Forces and Flight

National Museum of Flight Scotland

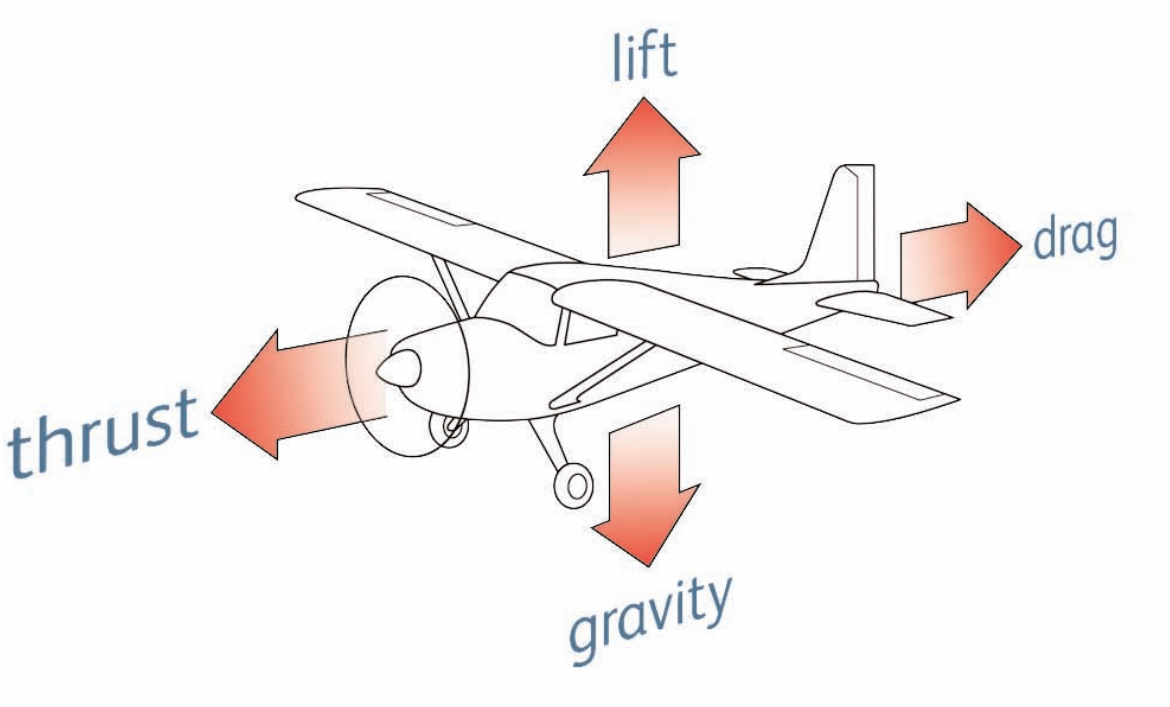


Illustration by Terry Pasteur

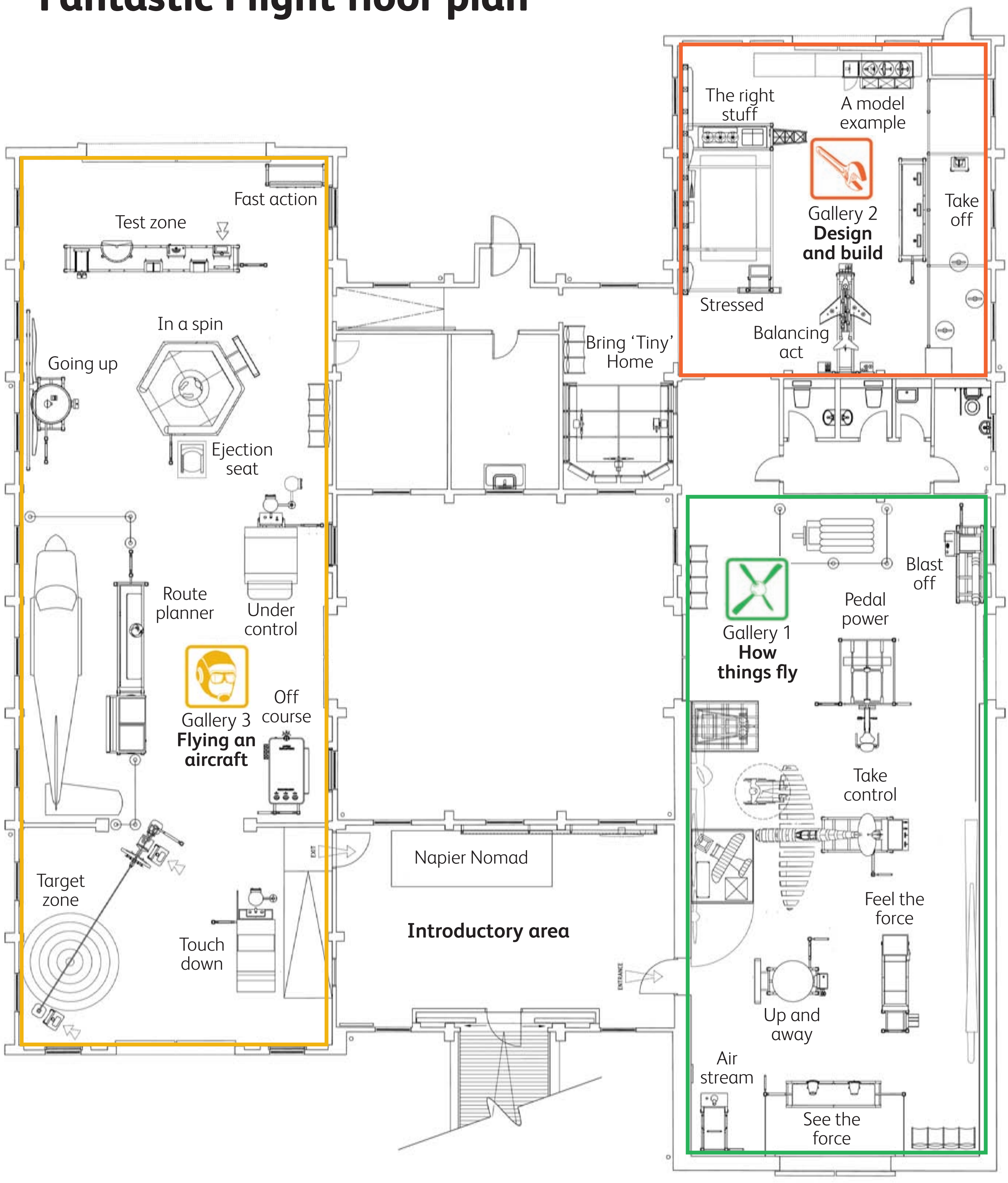
Teachers' Resource Pack

What are forces? What happens when they are balanced? What does "every action has an equal and opposite reaction" really mean?

The National Museum of Flight's interactive flight science exhibition "Fantastic Flight" is a learning environment which deals specifically with the subject of forces. The museum also offers a schools' programme on this topic which includes a science show "Flying Forces" which will help engage your pupils. The programme also takes advantage of the museum's extensive collection of aircraft to show children how the theory of forces applies to real machines. This pack includes activities to do before, during and after your visit.

National
Museum of Flight
Scotland

Fantastic Flight floor plan



Contents

Something to do – The Skateboard

Place a skateboard, roller skate, or anything with wheels on a table.

Key questions

Why is it not moving?

What could I do to make it move?

Write your class's suggestions on the board.

All the things you have suggested involve putting a force on the object.

Forces are pushes, pulls and twists.

Split your class into groups of 4-6 and get them to sort their suggestions to move the object into the three categories; pushes, pulls and twists.

Experiment – Toy Forces

Ask your class to bring in their favourite toys that move.

Give your class 10 minutes to play with their toys.

Key question

- **Do you pull, push or twist when you play with your toy?**
- **Compare the forces you apply.**

Ask your pupils to see if they can find the other types of forces with their toy or someone else's.

Look out for

- On a spinning top there may be a push down the handle but this is turned into a twist.
