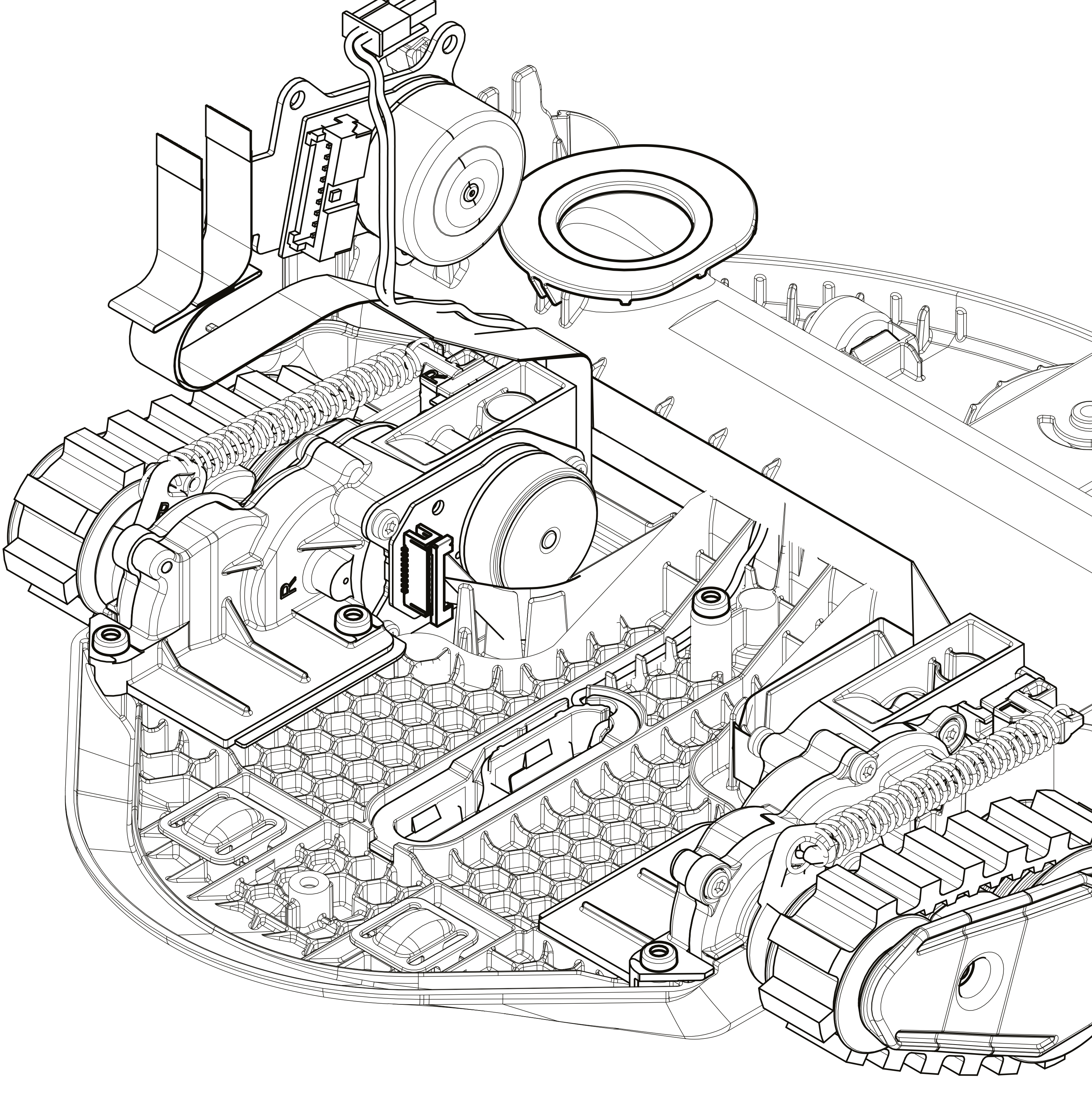
THE JAMES DYSON FOUNDATION

TEACHER'S PACK

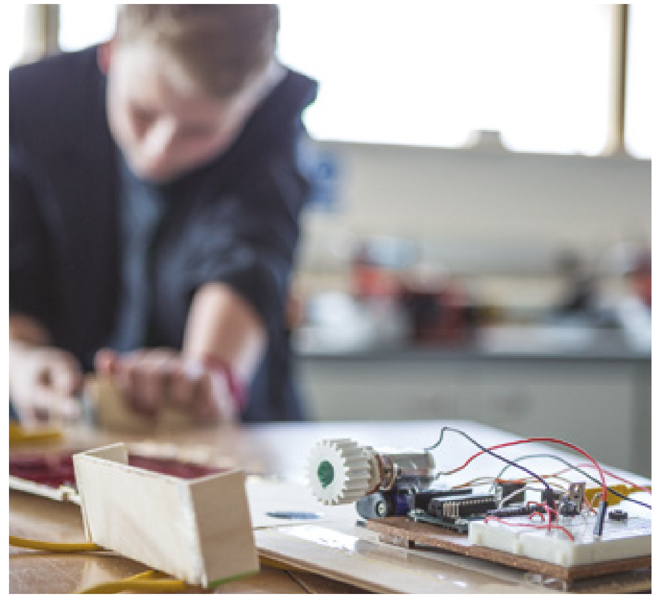


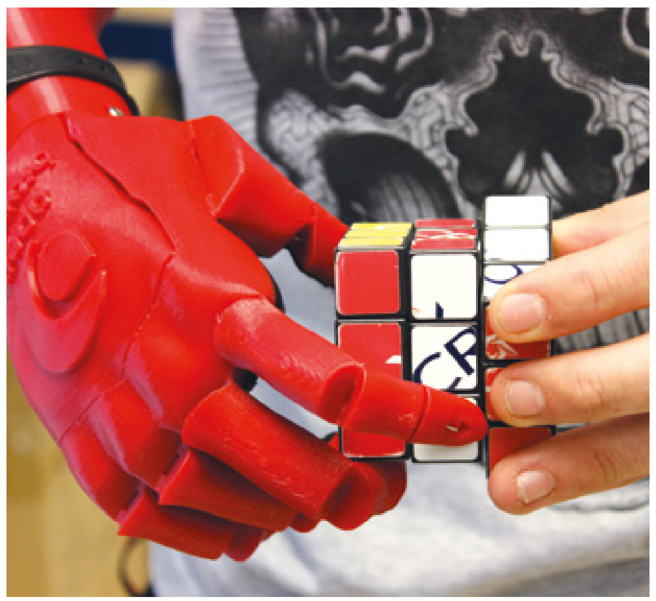
All of the videos referred to in the following lessons can be found on our website:
www.jamesdysonfoundation.org

