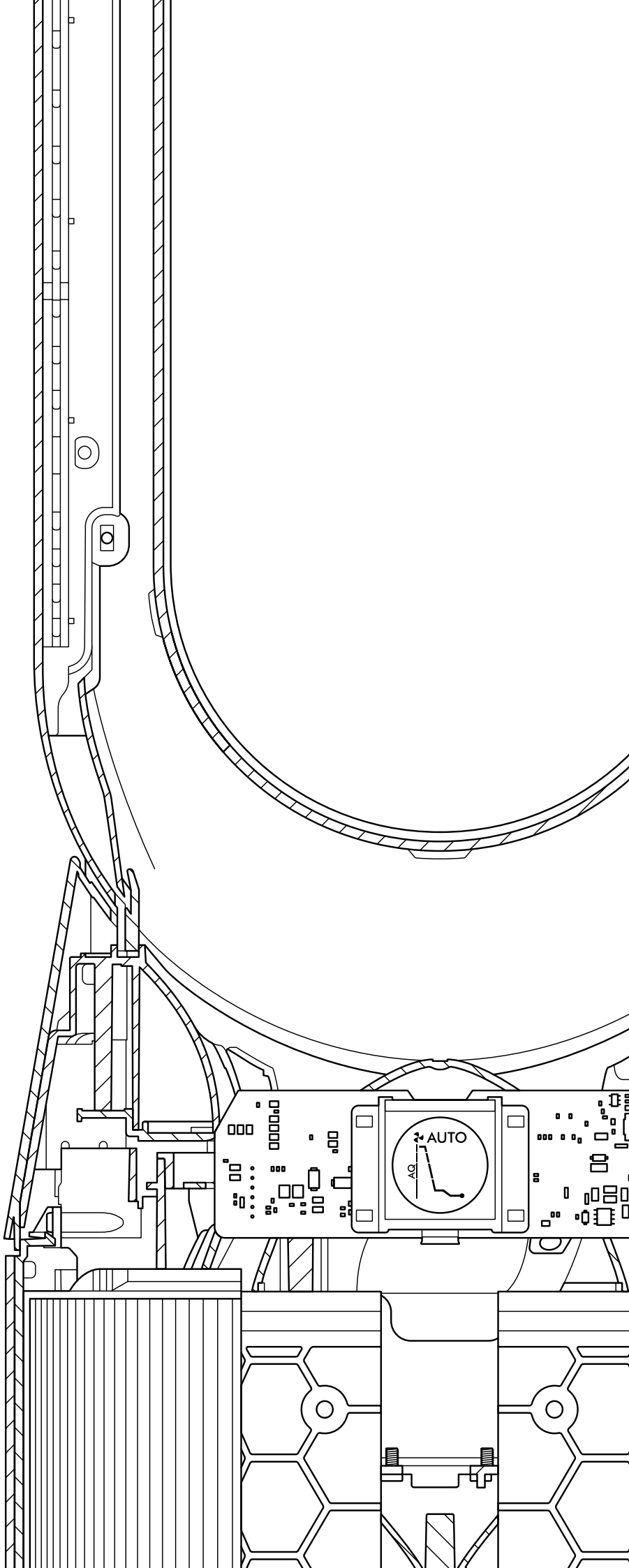
THE JAMES DYSON FOUNDATION

TEACHER'S PACK

Southeast Asia
Primary and Junior
High School Students
Engineering solutions:
Air pollution



INTRODUCTION

This teacher's pack will introduce your students to engineering and explore how engineers can solve global challenges, focusing on the problem of air pollution. Over five lessons, students will learn what air pollution is and how the Dyson Pure Cool™ purifying fan works as a solution to indoor air pollution. Students will consider their own exposure to air pollution and design and build a solution to the problem, by following the design process. The pack is designed to be complementary to Science curriculums at Primary and Junior High School levels.

If you follow the lesson plans provided, students will:

- Learn about air pollution and its global sources
- Consider their own exposure to air pollution
- Analyse the Dyson Pure Cool™ purifying fan
- Design, build and evaluate their own solutions to air pollution

Please note, each lesson is 1 hour, however you can adapt the lessons to suit different timetables – for example, the starter or wrap-up activities can be omitted to reduce each session to under an hour. It is also possible to teach each section in isolation if time is limited.

You can find the videos and posters on our website:
www.jamesdysonfoundation.co.uk

CONTENTS

Think before you print
Lesson plans and worksheets have been included on separate pages, listed above, so you shouldn't need to print the entire document.

SECTION 01: SENSE

Students will learn what air pollution is and what causes it. They will understand that air quality can be monitored using sensors and consider actions to reduce their exposure to air pollution on their journey to school.

UNDERSTANDING AIR POLLUTION

Air pollution

Air pollution is caused by a build-up of particulate matter and gases in the air, that come from a range of natural and human-made sources. It is one of the major global problems of the modern age. 91% of the population lives in places where the air quality exceeds the World Health Organisation's (WHO) guideline limits.[1]

Gas pollution

The air around us is mostly comprised of gases. It is made up of 78% nitrogen, 21% oxygen, and the rest is made up of argon, carbon dioxide and a small amount of other gases, all of which enter our lungs when we breathe. The presence of oxygen is fundamental to keep us alive, but other pollutant gases may cause us harm.

Particulate matter pollution

The air also contains particles and we breathe in millions of them every day. Particles are small pieces of matter and are measured in microns (μm), which is one millionth of a meter. They vary in size, shape and composition. Particulate matter (PM) is a form of air pollution and is a mixture of solid and liquid particles floating in the air.

