

**DEVELOPMENT OF MONITORING UNIT FOR DRILL BIT VISUAL  
INSPECTION USING DIGITAL MICROSCOPE**

By

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School of Aerospace Engineering

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**Declaration**

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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.....(candidate)

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## List of Abbreviations

NDT	Non-Destructive Test
CAD	Computer Aided Design
3D	Three-dimensional
ABS	Acrylonitrile-Butadiene-Styrene
PLA	Polylactic Acid
STL	Stereolithography

## Abstrak

Tesis ini membincangkan kajian untuk membangunkan unit pengesanan untuk pemeriksaan visual mata gerudi menggunakan mikroskop digital. Unit ini dibangunkan untuk menyokong program komputer pengesanan kehausan yang dibangunkan untuk mengkaji dan memeriksa haus dan lusuh pada bahagian bibir pemotongan bit gerudi. Unit ini dibangunkan dengan beberapa perkara yang sentiasa diingat; gerakan paksi (paksi-x, paksi y, dan paksi z), penempatan dan penjajaran kamera, kestabilan, bahan yang digunakan, dan kaedah fabrikasi. Percetakan 3D dan pemasangan mekanikal diamalkan dalam proses fabrikasi. Unit pemantauan juga dilengkapi dengan sistem pencahayaan. Sistem ini memberi tumpuan kepada memberikan lampu optimum ke arah kawasan bibir pemotongan bit gerudi. Pencahayaan diubah suai supaya ia memancar pada sudut  $50^\circ$ , untuk menyesuaikan bit gerudi jenis  $140^\circ$  yang digunakan dalam kajian ini. Apabila diubah suai dengan cara ini, cahaya yang dicerminkan akan memperlihatkan secara serentak ke arah lensa kamera. Apa yang menjadikan ini istimewa adalah cahaya yang bertindak begitu adalah hanya cahaya yang dipantulkan oleh kawasan bibir pemotong sahaja. Ini adalah dikehendaki dalam membuat imej yang ditangkap menghasilkan imej yang mana kawasan bibir pemotong mudah untuk dibezakan dengan kawasan lain. Cara lain pencahayaan diubah suai adalah dengan menyambungkan potensiometer untuk mengawal intensiti cahaya. Keamatan cahaya optimum adalah keperluan yang penting juga, kerana terlalu banyak pencahayaan hanya akan menghasilkan imej yang kabur yang rendah dalam kualiti. Untuk membuat cahaya dipancar daripada sudut  $50^\circ$ , motor servo telah digunakan untuk ketepatan dan kebolehubahsuaian. Servo dikendalikan oleh mikropengawal diprogram untuk tugas ini. Pada akhir kajian, imej dengan kualiti yang diharapkan telah dicapai dan dengan itu unit pemantauan ini sedia untuk digunakan.

## **Abstract**

This paper discusses the study of developing a monitoring unit for drill bit visual inspection using digital microscope. The unit is developed as to support a wear detection computer program developed to study and inspect wear and tear on cutting lips of drill bits. The unit is developed with several things being kept in mind; axial motion (x-axis, y-axis, and z-axis), camera placement and alignment, stability, material used, and fabrication method. 3D printing and mechanical assembly were practiced in the fabrication process. The monitoring unit also comes with an illumination system. This system focuses on giving optimal lighting towards cutting lips area of drill bits. The lighting was customized so it projects at the angle of  $50^\circ$ , to match the drill bit of the type  $140^\circ$  that this study is focusing into. When customized this way, the reflected light shall project perpendicularly towards camera lens. What makes this special is the light that does that only are the ones reflected by the cutting lips area only. This is a favourable in making the image captured are one with cutting lips area distinguishable to other areas. The other way the illumination is customized is by connecting a potentiometer to control light intensity. Optimal light intensity is a need too, because too much lighting will only produce a distorted image that is low in quality. To make the light projects at  $50^\circ$  angle, servos are used for accuracy and customizability. The servo is controlled by programmable microcontroller for this task. At the end of the study, image with expected quality was achieved and thus the monitoring unit shall be ready for use.