- A push may move a toy car but the friction on the wheel turns it into a twist.
- With a pull along toy it is obviously a pull, but if you pull it backwards is that a push?

Experiment – Toy Cars and Newton's Three Laws

This is a playful exploration of all of Newton's Laws of Motion

You may wish to split your class into teams, you will need:

- A toy car
- A ruler
- An elastic band
- Modelling clay

1st

Newton's First Law – Things stay still or keep going at the same speed unless there is a force acting on them.

Part One

Ask one member of the team to put their car on the table.

Key question

- **What do you think will happen to the car if no one pushes, pulls or twists it or moves the table or air?**

Answer: It should stay still

Get the team to watch the car for a minute to see whether their guess was right.

Part Two

Key question

- **What do you think will happen if you give the car a push?**

Ask one team member to push the car and all the team watch what happens.

Key questions

- **Was there a force to stop the car?**
- **How could we make the friction less?**

Answer: There is a force when anything touches anything else and this is called friction. Some of the friction comes from the air and some from the table.

Answer: Good answers might include making the table or the wheels smoother and making the car smaller or smoother to reduce air resistance.

Part Three

Key question

- **How can we stop the car slowing down and go faster?**

Ask one team member to try out the idea and the others can watch.

If they do not succeed then get them to try a different idea.

Good ideas might be giving the car another push, or blowing it or tilting the table. Make it clear to their teams that what they are doing is applying another force.

2nd

Newton's Second Law - the harder you push something the faster it will go. Heavier things need to be pushed harder than light things.

