# TWO DIMENSIONAL CAR BODY VISUALIZATION USING AIR FLOW BENCH

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

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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

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Position: VOCATIONAL TRAINING OFFICER
Date:

## 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 degree and is not concurrently submitted for award of another degree.

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Especially for my beloved family

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## ABSTRACT

In the automotive industry which is now very fast-paced, the production of the variety of cars have resulted that owning a car has become a necessary asset in life. More demands for cars have made most automotive companies to make a huge sale of their products. Therefore, more car makers are in the dilemma of tough competition to produce good cars in terms of shapes, capacity and horsepower. Hence, Engineers in this field have been fighting hard to come up with new creations of hybrid cars at the same with aerodynamic looks.

Eventually, tests will be conducted to achieve these aerodynamic cars. The use of "air flow bench" has been carried out to ensure it meets the aerodynamic criteria. In this project, it shows how all car models is being tested and how this "air flow bench" works. In conclusion, the project timeline has been met to the schedule and is in smooth operation.

## ABSTRAK

Di industri automotive yang semakin pesat membangun, penghasilan kenderaan yang pelbagai jenis telah membuktikan bahawa kenderaan merupakan aset yang amat diperlukan didalam kehidupan seharian. Semakin banyak permintaan terhadap kenderaan telah menyebabkan banyak syarikat automotive telah memasarkan kenderaan-kenderaan buatan mereka. Justeru itu, persaingan diantara syarikat-syarikat automotive telah membuatkan mereka menghasilkan kenderaan yang cantik, bentuk kenderaan yang menarik serta kelajuan yang boleh dihasilkan. Maka jurutera-jurutera didalam bidang automotive telah berusaha untuk menghasilkan kenderaan yang mepunyai reka bentuk yang mempunyai ciri-ciri yang aerodinamik. Maka, ujian perlu dilakukan untuk memastikan reka bentu itu dapat memenuhi ciri-ciri aerodinamik. Pengunaan alat “air flow bench” digunakan didalam ujian-ujian untuk memastikan reka bentuk itu memenuhi kriteria-kriteria aerodinamik. Di dalam projek ini juga menunjukan bagaimana menghasilkan model-model yang akan digunakan didalam ujian dan bagaiamana alat “air flow bench” berfungsi. Secara keseluruhan projek ini telah di siapkan mengikut masa yang telah di tetapkan dan berjalan dengan sempurna.

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# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

This project is an analysis vehicle model. So in this project a vehicle model is analyzed in two dimensional visualizations using an air flow bench. Usually there are many types of vehicle that have different shapes and in the industry where vehicle is made, the manufacturers design for the vehicle bodies in different shapes and different abilities depending on the type or category of the vehicle. When they finish with the designs of vehicle body, they send those designs of the vehicle body to be analyses. Aerodynamic is the important aspect in an analysis result. The best aerodynamic design can produce more efficient in vehicle performance. So, this project is to fabricate the vehicle body model and run a analysis to get the result of air flow streamlines that is from different category of vehicle. To make the model, it use a few software's such as CAD software such as autocad and solid work, laser cutting and the most important machine to make this project success is air flow bench equipment.

## 1.2 PROBLEM STATEMENT

In the automotive industry, one of the important aspects in making a vehicle the shape of vehicle body, this is because the shape of the vehicle body is related with the aerodynamic of vehicle performance. After the designers have finished with the design, they send the model for make analysis to analyze the aerodynamic

properties based on design that have been made. Commonly the item that they use to make the analysis is wind tunnel of air flow bench. So in this project, we use air flow bench to make the analysis.

## 1.3 PROJECT OBJECTIVE

To analyze two or more examples of vehicle body visualizations using air flow bench in two dimensions from different vehicle class. For this project, in order to get the different results of different shapes of vehicle models, more than two example of different vehicle class are used such as comparison about air flow between the sports car and the mini car. It takes two or more models of vehicle body in each of the different class.

## 1.4 PROJECT SCOPE

In order to finish this project, precise scope of work and proper planning are need to be planned and followed, and also needs to go through various processes before it can be produced. Besides that this project is analyze a vehicle body so from the analysis we can get a lot's of information. Besides we can learn to fabricate an sample model using different type of machine. So it gives us advantages to learn new process to produce this particular product and absolutely we could find lots of advantages. These are scope of work in this project.

(i) Find the current design from any source.
(ii) Analyze the air flow effect of vehicle model.
(iii) Use machine to fabricate the vehicle model.

