DESIGN AND FABRICATION OF TWO DEGREE OF FREEDOM FREE VIBRATION TEST RIG: COORDINATECOULPING

TAN SOON WEA

Report submitted in partial fulfilment of the requirements
for the award of Diploma in Mechanical Engineering

Faculty of Mechanical engineering
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

UNIVERSITI MALAYSIA PAHANG

BORANG PENGESAHAN STATUS TESIS ◆

JUDUL: DESIGN AND FABRICATE TWO DEGREE OF FREEDOM FREE VIBRATION COORDINATE COUPLING TEST RIG

SESI PENGAJIAN: 2012/2013

Saya, **TAN SOON WEA (910227-08-5487)**

mengaku membenarkan tesis (Diploma/~~Sarjana Muda / Sarjana / Doktor Falsafah~~)* ini disimpan di perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Tesis ini adalah hakmilik Universiti Malaysia Pahang (UMP).
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (√)

[ ]	**SULIT**	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
[ ]	**TERHAD**	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi / badan di mana penyelidikan dijalankan)
[√]	**TIDAK TERHAD**	

Disahkan oleh:

______________________	______________________
(TANDATANGAN PENULIS)	(TANDATANGAN PENYELIA)
Alamat Tetap:	
No 3486-46 LADANG AI SIEW 32300 PANGKOR, PERAK DARUL RIDZUAN..	**MUHAMMAD HATIFI BIN MANSOR**
Tarikh: **10 JUNE 2013**	Tarikh: **10 JUNE 2013**

CATATAN: * Potong yang tidak berkenaan.

** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh tesis ini perlu dikelaskan sebagai SULIT atau TERHAD.

◆ Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara Penyelidikan, atau disertasi bagi pengajian secara kerja kursus dan penyelidikan, atau Laporan Projek Sarjana Muda (PSM).

CHAPTER 1

INTRODUCTION

1.1 General introduction

Free vibration test rig is the equipment to conduct the vibration experiment. The free vibration on coordinate coupling is where have two different mass or load at the end of a rigid mass less bar. The systems have vertical translation and rotation motion. The origin considers at the point of static equilibrium. In free vibration, the system wills no external force act on it. In free vibration the system must be capable of producing restoring force which tends to maintain the oscillatory motion. These restoring forces can be produced by discrete elements such as linear and torsion springs or continuous structural elements such as beams and plate.

So, this project is to design and fabricate free vibration coordinate coupling test rig.

1.2 Problem statement

In the vibration lab there are only have single degree of freedom vibration test rig, either free or forced vibration. With the significant of vibration knowledge and had been decided to extend the knowledge to the double degree of freedom test rig. This rig organised free vibration on coordinate coupling experiment.

1.3 Objective

The main objective of this project is to design and fabricate free vibration coordinate coupling test rig.

1.4 Project scope

This project focus on the following matter:

i. Follow previous follow researcher.
ii. Sketch and design the concept of test rig.
iii. Searching material for choose concept design.
iv. Fabricate the choose design using fundamental engineer knowledge.
v. Run an example experiment on test rig.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A significant of this chapter is based on preliminary of vibration concept, design, and manufacture process. Basic understanding in safety was being recognizable before sketching, designing and fabricating of the test rig process occur.

2.2 Vibration concept

In vibration theory, which is concerned with the oscillatory motion of physical system, motion may be harmonic, periodic, or general motion in which the amplitude varies with time (A.A. Shabana, 2012). The oscillatory mation show in figure 2.1 is called harmonic motion and is denoted as

$$x(t) = Xcos\ \omega t \tag{2.1}$$

where X is called amplitude of motion, ω is the frequency of motion, and t is the time. The motion shown in figure 2.2 is called periodic motion, and shown in figure 2.3 is called nonperiodic or transient motion. The motion indicated in figure 2.4 is random or long duration nonperiodic vibration.

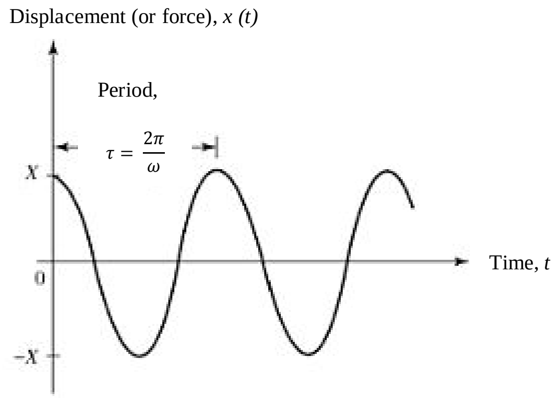


Figure 2.1 Periodic, harmonic

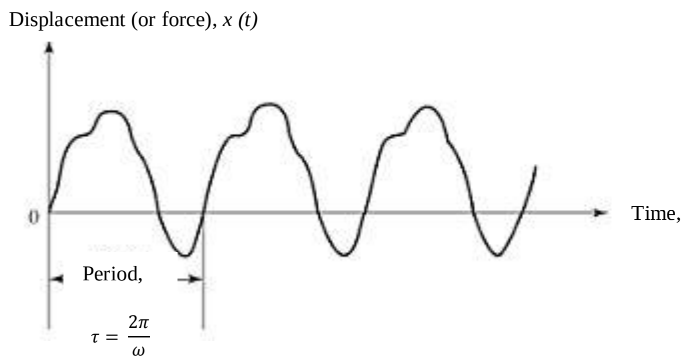


Figure 2.2 Periodic, nonharmonic

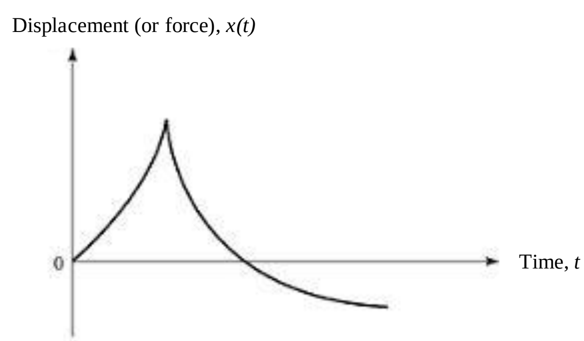


Figure 2.3 nonperiodic, transient

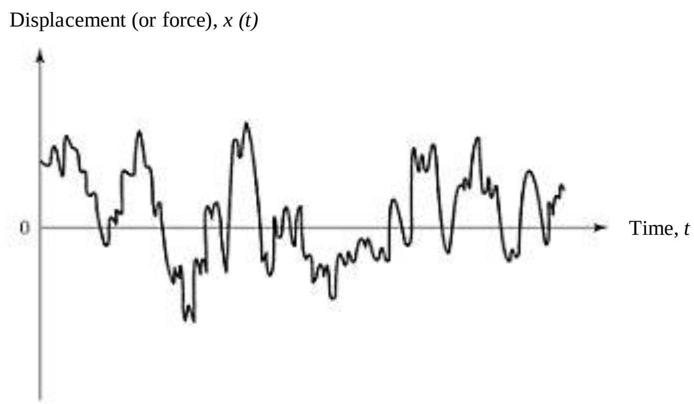


Figure 2.4 nonperiodic, random

Source: (S. S. Rao, 2007)

The phenomenon of vibration involves an alternating interchange of kinetic energy to potential energy and potential energy to kinetic energy. In the vibration system that will have one component is store kinetic energy and a component that store potential energy (Danial J. Inman, 2000).

Vibration can classified as free or force vibration. In free vibration, the system wills no external force act on it, while force vibration there is result of external excitations. In both cases of free and forced vibration the system must be capable of producing restoring force which tends to maintain the oscillatory motion. These restoring forces can be produced by discrete elements such as linear and torsion springs or continuous structural elements such as beams and plate (A.A. Shabana, 2012).

Both of these vibrations can either be damped or undamped. Undamped vibrations can continue indefinitely because frictional effects are neglected in the analysis. Since in reality both internal and external frictional forces are present, the motion of all vibrating bodies is actually damped (R. C. Hibbeler).

2.3 Degree of freedom

The degrees of freedom indicate how many numbers are required to express its geometrical position at any instant. In machine trains, the relationship of mass, stiffness, and damping are not the same in all direction (R. Keith Mobley, 1999). There are six number degrees of freedom. Three coordinates are to define the translation motions which are moving up and down (heaving), moving left and right (swaying) and moving forward and backward (surging). While others three coordinates to define the rotation motions which are tilts forward and backward (pitching), swivels left and right (yawing), pivots side to side (rolling).

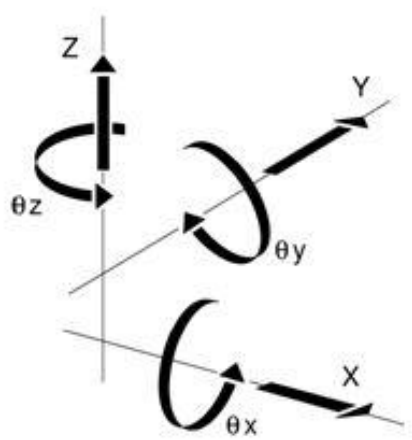


Figure 2.5: Six degree of freedom

Source: (Scott's Harangue, 2009)

2.3.1 One degree of freedom

In the single degree of freedom system consist one masses, stiffness and the system only have one direction. In the figure 2.6, it shows the mass m may be either an attached concentration or some fraction of the distributed mass of the pole. The single translation *u(t)* in the x direction is the only displacement coordinate required to describe the motion of the mass at any instant of time, *t* (W. Weaver et al.,1990).

