excel function, then use equation 1 to calculate uncertainty for the average.
2. Construct a scatter plot with **Rides (1000s)** on the x-axis and **Maintenance Costs** on the y-axis. There should be one (1) series on this plot, being the **Average calculated in step 1**. Add on error bars using the uncertainty calculated in step 1. This plot should be labelled **Figure 1**.

*Note: The error bars may be too small to be seen without changing the marker size. You should change the marker size until the error bars become visible, while still being able to see the points.*

3. Use the figure you constructed in **step 2** to determine the point where the maintenance costs become exponential. Once you have determined this point, copy that part of Table 1 into a new table that resembles Table 3 below. From there calculate the **Natural Logarithm (LN)** of the average and the uncertainty.

Table 3: Template for the exponential section of the data table

Rides (1000s)	Average Maintenance Costs (\$)	LN Average Maintenance Costs (\$)	Uncertainty Average [ $\pm$ \$]	Uncertainty LN [ $\pm$ \$]
---------------	--------------------------------	-----------------------------------	---------------------------------	----------------------------

4. Construct a new scatter plot with **Rides (1000s)** on the x-axis and **Maintenance Costs** on the y-axis. There should be **four (4)** series on this plot: the linear sections of Ride 1, Ride 2, Ride 3 and the Average. This plot should be labelled **Figure 2**. Add appropriate axis ranges, axis titles (with units), a **legend** using appropriate names for each series and the professional formatting presented in the excel tutorial module. Be sure to use **different colours** for each data series.

5. **Repeat** step 4 for the LN Average Maintenance Costs calculated from step 3. This should be the only series on this new plot. Please include the LN Uncertainty values as **error bars**. This plot should be labelled **Figure 3**.
6. Add **trendlines** to all four (4) series in Figure 2 and the one series in Figure 3, being sure to display all equations on the graph in the form showed by equation 3 below, where **m** is the slope and **b** is the y-intercept. Place each **trendline equation** next to their respective trendlines, using appropriate variable names. For Figure 3, note the y-variable is not the same as in Figure 2.

$$\text{maintenance costs} = m(\text{rides}) + b \quad (3)$$

*Hint: Define variables for maintenance costs and rides in your report before you present the figures. You may use subscripts in order to differentiate between the rides and the average.*

7. Use the trendline for the average series of the linear section to determine the maintenance costs of each of the options in Table 2. You may assume that each option will only be maintained once over the next season. Once you have determined the overall cost of each ride for each system, make a recommendation about which ride the park should invest in. You should consider not only the cost of the attraction, but also external factors, such as style of ride and the attendance it could bring.

In your report, show the steps for **one** of the calculations, using the **Equation** option in Word. In your steps, display the numbers up to **two decimal places**.

8. The fourth major ride at this theme park was not studied but can be assumed to follow the **average trend**. It has currently undergone 154 000 rides due to low ride time and high turnover, and the park owners realize they should undergo maintenance on it to maintain appropriate guest safety. Using your trendline from the linearized exponential section, determine how much it will cost to get this ride operational again.

*Hint: Don't forget that the linearized equation will give you LN(maintenance costs). You'll need to report your answer as simply maintenance costs.*

In your report, show this calculation as a **Sample Calculation** using the **Equation** option in Word. In your calculation, display the numbers up to **two decimal places**.

9. Moving forward, the park executives want to know how much they can expect to spend on maintenance on average for any one of their rollercoasters. Use **descriptive statistics** (in the **Analysis ToolPak**) to determine the mean and standard error of the **average maintenance costs** for rollercoasters. Ensure you check the **summary statistics** box and use a 68% confidence level. The average should be taken using **ALL provided data**, so be sure to use consistent units. Once you have determined these two statistics, place them in Table 4 below.

Table 4: The format of the table to present the results of the descriptive statistics analysis

Average Maintenance Costs Mean (\$)	Average Maintenance Costs Standard Error (\$)
-------------------------------------	---

### 4.3 Required Work

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.

#### 4.3.1 Introduction

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

1. An introduction to the scenario for which you are preparing this data. It could be as simple as discussing the simulation and the role you've been hired for, or as creative as naming the theme park and rides presented in Table 1. You may also choose to discuss cultural impacts of theme parks and thrill rides if it interests you. Cite any sources you use in IEEE format.
2. A brief introduction paragraph to describe the tables, graphs and equations that will be presented in your report. 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.

#### 4.3.2 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. The filled in copy of Table 1 from *Steps to Follow 1*.
2. Figure 1 showing the entire average trend from 0 – 200 000 rides from *Steps to Follow 2*.
3. The filled in copy of Table 3 from *Steps to Follow 3*.
4. Figures 2 & 3 from *Steps to Follow 4 & 5*
5. Equations of **All (5)** trendlines from Figures 2 & 3, presented using Word Equations
6. The filled in copy of Table 4 from *Steps to Follow 9*, created using descriptive statistics
7. The sample calculation from *Steps to Follow 8*, along with the answer for the predicted cost to maintain the 4<sup>th</sup> ride.
8. One of the calculations done for *Steps to Follow 7*. The results of your decision should not be presented in this section, but you may present **overall costs for all options**.