## Chapter 1 Introduction

### 1.1 Brief Introduction

Drilling plays a big part in a wide range of industries there are; aerospace industry is one of them. Since the industry is known to be conservative, which means that it typically makes use of assembly methods that are proven to be working in the past, this should hint that the conservative method of assembly, the drilling and fastening will not change for long from now. While the drilling method may be proven working and all, the method of inspecting drill bits can always be improved since it is relatively easier to improve that compared to change the assembly method instead.

To avoid defects mainly, the practice of inspecting drill bits is usually made compulsory in the aerospace industry. This is to ensure that defected drill bits are not used on good products, which will lead to worse consequence in quality and cost. The inspection process in aerospace is significantly critical. The requirements are usually set tight, and even then, a company should deal with further requirements from customers.

This project suggests that a monitoring unit should be developed for the inspection process. The unit will be equipped with a digital microscopic camera as the drill bit image-capturer and a computer program so that the drill bit can be inspected using image processing method. The method is thought to be good because minimizing the interference of human senses should increase the accuracy and speed of an inspection process. The unit should be able to carry out inspection with immediate result.

The unit would be designed with several factors kept in mind. The axial (x,y,z) motion control is to be taken into consideration. Camera placement and alignment will also be taken care of along with stability. Material selection will be chosen from the ones that are easily accessible ones. Fabrication method will be done manually and will be aided by the existence of the 3D printer available for more complex parts.

## 1.2 Problem Statement

The industry's current practice of monitoring and inspecting drill bit still depends on the use of human senses, normally visually, by touch, or both. As renowned as it is, the practice is doubtful for its accuracy. That would be because human perception and judgement are inconsistent, and are susceptible to being manipulated at that. With this inaccuracy, it can cause, companies could suffer loss, since inspectors can scrap drill bits pre-maturely, or worse if he allows the use of defected drill bits on the company's goods.

Besides that, a skilled or an experienced inspector would be needed for the current practice of monitoring and inspecting process of drill bits. To hire a skilled worker would be costly given the skills. To train a worker to be an equally skilled inspector could be as costly as to hire a skilled one. Either way, companies' resources will be affected anyway with the current practice.

The customers' demands on the other hand are tight with their requirements and usually are quite firm about it. This puts pressure into the industry in terms of the accuracy and quality of their products. It is to be understood that the drilling part is one of the major concern of these requirements. That means the industry should thrive for a more accurate result on their products all with the growing customer demands.

These call for a solution, that is to minimize the involvement of human senses or the need of an experienced worker in monitoring and inspecting process. For that, a monitoring unit will be developed and tested, which requires a computer program and a digital microscope as the sensor to capture images of drill bits for inspection.

It is not like there are no digital microscope with stand on the market, it is that they are not specifically designed to capture images of the cutting lips of drill bits. The thing is, a drill bit is to be captured while the camera is positioned towards the top part of the drill bits, which is unique since the many stands in the market are mainly to capture rather flat specimens. Some earlier stands being used for the study are between

them. They all needed to be reassembled and customized rather complexly just so the drill bits would fit under the camera lens. The bad thing about this is that it makes work unnecessarily complicated and long and that the adjustments made to them forced us to sacrifice things in the likes of accuracy and consistency.

The other problem with the ones in the market is that even when the one that suits the study's need is found, chances are that it is overly expensive. Such digital microscope stands are of the higher-end ones, the ones that equipped with high quality cameras and extra fine precision at adjustments, giving us the extra accuracy and precision at the rate which beyond over what this study needs at the cost of a very high price tag.

The study was expected to solve these problems as well. It would be customized to focus on capture drill bits' cutting lips at enough accuracy and consistency that we would later test while keeping the price tag low.

### **1.3 Objectives**

In this project, the objectives are:

- 1) To design and fabricate a monitoring unit that is focused to capture cutting lips area of drill bits.
- 2) To run tests on the fabricated unit to validate its usability.
- 3) To perform monitoring and inspection using the monitoring unit.

### **1.4 Scope of Work**

The development of a new monitoring unit is a critical task. It shall require some amount of work to be done in the right manner to achieve good results. The right manner would be to research, design, fabricate and then to test the developed result itself.