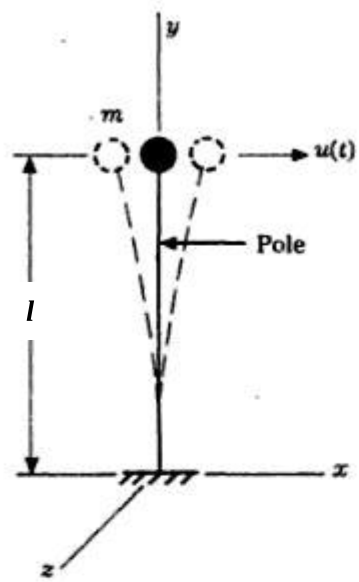


Figure 2.6: Single degree of freedom model

Source: (W. Weaver et al., 1990)

2.3.2 Two degree of freedom

In the two degree of freedom system consist two masses, stiffness and the system have two directions. In the figure 2.7, the springs are assumed massless and the coordinate x_1 and x_2 of the masses m_1 and m_2 respectively to define the position of the system at any instant of time. Thus, the figure 2.7 is a two degree of freedom system (J. S. Rao et al., 2004).

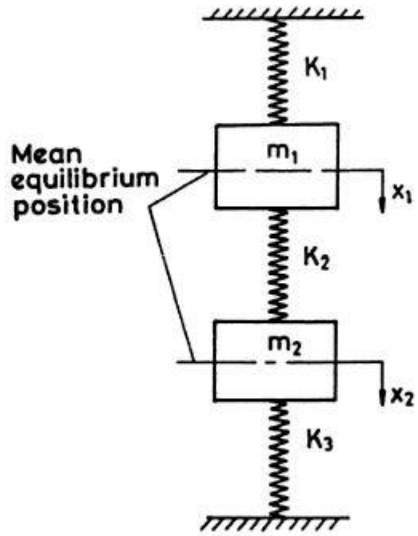


Figure 2.7: Two degree of freedom model

Source: (J. S. Rao et al., 2004)

2.4 Coordinate coupling

A system that has two masses and two springs are connected to the end of a rigid mass less bar. The system has vertical translation and rotation motion. The origin considers at the point of static equilibrium. The vertical translation y and rotation θ also show in the figure 2.8.

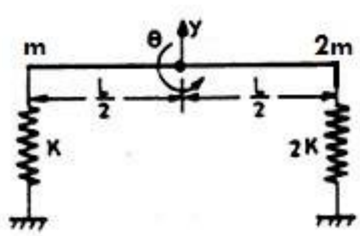


Figure 2.8 Dynamic model for coordinate coupling

Source: (Madhujit Mukhopadhyay, 2000)

2.5 Current test rig

To fabricate the two degree of coordinate coupling vibration test rig, the existing single degree freedom free vibration test rig in the vibration lab as the reference. Figure 2.9 below show the test rig in the vibration lab.

Figure 2.9 Single degree freedom free vibration test rig

2.6 Manufacture process

2.6.1 Shearing

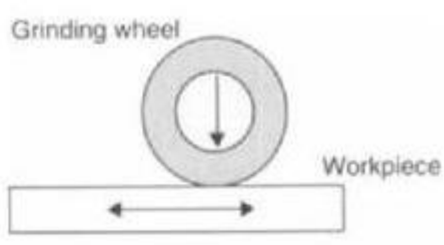
Shearing also known as sheet metal cutting, it is a process to separation of a part of the sheet into two parts. In sheet forming process, the stress is apply to the plane of the sheet metal, the sheet are generally tensile since compressive stresses in this plane lead to buckling or wrinkling(Helmi A. Youssef, 2011).

2.6.2 Drilling

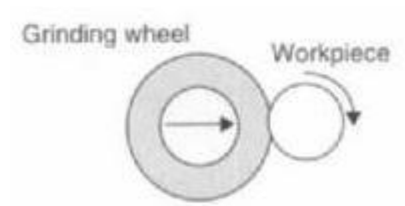
Drilling is a cutting process that use drill bit to cut or enlarge a hole in solid material. The drill bit cuts by applying pressure and rotation to the workpiece, chips will then form at the cutting edges. In this operation, the speed and rake angle along the edge are responsible for many aspects. Drills are slender, highly stressed tools, the flutes of which have to carefully design to permit chip flow while maintaining adequate strength. The helix angles and other features are adapted to the drilling of specific classes of material (E. Edward Moor Trent et at., 2000).

2.6.3 Grinding

Grinding is a process of shaping material. Grinding wheel and tools are generally composed of two materials which is tiny abrasive particle call gains or grits. The function of the gains or grits is to cut and act as a softer bonding agent to hold the countless abrasive grains in a solid mass (Stephen Malkin, 2008). There are numerous types of grinding operation which vary according to the shape of the wheel and the kinematic motion of the workpiece and wheelhead. In the figure 2.10 shown the four basic grinding process.



(a)



(b)

(c) (d)

Figure 2.10: Four basic grinding processes: (a) peripheral surface grinding, (b) peripheral cylindrical grinding, (c) face surface grinding and (d) face cylindrical grinding.

Source: (Brain Rowe at el., 2009)

2.6.4 Milling

Milling is a process to produce a variety of surface by using circular type cutter with multiple teeth or cutting edge which successively produces chips as the cutter rotates (Karl Moltrecht, 1981). Up milling and down milling are the general milling process. In figure 2.11, it shows up milling process. The workpiece is fed opposite to the cutter tangential velocity. Each tooth of the cutter starts the cut with zero depth of cut, which gradually increases and reaches the maximum value as the tooth leaves the cut. The chip thickness at the start is zero increases to maximum at the end of cut. In figure 2.12, it shows down milling process. The workpiece is fed in the same direction as that of the cutter tangential velocity. The cutter enters the top of the workpiece and removes the chip that gets progressively thinner as the cutter tooth rotates.

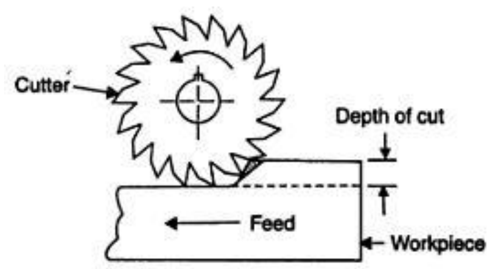


Figure 2.11: Up milling

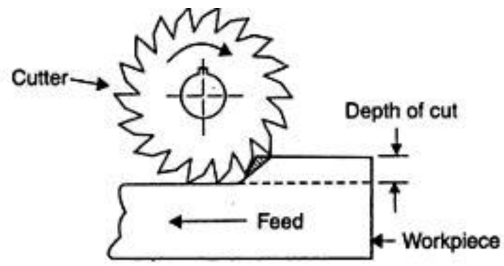


Figure 2.12: Down milling

Source: (R. K. Rajput, 2007)

2.6.5 Turning

In turning process, the raw material is held in the chuck of a lathe and rotated. The tool is held rigidly in a tool post and moved at a constant rate along the axis of the bar, cutting away a layer of metal to form a cylinder or a surface of more complex profile. The cutting speed (V) is the rate at which the uncut surface of the work passes the cutting edge of the tool. The feed (f) is the distance moved by the tool in an axial direction at each revolution of the work. In the figure 2.13, it show a vertical cross section at top right and a detail of the insert geometry at bottom right.

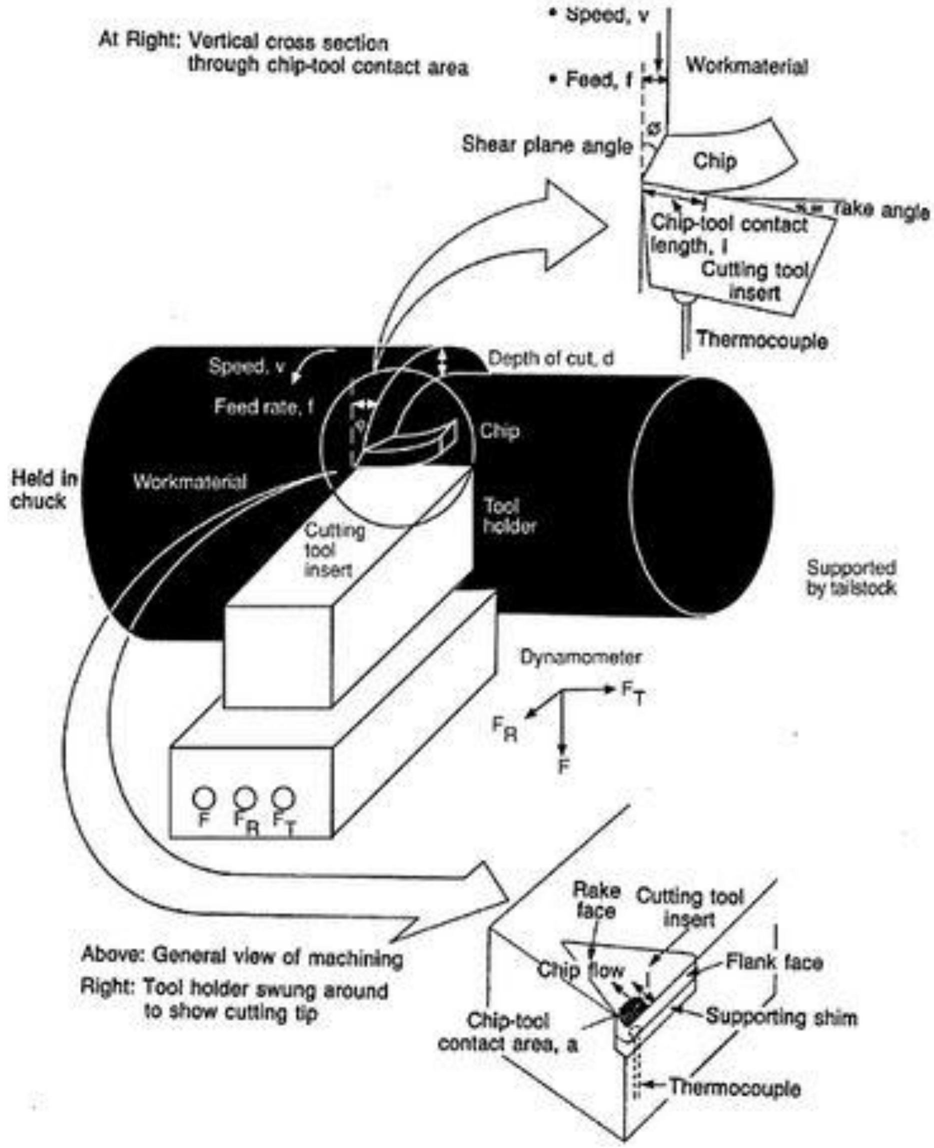


Figure 2.13: turning process

Source: (E. Edward Moor Trent et at., 2000)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter explains about the methodology that has used to fabricate the two degree of freedom coordinate coupling test rig. This chapter will also clarify on how the finalised concept is being obtained. Material selection and fabrication process are also being discussed in this particular chapter.

