Flying Start Challenge

Build Your Own Wind Tunnel

Project Activities

- Using materials found at home design and build a wind tunnel.
- Use the wind tunnel to conduct different experiments to understand how different shapes effect the flow of air over an object.

Areas Covered

- Understand the principles of a wind tunnel
- Brainstorm ideas for your own wind tunnel to meet a specification
- Present your final design
- Create technical drawings to help you manufacture a design
- Build a wind tunnel using materials found at home
- Test your wind tunnel and make improvements if necessary
- Perform 2 experiments to test the effect air flow has on different objects
- Relate your findings to a real life scenario

Learning about wind tunnels

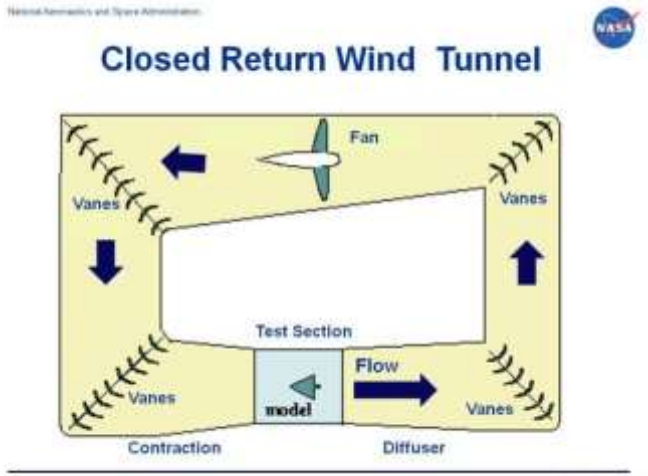
What is a wind tunnel?

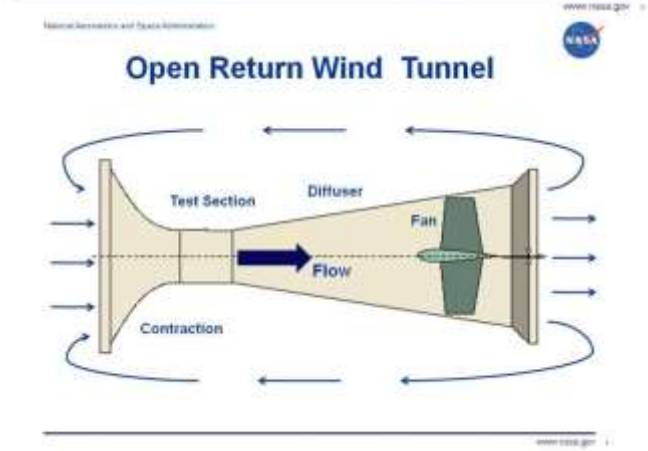
- Wind tunnels are large tubes with air moving inside. The tunnels are used to copy the actions of an object in flight. Researchers use wind tunnels to learn more about how an aircraft will fly. NASA uses wind tunnels to test scale models of aircraft and spacecraft. Some wind tunnels are big enough to hold full-size versions of vehicles. The wind tunnel moves air around an object, making it seem like the object is really flying.

Sourced from: https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-are-wind-tunnels-k4.html

How does a wind tunnel work?

- A closed return wind tunnel is a bit like a huge pipe that wraps around on itself in a circle with a fan in the middle. Switch on the fan and air blows round and round the pipe. Add a little door so you can get in and a test room in the middle and, hey presto, you have a wind tunnel. In practice, it's a bit more sophisticated than that. Instead of being uniformly shaped all the way round, the pipe is wider in some places and much narrower in others. Where the pipe is narrow, the air has to speed up to get through. The narrower the pipe, the faster it has to go. It works just like a bicycle pump, where the air speeds up when you force it out through the narrow nozzle, and like a windy valley where the wind blows much harder, focused by the hills on either side.