The research part was done by studying older papers that are expected to help the project; studying what each lack and what good each can contribute. They are summed up in the Literature Review chapter.

Design happens all along the study. The longer the study takes, the more things came into play; the more the designs change. Anyway, this part starts by sketching ideas which later turned into more complex and precise design.

Fabrication part is when the design is made in realization. The fabricated product would be tested at whence we will know whether the design would pass or not the requirements of the study.

## **1.5 Thesis Outline**

In this thesis, there are five main chapters that designate details from introduction until conclusion of this study. They all make up this thesis into one meaningful entry to be read and understood for their contents.

Chapter one is the introduction of this study. It describes the whole study by stating the brief introduction of the topic, problem statement, objectives and scope of work.

Chapter two signifies the literature review and theoretical background for the thesis. Papers and studies that have been made are studied upon and be compared to achieve higher understanding of the study and gives early ideas for the study.

In chapter three, the methodology of the project is clarified. It mentions step by step the methods used to finish the study. Things like design, fabrication and tests are explained deeply by sequence and order.

Chapter four provides the results of the analysis done in this study. It shows the results of the tests and the many analyses that have been made to validate the study's objective.



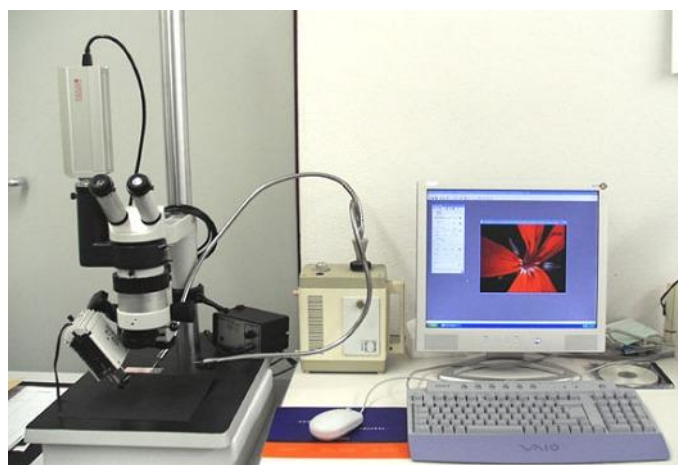
Chapter five is the conclusion of this project. This chapter concludes the study. In doing so, some recommendations for future study are slipped into for the case of newer studies focusing to better the results of this study.

## Chapter 2 Literature Review

### 2.1 Image Processing

There are some fundamental steps in doing image processing. Image acquisition simply means to acquire the digital image. Image pre-processing is a process to improve images so that the chances for success of other processes increase. Image segmentation partitions an input image to constituent parts. And then we have image representation that is to convert input data to a form that can work with computer processing. And that leaves image recognition and image interpretation on the steps where it is to provide meaning to the image processing[1]. These fundamental steps should explain the methodology of image processing a bit.

Microscopic image processing has been invented and used since long ago. It has shown some constant improvement and increasing use in many fields there are. The method has proven to be used with great success. It allows us to peer into parts that are too small to see with unaided eye. Most times of today, the images obtained from microscope are converted into digital form for storage, analysis, processing, and then interpretation. Because of that, digital processing has been an integral part microscopy[2]. This is what expected to be done in the project.



*Figure 2-1: A setup of microscopic image processing*

## 2.2 Wear Measurement Tool

A wear measurement system for drill bits was proposed in a study in 2006. The setup was to consist of a CCD camera, a macro lens, a circular light, a PC for image processing, and suitable software. The process was carried out by a CNC machining centre. The image of the cutting lips is captured by the CCD camera via a back-lighted source. The image then was registered for image processing[3]. It is as shown in figure below. The focus of the study was to measure flank wear of drill bits with different coats, which is a bit too analytical and less practical in the industry[4]. Our study suggests that the monitoring unit can be easily adapted in the industry.

The tools used were heavily customized just so that the tools can handle the unusual height of drill bits. The study will focus on making a monitoring unit that is easily usable to detect wear on drill bits.