Get a member of each team to loop an elastic band around one end of the ruler and around their car. Then ask them to pull back the car to a certain distance along their ruler and let go (how far this distance is will depend on the elastic band.)

Ask the teams to try it with the band stretched different amounts and ask them to see whether it goes faster with the elastic band stretched further or less. It should go faster with the elastic band stretched more as this will be giving it a bigger force.

The teams should then try it with a set stretch and measure how far their cars travel, or mark it with a piece of paper.

Key question

- **Will it go further or faster with more weight?**

They should now weight their cars down with a golf ball sized piece of modelling clay and repeat the experiment. The car should not go as far or as fast because it has a greater mass.

3rd

Newton's Third Law – Every action has an equal and opposite reaction, you cannot push, pull or twist without creating a force in the opposite direction.

Get all the pupils to stand up and push against the walls.

Since the walls will not move they will move away from the walls rather than towards them.

This demonstrates that by trying to create a push one way they will create a push in the opposite direction.

Key question

- **If someone stands on a skate board and throws something what will happen? Will they move the same way as the thing they throw?**

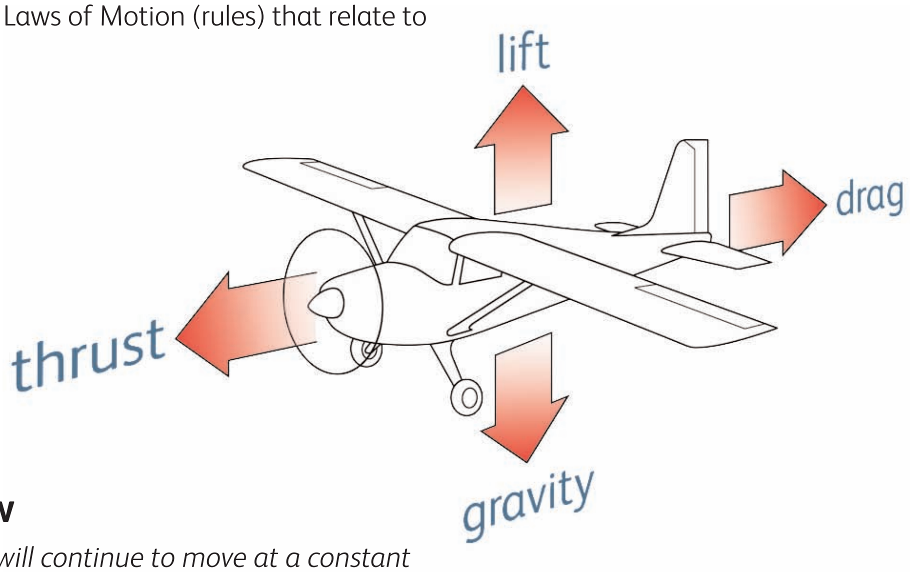
Try putting yourself or a volunteer on roller skates or a skate board. If they throw something relatively heavy (and safe) like a football or lots of footballs they should move in the opposite direction to the object thrown.

Using the cars your teams can stretch the elastic bands between both and let go of them both at the same time. They will both move in opposite directions.

An introduction to the science

A **force** put simply is a pull a push or a twist.

The way that science thinks about forces was defined by Sir Isaac Newton (1643-1727) He is also known for having discovered Gravity though whether this was whilst sitting under an apple tree we do not know. Newton created three Laws of Motion (rules) that relate to forces.



Newton's First Law

A body will remain at rest or will continue to move at a constant velocity, unless an external force is applied. This means that an object will stay still or move at the same speed if the forces are balanced. If you push on the back of a toy car with you finger it will move forward. If you push on the front with another finger and the same amount of force it will stay still.

Newton's Second Law

The rate of change in momentum of the body is directly proportional to the net force applied. When you apply a force to something (a force not balanced by an opposite force) it will slow down or speed up. This change in speed is directly linked to how large the force is and how much mass the object has. This basically means the harder you push something the faster it will go. Heavier things need to be pushed harder than light things.

Newton's Third Law

Every action has an equal and opposite reaction.

It is impossible to push one way without being pushed in the opposite direction. Whilst you are pushing one way with your hands your feet are pushing in the opposite direction. This is easiest to discover on ice.

These resources will also touch upon Gravity – the force that makes things move towards the earth (such as an apple falling from a tree) and Friction the force created when things touch each other. One form of Friction is Air Resistance or Drag. This is where the air flowing round any object will slow it down unless enough force is applied to the object to overcome Drag. The other forces involved in flight are Lift, usually created by the wings of an earoplane and Thrust, the force that drives an aircraft forward.

The Fantastic Flight programme

This programme was written specifically to use the interactive exhibition with pupils discovering about forces. It includes a specially written science show and you will have a facilitator with you to guide you through the topic. Contact the museum for more details about availability.

