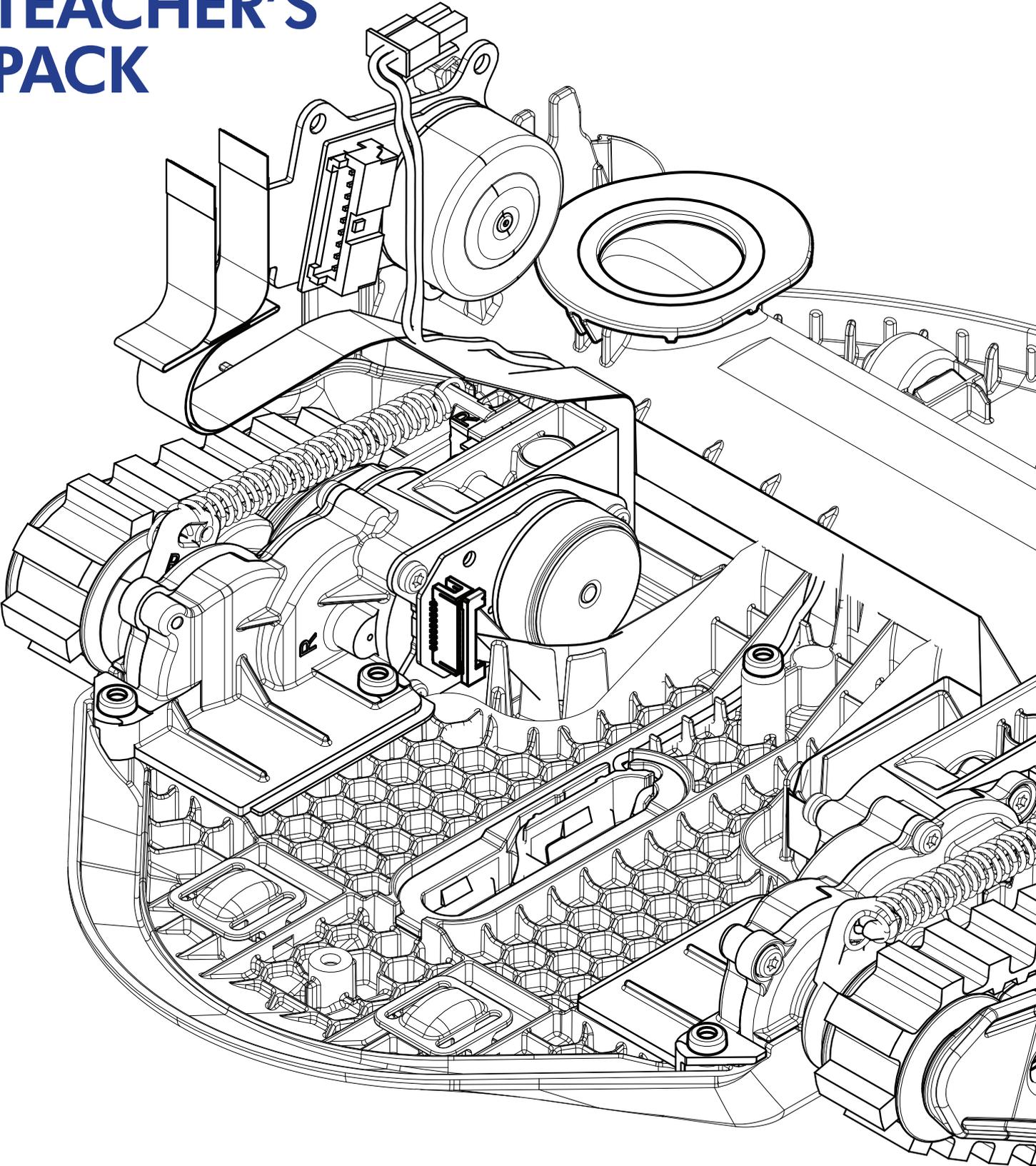


THE
JAMES
DYSON
FOUNDATION

TEACHER'S PACK





You'll find this USB in the Engineering Box.
It contains lots of useful videos to support your teaching.

Section 1

Today's engineers?

Meet Ruth: a research engineer

Meet Annmarie: a design engineer (new product innovation)

Meet David: a design engineer (new product development)

Meet Farai: a materials engineer

Meet Marcus: an electronics engineer

Meet Nathan: an acoustic engineer

Section 2

Advanced Dyson product analysis

Dyson DC39 disassembly

Dyson DC39 reassembly

Carbon Fibre Turbine Head disassembly

Tangle-free Turbine Tool disassembly

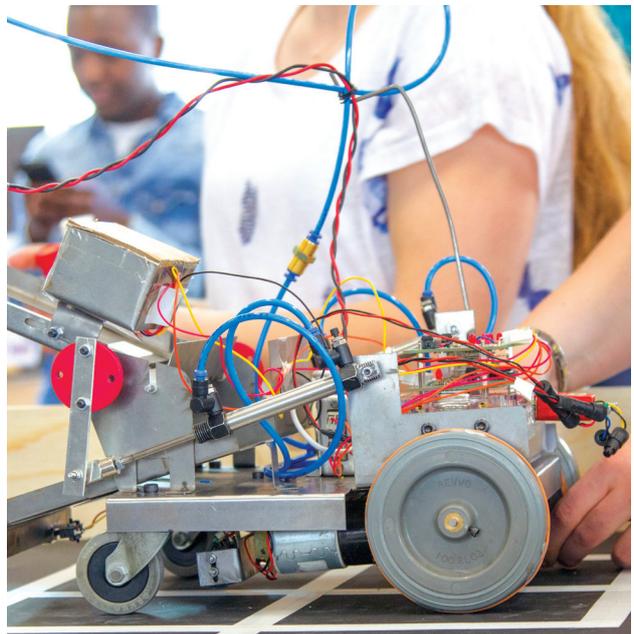
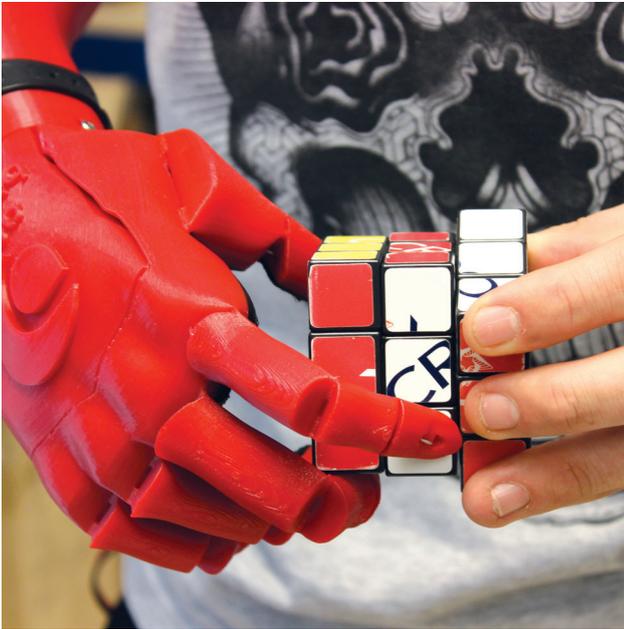
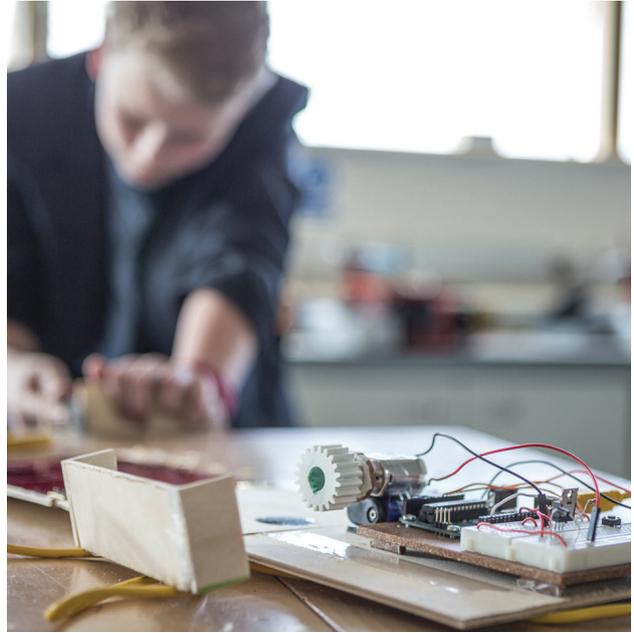
You can find all of the videos on our website:
www.jamesdysonfoundation.co.uk

The UK faces an annual
shortfall of 69,000 engineers.

Failure to address this shortage
could cost the economy
£27 billion per year from 2022.

Engineering UK, *The State of Engineering*, 2016





THE
JAMES
DYSON
FOUNDATION
INSPIRING THE
NEXT GENERATION
OF ENGINEERS

**BY ENCOURAGING
YOUNG PEOPLE TO GET
PRACTICAL, WE CAN
SHOW THEM WHAT A
HIGH-TECH, EXCITING
CAREER ENGINEERING
REALLY IS.**

This teacher's pack will help you to introduce your students to Dyson technology. It will show them the engineering thinking behind Dyson machines – and help them to think like an engineer themselves.

The teacher's pack accompanies the Engineering Box. The Engineering Box includes a Dyson DC39 vacuum, which students will disassemble and put back together, in order to better understand how the technology works. It also includes Carbon Fibre Turbine Heads, and Tangle-free Turbine Tools. Students will disassemble these, and consider the improvements that engineers made – and why.

Once they have got up close with Dyson technology, students will build on their knowledge of engineering thinking to understand the design process – working on their own problem-solving technologies.

Students will learn about the diversity of engineering jobs – and the passion for solving problems that all engineers have in common. The USB supplied with the pack includes interviews with Dyson engineers and videos to assist with the disassembly activities.

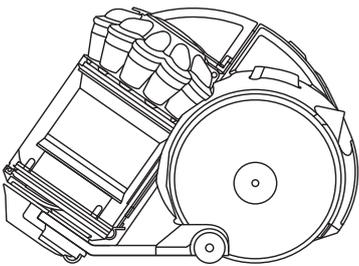
This pack contains eight lesson plans. It also contains summary information for you, the teacher, explaining how the lessons relate to design engineering at Dyson. Please read this information before you start teaching.

The Engineering Box is designed to support the learning objectives for Design and Technology at Key Stage 3 and 4.

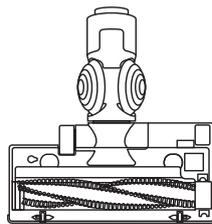
If you follow the lesson plans provided, by the time they have completed the Box your students will have:

- Identified and solved their own design problems
- Developed specifications to inform the design of a product
- Developed and communicated design ideas using annotated sketches and presentations
- Selected from and used tools, materials and components
- Evaluated and refined their ideas and products against a specification
- Understood how the properties of materials and the performance of structural elements achieve functioning solutions

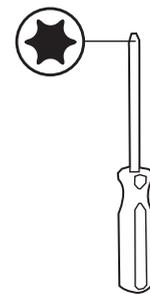
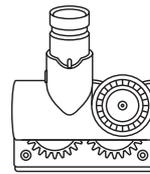
What's in the Box?



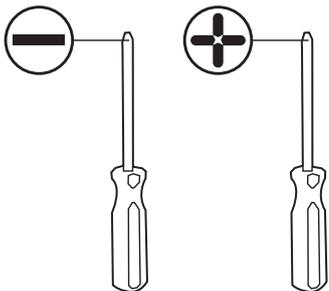
A Dyson DC39 vacuum cleaner



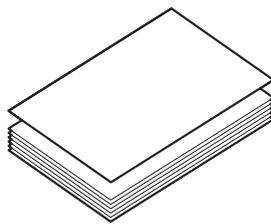
7 Carbon Fibre Turbine Heads
15 Tangle-free Turbine Tools



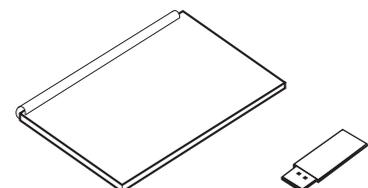
23 Torx screwdrivers
(15 x T8, 7 x T10, 1 x T15)



15 Phillips screwdrivers
7 Flathead screwdrivers



Posters for your
classroom wall



This teacher's pack and USB

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01

TODAY'S ENGINEERS

Learn about the variety
of engineering careers

**Titan Arm,
2013 James Dyson Award
International winner**

Titan Arm is a battery-powered robotic arm that exponentially increases human strength. It was developed by four mechanical engineering students from the University of Pennsylvania, USA: Nick Parrotta, Elizabeth Beattie, Nick McGill, and Niko Vladimirov.