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.

#### 4.3.3 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 have two (2) short paragraphs:

1. A paragraph outlining the decision made on which ride from Table 2 you would recommend for next season. Reasoning should include the monetary costs, as well as any societal or additional factors you considered in making your decision.
2. Citing at least one source, discuss how this research could apply not only to park economics, but also keeping parkgoers safe. Your source must be cited in IEEE format and included in your **references section**. Ideas for this source include safety standards, engineering ethics or the importance of regular maintenance on rollercoasters to promote safe operation.

## 5. Question 2: Fossil Dating

Fossils are old enough that carbon dating is not effective, as the carbon has broken down to a level where it cannot accurately determine relative age. As such, potassium-argon and uranium 235 - lead dating can be used on the rocks around the fossil [3, 4]. Following the rocks cooling to a critical temperature, the extremely long half-lives of potassium and uranium 235 result in an ability to determine rock age with increased ease. This relationship is defined by the half-life equation and is a common fossil-dating method.



Figure 2: An ammonite fossil, estimated to have lived around 66-201 million years ago [8]

**Disclaimer: This scenario is entirely fictitious. The data has been taken from the scientifically accepted half-lives of potassium and uranium, sourced in the references section, but was then altered to create reasonable computer and regression analysis error. This data should not be used for any purposes other than this assignment.**

### 5.1 Problem Scenario

You've been hired by a Paleontology Company by the name of Rock our Bones to determine the age of some of the fossils that they have found on a dig in Morocco. They have provided you with a copy of the data that their supercomputer simulation uses to guess at the time of the fossils, and now that you are at the site, you will have to use the provided data (in FossilData.xlsx) in order to determine the age of the fossil at the dig site. The computer has built in error for the percentage of potassium and uranium left after a given amount of time, which may result in your data being different than the ideal half-life curve for the two elements.

They recently found a fossil of an Orthoceras, which had been estimated to have lived around the beginning of the Triassic period, between 252 -201 million years ago [5, 6]. In this question, you'll need to determine the age of the fossil using both potassium and uranium dating. The requirement of accuracy in testing also means that you will have to think critically about the data provided for the degradation of both elements and compare it to the ideal curves of potassium and uranium in order to numerically verify whether your estimate of the fossil's age is accurate. The half-life equation is defined by equation 4 below, where  $t$  is time,  $N(t)$  is the amount of parent isotope remaining at any time  $t$ ,  $N_0$  is the amount of parent isotope present at time zero (0), and  $k$  is the rate constant for a first order reaction such as half-life [7].

$$N(t) = N_0 e^{-kt} \quad (4)$$

Note: For the purposes of this data set, the quantities of  $N(t)$  and  $N_0$  have been combined to form the quantity of % remaining at any time  $t$ ,  $P(t)$ , where  $P(t) = \frac{N(t)}{N_0}$ , valid between 0 & 1.

## 5.2 Steps to Follow

1. Copy the data provided in the Excel File named "Fossil Data.xlsx" to a new Excel Spreadsheet. Be sure to include the units in the column headers.
2. Construct **one (1)** scatter plot that has both the **Potassium & Uranium** curves on it. Since these elements have different half-lives, this plot may look uneven in terms of timing. The graph should have **Time (years)** on the x-axis and **% Parent Remaining** on the y-axis. Select appropriate axis ranges, axis titles (with units), and professional formatting. A legend will be needed for this plot.
3. Use the plot created in step 2 to **estimate the half-lives** of both Potassium and Uranium.
4. Use the LN() function in Excel to take the natural logarithm of the **% remaining** for **both** Potassium and Uranium.
5. Construct **two (2)** scatter plots for the logarithmic data, being sure to have one (1) plot for **Potassium** and one (1) plot for **Uranium**. These plots should have **Time (years)** on the x-axis and **LN(% Parent Remaining)** on the y-axis.
6. Add **trendlines** to both logarithmic plots, displaying the equations on the graphs using appropriate variable names. These names and corresponding variables should be defined clearly in your report **before** you present these figures. Note that the Excel Trendline is the result of a linear regression, which places a line of best fit to the data.
7. Use Excel Analysis to complete a **regression analysis** of the **logarithmic Potassium** data with a 68% confidence level. Produce both residuals and a residual plot for the data series. **DO NOT** force your regression through the origin. Use the **Regression** option under the data tab.

**Reminder: You cannot access Excel Analysis unless you have enabled the "Analysis ToolPak" plug-in.**

*Note: Do not worry if you do not understand the meaning of the confidence level. Confidence levels are related to standard error and will be explored in APSC 102.*

8. Add Table 5 below to your Excel spreadsheet. Complete the table using the values found in **step 7**. You should refer to the written or video Excel tutorial for which numbers to include in Table 5. Notice that when you take the LN of a quotient with homogenous units, it will result in a dimensionless quantity with arbitrary units. This is shown by including units of (a.u.).