The Fantastic Flight Exhibition

If you are only interested in studying forces you will find the first section of the exhibition, "How Things Fly", most useful. If you choose not to take part in the programme here are some key questions that will help you use the gallery for your pupils to discover the topic of forces.

1 See the force

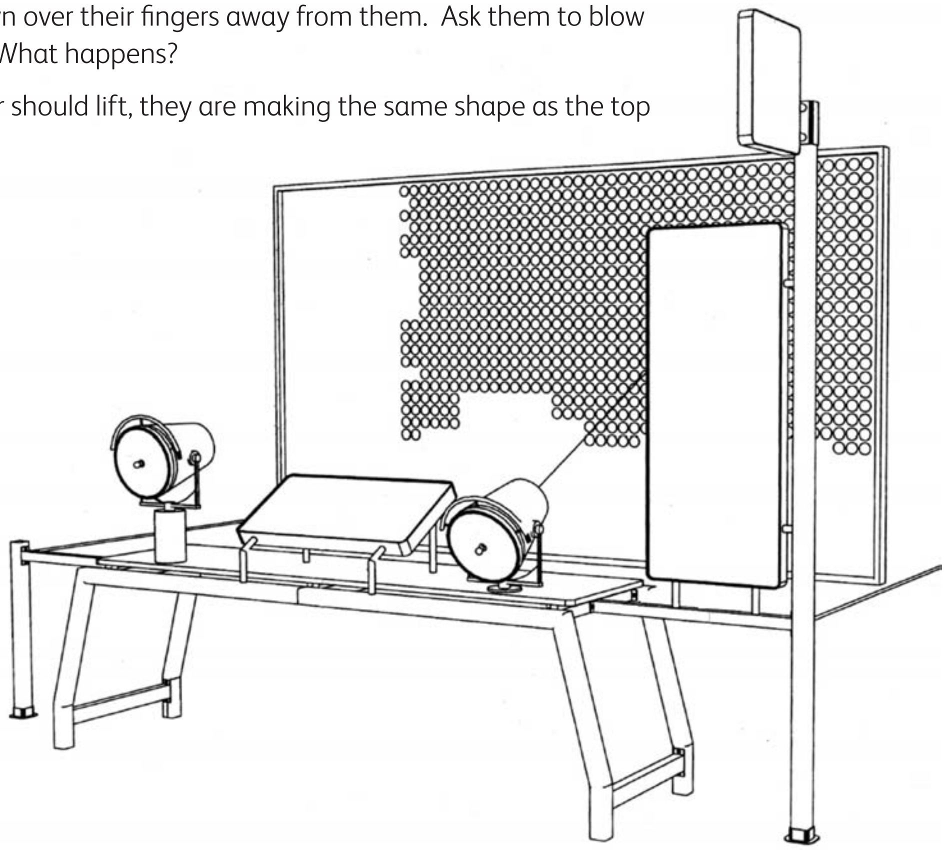
Key question

What is making a force act upon the shimmer wall?

Answer: The handle you pull back makes the air cannon move air which moves the wall. Just because it is air does not mean that it cannot create a force.

Now try this – Ask your pupils to hold up a sheet paper up to their mouths so that it flops down over their fingers away from them. Ask them to blow over the top of it. What happens?

Answer: The paper should lift, they are making the same shape as the top of a wing.



Forces and Flight

2 Air stream

Key questions

What force is overcoming gravity when the jet of air is leant over?