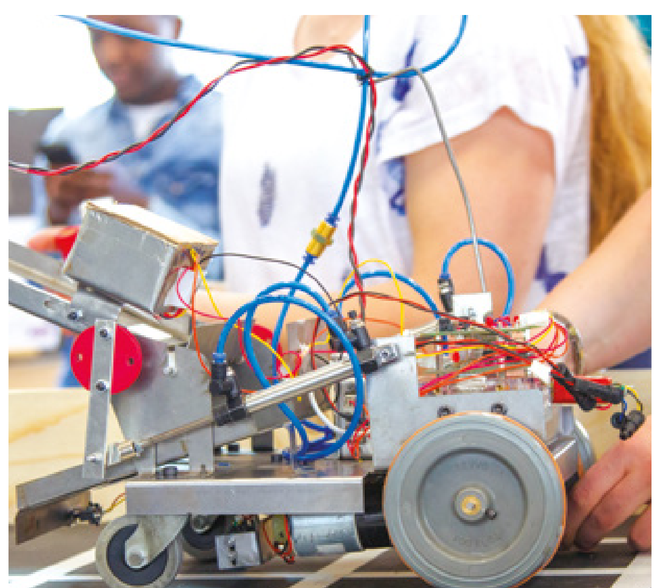
Section 1: Today’s Engineers
Meet Ruth: a research engineer
Meet Annmarie: a design engineer (new product innovation)
Meet David: a design engineer (new product development)
Meet Farai: a materials engineer
Meet Marcus: an electronics engineer
Meet Nathan: an acoustic engineer

In the United States, fewer than 40% of college students majoring in science, technology, engineering, or math (STEM) complete a STEM degree, resulting in 300,000 STEM graduates annually. In order to keep up with economic demand, the U.S. will need to produce approximately one million more STEM professionals over the next decade.

President’s Council of Advisors on Science and Technology, *Report to the President: Engage to excel*, 2012







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.

In the following lessons, students will learn about the diversity of engineering jobs – and the passion for solving problems that all engineers have in common. The videos referenced in the pack can be found on YouTube and include interviews with Dyson engineers. Once they have learned about the many career opportunities within the field of engineering, students will be introduced to the design process and use it to design their own problem-solving technologies.

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

The Engineering Box covers multiple national standards, including the Next Generation Science Standards and the Common Core.

COMMON CORE SPEAKING & LISTENING

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
CCSS.ELA-Literacy.SL.7.1	x	x	x	x	x	x
CCSS.ELA-Literacy.SL.8.1	x	x	x	x	x	x
CCSS.ELA-Literacy.SL.9-10.1	x	x	x	x	x	x
CCSS.ELA-Literacy.SL.11-12.1	x	x	x	x	x	x
CCSS.ELA-Literacy.SL.7.2	x	x	x		x	x
CCSS.ELA-Literacy.SL.8.2	x	x	x		x	x
CCSS.ELA-Literacy.SL.9-10.2	x	x	x		x	x
CCSS.ELA-Literacy.SL.11-12.2	x	x	x		x	x
CCSS.ELA-Literacy.SL.7.4	x	x	x	x	x	x
CCSS.ELA-Literacy.SL.8.4	x	x	x	x	x	x
CCSS.ELA-Literacy.SL.9-10.4	x	x	x	x	x	x
CCSS.ELA-Literacy.SL.11-12.4	x	x	x	x	x	x
CCSS.ELA-Literacy.L.7.1	x		x	x	x	x
CCSS.ELA-Literacy.L.8.1	x		x	x	x	x
CCSS.ELA-Literacy.L.9-10.1	x		x	x	x	x
CCSS.ELA-Literacy.L.11-12.1	x		x	x	x	x
CCSS.ELA-Literacy.L.7.2	x		x	x	x	x
CCSS.ELA-Literacy.L.8.2	x		x	x	x	x
CCSS.ELA-Literacy.L.9-10.2	x		x	x	x	x
CCSS.ELA-Literacy.L.11-12.2	x		x	x	x	x
CCSS.ELA-Literacy.L.7.6	x	x	x	x	x	x
CCSS.ELA-Literacy.L.8.6	x	x	x	x	x	x
CCSS.ELA-Literacy.L.9-10.6	x	x	x	x	x	x
CCSS.ELA-Literacy.L.11-12.6	x	x	x	x	x	x

COMMON CORE MATHEMATICS STANDARDS

	Lesson 3
CCSS.Math.Content.7.EE.B.3	x
CCSS.Math.Content.8.NS.A.1	x
CCSS.Math.Content.HSN.Q.A.1	x
CCSS.Math.Content.HSN.Q.A.2	x
CCSS.Math.Content.HSN.Q.A.3	x

NEXT GENERATION SCIENCE STANDARDS

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
MS-ETS1-1		x	x	x	x	x
MS-ETS1-2		x	x	x	x	x
MS-ETS1-3		x	x	x	x	x
MS-ETS1-4		x				
HS-ETS-1-1						x
HS-ETS-1-2						x
HS-ETS-1-3						x
HS-ETS-1-4						
CCSS.ELA-Literacy.RI.7.3	x		x			x
CCSS.ELA-Literacy.RI.8.3	x		x			x