ENGINEER PROFILE

Engineering is vital to our everyday lives – from essentials like running water and transport to mobile phones, household appliances and the Internet.

There are many different types of engineer, from acoustic to design to electrical. Their skill sets can be very diverse, but they all have one thing in common: they love problem solving.

“As a young girl, it never occurred to me that I would grow up to be an engineer. My real passion was art and design, and I thought I might go into the jewellery or fashion industry. But when I started researching degrees, I came across Product Design – and knew straight away that was the path for me. The thought of creating objects that could make people’s lives a little bit better was exciting!

I studied Product Design and Innovation at Strathclyde University, and spent a year at Mars Chocolate before joining Dyson as a design engineer. I work in the New Product Innovation (NPI) team, where I conceptualise and create new ideas.

On a day to day basis, I’m typically sketching out new product ideas and concepts, or solutions to existing problems. I’m constantly thinking about how

things work, and how they could be better. There’s no right or wrong way to approach a problem, and that’s really liberating. The most exciting part of working in NPI is turning 2D sketches into reality by creating visual – and working – prototypes. Using these prototypes to communicate how an idea might work or feel to use is satisfying – especially when I get to review the concepts with James Dyson.

There can be a perception that engineering is all about Maths and Physics – that it’s a cold, unfriendly, calculation-centered career. It’s enough to put anyone off! But really, engineering is a wonderfully holistic blend of the technical and the creative. It’s all about putting theory into practice; a perfect job for anyone who likes making things.”

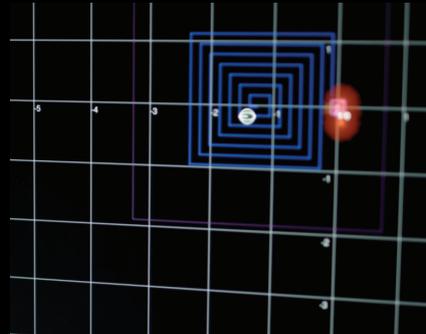
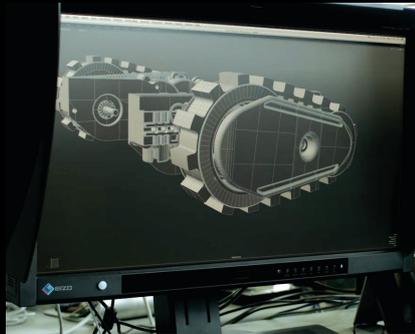
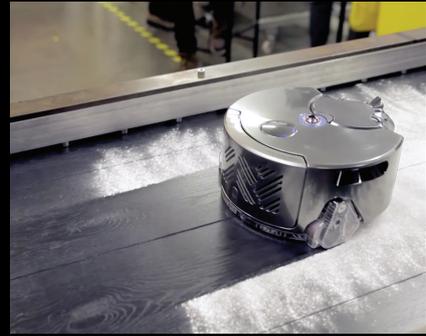
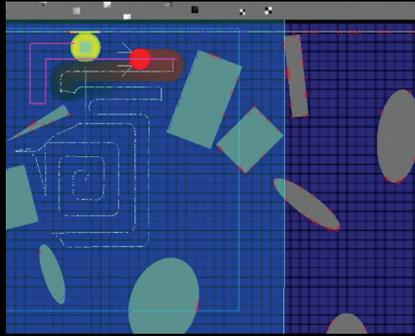
Engineer profile

Name: Annmarie
Age: 26
Job: Design engineer at Dyson



CASE STUDY

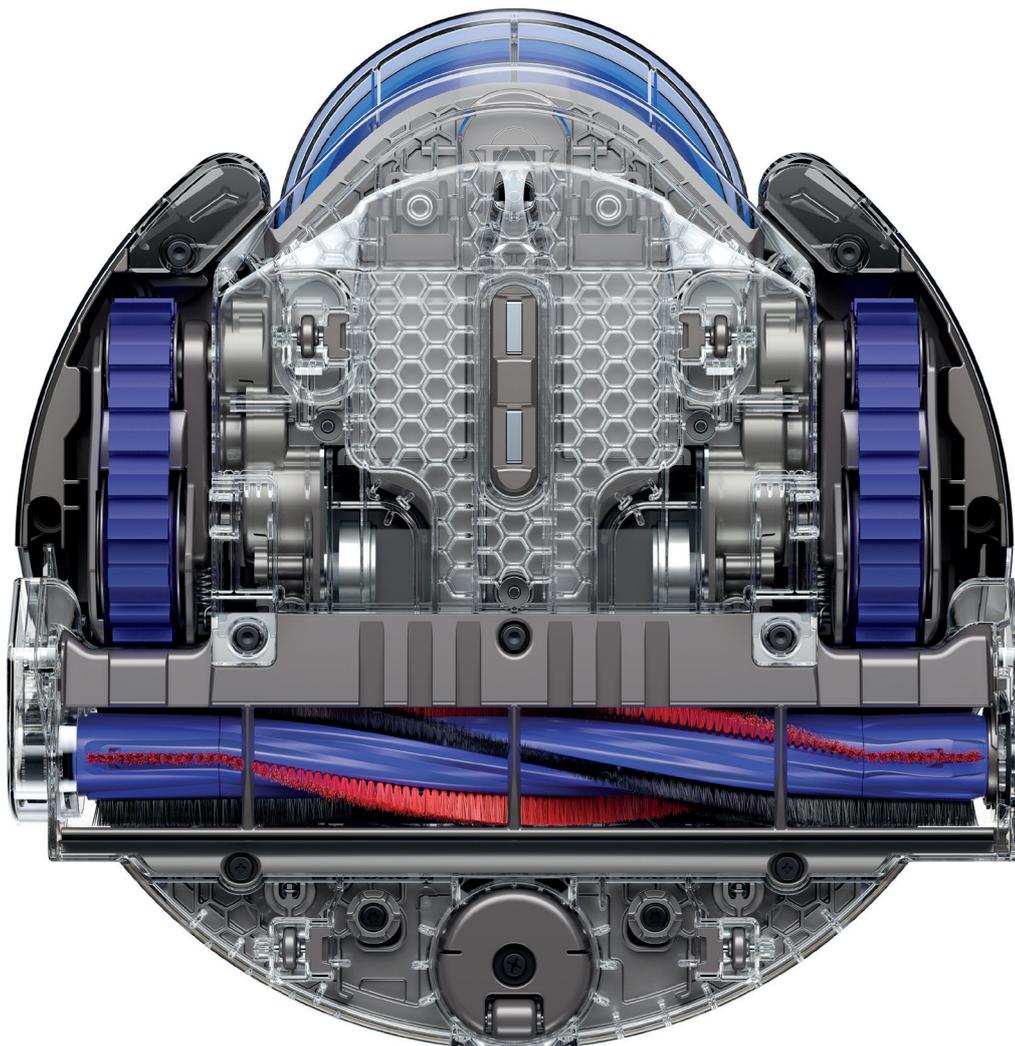
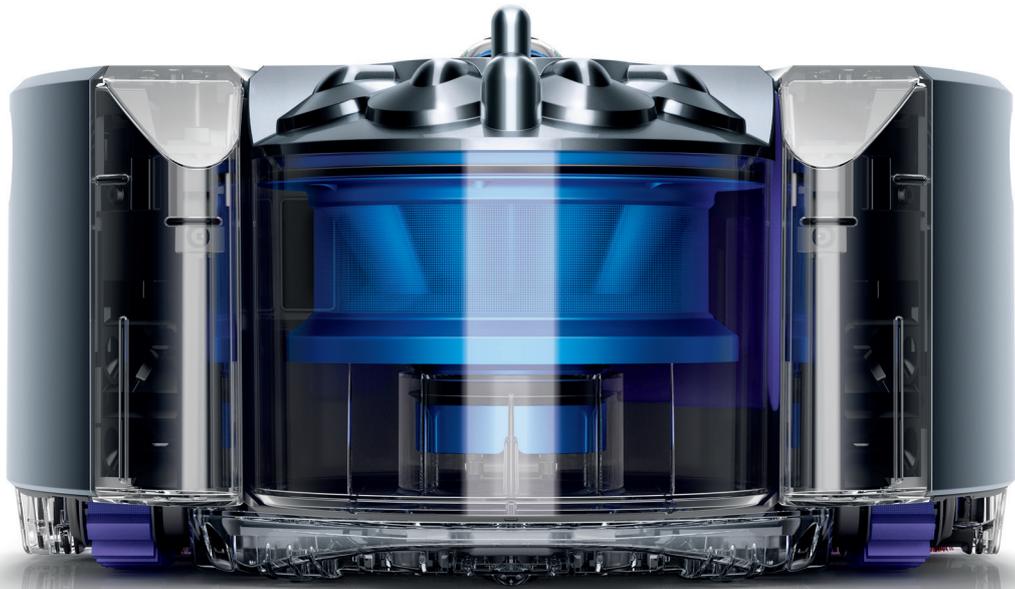
THE DYSON 360 EYE™ ROBOT



While the initial concept for a machine is developed by design engineers working in Dyson's New Product Innovation department, it takes the combined work of a variety of engineers – with different skills and specialties – to make it a commercial reality.

The Dyson 360 Eye™ robot vacuum cleaner is a complicated piece of technology. An intelligent mix of hardware and software, it took a lot of different engineering brains – and 16 years – to make it a success.

The Dyson 360 Eye™ robot was Dyson's first foray into artificial intelligence, and it required new types of engineer: robotics engineers, to design the plans needed to build the robot, and the processes necessary for it to run correctly. And software engineers, to apply mathematical analysis and computer science principles in order to design and develop software.



WHAT DID THEY DO?

Robotics and software engineers worked together to develop the vision system that allows the Dyson 360 Eye™ robot to know where it's been, and where it's yet to clean. A unique algorithm enables the robot to take calculated decisions about its next course of action based on time, area covered and complexity. But the Dyson 360 Eye™ robot is a vacuum first, and a robot second. It has to be able to clean properly – and this required input from many different engineers.

Power systems engineers designed the battery, working out how to get sufficient run time and support other processes at the same time.

Motor engineers designed the motor that draws in the air – and dust – while analysis engineers validated the motor design and made sure it would survive the forces deployed in operation.

Mechanical engineers worked out how to transfer power to the brush bar and tank tracks: making sure that the correct gear ratio was chosen to magnify the torque correctly.

Electrical engineers looked at how to transfer power from the battery, to where it was needed – incorporating elements like proximity sensors to help guide the robot around the room.

Aerodynamics engineers mapped the flow of air around the machine, spotting blockages – making sure the air flowed as efficiently as possible.

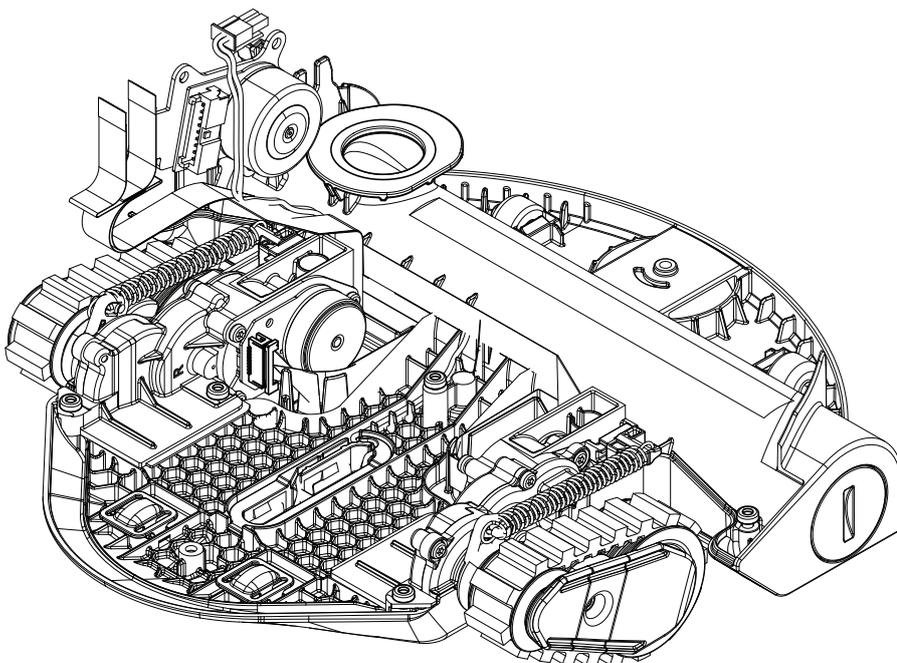
Separations systems engineers looked at the cyclonic separation system and the filters. They worked out how to get rid of pollutants from the air – and advised the design team on how to improve filtration performance.