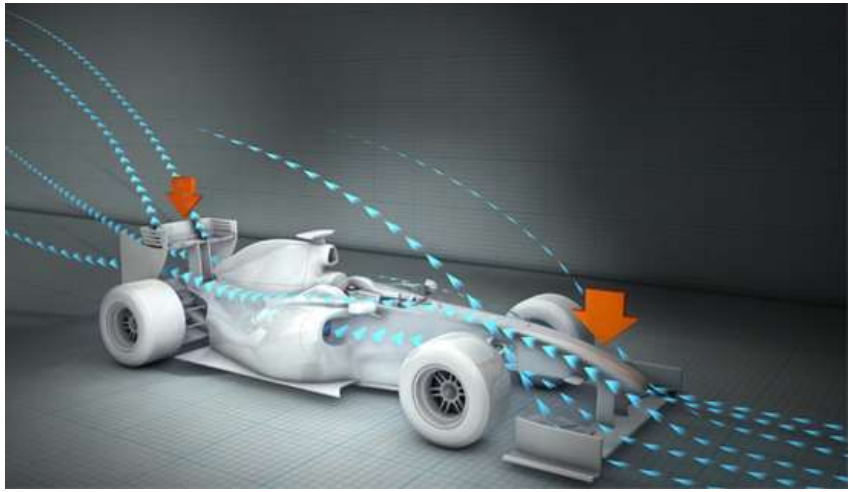


Sourced from: https://www.explainthatstuff.com/windtunnel.html

Why do we use wind tunnels?

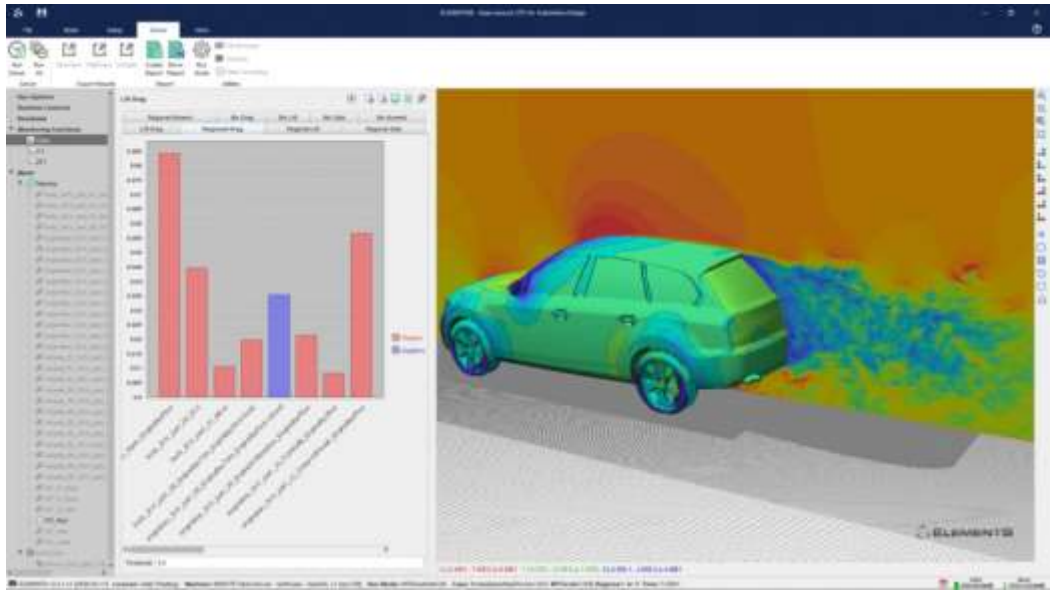
Currently, the world is facing many environmental problems every day planes and automobiles consume lots of oil or fuel. By improving the shapes of planes and automobile we can improve the efficiency and save fuel. For this reason wind tunnels have been known to be used in the following areas:

- Ground Vehicle applications – for example buses, motorcycles, trucks and racing cars.
- Architecture engineering applications - Wind tunnels are used to help design very tall building as well as structures such as bridges.
- Aerospace – Wind tunnels can be used in aero space to prove the feasibility of new concepts as well as improving current design to make them more efficient or reduce wind noise.



What is the alternative of using a wind tunnel?

