Schools Activities

How A **Jet Engine Works**

Description:

This presenter led workshop, delivered onsite at GE Aviation sites, looks at how a jet engine works, and how Newton Laws are applied. It explores basic flight physics and gives pupils the opportunity to handle real components of a jet engine.

The workshop is based on a series of PowerPoint slides, practical demonstrations and hands-on activities to allow pupils to explore the concepts, whilst being guided through the physics and engineering principles involved.

Some demonstrations use easy to source material, such as string and balloons, whereas other demonstrations require the use specialist resources, such as components of a jet engine.

Age:

13 – 16

Group size:

10 pupils

Time needed:

45 – 60 mins

Intended learning aims:

Through this activity pupils will have an opportunity to:

- Learn about the importance of gravity
- Learn about Newton's laws of motion and how they are
- Learn about the forces which act on a plane
- Introduction to the main components that make up a jet

Key words:

- Thrust
- Drag
- Mass
- Acceleration
- Weight
- Lift
- Velocity

Equipment:

- Laptop
- Poster
- Stress ball
- Balloons
- String
- Printed paper plane templates
- Bulldog clip
- Straw
- Double sided sticky tape
- Blue-tac
- Printed labels for Thrust, Drag, Weight and Lift
- Printed arrows
- Fan blade
- Compressor blades to illustrate size variation
- Turbine blades to show cooling holes
- Engine assembly models
- Tape or string for jet engine demonstration
- Cones

STEM Inspiration

Schools Activities | **How A Jet Engine Works** Overview | Visit: **gecommunity.co.uk**

Challenging activities to promote thinking and discussion e.g. sorting/TF/grouping/ deliberate mistakes/ odd one out/ novel context	Balloon Powered Plane Activity Forces on a Plane Engine Build Activity Engine Adventure Activity
Rich questions e.g. How?/Why?/Evaluation/ Devil's advocate/ big over-arching question	How does a plane get off the ground? Where does lift come from and what other forces exist? Why are engines so important? What does a fan, compressor, combustor, HPT, LPT do?
Supporting all learners in sharing ideas e.g. wait time/ note down ideas/ exploration of incorrect ideas/ Predict. Observe. Explain	Pupils will be given adequate time to learn, and ask questions
Opportunities for peer discussion e.g. think, pair, share/ concept cartoon/ quantify responses.	Discussions can be had, over the question asked
Sharing learning goals/ reviewing and reflecting/ gauging understanding	Learn Jet Engine Basics

Preparation

Before you deliver this activity it is important that you speak to the teacher who you will be working with.

The teacher will know the class, their ability and how this activity fits into their learning and wider curriculum. When you speak to the teacher it is recommended that you talk to them about:

The group size - the recommended capacity for this workshop is 10 pupils. If you have more than 10 in the group then discuss with the teacher and the Planning Leader discuss how best to deliver this activity.

Level of understanding – ask the teacher whether the group would have already covered the key concepts and vocabulary in class. Some groups may not have come across some of the terms you will be using, so you may have to explain things in a bit more detail.

Equipment – some equipment, such as balloons, will be easy to source. Other equipment, such as the jet engine components, will need setting up in advance.

Timings – find out how long you have with the pupils. The recommended timing for this activity is 45 – 60 mins (see breakdown below). If you are limited on time you may need to selectively cut some PowerPoint slides and shorten some sections.

Staffing – it is important for the teacher to stay with the class at all times. It is also recommended that you ask one or two colleagues to be available to help you throughout your session.

Risk assessments – things to consider for this activity could be:

- Pumping up a balloon
- Paper cuts (making paper planes)
- Touching blades - need to ensure they are clean and have no sharp edges
- Walking around shop floor staying on pathways
- Refer to EHS risk assessments

Delivery

Below is an outline of how you can present this workshop. Before you deliver this activity do a run through so that you are aware of the time it takes.

Don't be afraid to let your personality shine through, the pupils will be interested in you and your work so give them opportunity to ask you questions and explore the things that they find particularly interesting – you may not know what sparks their enthusiasm until you start talking to them.