Air pollution on a journey to school
Nigeria

[1]World Health Organisation, https://www.who.int/airpollution/ambient/en/

SOURCES OF AIR POLLUTION: NATURAL SOURCES

Weather

Temperature, rainfall and the wind all influence air pollution. For example, wet and windy conditions reduce air pollution in certain locations by washing it out of the air or moving it elsewhere. Whereas dry and still conditions cause poor airflow which can trap air pollution. This means that in landlocked places, such as mountain towns, air pollution can build up.

Desert dust storms

Desert dust comes from the surface of arid and semi-arid regions around the world such as the Sahara Desert, Eastern Australia and the Gobi Desert. High winds cause dust particles to lift from the ground into the air resulting in a dust storm. Wind can cause dust storms to travel thousands of kilometers and can combine with human-made air pollution. This means desert dust can cause air pollution in parts of the world that are nowhere near a desert.

Volcanoes

Volcanic eruptions release volcanic ash into the air. Wind can carry this ash thousands of kilometers away from the volcano itself. For example, in 2010 a volcano called Eyjafjallajökull erupted in Iceland. Around 50% of the ash was carried across Europe and the North Atlantic. Air traffic in these locations was halted for several days after the eruption.

Forest fires

Forest fires occur across the world and produce a substantial amount of smoke pollution. These fires are increasing in prevalence and severity due to changes in temperature and rainfall across the globe, resulting in longer fire seasons and larger geographic areas being burned. Forest fire smoke is a complex mixture of PM, nitrogen oxide (NO_2), carbon monoxide (CO), ozone (O_3) and volatile organic compounds (VOCs) generated from burning a wide variety of fuel sources such as trees, dried leaves, litter and – unfortunately – local homes. These forest fires often occur in California where the dry environment means it is easier for fires to start from a natural event such as lightning, or a human-made source such as campfires. Wind also causes the smoke generated from forest fires to travel long distances and pollute air in cities and towns.

Volcanic eruption
Eyjafjallajökull Iceland


Dust storm


Forest fire


Rain


Pollen


Forest fire


Wind


Dry and still conditions


Cold conditions

SOURCES OF AIR POLLUTION: HUMAN-MADE SOURCES

City pollution
Shanghai

Transport

Road transport is one of the main sources of air pollution in cities. Exhaust fumes from motor vehicles release harmful gases and soot particles, coated with toxic substances, into the air. Diesel vehicles are especially harmful, producing high concentrations of these pollutants. Air pollution is also caused by small bits of metal and rubber that come off brakes and tyres, as well as by dust kicked up from road surfaces. They're suspended in the air by moving traffic.

Energy generation

Much of the electricity we use in our homes comes from power stations that burn coal, oil, gas and wood. These processes release harmful amounts of gas pollution into the atmosphere.

Industrial processes

Industrial processes such as the production of cement, iron, steel, glass and paper create air pollution. Areas with high numbers of industries and factories have high levels of air pollution.

Urbanisation

Urban areas, particularly large cities, have higher levels of air pollution than most rural areas due to high numbers of people, transport and industries. For example, megacities such as Tokyo, Shanghai and Delhi face huge air pollution problems. Pollution builds up in these highly populated places and can often be seen as a brown haze that appears to hang in the air over cities. Rural areas tend to be more exposed and windier, meaning air pollution is more easily dispersed. This results in better air quality.

Household products

Studies have found that indoor air quality can be worse than outdoor air quality.[2] Air pollution is released from household items such as building materials, cleaning products, furniture, pets, candles, plants and aerosols. It is also emitted from activities such as heating and cooking. Outdoor air pollution can also enter homes through ventilation, doors and windows and then become trapped.

[2] Hulin et al, Respiratory Health and Indoor air pollutants based on quantitative exposure assessments, European Respiratory Journal, Oct 2012.


Energy generation


Industrial processes


Exhaust fumes


Urbanisation


Spreading inorganic fertilisers


Burning candles


Cooking fumes


Cleaning products and aerosols

THE IMPACT OF AIR POLLUTION AND WHY IT'S DIFFICULT TO SOLVE

Health

Air pollution can impact our health in a number of ways including nose, eye or throat irritation, coughing, chest tightness, shortness of breath, reduced lung function or asthma attacks. Some people are more at risk of being affected by air pollution than others.

Environment

Air pollution can also have adverse effects on the environment such as acid rain, soil depletion, damage to forests and crops, reduced visibility, damage to buildings and climate change.

Air pollution is a difficult problem to solve for a number of reasons:

It is largely an invisible problem because most air pollution is made up of very small particles that can't be seen by the naked eye.

Our lifestyles currently depend on activities that contribute to air pollution such as driving cars and heating our homes using fossil fuels.

Air pollution is a complicated global problem with a multitude of causes, which vary in scale and severity across the world.

But engineers have the skills and knowledge to start addressing the problem.

Air pollution in Beijing
China

CASE STUDY: THE BREATHE LONDON WEARABLES STUDY

Since 2009 Dyson has been developing machines that use air quality sensing technology. These devices measure air quality levels, making invisible air pollution visible through data. Dyson engineers used their knowledge of this technology to develop a wearable air quality sensor. This sensor was used in the Breathe London Wearables Study to monitor the air quality school children experience during their journey to and from school. 250 pupils, across five primary schools in London, took part in the study. Each student carried a backpack containing the wearable sensor and GPS. The sensors measured the particulate matter and NO_2 levels students were exposed to as they travelled to and from school for a week. An algorithm processed the information collected by the sensors. Using this data, researchers at Kings College London mapped areas of good and bad air quality.

