Title of the report

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Abstract

This is a template of the formatting requirements for the report of Practical 1, as part the assessed assignments of MECH5465M Experimental Methods and Analysis module. Please keep 1.5 spacing between the lines throughout the report. The Abstract should be a concise statement of the problem, approach, findings, and implications of the work described within a single paragraph. The abstract should be maximum 500 characters without spaces, use Microsoft Word/Tools/Word Count to check that your abstract is within the eligible length limit. Do not change the size and style of the fonts in this template when preparing your report.

1. Introduction

The heading of a section should be in Times New Roman 11-point bold. Sections should be numbered and in sentence structure. Generally, everything but the title is Times New Roman 11-point font. Do not modify the margins of the document. The report should be maximum 5 pages long, including the title page, the 4 mandatory figures, conclusion, and references. Include a brief description of the problem of interest here. It is important that you include all the information within this page limit. Note that you will not lose any mark if your report is complete but is shorter than 5 pages. All figures and data included in this report will be assessed. On each numbered page, your material should fit and be justified within the margins of this template in a single column. Headings of sub-sections should be in Times New Roman 11-point bold. All figures and their captions must be centred in the page. Arial font should be used in all figures. Fonts on the figures should not appear smaller than 10-point on this document.

2. Experimental methods and analysis

Include the description of the experimental setup and the measurement variables and parameters in this section. The first figure of your report, Figure 1, should be placed in this section. Figure caption should be in Time New Roman 11-point. Figure 1 must include two panels: a and b. Write a and b in between parentheses on the corresponding panels, similar to the figure provided on slide 13 of Week4_Lecture4-1. Panel (a) must show a schematic of the cantilever beam identifying the displacement. This can be similar to, but not copied from, the schematic of the cantilever in the slides. Panel (b) must show an example graph of displacement versus time, recorded using ReLOAD at the preliminary settings for damping, duration, and filtering frequency, as indicated in Week4_Lecture4-1. Do not forget to submit a copy of the Excel file with all your raw and analysed data at the time of

the report submission. When referring to figures in the text, mention both the figure number and the panel reference, if applicable. For example, use Figure 1a to refer to panel (a) of figure 1.

3. Results and discussion

At the beginning of this section describe a summary of the results. Mention the number of runs, repeats and different setting parameters that you used for this practical. A separate PDF file representing a table of four columns including run number, and values of damping, duration, and filtering frequency, used in your experiments, should be submitted at the time of the report submission. You do not need to include the table in this report.

3.1. Cantilever beam vibration

Start with an example of the raw data acquired with 'no filtering' for the duration of 10 s using ReLOAD. Calculate the mean of the signal and use the mean to centre the signal/time series at 0. Include Figure 2 with panels (a) and (b) in this subsection. Panel (a) should include the graph of displacement versus time for the centred signal, using the average. Panel (b) should include the mean and the variance of the signal in time. Calculate the mean and variance **over every period of the signal** in time and plot the values on a single graph versus time in panel (b). Identify if the signal is stationary or non-stationary and discuss the reason by referring to your data in Figure 2(b). Refer to slides of the Week3_Lecture3-2 for examples of similar discussions on signal stationarity.

3.2. Measurement of natural frequency of the beam

Include results and discussions on natural frequency of the time series acquired with 'no filtering' setting here. Analyse the signal in both time and frequency domains and compare the results in the subsections 3.2.1, 3.2.2 and 3.2.3, respectively.

3.2.1. Time domain analysis

The average natural frequency of signal can be calculated by dividing a specific duration of the signal by the number of oscillations in that period of time. Therefore, you can calculate one mean value for every signal that you record. In order to have enough statistics, repeat your experiments at these settings (no damping, no filtering, fixed duration) at least 3 times. Report the value of mean main frequency of the signal (the natural frequency), its standard deviation and standard error in your experiments. Discuss the impact of duration and number of repeats on your statistics.

3.2.2. Frequency domain analysis

Average the multiple signals that you have obtained through repeats and discussed in 3.2.1 to generate a single mean signal in time for the same duration of recording. For the average signal, perfom the FFT analysis using Excel/data analysis/Fourier Transform function. If you cannot find the Data Analysis in the tab Data in Excel, follow the guideline at https://support.microsoft.com/en-us/office/load-the-analysis-toolpak-in-excel-6a63e598-cd6d-42e3-9317-6b40ba1a66b4 to add the toolpak in Excel. Remember that Excel requires a power of 2 data points for FFT analysis. If you are not familiar with FFT analysis in Excel, the link to a tutorial was

provided in Week3_Lecture3-2. Include Figure 3 with panels (a) and (b) in this subsection. Panel (a) should show the average signal in time and panel (b) should include the FFT analysis. Panel (b) is a graph of magnitude of FFT versus frequency. Identify and report the natural (main) frequency of the signal, based on the frequency of the maximum amplitude of the FFT results. Similar graphs were discusses in Week4_Lecture4-1.

3.2.3. Comparison between the time and frequency domain analyses

The purpose of this section is to compare the natural frequencies calculated using time and frequency domain methods. List your mean values calculated using the time domain method. These should be at least three measurements. From the FFT analysis, you will obtain one single measurement corresponding to the frequency of the maximum FFT amplitude. However, note that due to the discrete nature of the frequency domain in the FFT analysis, the frequency of the maximum magnitude of FFT of the signal falls in the range between the two values of the frequencies located right before and after the frequency of the apparent maximum. Please refer to the discussions of Week4_Lecture4-1.

For this comparison, consider the three frequencies associated with the largest FFT amplitudes as your three measurements of signal main frequency, using frequency domain method. Establish the statistical null and alternative hypotheses for this comparison, refer toWeek2_Lecture2-2 for examples of similar analyses. Perform a t-test, using the Data Analysis in Excel, between the frequency values of the mean main frequencies calculated in time and frequency domain methods considering a 5% level of significance and a two-tailed test. Report the P-value and make a statistical conclusion comparing the two values.

3.3. Sampling and filtering frequency

Based on the average natural frequency of the signal calculated in section 3.2, estimate the Nyquist rate. Report the Nyquist rate in one significant digit in Hz by rounding up the estimate. Perform the experiments with no filtering, and filtering rates equal to the Nyquist rate and smaller and larger than this rate. Plot the displacement versus time for these four conditions in Figure 4 that should be included in this section. Do all recorded signals correctly capture the significant features (amplitude and natural frequency) of the original data (with no filtering)? Answer to this question and include a brief discussion on this topic in this subsection.

4. Conclusion

Briefly explain what has been done during these experiments and the conclusions that have been made based on various data analyses methods.

References

Include any references, such as articles, online websites, online videos, books in this section. References should be numbered in the order of citation in the text. Follow the APA 7th citation (https://pitt.libguides.com/citationhelp/apa7) to style your citations in this section. In order to cite a reference in the text mention the number of citations in square brackets as a superscript, for example [1].