*Table 5: The format of the table to copy into an excel spreadsheet in order to summarize the regression analysis performed.*

Slope (years <sup>-1</sup> )	Standard Error [± years <sup>-1</sup> ]	Intercept (a.u.)	Intercept Standard Error [± a.u.]

9. Repeat **steps 7 & 8** for the **logarithmic Uranium data**. You may choose to consolidate the results of the two regression analyses into one table by adding an extra column and row to Table 5 that delineates the element for the given analysis.
10. The Orthoceras fossil has both Potassium and Uranium in the rocks around it. The senior lead at the site estimates that there is about 77% of the original Uranium remaining, and about 86% of the original Potassium remaining. Using these estimates, estimate the age of the fossil **using the equations produced from the regression analysis**. Do the two answers match up? Why might there be differences between the dating elements?
11. Calculate the half-life of both Uranium and Potassium using equation 4, and a  $P(t)$  value of  $\frac{1}{2}$ .

***PLEASE NOTE: Due to the restraints on the  $\ln$  function and the data set provided, you will have to treat percentages differently based on the equation you are using them in. If using the half-life equation presented by equation 4,  $P(t)$  is bound between 0 & 1. The data set that was provided to you left the percentages as numbers between 0 & 100 so as to make it easier to read on a plot. As such, when using equations produced by the regression analysis, you must use numbers between 0 & 100 for  $P(t)$ . You'll find the slope does not change on the  $\ln$  plots regardless of the range of  $P(t)$ , and neither does the value the slope represents.***

### 5.3 Required Work

Just like the first question, the report for this question will be split into three (3) sections: Introduction, Results and Analysis, and Conclusions.

#### 5.3.1 Introduction

For this introduction section, you will need two (2) short paragraphs:

1. An introduction to this scenario. This should include all the relevant information about the dig site, the fossil and the computer simulation that was presented by the question. You may also choose to add on any additional information that you feel may enhance the reader's understanding, citing any sources used in IEEE format.
2. A brief introduction paragraph to describe the tables, graphs and equations that will be presented in your report. 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

This results and analysis section has fewer physical results, but more analysis. For the results, your report must include all the following, in any order that keeps the flow of the report intact.

1. The plot from *Steps to Follow 2*
2. The two (2) plots from *Steps to Follow 4* & the residual plots from *Steps to Follow 7*
3. The filled in copy (or copies if you left the tables separate) of Table 5 from *Steps to Follow 8 & 9*
4. The estimated age of the fossil from *Steps to Follow 10*, showing the sample calculations for one (1) of the elements. The final answer should include both estimates compared against each other.

- The half-life of Uranium and Potassium from *Steps to Follow 11*, showing the sample calculations for **both** elements

In terms of analysis, there are a few questions that may be interspersed throughout this section at your discretion, or simply placed at the end of the section; whichever choice makes the report flow best is the choice you should make. These analyses include:

- A short paragraph discussing the differences between the answers from the dating techniques for the age of the fossil from *Steps to Follow 10*.
- What does the slope of the trendlines on the LN plots represent? Use Word equations to present the LN form of the half-life equation for both elements from **the regression analysis**. Present the slope as what it represents for both figures, making sure to use appropriate units and error.

*Hint: It may be helpful to present equation 4 from this document in order to define the ln form of the equation. This may also help you determine exactly what the slope represents.*

- The actual half-life of Potassium is 1.28 billion ( $10^9$ ) years, and the half-life of Uranium is 704 million ( $10^6$ ) years [4]. Construct a table depicting the estimated of half-lives *Steps to Follow 3*, the calculated half-lives from *Steps to Follow 11* and the actual half-lives. Are your calculations within error of the actual value? If it is not within error, what are some potential reasons for this?

*Hint: To determine the error of the half-life, take the error from the slope of the regression analysis, denoted  $\delta k$ , and use it in equation 5 below. You will learn how to determine this equation for yourself in APSC 102. The error for the half-life has been denoted  $\delta t$ .*

$$\delta t = \pm \delta k \left| \frac{\ln\left(\frac{1}{2}\right)}{k^2} \right| \quad (5)$$

### 5.3.3 Conclusion

In this conclusion, you'll need to think critically about the equations and the answers they produced in order to determine the accuracy of your answers. This will be split into three (3) short paragraphs:

- For the purposes of these calculations and the regression analysis, the half-life equation was changed so that  $N(t)$  and  $N_0$  became  $P(t)$  for the percent of the parent isotope remaining at any given time. Why was this change necessary?
- The computer simulation did not provide an ideal half-life curve when plotted. Though you calculated whether your equation was within error in *Analysis 3*, are the equations that the regression analysis produced still good fits for the data? A good answer should reference the residuals plots presented in your *Results & Analysis* section.
- Is the answer for the age of the fossil within the range of the Triassic Period? How might you present this data to colleagues, including any relevant assumptions that were made? You may choose to include more information about the fossil, in which case cite your sources in IEEE format and include it in your references section.

## 6. References

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