*Figure 2-2: Wear measurement tool*

## 2.3 Illumination System for Drill Bit Wear Inspection

Light importantly affects picture review and estimation. On the off chance that the chose enlightenment framework is appropriate, an astounding picture can be procured, which benefits the resulting picture review and estimation. The PCB boring

apparatus edge and the required assessment things demonstrate that if a picture investigation is actualized for a PCB bore, a great quality picture is required. Be that as it may, the two sharp edges of the PCB boring tool point cross spatially, and the edge between them is around 130 degrees as appeared in figure below[5].

In this manner, a great nature of picture can't be gained utilizing regular brightening types of gear. Since the imaging of CCD predominantly lies on the force of lights sparkling in CCD and reflecting from articles, if the lights reflecting from the surfaces of the deliberate and assessed objects can't sparkle in CCD, the picture might be dark or not clear[5].

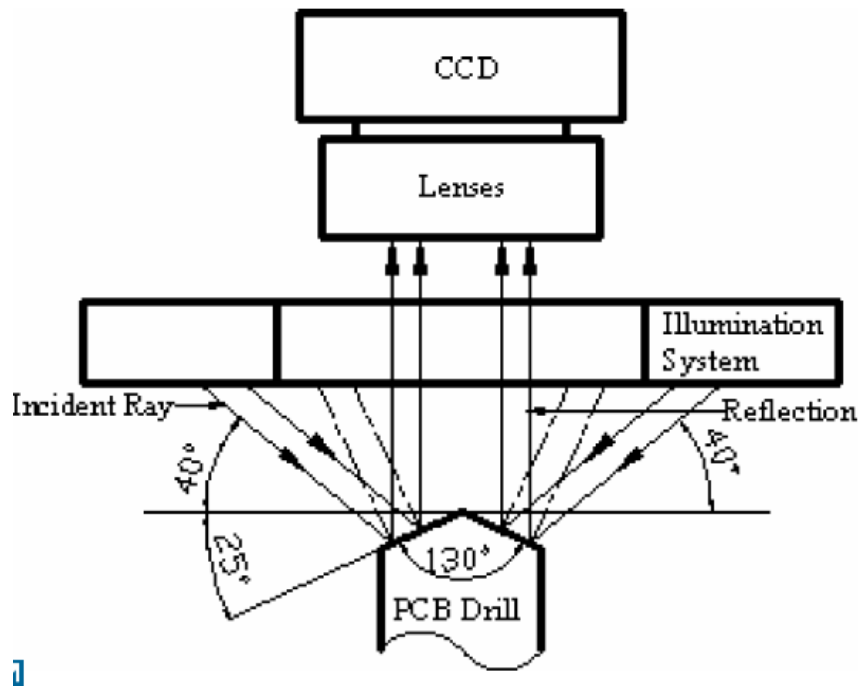


Figure 2-3: Law of illumination

## 2.4 Mounting Camera on a Microscope

Regularly, the camera is mounted specifically on a C mount string without screwing an imaging focal point into the camera. In such a case, the photograph recognizing surface, be it a tube or a CCD chip, must be situated at either the transitional picture plane or the anticipated picture of the middle picture plane. On the

off chance that the distinguishing surface is situated at some other plane, one will see that the concentration for the example in the oculars will be not the same as the concentration expected to acquire a picture on the screen[6].

This speaks to something other than a bother; the picture quality as observed by the camera will be not as much as ideal, because the target remedies are intended for a picture that is anticipated to the outline separation of the transitional picture plane. This implies one ought to buy video connector tubes that are intended to be utilized on the specific magnifying lens one is utilizing[6].