Monitoring air quality in this way increases awareness of the air pollution we're exposed to everyday and can stimulate positive behaviour change to reduce exposure. For example, students in this study started walking along side roads instead of busy main roads on their way to school to avoid the high levels of pollution that come from vehicle exhausts.

Find out more about the Breathe London Project at **www.breathelondon.org**

Backpack containing the Breathe London wearable sensor

Students participating in Breathe London Wearables Study

LESSON 01
AIR POLLUTION AND ITS SOURCES

Duration: 1 hour

Learning objectives

1. Understand the sources and types of air pollution.

2. Understand that air pollution is made up of particles of different sizes.

3. Consider the effects of air pollution on health and the environment.

4. Consider some of the challenges in addressing the problem of air pollution.

Activity outcomes

Class activity about the natural and human-made sources of air pollution

Activity on the effects of air pollution on the human body

Consideration of the effects of air pollution on health and the environment

Class discussion about the challenges of solving the problem of air pollution

Things you will need:

Pens and pencils

Paper

Whiteboard

Poster: Air pollution sources

Poster: Air pollution magnified

Poster: Air pollution size

Starter: 10 minutes
Introducing air pollution

Learning objective	Activity
1	Explain that air pollution is a global problem that effects everyone. Engineers have the skills and knowledge to help solve it. However, before attempting to solve air pollution engineers must understand the problem in detail. Explain that in this lesson students are going act like engineers and learn about what air pollution is in order to help them design possible solutions in a later lesson.

Learning objective	Activity
1	As a class, discuss why air is important for human life. Ask the class what they think air pollution is. Write down the key points on the board. Explain that air pollution is a mixture of particles and gases in the atmosphere which could harm us if we breathe them in.

Main: 45 minutes
Understanding the sources and types of air pollution

Learning objective	Activity
1	As a class identify as many sources of air pollution as they can. Write students' answers on the board. Explain the difference between natural and human-made sources of air pollution, noting that human-made air pollution is the product of human activity such as driving a fossil-fuel powered car. Ask students to divide the answers you have written down into two lists: natural and human made sources of air pollution. Put up the **Poster: Air pollution sources** and highlight any additional sources that have not yet been identified. Were there any that surprised students? Explain to students that they are going to look more closely at what makes up air pollution.
2	Display **Poster: Air pollution size.** Explain that there are two types of air pollution, particulate matter pollution and gas pollution. Gas pollution is made up of different types of gases that can be harmful in large quantities. Particulate matter pollution consists of lots of small particles floating in the air. Explain that air pollutant particles can be very small, often much smaller than a strand of human hair. Display **Poster: Air pollution magnified** to demonstrate that pollutants are very small and can't be seen by the naked eye. Ask the students what they notice about the size and shape of the particles. They should notice they are lots of different sizes.
3	**The following activity can be used to demonstrate how air pollution can inhibit breathing.** – Ask the students to share their thoughts on how air pollution might impact health and the environment. – Divide the students into three groups and assign each group one of the following roles - pollutant, oxygen and the human body. – Mark an area in the classroom that represents the lungs. – Ask the students representing the human body to position themselves a few meters away from the lungs. The students representing oxygen should pass through the lungs and then weave around the students representing the human body, before passing back through the lung to the start.

	This demonstrates how oxygen is breathed in and delivered to different body parts before returning to the lungs and then leaving the body. Ask each oxygen molecule to pair with a pollutant. In pairs, the students should repeat their journey but each time the pollutant should remain in the lungs while the oxygen molecule continues its journey through the human body and back out of the lungs. Ask students what impact the increasing numbers of pollutant particles have on the oxygen molecules trying to enter and leave the body.

Wrap up: 5 minutes
Understanding the challenges of air pollution

Learning objective	Activity
4	As a class discuss why air pollution is a difficult problem to solve, identifying the following: – Its invisibility – Our lifestyles – many of us rely on things that cause air pollution such as cars and heating – The scale of the problem

LESSON 02
MONITORING AIR QUALITY

Duration: 1 hour

Learning objectives

1. To consider air pollution exposure.

Activity outcomes

Completed **Worksheet 01: Your journey to school**

Consideration of ways to reduce exposure to air pollution during journey to school.

Things you will need:

Pens and pencils

Paper

Whiteboard

Worksheet 01: Your journey to school

[Optional] Computers for research

Video: Breathe London

[Optional] Red, orange and green colouring pencils

Starter: 5 minutes
Making the invisible, visible

Learning objective	Activity
1	Explain that air pollution is invisible which makes it difficult to know when we are being exposed to it. Explain that this also makes air pollution a more difficult problem for engineers to solve. Ask the class what they think could help engineers to see air pollution.

Main: 45 minutes
Monitoring air quality

Learning objective	Activity
1	Watch **Video: Breathe London.** Explain to the students that by developing air quality monitoring sensors that could fit onto a backpack, Dyson engineers were able to visualise the air pollution on students' journeys to school. Explain that students will now think about air pollution they are exposed to on their own journey to school. Ask students to complete **Worksheet 01: Your journey to school.** Ask them to circle where they might be exposed to air pollution using their knowledge of air pollution sources learnt in the previous lesson. **[Optional] You could extend this activity to teach students about heat maps as a tool of visualising air pollution data.** Give each student a red, orange and green pencil. They should colour red where they think they might be exposed to high levels of air pollution, orange for where they might be exposed to a moderate levels of air pollution and green where they think levels of air pollution would be low. Explain that the students are creating a heat map which is a way of visually representing data – such as air pollution levels – to make it easier to understand.

