Student Name: ______________________________

Australian Government

Department of Defence

Defence Materiel Organisation

THE LIVING TOOLBOX

INDUSTRIAL TECHNOLOGY - ENGINEERING

CO_2 Powered Race Car Unit -

Research & Engineering Portfolio

Acknowledgments

This document has been developed in cooperation with Re-Engineering Australia. Re-Engineering Australia Foundation was founded in 1998 by engineer, businessman and passionate Australian, Dr Michael Myers OAM, in response to the drastic shortage of skilled young people wanting to pursue engineering-technical-manufacturing career paths.

Dr Myers linked with forward-thinking companies, organisations, government departments, educators and individuals who are passionate about enthusing, equipping and guiding our next generation.

Many of the resources presented in this document have been developed by Re-Engineering Australia and the authors of this document wish to acknowledge the fantastic contribution that REA have had on the success of technology education throughout Australia.

The Technological Literacy Group through their Science of Speed web site also kindly allowed the use of images and information for this document. The Technological literacy group is dedicated to STEM education based in the USA it provides excellent resources for CO_2 powered racing.

Funding for the collation of this document has been provided by the ME program. This program is about creating a path for high school students to experience and explore the career opportunities that are possible in the manufacturing industry.

These opportunities are delivered through a school program tailored to students from years 9-12. Schools provide core subjects like Mathematics, English, Science, Information and Communication Technology and Engineering Studies to provide the foundations for pursuing a career in manufacturing.

The ME program is sponsored by Regional Development Australia Hunter and the Department of Defence, Defence Materiel Organisation.

The Living Toolbox is an initiative of the ME program which was developed to provide hands-on resources to support teaching and learning of advance manufacturing in our schools.

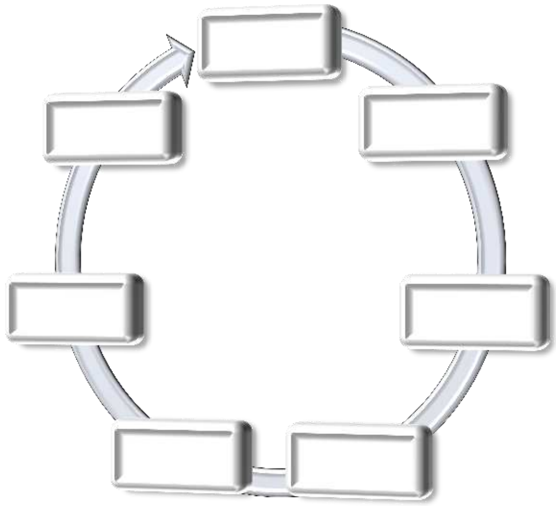
This document has been prepared by Mr Ces D’Amico and Mr Scott Sleap from Maitland Grossmann High, East Maitland NSW, Australia.

Team Work

Now that your team members are aware of the responsibilities that each role entails, you may now wish to decide on which team member is best suited to which role and designate the appropriate role. In the table below, give a brief description of what that each role will entail in your group, add a photograph of each team member and in the name section add each team members name and a brief description of them. Eg. John Smith is 14 years old and enjoys playing ruby…..

Role	Photograph	Name
Team Manager		
Resources Manager		
Manufacturing Engineer		
Design Engineer		
Graphic Designer		

The Science of Going Fast

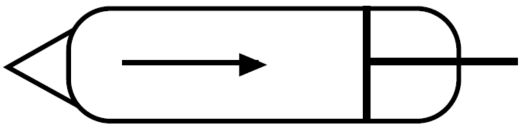


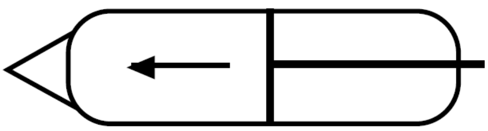
The Design Process

In the figure below fill out the missing spaces which demonstrate the basic design process to be used to develop a CO_2 powered racer.

Boyles Law

Boyles law states that as the volume of a gas changes, so does pressure. Complete the following sentences as they relate to the figures above;