Materials engineers researched and advised on which materials should be used for which aspect of the machine. For example, the bin needed to be clear, but also hard wearing – so it could survive bumps and bangs.

Acoustic engineers looked at the noise of the machine, employing insulation and other tricks to make it quieter.

Test engineers put the Dyson 360 Eye™ robot through its paces and found the failures.

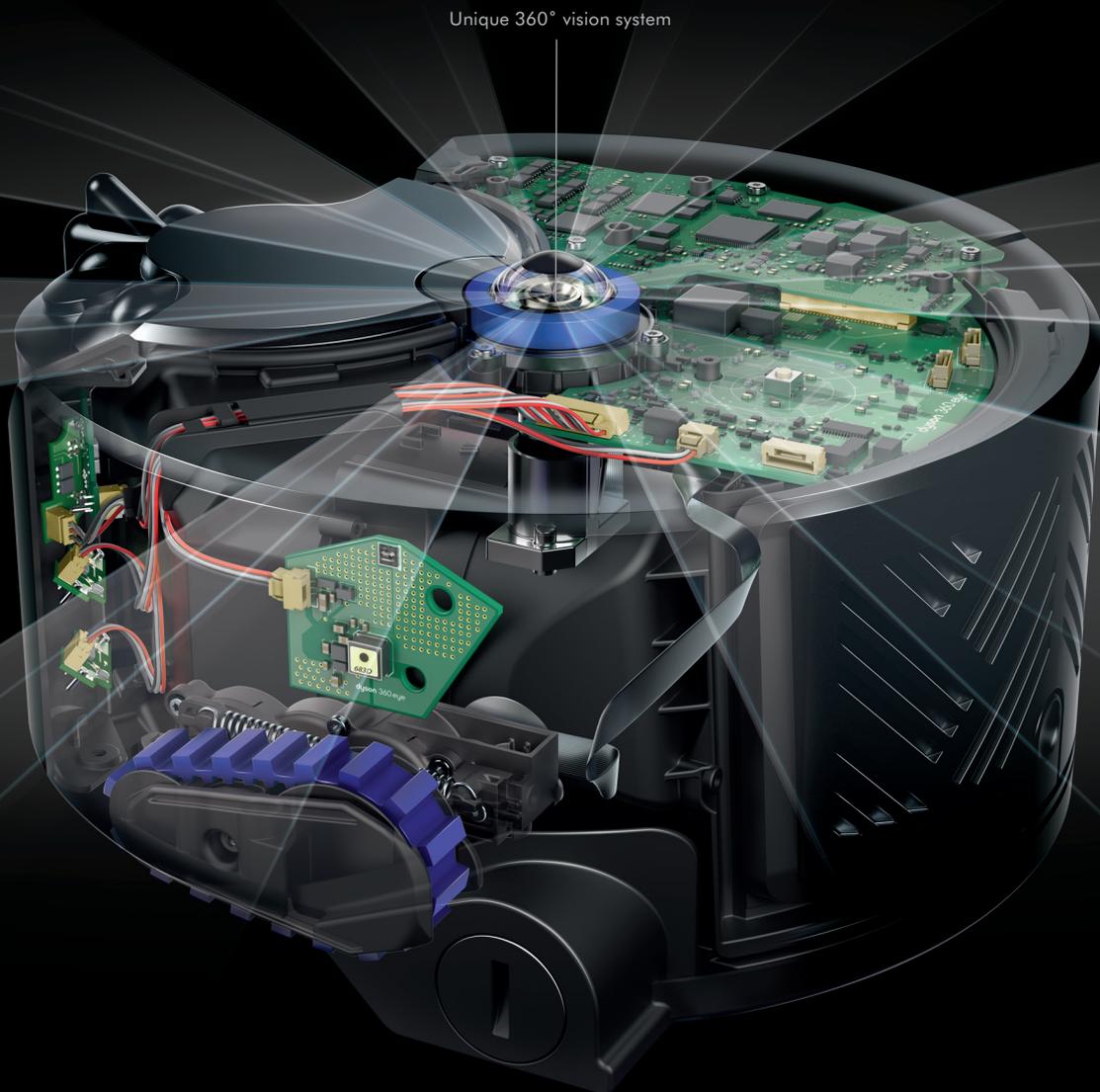
Manufacturing engineers looked at how the final machine would be made – defining the best way to manufacture every component, and making sure they were designed to fit together as easily as possible on the assembly line.



HOW DOES IT KNOW WHERE TO CLEAN?

Infrared sensors work alongside a lens on top of the machine which houses a 360° panoramic camera. The camera takes 30 frames every second, providing up-to-date information on its surroundings.

Before the Dyson 360 Eye™ robot begins cleaning, its vision system locates potential challenges and pinpoints landmarks. It translates these into coordinates, creating a virtual map. Having created this map, the robot vacuums the room systematically from edge to edge.



LESSON 1

Today's engineers

Duration: 1 hour 30 minutes

Learning objectives:

1. Understand that there are lots of different types of engineers.
2. Develop an in-depth understanding about different types of engineering careers, and how they each contribute to the development of technology.
3. Understand the similarities between different types of engineers, as well as the differences.

Activity outcomes:

- Class discussion about what engineers do
- Completed group research into an engineering career
- Completed group presentations about a type of engineer

Things you will need:

- The **Meet an engineer** videos on the USB
- Computer access for groups of students
- Pens and paper
- Poster 1: **Today's engineers**

Starter: 15 minutes

What do engineers do?

Learning objective	Activity
1	Before the class, put up Poster 1: Today's engineers . As a class, discuss what the students already know about engineers and what they do.  Write down key points on the board.
2	As a class, watch the Meet Annmarie: a Design engineer (new product innovation) video. Talk about Annmarie and her job. Is there anything that surprised the students? Refer to Annmarie's profile on page 10 for extra information.

Main: 45 minutes

Get to know a real engineer

Learning objective	Activity
1	 Explain that in this lesson, the students are going to learn about different types of engineers.
1, 2	<p>Break the class into six groups. Give each group a different Meet an engineer video to watch.</p> <p>Explain that the engineers in the videos will all talk about how they contributed to the development of the DC39, a Dyson vacuum cleaner. The students will be learning more about this vacuum cleaner – and taking it apart – in the next lesson.</p> <p>If your class is large, break the students into smaller groups and duplicate the videos you are asking them to watch.</p>
2	<p>Ask the students to spend the next 30 minutes learning more about the engineering career that corresponds to their video. Explain that they will be asked to give a two minute presentation of their findings to the class. They may want to consider:</p> <ul style="list-style-type: none"> – What this engineer does – Why this type of engineering is important – Key skills this engineer needs – Famous examples of this type of engineer – How you become this type of engineer

Wrap up: 30 minutes

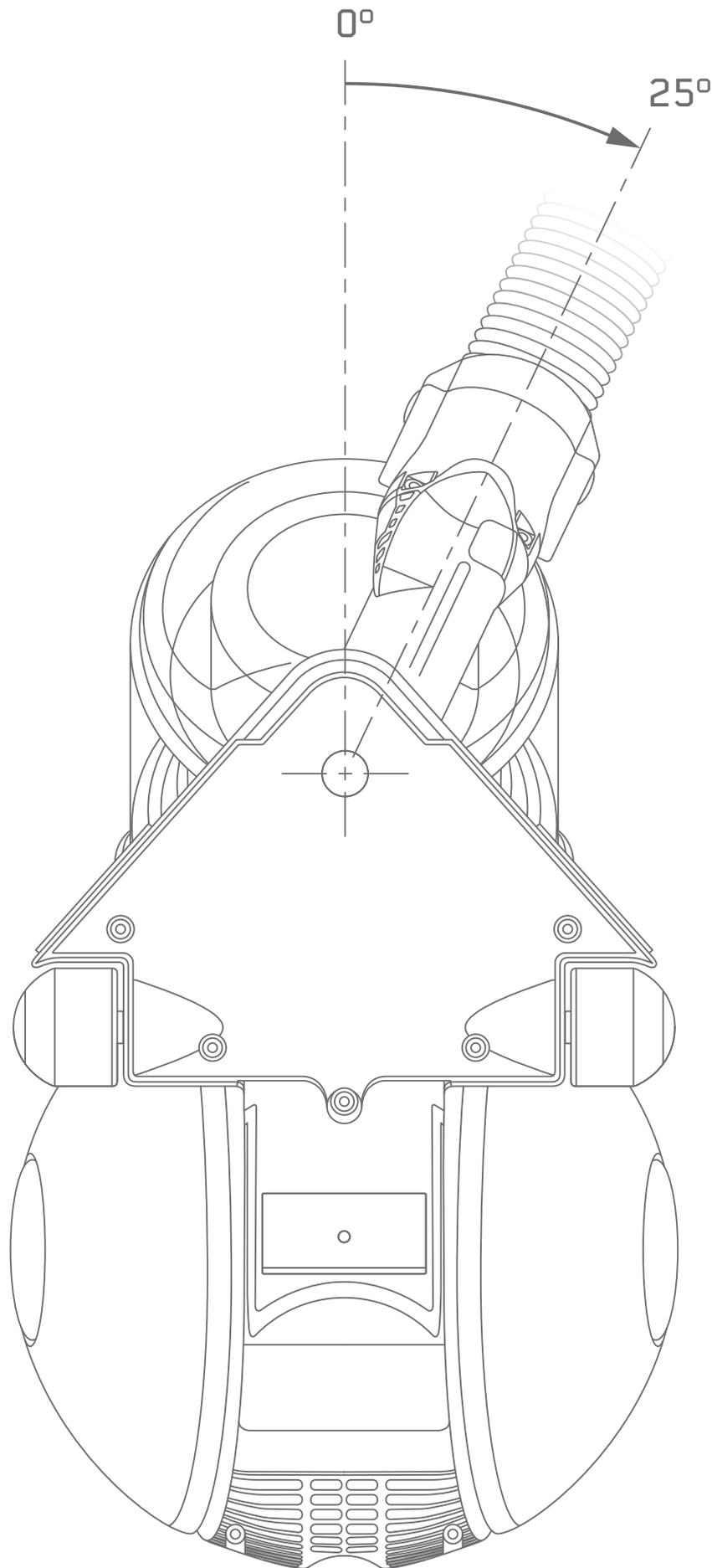
Present your findings

Learning objective	Activity
1, 2	<p>Ask the student groups to present their research to the class.</p> <p>Encourage the class to ask questions.</p>
3	<p>Once all of the presentations have been given, discuss as a class whether the different types of engineers have anything in common. If required, prompt them to think about:</p> <ul style="list-style-type: none"> – Interests as children – Love of problem solving – Technical skills

02

ADVANCED DYSON PRODUCT ANALYSIS

Understand how
Dyson technology works



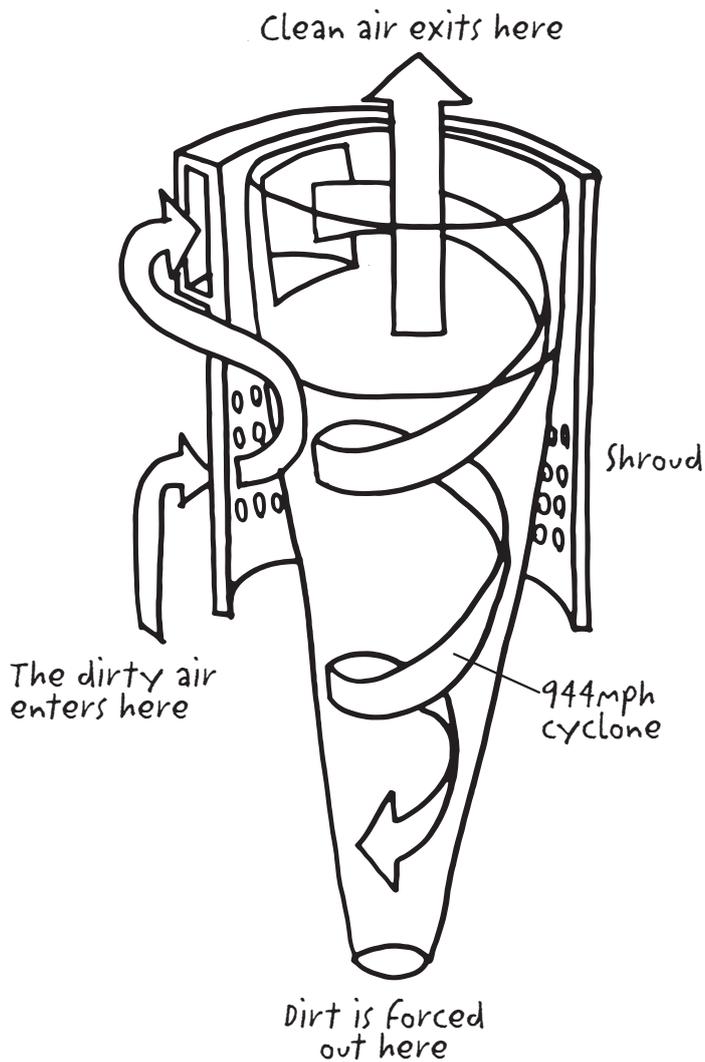
THE FIRST BAGLESS VACUUM CLEANER



When James Dyson got frustrated by his Hoover Junior, which kept losing suction, the first thing he did was strip it apart so he could see how it worked – and where the problem was. He discovered a layer of dust inside the vacuum cleaner bag, clogging the pores and preventing suction. A fundamental flaw with vacuum technology, undetected and unchallenged for almost 100 years. James became determined to develop a better vacuum cleaner that worked properly.