Wrap up: 10 minutes
Taking action

Learning objective	Activity
1	Split the class into pairs. Ask the students to think about changes they could make to their journey to school to reduce their exposure to air pollution. If required, prompt them to think about: – Methods of transport – Choice of route Ask the students to feed back to the rest of the class and write a list of actions on the board. Explain that even small actions can help reduce exposure to air pollution.

SECTION 02: CAPTURE

Students will learn how Dyson engineers developed the Dyson Pure Cool™ purifying fan to help tackle the problem of indoor air pollution. They will learn how filters capture air pollution and about the iterative design process.

PRODUCT ANALYSIS: THE DYSON PURE COOL™ PURIFYING FAN

Dyson engineers developed the Dyson Pure Cool™ purifying fan to help solve the problem of indoor air pollution. When developing this machine, Dyson engineers identified three main things a purifying fan needs to be able to do:

1. Monitor air quality
2. Capture air pollution
3. Distribute clean air

Monitoring air quality

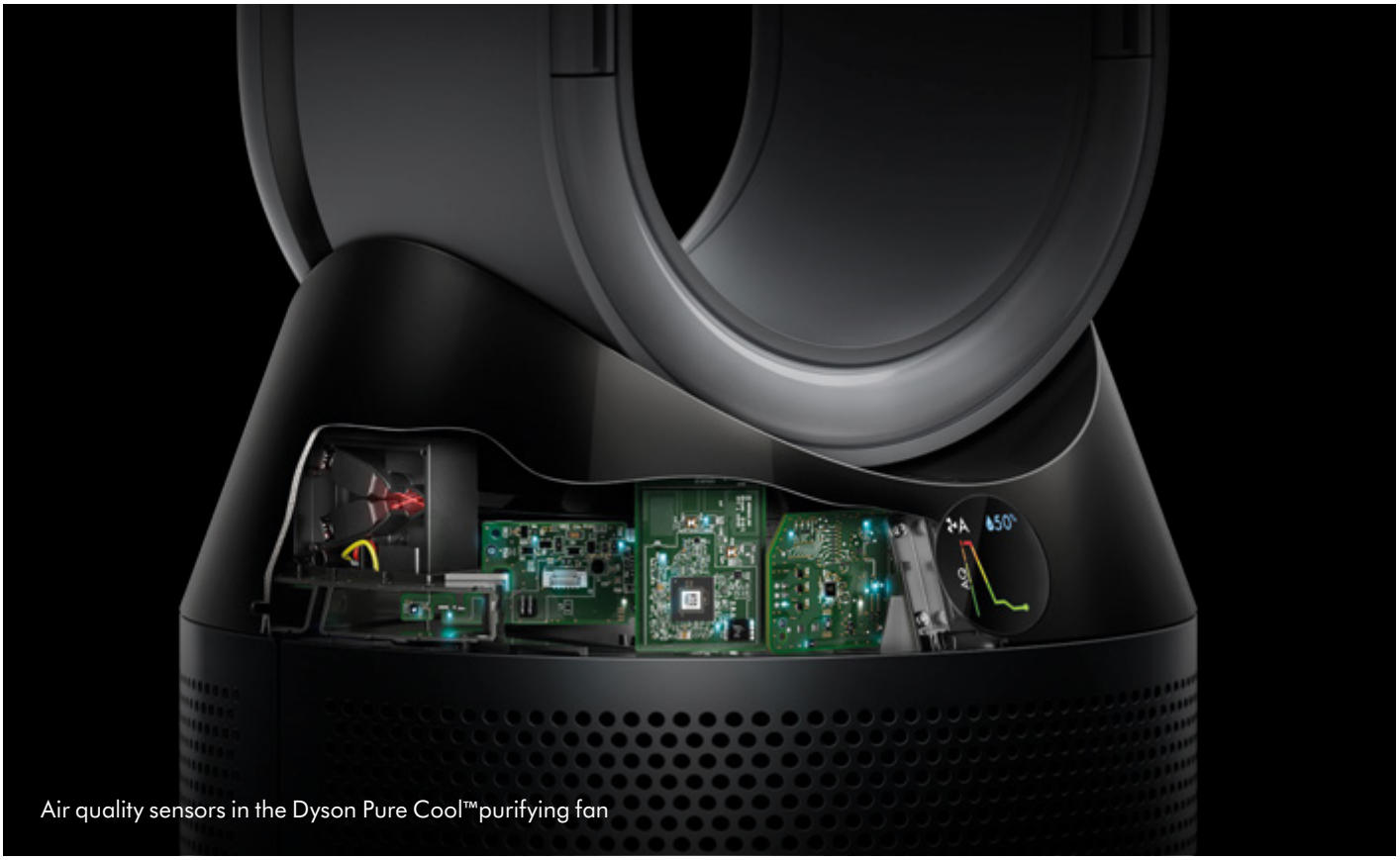
The Dyson Pure Cool™ purifying fan automatically senses air pollution using particulate and gas sensors. The data collected from these sensors is used to activate the machine and keep indoor pollution levels low.

Particulate sensor

The particulate sensor draws air into a small chamber and uses lasers to detect the concentration of particulate matter present in the air. It can detect particles smaller than the width of human hair.