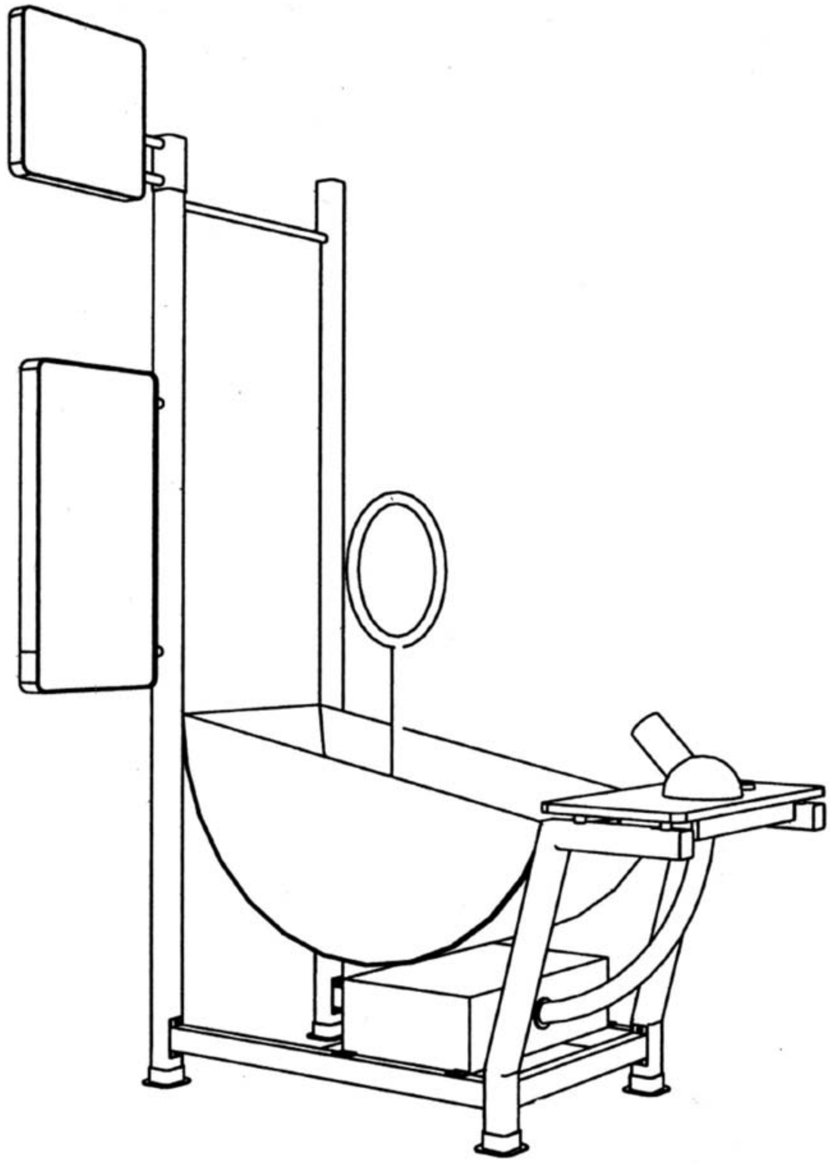
If the ball is staying in the same place what does that say about how strong the forces are in comparison to each other?

Answer: The air around the ball is creating lift in the same way as air around a wing.

Answer: If something is staying in the same place then the forces must be balanced.

Now try this – Ask your pupils if they think it would work with something other than a smooth ball? Why would it not work?

Answer: It would not work as the air has to move quickly and smoothly around the outside, it also needs to be the same whichever way it turns.