3.2 METHODOLOGY FLOWCHART

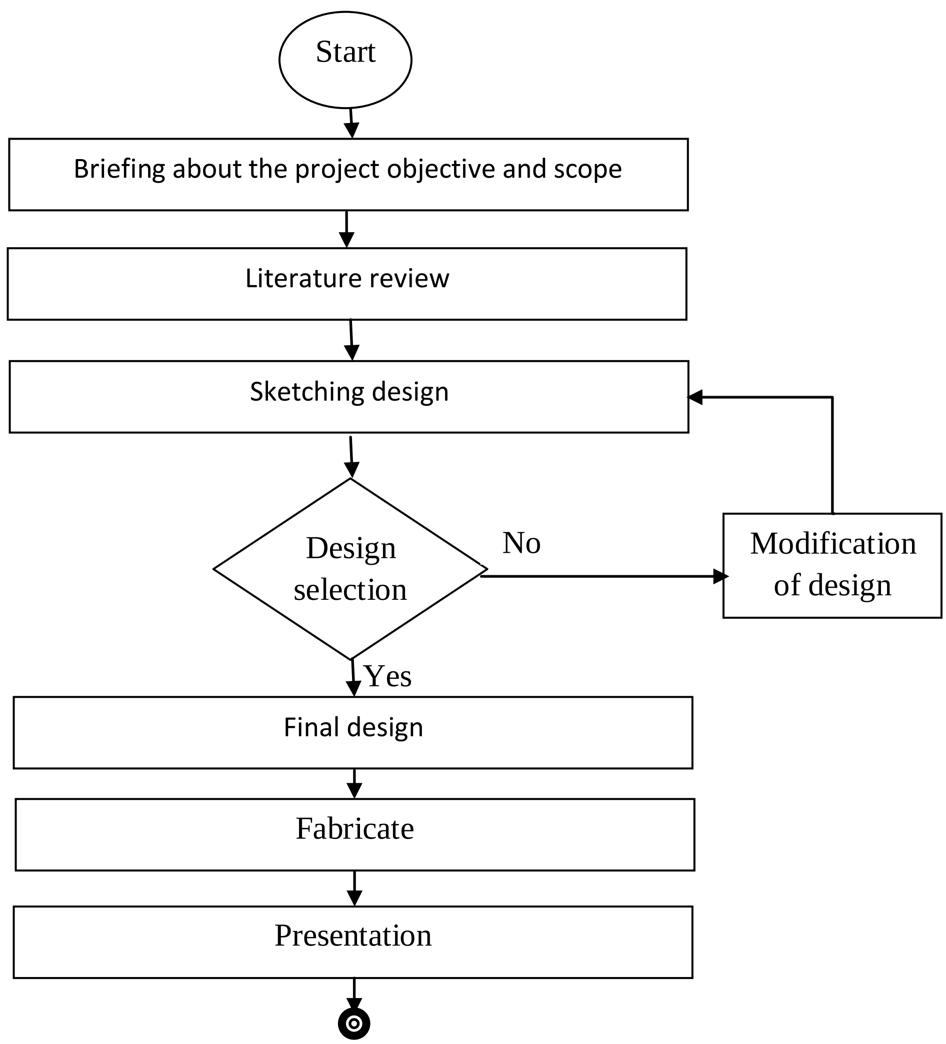
First of all, the problem is being identified and the objective and scope were set up. The Research will then be conducted regarding the title of the project. This is where literature review started by reviewing the literature studies of the past papers. Figure 3.1 shows the flow chart for this project.

Then, hand sketching and drawing phase was started. The hand sketching is referenced the single degree test rig in the ASIVR lab in UMP and editing it to become achievable. Three designs are made and the best design is selected with the best design specification. After the best sketching is selected, the designs drawn into a three dimensional drawing by using the Solidworks software.

After that, the lists of the materials are being listed. The materials are prepared and had been choose base on the characteristic of material. After selection process, fabrication process was occurred with the manufacturing process involved.

The fabrication test rig will be tested in the lab after fabrication process complete. An experiment will be run to improve the vibration concept.

Finally, the final report writing and presentation slides were prepared. Everything regarding the project was then presented to the panels and draft report is submitted to the supervisor.



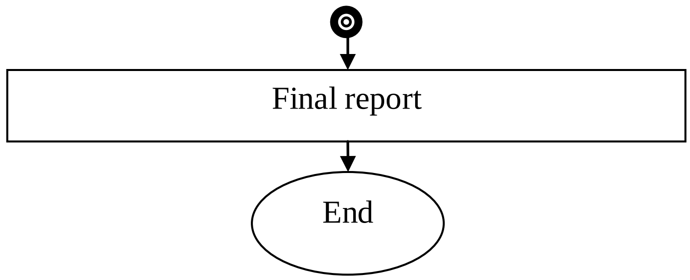


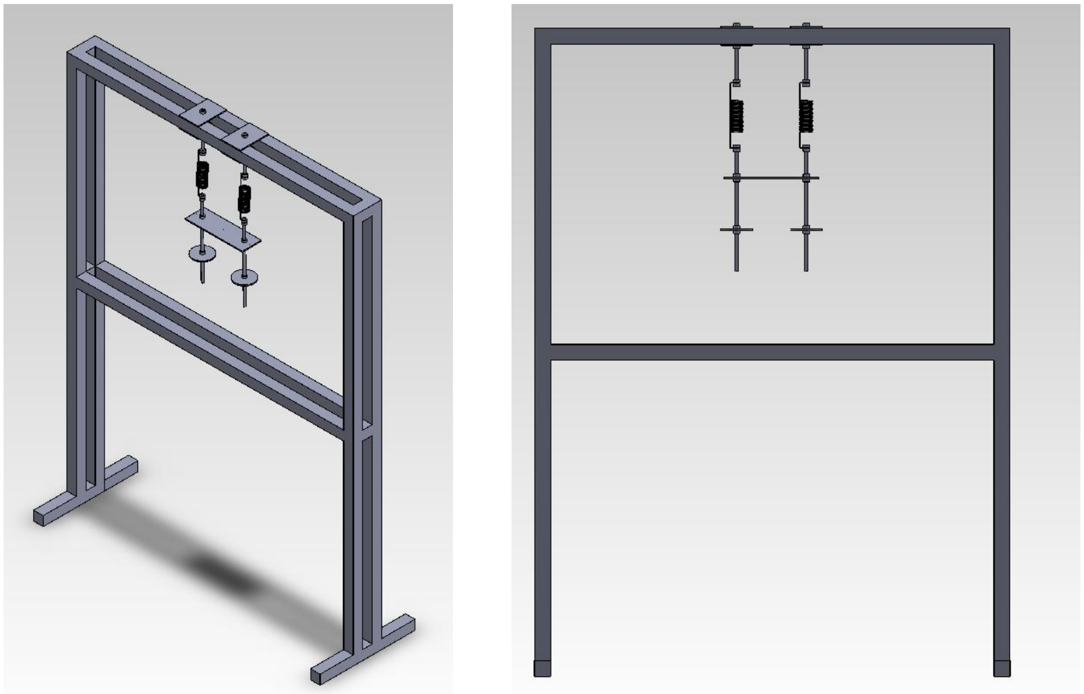
Figure 3.1: Project Flow Chart

3.3 DESIGN CONCEPT GENERATION

Among the three design made, one of the best design was chosen based on the design specification. The design specification includes:

a) the stability
b) space occupied
c) assembly and disassembly
d) durability
e) portability of the vibration test rig
f) material saving

3.3.1 Design Concept

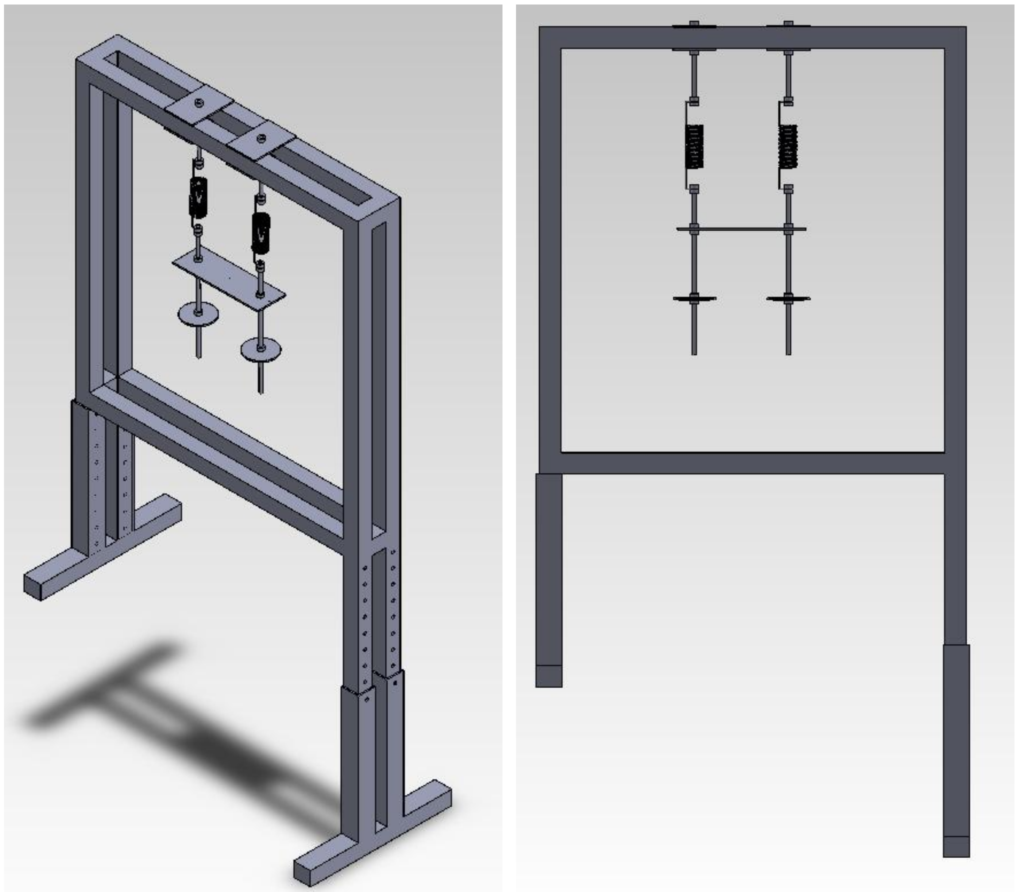


(a) (b)

Figure 3.2: Design Concept 1 (a) isometric view, (b) front view

The design concepts 1 is base on the sample in lab ASIVR then improve it to become two degree freedom coordinate coupling test rig. The frame of the test rig is 1000mm (height) x 1000mm (length). It is stable but assembly and disassembly is difficult. It also occupied space.

