


KERTAS PENERANGAN

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OPEN-ENDED LABORATORY INSTRUCTION SHEET

1.0 Introduction

Laboratory work is full of activities. In the laboratory, one would find equipment, gadgets, measuring tools, sensors and electrical equipment that are related to the research or experimental activities. Some equipment is monstrous and others could be kept in a small box and place in the laboratory cabinet. There were also safety instruments that responding to the fire and health hazards. Anybody working in the laboratory should be aware the location of these safety equipment.

Basically a lot of time is spent in the laboratory because conducted experiments took a long time to complete. However there are a few exception where the intended experimental works test rig are available and its related instrumentations are believed to provide good measurement data. If new students started working in the laboratory, they should realize the initial position they are working with. Starting a new in a laboratory, the students should be acting as if they are scientist or engineers. Their attitude towards working in the laboratory should be guided by the ethics, rules and regulations. The actual working should be originating from the scientific method where experiment or project must be thought out thoroughly.

In this particular laboratory works, students are expected to applied techniques taught in the **MAKMAL KEJURUTERAAN MEKANIKAL 2A, BMCJ 2931** lectures. These skills are supposed to be gain by providing a hard and smart works. Lecturers and laboratory technicians are available during laboratory session and could provide good advices and guidance as how to use measuring instruments and conducting experiments correctly and safely.

2.0 Hypothesis

Before any intended laboratory works begin, students should plan their work. The objectives of the experiments should be scrutinized carefully. Students should asked

questions pertaining to the experimental topics or projects at hand. These second year open – ended lab works are related to the topics covered in the lectures. **Examples of the projects include a refrigeration system, fluid friction and others.**

Hypothesis is presented because it would become a strong statement when proven right. If everybody in this world proves that the hypothesis is right, then it became a thesis. The next relation would be a new theory arises. **The hypothesis would come from many sources and the most interesting is from our own observation.** One would like to ask question like what is the relation between considered parameters. Hence thinking about a problem and giving solution to it is natural and the phenomena studied were worded correctly to form a hypothesis. **The hypothesis can be worded as follows:-**

‘The measurement made using a highly precise instrument is more accurate than measuring using crude and cheap ruler’

or

‘The volume measured using good measuring equipment is lower than using a crude cheap measuring ruler’.

Hence, a hypothesis is a reflection of the thinking or study done by a researcher. In practical term, a hypothesis should be related to the work at hand especially when it relates to the engineering experimentation. In short, hypothesis is a statement that resulted from a properly defined problem.

3.0 Objectives

Hypothesis is postulated when we are interested with the phenomena that we wanted to study. To prove the hypothesis, there are many other steps that are to be followed (as stipulated by a scientific method). The first and foremost is to extend or explore in depth the made statement (hypothesis) in detail. Let us consider an example from the given hypothesis above. **The objective might sound like:-**

1. *To calculate and compare area and volume of an object using three different measuring instrument.*

or

2. *To establish factors that influenced the frictional effect of two different materials surfaces when rubbing horizontally.*

In essence your objectives would be what you want to do or rather what are the works you need to show so that your hypothesis is proven right.

4.0 Methodology

The next step of the laboratory work is to plan how to carry to achieve the objective. Here, the students should think of **three most important factors** in conducting experiment. As iterated in much **project management theory, factors of human resource, time and equipment (money) are of outmost important to consider.**

Group members are to be introduced, making friend along the way and share the anxiousness of completing the experiment and curiosity what to do next. Plan to optimize time should be presented because of the initiation and ending of a project is vital. **If you are given four weeks to complete your assignment, plan as how many hours you should spent doing the experiment outside the formal laboratory session.** Last but not least is to gather and study the kind of equipment and instrument that you are going to use to gather and record your experimental data.

5.0 Experimentation

Any experimental endeavor must be carefully crafted especially the experimental procedures. Precaution should be the order of the day when comes to the use of heavy equipment. Normally the procedure started with linking (integrating) all relevant connection (circuit) before switch on the equipment, if any. **The independent and dependent variables must be separated and their relation must be presented.** Variables to be measured and recorded will come from the equipment themselves. This means if velocity is to be measured, use of velocimeter is recommended. Hence all the relevant variables need to be considered well before starting the experiment. **In this case, any theory related to the hypothesis and objective need to be studied. Any comparison, either similarity or differences, will be used as guideline to the experiment. Good data keeping will enhance the reliability of the experiment. Repeating the experiment more than three times will help at the arrived conclusion as verification process has been undertaken.** Hence starting with switch on and ending with test rig shut down, the engineering experimentation need to be safe and the gathered data should be as good as one wishes. All code of conduct and procedural guideline from the equipment manual should be referred when in doubt.

Apart from the precaution and procedures to follow, the real experiment is to be conducted at various settings or conditions. These necessary conditions are the variation to the experimental scope. All considered scope, if considered, will portray the actual 'result' of any experiment.