Forces and Flight

3 Feel the force

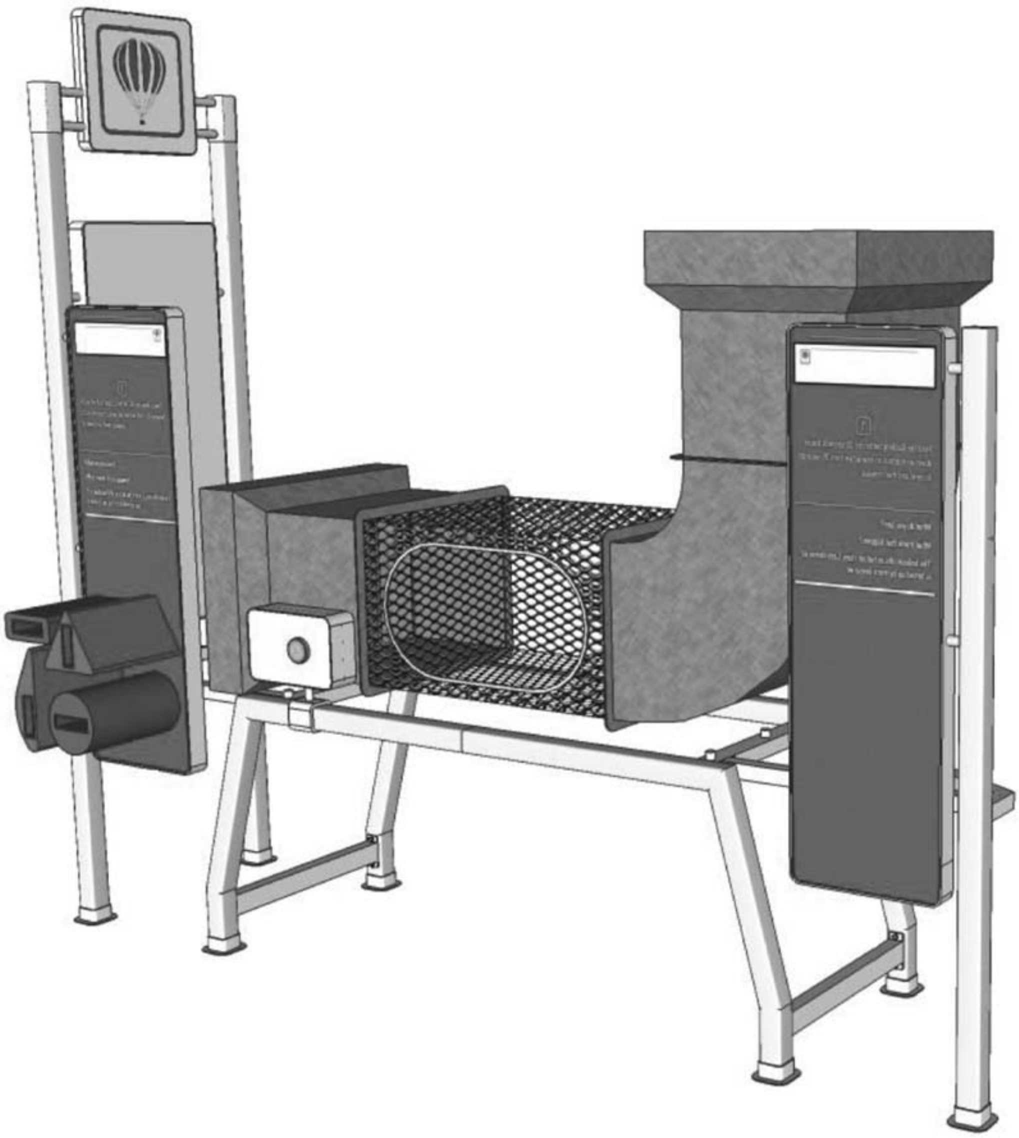
Key question

Why is the amount and direction of force that you feel different with different shapes?

Answer: Some shapes have more surface area facing into the air so that they create more drag. One of the shapes (the Aerofoil) is shaped like a wing so will create lift.

Now try this – Ask your pupils to try without the foam gloves. Ask them why it does not feel the same? Can they spot anything in the museum that is the same shape as the wing but it not a wing?

Answer: Propeller blades and the blades on helicopters are also this shape because they are essentially whirling wings.



Forces and Flight

4 Blast off

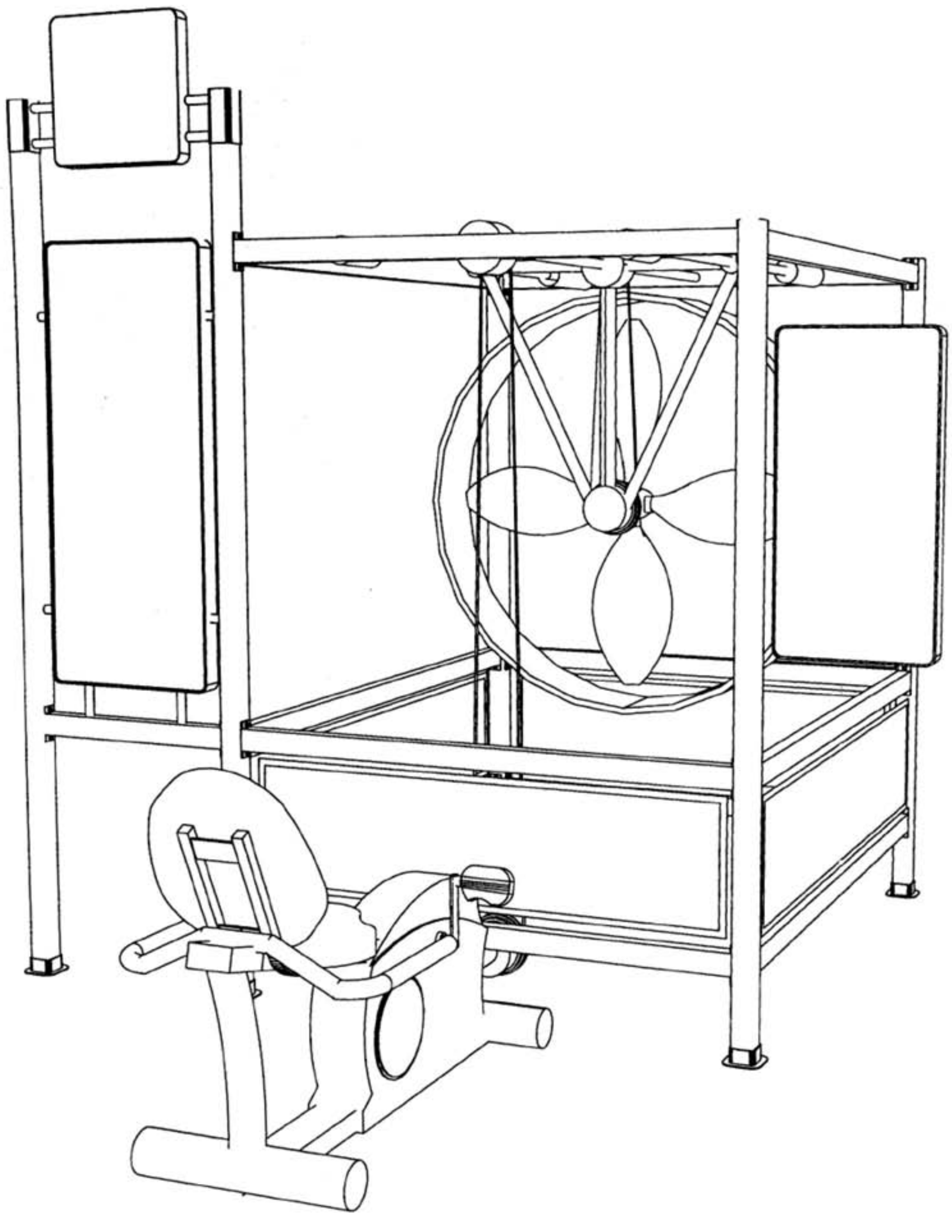
Key question

What is the rule (or Law) that applies to this?