3.3.2 Design Concept 2

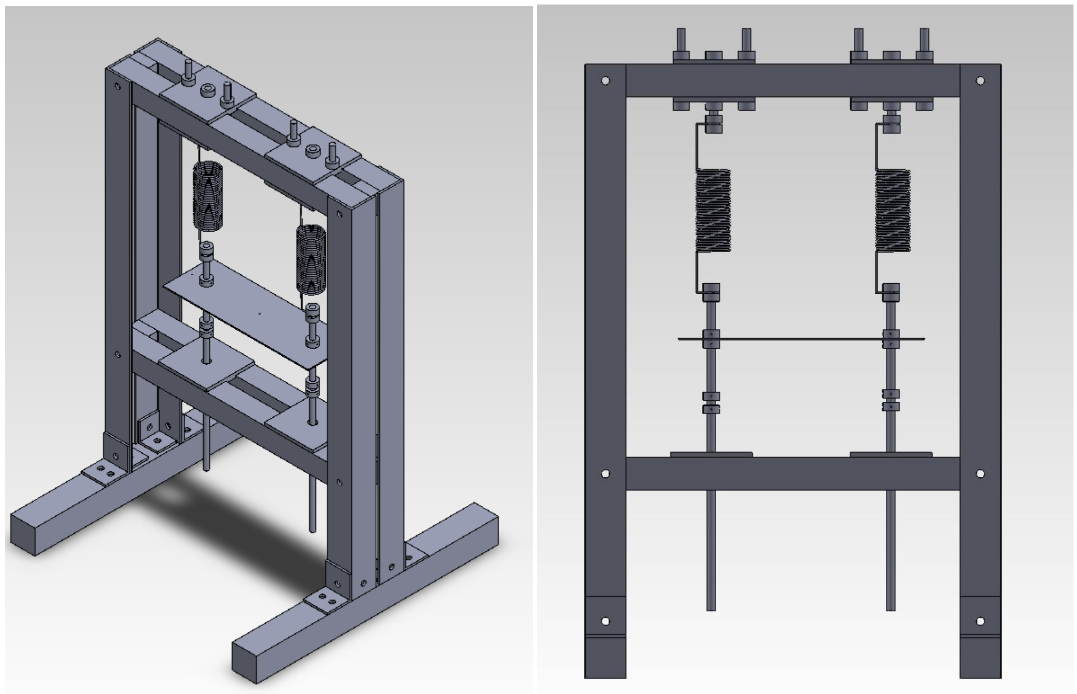


(a) (b)

Figure 3.3: Design Concept 2 (a) isometric view, (b) front view

The design concept 2 is base on the adjusted height of the test rig. The frame of the test rig is 1000mm (height) x 1000mm (length). The height of the test rig can be adjusted according to the person. It occupied space.

3.3.3 Design Concept 3

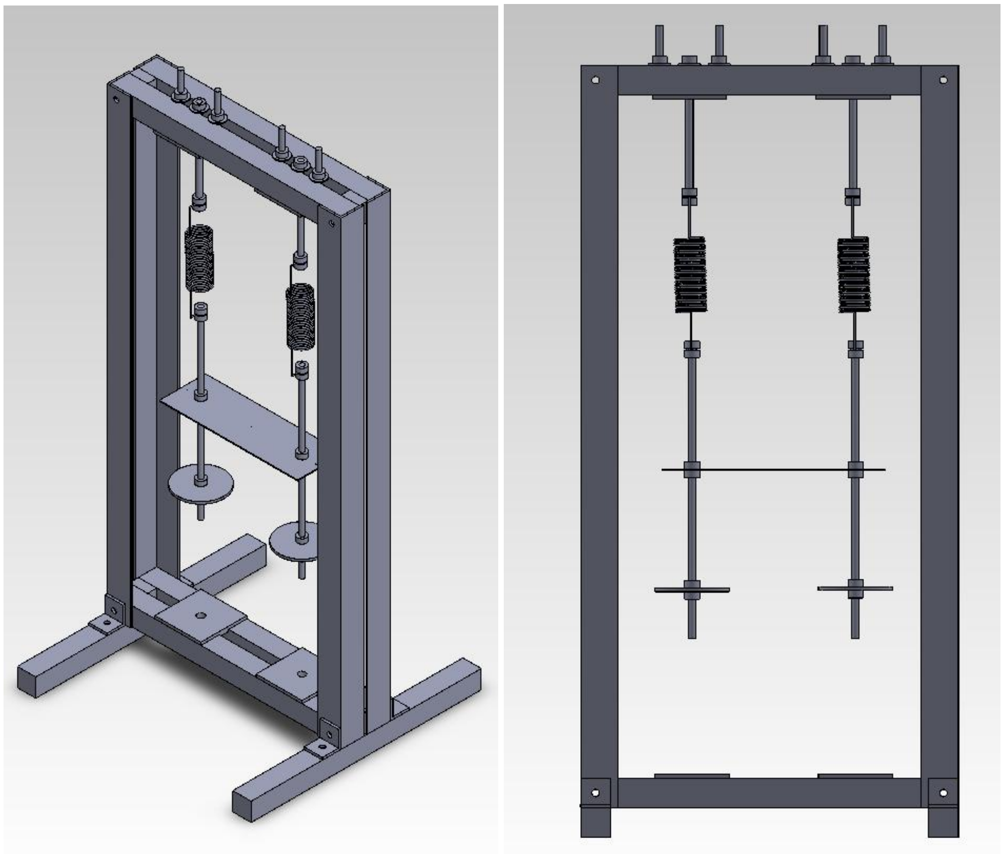


(a) (b)

Figure 3.4: Design Concept 3 (a) isometric view, (b) front view

The design concept 3 is base on the side of the test rig. The frame of the test rig is 700mm (height) x 600mm (length). It is easy to assembly and disassembly. It can be put on the table and stable.

3.3.4 Design Concept 4



(a) (b)

Figure 3.5: Design Concept 4 (a) isometric view, (b) front view

The design concept 4 is base on the top of the system and the length of the spring. The system can be easy to adjust. The frame of the test rig is 1000mm (height) x 600mm (length). It is easy to assembly and disassembly. It not suitable put on the table.

3.4 DESIGN CONCEPT SELECTION

The design is selected based on their 6 concept design specification. The datum is set up based on the test rig in the vibration laboratory as shown in the literature review (Figure 2.3). "+" indicates it is better than, "0" indicates it is same as, and "-" indicates it is worse than. The highest score in the concept scoring matrix will be the final design concept of the vibration test rig.

Table 3.1: Design Concept Matrices

Design Specification	**Design Concept**				
	1	2	3	4	Datum
1. stability	0	0	+	0	0
2. space occupied	0	0	+	+	0
3. assembly and disassembly	0	+	+	+	0
4. durability	0	0	+	+	0
5. portability of the vibration test rig	0	+	+	+	0
6. material saving	-	-	+	+	0
Plus (+)	0	2	6	5	0
Same (0)	5	3	0	0	0
Minus (-)	1	1	0	0	0
Net score	-1	1	6	4	0
Rank	4	3	1	2	-

3.5 DESIGN CONCEPT FINALIZATION

From the design concept matrices results, Concept 3 have the high net score so it is chose to be fabricated. The stability of the test rig and the space occupied better then other design.

3.6 PREPARATION OF MATERIAL

After the design stage completed, preparation of material will be start. Materials are list out and have been choose to fabricate the test rig. Every single dimension of the part is cut accurately so that it will not affect the fabrication process.

3.6.1 Sort List of Materials

The table below show the materials and it dimension.

Table 3.2: Sort list of materials

No	Materials	Length	Quantity
1	4mm x 4mm aluminium profile	600mm	4
2	4mm x 4mm aluminium square bar	500mm	2
3	5mm x 5mm aluminium L bar	700mm	4
4	5mm x 5mm aluminium L bar	50mm	4
5	5mm x 5mm aluminium L bar	40mm	4
6	100mm x 100mm flat plate	10mm	6
7	Ø8mm round bar	400mm	2
8	Ø10mm treated round bar	100mm	6
9	300mm x100mm mild steel	1mm	1
10	M10 Hex bolt, nut and washer	120mm	4
11	M8 pan head bolt, but and washer	20mm	20
12	M10 wing nut	-	6
13	M10 nut	-	18
14	M6 nut	-	4
15	Silver spray	-	1

3.7 FABRICATION FLOW

Fabrication flow is prepared after the material is selected so that the fabrication can done in time.