Timings:

5 mins – Welcome and introduction
10 mins – Introduction Newton's Laws and the balloon plane experiment
10 mins – Discussion of the forces acting on a plane (thrust, drag, weight and lift)
10 mins – Introduction to the Turbojet and Turbofan engine and talk through the cross section of an engine and its parts
5 mins - Build an engine experiment
10 mins - Engine adventure experiment
5 mins – Feedback and round up

Introduction:

Introduce yourself and describe what you do for a job. Tell the pupils you want to find out something about them.

Energizer – Pass a ball about, asking the pupils to say their name, something about them and what they would like to be when they grow up.

Slide: 2:

Introduce Isaac Newton and ask what concept did he discover? Gravity. You can drop the ball that you used during the energizer to catch their attention!

Newton also identified three laws of motion...

Slide 3:

Give the group the timings, but let them know that you will help keep them on track. You may want to let them know that there will be prizes involved at this stage. Ask if there are any questions before they get into teams.

Slide 4:
Newton's second law – The force needed to accelerate an object equals the mass of the object multiplied by its acceleration (F=MA).

You can use an example of two rugby players where the rugby player with a greater mass will create the greater force, provided acceleration is constant.

Slide 5:
Newton's third law – For every action there is an equal but opposite reaction.

You can use an example of someone sitting on a chair. When they are sitting on the chair and chair is pushing back on them.

Slide 6:
Balloon plane experiment:

Ask the group to each choose and make a paper plane from different printed templates. Once they have made them, attach a paper plane to an inflated balloon with the help of a double sided tape.

The inflated balloon is closed by a bulldog clip and string is fed through a straw which is then attached to the balloon. Ask the teacher to hold one end of the string whilst you hold onto the other end – try to make sure the string reaches across the room and hold the string as tight as you can.

The balloon air is released by undoing the clip which allows the balloon powered plane to fly from one side to the other.

Explain how this experiment relates to Newton's second law and to aerodynamics.

Slide 7:
Question: Ask pupils how do the planes fly?
Lift acts oppose to weight.

Slide 8:
Question: Where does the lift come from? And what other forces exist?

An aircraft generates lift as a result of having forward airspeed/ velocity. The four forces are Thrust, Drag, Weight and Lift.

Slide 9:
Question: Why are engines so important?
They generate thrust, which opposes drag, and provides the forward airspeed that enables the aircraft to generate lift.

Slide 10:
Forces on a plane exercise:

You will need some printed out labels for each force – Thrust, Drag, Weight and Lift – along with the arrows. Ask pupils to stick the force labels, with arrows on a poster of an aeroplane with blu-tac.

Depending on the size of your group and the time you have, you may want to ask pupils to work in small groups of two or three, then feedback their answers, or ask them to agree where the labels should go as a bigger group.

Slide 11:
Explain that forcing air out the back of an engine, causes it to move forward. Tell the pupils to think back to Newton's third law "For every action, there is an equal but opposite reaction".

Slide 12:
Question: What is the difference between these two planes?
One is a military jet and the other is a commercial passenger airliner.

You can expand on the characteristics for each plane if you have time, for example, ask the pupils to think about what they are designed for (long distance carrying passengers vs high speed agility).

Slide 13:
Explain simply each main component of a Turbojet engine as shown on the slide.

Explain that Turbojet and Turbofan engine are really similar and the only really big difference is the size of the fan on the front.

Slide 13:
Explain that a Turbofan engine has a massive fan on the front, and that 80 percent of the air bypasses the core of the engine, with only 20 percent of the air actually going through the core.

Why? Fuel efficiency and noise. These are the most important parameters in designing an engine for Commercial application. In military, maximum performance at the expense of running cost and noise is what's needed.

Slide 14:
Explain that a Turbofan engine has a massive fan on the front, and that 80 percent of the air bypasses the core of the engine, with only 20 percent of the air actually going through the core.

Why? Fuel efficiency and noise. These are the most important parameters in designing an engine for Commercial application. In military, maximum performance at the expense of running cost and noise is what's needed.