Answer: Every action has an equal and opposite reaction, you cannot push one way without a push being created in the opposite direction.

Now try this – Ask your pupils to imagine they are on ice, if they throw a heavy weight away from them what will happen?

Answer: The force that results will make them move the other way or fall over. They can try this at home with a skateboard.



5 Balancing act

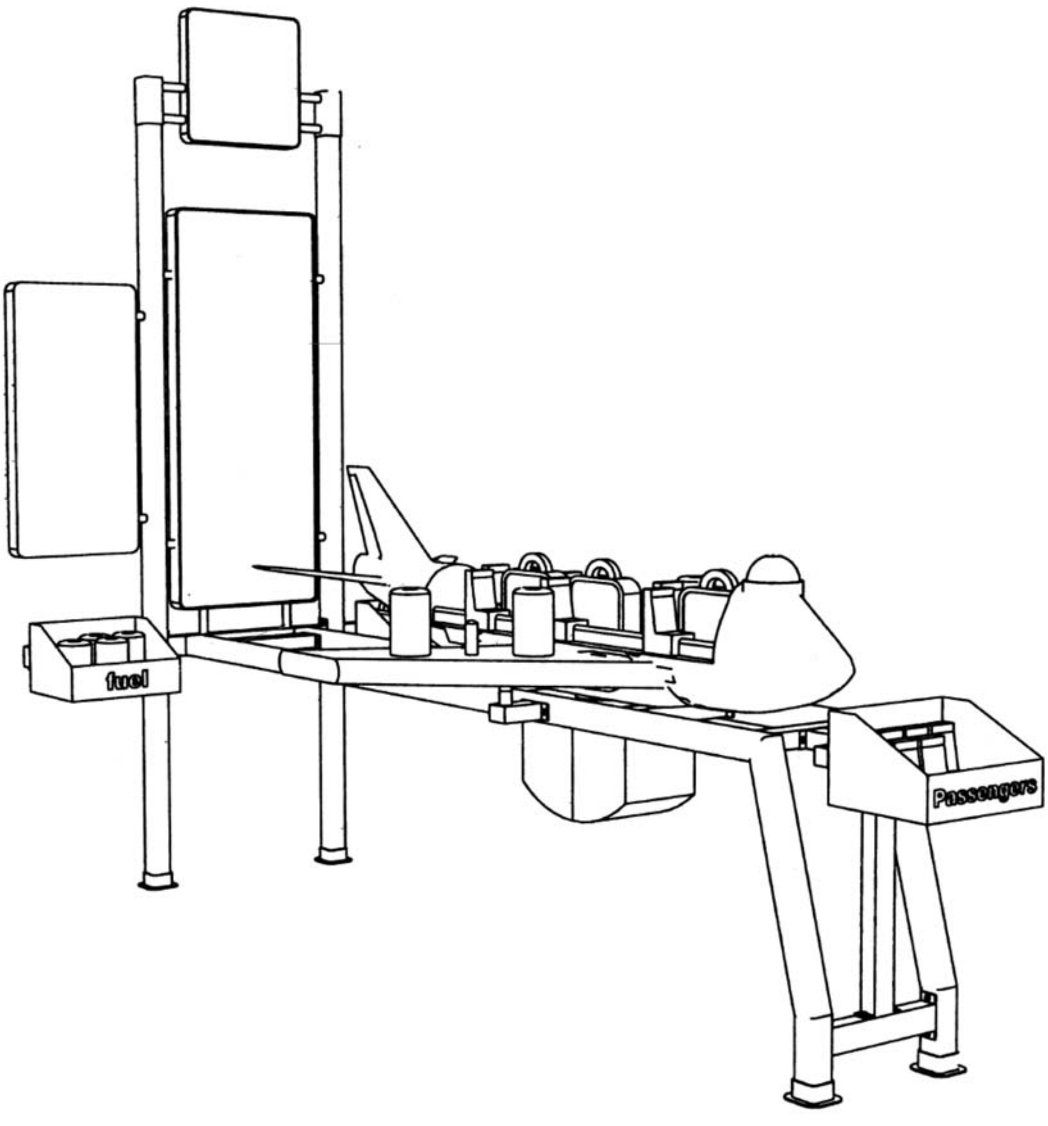
Key question

Is the only way to balance it to put the same amount of weight the same distance from the middle but on the other side?