There is no real alternative to a wind tunnel as it is such a simple idea, however there is an alternative way to get the results produced from a wind tunnel. This is by using computational fluid dynamics (CFD). By using CFD it reduces the amount of time needed in a wind tunnel to develop projects. This is good as it costs a lot of money to run a wind tunnel and it is free to run a simulation of CFD.



Design and build your own wind tunnel

What your wind tunnel needs to be able to do?

- Specification – all design projects have to work to a specification. This is a list of requirements that the customer expects to be met.
- Specification for your wind tunnel:

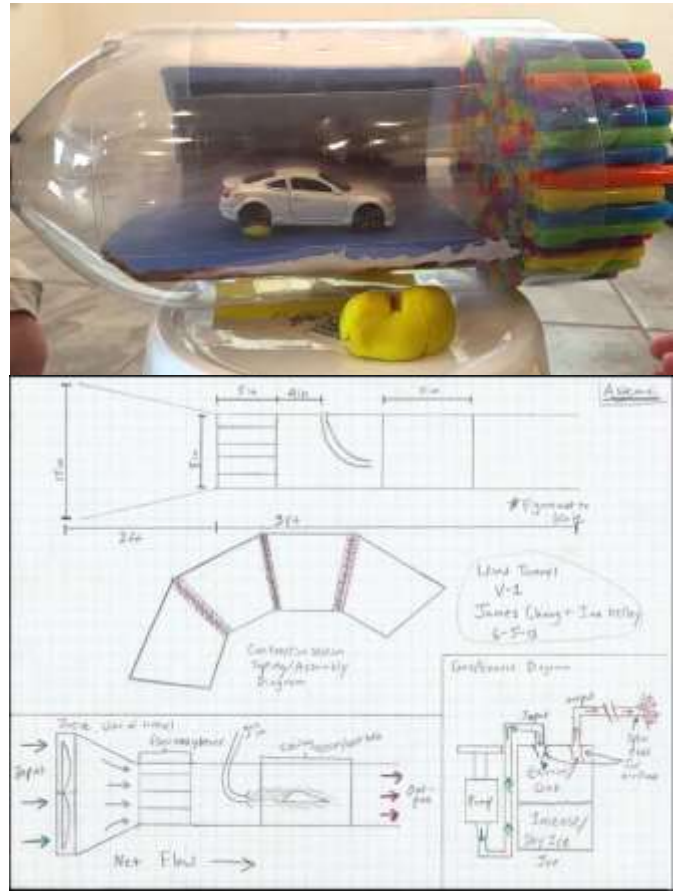
  - Having a constant air flow through the wind tunnel
  - Having a viewing window large enough to see objects being tested
  - A test area large enough to carry out the 2 experiments. (Max wing span is 10cm)
  - Have a way to load and unload objects
  - Use a funnel shape at the inlet to make the air speed increase

Additional things to consider when designing your wind tunnel

- Things to also consider:
  - Air speeds up as it moves from larger areas to smaller areas. This means using a cone design funnelling the air to a smaller area will create air with a greater velocity.
  - The air can either be pushed in to the wind tunnel or sucked out the effect is the same for both.
  - The test area needs to be able to hold a test object with out the object moving, therefore it should have a way to secure it.

Produce sketches of initial ideas

- Sketches:
  - Initially it is good to brainstorm ideas that you may have and sketch down ideas of layouts for a wind tunnel. Consider if you are able to do an open of closed return wind tunnel.
- The wind tunnel should contain these parts:
  - A source of wind/air
  - A funnel inlet
  - A test area
  - An exhaust