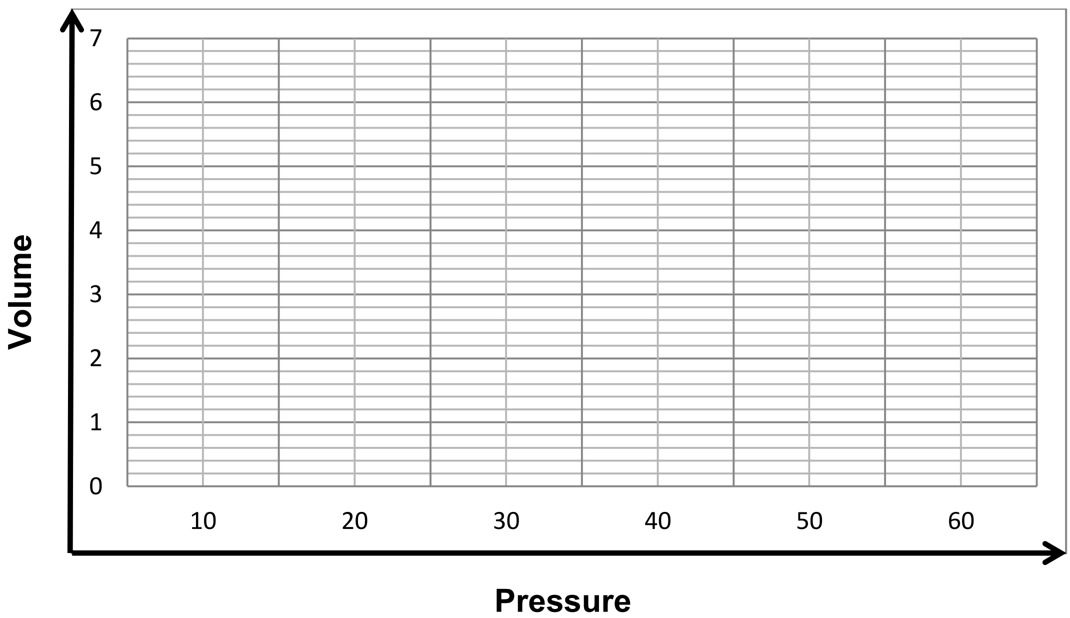
If the volume of a gas_____________,

then the pressure ________________.

If the volume of a gas____________,

then the pressure ________________.

Boyles law is said to have an inverse relationship between volume and pressure, on the graph below show this relationship.



Force

It is the gravitational pull acting on the mass of a body which gives us that force known as ***weight*** of the body. From Newton's second law, $F = ma$, the weight-force is found from $W = mg$, where m is the mass of the body and g the acceleration due to gravity.

Consider a man of mass 100 kilograms standing on his bathroom scales. The force in newtons that the man exerts on the platform of the scales is found from

$$\begin{aligned} W &= mg \\ &= 100 \times 10 \\ &= 1000\ \text{N} \end{aligned} \qquad \text{where: } m = 100\ \text{kg},\quad g = 10\ \text{m/s}^2$$

Thus the man exerts a force of 1000 newtons on the platform of the scales; this force is his *weight*, or, more properly, his *weight-force* or *gravity force*.

Exercise 1: Measure your mass in kg using a set of bathroom scales and determine your weight force.

My weight force = ***newtons***

Exercise 2: A set of scales is being used to weight a model CO2 car made of Balsa. The scales show a reading of 0.5 kg. What force is the bottom hook supporting?

Force: _________N

Exercise 3: The minimum weight permissible in the rules for a Formula 1 car is 640 kg (including the driver). What is the magnitude of the force exerted by each wheel on the track surface?

Force exerted by each wheel ______________ N.

Hydrostatic Pressure

If an object is placed into a fluid then the fluid pressure will act upon the entire surface of the object at right angles to the surface. The pressure may be defined as the force per unit area, thus:

$$P = \frac{F}{A}$$

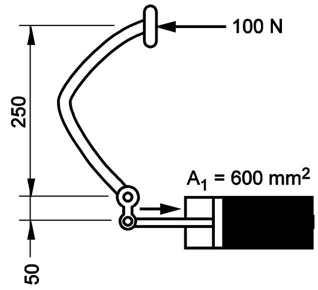
P = pressure (Pa)

F = force (N)

A = area (m^2)

Exercise: The figure below represents a sealed hydraulic braking system. A force of 100 N is applied to the brake pedal as shown, which produces a force of 500 N on cylinder A_1.

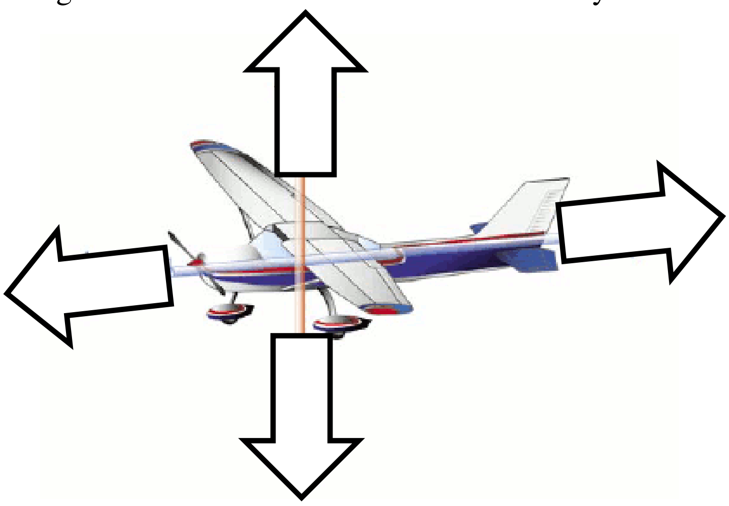
Determine the pressure in Pascals in cylinder A_1.