Answer: A big weight near the middle can be balanced by a smaller weight further away.

Now try this – Ask your pupils to stand on one leg. Ask them to try to do it with their hands by the sides and then with their arms out. Which is easier?

Answer: When your hands are a long way from you, despite the fact they are light just a small movement has quite a lot of force. It also takes quite a lot of wobble from the middle to move them. For these reasons they help you to balance.



6 A model example

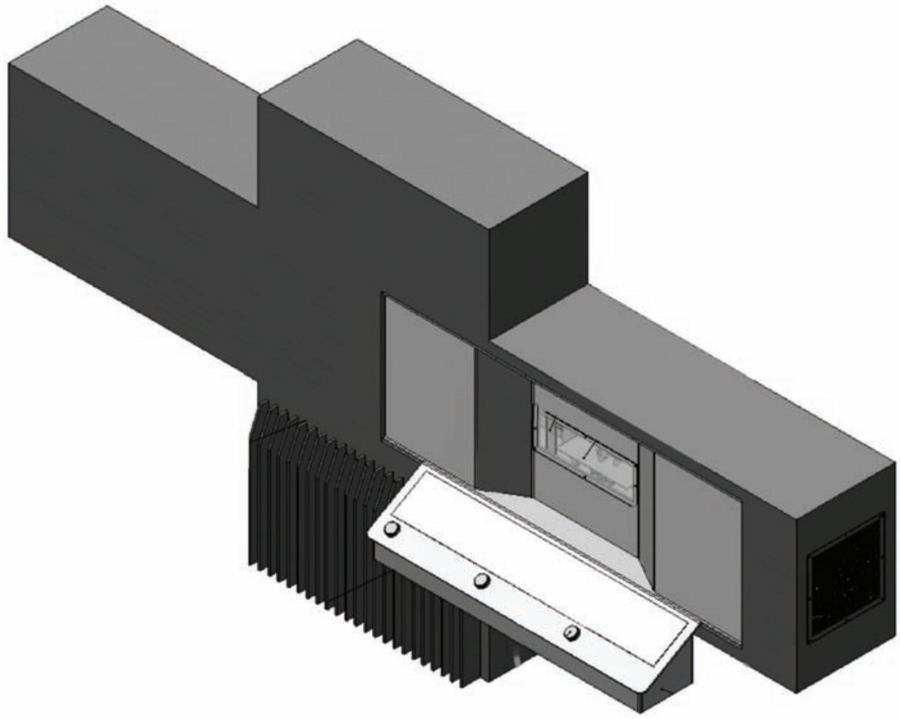
Key question

What do you notice about modern aeroplanes' wings that might make them have less drag?

Answer: There is only one wing on each side, it tends to be thin and smooth.

Now try this – Ask you pupils to describe the shape of a formula one car as compared to their family car, why are they different?

Answer: The faster you want something to go the more important streamlining is.



The Collection

The way that forces affect an aeroplane is the main reason for the shape of an aeroplane. Whereas cars are designed to look good, so that they will sell, aeroplanes are designed purely for performance. This is especially true of military aeroplanes. Some of the fastest aeroplanes ever built are in the Military Hangar. Take your pupils there and ask them if they can see any similarities between how the aeroplanes have been designed to make them fast. Most of these will be ways of reducing drag or air resistance:

- Pointed noses
- Thin wings
- Wheels that fold away
- Enclosed cockpits
- Big engines

Something fun to make – Forces on Me

Get your pupils thinking about forces in the everyday life. What are the forces that are trying to push, pull or twist us all the time?

you will need:

- Pens for colouring in
- Wall paper or lining paper (plain wall paper)

Instructions

Either individually or in teams get your pupils to lie down on a piece of paper (it needs to be longer than they are tall) and draw around themselves.

Key question

What are the forces that are trying to push pull or twist us all the time?

Using arrows ask your pupils to mark all the forces that might be on them. Examples might be; Gravity pushing them down, friction stopping them moving along the ground, air causing drag, wind trying to push them along. Put these on the wall as reminders whilst you are working on this topic.

This can be applied to any object, when they have done themselves they can do the same with a bicycle (think about all the forces around the chain, pedals etc.) They could also draw outlines of aeroplanes, cars, boats or anything that moves.

Something fun to do – Tug of War

you will need:

- A rope

Instructions

Pick two similar sized pupils and get them to pull on either end of the rope. They should stay fairly still. Ask the other pupils about what they are seeing:

Key question

If the rope does not move does that mean that they are not putting any force on the rope?

If the rope is not moving is one of them pulling harder than the other?

This is what is meant by balanced forces.

Add in other pupils and get the children to predict what will happen.