Produce sketches of initial ideas

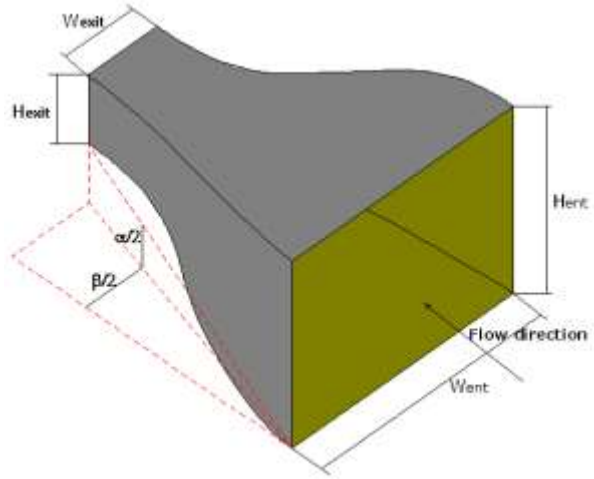
A source of wind/air

- The most important part of a wind tunnel is having a good air flow over the part.
  - Think about different ways you could do this. The air can either be pushed or sucked into the system some examples that could be used are:
    - A hair dryer
    - A vacuum cleaner
    - A fan

Produce sketches of initial ideas

A funnel inlet

- Using a funnel inlet helps increase the air speed of the air entering the wind tunnel.
- It does this by channelling the air from a larger area to a smaller area
- This therefor increases the pressure of the air resulting in an increase in velocity.
- This is needed for the wind tunnel as it allows you to simulate higher wind speed.
- You could also consider a flow straitener to direct the air evenly into the test area. You could use straw or old toilet paper.



Produce sketches of initial ideas

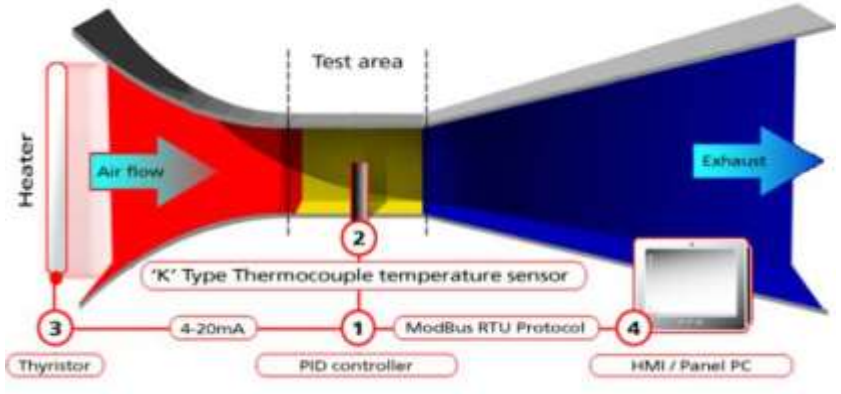
A test area

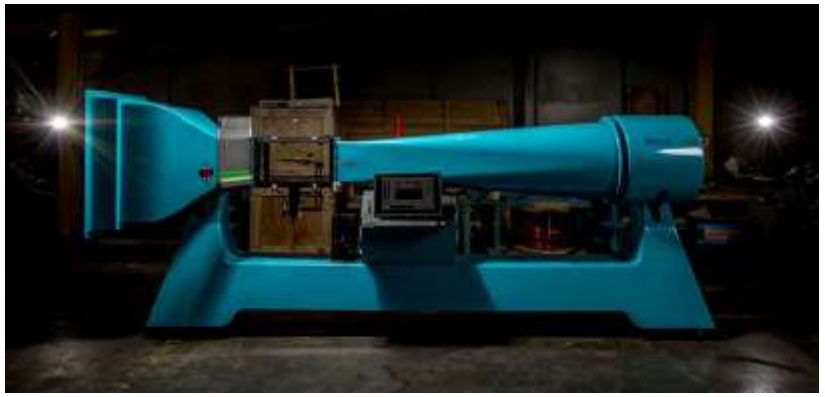
- The test area is where you would place your test objects.
  - It is important for this area to be easy to access to allow the objects to be placed in. This area should be able to viewed while the wind tunnel is closed and should have a flat surface that the object can be stuck to by using an adhesive such as Blu Tack. Some examples of a test area include:
    - A cardboard box with a cut out area for a window. This would be cover by a see through material such as plastic.
    - A large plastic bottle
    - A plastic see through box/large plastic lunch box

Produce sketches of initial ideas

An exhaust

- The exhaust is used to allow the air to exit the test area. The source of air can be placed in this area in the case of vacuum cleaner. The exhaust can be anything as long is allows the air to escape easily.