During a chance visit to a local sawmill, James noticed how the sawdust was removed from the air by large industrial cyclones. Could that principle work on a smaller scale in a vacuum cleaner? He took his vacuum apart and rigged it up with a cardboard cyclone. He then began to clean the room with it. While it didn't look great, it picked up more dust than his old bagged machine.

5,127 prototypes later, James had developed the DC01: the world's first working vacuum cleaner with no bag.



HOW DOES CYCLONE TECHNOLOGY WORK?

Cyclonic vacuum cleaners don't have a traditional bag or filter system. Instead, the air stream is sent through one or more cylinders, along a high-speed spiral path. This motion works something like a dryer, a roller coaster or a merry-go-round.

As the air stream shoots around in a spiral, all of the dirt particles experience a powerful centrifugal force. They are whipped outward, away from the air stream and fall into the bin.

The airflow moves through the bin and passes through a shroud where fluff and hair is captured. The air then proceeds through to the inner cyclone, which separates finer particles of dust.

This dust separation system doesn't rely on large barrier filters to trap the dust so it doesn't clog, resulting in powerful suction.

ENGINEERING

DYSON DC39

Radial Root Cyclone™ technology



Cylinder vacuum cleaners are often awkward to steer and can topple. They lurch into furniture, veer off at tangents and may be difficult to pull. Like an errant shopping trolley, their casters can drift across hard floors and get buried in carpets – more force is needed to keep them on track. Reliant on bags or filters – they can lose performance, too.

Sitting on a ball, DC39 has a lower centre of gravity and is easier to pull without snagging on corners or carpet pile. Coupled with a central steering system, it uses an articulating chassis and central pivot point for negotiating tight turns and circumnavigating sofas.

DC39 is also equipped with Dyson's Radial Root Cyclone™ technology – designed to increase suction power. Improved airflow efficiency reduces turbulence and preserves air pressure, so more microscopic particles are extracted from the air by the inner cyclones. These refinements help capture dirt, dust, allergens and pet hair.



Acoustics



Air muscle



Cyclone integration



Manoeuvrability rigging



Product assembly

From a rough start to finishing touches

Offline rigs are used to test individual elements of the machine. The rig on the top left (that resembles one half of the Lunar Module) was used to improve acoustics within the ball. The other rigs show experimentations with everything from airflow to manoeuvrability.

The last rig is a fully functioning, 3D-printed prototype. Once designs are finalised, they're sent to Dyson's manufacturing facility in Malaysia.

DC39 INTERESTING FACTS

DC39 was the result of three years of intensive research and development by a team of 70 Dyson engineers.

Over 500 prototypes were developed, and myriad tests – from a complex steering track, to a laser, to map trajectory.

One test involved 50,000 repetitions of pulling the machine around corners to ensure it was stable.

There are 112 components crammed into the ball including the motor, ducting and 21 feet of cable.

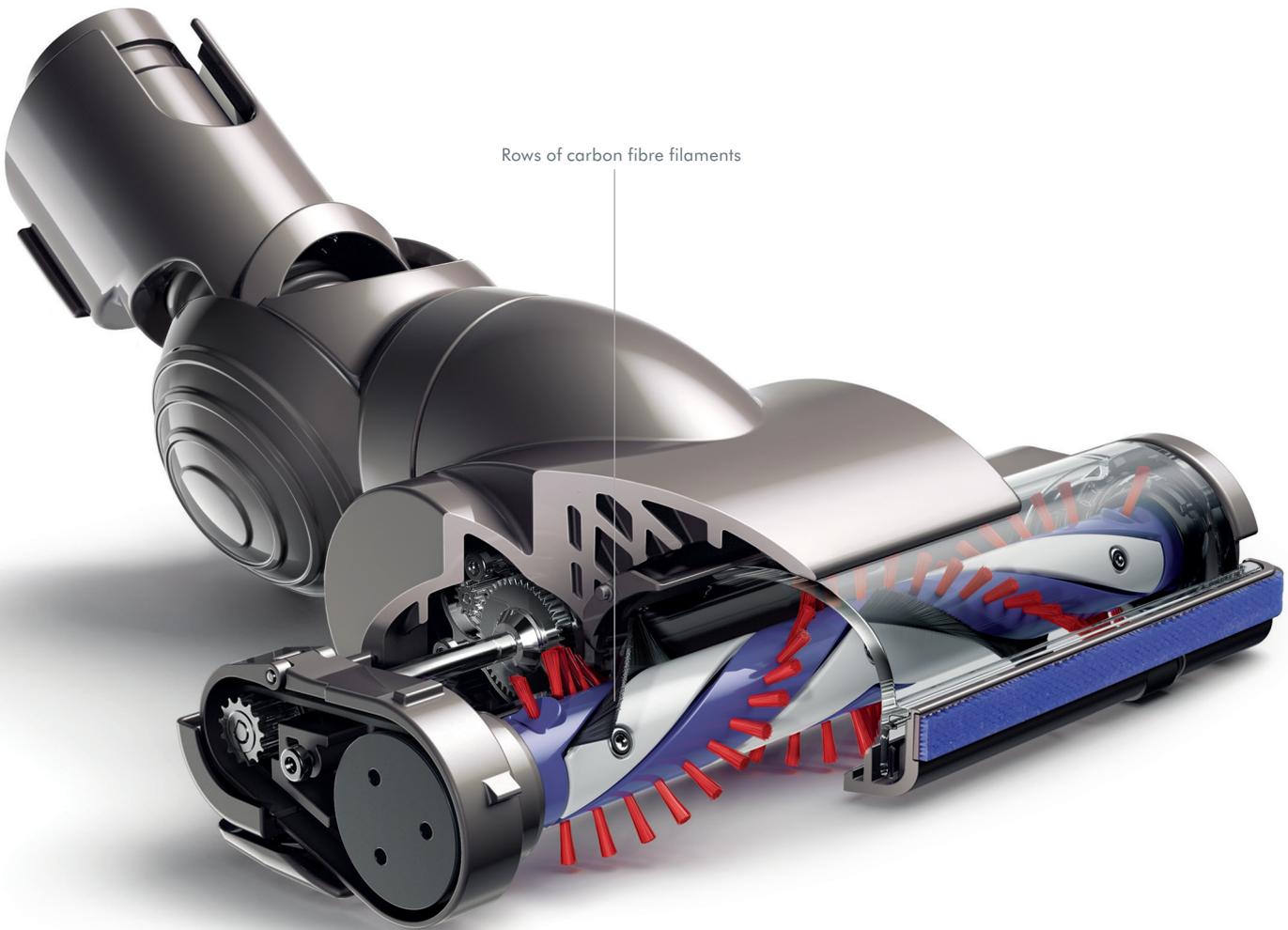
CARBON FIBRE TURBINE HEAD

It's not just the main machine that Dyson engineers apply their critical minds to. They consider everything that relates to it, including tools and accessories.

The original Dyson floor tool had stiff nylon brushes to pick up ground-in dirt from carpets. But when testing the tool on hard floors, Dyson engineers realised that some fine dust was difficult to suck up. They discovered the high speed spinning of the brush bar generated static, meaning that fine dust was attracted to the floor.

Engineers investigated different brush materials to add to the floor tool, finally selecting carbon fibre. Carbon fibre has anti-static properties that reduce the buildup of static charges so dust pick up is increased. Carbon fibre is a composite material. This means that two or more materials are combined together to give enhanced physical properties. Carbon fibre is made up of carbon and silica (glass fibres). This makes the material very strong when compared to its weight.

Rows of carbon fibre filaments



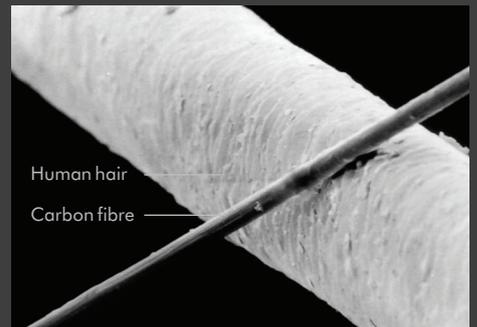
WONDER MATERIAL

High stiffness, high tensile strength, lightweight, high temperature tolerance – these are just some of the properties that make carbon fibres a top choice for materials engineers.

Carbon fibres are usually combined with other materials to form composites, making them stronger. For example, reinforcing them with polymers gives them a higher strength-to-weight ratio.

Carbon fibres are used in everything from tennis rackets to fishing rods – and even in the uncompromising aerospace industry. The Eurofighter aircraft is 70% carbon fibre, resulting in a plane that is 30% lighter than if it had been constructed from modern metals.

Carbon Fibre Turbine Head



Human hair

Carbon fibre



TANGLE-FREE TURBINE TOOL

While the design of the Carbon Fibre Turbine Head was certainly an improvement, it wasn't quite perfect for all cleaning scenarios.

The spinning action of a brush bar can cause hair or other long fibres to wrap around the bar, slowing it down or stopping it altogether. This can leave you having to tug or cut the hair off the brush bar: a messy task. Instead of ignoring this problem, Dyson engineers set out to design a solution.

It took a team of 49 Dyson engineers four years to create the Tangle-free Turbine Tool. The design brief: create a cleaner head that doesn't tangle hair or fibres.

Design engineers thought about the fact that rubbing hair in a circular motion creates a ball – easy to suck up and no tangles. With this theory in mind, they tested dozens of ways to simulate the circular motion. The result was two counter-rotating discs, each with sturdy bristles, enclosed in polycarbonate casing. The spinning discs ball the hair, then it is sucked straight into the vacuum cleaner bin. Hygienic, with no mess. The parts at work to create that perfect hair ball: gears and a turbine.





Regular brush bar. Tangles.



Counter-rotating discs.

No tangles.