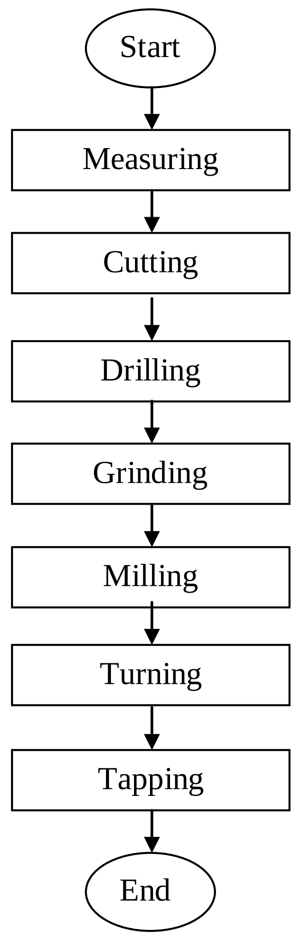


Figure 3.6: Fabrication flow

3.7.1 Measuring and Marking Process

Measuring tap and ruler are use in this state. To get the accurate reading, eye must be perpendicular to the reading and the dimension is mark with pencil.

Figure 3.7: The marking process while measuring

3.7.2 Cutting process

After the measuring and marking is done, the raw materials will undergo cutting process. Shearing machine is use to cut the sheet metal and the chopsaw use to cut the mild steel and other material.

Figure 3.8: Cutting process using metal cutting chopsaw and shearing machine

3.7.3 Drilling

Drilling is a process to make hole. Before drill, a centre punch is use to make a fix point therefore when drilling the position will accurate.

Figure 3.9: Drilling machine

3.7.4 Grinding

Bench grinding machine is use to remove the chip beside the work piece. Hand grinding machine also is use in the fabricate process.

Figure 3.10: Bench grinding machine and hand grinding machine

3.7.5 Milling

Milling machine is use to fabricate the system of the test rig. When milling process is taking place the coolant will be use to reduce the heat so that the heat will no break the tool bit and workpiece. Face milling is the 1st process in milling. It will give results in a flat and clean surface. After then, the milling process will be take place to remove the unwanted material. The spindle speed is calculated so that the surface has good finishing. Spindle speed is calculated using the equation of:

$$\text{Spindle speed} = \frac{\text{cutting speed} \times 1000}{\pi \text{d}} \tag{3.1}$$

Figure 3.11: milling process

3.7.6 Turning

Turning is step to fabricate round material. Before do the outer track in the 400mm rod, lathe machine is use to facing the rod and remove the unwanted part.

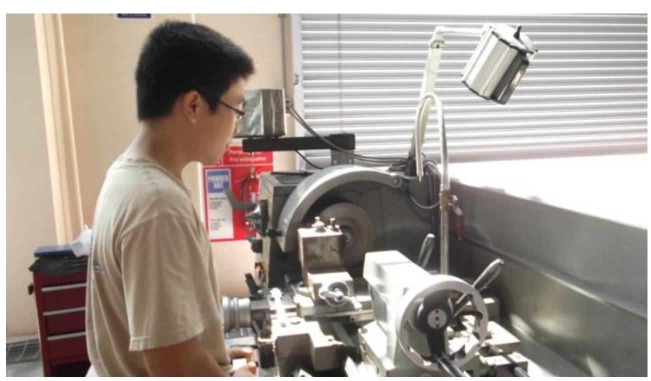


Figure 3.12: turning using lathe machine

3.7.7 Tapping

Tapping process is to make the screw thread either it is internal or external. The hand tap use to make internal tap while the die tap use to make external tap. The process of tapping should be perpendicular to the workpiece surface area. At the same time, oil should be applied to the drilled part frequently to prevent the break of taps. When rotating the hand tap, it is rotated clockwise and anticlockwise repeat so that the hand tap can slowly feed the material.

Figure 3.13: hand tap and die tap

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The result and discussion function as an achievement of the target for the final year project. However if the target is not met, it means there were problem faced during the process and will be discussed. If the result proven the objective is accomplished, the process is discussed too. This part also will discuss the part of the test rig.

4.2 Final product

4.2.1 Overview of product

Figure 4.1: Overview of the test rig

4.2.2 Overview test rig frame

The frame of the test rig is combining by using bolt and nut. Top and bottom of the frame is using aluminum profile as the support of the system. While the side of the frame using aluminum L bar. It acts as support for put in system.

Figure 4.2: frame of the test rig

4.2.3 Overview system of the test rig

The system of the test rig is making by steel and painted. All of the part combined using bolt and nut so that it can be assembly and disassembly.

Figure 4.3: Overview system of test rig

4.2.4 Overview of the supporting plate

The supporting plate acted as clamp to fix the system of the test rig. It assembly the system by using bolt and nut. It also will act as support to the lower part of the system. The bottom supporting plate is to fix the bar so that it wills no effect the result.

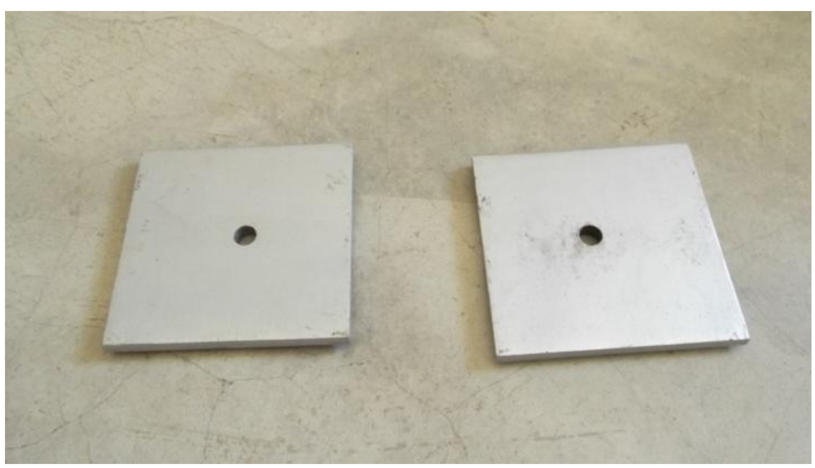


Figure 4.4: Overview of the supporting plate

4.2.5 Overview of the sheet metal

The sheet steel act as the support to the sensor LVDT (linear variable differential transformer) and accelerometer.

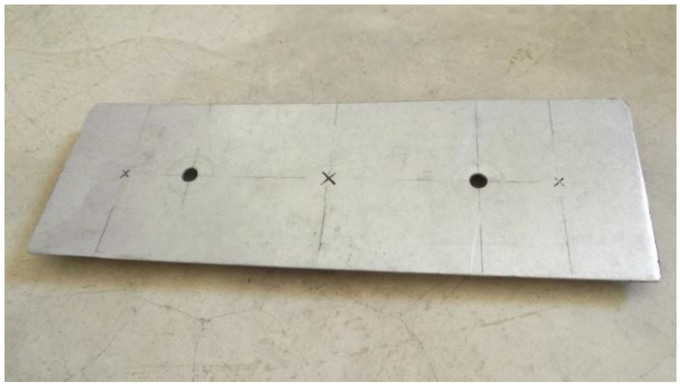


Figure 4.5: Overview of mild steel

4.2.5 Overview of the round bar

On the round bar the nut, mild steel and the mass will fix on it. It also will combine with the spring.

Figure 4.6: Overview of round bar

4.2.5 Overview of the nut

The nut is to support the mass. The nut can adjusted by tight and release on the screw.

Figure 4.7: Overview of nut

4.3 Procedure to test the test rig

Some step is take place to test the test rig.

1) Different load is inserting into the system.
2) The load is pushed simultaneously.
3) The result is recorded and the test is repeated by adding different masses.