Building Your Wind tunnel

Design your own wind tunnel to meet the specification

- Comparison:
  - Once you have came up with some concepts try and compare the advantages and disadvantages to narrow it down to your favourite design.
  - You should consider things like ease of manufacture, cost, durability and suitability to the specification when comparing your ideas.

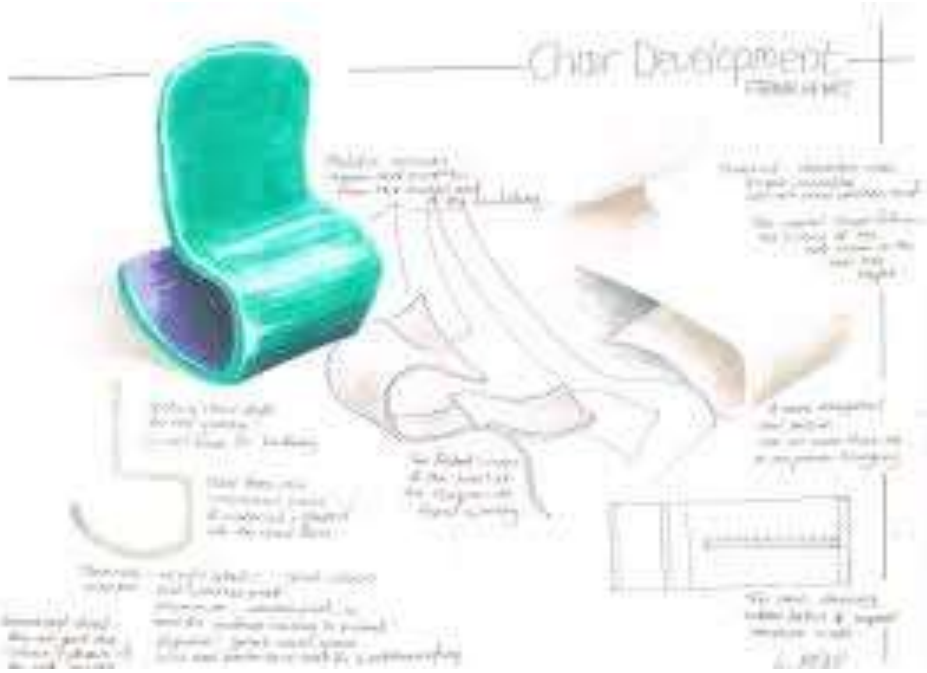
Building Your Wind tunnel

Design your own wind tunnel to meet the specification

- Feasibility:
  - You should now consider the feasibility of your design. This is essentially making sure your design is possible for you to make. For example make sure you have access to the relevant materials and that you have the tools to build the design.

Final Design Presentation (10 Marks)