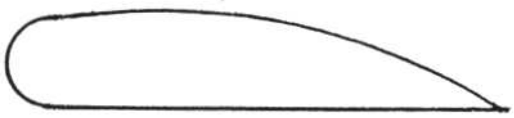
Pressure in cylinder A_1______________Pa

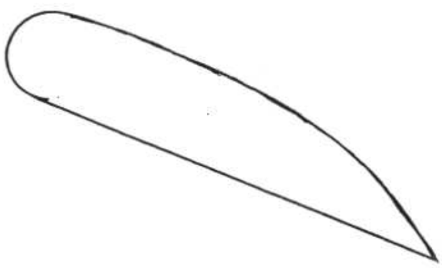
Aerodynamics

Exercise 1: On the diagram below indicate the four forces aerodynamic forces related to flight.



Exercise 2: The basic principle of flight is centered around airflow on an aerofoil. Complete the diagrams below illustrating over the cross-sectional shape of the aerofoils, showing the type of airflow (Laminar or Turbulent).



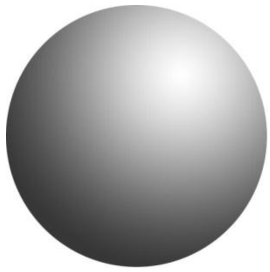


Exercise 3: Why do golf balls have dimples?

____

____

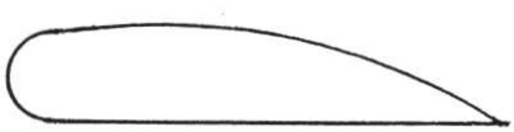
Exercise 4: Show the air flow around a golf ball and a sphere on the diagrams below. Indicate turbulent air and the boundary layers.



Exercise 5: Indicate the comparative drag coefficients C_d of the following objects.

1. Indy Car (Short Track) ______________________
2. Sphere ______________________
3. Sports Car (Corvette) ______________________
4. Bullet ______________________
5. Airfoil ______________________

Exercise 6: On the two cross sections of the foils shown below draw an arrow on each to indicate the relative direction of lift.

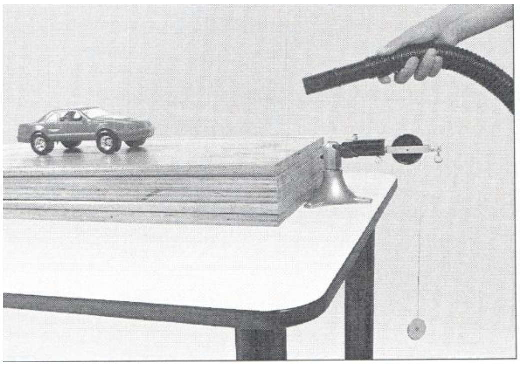


Exercise 7: Who was Osborne Reynolds and what was his main contribution to engineering.

____

____

Drag Experiment



Step1: Clamp a pulley onto the edge of a table as shown in the figure.
Step2: Cut a piece of string that is 300 mm long. Tie one end to a toy car or dragster.
Step 3: Bend a paper clip into a loop and tie the other end of the string to the loop.
Step 4: Bend the other end into a hook to hold washers or weights.
Step 5: Place two to three washers or know weights on the hook and then loop the string over the pulley. Pull the car back until the paper clip is just below the pulley.
Step 6: Turn on a vacuum or hair dryer and point it at the car. Add more weight until the car and the air stream are balanced (the car does not move forward or backwards). The weight or the number of washers added represents the drag of the car.

Bernoulli's Principle Experiments

1: Obtain an A4 sheet of paper and place your fingers on each side as shown in the figure. With your mouth level with the paper, try to blow across the top of the piece of paper. Record the direction that the paper moves.

2: Place two softdrink cans of a bench 20 mm apart. With a straw blow between the gap in the cans and record the direction of movement.

3: Using a blow drier and a ping pong ball, place the ball directly in the flow of the air and then tilt the hair drier on an angle and discuss the results.

Newtons First Law Activity:

And they're off!

In this experiment you will learn more about why Newton's First Law of Motion is also called the Law of Inertia. In this experiment you will discover how Newton's First Law works by conducting a race.