4.4 Result of the test

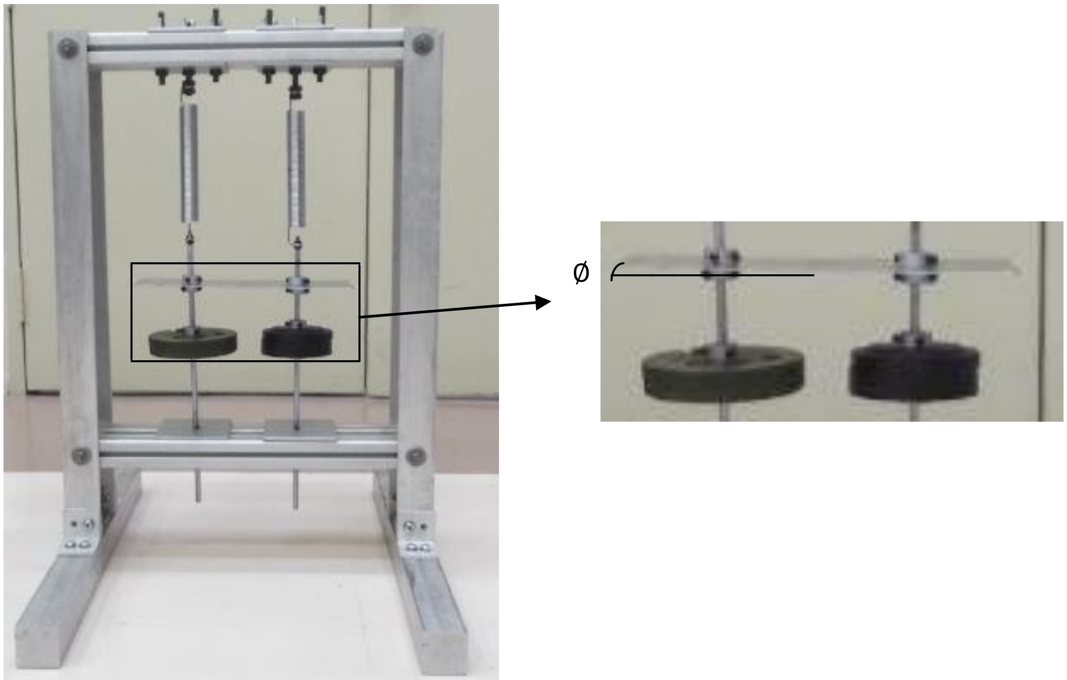


Figure 4.8: Experiment test with 2kg and 1.5 kg

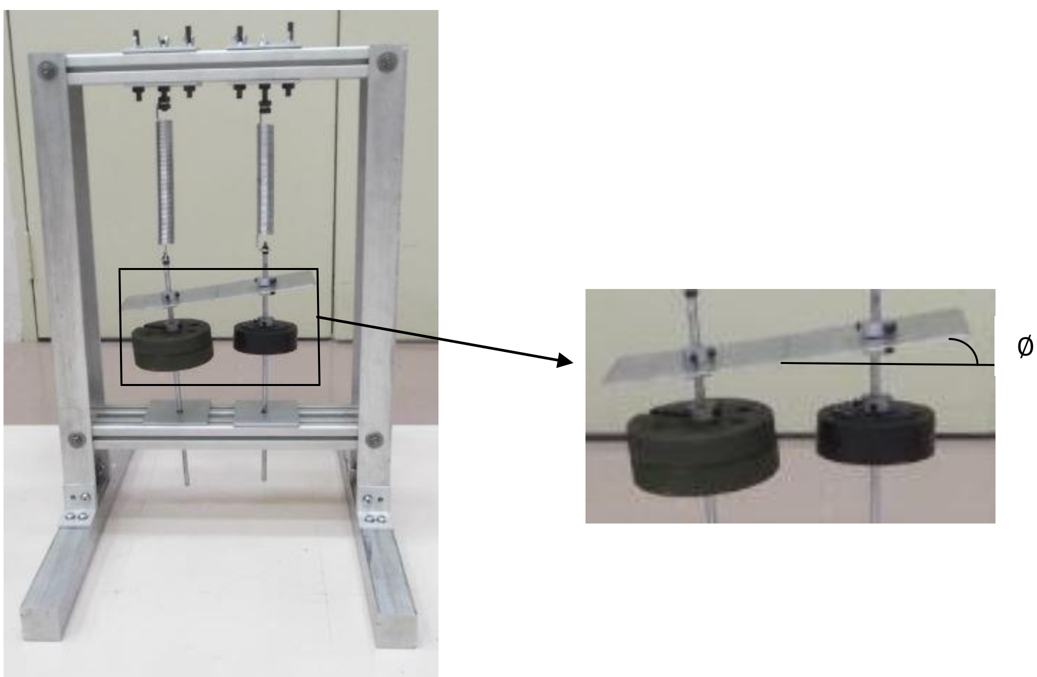


Figure 4.9: Experiment test with 4kg and 1.5 kg

From the result shown in figure 4.8 and 4.9 some of the discussion or recommadation was make to imporve the test rig.

First is the sheet metall to put sensor. When the test was occur, the displacement occupaied is too small because the mass of the sheet metal is too light. To solve the problem square bar is recommed to subsitude the sheet metal.

Second is the stiffness of the spring. The stiffness of the spring in the ASIVR lab is too high. When the test is occur, the oscillation of the spring too least. The spring must have lower stiffness or the masses added in the experiment must greater.

4.5 Problems face and solutions

The first problem that I face is lack of the material in the mechanical store. The aluminum profile in the lab is no enough for fabricate the test rig. For the alternative way, aluminum L bar was choosing to solve the problem.

The second problem that I meet is the lack of the drill bit. The size or dimension of the drill bit in the mechanical lab is not suitable for my fabrication process and some of the drill bit already broken and blunt. To solve this problem, the drill bit was buying from outside market and the blunt drill bit is repair by the lab assistance so that it can be reuse.

The third problem I face is the drilling machine. The lab has 8 drilling machine but only have 6 of them is fully friction. From the fully function drilling machine only 2 of them have clamp but the clamp also cannot be fix because lack of the screw. Some of the suitable screw is found at lab so that the clamp can be fixing.

CHAPTER 5

CONCLUSION

5.1 Conclusion

In conclusion, the objective of the final year project was achieved. The vibration coordinate coupling test rig had been fabricated according to the design draw in the solidwork. The test rig success fabricate within 14 week. The test rig can be supported the load more than 4kg according to the stiffness of the spring. Beside that, the space needed to put the coordinate coupling test rig is small. The other type of test rig can be added into the lab so that student can get more knowledge. The test rig also light weight due to the material use and easy to assembly and disassembly. The fabrication process required many skills that have been learnt in pervious mechanical laboratory such as material measuring, marking, cutting, drilling, grinding, turning and milling. The fabrication process can let student gain more experience and develop the skill and the ways to operate the machine to complete the project. Besides that, the student also learnt how to solve the problem and critical thinking during design and fabricate the test rig. It was a motivation for student to face the challenge as a professional engineer in this global era.

5.2 Recommendation

There is some recommendation related to the facility in the mechanical lab. The machine and the tools in the lab must have maintainer every semester. So that, the student can uses the machine to fabricate some product or project. Besides that, the facility in the lab also must be improving due to the increase of the project and the amount of student use it.

REFERENCE

This thesis is prepared based on the following references:

A.A. Shabana. *Theory of Vibration: An introduction (Mechanical Engineering Series)*, Second edition, Springer-Verlag New York, 2012.

Brian Rowe and W. Brian Rowe. *Principles of Modern Grinding Technology Brian Rowe,* First edition, William Andrew, 2009.

D. P. Sharma, R.C Hibbeler, and Irving H Shames. *Engineering Mechanics*. Pearson Education, 2011.

Daniel J. Inman. *Engineering Vibration.* Second edition, Prenctice Hall, 2001.

E. Edward Moor Trent and Paul Kenneth Vight. *Metal Cutting*, fourth edition, Butterworth-Heinemamn,2000.

Helmi A. Youssef, Hassan A. El-Hofy and Mahmoud H. Ahmed. *Manufacturing Technology: Materials, Processes, and Equipment*, First edition, CRC Press, 2011

Hong Zhu and Xin Hai Zhu. *A Mixed-Mode Fracture Criterion for AHSS Cracking Prediction at Large Strain*. SAE Int. J. Mater. Manuf. 2011, 4, 289- 297

J. S. Rao and K. Gupta. *Introduction Course On Theory And Practice Of Mechanical Vibration,* First edition, Wiley Eastern, 1984.

Karl Moltrecht. *Machine Shop Practice*, Second sub edition, Indusrtial Press, 1981.

Madhujit Mukhopadhyay. *Vibrations, Dynamics and Structual System*, Student edition, Talyor & Francis, 2000.

Rao V. Dukkipati, Guojun Qie, Jun Zhu, and Mohamad Qatu. *Vibrations and instability in Automotive Front end Acceddory Drive Belt System.* SAE Int. J. Passeng. Cars – Mech. Syst. 2009. 2, 1222-1236.

R.C. Hibbeler. *Engineering Mechanics: Dynamics in SI Units Pack.* Twelfth edition, Person Education Canada, 2009.

R. K. Rajput. *Manufacturing Technology: Manufacturing Processes*, Laxmi Publications, 2007.

R. Keith Mobley. *Vibration Fundamentals*. Elsevier Science, 1999.

Singiresu S. Rao. *Vibration of Continuous System*, First edition, Wiley, 2007.

Stephen Malkin. *Grinding Technology: The Way Things Can Work: Theory and Applications of Machining with Abrasives.* Second edition. Industrial Press, Inc., 2008.

W. Weaver Jr., S. P. Timoshenko and D. H. Young. *Vibration Problem In Engineering*, Fifth edition, Wiley-Interscience, 1990.

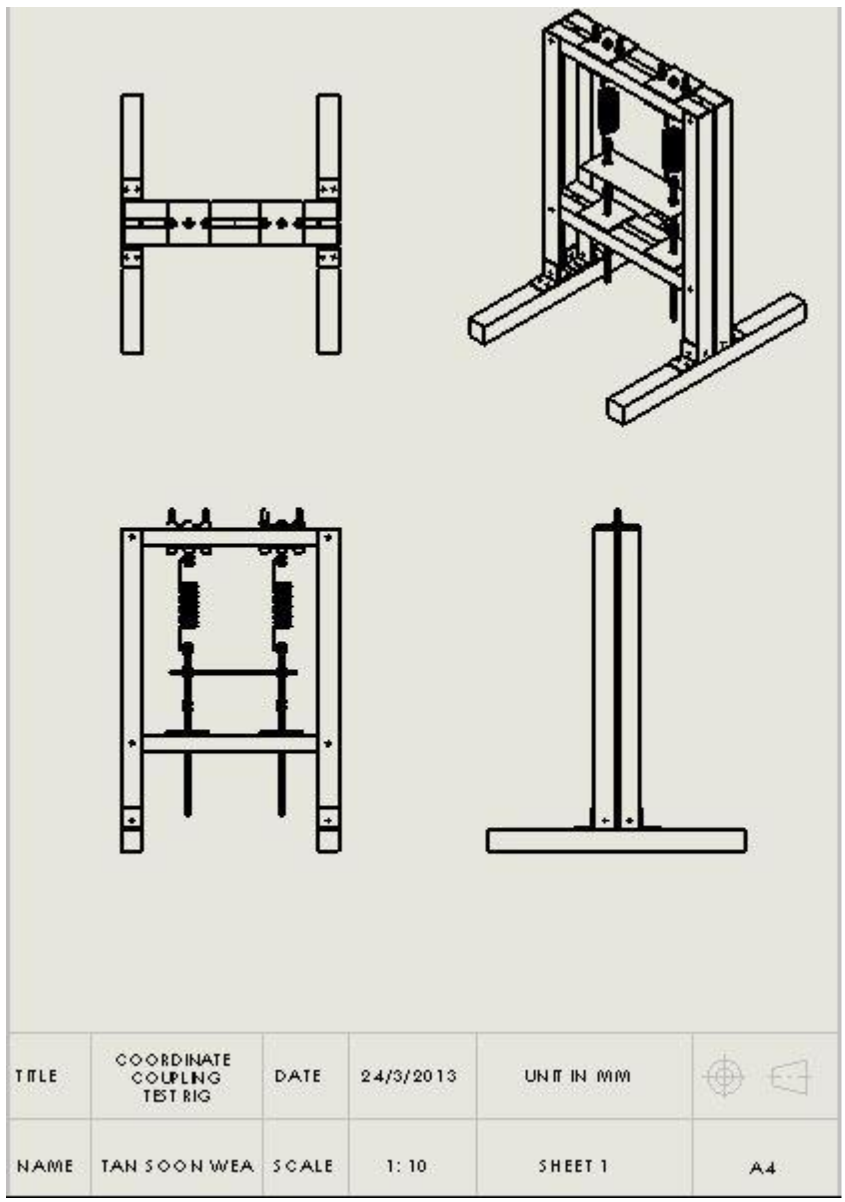
APPENDIX A1

GRANTT CHART

Project activities	Week														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Literature review	Plan														
	Actual														
Sketch the design	Plan														
	Actual														
Final design in solidwork	Plan														
	Actual														
Find material for design	Plan														
	Actual														
Fabricate the design	Plan														
	Actual														
Evaluate the product	Plan														
	Actual														
Report writing	Plan														
	Actual														
Final presentation	Plan														
	Actual														