The limiting case would be some experiment range, for example, we do this experiment of establishing pipe effect to the exposed temperature from 60 °C to 200 °C. Other researchers are conducting similar experiment but with 100 °C – 500 °C temperature range. Another aspect to consider is to state any assumption made. With this the experiment will looks more practical and results were believed to be true. **Hence the hypothesis is proved and the objectives achieved.**

The engineering experimentation especially when comes to the product development and performance testing is an expensive business. The students cannot afford to neglect the precaution and procedures since any undue mistakes or blunder will cost money (for repair and calibrations work) and worst still will cost us life. God forbid.

6.0 Data Tabulation

Before data gathering exercise is done, data arrangement or tabulation must be thought off. Three common variables involved here i.e. constant, dependent and independent variables. Experimental must cover reasonable range in order to establish the trend and at later stage to form the relation. Simple example would be the variation of mass weight from 0.5 kg to 10 kg in 0.5 kg increment. Thus a beam deflection of due to the force increment can be established ranging from light weight to the common operating load. Independent variable will be the mass weight and the dependent variable will be the beam deflection. **Students are expected to draw their own tables to present the collected data. Caption with proper numbering system must be shown.** *Caption for table is placed at the top.* Unit of the variables are included if these help the readers.

Order of magnitude must be right. If there is need to present data in scientific notation, it must be done correctly. This goes with the significant figures and round-off guideline. **Tabulated data is very important because it is the first step to draw any initial conclusion about the experimental trend.**

7.0 Data Analysis

Experimental data is very important as long as the data is used to draw some conclusive evidence about the experimented phenomena. Basic data analysis is to make some general statement with regard to the data arrangement, range, increment or decrement of values as well as relation between the considered variables. **Graphs are used to represent the data in terms of algebraic relations.** This is what is called the basic data analysis.

The advanced data analysis is where the phenomena is described and discussed deeply. The phenomenon is reflected by the data with the help of many other findings that were postulated by researchers all over. This is where the literature review is important in shaping up to explain the project phenomena or enhancing the experimental finding. **The literature survey is always done prior to the experimental undertaking so that background materials with regard to the project, experiment or subject matters are better understood.** Again any found relation can be forwarded by means of graphs or algebraic equations of some order. *Graphs can be of linear or log form.*

In measurement or experimentation, data are bounded by many errors, to name a few, such as systematic error, random error and personal error. Absolute and relative errors are to be presented if necessary. This is more so when the experiment needed to show the error rose in the experiment. Hence error analysis is part of the overall experimental data analysis.

Discussion on the experimental data is always geared toward to prove the hypothesis. Adding up the data analysis with the discussion that compare and contrast with the existing facts will derive the researcher to make conclusion about the project or experiment.

The students are expected to tabulate the experimental data nicely. Graphs are to be shown using good standard available software. **Discussion on the subject has to be made in view of other researcher works so that any additional information about the phenomena will help enhancing the existing knowledge or may validated previously made statement.**

8.0 Report

The last step in scientific method is to communicate the experimental result with other interested party. This is done by many means including writing a good report. In this course, students are expected to present their works in form of a report. Many report formats have been introduced. It is expected that the students are adopt the best standard practice in report writing.

The steps to be taken in **writing a report** at least consist of the following items:-

- a. Title
- b. Objectives
- c. Introduction & Theory
- d. Procedure and Apparatus
- e. Data and Result
- f. Analysis and Discussion
- g. Conclusion
- h. References

8.1 Research/Project Proposal

The students are required to discuss in their group as how to manage this project. **The given time is four (4) weeks.** The **first week** will be used to **get to know the assignment better** by talking and asking questions, amongst group member or asking lecturer and/or technician regarding the experiment. The **second until fourth week** are spent on **presenting a research proposal, conducting experiments, discussion and writing report.**

The **second week assignment** wills focused on the **group research proposal** which at least consist of the following items:-

1. Hypothesis and Objectives

Having read some background materials on the relevant subject matter, the students are expected to have some useful information. In this respect, students are supposed to write their own hypothesis in view of their experiment. The

objectives are also required as this will form a strong structure of engineering report.

2. Literature review/background studies of subject matter

If more reading is done, the better understand one becomes. Facts and figures from various sources and researchers are sought so that in discussion section, this information can be used to support the arguments.

3. Methodology – identification of variables, experimental procedures, apparatus, data tabulation, graphs to be plotted

In this section, students are supposed to present the overall activities related to the conduct of experiments. Flow charts, Gantt chart, graphs, tables, figures and other diagrams are used extensively here. Picture of apparatus, standard data and physical constant, techniques and software used should be the main component here. Students need to sketch and fill table with experimental data.

4. References/Appendix

All the relevant references and appendix should be attached to the research proposal. This is a permanent document that the data needs to be verify in the future and in this respect references and appendixes should documented properly and be rightly done.

The research/project proposal must be shown for approval to the respective lecturer before the commencement of the laboratory work.

9.0 Assessment Methods

The effort to undertake an open-ended laboratory session will be appreciated if grades are given appropriately. In this case, we have employed a few means to evaluate students' performance. The performance of students is based on the following item:-

- 1. Group Formal Report**
- 2. Individual Formal Report**
- 3. Group Informal Report**
- 4. Direct observation**