Gas sensor

The gas sensor detects the Volatile Organic Compounds (VOCs) and gases such as NO_2 that are present in the air.



Air quality sensors in the Dyson Pure Cool™purifying fan

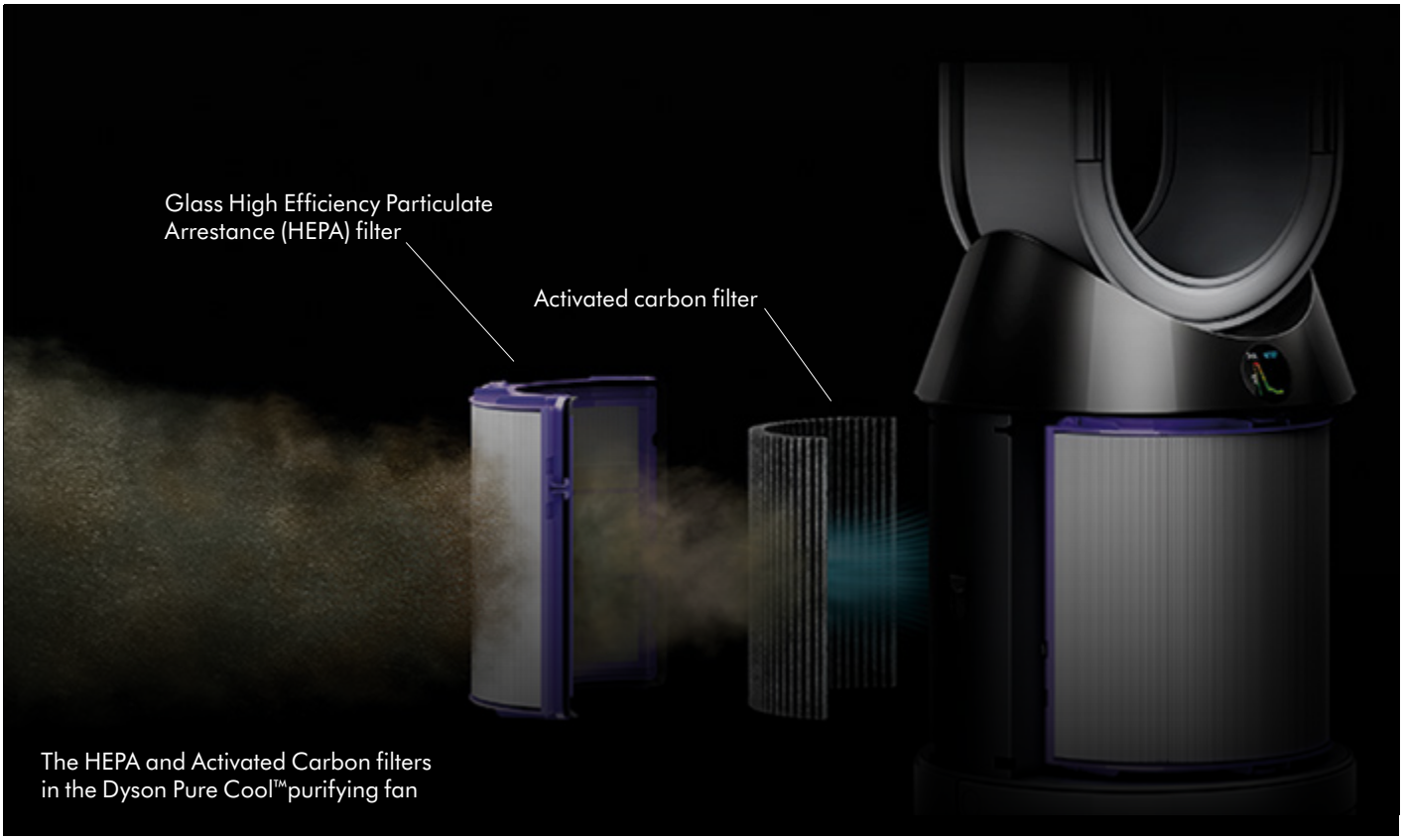
PRODUCT ANALYSIS: COMMUNICATING AIR QUALITY

The information from the sensors in the Dyson Pure Cool™purifying fan is also communicated to an LCD screen on the purifier and to the Dyson Link app, which can be downloaded onto a smartphone. The screen and app allow users to monitor their indoor air quality by displaying the type and concentration of air pollution present. The app also allows users to set a schedule for when their purifier is turned on and monitors the lifespan of the filters.