GEARS AND TURBINES

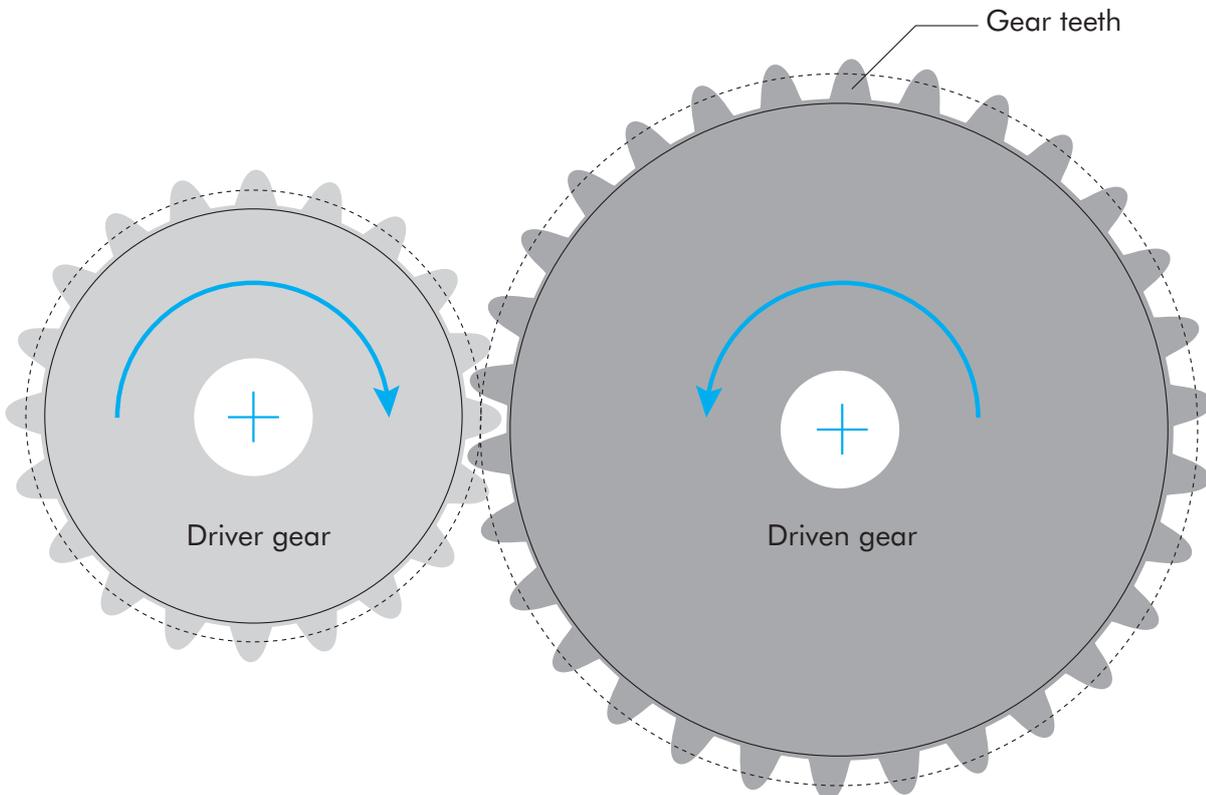
Gears are toothed machine parts that work together to create movement. The gear's teeth interlock with other toothed parts to transmit power, change speed or change direction.

When the first gear – called the driver gear – is rotated, motion is transmitted to the second gear – called the driven gear.

Where there are two gears of different sizes, the smaller gear will rotate faster than the larger gear. The difference between these two speeds is called the gear ratio. The gear ratio can be calculated using the following formula:

Gear ratio = number of teeth on driven gear ÷ number of teeth on the driver gear

When two or more gears connect together they are called a gear drive. The driver source or input – e.g. a motor – is connected to the driving gear. The output – or what is being powered – could be the wheel of a vehicle, a pump or the hands on a clock is connected to the driven gear.



INSIDE THE TANGLE-FREE TURBINE TOOL

In the Tangle-free Turbine Tool, the gear drive is a step down drive – it increases torque while, at the same time, decreasing the output speed.

The Tangle-free Turbine Tool is driven by the red turbine on top of the tool, which extracts power from the airflow. The air spins the turbine's blades, which drive the gears – which in turn spin the discs inside the Tangle-free Turbine Tool.

Balance of the airflow is crucial – it's split between the turbine and the cleaner head's own suction. Too much airflow in the turbine and the discs will spin quickly but not suck up the dust and the dirt. But too little airflow and the discs will not spin. Turbines work well at high speeds, but the turbine doesn't deliver nearly enough torque to spin the discs on its own. This is why gears are used – to increase the torque.



LESSON 2

DC39 disassembly

Duration: 1 hour 45 minutes

Learning objectives:

1. Understand how the DC39 works.
2. Learn how to disassemble a DC39 vacuum cleaner.
3. Understand the design decisions that the engineers made when developing DC39.

Activity outcomes:

- Completed disassembly of the DC39
- Completed reassembly of the DC39

Things you will need:

- DC39 vacuum cleaner
- Torx T15 screwdriver, flathead screwdriver, Phillips screwdriver
- Debris to vacuum up (e.g. cereal, rice, talcum powder)
- **DC39 disassembly: Video support sheet** (page 34)
- The **DC39 disassembly** video on the USB
- The **DC39 reassembly** video on the USB

Starter: 30 minutes

Observations

Learning objective	Activity
1	Display the DC39 vacuum cleaner at the front of the class. Ask for volunteers to use the vacuum in different ways: cleaning different types of debris, around obstacles, at different heights (using a stool or chair), on different surfaces. The other students should record what they observe.
1,3	Break students into eight groups and assign each group one of the questions below. Each group should jot down their responses on A3 paper to share with the class later. <ul style="list-style-type: none">– Group one: How would you describe the design of the DC39? What is good about this design and what is bad? What do you find interesting or different about how the DC39 looks, feels or sounds?– Group two: Why is it important to think about cost when designing a product? What aspects of the design would add extra cost to the DC39 and why did the engineers choose to include them?– Group three: Who would buy this product? What are their needs? Think about how needs change depending on age, height, lifestyle etc. What works well about this design for a customer, and what doesn't?

Learning objective	Activity
1, 3	<ul style="list-style-type: none"> – Group four: What about this product and its design might have a negative impact on the environment or the place where it's used? – Group five: What safety aspects were considered to prevent potential harm to the user? What aspects were considered to prevent damage to the environment in which the vacuum is used? – Group six: Why is the vacuum this size? How does the size work with different users, in different environments? Think about the size of individual parts, too – like the brush bar and power button. – Group seven: What are the most important functions of a vacuum cleaner? Does the DC39 do these things? What could it do, but doesn't? – Group eight: Think about the materials used to make the DC39. What are the benefits of the materials they used? What other materials could have been used?
	Ask for one leader from each group to share out their observations. Note their key findings on the board.

Main: 45 minutes

DC39 disassembly

Learning objective	Activity
1, 2	 Play the DC39 disassembly video on the USB, and use this as a guide to take apart the machine. Stop and start the video as required. As the teacher, you can lead the disassembly – or you can ask students to take it in turn to help.
1, 3	You will see six red flags with numbers pop up while you are watching the DC39 disassembly video. These flags highlight an interesting fact or scientific principle that you can discuss with your students. To learn about the facts associated with these flags, refer to the DC39 disassembly: Video support sheet (page 34).

Wrap up: 30 minutes

DC39 reassembly

Learning objective	Activity
1, 2	 Play the DC39 reassembly video on the USB, and use this as a guide to put the machine back together. Stop and start the video as required.

LESSON 3

Improving Dyson technology

Duration: 1 hour 45 minutes

Learning objectives:

1. Understand how engineers improve existing technology.
2. Learn how to take apart the Carbon Fibre Turbine Head.
3. Learn how to take apart the Tangle-free Turbine Tool.
4. Understand how Dyson technology works.

Activity outcomes:

- Complete disassembly and reassembly of the Carbon Fibre Turbine Head
- Complete disassembly and reassembly of the Tangle-free Turbine Tool
- Class discussion of the problems with the Carbon Fibre Turbine Head, and how the Tangle-free Turbine Tool resolves them

Things you will need:

- Carbon Fibre Turbine Heads
- Tangle-free Turbine Tools
- Paper and pens
- **Carbon Fibre Turbine Head disassembly and Tangle-free Turbine Tool disassembly** videos on the USB
- **Carbon Fibre Turbine Head disassembly: Video support sheet** (page 36)
- **Carbon Fibre Turbine Head reassembly instructions** (page 37)
- **Tangle-free Turbine Tool disassembly: Video support sheet** (page 38-39)
- **Tangle-free Turbine Tool reassembly instructions** (page 37)
- 15 Torx T8 screwdrivers, 7 Torx T10 screwdrivers, 7 flathead screwdrivers, 15 Phillips screwdrivers, 15 coins.
- Poster 2: **Constant improvement**

Starter: 15 minutes

Introduce

Learning objective	Activity
1	Explain to the students that in this lesson, they will be learning about two Dyson vacuum tools. They both solve problems – but the second addresses issues with the first. A good engineer will keep developing a solution until it works perfectly.
1, 4	Show the class the Carbon Fibre Turbine Head. Ask them what they think it's for, how they think it works and whether they can notice any interesting design features.

Main: 45 minutes

Carbon Fibre Turbine Head

Learning objective	Activity
2	Split the class into seven groups. Give each group a Carbon Fibre Turbine Head.  Play the Carbon Fibre Turbine Head disassembly video on the USB, and use this as a guide for the students to take apart the machine. Stop and start the video as required.

Learning objective	Activity
2, 4	<p>You will see three red flags with numbers pop up while you are watching the Carbon Fibre Turbine Head disassembly video. These flags highlight an interesting fact or scientific principle that you can discuss with your students.</p> <p>To learn about the facts associated with these flags, refer to the Carbon Fibre Turbine Head disassembly: Video support sheet (page 36).</p>
2	Reassemble the Carbon Fibre Turbine Head, following the instructions (page 37).
1	Discuss as a class whether there are any problems with the design of the Carbon Fibre Turbine Head. Write down key points on the board. Prompt the students to think about the issues with a spinning bar if necessary (refer to page 24 of the teacher's pack).

Wrap up: 45 minutes

Detangling the brush bar

Learning objective	Activity
1, 4	<p>Reveal the Tangle-free Turbine Tool. Ask the students how they think this tool might solve some of the problems they identified with the Carbon Fibre Turbine Head.</p> <p>Plug the DC39 in, and demonstrate the Tangle-free Turbine Tool. Hold it up, so they can see the two contra rotating discs in action. Swap over to the Carbon Fibre Turbine Head, so the students can appreciate the difference in action.</p>
3	<p>Split the class into 15 pairs (or small groups). Give each group a Tangle-free Turbine Tool.</p> <p> Play the Tangle-free Turbine Tool disassembly video on the USB, and use this as a guide to take apart the machine. Stop and start the video as required.</p> <p>As the teacher, you can lead the disassembly – or you can ask students to take it in turn to help.</p>
3, 4	<p>You will see six red flags with numbers pop up while you are watching the disassembly video. These flags highlight an interesting fact or scientific principle that you can discuss with your students.</p> <p> To learn about the facts associated with these flags, refer to the Tangle-free Turbine Tool disassembly: Video support sheet (page 38-39).</p>
3	Reassemble the Tangle-free Turbine Tool, following the instructions (page 37).

DC39 disassembly: Video support sheet

The **DC39 disassembly** video features numbered flags. When one of these flags is shown, it means there is an interesting fact or scientific principle that you can discuss with your students.

When you see:	Pause the video, and ask your students:	After they guess, inform students that:
	How does cyclonic separation work?	<p>Cyclonic separation is a method of removing particulates from air.</p> <p>Air and dust are sucked in through the cleaner head and, when they enter the bin, start to spin in a cyclone. As the air spins faster and faster, so does the dust. At high speeds, the dirt experiences a powerful centrifugal force. It is flung out of the airflow, falling to the bottom of the bin where it collects. (See page 21 for more information).</p>
	<p>Look inside the cyclone assembly where the pre-motor filter sits. Along the top, you'll see the top of the two tiers of small cyclones. Why did the engineers add this to the design when an outer cyclone already filters dirt and debris in the bin?</p> <p>Why is the pre-motor filter made of foam?</p>	<p>The air flows through a second stage of smaller cyclones before reaching the pre-motor filter. These smaller cyclones generate higher centrifugal forces. With both tiers of cyclones at work, more microscopic dust, which contains allergens and bacteria, can be extracted from the airflow.</p> <p>Foam is a 'depth loading' material, which means it can trap a high capacity of tiny particles from the cyclone through its entire thickness. It's also a washable material.</p>
	Look at the post-motor filter – why do you think the material is pleated?	<p>The post-motor filter is pleated – this design increases the surface area of the filter so that it can capture more fine dust. The post-motor filter is a HEPA (High Efficiency Particulate Air) filter. HEPA filters remove 99.97% of particles as small as 0.1 microns (like pollen and mould spores). The HEPA filter here is made to trap emissions from the vacuum's motor as well as the small particles the vacuum picks up.</p>

When you see:	Pause the video, and ask your students:	After they guess, inform students that:
 <p>4</p>	<p>Why is it useful to be able to retract the cable at the push of a button?</p> <p>How does the cable rewind unit work?</p>	<p>The cable rewind unit allows the cable that connects the machine to the power to be retracted quickly and easily – this means the cable can be stored neatly, without tangling.</p> <p>When the cord is pulled out, a torsion spring exerts torque in the opposite direction proportional to the amount it is twisted. When the button to retract the cable is pressed, the tension on the spring is released, and the cord is wound back around the axis.</p>
 <p>5</p>	<p>What is an electric motor – and why is it needed in the DC39?</p>	<p>An electric motor is a motor that is powered using electricity and magnets. It contains two permanent magnets with a coil of copper wire between them.</p> <p>When an electric current flows to the motor, the coil of copper wire becomes an electromagnet with both a north and a south pole. These poles are attracted to the opposite poles of the permanent magnets on either side, causing the copper wire to rotate.</p> <p>Once the opposite poles are aligned, the direction of the current is reversed, meaning the poles have now switched. The side of the coil that used to be a south pole is now a north pole. The permanent magnets repel these new poles so the coil rotates again until the opposite poles are aligned once more. By changing the direction of the current each half turn, the coil, and therefore the motor, can be kept spinning.</p> <p>The spinning of the motor powers the impeller inside the DC39, which produces the suction that the vacuum cleaner utilises to clean.</p>
 <p>6</p>	<p>How does the relief valve know when to open?</p>	<p>Relief valves control or limit pressure in a system – which can build up as a result of a blockage and cause equipment failure.</p> <p>The relief valve is designed to open at a predetermined set pressure. When the set pressure is exceeded, the relief valve becomes the “path of least resistance”: the valve is forced open and the airflow is diverted through the auxiliary route.</p>

Carbon Fibre Turbine Head disassembly: Video support sheet

The **Carbon Fibre Turbine Head disassembly** video features numbered flags. When one of these flags is shown, it means there is an interesting fact or scientific principle that you can discuss with your students.