COMMON CORE READING & WRITING

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6
CCSS.ELA-Literacy.RI.7.1	x	x				x
CCSS.ELA-Literacy.RI.8.1	x	x				x
CCSS.ELA-Literacy.RI.9-10.1	x	x				x
CCSS.ELA-Literacy.RI.11-12.1	x	x				x
CCSS.ELA-Literacy.RI.7.2	x					x
CCSS.ELA-Literacy.RI.8.2	x					x
CCSS.ELA-Literacy.RI.9-10.2	x					x
CCSS.ELA-Literacy.RI.11-12.2	x					x
CCSS.ELA-Literacy.RI.7.3	x		x			x
CCSS.ELA-Literacy.RI.8.3	x		x			x
CCSS.ELA-Literacy.RI.9-10.3	x		x			x
CCSS.ELA-Literacy.RI.11-12.3	x		x			x
CCSS.ELA-Literacy.RI.9-10.4	x					x
CCSS.ELA-Literacy.RI.7.4	x					x
CCSS.ELA-Literacy.RI.8.4	x					x
CCSS.ELA-Literacy.RI.11-12.4	x					x
CCSS.ELA-Literacy.RI.9-10.5						x
CCSS.ELA-Literacy.RI.7.5						x
CCSS.ELA-Literacy.RI.8.5						x
CCSS.ELA-Literacy.RI.11-12.5						x
CCSS.ELA-Literacy.RI.7.7	x	x				x
CCSS.ELA-Literacy.RI.8.7	x	x				x
CCSS.ELA-Literacy.RI.9-10.7	x	x				x
CCSS.ELA-Literacy.RI.11-12.7	x	x				x
CCSS.ELA-Literacy.W.7.1					x	
CCSS.ELA-Literacy.W.8.1					x	
CCSS.ELA-Literacy.W.9-10.1					x	
CCSS.ELA-Literacy.W.11-12.1					x	
CCSS.ELA-Literacy.W.7.2	x			x	x	x
CCSS.ELA-Literacy.W.8.2	x			x	x	x
CCSS.ELA-Literacy.W.9-10.2	x			x	x	x
CCSS.ELA-Literacy.W.11-12.2	x			x	x	x
CCSS.ELA-Literacy.W.7.4	x		x	x	x	x
CCSS.ELA-Literacy.W.8.4	x		x	x	x	x
CCSS.ELA-Literacy.W.9-10.4	x		x	x	x	x
CCSS.ELA-Literacy.W.11-12.4	x		x	x	x	x
CCSS.ELA-Literacy.W.7.5	x				x	
CCSS.ELA-Literacy.W.8.5	x				x	
CCSS.ELA-Literacy.W.9-10.5	x				x	
CCSS.ELA-Literacy.W.11-12.5	x				x	
CCSS.ELA-Literacy.W.7.6						x
CCSS.ELA-Literacy.W.8.6						x
CCSS.ELA-Literacy.W.9-10.6						x
CCSS.ELA-Literacy.W.11-12.6						x
CCSS.ELA-Literacy.W.7.7	x			x	x	x
CCSS.ELA-Literacy.W.8.7	x			x	x	x
CCSS.ELA-Literacy.W.9-10.7	x			x	x	x
CCSS.ELA-Literacy.W.11-12.7	x			x	x	x
CCSS.ELA-Literacy.W.7.8	x				x	x
CCSS.ELA-Literacy.W.8.8	x				x	x
CCSS.ELA-Literacy.W.9-10.8	x				x	x
CCSS.ELA-Literacy.W.11-12.8	x				x	x
CCSS.ELA-Literacy.W.7.9B					x	
CCSS.ELA-Literacy.W.8.9B					x	
CCSS.ELA-Literacy.W.9-10.9B					x	
CCSS.ELA-Literacy.W.11-12.9B					x	
CCSS.ELA-Literacy.W.7.10				x	x	x
CCSS.ELA-Literacy.W.8.10				x	x	x
CCSS.ELA-Literacy.W.9-10.10				x	x	x
CCSS.ELA-Literacy.W.11-12.10				x	x	x

CONTENTS

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: 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 cell phones, household appliances and the Internet.

There are many different types of engineers, 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 jewelry or the 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 conceptualize 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 Math and Physics – that it's a cold, unfriendly, calculation-centered career.

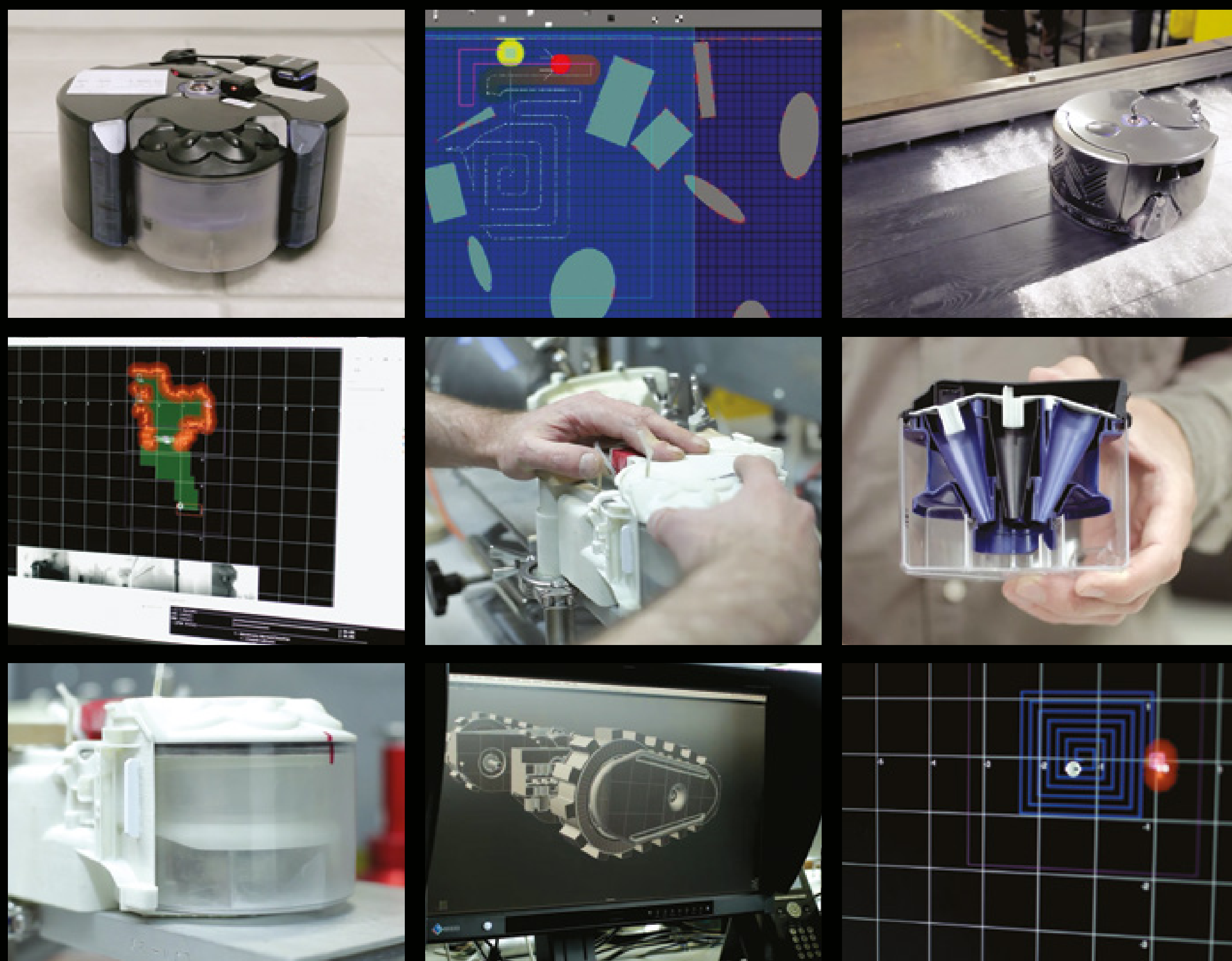
It's enough to put anyone off! But really, engineering is a wonderfully holistic blend of the technical and the creative. It's all about putting theory into practice; a perfect job for anyone who likes making things."