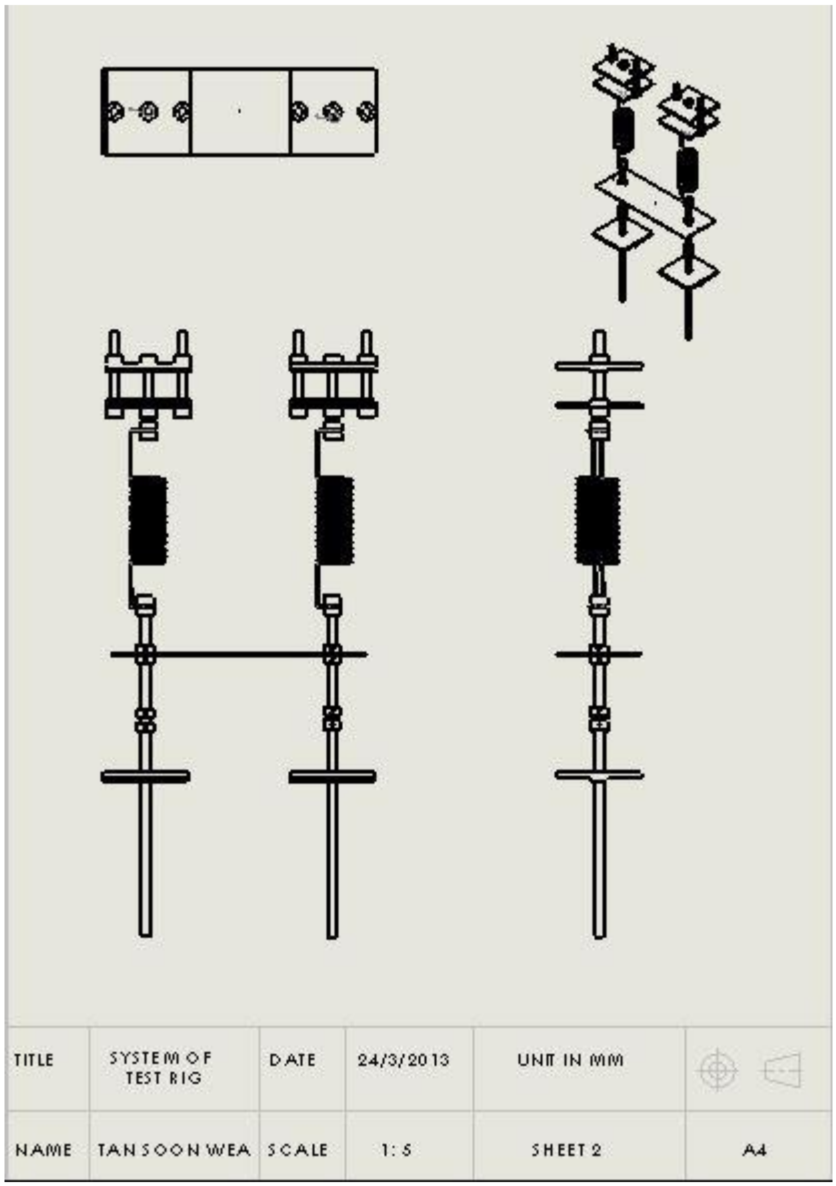
APPENDIX B1

SOLIDWORK OF THE COORFINATE COUPLING TEST RIG



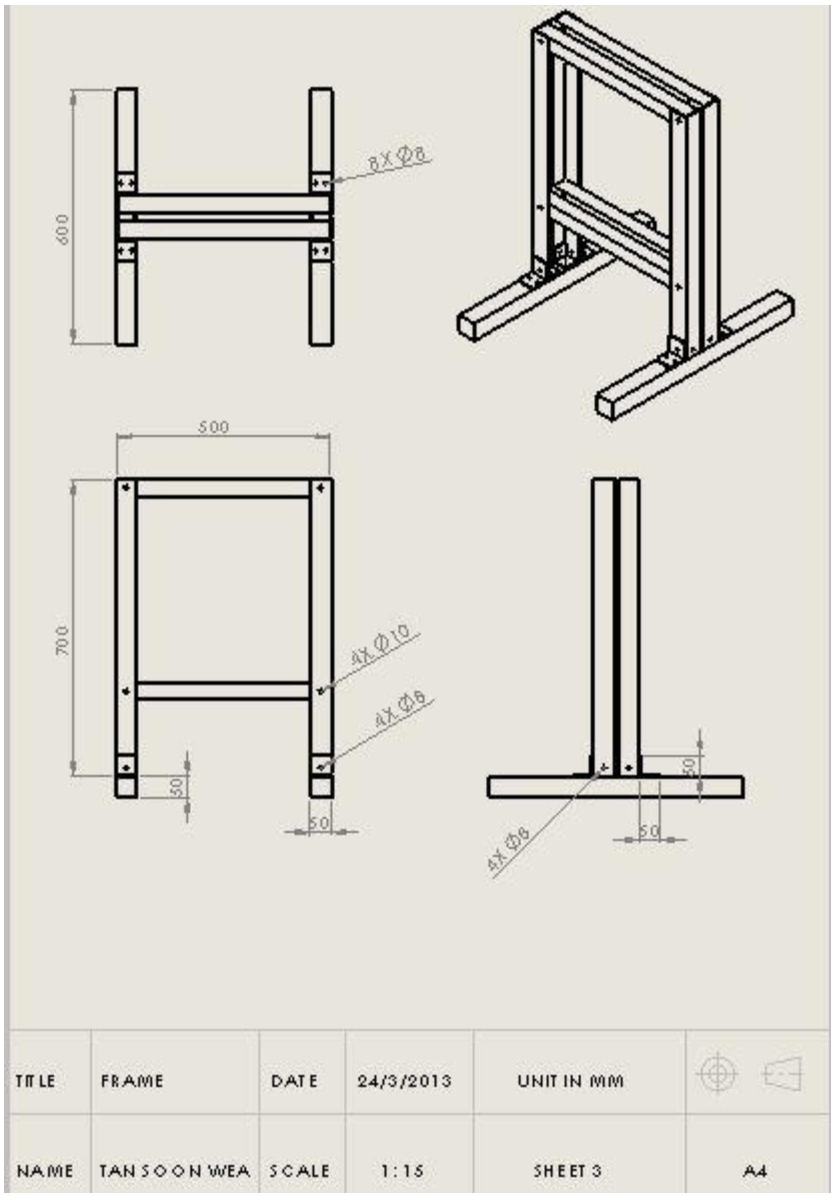
APPENDIX B2

SOLIDWORK SYSTEM OF TEST RIG



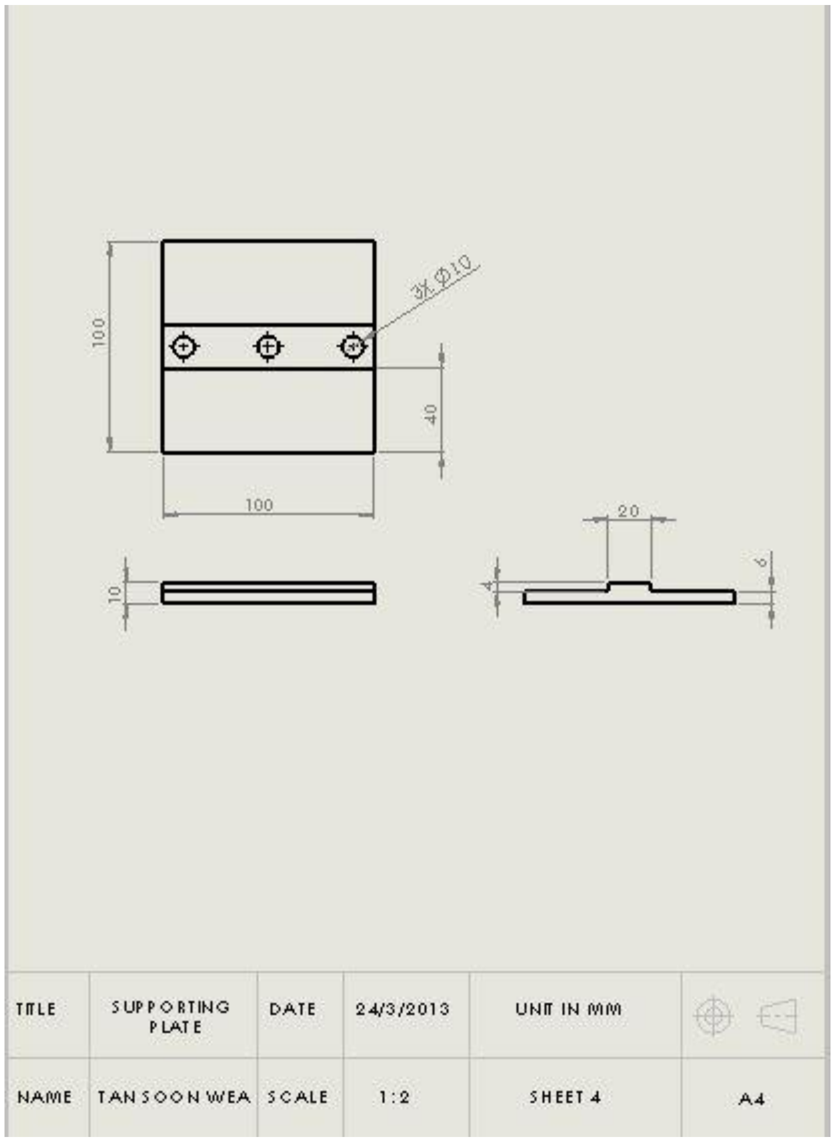
APPENDIX B3

SOLIDWORK OF TEST RIG FRAME



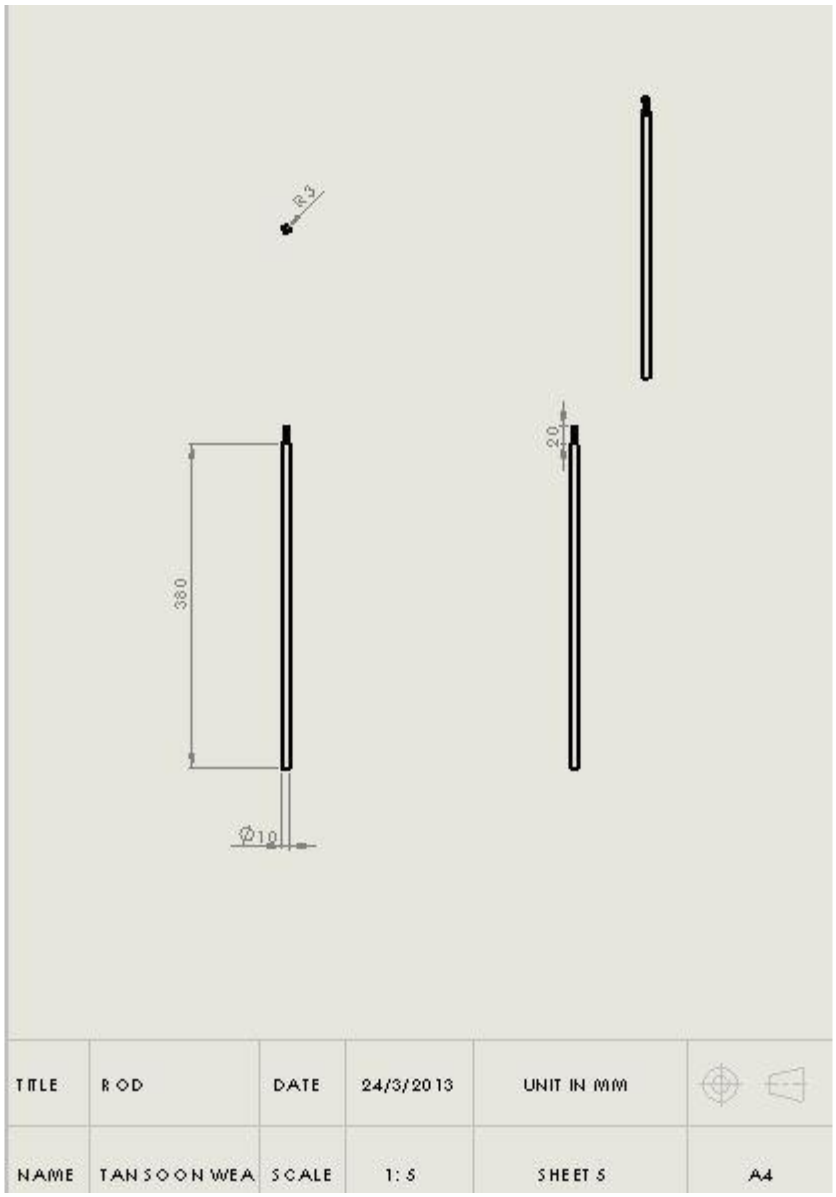
APPENDIX B4

SOLIDWORK OF SUPPORTING PLATE



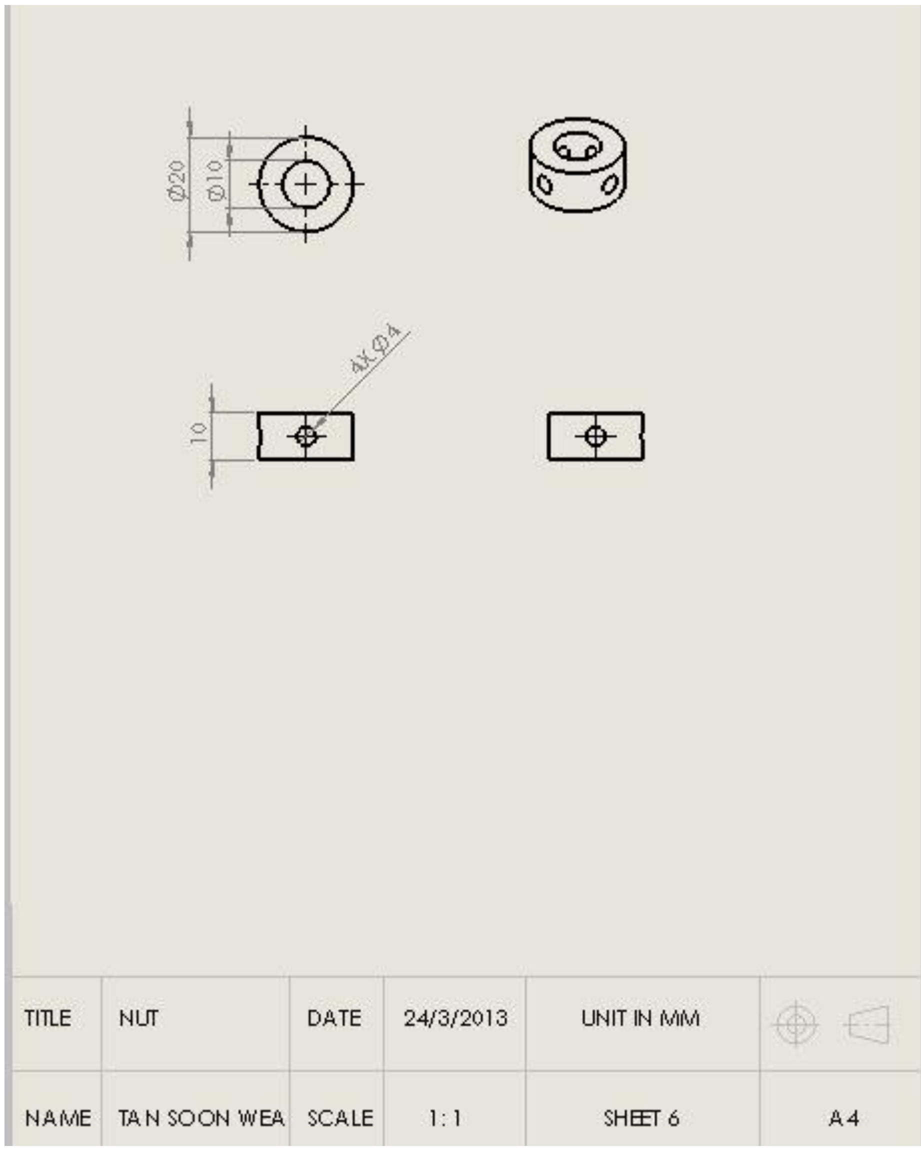
APPENDIX B5

SOLIDWORK OF ROD



APPENDIX B5

SOLIDWORK OF NUT



SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma in Mechanical Engineering.

Signature:
Name of Supervisor: MUHAMMAD HATIFI BIN MANSOR
Position: LECTURER
Date: 10th JUNE 2013

STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any diploma and is not concurrently submitted for award of other diploma.

Signature:

Name: TAN SOON WEA

ID Number: MB 11264

Date: 10^{th} JUNE 2013

ACKNOWLEDGEMENTS

I am grateful and would like to express my highest gratitude to my supervisor Muhammad Hatifi bin Mansor for her germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He had always impressed me with his outstanding professional conduct and his supervision method for bringing up my creativity. I am truly grateful for his progressive vision about my final year project, his tolerance of my naive mistakes, and his commitment to my future career. I also sincerely thanks for the time that he spent proofreading and correcting my many mistakes.

I sincerely thank to all lab assistant and members of staff in the Faculty of Mechanical Engineering, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable. Many special thanks go to my course mates for excellent co-operation, inspirations and supports during this study.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. The highest honour is given for their devotion, support and faith in my ability to attain my goals.

ABSTRACT