When you see:	Pause the video, and ask your students:	After they guess, inform students that:
	The engineers have chosen to use a quarter-turn fastener rather than a screw. Why do you think that is?	Quarter-turn fasteners are used where the person using the machine will need access, for example to clear debris from the brushbar in the turbine head. Using this kind of fastener means that the user doesn't need special tools to get into the machine.
	What do you think the brushbar is for? Why are there two types of bristles on the brush bar?	The brushbar spins, powered by the turbine, brushing dust and debris out of the carpet. This improves cleaning performance. The red bristles are made of stiff nylon, which helps the brush bar remove ground-in dirt from carpets. However, when testing the floor tool on hard floors Dyson design engineers realised that some fine dust was difficult to suck up. This was because the spinning of the brush bar generated static, meaning the fine dust was attracted to the floor. To solve this problem, the engineers added the black bristles, which are made of carbon fibre. Carbon fibre has anti-static properties which reduce the buildup of static charges, so fine dust pick up is increased. (See pages 24 and 25 for more information).
	How is airflow used to power the brush bar? Notice the minimal gap between the edge of the turbine blades and the internal housing, as well as the black rubber over-moulded gasket. Why is it important that there is so little space around the turbine?	Airflow enters the machine and hits the blades of the turbine – making the turbine spin. This creates continuous power which drives a set of gears, linked through a shaft in the turbine housing. It is these gears which cause the brush bar to turn. The turbine relies on a sealed system to force as much airflow through the blades as possible. Air is like water; it will always take the easiest path. So it's crucial to minimise any 'escape routes' around the turbine.

Carbon Fibre Turbine Head reassembly instructions

Step 1

Screw together the turbine assembly using the three T8 screws, then replace the turbine assembly and put the single T10 screw in the side of the cleaner head.

Step 2

Refit the duct cover and brushbar housing onto the rest of the vacuum head.

Step 3

Slide the brushbar back into the brushbar housing, cog first.

Step 4

Replace the endcap on the side of the brushbar housing, then use a coin to secure it in place.

Tangle-free Turbine Tool reassembly instructions

Step 1

Reattach the bristle head discs with the two Phillips screws.

Step 2

Put the intermediate gear back on the turbine drive shaft, ensuring the teeth of the intermediate gear fit with the teeth of the larger gears.

Step 3

Reassemble the turbine assembly by screwing the J-shaped duct piece back onto the assembly. Now fit the turbine assembly back onto the bottom of the main housing. Make sure the turbine drive shaft fits into the bottom of the turbine assembly.

Step 4

Merge the top casing of the main housing with the bottom casing. Replace the four screws on the top casing. Now, on the bottom casing, replace the two screws beneath the bristle head discs.

Step 5

Replace the mesh filter on top of the guide vanes, ensuring it clicks into place.

Step 6

Reattach the soleplate by snapping it back onto the pivot points.

Step 7

Reattach the neck attachment by snapping it back on the pivot points.

Tangle-free Turbine Tool disassembly: Video support sheet

The **Tangle-free Turbine Tool disassembly** video features numbered flags. When one of these flags is shown, it means there is an interesting fact or scientific principle that you can discuss with your students.

When you see:	Pause the video, and ask your students:	After they guess, inform students that:
	<p>What is the neck of the Tangle-free Turbine Tool made of?</p> <p>Why is it important that the Tangle-free Turbine Tool is made out of a tough material?</p>	<p>The neck of the Tangle-free Turbine Tool is made out of acrylonitrile butadiene styrene or ABS – the same material used to make riot shields! ABS is strong because it has gone through a process called rubber toughening, in which elastomer chains are added to a more brittle polymer. Elastomers are polymers with viscoelasticity. By spreading elastomer chains throughout the material, the energy needed to break it is increased. In other words, it has become tougher.</p> <p>The Tangle-free Turbine Tool must be able to withstand years of use – without breaking. This may include being dropped or hitting obstacles. Dyson engineers test their products to breaking point to identify any weak points prior to manufacturing. This information is then used to further improve the design.</p>
	<p>Why is the soleplate spring loaded?</p>	<p>The flat spring allows the soleplate to maintain contact with the surface of the floor, adjusting between carpets, hardwood floors and other surfaces. Maintaining a seal with the floor is crucial to providing good suction.</p>
	<p>Why does the turbine drive gears, instead of just driving the discs?</p>	<p>By itself, the turbine can't deliver enough torque – a force that causes rotation. Gears are used to increase the torque (see pages 28 and 29 for more information).</p>

When you see:	Pause the video, and ask your students:	After they guess, inform students that:
	<p>Compare the teeth on the various gears. What's different and how does this impact the function of the tool?</p> <p>What material are the two main gears made out of? Why is this material important?</p>	<p>The teeth on the larger gears are cut vertically while the teeth on the smaller gears are cut helically – or diagonally. When gears come together they make a chattering noise. The helical teeth produce less noise than vertically cut teeth.</p> <p>The smaller gears also have teeth that are shaped like spear heads – this very precise profile is called an involute curve. This shape reduces the gear-on-gear impact and wear as the teeth turn, as well as reducing noise.</p> <p>The two large gears are made of Polyoxymethylene (POM), also known as acetal, polyacetal and polyformaldehyde. POM is an engineering thermoplastic used in parts that require high stiffness, low friction and excellent dimensional stability. It is ideal for gears which require smooth operation and low wear.</p>
	<p>What do you notice about the shape of the screw boss? What is the purpose of this shape?</p>	<p>The screw boss is an aerofoil shape, just like the wing of a plane or the blade of a propeller.</p> <p>The aerofoil shape is very aerodynamic: that means that it reduces drag, allowing the air to travel efficiently around the cleaner head, without losing velocity.</p>
	<p>Why are the bristles red?</p> <p>What is the function of the bristles and what are they made of?</p> <p>Why are the discs oval in shape?</p> <p>Why do the discs counter-rotate?</p>	<p>The bristles are red to draw the eye of the consumer. The bristles may need to be cleaned periodically due to hair build up, so they need to be highly visible.</p> <p>The bristles are made from very fine filament – nylon plastic. Their job is to agitate the surface and pick up dirt. As they run across the surface, they splay out and then spring back together. The action of springing back together is what actually draws in the dirt.</p> <p>The rotating discs are oval because this shape allows the discs to overlap in the middle during their rotation cycle, so no area of floor is left untouched. The oval shape also makes sure hair gets pulled off the paddles and into the airway.</p> <p>The spinning discs ball the hair, meaning it doesn't wrap around the brush bar and is instead sucked straight into the vacuum cleaner bin. The discs rotate in opposite directions so that they both feed in toward the airway in the middle.</p>
	<p>Why does the bottom of the paddle feature raised lumps of plastic?</p>	<p>The bottom of the paddle has been manufactured so it can only be put in the right way round. This is an example of Poka Yoke, a Japanese term that means 'mistake proofing'. Its purpose is to prevent or correct human errors – eliminating defects before machines or products can reach the market.</p>

03

DESIGN PROCESS

Understand the
design process and
put it into practice

SPECIFY

PLAN

DESIGN

BUILD

TEST

ANALYSE





WHAT IS THE DESIGN PROCESS?

Engineers use their knowledge of science, technology, engineering, maths and creative thinking to solve problems. Engineers refer to the stages of the design process as: Specify, Plan, Design, Build, Test, Analyse. This process is iterative and non-linear.

SPECIFY

Every Dyson project starts with a problem: unhygienic hand-dryers, vacuum cleaners that lose suction or robotic cleaners that fail to navigate intelligently.

The brief that design engineers start with is very broad. A list of requirements is then compiled, forming the product specification. This is the measuring stick for assessing a product's success.

The following key criteria and constraints can be remembered with the acronym 'ACCESS FM'.

Aesthetics

What will the product look, feel or sound like?

Cost

What is the estimated manufacturing cost of the product, and what will its retail price be?

Customer

Who is the product designed for?

Environment

What is the product's impact on the environment?

Safety

How will the user be kept safe from harm?

Size

Are the proportions of the product appropriate?

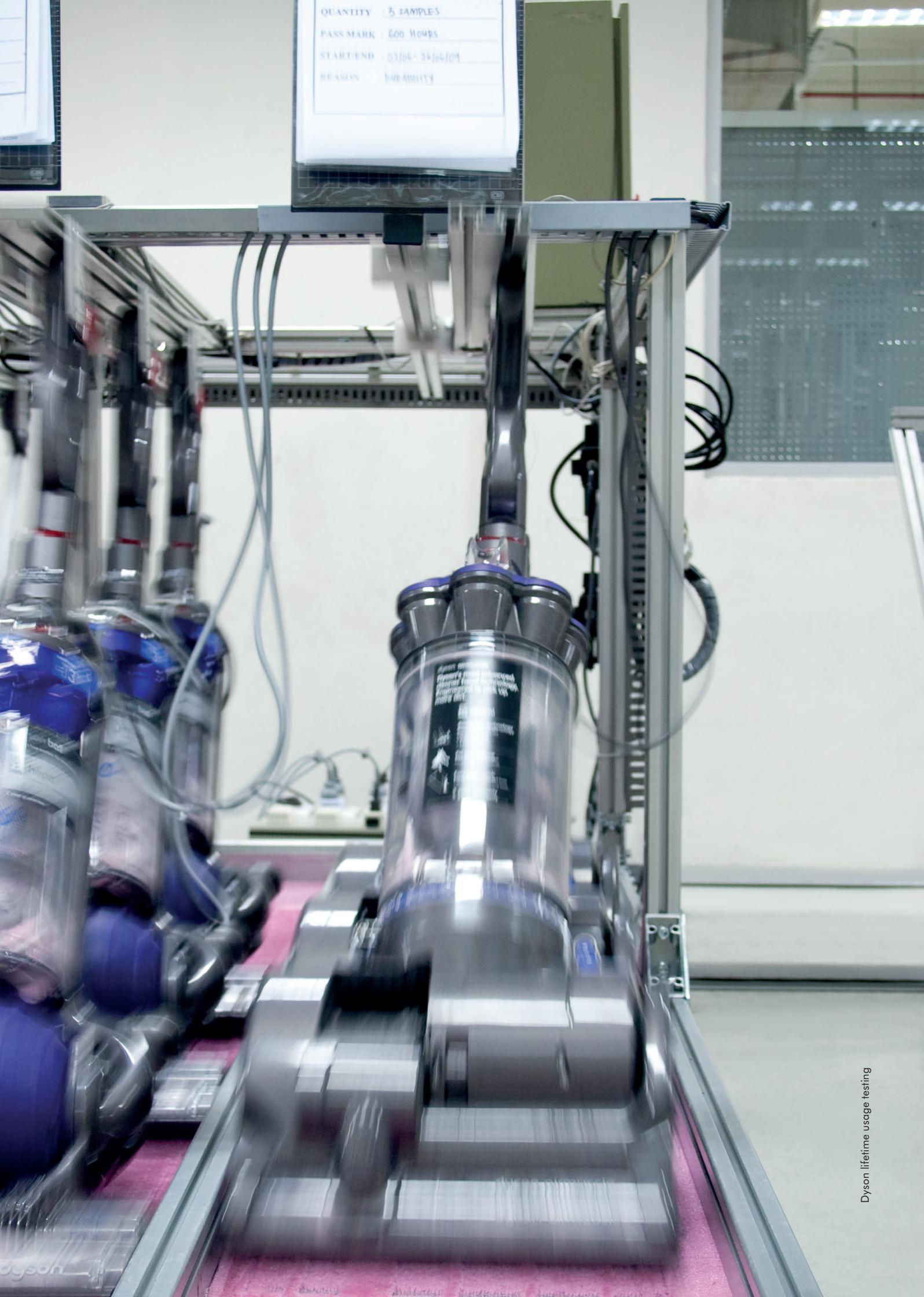
Function

How well does the product work – and is it easy to use?