Dyson Link app

PRODUCT ANALYSIS: CAPTURING POLLUTANTS

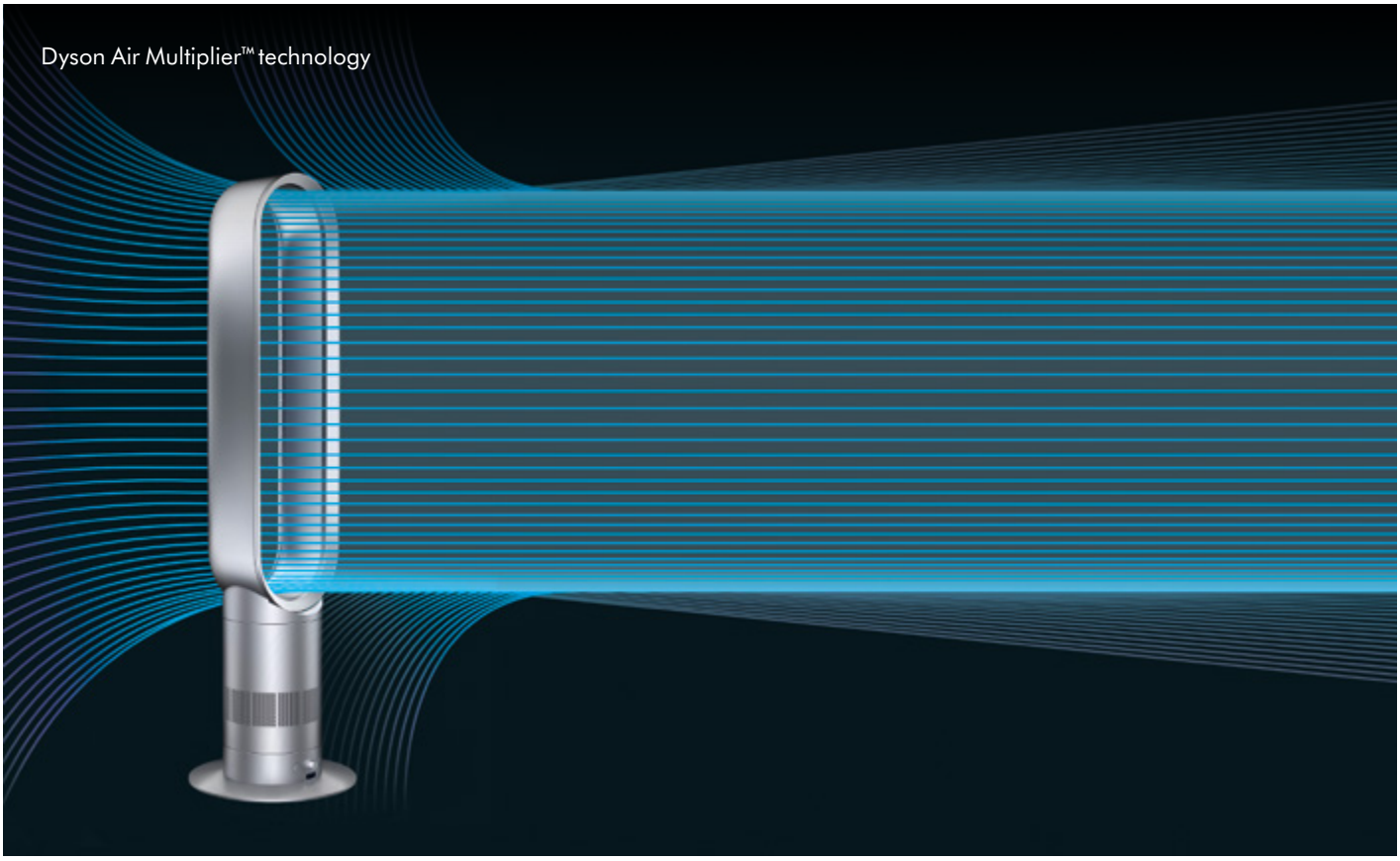
Filters are materials that can be used to remove pollution from the air. They do this by capturing small particles and gases as air flows through the filter, allowing clean air to flow out the other side. The Dyson Pure Cool™ purifying fans contain two types of filter: the HEPA filter and activated carbon filter, which can capture very small particles. You can find out more about the filters using **Poster: Air pollution filtration.**



The HEPA and Activated Carbon filters in the Dyson Pure Cool™ purifying fan

PRODUCT ANALYSIS: DYSON AIR MULTIPLIER™ TECHNOLOGY

Once Dyson engineers had found ways to remove pollutants from the air, they needed to find a way to distribute the purified air back around a room. They recognised that they had already developed technology that could help them: Dyson Air Multiplier™ technology. Dyson desk fans can channel up to 370 litres of air per second. That's 1,121 cans of soda. Dyson engineers applied this technology to the Dyson Pure Cool™ purifying fan to efficiently distribute clean air throughout a room.



LESSON 03 CAPTURING AIR POLLUTION

Duration: 1 hour

Learning objectives

1. Understand how filters capture air pollution.

2. Understand the iterative design process.

Activity outcomes

Class discussion about how the Dyson Pure Cool™ purifying fan works

Completed build a filter activity

Things you will need:

Pens and pencils

Paper

Video: Smoke box

Video: Dyson purifying technology – how it works

Poster: Air pollution size

Poster: Air pollution filtration

Poster: The design process

Build a filter activity

– Picture frame or cardboard cut into a frame, roughly 10 x 20 cm (one per student group)

– Elastic bands (a minimum of 10 per student group)

– Small balls of different sizes e.g. ping pong balls, bouncy balls, marbles

Starter: 15 minutes
Introducing the Dyson Pure Cool™ purifying fan

Learning objective	Activity
1	As a class, watch **Video: Smoke box.** Ask the students to consider what they think happens to the smoke in the box. Explain that through their research into air pollution, Dyson engineers found out that indoor air pollution can often be worse that outdoor air pollution. Ask the students why this might be the case. Explain that Dyson engineers worked to develop a technology to remove air pollution inside homes – the Dyson Pure Cool™ purifying fan.

1, 2	As a class, watch the **Video: Dyson purifying technology – how it works.** Discuss the following questions and write the answers on the board: **1.** Name three sources of indoor air pollution **2.** What problem does the Dyson purifying fan solve? **3.** How many filters are used in the purifying fan? **4.** What do the filters do? Explain that in this lesson students are going to learn how filters can capture air pollution.