Engineer profile

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

CASE STUDY

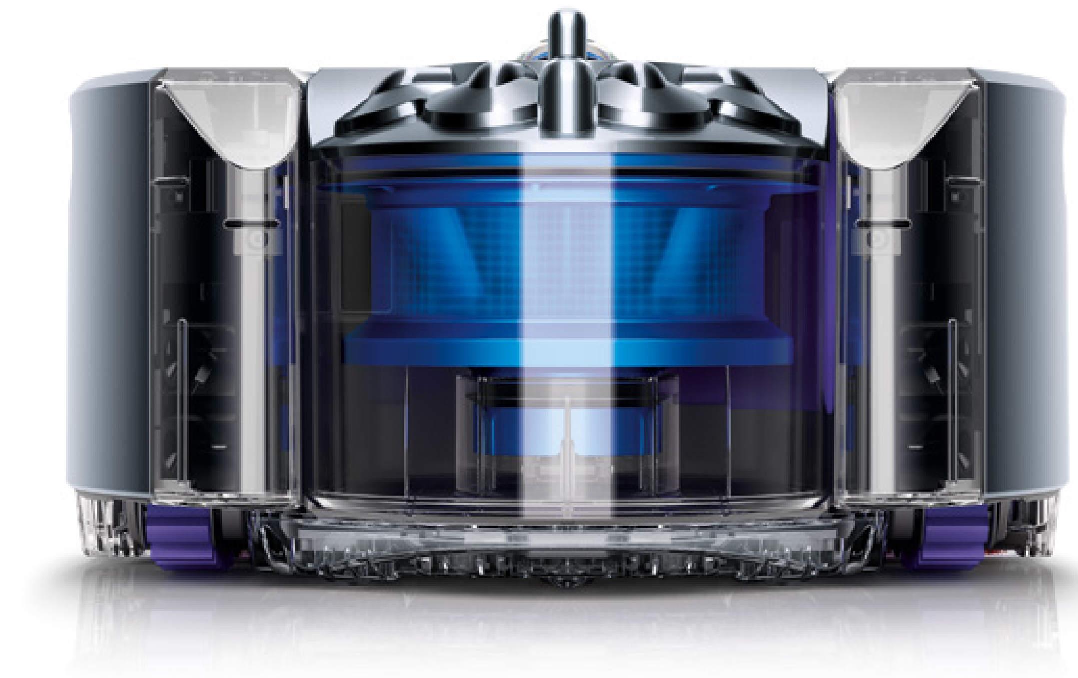
THE DYSON 360 EYE™ ROBOT

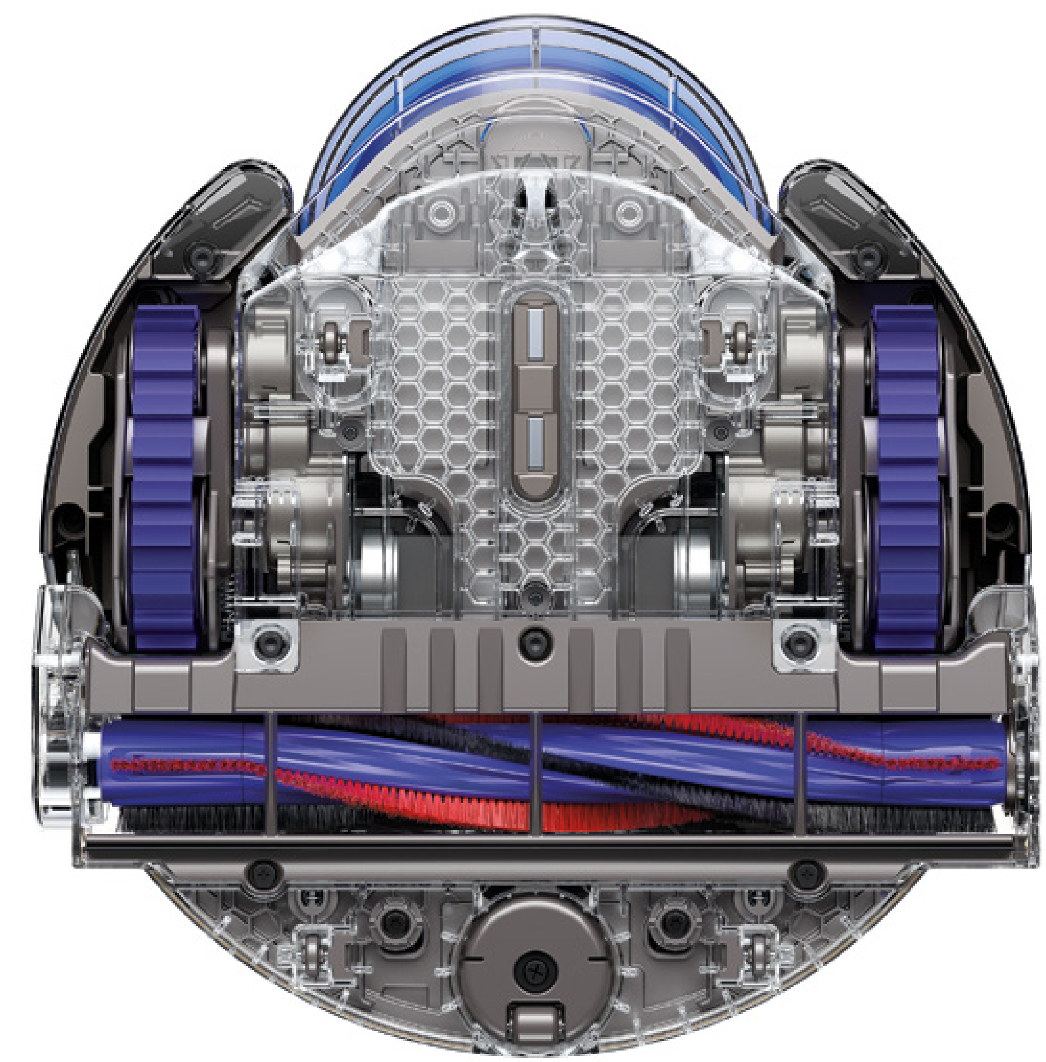


While the initial concept for a machine is developed by design engineers working in Dyson's New Product Innovation department, it takes the combined work of a variety of engineers – with different skills and specialties – to make it a commercial reality.

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.

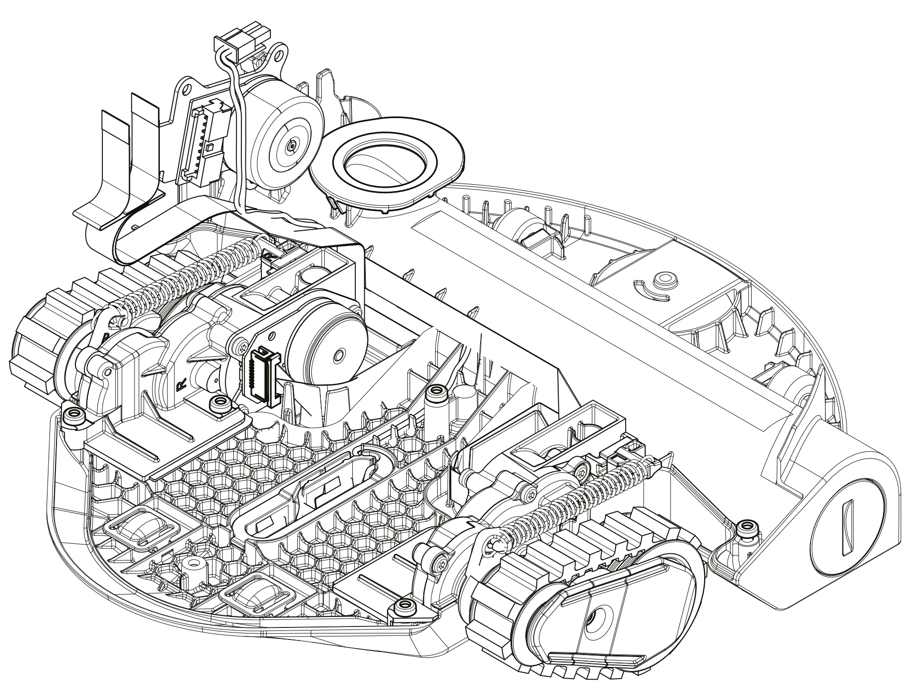