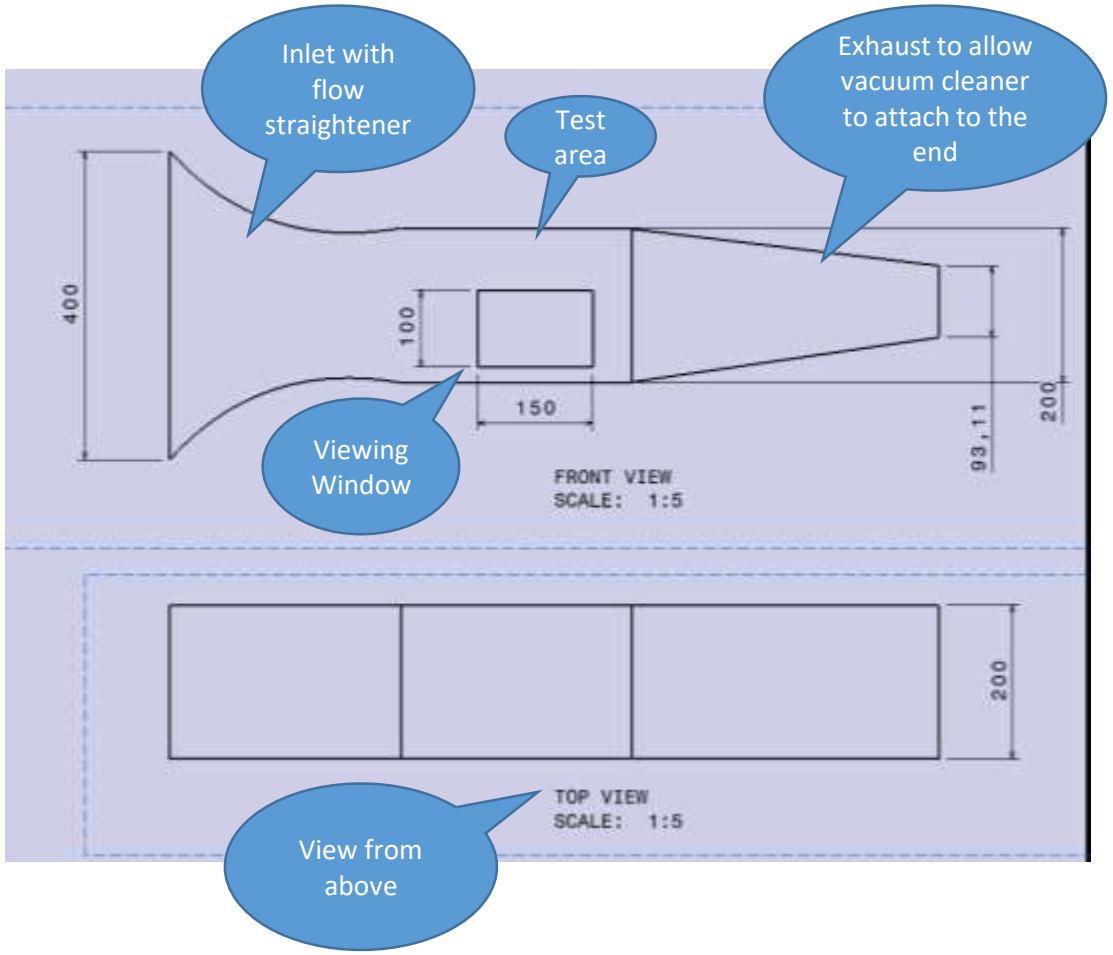
- Final Drawing:
  - After you have made sure that your chosen design is feasible you can create a final presentation of your design showing off the features. It is important to cover everything here as your design will be marked against the specification, as well as for creativity and likelihood to work. You can create sketches or use other means to show your ideas such as PowerPoint or modelling software.



Final Design

Producing a technical drawing

- Technical drawings are used to help aid the manufacture of parts. In your project you should use the technical drawing you produce to help manufacture your wind tunnel. An example of a technical drawing is shown bellow. The dimensions are given in mm and show the size of the features on the wind tunnel