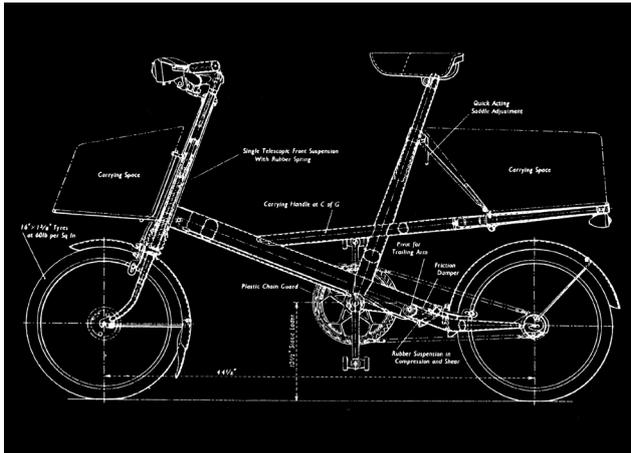
Materials

What is the product made from, and what does this mean for manufacturing?

QUANTITY : 3 SAMPLES
PASS MARK : 600 HOURS
START/END : 03/06 - 24/06/09
REASON : DURABILITY



Dyson lifetime usage testing



Moulton Bicycle design drawing



Morph™ wheel development

PLAN

Projects run to a tight schedule. The iterative nature of the design process means that the idea will need to be prototyped, tested and then improved – again and again. Project milestones help to keep the engineers on schedule.

DESIGN

Designs are never perfect the first time. Engineers will repeat the design process cycle several times, tweaking and changing their design slightly each time. It took James Dyson 5,127 prototypes to get the first cyclonic vacuum right.

Engineers work in teams. Sharing ideas and challenges leads to more creative solutions. With a design brief in hand, Dyson engineers will start by brainstorming solutions. No idea is wrong – and everything is written down.

Sketching is next. Engineers keep the sketch rough and ready – it's about communicating complex ideas, simply. Sketching also helps the team plan the layout of the parts and how the machine might look.

BUILD

Engineers make 3D prototypes early on. It's quite crude in the beginning: a cardboard model. Cheap and pliable, cardboard allows the engineers to model basic functions, quickly. They then move on to computer-aided design (CAD). This allows engineers to test calculations and airflow dynamics as well as send the CAD parts to a 3D printer. The 3D printed parts can be assembled with motors and electronics into fully functioning machines.

TEST

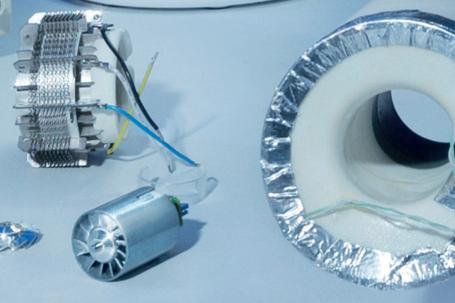
Testing makes or breaks a product – literally. Engineers test prototypes, often to destruction. This allows them to ensure that the machine fulfills the design specifications and will survive usage in a home. After the design has been tested, it will be redesigned, rebuilt and tested again. This process will be repeated many times.

ANALYSE

Once engineers are confident with the design, the product will move on to manufacture. The first run of machines – Engineering Build 1 (EB1) – will go through extensive testing to ensure the materials and moulding work meet the design specification, and that they will last for the machine's expected lifetime. The design will often meet some failure at the manufacturing stage. But engineers take on those challenges again to make the machine better.

CASE STUDY

THE DYSON SUPERSONIC™ HAIR DRYER





Teamwork between different types and teams of engineers is essential to overcoming the challenges that can be encountered when developing a new product.

For example, the Dyson Supersonic™ hair dryer has a unique shape: it has a hole in the middle. This shape is essential to the function of the machine – but it created challenges for its development.

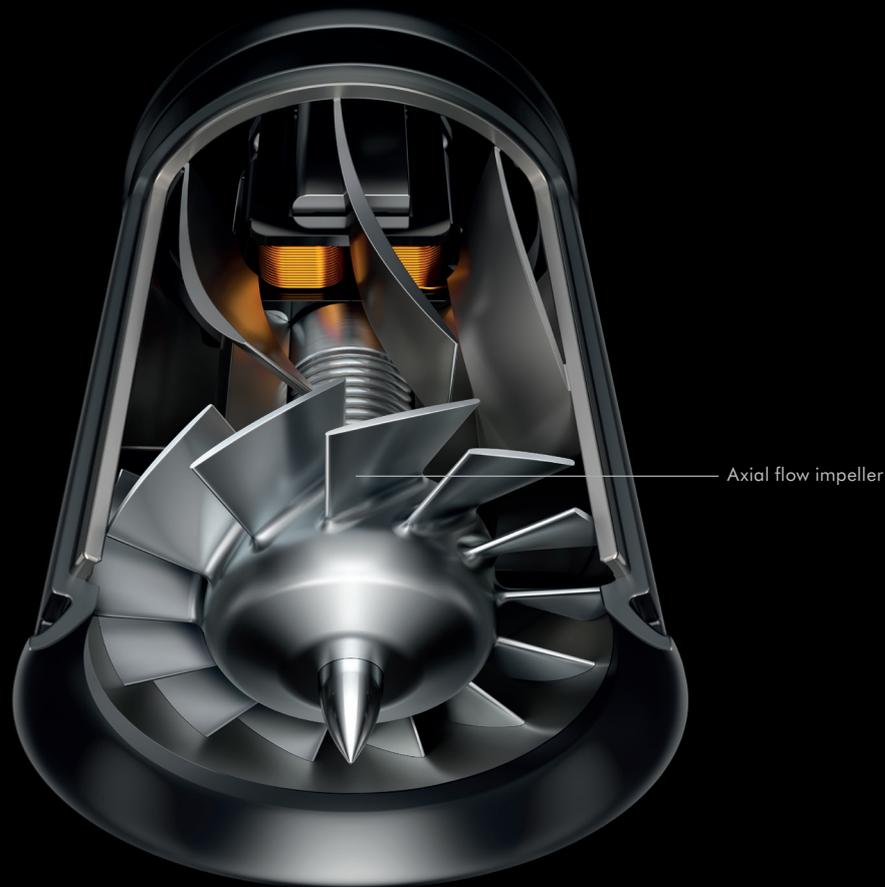
Conventional hair dryers often use flat sheets of Mica slotted together in a Christmas tree shape for the heating element. Wire is then wrapped around this structure. Dyson engineers needed to develop a heating element which worked within the unique shape of the Dyson Supersonic™ hair dryer. They designed a heating element which uses specially produced Mica tubes, positioned in a doughnut shape with two, resistive wires wrapped around them. These wires are structured in a wave-form pattern and interwoven around the tubes.

Initially the engineers developed a one-layer heating element, using wire which was more loosely woven, creating larger wave shapes. However, they found that this solution had limitations. The large wave shapes of the wire would wobble and touch each other, causing the machine to cut out. This is why the heating element has two layers and two wires – allowing for smaller wave patterns, tightly woven.

Design, electrical and test engineers had to work together to make sure that the heating element worked properly, fitted into the unique format of the machine – and was reliable. The process took a total of three years, making iterative developments and doing extensive testing on the element to ensure it worked and did so safely.







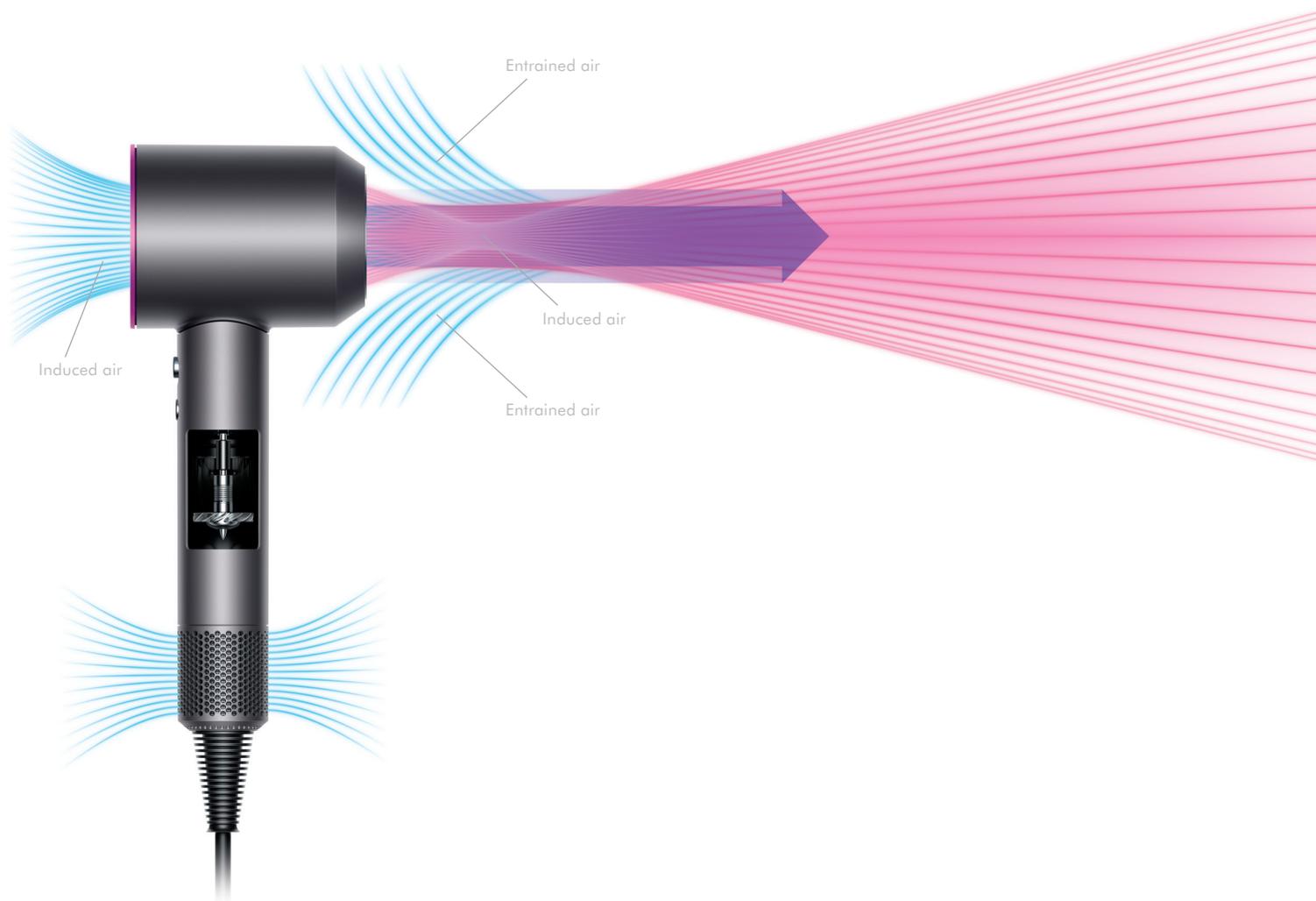
Acoustic engineering

One of the key aspects of the brief for the Dyson Supersonic™ hair dryer was that it had to be quiet. Using Dyson Air Multiplier™ technology was a good start, but really addressing the problem meant calling in the experts: acoustic engineers. Acoustic engineers are experts in the science of noise and vibration: they are concerned with the design, analysis and control of sound.

But sometimes even the experts require support. Aerodynamics engineers helped the acoustic engineers to map the flow of air through the machine, so they could understand how to optimise it. They soon discovered that the motor was a key area for improvement. This required more teamwork – with the motor engineers.