Main: 40 minutes
Understanding filtration

Learning objective	Activity
1, 2	Explain to the class that they are going to create their own filter. Start by throwing the balls of different sizes to the children to see if they can catch them. Explain that the balls represent particles in the air. The bigger the ball (particle), the easier it is to catch. Split the students into groups and give each group a frame, elastic bands and collection of different sized balls. Tell the students to stretch three of the elastic bands over the wooden frame in multiple directions to create a criss-cross effect with the bands. Explain to the students that the different sized balls represent different sized air pollutants. The students will use the balls to test how effective their filter would be at capturing air pollutants. Students can do this by gently dropping the balls onto the filter to see if they pass through or get stuck. Tell the students to gradually add elastic bands to their filter, positioning them to capture as many of the balls as possible. Explain that this form of trial and error is part of the iterative design process. Explain that as air moves through the Dyson Pure Cool™ purifying fan, pollutant particles are captured by the filter in this way. The filter used in the fan has so many tightly packed fibres, it can capture particles that are smaller than the width of human hair (refer back to **Poster: Air pollution size** to give context).
2	Explain to the class that in the video the engineers talked about the design process. Explain that this is the process engineers practice when creating new products. Put up the **Poster: The design process.** Ask the class to identify the three main stages of the design process and explain how it is a cycle that is repeated over and over again until the product is the best it can be.

Wrap up: 5 minutes

Analysing the Dyson Pure Cool™ purifying fan

Learning objective	Activity
2	Explain that engineers always look to improve products, to make them easier to use, or perform better. They also look for ways a product can be adapted to suit different users or environments, to better solve a problem. Ask the students to consider how well the Dyson Pure Cool™ purifying fan solves the problem of air pollution. Students should recognise that the fan is only a solution to indoor air pollution.

SECTION 03: SOLUTION

Students will learn about how air pollution is a global problem and how engineers around the world are working to help solve it. They will follow the design process to design and prototype their own solution to the problem of air pollution on their journey to school.

THE DESIGN PROCESS

The global population is projected to reach 10 billion by 2050. To ensure that this growth does not result in even greater levels of air pollution, we need to take action to ensure a sustainable future. Engineers, with the help of scientific knowledge, have the skills to develop technologies that could help.

Engineers are problem solvers. They research and develop ideas for new products and think about how to improve existing technologies. They start with a problem, then think of ways to solve it. This is called the design process. It revolves around three main stages: **design, build, test.**

Design – at this stage engineers identify the problem they are trying to solve and think about possible solutions. They first produce a specification – a list of requirements and features the product should have. They then sketch a design of what a solution might look like.

Build – using these sketches, engineers build a prototype using simple modelling materials, such as cardboard, or more advanced ones, such as 3D printed parts. A prototype is the first version of a product from which other versions are developed.

Test – engineers need to test the prototype to see if it works and if it is an effective solution to the problem.

This is a circular process as testing identifies weaknesses and faults in the prototype that can be addressed when engineers build the next prototype. This cycle continues until it results in a finished product that successfully solves the problem. For the Dyson Pure Cool™ purifying fan, Dyson engineers designed, built and tested 2,605 prototypes.