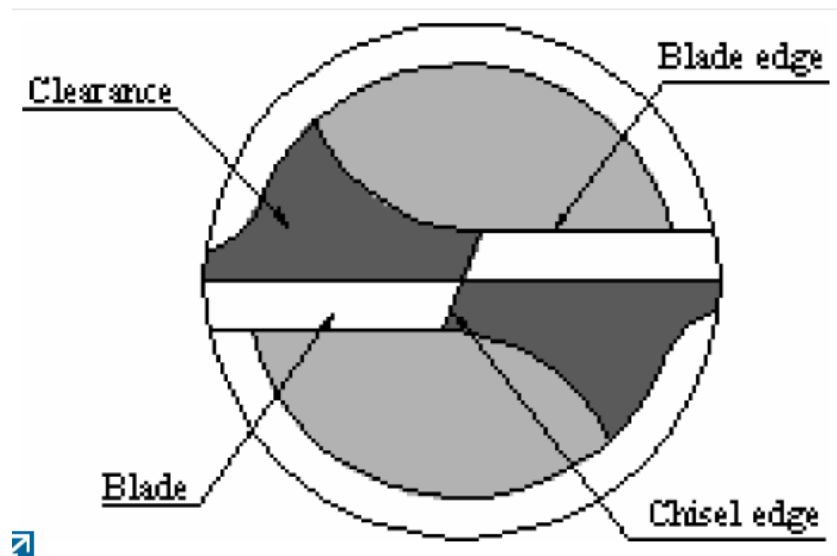
Even though not usually utilized, a moment approach to mount a camera is to utilize an anticipating visual to frame a genuine picture of the example on the distinguishing surface of the camera. In such cases, it is vital to utilize an anticipating visual because a regular visual won't create a genuine picture of the example on the photograph distinguishing surface unless the camera is put at a terribly unseemly area.

If one is to utilize a traditional visual, an imaging focal point, for example, one used to picture open air scenes, must be mounted on the camera. The camera is put on a rail or stand near the visual with a light-retaining sleeve between the visual and the camera focal point to piece stray light.

In such a case, the camera focal point ought to be set at interminability with the goal that slight changes out yonder between the visual and the camera focal point won't change the concentrate of the picture on the photograph identifying surface. This is a useful concern when one is utilizing a magnifying instrument in which the entire head moves when one changes centre.

## **2.5 Cutting Lips Area**

There is a need to distinguish the cutting lips area from the rest as to ease the wear calculation. The image below represents the typical different drill bits' areas captured when captured from top of a drill bit. There shall be blade (cutting lips), blade edge, chisel edge and clearance[5].



*Figure 2-4: Top view of common drill bit*

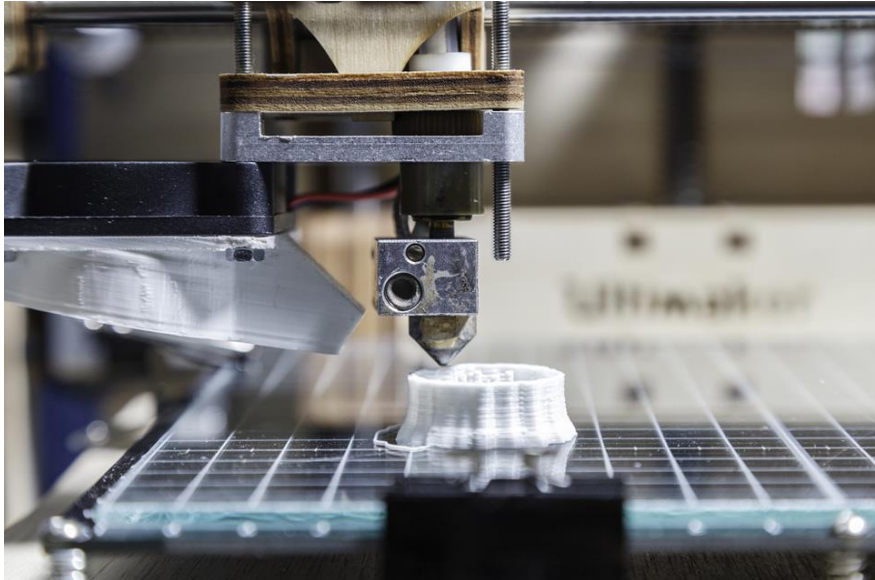
## **2.6 3D Printing**

Over the most recent couple of years, 3D printing is getting increasingly famous and utilized as a part of many fields going from assembling to modern plan, design, restorative support and aviation. 3D printing is a development of bi-dimensional printing, which permits to acquire a strong protest from a 3D show, acknowledged with a 3D demonstrating programming[7].