Separations systems engineers
looked at the cyclonic separation system and the filters. They worked out how to get rid of pollutants from the air – and advised the design team on how to improve filtration performance.

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.

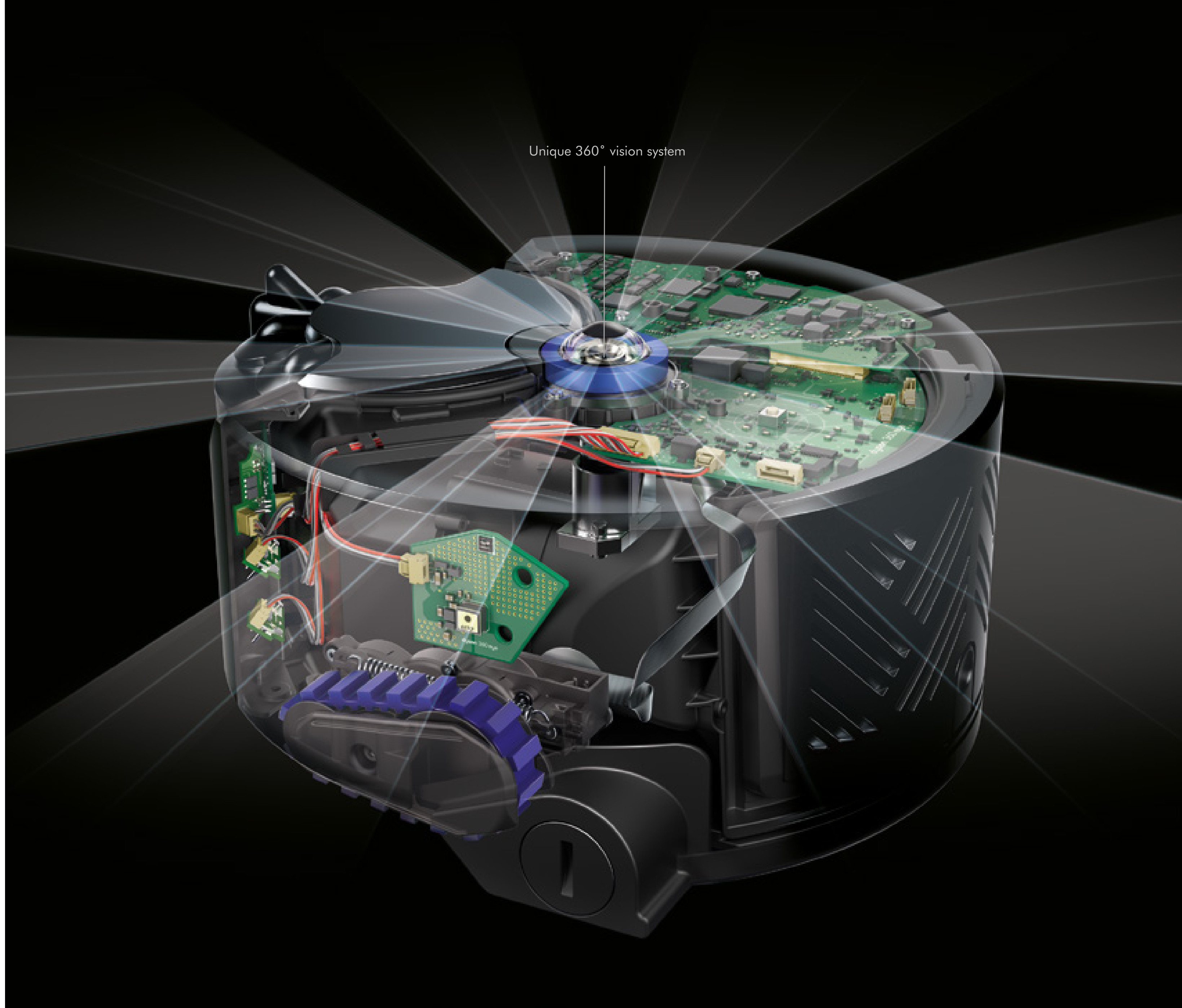
Manufacturing engineers
looked at how the final machine is made – defining the best way to manufacture every component, and making sure they were designed to fit together as easily as possible on the assembly line.