1. Build a ramp for the two cars can race. (A piece of plywood with one end propped up by book will do.)
2. Place two identical F1inSchools cars or dragsters at the starting line.
3. Add weight to one of the cars so it is heavier than the other.
4. Release each car both from the top of the "ramps" at exactly the same time.
5. In the Table below, record how far each car rolled. Do not measure the ramp itself, just the distance from the end of the ramp to where each car actually stopped.
6. Repeat Steps 3-4 for each of the surfaces listed on the table.
7. Fill in the table with your results for each race.

Race	**Surface**	**How far did the lighter car travel?**	**How far did the heavier car travel?**
1	**Wooden Floor**		
2	**Carpet**		
3	**Linoleum**		
4	**Tile Floor**		
5	**Other (___________)**		

Examine your data to look for trends and record your observations. This will prepare you for the questions that follow. For example, determine if one car always rolled farther than the other. Look to see which car rolled farthest on a given surface. Try to figure out why you got the results you did for each car on each surface.

Think About It

1. Did the results depend on whether the car was heavier or lighter? If so, in what way?

____

2. Did the results depend on the kind of surface you used? If so, in what way?

____

____

3. What can you say about a body's tendency to maintain its status quo – its inertia?

____

____

What Do We Need to Know About Mass to Design Fast CO_2 Car?

All CO_2 cars will be powered with an identical force. Basically you all will be using the same engine a CO_2 canister. You will gain an advantage over your competitors by concentrating on streamlining, reducing friction and reducing mass.

$$F = M \times a$$

Assume the CO_2 is propelled with a force of 20 Newtons (20N) in all cases;

Exercise 1: If the CO_2 car has a mass is 2kg what will be its acceleration?

Exercise 2: If the CO_2 car has a mass is 0.5grams what will be its acceleration?

Exercise 3: Determine the mass of your own CO_2 car by weighing it on electronic scales and then estimate its acceleration? (Note: Assumed Force = 20N)

Exercise 4: Determine the mass of a CO_2 car if its acceleration is $30 m/s^2$

Other Physics Exercises!

$$\textbf{Acceleration} = \frac{\textbf{Final speed} - \textbf{beginning speed}}{\textbf{time}}$$

$$\textbf{speed} = \frac{\textbf{distance}}{\textbf{time}}$$

Exercise 5: Your dragster is at the start line. You push the trigger and the dragster accelerates to a velocity of 20 m/s. It takes 5 seconds for the car to reach this final speed. What is the acceleration?

____________________ m/s^2

Exercise 6: When travelling to the regional finals of the F1inSchools competition, you time your family's driving speed. You drive 20 kilometres in 0.4 hours, followed by 35 kilometres in 0.6 hours. What is the average speed of your family's car?