The last item is acquired utilizing an added substance handle, in which progressive layers of material are set down one over the other. A 3D printer permits to acknowledge, just, exceptionally complex shapes, which would be very hard to be created with devoted ordinary offices. Because of the way that the 3D printing is acquired superposing one layer to the others, it needn't bother with a specific work process and it is adequate to just draw the model and send it to print.

Various sorts of 3D printers exist considering the innovation and material utilized for layer statement. A typical material utilized by the toner is ABS plastics,

which is a light and unbending thermoplastic polymer, whose exceptional mechanical properties make it diffusely utilized as a part of a few fields, like channels generation and autos insides fabricating[7].



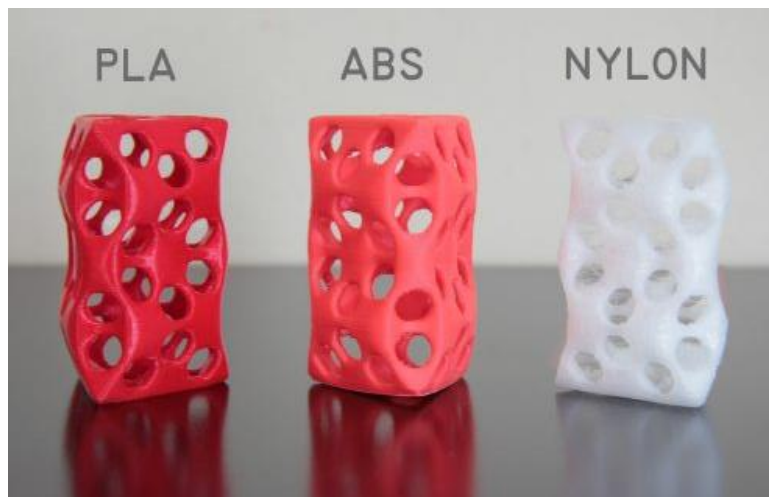
*Figure 2-5: 3D printing in progress*

3D printing is likewise a simple and fast creation procedure, which can wind up noticeably valuable in the specially appointed acknowledgment of mechanical segments for optical setups to be utilized as a part of a lab for new idea studies and approval, decreasing the assembling time. With this method, to be sure, it is conceivable to acknowledge in couple of hours specially designed mechanical parts, with no information and ability in device hardware, the length of the determination and size are agreeable with the necessities.

3D printing is additionally a simple and snappy generation strategy, which can end up noticeably valuable in the specially appointed acknowledgment of mechanical parts for optical setups to be utilized as a part of a research facility for new idea studies and approval, decreasing the assembling time. With this procedure, to be sure, it is conceivable to acknowledge in couple of hours specially designed mechanical parts, with no learning and aptitude in instrument apparatus, if the determination and size are agreeable with the prerequisites.

3D printing is all in all a substantial procedure for quick prototyping that grants to have each question in various shapes sparing cash and time. Truth be told, it is adequate to draw what you require and send it to print very as effortlessly as printing an archive. Along these lines, it's conceivable to skirt some tedious strides like authorizing the work to outsiders.

The tool has some positive viewpoints and a few points of confinement. With it you can without much of a stretch make complex shapes that would be difficult and that would require labour and complex metalworking.



*Figure 2-6: Different 3D printing materials*



## Chapter 3 Methodology

### 3.1 Overall Project Flow

*Table 1: Overall Project Flow*

<b>Flow</b>	<b>Description</b>
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">Start</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Literature Review</p> </div>	Literature review of research papers.
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Preliminary Design</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Finalize Design</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Fabricate Design</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Integrate program into unit</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">System Testing</p> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	Try out some design ideas on CAD.
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	Choose the best design.
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	Start fabrication part by part.
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	Make sure work well with computer program.
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	See if the unit can work.
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	Collect data from testing. Provide discussion and conclude well.
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	Collect data, results & discussion
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	Complete thesis
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	Finish thesis writing.
<div style="border: 1px dashed gray; padding: 5px;"> <p style="text-align: center;">↓</p> <p style="text-align: center;">Satisfactory?</p> </div>	End