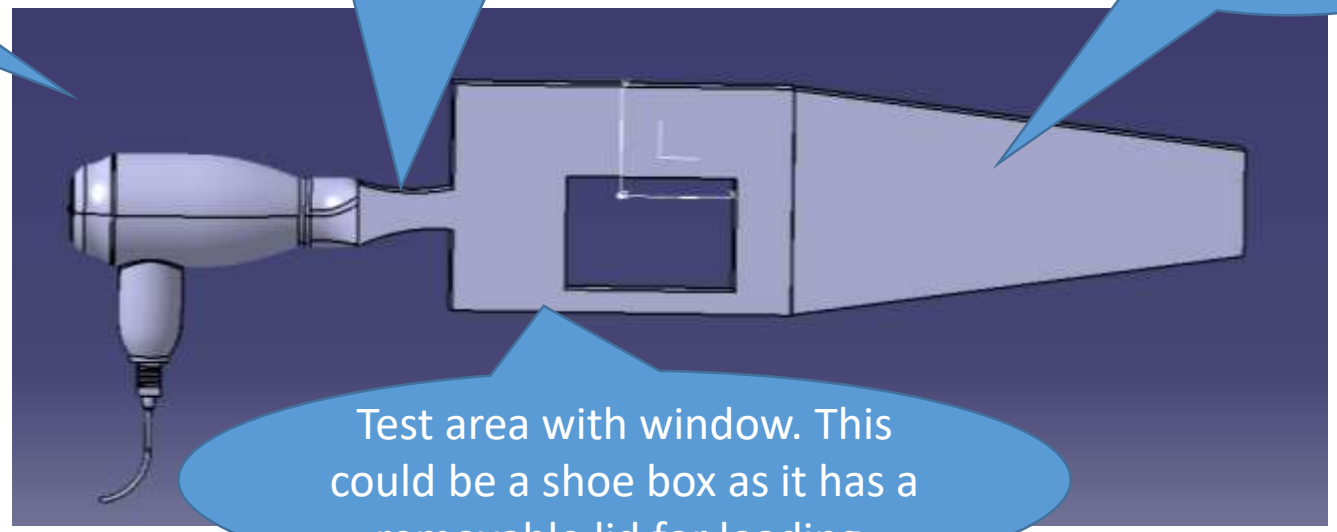
Building your wind tunnel

Building Your Wind tunnel

Task overview

- Now you have developed a greater understanding about wind tunnels it is now time to build and use your own. You can either use your own design or build one using the design idea shown on the next slide.
- Your wind tunnel should be able to carry out 2 experiments.
  - 1- Wing Design- test the effect shape has on lift
  - 2- An experiment to demonstrate the effect different objects have on air flow using small household objects

Proven design CAD Model



Proven design

This funnel was mad from cardboard boxes

Hairdryer

Exhaust.

Test area with window. The window could be made from any clear piece of plastics.

Begin to build your own

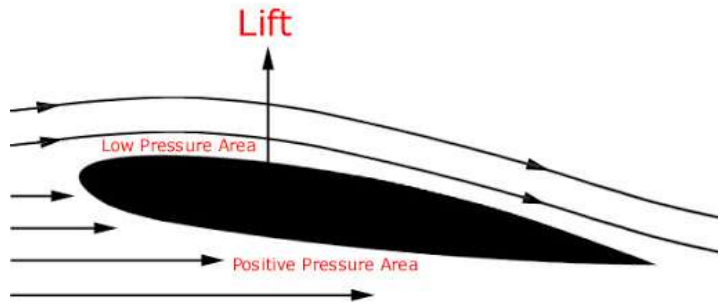
- If you are building your own design make sure you use your design drawing and technical drawing to give you guidance for sizing and what your wind tunnel will be made of.
- If you are using the proven design. Plan what you are going to use for each section and build a wind tunnel similar to the one shown in the previous slides.

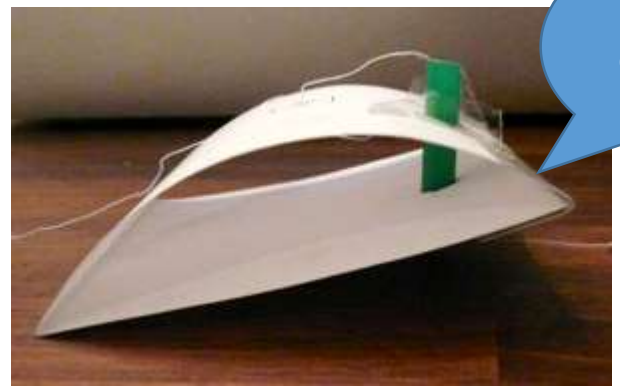
Test your wind tunnel

- Now you have built your wind tunnel you will need to test it to make sure it works. Turn you wind source on and make sure that you can feel air passing through the test area.
- As well as this compare your wind tunnel to the initial specification. If your wind tunnel meets the specification you can move on to the experiments. If it doesn't analyse your model and make modifications that you think will benefit the design.
    - Having a constant air flow through the wind tunnel
    - Having a viewing window large enough to see objects being tested
    - A test area large enough to carry out the 2 experiments. (Max wing span is 10cm)
    - Have a way to load and unload objects
    - Use a funnel shape at the inlet to make the air speed increase