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, never cleaning the same spot twice.



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 YouTube
– Computer access for groups of students
– Pens and paper

Starter: 15 minutes

What do engineers do?

Learning objective	Activity
1	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 12 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	Break the class into six groups. Give each group a different **Meet an engineer** video to watch. Meet Ruth: a research engineer Meet Nathan: an acoustics engineer Meet Farai: a materials engineer Meet David: a design engineer Meet Catriona: an aerodynamics engineer If your class is large, break the students into smaller groups and duplicate the videos you are asking them to watch.
2	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: – 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

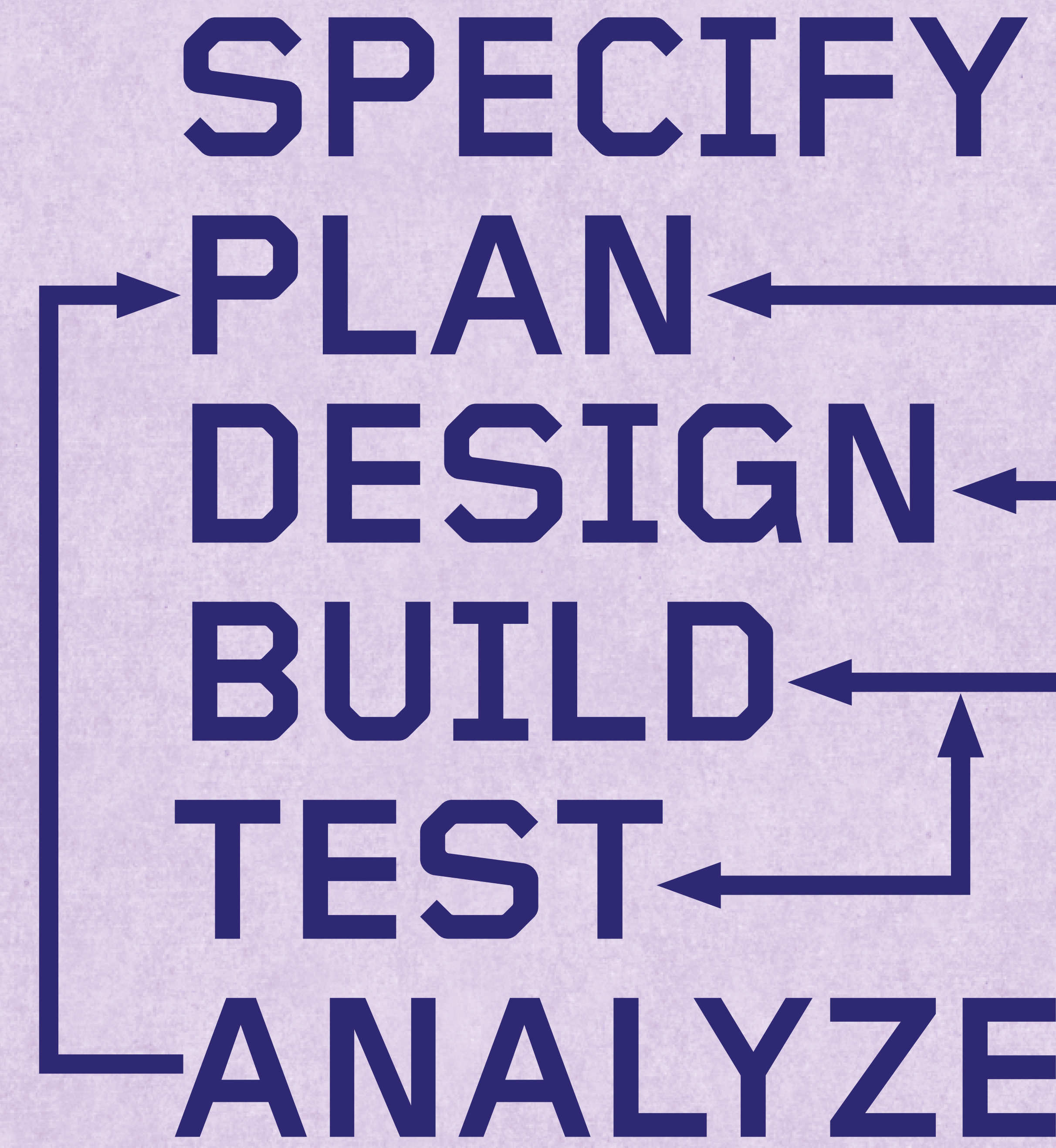
Wrap up: 30 minutes

Present your findings

Learning objective	Activity
1, 2	Ask the student groups to present their research to the class. Encourage the class to ask questions.
3	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: – Interests as children – Love of problem solving – Technical skills

02 DESIGN PROCESS

Understand the design process and put it into practice



WHAT IS THE DESIGN PROCESS?

Engineers use their knowledge of science, technology, engineering, math and creative thinking to solve problems. Engineers refer to the stages of the design process as: Specify, Plan, Design, Build, Test, Analyze. 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?

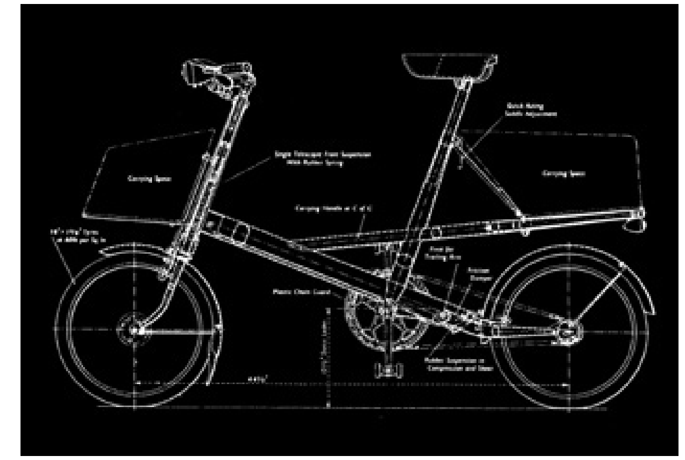
Function

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?

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.

ANALYZE

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 molding 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

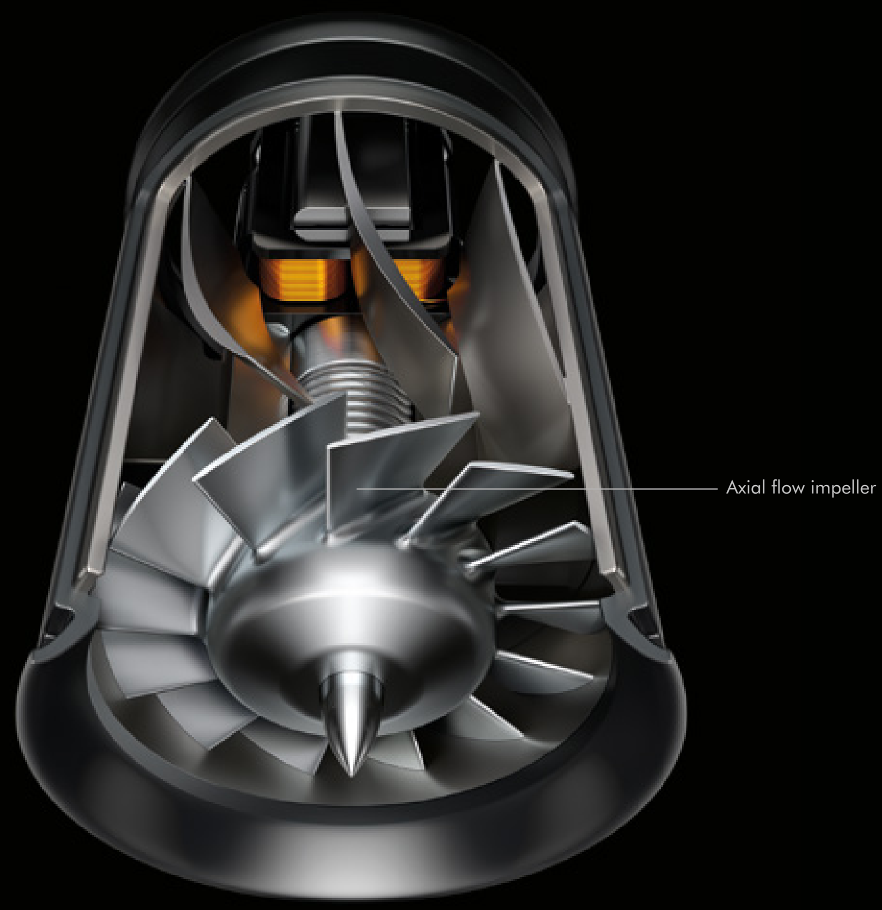
Teamwork between different types and teams of engineers is essential to overcoming the challenges that can be encountered when developing a new product.

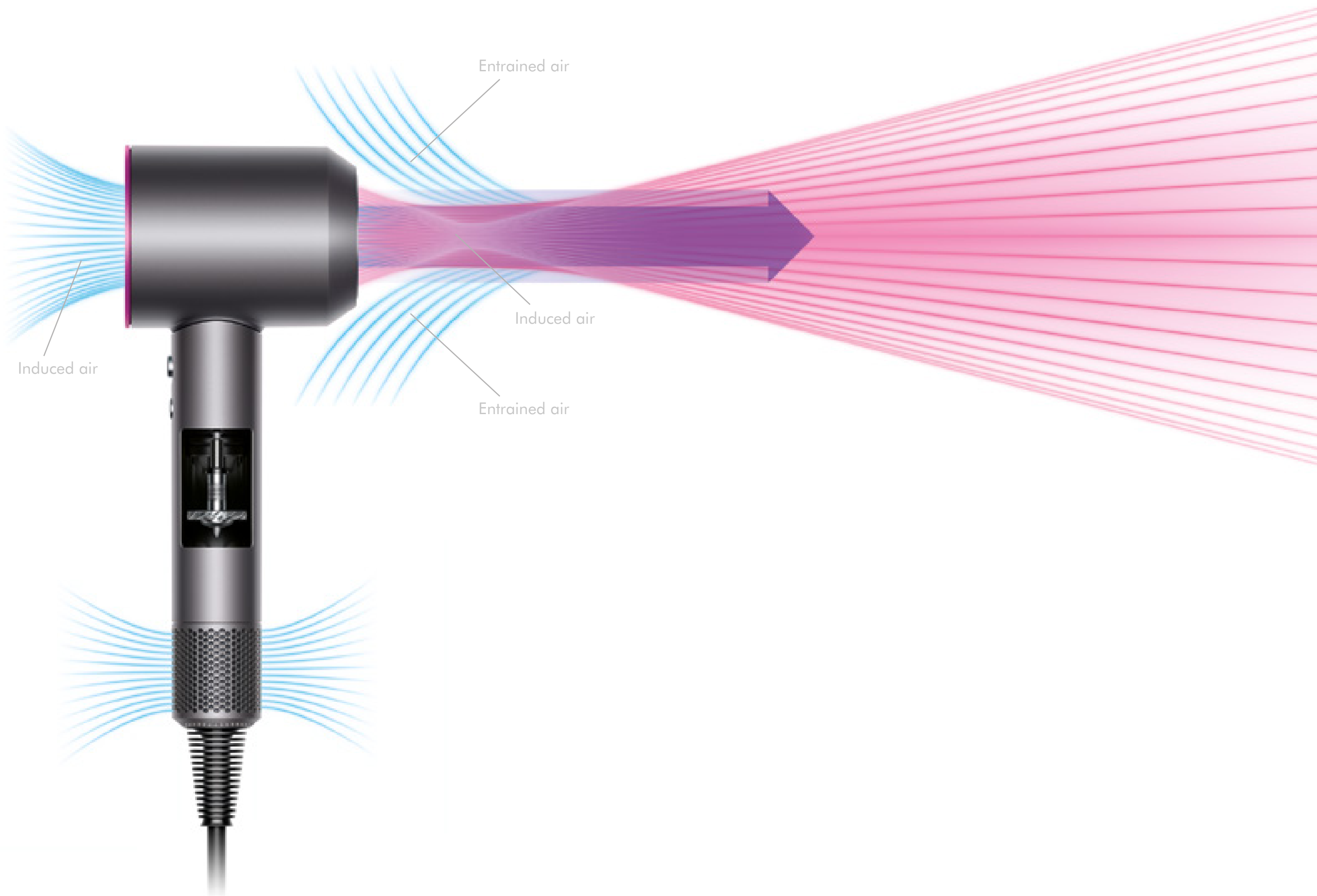
For example, the Dyson Supersonic™ hair dryer has a unique shape: it has a hole in the middle. This shape is essential to the function of the machine – but it created challenges for its development.

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 donut 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 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 – quieter than existing hair dryers. Using 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. The acoustic engineers worked with the aerodynamics engineers to help them map the flow of air through the machine, so they could understand how to optimize 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 have 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 quieter than others, 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 airfoil-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 2

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 Supersonic™
- 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 42)
- Copies of the Supersonic™ case study

Starter: 15 minutes

What are briefs and specifications?

Learning objective	Activity
1	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. Photocopy the Dyson Supersonic™ hair dryer case study (pages 26–31) and distribute to students. Explain that, for the Supersonic, the brief was to design a quieter device with precise heat and airflow.
1	As a class, discuss the criteria that were considered when developing the design specification for Supersonic.™
1	Prompt the students to consider the brief in terms of ACCESS FM. Ask the class to draw on what they learned in the reading about the Supersonic.™ – Aesthetics – Cost – Customer – Environment – Safety – Size – Function – Materials

Main: 45 minutes

Take on the brief

Learning objective	Activity
1, 2	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 conceptualizing, researching and prototyping products to meet these specifications. Break the class into six groups. Give each group one of the following six briefs: – Design a product that will encourage high school students to lead a healthier lifestyle. – Design a product that will improve the safety of high school students walking home from school. – Design a product that that will improve the safety of elderly people alone in the home. – Design a product that will help high 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 42).
2	Explain that each group should use the worksheet to define specific and realistic qualitative or quantitative criteria and constraints for their design.

LESSON 3

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 42)

Starter: 10 minutes

Take on problems as a team

Learning objective	Activity
1	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. They will need to conduct research, and make a plan to keep development on track.
2, 3	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. Refer back to the Dyson Supersonic™ hair dryer case study. This will help to explain that while engineers have different specialties, they work together to solve problems.

Main: 60 minutes

Research the specifications

Learning objective	Activity
1, 2	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? 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.
1, 3	Ask each group to review their completed **Specification worksheets** and divide responsibility for the other criteria among themselves.
3	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. 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.
	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	Ask the students to present their findings to their group. Encourage the group to ask questions.

LESSON 4

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	Building on the research carried out in the previous lesson, ask the student groups to sketch their product. 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.

Main: 45 minutes

Build the prototype

Learning objective	Activity
1	Explain that in this lesson, the students are going to create a rough-and-ready prototype of their product. Students should consult their parts list and work together to build each part.
1, 2	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. This lead engineer should also ensure that the build process is finished within a reasonable time frame.
1, 2	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. Remind them that the design process is iterative, and encourage them to work together to modify and improve their design as they encounter difficulties. Make sure that any changes to the design or function are recorded by the lead engineer.
	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	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: – What changes were made to the product's design, and why? – How will the changes impact the design specification? – How did you ensure whether a part's design would function appropriately? – How might this affect the materials used to create that component?

LESSON 5

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	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 what cost they will sell their product for. Explain that cost engineers use engineering principles to control costs and make sure projects are completed within budget. Cost engineers consider the labor 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.
1	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: – The cost of each part – The cost of finishing – such as paint – The cost of labor to make the product 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. If the profit margin is not healthy, the group may want to consider making some changes to their design.

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 infomercial 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 6

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

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, summarizing: the name, novelty, function, price, and persuasive arguments.
1	Make sure each group answers 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?
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 a 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?	

You can find more James Dyson Foundation educational resources online at **www.jamesdysonfoundation.org**

Share your experiences with us:

THE
JAMES
DYSON
FOUNDATION
INSPIRING THE
NEXT GENERATION
OF ENGINEERS

The James Dyson
Foundation is a charity
supported by Dyson Ltd.

dyson

 ©2019 DYSON