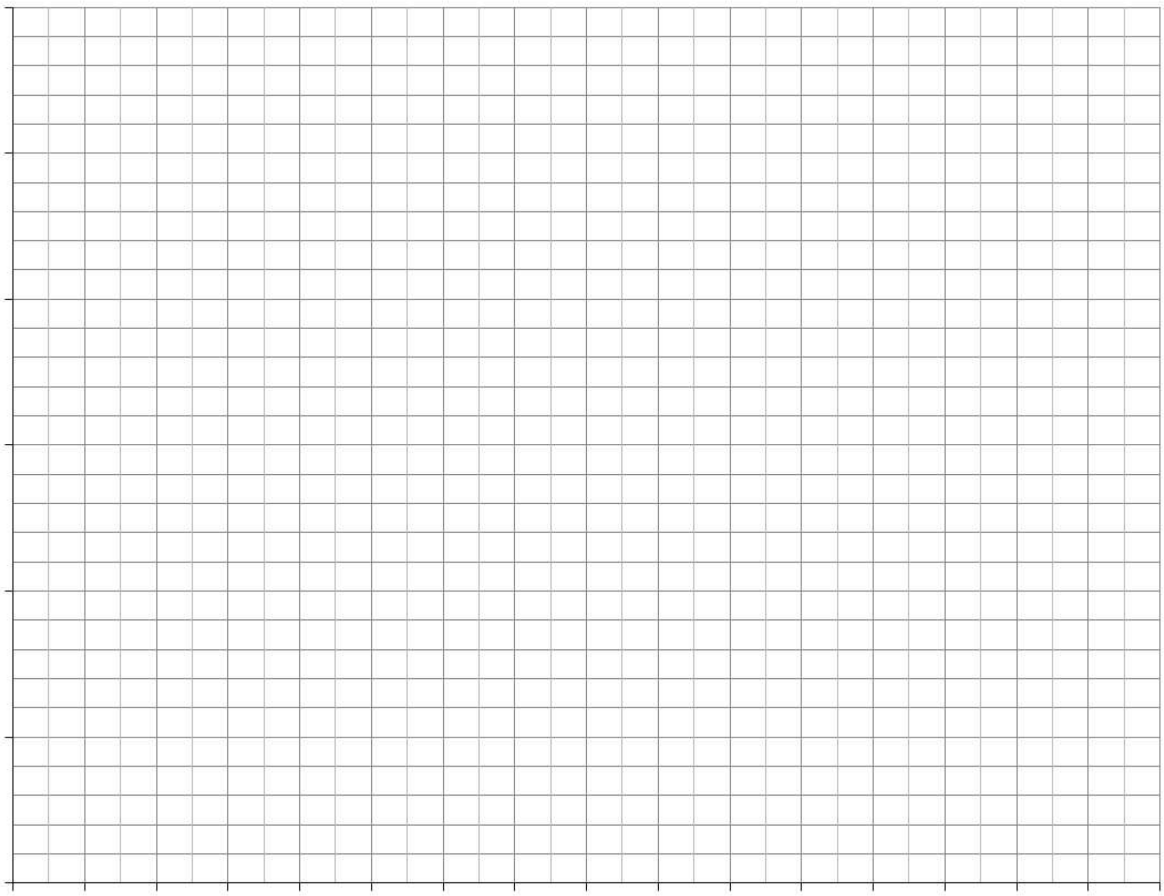
____________________km/hr

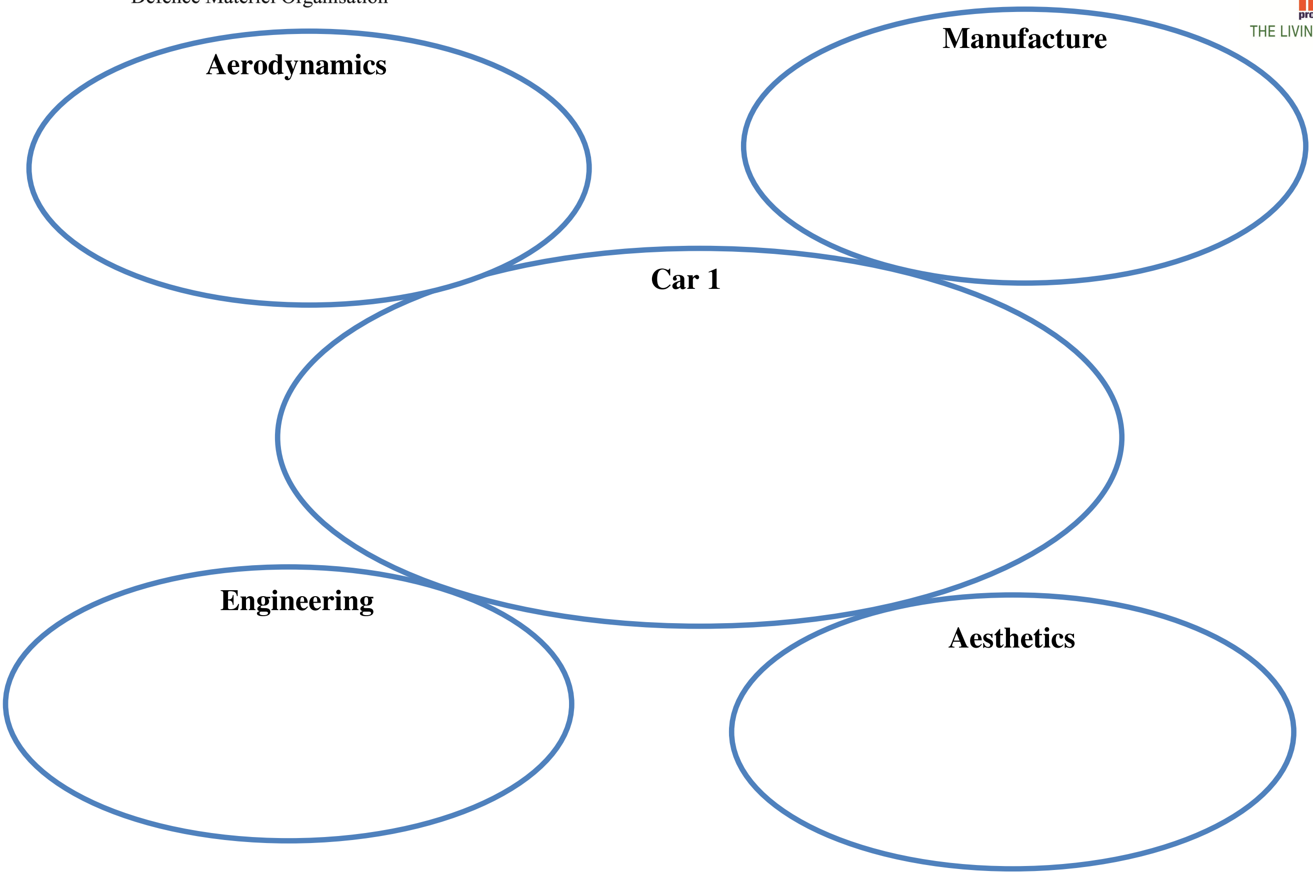
Investigating Newtons Laws

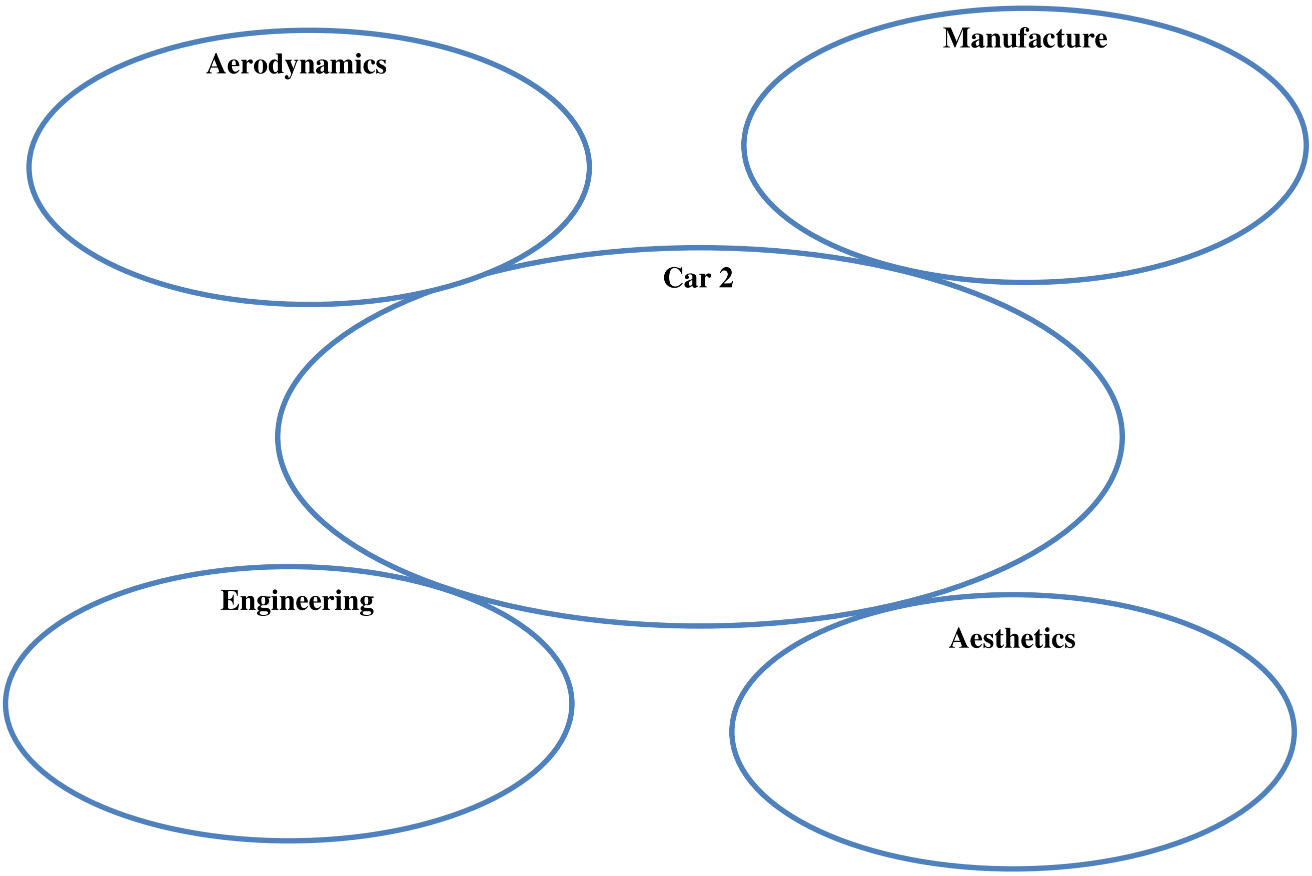
Task1: Read the "CO_2 racers through the eyes of Newton" resource page.
Task 2: Construct two identical CO2 dragsters out of two balsa blanks which have different masses. Do not cut, shape, or sand the blanks
Task 3: Measure the mass of the two dragsters. (make sure one is relatively heavier than the other). Record mass in worksheet below.
Task 4: Race each dragster recording the time for each dragster.
Task 5: Calculate the average time for each dragster. Complete the rest of the worksheet.
Task 6: Using MS Excel spread sheet, enter all the times of both dragsters. Graph the results.