Experiment 1 – Wing Design

- The shape of a wing is called an aerofoil. The underside of the wing should be flatter, whilst the upper side is more rounded.
- When an airplane is moving forward, the air is split at the front edge of the wing, passing above and below the wing. The air will move at different speeds so that it will meet at the back edge of the wing at the same time
- The air will rush over the top and stretch out. This will decrease the air pressure on top of the wing.
- Conversely, the air below the wing moves in an almost straight line, meaning it stays at the same speed and pressure.
- Because high pressure always moves towards lower pressure, the air below the wing pushed up towards the lower pressure above the wing, therefore creating lift on the wing.
- When this lift outweighs gravity, the airplane rises into the air.
- The faster an airplane moves, the more lift is created.
- This is called Bernoulli's Principle.

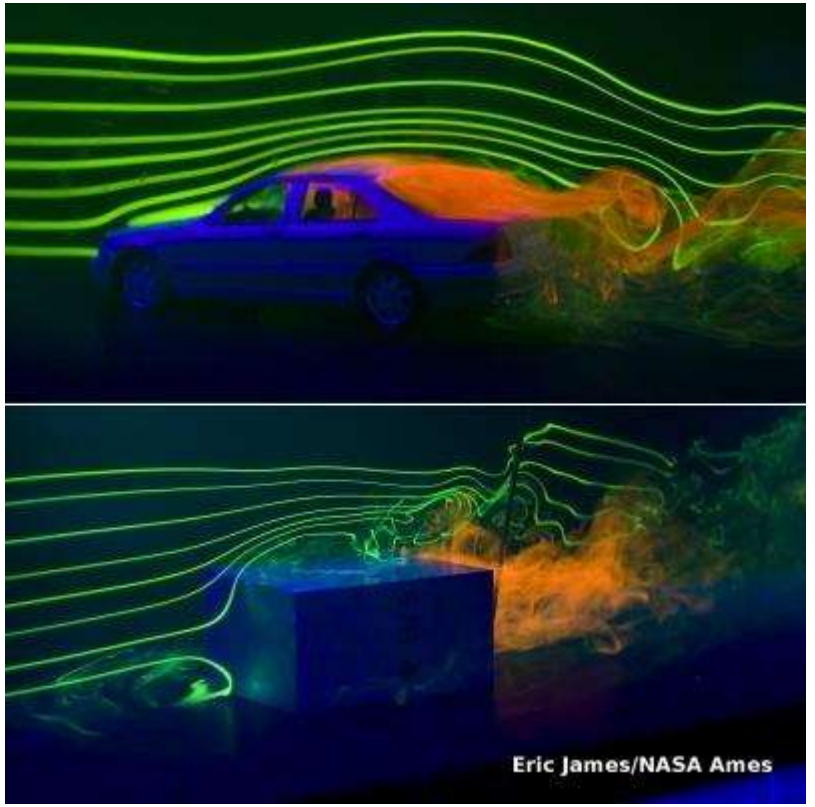




Aerofoil design. It would have card at the ends as support.

Experiment 2 – Demonstrate the effect different objects have on air flow

- When the thread shows that the air is separating away from the shape, this indicates a position where the airflow is transitioning from laminar (smooth layers) to turbulent (swirling).
- The thread should be seen to move away from the shape if airflow becomes separated. If the thread is seen to stay quite close to shape, indicating that the airflow is attached.
- If the airflow separates, the air pressure will be lower in the zone of separation. This shows where a region of low pressure will be. This region of low pressure is the cause of pressure drag. Finding shapes that reduce separation to keep the airflow close to the surface will reduce this zone of low pressure and so will reduce drag.



The wavy flow shows that the air has been disturbed and creates and area where the air doesn't hit.

The solid flow of air shows the air moving quickly and not disturbed by the shape.