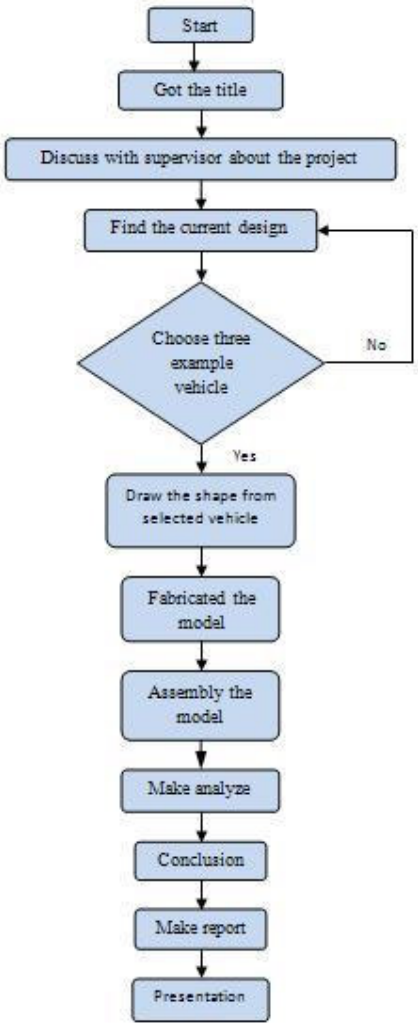
## 1.5 PROJECT BACKGROUND

Aerodynamics is a branch of dynamics concerned with studying the motion of air, particularly when it interacts with a moving object. Aerodynamics is closely related to fluid dynamics and gas dynamics, with many theories shared between them. Aerodynamics is often used synonymously with gas dynamics, with the

difference being that gas dynamics applies to all gases. Understanding the motion of air (often called a flow field) around an object enables the calculation of forces and moments acting on the object.

So when the engineers want to make a new vehicle with a good aerodynamic, they design the vehicle that has a good shape because the air friction factors is given priority in designing vehicle body. When all the designs have been finalized, the vehicle body should be tested in the air flow bench equipment. So this project uses different sample of vehicle body in different class to know the result of aerodynamic in each type.

## 1.6 FLOW CHART



## 1.7 PROJECT SCHEDULE

| Activies | | week 1 | week 2 | week 3 | week 4 | week 5 | week 6 | week 7 | week 8 | week 9 | week 10 | week 11 | week 12 | week 13 | week 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Briefing with lecturer | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| Got the tittle | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| built up gant chart and flow chart | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| Do some literature collection | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| sketch the idea and another idea | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| choose the best model from literature review | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| start to make design using autocad sofware | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| made progress presentation and then try to learn equipment | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| start to fabricated model | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| made anaylsis to each model | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| Present the final | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |
| make the report for the project | planning | | | | | | | | | | | | | | |
| | actual | | | | | | | | | | | | | | |

**Table 1.1 Gantt chart**

## 1.8 PROJECT EXPECTATION

From this project, firstly the students will know the air flow in each vehicle that has different shape body when making the analysis using the air flow bench. Secondly the student will know how to use the air flow bench to make the analysis of the vehicle model and also another example. Thirdly the student will know how to use the laser cutting to cut acrylic or to make another prototype. Lastly the student will know how to use CAD software like autocad or solidwork to make the design and transfer it to the machine to fabricate the prototype.

## 1.9 CONCLUSION

This chapter is explains all the planning it takes to make this project success. This project is an analysis project and it analyzes the air flow of vehicle body that can be obtained from the air flow bench. In order to make this project more interesting, three examples of current vehicles have been take to make this analysis. This project enable to know about the air flow when the smoke moving through the model and in different vehicle body.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

This project is based on an analysis project, so mostly it is based on the data that can be obtained from any source like article or from experiment. Commonly, to make the analysis of the vehicle body, smoke is used in order to see the result from the air when it comes through the vehicle body. All vehicles before being displayed to universal, vehicle must be sent to the analysis room to test vehicle in aerodynamic properties aspects.

In aeroplane analysis, they use wind tunnel to analyses it. They make the prototype from the aeroplane and put in the center at wind tunnel. When they switch on the fan, the fan will produce a wind and then they put a smoke to see the streamline that is a created when the smoke comes through the aeroplane model.

Commonly to make the analysis about the aerodynamic, they have a few items that are always using in this experiment:-

i. Educational Wind Tunnel.
ii. Airflow Study Unit.
iii. Flow Visualization Wind Tunnel.
iv. Compressible Flow Unit.
v. Airflow Bench.

## 2.2 AIRFLOW BENCH

**Figure 2.1 Air Flow Bench**

### 2.2.1 Technical Description

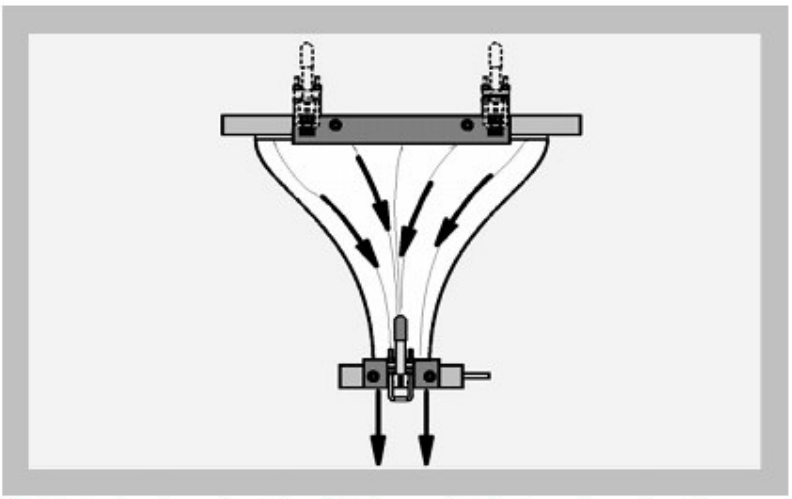
The test stand is fitted to a trolley, this makes it flexible in use. A radial fan generates velocities of up to 40m/s in a vertical test duct. A flow straightened provides for a low turbulent flow.

The specially shaped nozzle provides a homogeneous velocity distribution in the air flow. The outlet air is fed to the rear using a hood. Experimental set-ups available as accessories are attached to the outlet of the nozzle. Measuring glands are fitted to the test duct for recording pressure differences. The flow velocity can be continuously adjusted using a fine regulator.

### 2.2.2 Type Of Air Flow Bench

i. Experimental set-up on laboratory trolley.
ii. Accessories covering just about all areas of aerodynamics.
iii. Flow velocities of up to 40m/s possible.

iv. Homogeneous flow due to specially designed flow straightened.



The illustration shows how the air in the nozzle (also termed an effuser) is accelerated.

**Figure 2.2 The Illustration**

### 2.2.3 Air Flow Bench Specification

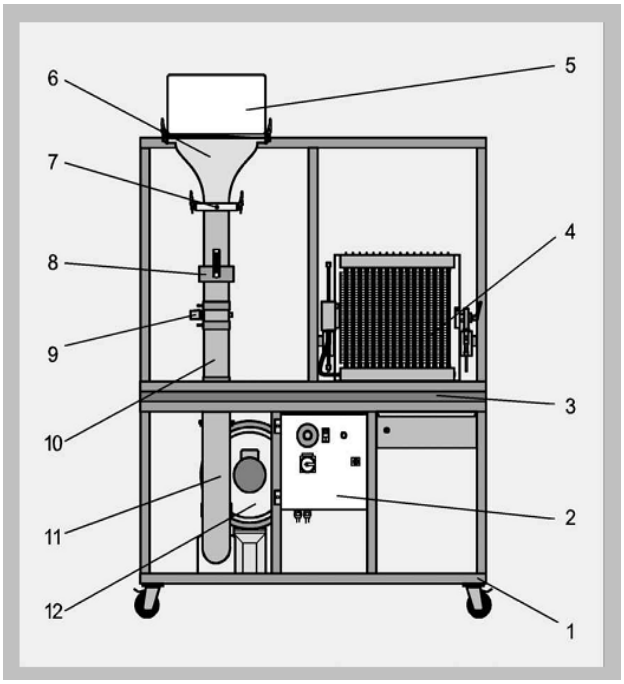



**Figure 2.3 Air Flow Bench**

1. Laboratory trolley.
2. Switch box.
3. Bench top.
4. Manometer panel.
5. Flow straightened.
6. Nozzle.
7. Receptacle for the accessory modules with measuring glands.
8. Thermometers.
9. Regulator flap.
10. Feed pipe.
11. Outlet pipe with hood.
12. Radial fan.

## 2.3 AIR FLOW VISUALISATION APPARATUS

**Figure 2.4 Flow Visualization**

### 2.3.1 Technical Description

The flow visualization experimental set-up is used in combination with the Air Flow Bench to make flow lines around bodies visible. A smoke generator evaporates liquid paraffin, the smoke is blown via a slotted tube into a vertical smoke duct. A viewing window fitted to the front of the smoke duct enables the interior of the duct to be observed with ease. The inside of the duct is black to make the flow lines easier to see. The flow around bodies can be investigated using various models.

### 2.3.2 Experiments

i. Flow diagrams for a real fluid when flowing around bodies.
ii. Appearance of separation on bodies in a flow.
iii. Flow around various bodies.

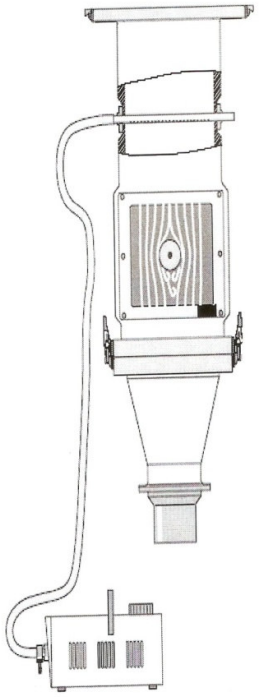


Figure 3 Sample of Streamline that can be Visualized

### 2.3.3 Specification

i. Accessory for the HM 225 Air Flow Bench.
ii. Experimental set-up for visualising flow lines.
iii. Vertical smoke duct with viewing window.
iv. Smoke generator 230V,~50Hz, operation with liquid paraffin.
v. 3 drag bodies for placing in the smoke duct.

## 2.4 FLOW VISUALIZATION WIND TUNNEL


**Figure 2.5 Wind Tunnel**

### 2.4.1 Technical Description

The benchtop unit contains a narrow flow chamber with viewing window in which the drag model is placed. The airflow is generated using a blower. To obtain a flow with low turbulence, the air passes through a settling chamber, a fine sieve and a flow straightener. Smoke is used to make the streamlines visible. The smoke is generated by vaporising a glycol mixture and enters the tunnel via a manifold with a large number of outlet holes. The flow patterns can be clearly seen due to the black background of the flow chamber and additional lighting. Four different models

(cylinder, orifice and two wing sections) are supplied. They can be interchanged and have an adjustable angle of attack.

### 2.4.2 Learning Objectives / Experiments

i. Flow diagrams for a real fluid when flowing around bodies .
ii. Onset of boundary layer separation on bodies.
iii. Demonstration of turbulent and laminar flow.
iv. Influence of angle of incidence.
v. Flow around a symmetrical and an asymetrical wing.
vi. Flow through slit diaphragm.

## 2.5 EDUCATIONAL WIND TUNNEL


**Figure 2.6 Wind Tunnel**

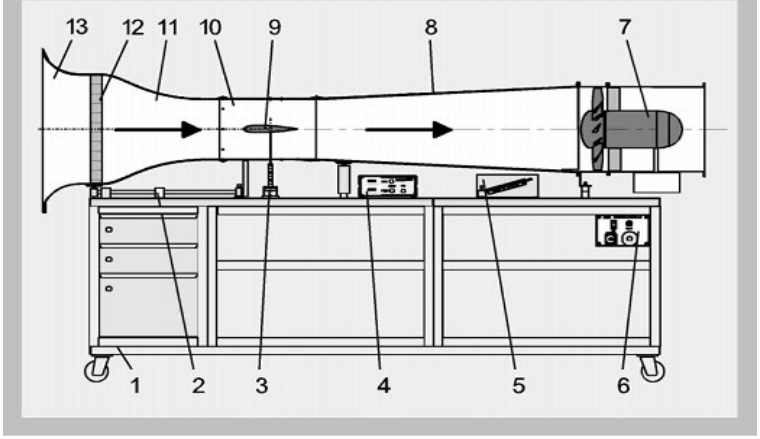
### 2.5.1 Technical description

The educational wind tunnel HM 170 is a so-called "Eiffel type" of open subsonic wind tunnel. With this type of tunnel the air is taken from the atmosphere

and returned to the atmosphere. A vehicleefully designed nozzle shape guarantees the constant distribution of velocity within the closed measurement section. Velocities of around 100km/h are reached. A flow rectifier at the inlet ensures a low degree of turbulence. The wind tunnel consists of the following components: inlet hopper with flow rectifier, nozzle, measurement section, diffuser and fan. The nozzle, inlet hopper and the measurement section are mounted on a guide rail and can be moved in order to access the measurement section. An axial fan with guide wheel is used which is characterised by its low noise level and high efficiency. The fan is mounted on rubber elements to minimise vibration during operation. It is driven by a speed-controlled motor with frequency converter. The fan is connected permanently with the diffuser. An electronic 2-component force transducer permits the measurement of resistance and buoyant forces at various objects. The measured values are displayed on a measuring amplifier. It is also possible to process the data via PC-data acquisition (available as an accessory). A slanted tube manometer is used to display the current

### 2.5.2 Features

Open wind tunnel for experiments in aerodynamics and fluid mechanics Homogeneous flow through flow rectifier and specially shaped nozzle measurement section visible on all sides Smooth inner surface




1 laboratory trolley, 2 guide rail for adjustable nozzle, 3 electronic force transducer, 4 measuring amplifier for force transducer, 5 slanted tube manometer, 6 switch box, 7 axial fan, 8 diffuser, 9 measurement object, 10 measurement section, 11 nozzle, 12 flow rectifier, 13 inlet hopper

**Figure 2.7 Wind Tunnel**

## 2.6 VEHICLE MODEL

i. Bmw.
ii. Bus.
iii. Perodua kenari.

### 2.6.1 Bmw

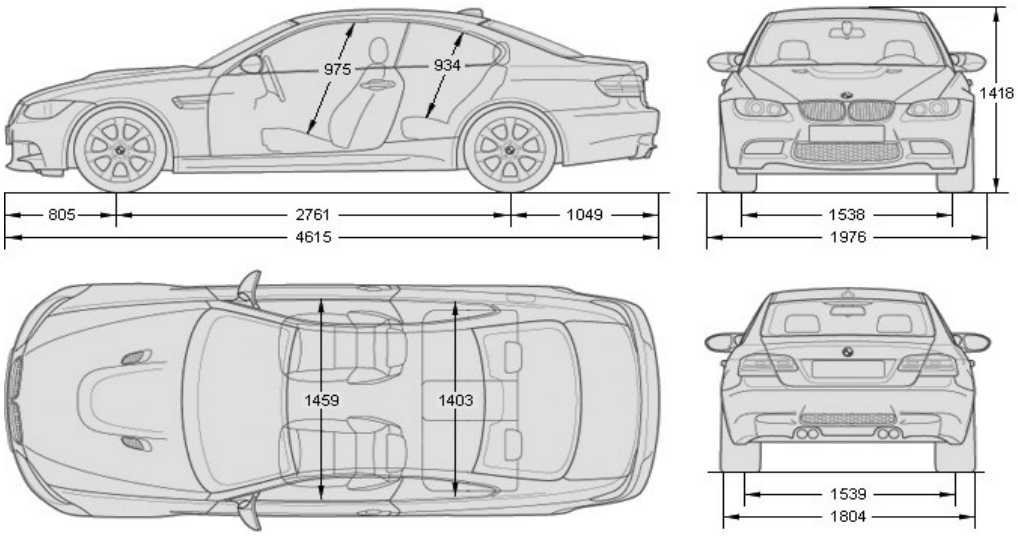



**Figure 2.7 Bmw M3 Vehicle Blue Print**

### 2.6.2 Bus (scania)

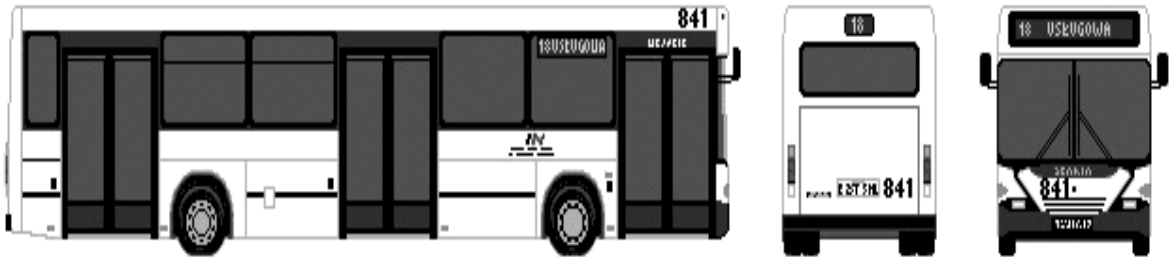



**Figure 2.8 Bus Blueprint**

### 2.6.3 Perodua Kenari

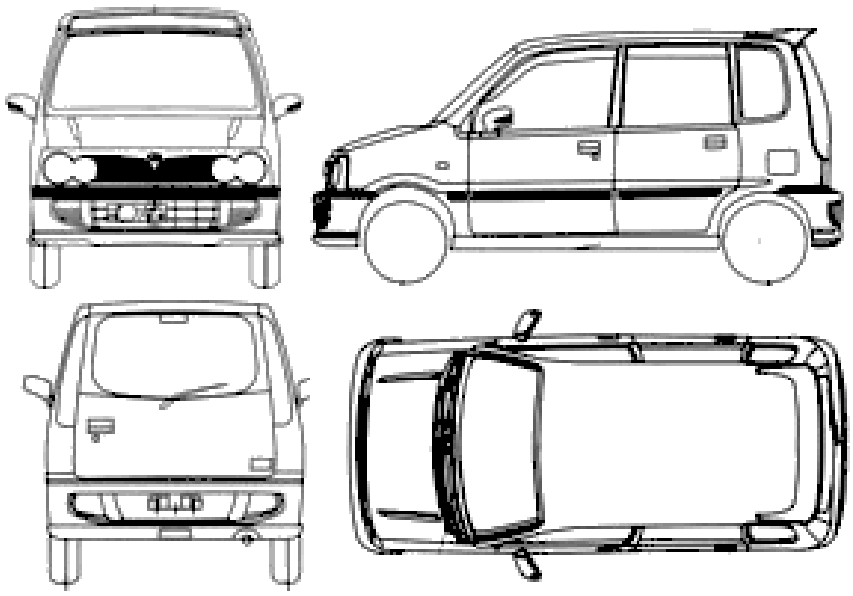


**Figure 2.9 Perodua Kenari Blueprint**

## 2.7 CONCLUSION

In this chapter, it describes the equipment that is use in this project and also another equipment that has been used to make analysis to get the air flow. There are a lot of equipment that can be used to analyze the air flow and for this project air flow bench is used to make this analysis, moreover it describe the three example of current vehicle models and another vehicle that is bus. The three examples are from different type class