Dragster	**Initial mass of blank (g)**	**Completed mass (g)**	**Time Trial 1 (sec)**	**Time Trial 1 (sec)**	**Time Trial 1 (sec)**
#1					
#2					

Using the average times plot the position of the two dragsters on the graph below. Use a blue pen for dragster #1 and a red pend for dragster #2.




Aerodynamics
Manufacture
Car 1
Engineering
Aesthetics


Aerodynamics
Manufacture
Car 2
Engineering
Aesthetics

Rules and Regulations

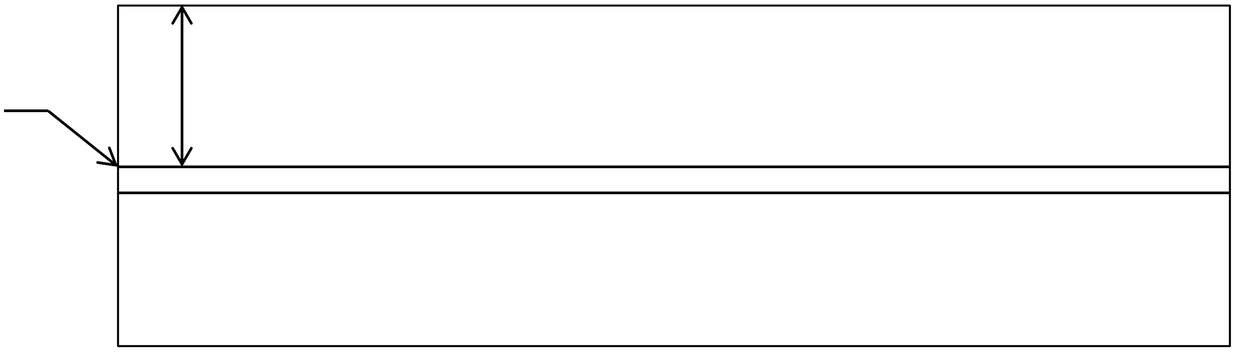
One of the limitations of your CO_2 car design is going to be the F1inSchools standard balsa wood blank shown. In the spaces provided below enter all the measurements for each part of the blank.

A) Overall Size of Blank

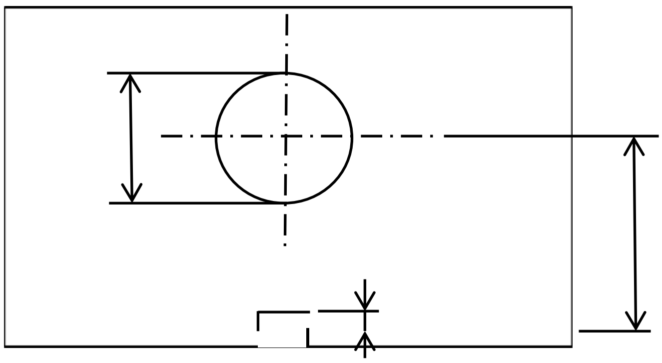
Width	Thickness	Length

B) Location of Tether Line

On the diagram below add the sizes for the tether line recess and its location.

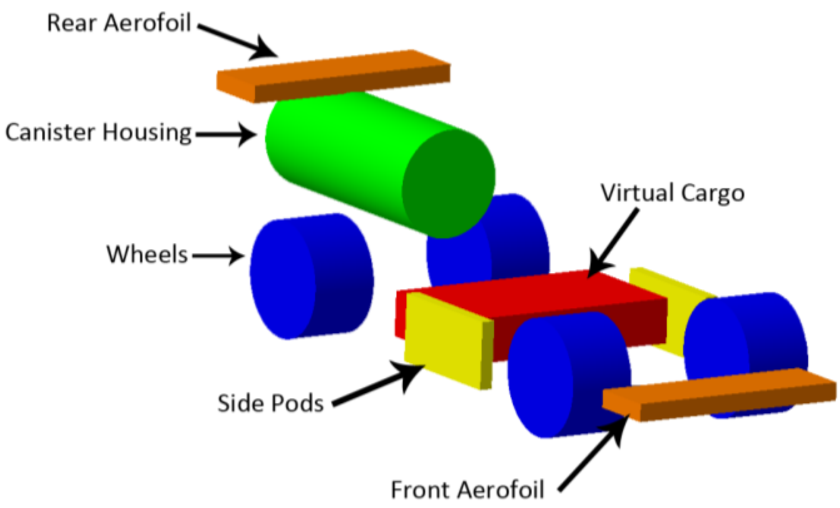


C) Location of CO_2 Cartridge Chamber



In order to be successful in this assessment task teams must be able to design a car which follows the rules and regulations set by the teacher. These rules and regulations are set out in the assessment task sheet that you received at the beginning of this task. General rules and regulations for this task however, are set out on the following page.