By using an axial flow impeller inside the motor, Dyson engineers simplified the pathway of the air, reducing turbulence and swirling. And by giving the motor impeller 13 blades instead of the usual 11, they pushed one tone within the motor to a sound frequency beyond the audible range for humans. It was up to another engineering team, analysis engineers, to consider this new motor design and validate it – ensuring that it could survive the intense centrifugal forces that a motor experiences during operation.

Finally, the acoustic engineers surrounded the motor in the handle of the machine with acoustic silencers, to further muffle the sound. Making the Dyson Supersonic™ hair dryer quiet, without compromising on performance.



HOW DOES IT WORK?

Air is drawn in by the motor and accelerated over an annular aperture. This creates a jet of air which passes over an aerofoil-shaped ramp that channels its direction. Surrounding air is drawn into the airflow (this is called inducement and entrainment). The result is that the volume of air coming out of the hair dryer is three times that going into the motor. This system is called Air Multiplier™ technology – it's patented by Dyson.

LESSON 4

Taking on the brief

Duration: 1 hour 30 minutes

Learning objectives:

1. Understand the importance of design briefs and specifications.
2. Develop qualitative and quantitative criteria and constraints for a brief.

Activity outcomes:

- Class discussion about the brief and design specifications of the DC39
- Completed group brainstorm for a product that solves a specific problem
- Completed group product specifications

Things you will need:

- Pens and paper
- **Specification worksheet** (page 62)
- Poster 3: **Development analysis**
- Poster 4: **This is engineering**

Starter: 15 minutes

What are briefs and specifications?

Learning objective	Activity
1	<p>Explain to students that engineers are given a brief, which explains the challenges that must be answered by a product and the parameters in which a design engineer must work. For example, a product might need to be a certain size or perform a particular function.</p> <p>For the DC39, the brief was to create a vacuum that uses Dyson Ball™ technology to make the most manoeuvrable cylinder machine.</p>
1	<p>As a class, discuss the criteria that were considered when developing the design specification for DC39.</p>
1	<p>Prompt the students to consider the brief in terms of ACCESS FM. Ask the class to draw on what they learned in Lesson 2: DC39 disassembly when they discussed the design of DC39.</p> <ul style="list-style-type: none">– Aesthetics– Cost– Customer– Environment– Safety– Size– Function– Materials

Main: 45 minutes

Take on the brief

Learning objective	Activity
1, 2	<p>Put up Poster 3: Development analysis and Poster 4: This is engineering. Explain to students that for the next four lessons, they are going to think like engineers. In this class, the students will be taking on a design brief and developing specifications. In the next classes, they will be conceptualising, researching and prototyping products to meet these specifications.</p> <p>Break the class into six groups. Give each group one of the following six briefs:</p> <ul style="list-style-type: none"> – Design a product that will encourage secondary school students to lead a healthier lifestyle. – Design a product that will improve the safety of secondary school students walking home from school. – Design a product that will improve the safety of elderly people alone in the home. – Design a product that will help secondary school students to pay more attention in class. – Design a product that will help to address the isolation and loneliness experienced by some elderly people. – Design a product that will help owners to make sure their pets are cared for when they are away from home.
1, 2	Give students 30 minutes to independently think about and sketch possible solutions to their group's brief. Encourage preliminary online research.
1, 2	Ask students to present their ideas to their group. Encourage students to ask questions, and then agree upon a final solution – as a group.

Wrap up: 30 minutes

Develop the specification

Learning objective	Activity
2	Once each group has agreed on a design, give them a Specification worksheet (page 62).
2	Explain that each group should use the worksheet to define specific and realistic qualitative or quantitative criteria and constraints for their design.

LESSON 5

Product development – Research and planning

Duration: 1 hour 30 minutes

Learning objectives:

1. Understand how to use a specification to guide product development.
2. Understand how to work as a team to achieve an objective.
3. Develop independent research skills.

Activity outcomes:

- Completed group research into product specification
- Presentation of specification research

Things you will need:

- Pens and paper
- Computer access for each student
- **Specification worksheet** (page 62)

Starter: 10 minutes

Take on problems as a team

Learning objective	Activity
1	<p>Explain to the students that today they will be continuing to work in their groups to develop the designs they chose in the last lesson.</p> <p>They will need to conduct research, and make a plan to keep development on track.</p>
2, 3	<p>Explain that in order to develop the best solution possible, the students will need to take individual responsibility for different aspects of the specification – reporting their findings to the group, so that collective decisions can be made.</p> <p>You may want to photocopy the Dyson Supersonic™ hair dryer case study (pages 46-51), and distribute to the students. This will help to explain that while engineers have different specialties, they work together to solve problems.</p>

Main: 60 minutes

Research the specifications

Learning objective	Activity
1, 2	<p>Ask each group to work together to consider the 'function' aspect of the Specification worksheet, which they completed in the last lesson. What does the product do, and how does it work?</p> <p>The students should write a list of the different aspects that will be required to make the product work – such as electronics and sensors, power sources, LEDs, etc. The students should work together to research these elements, and uncover any potential issues.</p>
1, 3	Ask each group to review their completed Specification worksheets and divide responsibility for the other criteria among themselves.
3	<p>Explain that the students now need to individually research their criteria, and that they will give a two minute presentation of their findings to their group. While they are researching as individuals, they will come back together as a group to think about how the findings will impact on the development of their product.</p> <p>The students may want to research online or, if appropriate, they may want to survey their classmates or potential users. This is a good opportunity to build in a homework or extension exercise.</p>
	This part of the lesson can be extended or repeated if more time is required.

Wrap up: 20 minutes

Present your findings

Learning objective	Activity
1, 2	<p>Ask the students to present their findings to their group.</p> <p>Encourage the group to ask questions.</p>

LESSON 6

Product development – Building and testing

Duration: 1 hour 30 minutes

Learning objectives:

1. Understand the myriad parts needed to create a functional product.
2. Appreciate the importance of continuous iteration to the design process.

Activity outcomes:

- Completed student annotated sketches and parts list
- Completed group prototype
- Completed student reflections

Things you will need:

- Pens and paper
 - Prototype building supplies and equipment (cardboard, tape, scissors, glue, etc.)
-

Starter: 15 minutes

Annotated parts

Learning objective	Activity
1	<p>Building on the research carried out in the previous lesson, ask the student groups to sketch their product.</p> <p>Explain the sketch should be annotated to identify each part needed for the product to function – and what those parts will be made of. Make sure the groups think about what's on the inside of the product, as well as the outside.</p>

Main: 45 minutes

Build the prototype

Learning objective	Activity
1	<p>Explain that in this lesson, the students are going to create a rough-and-ready prototype of their product.</p> <p>Students should consult their parts list and work together to build each part.</p>

Learning objective	Activity
1, 2	<p>Explain to students that they should select a lead engineer. This person should delegate who is building which parts, ensure consistency in dimensions and quality, and note any additions or adjustments made to the product's design and parts list.</p> <p>This lead engineer should also ensure that the build process is finished within a reasonable time frame.</p>
1, 2	<p>Ask the students to construct their prototype. Encourage the groups to test their product as they go along, to understand how a user would interact with it, and ascertain where there may be design flaws.</p> <p>Remind them that the design process is iterative, and encourage them to work together to modify and improve their design as they encounter difficulties.</p> <p>Make sure that any changes to the design or function are recorded by the lead engineer.</p>
	This part of the lesson can be extended or repeated if more time is required.

Wrap it up: 30 minutes

Reflect

Learning objective	Activity
1, 2	<p>Once the prototype's construction is complete, ask each student to write their reflections on the building and testing experience. They may want to consider:</p> <ul style="list-style-type: none"> – What changes were made to the product's design, and why? – How will the changes impact the design specification? – How did you ensure that a part's design would function appropriately? – How might this affect the materials used to create that component?

LESSON 7

Go to market

Duration: 1 hour 30 minutes

Learning objectives:

1. Understand how to calculate profit margins.
2. Learn how to think about a product in a market context.
3. Develop critical analysis skills.
4. Develop skills in persuasion.
5. Develop presentation skills.

Activity outcomes:

- Estimate of manufacturing costs and profit margin calculation
- A business and marketing plan

Things you will need:

- Pens and paper
- Computer access

Starter: 45 minutes

Go to market

Learning objective	Activity
1	<p>Explain that in today's lesson, the student groups will be preparing to pitch their products. But before they can start planning their presentations, they need to work out how much they will sell their product for.</p> <p>Explain that cost engineers use engineering principles to control costs and make sure projects are completed within budget.</p> <p>Cost engineers consider the labour and manufacturing costs, the purchase price of every part, and finishing elements such as coats of paint. They make suggestions as to design changes that will improve a product's profit margin.</p>
1	<p>Ask the student groups to estimate what they want to sell their product for, and how much profit they would like to make. The students should then work in their groups to estimate the manufacturing costs of their finished product. They should think about:</p> <ul style="list-style-type: none">– The cost of each part– The cost of finishing – such as paint– The cost of labour to make the product <p>Once they have this estimate, ask the students to subtract the cost of manufacturing from the amount they plan to sell the product for. This figure is their profit margin.</p> <p>If the profit margin is not healthy, the group may want to consider making some changes to their design.</p>

Learning objective	Activity
1, 2	Now ask the groups to consider other, similar products that are already on the market. How much do these products sell for? Will their price be competitive – or do they believe that their design is unique enough to justify a higher price point?
2, 3	Give the students 10 minutes to consider whether they would like to make any design changes in light of their findings.

Main: 30 minutes

Planning the pitch

Learning objective	Activity
3	Now that they know how much they will sell their product for, the student groups need to decide how to market it. Explain that for the next 30 minutes, they will be working on a plan that explains their business and marketing strategy. This plan will be presented to the class – so it needs to be visually engaging.
3, 4	The plan should identify the strengths and weaknesses of their products, and should address the following questions. – What is it, and what problem does it solve? – How does it work, and why is it better than existing solutions? – Who will use it? – How will it be manufactured and what will it cost? What will the profit margin be? – How many units of the product will be sold every year? – How will people get to know about the product – and how will they be convinced to buy it?
3, 4	This activity can be extended by asking the students to develop marketing materials to support their presentation: – An advert explaining what the product is, its key features, and how it is different to or better than rival products. – An instructional video or brochure explaining how to use the product. – A print advert that highlights the features and functions of the design.

Plenary: 15 minutes

Prepare for launch

Learning objective	Activity
5	Ask the groups to practice their presentations, and identify any areas they need to improve before the next lesson.
	This activity can be extended as homework – ask the students to perfect their presentations and supporting materials before the next lesson.

LESSON 8

The big pitch

Duration: 1 hour 30 minutes

Learning objectives:

1. Develop presentation skills.
2. Develop critical analysis skills.

Activity outcomes:

- Presentation
- Critical discussion of products and business plans

Things you will need:

- A projector
 - Computer access
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Starter: 45 minutes

Preparation

Learning objective	Activity
1	Explain that today's lesson will be focused on group presentations. Give the students 10 minutes to prepare their presentation.

Main: 1 hour

The big pitch

Learning objective	Activity
1, 2	Ask each group to present. Explain that the other students should take notes during each presentation, summarising: the name, novelty, function, price, and persuasive arguments.
1	Make sure each group answers the following questions: <ul style="list-style-type: none">– What is it, and what problem does it solve?– How does it work, and why is it better than existing solutions?– Who will use it?– How will it be manufactured and what will it cost? What will the profit margin be?– How many units of the product will be sold every year?– How will people get to know about the product – and how will they be convinced to buy it?
2	At the end of every presentation, encourage the class to ask questions.

Wrap up: 15 minutes

Best product design

Learning objective	Activity
2	Ask students to refer back to their notes on the other groups' presentations.
2	Explain they should vote for the team (that is not their own) that had the most persuasive presentation. Count the votes and award a small prize to the winning team.

Top tip

An alternative to this lesson is to hold a design exhibition, which other students and teachers can visit. Student groups can display their prototypes, and pitch their product to the attendees. To make the event even more exciting, you could ask a local engineer to come in and meet the students – and even judge the best product.

Specification worksheet

This worksheet should be used to record the key criteria and constraints. This is your product specification – the measuring stick for assessing your product's success.

Aesthetics What will the product look, feel or sound like?	
Cost What is the estimated manufacturing cost of the product, and what will its retail price be?	
Customer Who is the product designed for?	
Environment What is the product's impact on the environment?	
Safety How will the user be kept safe from harm?	
Size Are the proportions of the product appropriate?	
Function How well does the product work – and is it easy to use?	
Materials What is the product made from, and what does this mean for manufacturing?	

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