This thesis shows the design and fabrication of a vibration test rig with two degree of freedom free vibration in coordinate coupling. The objective for this project is to design and fabricate lab test rig for free vibration in coordinate coupling. Basically, the vibration test rig applied with the dynamic concept such as angular displacement, angular velocity, frequency, two degree of freedom and free vibration. Design generation of the test rig is portrayed and three dimensional view as well as orthographic view was done using Solidworks software. The needed fabrication process is briefly described and the main material used in this project is aluminium and mild steel. Process like cutting, drilling, grinding, tapping and etc is needed to fabricate the test rig. Some methods of improvement for the combination of test rig are also provided for further improvement of the test rig. Finally the test rig can experiment to test the coordinate coupling theory of vibration.

ABSTRAK

Tesis ini menunjukkan reka bentuk dan pembuatan alat uji getaran yang mempunyai getaran bebas dua darjah kebebasan dalam pasangan koordinat. Objektif projek ini adalah untuk reka bentuk dan pembuattan tentang alat uji getaran bebas Asasnya, alat ujian getaran telah menggunakan konsep dinamik seperti anjakan sudut, kelajuan sudut, kekerapan, dua darjah kebebasan dan getaran bebas. Generasi reka bentuk alat ujian digambarkan dan tiga dimensi pandangan serta pandangan berhubung tiga sudut telah dilakukan menggunakan perisian Solidworks. Laporan ini juga menerangkan aliran projek. Proses fabrikasi diperlukan secara ringkas diterangkan dan bahan utama yang digunakan dalam projek ini adalah keluli aluminium dan sederhana. Proses seperti memotong, penggerudian, pengisaran, penorehan dan lain-lain adalah digunakan untuk memalsukan pelantar ujian. Idea penambahbaikan untuk alat uji getaran juga disediakan untuk pembaharuan masa akan datang. Akhirnya pelantar ujian boleh mencuba untuk menguji teori gandingan menyelaras getaran.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE