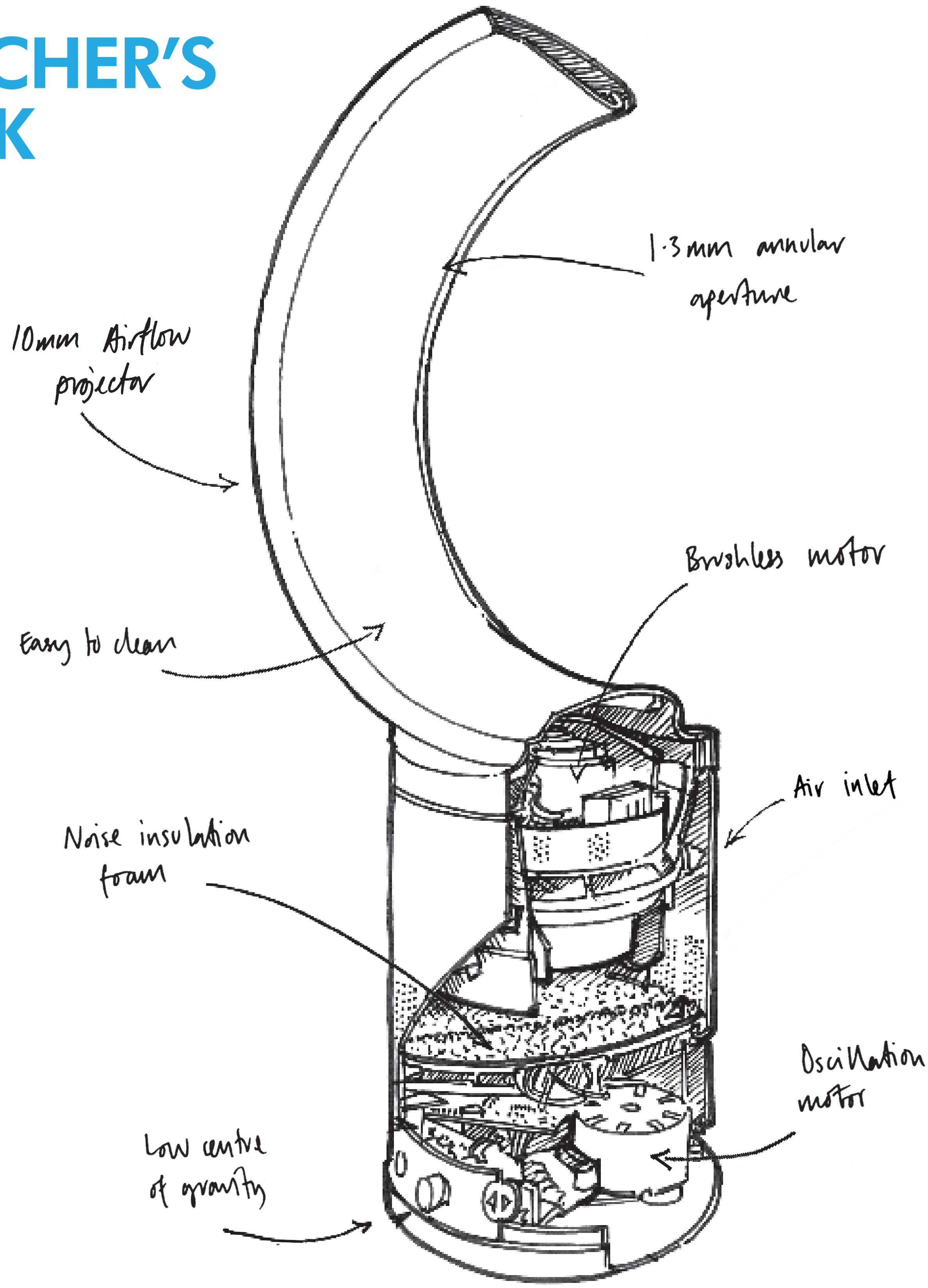
THE JAMES DYSON FOUNDATION

TEACHER'S PACK



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

Section 1
What is a design engineer?
James' story
Characteristics of a design engineer
How I became a design engineer

Section 2
Product analysis
Product analysis: what am I?
Developing Air Multiplier™ technology

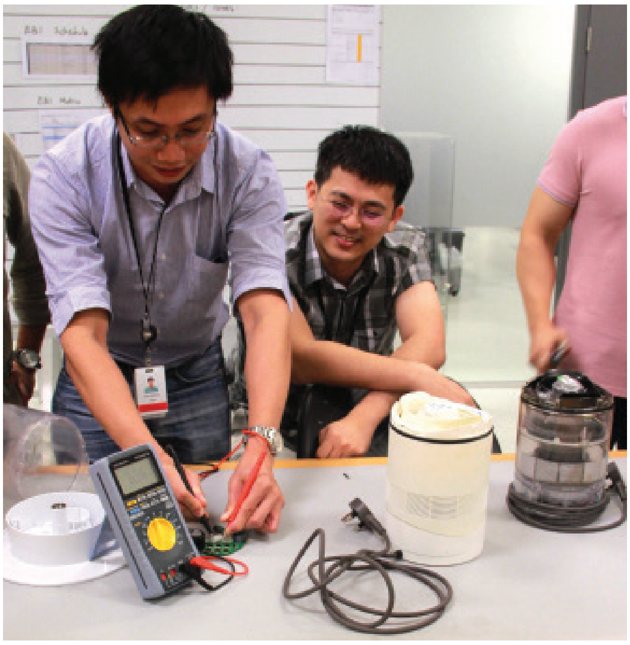
Section 3
Design. Build. Test.
Sketching
Cardboard modeling
Dyson does it: build
Dyson does it: test

If you lose the USB, you can find
all of the videos on our website:
www.jamesdysonfoundation.org

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 TEACHING STUDENTS THE DESIGN PROCESS, WE CAN SHOW THEM HOW EXCITING A CAREER IN ENGINEERING IS.

This teacher's pack will introduce your students to the design process, developing their analytical skills and helping them to understand the thinking behind the products they use every day.

The teacher's pack accompanies the Design Process Box. It includes a Dyson Air Multiplier™ fan as an example of an invention that solves an everyday problem. Students will learn about the fan's development, and use their analytical skills to redesign something in their classroom.

Students will also learn what a design engineer is – spotting stereotypes and challenging preconceptions. The USB supplied with the pack includes interviews with Dyson design engineers to give an insight into the world of design engineering.

This pack contains five lesson plans and posters for your classroom wall. 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.

NEXT GENERATION SCIENCE STANDARDS

	Kindergarten	1st Grade	2nd Grade	3rd Grade	4th Grade	5th Grade	6th Grade	7th Grade	8th Grade
K-5-ETSI-1	2, 3, 5	2, 3, 5	2, 3, 5	2, 3, 5	2, 3, 5	2, 3, 5			
K-5-ETSI-2	1, 2, 3, 5	1, 2, 3, 5	1, 2, 3, 5	1, 2, 3, 5	1, 2, 3, 5	1, 2, 3, 5			
K-5-ETSI-3	2, 3, 4, 5	2, 3, 4, 5	2, 3, 4, 5	2, 3, 4, 5	2, 3, 4, 5	2, 3, 4, 5			
5-PSI-3							3, 4		
MS-ETSI-1							2, 3, 5	2, 3, 5	2, 3, 5
MS-ETSI-2							2, 3, 5	2, 3, 5	2, 3, 5
MS-ETSI-3							2, 3, 4, 5	2, 3, 4, 5	2, 3, 4, 5
MS-ETSI-4							2, 3	2, 3	2, 3
MS-PSI-3							3, 4	3, 4	3, 4

COMMON CORE MATH STANDARDS

	Kindergarten	1st Grade	2nd Grade	3rd Grade	4th Grade	5th Grade	6th Grade	7th Grade	8th Grade
OA. 1		3, 4	3	3, 4	3	3, 4			
OA. 2						3, 4			
OA. 3		3, 4	3	3, 4	3				
OA. 4				3					
OA. 5		3, 4		3, 4					
OA. 6		3, 4							
OA. 7		3, 4		3, 4					
OA. 8		3, 4		3, 4					
OA. 9				3, 4					
NBT. 1		3, 4	3, 4		3	3, 4			
NBT. 2				3, 4	3				
NBT. 3			3	3	3	3, 4			
NBT. 4		3, 4			3	3			
NBT. 5			3, 4		3	3, 4			
NBT. 6			3, 4						
NBT. 7			3, 4						
G. 1							3, 4	3, 4	3, 4
G. 2							3, 4	3, 4	3, 4
G. 4							3, 4		3, 4
G. 6								3, 4	
G. 9									3, 4

COMMON CORE READING & WRITING STANDARDS

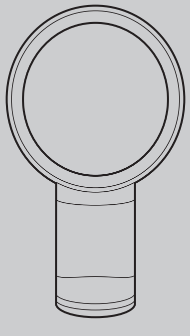
	Kindergarten	1st Grade	2nd Grade	3rd Grade	4th Grade	5th Grade	6th Grade	7th Grade	8th Grade
RI.K-8.3	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
RI.K-8.4	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
RI.K-8.6	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
RI.K-8.7	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
RF.K-1.1	1	1							
RF.K-1.2	1	1							
RF.K-2.1	2, 3, 4, 5	2, 3, 4, 5							
RF.K-2.2	2, 3, 4, 5	2, 3, 4, 5							
RF.K-5.3	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5			
RF.K-5.4	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5			
W.K-8.2	2, 4, 5	2, 4, 5	2, 4, 5	2, 4, 5	2, 4, 5	2, 4, 5	2, 4, 5	2, 4, 5	2, 4, 5
W.2-8.1			3	3	3	3	3, 4, 5	3, 4, 5	3, 4, 5
W.2-8.6			2, 3	2, 3	2, 3	2, 3	2, 3, 4	2, 3, 4	2, 3, 4
W.2-8.8			2, 3	2, 3	2, 3	2, 3	2, 3, 4	2, 3, 4	2, 3, 4
W.4-8.9					2, 3	2, 3	2, 3, 4	2, 3, 4	2, 3, 4

CONTENTS

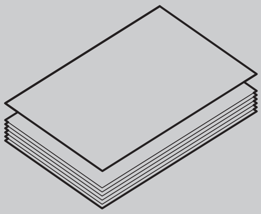
What's in the box?

Please remember!

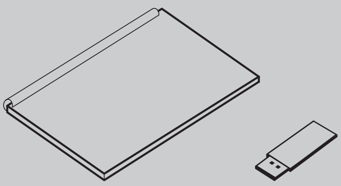
Keep the box for returning the Design Process Box and Dyson Air Multiplier™ fan to the James Dyson Foundation.



A Dyson Air Multiplier™ fan.



Informative posters for your classroom wall.



This teacher's pack and USB.

01

WHAT IS A DESIGN ENGINEER?

Key learning objective:

Understand what it's like to be a design engineer.

CASE STUDY

JAMES' STORY

James was born in Norfolk in 1947. After studying Art and Classics at school, he went to the Royal College of Art (RCA). James studied many different types of design at the RCA, but developed a real interest in design engineering. When he graduated in 1970, James joined an engineering company called Rotork. His first project was the Sea Truck, a high speed boat for use in the Royal Navy.

A few years later, James was renovating his house. He became frustrated with his wheelbarrow – the narrow wheel meant it got stuck in the mud and was hard to balance, and cement stuck to the metal sides.

This frustration inspired James to develop the Ballbarrow. James replaced the small wheel with a large inflatable ball making it easier to move. He also changed the material to lightweight, non-stick plastic. Thinking differently helped James to solve a design problem.

In 1978 James bought a new vacuum cleaner – the Hoover Junior. However, it didn't work as well as he'd hoped: as he vacuumed the Hoover lost suction and didn't pick up the dirt. Taking it apart, he discovered that its bag was clogging with dust, causing the suction to drop.

One day, when James was out walking, he passed a factory. On its roof was a special system to separate dirt from the air, and expel clear air – it was a cyclone.

This inspired James to try the same with his vacuum. He rushed home and built a mini cardboard cyclone – and it worked! James knew he was on to something.

There was still a long way to go. James persevered with his idea and after 5,127 prototypes, he produced the first bagless vacuum cleaner.

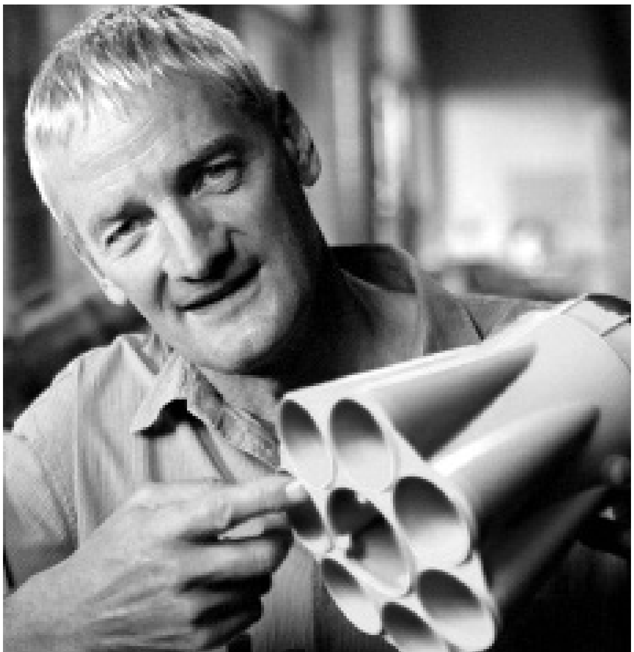
CHARACTERISTICS OF DESIGN ENGINEERS AND INVENTORS

Frustration

Frustration can be seen as a bad thing, but for design engineers it can be the starting point for a really good idea. Identifying what frustrates you about an existing product can help you to make it even better. A successful and well-designed product is something that is easy to use.

Wrong thinking

Wrong thinking is allowing yourself to think differently, not just going along with what everybody else thinks. Keeping an open mind can lead to a solution that no one has ever thought of before. It's about thinking your way around a problem, and seeing solutions that other people might not.



James Dyson

James' frustration with the vacuum bag encouraged him to rethink it, and use a cyclone design instead.

Alec Issigonis

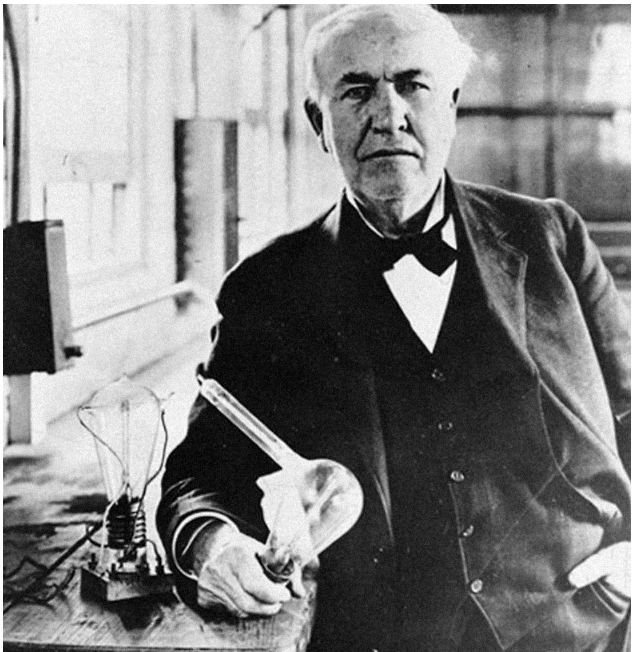
To answer his brief of creating a small car that could still carry four adults, Alec decided to put the engine in the opposite way round. Sideways rather than lengthwise.

Perseverance

A perfect design doesn't happen straight away; design is a process. When something doesn't work first time, it's about sticking with it, making small changes, and ultimately making your design stronger. You have to learn from the things that went wrong, find out why and use that experience to make them better.

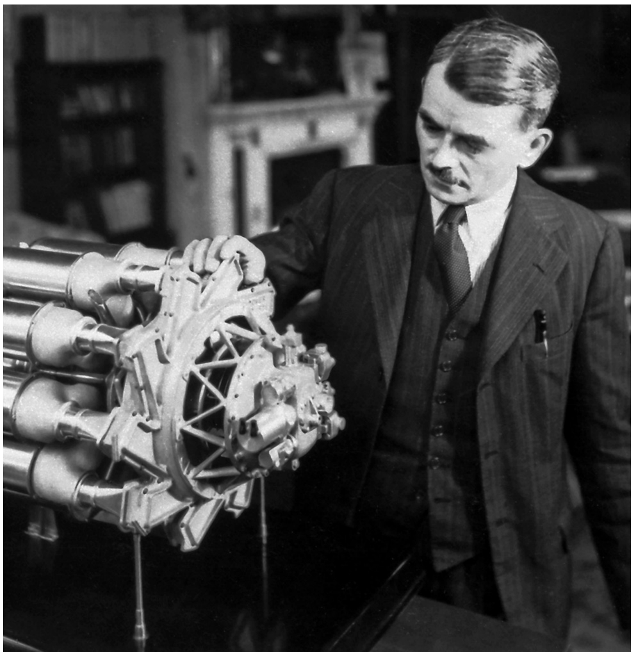
Underdog

If you're designing a new product, or improving someone else's, you will have to convince people that your product is better. You will have to explain your product clearly, and talk passionately about it. Design engineers need to be determined.



Thomas Edison

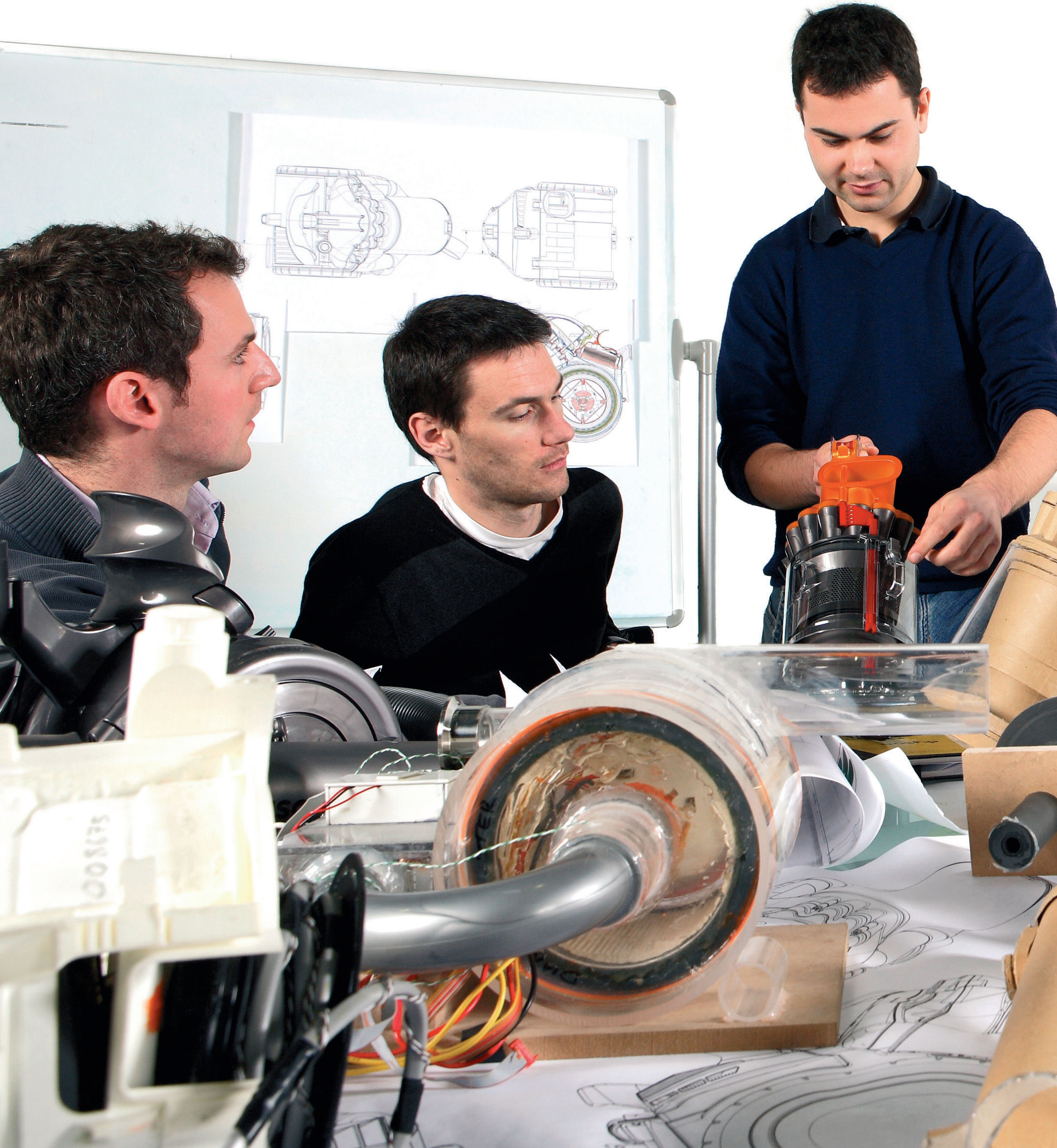
"I haven't failed, I've just found 10,000 ways that didn't work."



Frank Whittle

The Air Ministry turned down Whittle's idea for gas turbine driven propellers - so he patented the idea himself. The jet engine went on to revolutionize flight.

WHAT DO TODAY'S DESIGN ENGINEERS DO?



Design engineers are problem-solvers. They research and develop ideas for new products, and think about how to improve existing products.

Everything around you has been designed: from the smart phone in your pocket to the pen in your hand. Design engineers work on lots of different products. Their day-to-day job is varied, but centers around the design process. Tasks may include brainstorming, sketching, computer-aided design or prototyping new product ideas.

Design engineers work within the Research, Design and Development department at Dyson, known as RDD. It's a top secret department – only the engineers are allowed in.

LESSON 1

What is a design engineer?

Duration: 1 hour

Learning objectives:

1. Understand what design engineers do and recognize stereotypes.

2. Improve knowledge of famous design engineers and inventors.

3. Recognize the characteristics that successful design engineers share.

Activity outcomes:

– Completed drawing of what a design engineer looks like
– Class discussion about the characteristics of a design engineer
– Class discussion about what design engineers do

Things you will need:

– Pencils and paper to draw a picture of what a design engineer looks like
– Poster 1: **Real life engineers**
– The **James' story** video on the USB
– The **Characteristics of a design engineer** video on the USB
– The **How I became a design engineer** video on the USB
– A computer and projector to play videos from the USB

Starter: 15 minutes

What does a design engineer look like?

Learning objective	Activity
1	Introduce the session and its objectives. Hand out pencils and paper. Ask the class to draw what they think a design engineer looks like. Prompt questions could be: – What do they wear? – Where do they work? – What do they use?
2	Collect in the drawings. Discuss any significant differences and also common themes between the drawings. Explain that the class will redraw their pictures at the end of the project, to see how their ideas have changed. Put up Poster 1: **Real life engineers.**

Main: 30 minutes

Characteristics of a design engineer

Learning objective	Activity
1, 2	Explain that a design engineer is someone who designs products, and that everything they use has been designed by someone. Take suggestions from the class of inventions and design engineers they know and record them on the board.
1, 2	Introduce James Dyson using the **James' story** video.
1, 2, 3	As a class, discuss the characteristics that James showed when developing the bagless vacuum cleaner. List them on the board.
2, 3	Watch the **Characteristics of a design engineer** video.
2, 3	Discuss the video. Were any of the characteristics surprising?

Wrap up: 15 minutes

Real life design engineers

Learning objective	Activity
1	Watch the **How I became a design engineer** video.
1	In groups, discuss the following questions: – What did the design engineers enjoy when they were young? – What did the design engineers study at school? – What did the design engineers study at university? – What do the design engineers do day-to-day?
1	As a class, ask the students to discuss what they think they would like and dislike about being a design engineer. Explain that they will have the chance to find out as they will be acting as design engineers during this project and making their own invention. To be good design engineers, it's important that they keep in mind everything they've learned.

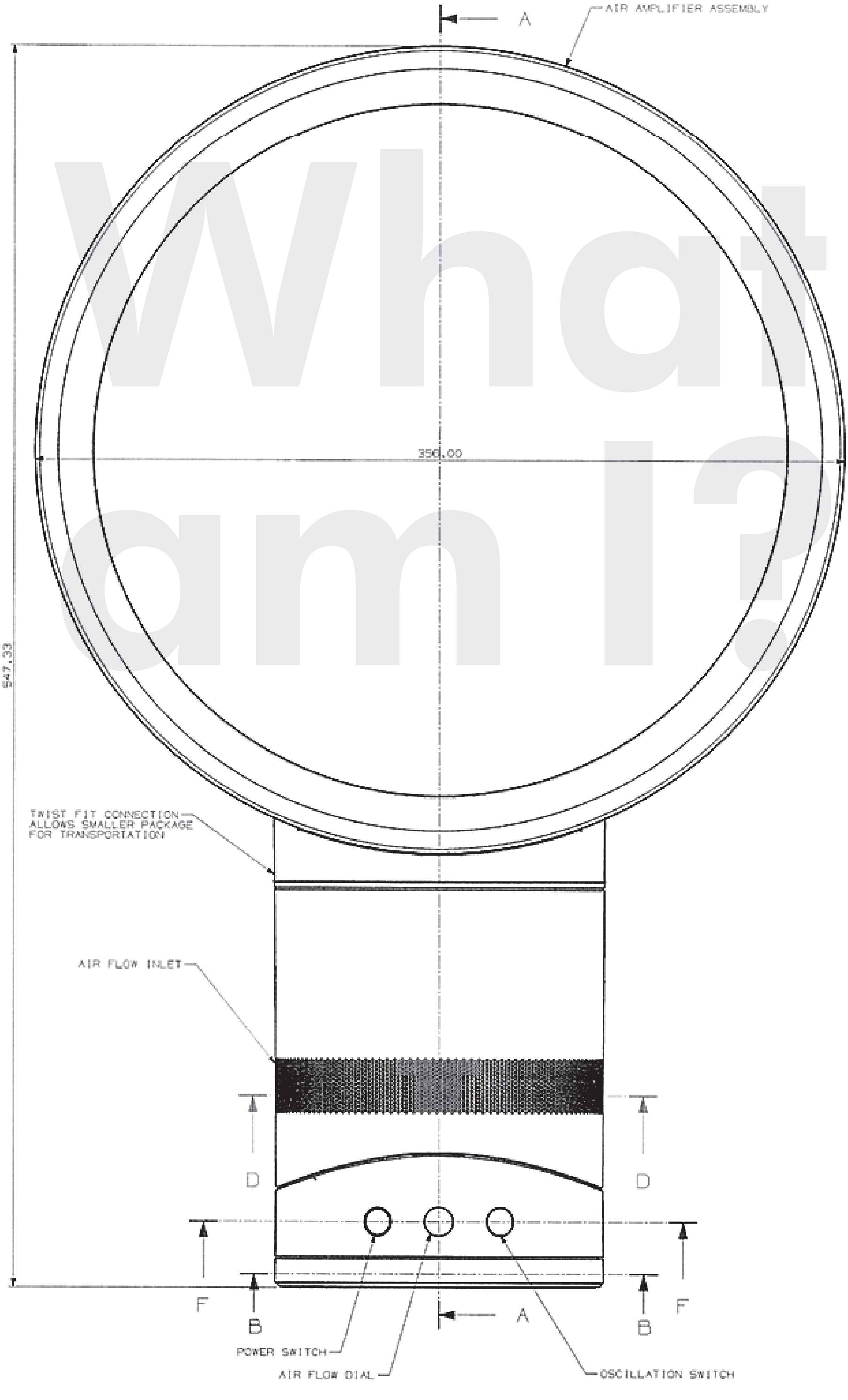
02

PRODUCT ANALYSIS

Key learning objective:

Understand how problems with products are identified and solved by design engineers.

What am I?



A
AIR AMPLIFIER ASSEMBLY
356.00
547.33
TWIST FIT CONNECTION ALLOWS SMALLER PACKAGE FOR TRANSPORTATION
AIR FLOW INLET
D
D
F
F
B
B
A
POWER SWITCH
AIR FLOW DIAL
OSCILLATION SWITCH

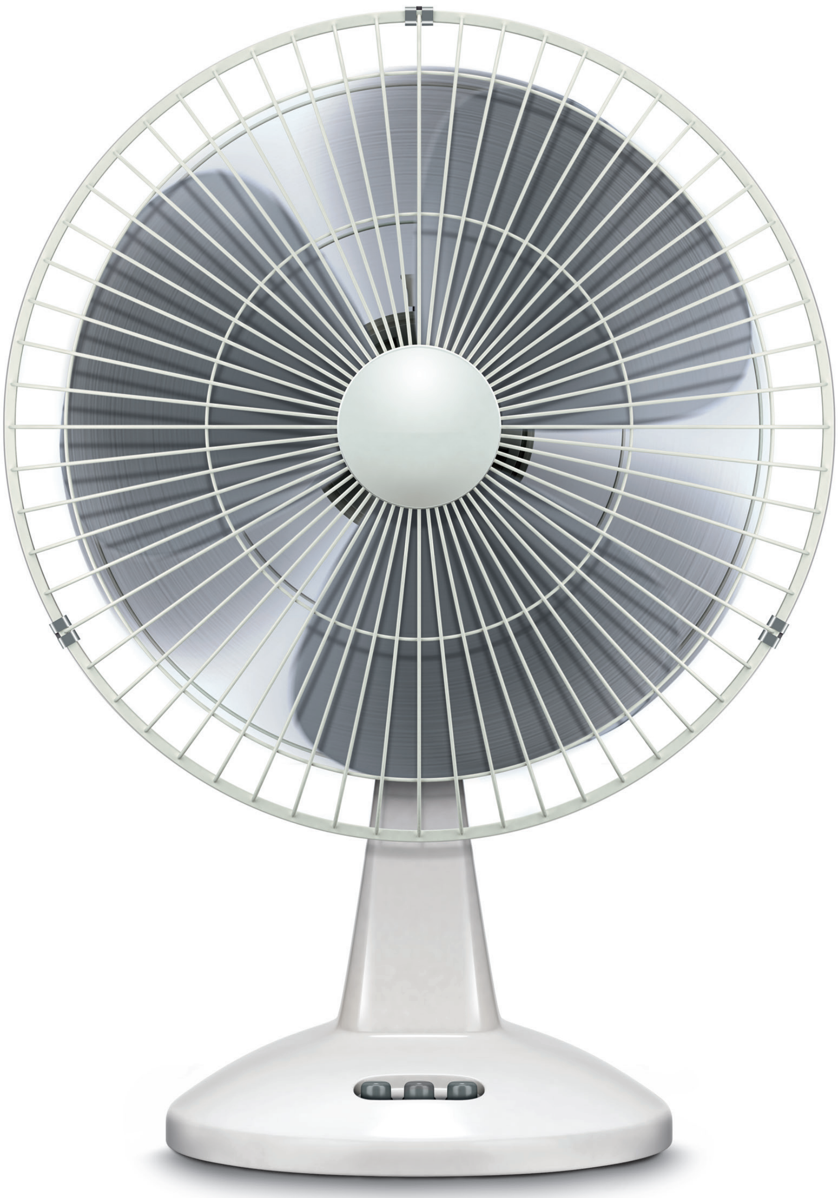
CASE STUDY

THE DYSON AIR MULTIPLIER™ FAN

First, identify the problem.

Since 1882, electric fans have relied on spinning blades to cool people. But fast-spinning blades can be dangerous.

The very first fans had no cover to protect users. Even with the grill on modern fans, children can put their fingers through, or objects can be pushed into the blades. Bladed fans are also hard to clean when they get dusty. These were the problems that Dyson engineers solved when they developed the Dyson Air Multiplier™ fan.

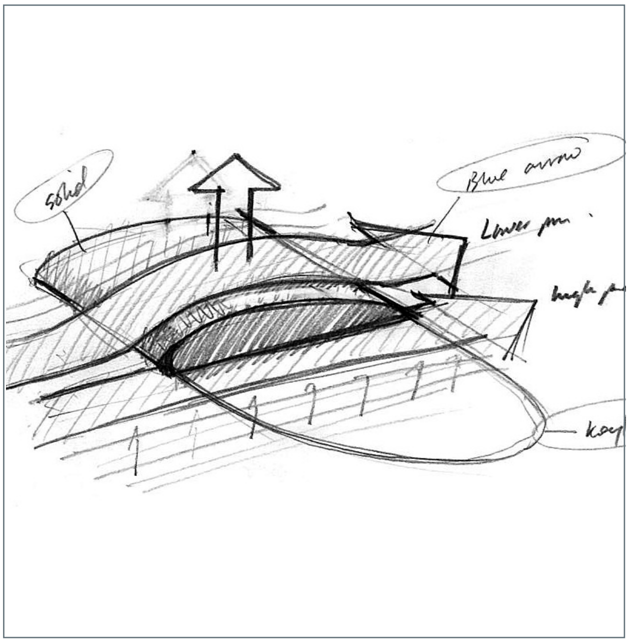


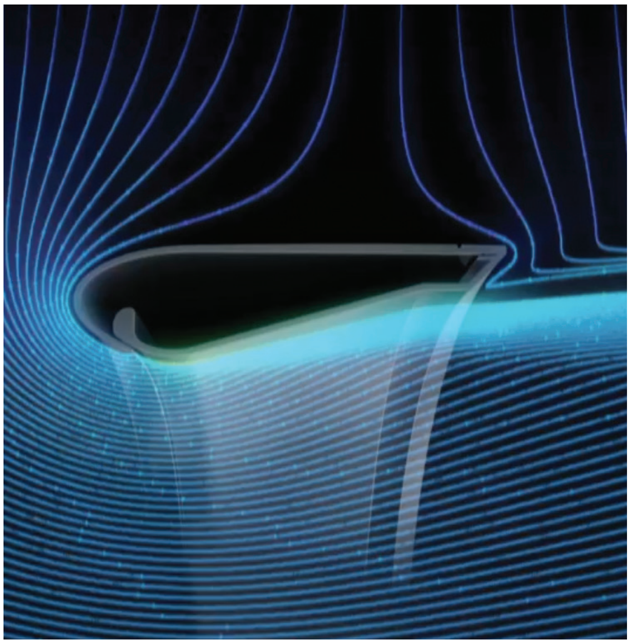

Then, find
a way to
solve it.

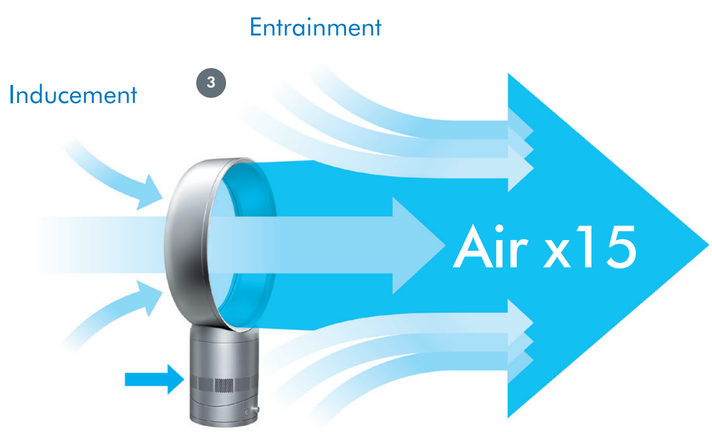
TWO MAJOR FACTORS WERE CONSIDERED: FLOW RATE AND VELOCITY.

Flow rate is the volume of air moved, while velocity is the speed at which the air moves.

An airfoil-shaped ramp within the fan loop generates optimum air flow. Engineers studied the wings of owls and other birds of prey to help develop the aerodynamic geometry. The ramp is angled at sixteen degrees to create an ideal balance of air velocity and flow rate – a refreshing flow of air which doesn't blow things off your desk.







HOW DOES IT WORK?

1 Air is drawn into the base by an impeller spinning 6,800 times a minute. This works in a similar way to the inlet of some jet engines.

2 Air is forced up into the loop and accelerated out through a small gap the size of a fingernail. This creates a jet of air. This air then passes over the ramp visible from the outside which channels its direction.

3 As the jet of air passes over the ramp, it creates a region of low pressure which draws air in from behind the fan: this is called inducement. As it exits the amplifier, more air is dragged in from around the fan. This is called entrainment. As a result of the inducement and entrainment, the amount of air expelled is multiplied 15 times.

OTHER DYSON AIR MULTIPLIER™ FACTS

The motor has been tested to the equivalent of 38,000 hours usage; that's 10 years' usage at 10.5 hours a day.

The latest Dyson desk fan channels 6 gallons of air per second on its maximum setting - that's 1,121 cans of soda.

It took 68 engineers three years to develop the latest Dyson Air Multiplier™ technology.

There are more than 400 patents on Dyson Air Multiplier™ fans worldwide.

The latest Dyson desk fan weighs in at less than 4 lbs., almost half the average weight of other fans.

LESSON 2

Design detectives

Duration: 1 hour

Learning objectives:

1. To become familiar with the idea of radically re-designing everyday objects.

2. To develop critical analysis skills.

3. To share ideas and discuss design possibilities.

Activity outcomes:

– Class discussion around the Dyson Air Multiplier™ fan
– Completed design hunt around the classroom
– A class list of chosen products to improve

Things you will need:

– The Dyson Air Multiplier™ fan
– The **Product analysis: what am I?** video on the USB
– The **Developing Air Multiplier™ technology** video on the USB
– A computer and projector to play videos from the USB
– Poster 2: **Everyday design icons**
– Individual copies of the **PMI worksheet** (page 46)

Starter: 10 minutes

What am I and why?

Learning objective	Activity
1, 2	Before the lesson, set up the Dyson Air Multiplier™ fan and cover it with a cloth. Don't reveal its purpose, name, or turn the machine on.
1, 2	Use the **Product analysis: what am I?** video to increase suspense. It shows design engineers using the fan to create a balloon run.
1, 2	Take answers and possible suggestions as to its purpose. You could use these six essential questions to structure your discussion: – User: Who has it been designed for? – Purpose: What need has it been designed for? – Design decisions: What choices have been made? E.g. materials, style, color, textures, shape. – Innovation: How is this machine unique? – Functionality: Does it work? How well does it work? – Authenticity: Is it being used for the purpose it was designed for?
1, 2	Reveal its purpose, and use the **Developing Air Multiplier™ technology** video to help explain the technology. Use pages 22 and 23 of the teacher's pack to help you to answer any questions your students might have.
1, 2	It is important to emphasize that the Dyson Air Multiplier™ fan was designed to solve some of the problems with conventional fans, and that the students will be doing the same with this project – solving everyday problems. Remind them about the characteristics of a design engineer discussed in lesson one.

Main: 30 minutes

Design hunt

Learning objective	Activity
2	Explain to students that this part of the lesson is about them being design detectives. They will be applying their critical analysis skills to everyday objects, and working in groups to improve them.
2	Use Poster 2: **Everyday design icons** to introduce the idea of design being all around them.
2	Explain to the students that they will be going around the classroom and hunting for objects or products that don't work well or have design possibilities. Give the students some suggestions to inspire them. For example: a school chair, a pencil case, a desk organizer or a book bag.
2	Explain that to support their thinking, the class will use an analysis technique called Plus, Minus, Interesting (PMI). Allow students time to discuss what they think Plus, Minus, Interesting means. Definition for the teacher: PMI is a way of looking at existing products from all points of view. – Plus – students should list all the good or positive aspects of the product. – Minus – students should list all the features that are not positive, are bad or do not work. Interesting – students should list the features that are interesting and could be developed further; they should look for possibilities in the product.
2	Split the class into pairs and give them each a **PMI worksheet** to complete after they have considered different objects in the classroom and decided which one they would like to focus on. An alternative method is to identify in advance a selection of objects around the classroom which you would like the students to analyze, including ones that you think would be a good project focus. Attach a large **PMI worksheet** to each of these so that the students can record their thoughts as they visit each object.

Wrap up: 10 minutes

Ideas evaluation

Learning objective	Activity
3	Ask students to share their findings. Students should be encouraged to talk about which aspects of the product frustrated them.
3	Decide as a class which objects could be redesigned and improved: this will be the focus of the project. Divide the class into small groups, each with a different object to work on in the next lesson.

Early prototype of the first Dyson
cylinder ball vacuum cleaner.

03
DESIGN. BUILD. TEST.

Key learning objective:
Understand the design process and put it into practice.

THE DESIGN PROCESS ALWAYS BEGINS WITH A BRIEF.

The design process revolves around three stages: Design, Build, Test. The process is not linear: design engineers will go back and forth between these stages when developing an idea.

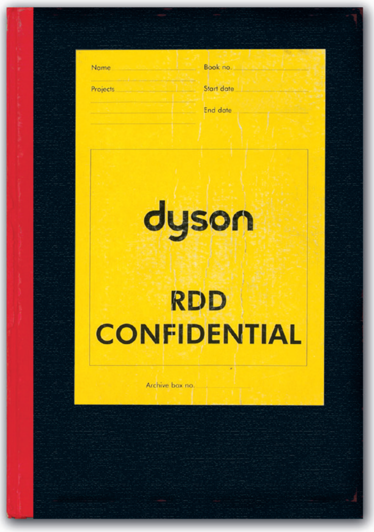
The design brief explains the problem that the new product must solve, and any other factors the design engineer must consider. A product might need to be a certain size or perform a particular function. And it will always have an intended end user.

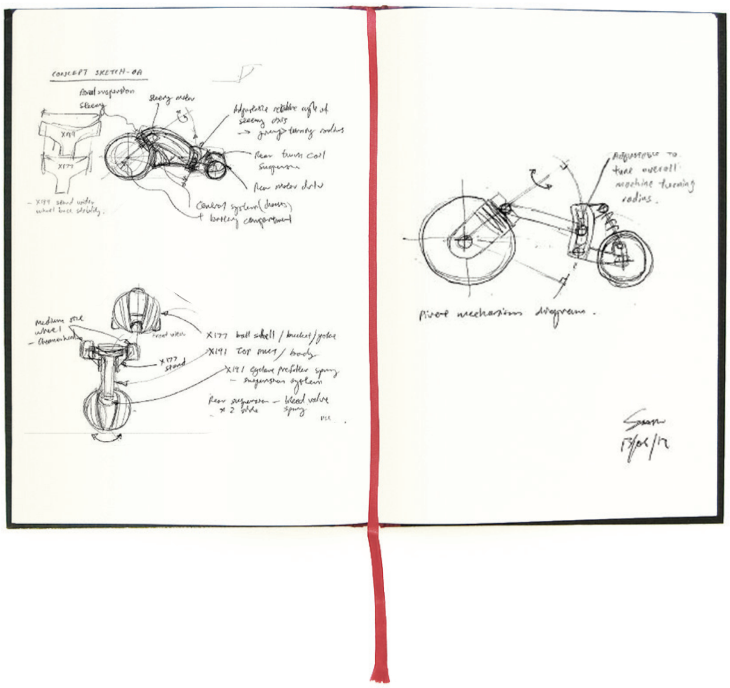
The specification is then the measuring stick for a design – it's a list of requirements and features that a machine should have. It should always be referred back to throughout the design process.

The Brompton Bicycle began with a brief to make a bicycle that would be easy to use in the city and on public transport. The specification was that it must be foldable, light – and easily stored away in small places. The bike is now a recognized icon of British design – and it's still being continuously refined.

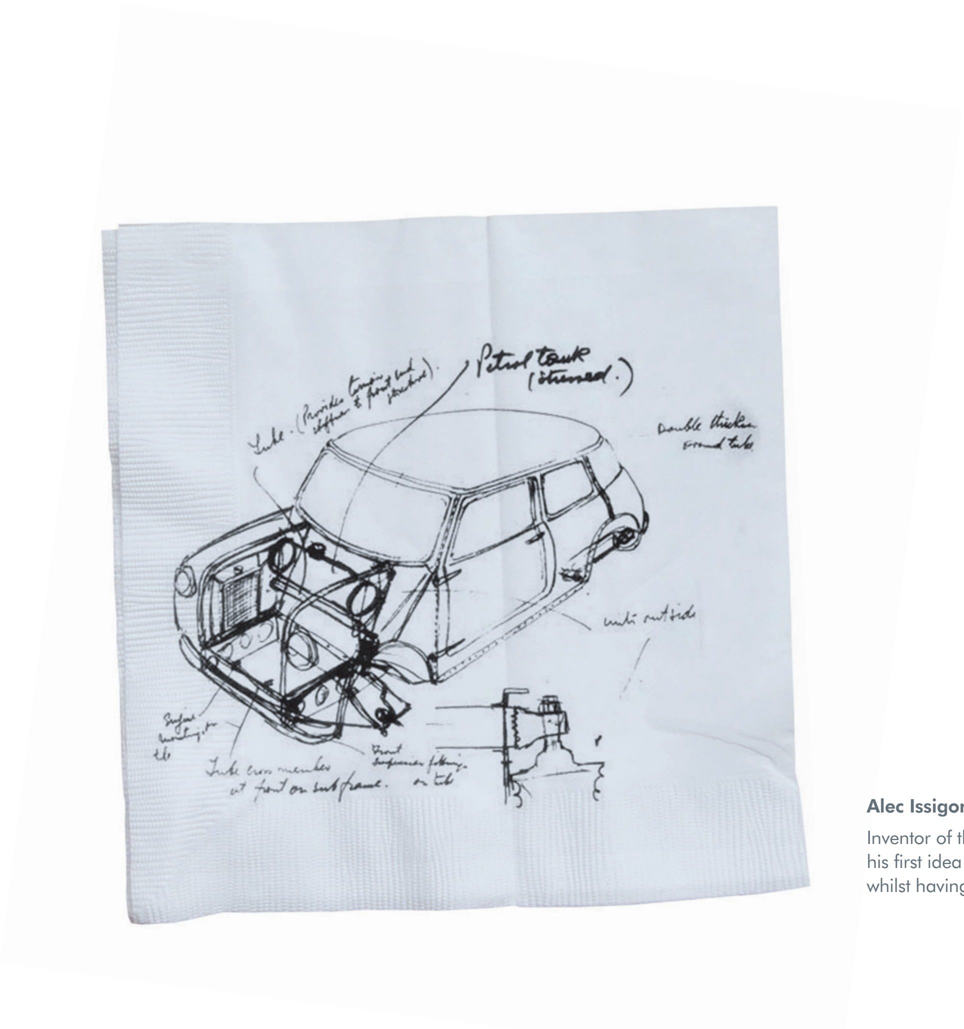
"SKETCHING BRINGS SCIENCE AND ART TOGETHER. A DESIGN ENGINEER USES SKETCHES TO SHOW HOW SOMETHING WILL WORK AS WELL AS WHAT IT MIGHT LOOK LIKE."

James Dyson





Sketching is an important way of communicating ideas. Every engineer at Dyson carries a sketchbook which they use to jot down their ideas. They must sign and date each page to show who the idea belongs to. When they're working on a new design, they give it a code name so they can talk about it without giving away their secrets.



Alec Issigonis

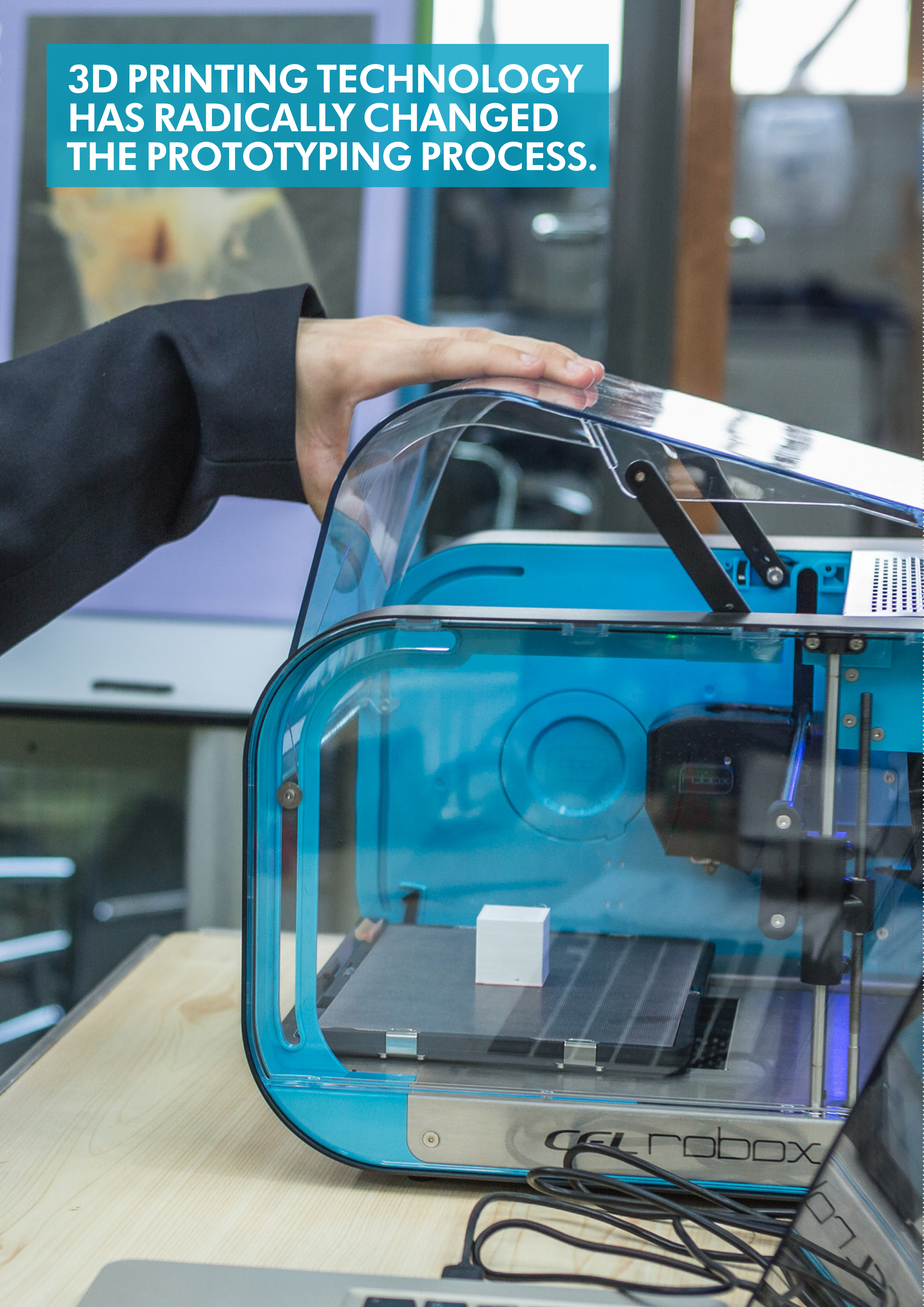
Inventor of the Mini, sketched his first idea on a napkin whilst having dinner.

Once design engineers have decided on one or two ideas they'd like to pursue, they start making 3D models of their design.

Hundreds of prototypes of every Dyson machine are created, starting with cardboard models – a simple, cheap and effective way to demonstrate what something might look like in 3D. Design engineers may add weights so they can get an idea of what the product will feel like in use.

Early prototypes for the Dyson DC16 cord-free vacuum cleaner.

3D PRINTING TECHNOLOGY HAS RADICALLY CHANGED THE PROTOTYPING PROCESS.



Computer-aided design (CAD) is used to create detailed, computerized 3D images of individual parts – and even to do virtual testing. After the CAD file has been created, it is sent to the 3D printer – in the same way you would send a normal document to a printer. At Dyson, rapid prototyping machines are used. These take the CAD image and slice it into many thin layers. The rapid prototyping machine prints each of these layers, stacking them on top of each other to create a 3D model.

Rapid prototypes are essential to give the design engineers an accurate idea of how a machine will perform. By testing them and finding weak spots, the design can be improved. Many different models are made and improved before the machine is ready for manufacture.

A working product is not the end of the design process. You must test your design to find the weak points.

Failure is a good thing: it helps design engineers to improve the product.

Design engineers create tests that replicate how the machine will be used so they can get an insight into what might go wrong when people start to use it. This will mean lots of mechanical and scientific testing – as well as real life testing. There's no substitute for getting a machine into human hands. Dyson has a team which tests every one of its machines to breaking point.

DURING TESTING A DYSON PROTOTYPE VACUUM CLEANER TRAVELS 9,320 MILES. – THAT'S FROM NYC TO LA 3 TIMES..

CASE STUDY

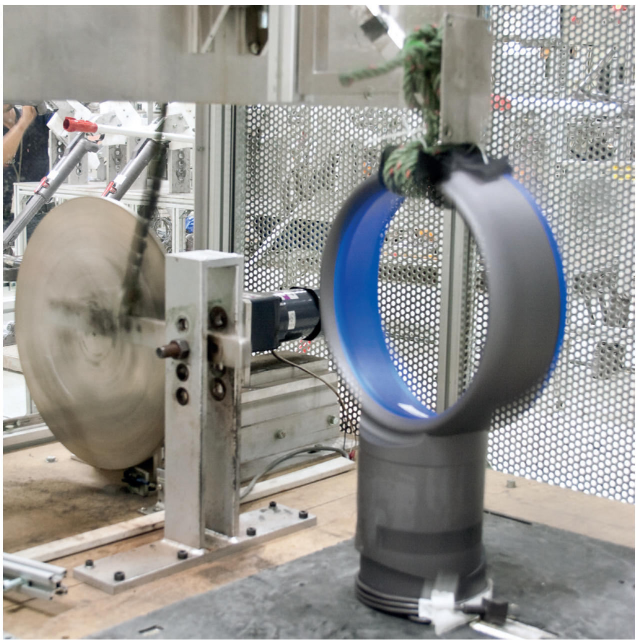
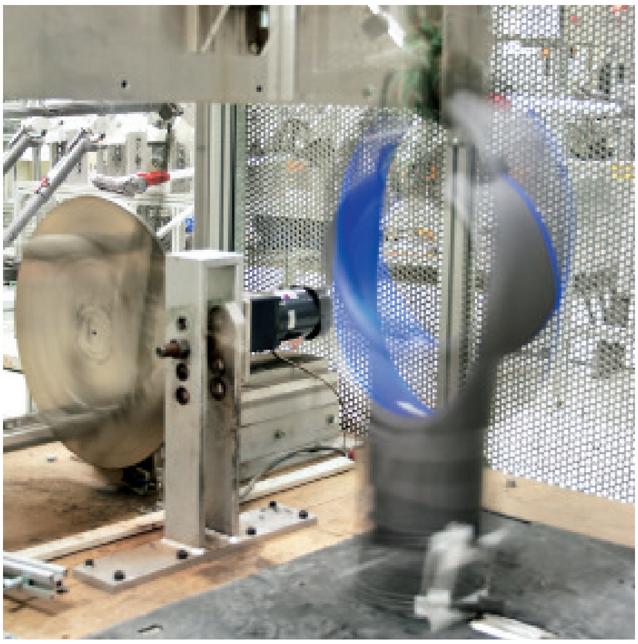
TESTING THE DYSON AIR MULTIPLIER™ FAN

Dyson uses test robots to simulate a lifetime of use. Robots can repeat complex actions many times, in a controlled manner: the Dyson Air Multiplier™ fan's tilt operation was tested to 54,750 cycles, back and forth.

Dyson's fluid dynamics engineers ran hundreds of simulations to measure and map airflow – allowing them to better understand the airflow, and how to control it. High speed cameras were used to analyze what was happening. The high speed camera takes 40,000 frames a second, allowing the engineers to see things like tiny dust particles moving through the machine.

Every aspect of a Dyson machine's performance is tested – even the way it sounds. The Dyson Air Multiplier™ fan was tested in a semi anechoic chamber; a soundproof room. 10 microphones recorded every noise that the machine made, helping the engineers to identify unpleasant tones. The engineers then built a transparent prototype and passed ultraviolet paint through the machine. Where the paint stuck to the fan loop the engineers knew there was an obstruction: causing turbulence in the airflow, and creating noise.

Another test involved replicating conditions in a busy kitchen. The Dyson Air Multiplier™ was confined in a box into which flour, cooking oil and dust were pumped, to make sure the 1.3mm aperture didn't block.

The Dyson Air Multiplier™ fan was subjected to thousands of drop tests – literally dropping the machine from a height, repeatedly, to understand how durable it was.

Millions of tiny particles were injected into the airflow to make flow patterns visible to laser technology. This technique is called Laser Doppler Anemometry. The engineers were then able to use lasers to track the speed and direction of the particles, allowing them to create a detailed map of the airflow.

LESSON 3

Design

Duration: 1 hour 30 minutes

Learning objectives:

1. Understand the importance of planning before making.
2. Exercise planning ahead skills.
3. Learn how to break a challenge down into a series of tasks.
4. Understand how to use sketches to communicate ideas.

Activity outcomes:

– Design specification(s) for the project
– An annotates sketch of the product
– A production plan

Things you will need:

– Pencils and paper for sketching
– **My specification worksheet** (page 47)
– The **Sketching** video on the USB
– A computer and projector to play the video from the USB

Starter: 10 minutes

Introduce the brief and example specification

Learning objective	Activity
1	Give the students their brief: *Choose something in your classroom or in the home that does not work well. Identify the main problems with the product, and design something that works better. Make your idea using paper, card, wood – or any other materials you have available.* Ask the students to discuss the brief. Gather their initial thoughts about the project.
1	Go back to Lesson 1: **What is a design engineer?** Think about the characteristics of a design engineer. Question their ideas and challenge them to start thinking about the project as a design engineer.
1	Show the class the words 'design specification' – what do they think this means?
1	Ask the students to think about why a design engineer would need to come up with a design specification. Explain that it helps to channel their thinking about the user and purpose of the product. It also helps to give them some parameters to work within.

Main: 1 hour

Writing a specification and sketching ideas

Learning objective	Activity
1, 2	Break the students back into the groups chosen at the end of Lesson 2: **Design detectives.** Ask the groups to think carefully about who will be using their product and what its function is. You may want to ask them to draw their user.
1, 2	Ask students to work in their groups to produce a specification. Hand out the **My specification worksheet** (page 47). Give them a limit on the number of criteria. You might like to decide on some criteria as a class and then allow the students to set a few more themselves. Students will need to consider the size, weight, appearance and function of the product when thinking about the specification, which will vary depending on the project undertaken. Divide the specification into: – It must… – It should… – It would be nice if…
1, 2	Explain to the students that they will refer to this specification throughout the designing and making process to make sure they are on track. They can then use the specification to test and evaluate their product once it is complete.
1, 2	Once the students have identified the specification for their design, they can begin to sketch their product. Explain that sketching is an important communication tool for engineers. Sketches show not only how the product will look, but also how it will work. Use the **Sketching** video to support your explanation.
4	Ask students to draw a picture of what they think their product should look like, using annotations to explain how it will meet the specification criteria. Encourage groups to discuss different possibilities.
2, 3, 4	Ask groups to share their specifications and annotated sketches with the class.

Wrap up: 20 minutes

Production planning

Learning objective	Activity
2, 3	In their groups, students should produce a production plan.
2, 3	Consider using techniques such as flow charts. Key questions could include: – What steps do you think you will need to take? – How many steps will it take to make your product? – Have all the steps been included? – Is more detail required? – Can your plan be understood by someone other than you?
2, 3	Make sure students record their production plan in a format that can be easily followed during the next lesson.

LESSON 4

Build

Duration: 1 hour 30 minutes

Learning objectives:

1. Develop practical skills.
2. Learn that design is an iterative process: designs are constantly improved.
3. Consider the properties of materials and make judgments as to the most appropriate.
4. Reinforce design decisions that were made, and learn to keep a specification.
5. Develop self-evaluation skills.

Activity outcomes:

– A series of prototypes experimenting with different materials and their properties
– A final version of the product

Things you will need:

– Paper and pencils
– A range of materials to construct prototypes with
– A range of adhesives to join parts together
– A range of tools to cut up material and construct prototypes
– The **Dyson does it: build** video on the USB
– The **Cardboard modeling** video on the USB
– A computer and projector to play videos from the USB
– Poster 3: **Design process**

Starter: 15 minutes

Prepare

Learning objective	Activity
2	Begin the lesson by explaining that design is a process, and part of that is prototyping and trying different ways to achieve your design. Refer to Poster 3: **Design process**.
3	Explain that in this lesson the students will be working in their groups to prototype their product. Show the students the different materials they will have to work with. As a class, discuss the properties of these materials and consider which will be most appropriate for different aspects of construction.
1 & 3	Ask the students to think about the different ways they can use each material. Show them the **Cardboard modeling** video – this will give them tips to help them manipulate cardboard.
4	Remind the groups to have their specification and production plan to hand, and to keep referring to them.

Main: 1 hour

Go! Production

Learning objective	Activity
1, 2, 3	Based on their sketches from the previous lesson, the student groups should begin to produce their model. Remind them that they don't need to produce a perfect model straight away: an important part of the design process is iterative improvement. They should build several prototypes of part or all of their product before settling on a final version. Stop activities to highlight unsafe/safe practice.
2, 4	During production, encourage student groups to discuss the development of their product, including changes that should be made and the reasons for these. Support the use of correct terminology. Make sure that students record how each prototype has changed – and why.
	This part of the lesson can be extended or repeated if more time is required.

Wrap up: 15 minutes

Specification check

Learning objective	Activity
4	Ask the students to re-visit their specification and compare it to their prototype.
4, 5	Ask the student groups to share their products. They should identify where they have deviated from the specification and offer reasons for these changes: – How did the change improve the product? – What part of the product did it affect? – Why did this need changing/improving?
2	Finish the lesson by watching the **Dyson does it: build** video, to understand the high-tech prototyping methods used at Dyson.

LESSON 5

Test and evaluate

Duration: 1 hour

Learning objectives:

1. Understand that testing helps to find the weak points and improve the design.

2. Reinforce that designing and making is producing something, for someone, for some purpose.

3. Develop analysis skills through using PMI.

4. Relate the design process in the classroom to the real life design process and the need to revisit and improve.

5. Appreciate how perceptions of the work of a design engineer have changed in light of the project.

Activity outcomes:

– Completed testing plan and PMI worksheets
– Completed drawing of what an engineer looks like
– Comparative display
– Students presented with **Dyson design challenge certificate** (page 49)

Things you will need:

– Individual copes of the **PMI worksheet** (page 46)
– Individual copies of the **My next one would be...** worksheet (page 48)
– The **Dyson does it: test** video on the USB
– A computer and projector to play videos from the USB
– **Dyson design challenge certificate** (page 49)

Starter: 25 minutes

Planning the test

Learning objective	Activity
1	Explain to students that today's lesson focuses on the last two steps of the design process: testing and evaluation. Ask students to consider: – Why do you think it is important to test a prototype? – What could happen if an engineer does not test their design? – What do you think happens if a design passes a test? What happens if it fails?
1	Introduce the Dyson testing process using the **Dyson does it: test** video. Discuss the video as a class.
1, 2	In their groups, ask the students to design a plan for how they would test their own products. Explain that the test should identify the aspects of the design that need improving. You may want to ask them to consider the following questions: – How will users interact with the product? – What types of accidents could happen while someone is using the product? – Which are the strongest and weakest parts of the product?
1	Ask the groups to share their testing plan with the rest of the class. Discuss and give feedback.
	If you have time, consider extending this opportunity by trying one or more of the student-designed tests.

Main: 1 hour

Product analysis

Learning objective	Activity
1, 4	Explain that once engineers have completed testing, they evaluate their results – and then improve their design.
3	Ask student groups to review the original design specifications for their products. Next, ask them to use the **PMI worksheet** (page 46) to evaluate either their own work, or the work of a different group.
3	Using the results of the PMI exercise, explain that the students will now consider what **My next one would be…** using the worksheet on page 48. Refer back to James' story (page 10) and his 5,127 prototypes.
2, 4	Capture students' thoughts on how their ideas would develop. Consider using techniques such as photographing final products and sketching on improvements. Mark the photograph with minus or plus points on parts that would be improved or changed. Consider problems experienced during the project or how they think their product would endure the tests they designed. How would they overcome or avoid problems or failed tests next time? Produce top tips for another class doing this activity.

Wrap up: 10 minutes

What is a design engineer?

Learning objectives	Activity
4	Ask students to think about what they now feel about the work of a design engineer. Have their ideas changed? Repeat the drawing of an engineer (page 16) exercise from Lesson 1.
4, 5	Allow students time to share their ideas with the class. Students could create a comparative wall display of their work. It could include their sketches, photographs of their work and their final products. The display could include information about the design process.
5	Use a whole school assembly to present the students with their **Dyson design challenge certificate** (page 49). You could also consider inviting a local engineer into the class, to talk about their work – and provide feedback on the group designs.

PMI WORKSHEET

NAME:
(Design engineer in training)

PRODUCT:
Draw a quick sketch

PLUS	**MINUS**	**INTERESTING**
What works well?	What does not work well?	What do you find interesting or different about the product?

MY SPECIFICATION WORKSHEET

NAME:
(Design engineer in training)

Write a list of things you want from your product.
Divide it in to three sections based on how important each item is.