of vehicle that are BMW from sport car, bus from type of buses and the last one is Produa Kenari that is from mini car that have five door.

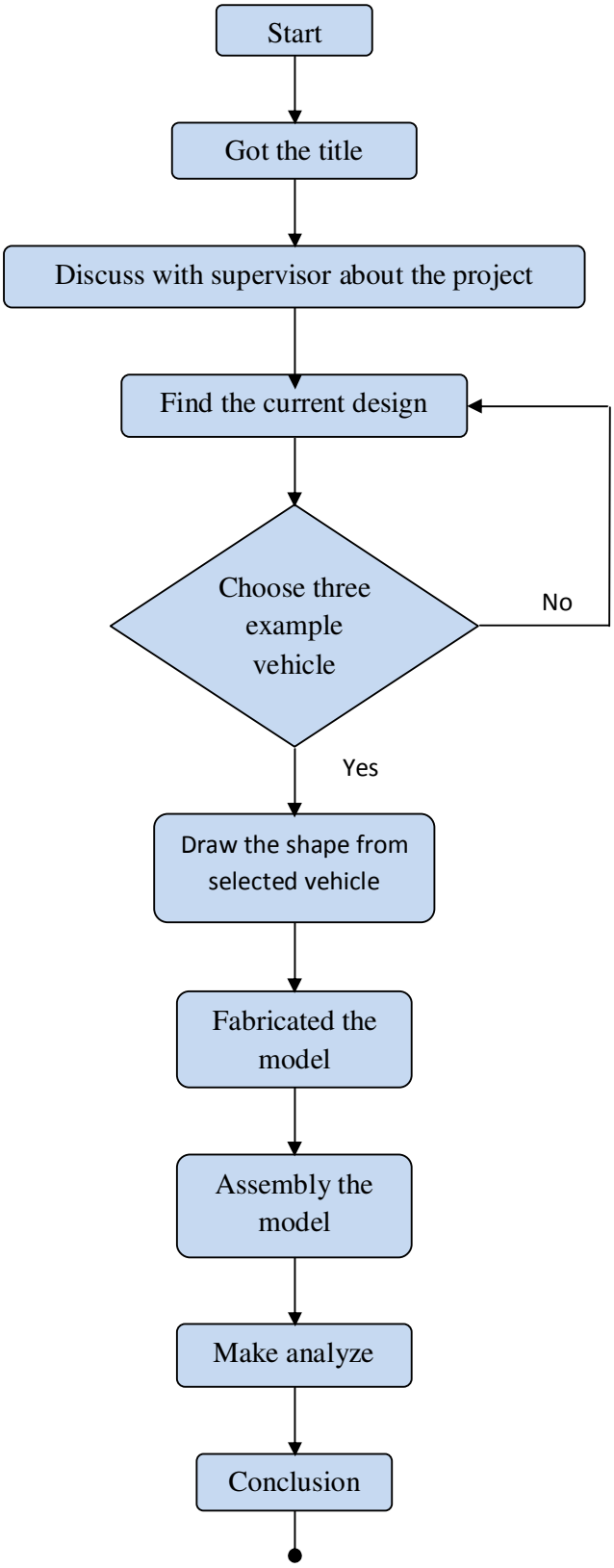
# CHAPTER 3

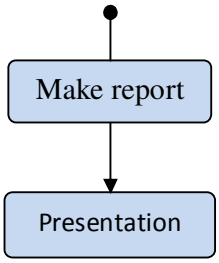
# METHODOLOGY

## 3.1 INTRODUCTION

Methodology is a collection of methods, practices, procedures and rules used by those who work and also refer to more than a simple set of methods. In this chapter, it describes the way how the product is made from the material to product. Firstly before starting to fabricate the product, the flow chart should be made because we can use the flow chart as a reference. This chapter will show a few methods that use in this project. These methods are planned to make the product from material.