Measuring for Specifications Worksheet

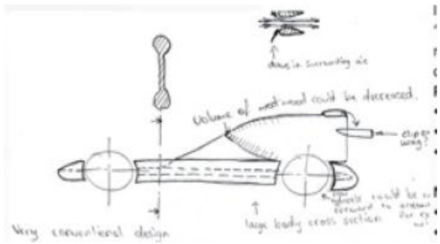


View the General Rules and Regulations Section of your resource folio and (F1inSchools rules and Regulations, CO_2 Dragster rules or rules in the assessment task given to you by your tacher at the start of this unit) and for each specification listed, fill in the appropriate values for the specification in the table below. After you have completed your dragster or F1inSchools CO_2 racer, enter what your actual measurement was, and if your measurement was within range of values that would meet the specifications. Look at the diagram above to understand some of the specifications.

Specification Description	**Specification Value**	**Measurement**	**Within Spec (Y/N)**
Designed using CAD/CAM	Y / N	Y / N	
Open Wheeled	Y / N	Y / N	
Overall length Max			
Overall length Min			
Car Mass			
Cartridge hole depth			
Cartridge hole diameter			
Cartridge hole height			
Thickness of wood around Cartridge hole			
Overall width			
Front wheel diameter			
Rear wheel diameter			
Distance between screw eyes			

Preliminary Design Sketches

In this section of the design process your team needs to translate your own design ideas in the form of sketches the shapes and ideas for your CO_2 car and note them down. These may be simple thumbnail size sketches of concepts that you are considering. You should do as much research as possible prior to doing this section. Some great areas to look at are photos of real Formula 1 cars, planes (due to the aerodynamics), magazines, etc.



In the space below produce thumbnail sketches of your ideas and concepts for your overall car design. Use labels and annotation to explain your ideas

Thumbnail Sketches

Scale Sketches

From the initial thumbnail sketches your team is to choose three possible design concepts for which you want to develop further. Using the three grids below scale up your drawings and produce more detail on each.

Idea 1:

Idea 2:

Idea 3:

Development of Preliminary Sketches

When you study your preliminary designs, you should evaluate them for acceptability in terms of meeting all of the rules and regulations. If there are conflicts in the design, or areas that can be improved, make the change, but keep a baseline copy to go back to if the idea didn't work. Make sure that all parts, ideas and changes are labelled. Justify each one of your changes and improvements. In the space below select two design to develop further.

Development of Idea 1:

Notes/Evaluation:

Development of Idea 2:

Notes/Evaluation:

Selection of Final Car Design

This section is not really the final design as you will continue to alter your design right up until you manufacture it. Actually, it is the complete design. This is where you start working with your CAD package. The aim of this design section is to assemble the entirety of the parts you have in your designs into one racer.

By now you should have 2 designs that you could realistically make and race. You should choose one of these as the basis for your CO_2 racer. You must explain why this design has been chosen over the others. You must give technical reasons explaining your choice.

It is also a good idea to compose a freehand sketch of what your concept for the finished car is at this point so that all team members have a visual reference point and can add their thoughts.

Final Concept Sketch

Justification for Final Car Design

In the space below you need to detail the justification for the selection of your final design concept.

CAD Design Drawing

Complete the CREO user guide provided in this package and produce a 3D rendered drawing of your final CO_2 race car. Print out various 3D views as well as an orthographic drawing and place on this page.

Steps in Production

In the table below record the steps in production for your CO_2 racer.

STEPS	DATE COMPLETED	RECORD OF PRODUCTION
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Testing Results

In the space provided below detail the results of testing your CO_2 car design. Add data such as time for test races, wind tunnel results, smoke tunnel results and add final specifications such as weight, length, etc.

Analysing Results

In the space provided below complete a short analysis of the results gained above. In this section suggest how you could improve your designs if you had time to complete the task again. Discuss race times in relation to aerodynamics and wind tunnel results.

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Final Evaluation

To help you arrive at some conclusions about your work, carefully answer the following questions.

1. Was the final CO_2 car design different from the one you planned? If so explain how it was different and why?

2. What were the difficulties that you encountered whilst making your CO_2 car?

3. Complete the following table.

Good features of CO_2 car design	**Features that could be improved**

4. Indicate on the line below, by draw a dot in the appropriate location, how successful you think you have been in achieving your goal as stated in the design brief?

Very successful **Not very successful**