I AM DESIGNING…

IT MUST…

IT SHOULD…

IT WOULD BE NICE IF…

MY NEXT ONE WOULD BE…

NAME:
(Design engineer in training)

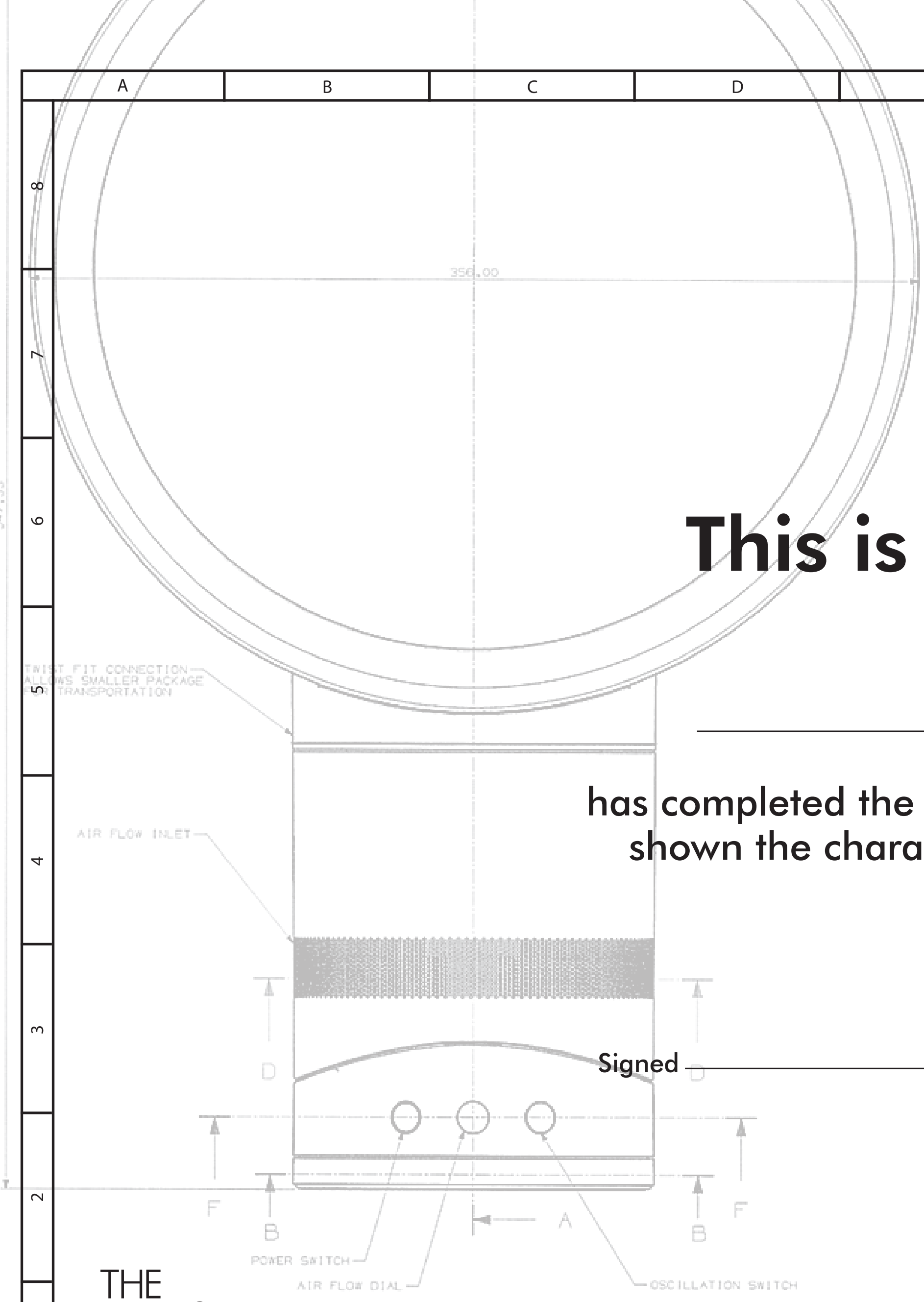
Having a working product is not the end of the design process. Design engineers will repeat the Design. Build. Test. loop many times to make their product as good as possible.

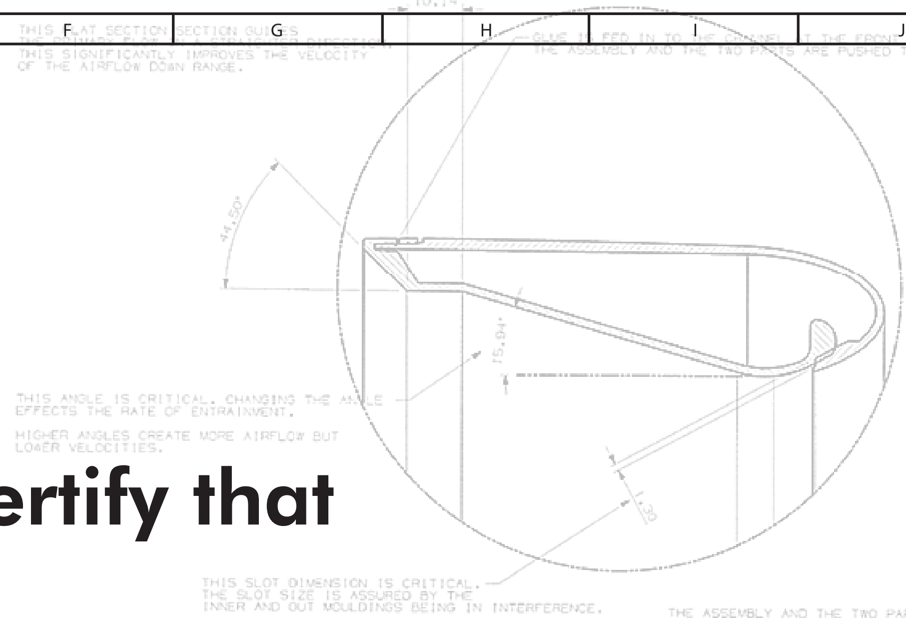
Use the minus points from your completed PMI worksheet to identify how you could make your product better next time.

MINUS POINTS	WAYS IN WHICH I WOULD SOLVE THEM NEXT TIME

Making a product is difficult. Write down some of the problems you had and think about ways you could solve them next time.

PROBLEMS I HAD	WAYS IN WHICH I WOULD SOLVE THEM NEXT TIME



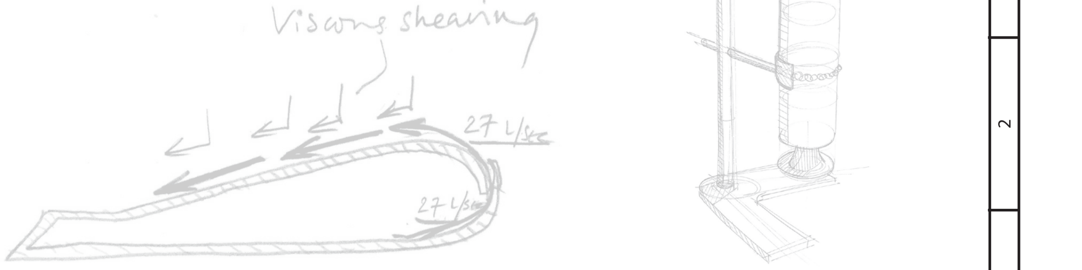


This is to certify that

____

has completed the Dyson design challenge and has shown the characteristics of a design engineer.

Signed ________________________ Date ____________________



THE JAMES DYSON FOUNDATION

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Extension activities

Literacy and writing skills

Activity	Learning objective	Activity outcome
Write instructions for how to use the group product	Develop explanatory skills through writing	Instructions
Write a letter to a friend or relative, persuading them to buy their product over a competitor	Practice persuasive writing Improve familiarity with letter writing	A persuasive letter
Create a brochure for the group product	Improve non-fiction writing Improve IT skills and enterprise awareness	Product brochure

History

Activity	Learning objective	Activity outcome
Research a design engineer using the internet and other resources	Develop research skills and knowledge of design engineers	Information gathered
Create a design timeline for the classroom	Improve awareness of design and how it has evolved	Class display

Enterprise

Activity	Learning objective	Activity outcome
Research different types of advert and discuss which the class finds most effective	Improve awareness of the different ways of explaining and marketing a product	Class discussion of differences and similarities
Create an advert for the group product: print or film	Learn how to persuade through advertising Practice IT skills	Film or print advertisement
Strategy plan: work in groups to think about the product's strengths and weaknesses, and how people could be persuaded to buy it. Write a plan for a product pitch	Identify strengths and weaknesses Develop planning skills in relation to presentations	Written presentation plan
The pitch: groups have two minutes to persuade the rest of the class to buy their product	Develop persuasive speaking skills	Series of presentations from the class

Numeracy and enterprise

Activity	Learning objective	Activity outcome
Before the Lesson 4: **Build** class, set up a shop. It should contain all the materials and tools they will need to use, along with a price. As each student comes into the class, give them a set number of tokens Explain the difference between cost and profit, and how important they are for business	Increase business skills and awareness	Practice using number sense skills, addition and subtraction Listening and discussion activity
Ask the students to look at their designs and make a shopping list of what they need. They will then visit the shop, write the cost next to the material, and add up the price of their list They can then re-visit and adjust their designs or material choices depending on their number of tokens and budget	Exercise planning skills Learn to think about materials and their properties and apply that knowledge. Develop basic arithmetic. Raise awareness of budgeting and related decision making	A materials shopping list for their design to which prices can be added and amended according to their budget
Recap and review: – What changes did they have to make? – Were some decisions harder than others? Why? – Whose project was the most expensive? Why? – Whose was the cheapest? (this could be shown in graph form)	Exercise speaking and listening skills Reinforce decisions made and reward positive processes	Class discussion

Continued overleaf

Science

Activity	Learning objective	Activity outcome
Before the lesson, find a selection of seeds. Ask if the students recognize any. Explain that many types of seeds are naturally designed to disperse in the wind This activity could also be done with light everyday objects to see which travel furthest – e.g. feathers, paper and leaves	Increased knowledge of plant structures Increased awareness of what's in their local environment An awareness of the presence of design in nature	Class discussion
Using the Dyson Air Multiplier™ fan as a source of wind, measure which seeds are best at travelling the furthest by wind	Practice measuring and recording skills Improved observational skills	Measurements of distance by seed type (this could be recorded in a chart format)
Discuss how different objects behave in the wind. Discuss how the shape of the seed is adapted to travelling by wind. Opportunity to discuss other methods of seed dispersal	Understanding of how wind affects the movement of objects and how shape can have an impact Understand that seeds are adapted	Class discussion

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

Share your experiences with us:

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INSPIRING THE NEXT GENERATION OF ENGINEERS