### 3.2 FLOW CHART






## 3.3 DESIGN

To chose the design it must consist the type that have been selected and in this project it make the analysis in different type of car class and we have choose different of the car class that we can make the analyze is

i. Sport car
ii. Mini car
iii. Bus

We chose this different car class because we want to know the different result the air flow that can be see it this three different type classes. The car for each type of car class that have been chose is

i. Bmw m3
ii. Perodua kenari
iii. Scania L94 (Bus)

### 3.3.1 BMW M3

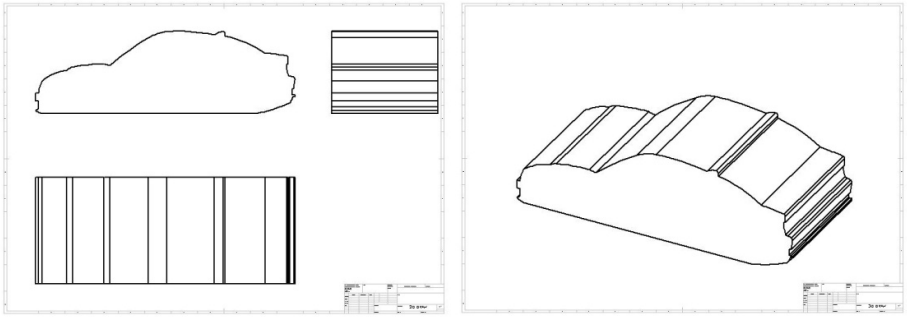


**Figure 3.1 Designs For Bmw**

### 3.3.2 PERODUA KENARI

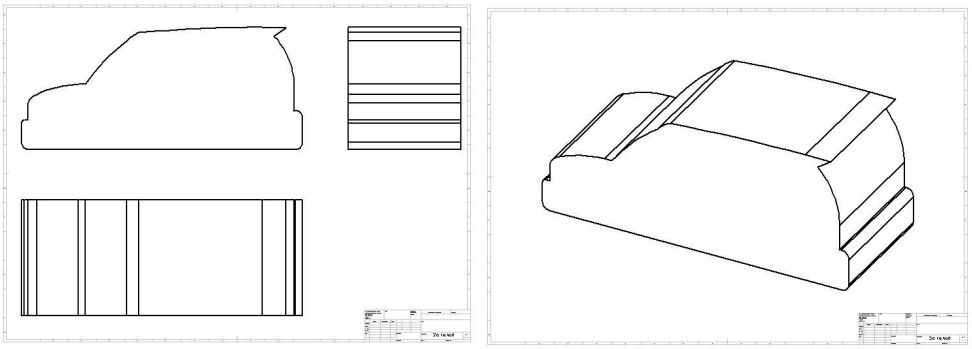


**Figure 3.2 Design For Perodua Kenari**

### 3.3.3 SCANIA L94

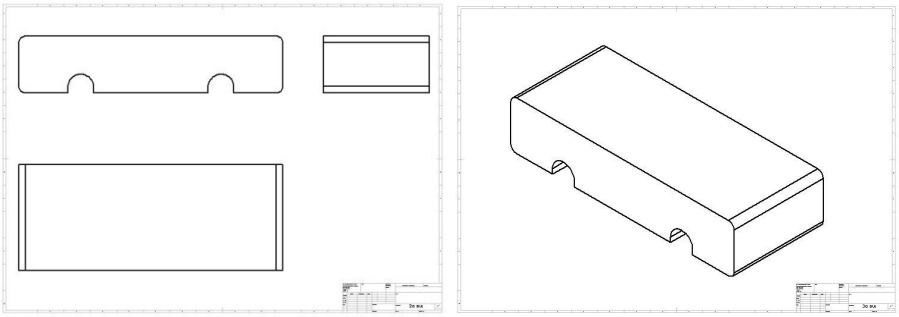


**Figure 3.3 Designs For Bus**

### 3.3.4 BASE FOR MODEL

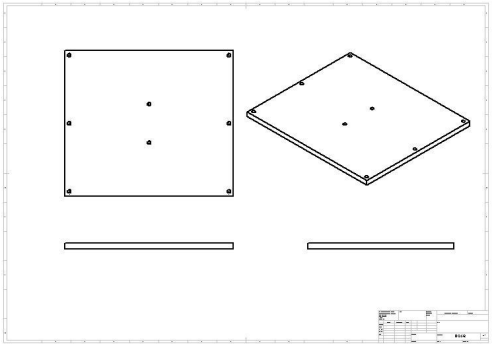


**Figure 3.4 Base Design**

## 3.4 BILL OF MATERIAL

| No | Name material | Dimension (pxlxt)(mm) | quantity |
|---|---|---|---|
| 1 | acrylic(part 2) | 290 x 250 x 5 | 3 |
| 2 | acrylic (part 1) | 150 x 100 x 5 | 27 |
| 3 | Screw | Diameter 6mm | 24 |
| | | | |