Slide 15:
Explain the colour coded system, where green works with green (the low pressure turbine extracts energy to spin the fan) and purple works with purple (the high pressure turbine extracts energy to spin the high pressure compressor).

Slide 16:
Question: What does the fan do?
Sucks air into the engine to create thrust.

Slide 17:
Question: What does the compressor do?
Increases the pressure of the air by forcing it through a decreasing volume.

Slide 18:
Question: What does the combustor do?
Mixes the compressed air with fuel and ignites it.

Slide 19:
Question: What does the high pressure turbine do?
Extracts energy to spin the compressor.

Slide 20:
Question: What does the low pressure turbine do?
Extracts energy to spin the fan.

Slide 21:
Questions: How many horsepower do a normal car, formula one car, and a Turbofan engine have?
Around 70, 750, and 50,000 BHP

Slide 22:
Tell the pupils that a fully assembled CF6 engine is worth around 7 million pounds. If you can source them, pass round various blades and tell students how much they are worth.

Slide 23:
Try to point out the HPC Spools, and tell the pupils what they are worth.

Slide 24:
Build an engine experiment:

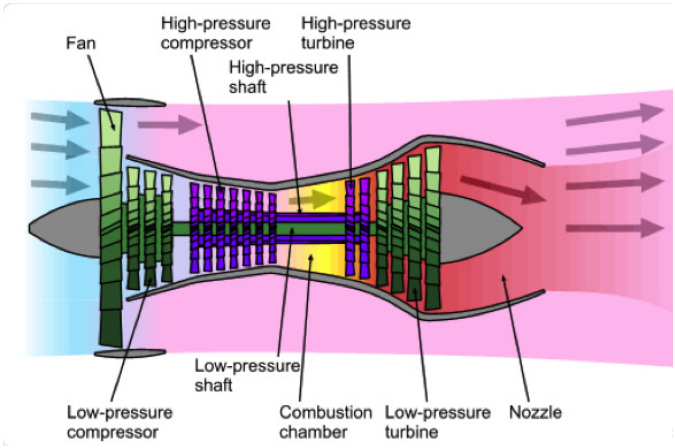
Provide nylon models of engines unassembled. Have two teams race to finish assembling the engine first.

If you have someone helping you, then each of you sit with one of the teams and ask them to describe what they are doing as they assemble the components so that you can assist with anything they are unsure of. If you are running this on your own then move between the teams and ask them to describe what they are doing as they work through the task.

Ask the teams to describe the order of jet engine components. Fan> compressor > combustor > HPT > LPT > exhaust with all parts slid on to the shaft. Check to make sure engine models are assembled correctly afterwards.

Slide 25:
Engine adventure experiment:

Walk along passageway to the Expeditors Hold Area where the engine layout will be. Map out an engine shape outline on the floor with tape or string – large area for fan, decreasing area for compressor, and increasing again for turbines – see picture below.



Assign each pupil (and helpers if necessary) to different engine components:
1. Fan
2. HPC
3. HPT
4. LPT
5. Air particle

For the compressor, use two cones (or equivalent apparatus) with decreased volume which the 'air particle' must pass through. Connect the pupil at the HPT and HPC with a piece of string, with the HPT having string wound around their waist.

Have the pupil as the fan pull the air particle pupil into the cross section and follow through each section of the engine. Pass through the compressor at decreased volume and then on to turbine section. When they get to the combustor get them to think about the energy added here.

The pupils at the HPT and HPC are connected with string as one system. The HPT pupil will be 'wound up' and when the air particle passes they give the HPT pupil a high five which will cause this one to unwind. The HPT pupil then winds up the string around their waist, showing it as a connected system. You can illustrate a separate system with string between the LPT and the fan.

Mention that the turbines extract energy added by combustor to power the fan and HPC, and emphasise how the two systems work together and allow the front systems to continue to suck in air and feeding it through the engine.

Keep asking questions to ensure understanding about all components and how the engine works. Ensure safety of all children during this activity.

To round up give the group some time to ask you questions and ask them to tell you what they enjoyed or something new that they've found out today.