## 3.5 PART OF THE MODEL

In this project, the model made consists of 2 parts to be attached together when we want to make the analysis. Part 1 is the shape or car body and part 2 is the acrylic that is attached with part 1

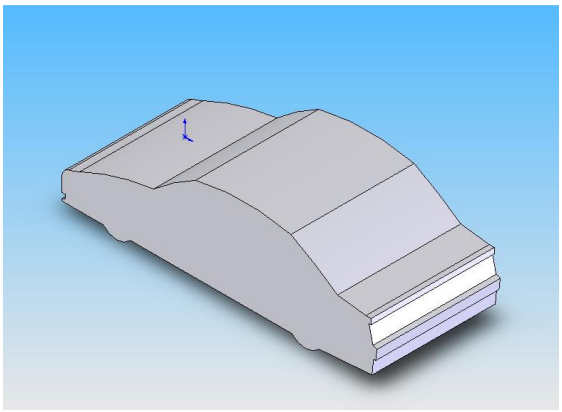


**Figure 3.4 Example Model Car Shapes (Part 1)**

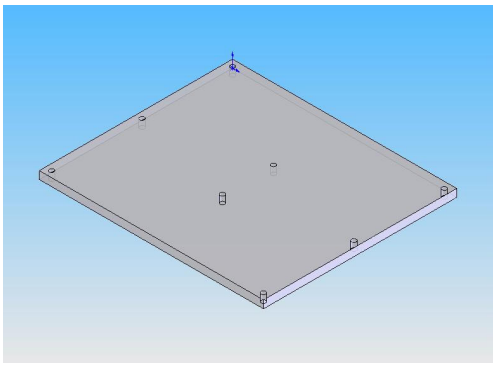


**Figure 3.5 Additional Device Uses To Attach With Car Model (Part 2)**

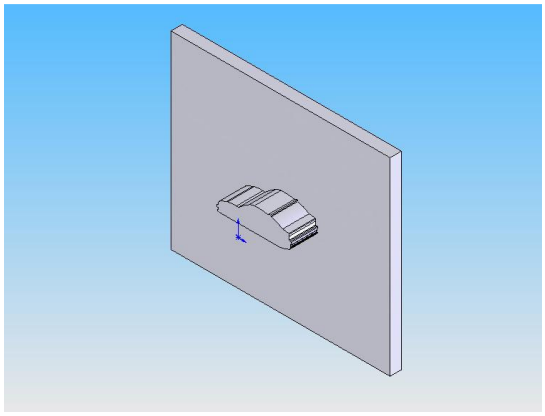


**Figure 3.6 The Combination Part 1 With Part 2**

## 3.6 FABRICATION

For fabrication there consists a few steps to complete this project.

### 3.6.1 Material Preparation

After the design has been made, material should choose to make the design become a solid part. In this process the material is chosen according to the suitable material at FKM laboratory. Besides that other materials that are needed to be used have to be purchased at elsewhere. After that, the design in engineering drawing will go through fabrication process after the measuring and cutting material is done.

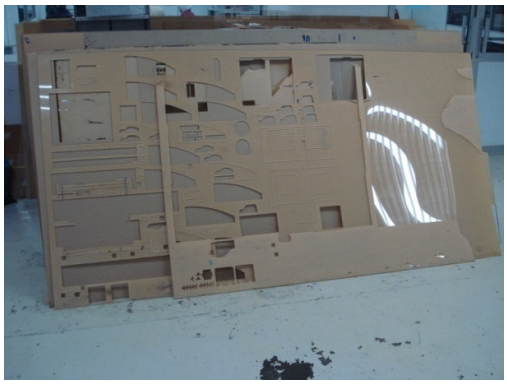


**Figure 3.7 Plastic Acrylic**

### 3.6.2 Fabrication Process

To make the model of the workpiece, it must go through a few steps to make this workpiece becomes the model. For part 1 that is acrylic, it must use the laser cutter to make the workpiece into a model. The Dimension for this is 120x50x40.

#### 3.6.2.1 Procedure To Cut Using Laser Cutting

1. Convert design into drawing file (.dwg).
2. Open using art cam.
3. Setup the cutting speed and toolpath.
4. Save toolpath into text file (.txt) and edit the text.
5. Open pcnc.exe and the open the toothpath using the save name.
6. Switch on the laser.
7. After finish the cutting switch off the laser.
8. Repeated step 1 to step 7 if want to cut another design.

For part 1 and 2, to cut the acrylic it uses the laser cutting in fkm lab.


**FIGURE 3.8 Cutting Acrylic**

## 3.7 ANALYSIS PROCESS

Analysis process is a next step to do after fabrication process. This process uses air flow bench to make the analysis. The smoke that comes from smoke