Dyson engineers

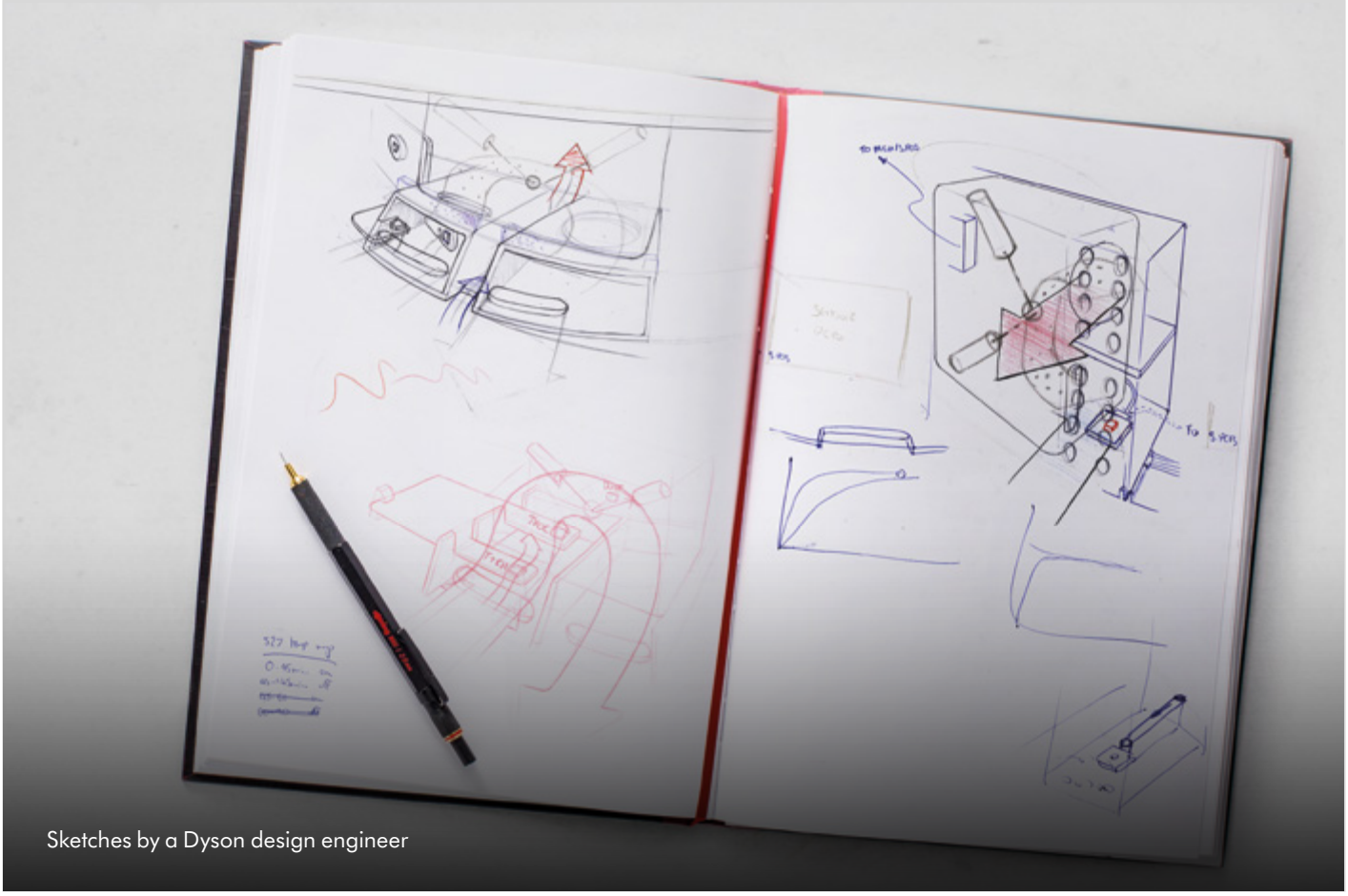
DESIGN DEVELOPMENT

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.

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, and moving on to more detailed computer-aided design (CAD) models using specialist software and 3D printers.

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.



Sketches by a Dyson design engineer

EXAMPLES OF ENGINEERING SOLUTIONS TO AIR POLLUTION

Caeli, James Dyson Award international finalist 2019 (India)

Delhi is the third most polluted city in the world. When the air quality in the city is particularly bad, many asthma sufferers are hospitalised. Caeli was developed to enable patients to stay healthy when air quality is poor and improve their quality of life. It is an anti-pollution mask which filters air via a six-layer filter and centrifugal fan. This provides a continuous flow of purified air. The mask also contains sensors which monitor air quality, sending data to an app and a drug administrator which allows users to take medication when required.

PhotoSynthetica (UK)

PhotoSynthetica is an urban curtain that captures CO_2 from the atmosphere and stores it. It can store around one kilo of CO_2 per day – equivalent to the CO_2 storing capabilities of 20 large trees. It's made up of large modules that can be attached to the outside of buildings. Air enters through the bottom of the modules and travels through a watery medium that contains a special type of algae which traps the CO_2, removing it from the air.

Smog-Free Tower (China)

The Smog-Free Tower is a 100-meters high air purification tower designed to reduce smog levels in cities. It's seven meters tall and uses ionising silver plates and filters to remove particulate matter from the air.

Smog-Free Bike (China)

The Smog-Free Bike sucks polluted air into a filtering system. Pollutants are removed from the air and the filtered air is projected towards the cyclist.

Sponge Mountain (Italy)

Sponge Mountain is a project that uses soil excavated from the construction of a railway tunnel connecting Turin to Lyon, to create a 90-meter high mound of soil. The mound of soil absorbs CO_2 from the air helping to reduce air pollution levels in Turin, one of the most polluted cities in Europe.

Electrified Roads (Sweden)

eRoadArlanda in Sweden developed the world's first electrified road. The road recharges the batteries of electric vehicles as they drive along it using conductive technology similar to a Scalextric track. Conductive rails run along the road and transfers electricity via an arm attached to the bottom of vehicles.

Vertical Forest (Italy)

Vertical Forest is a model for a sustainable residential building. The building houses 800 trees, 4,500 shrubs and 15,000 plants – the equivalent of 20,000 square meters of forest. The vertical forest creates a microclimate that absorbs CO_2 and dust particles, and releases oxygen.

Smog-Free bike
China

Electrified Roads
Sweden

Sponge Mountain
Italy

Smog-Free Tower
China

LESSON 04
DESIGNING A SOLUTION TO AIR POLLUTION

Duration: 1 hour

Learning objectives

1. Understand how engineers can help to develop solutions to air pollution.

2. Design a solution to air pollution using sketching.

Activity outcomes

Learnt about existing engineering solutions to air pollution

Completed **Worksheet 02: Specification**

Completed sketches and parts list

Things you will need:

Pens and pencils

A3 paper

Poster: The design process

[Optional] Computers for research

Worksheet 02: Specification

Starter: 5 minutes
Engineering solutions to air pollution

Learning objective	Activity
1	Explain that in the last lesson students learnt that the Dyson Pure Cool™ purifying fan is solution to indoor air pollution. Using an engineering solution example from pages 29-31, explain that engineers all over the world have developed different types of technology to help solve the problem of air pollution in different outside environments. Explain that today, students are going to act as engineers and design their own solutions to the problem of air pollution on their journey to school.

Main: 50 minutes
Designing a solution to air pollution

Learning objective	Activity
1	Split the class into groups of three, explain that in their groups, students are going to work like engineers to design and build a prototype of their own solution to air pollution. In this lesson they will undertake the first stage of the design process. Refer to **Poster: The design process.**

1	Explain to the students that their brief is: **Design a product that will solve the problem of air pollution, on your journey to school.** Ask the groups to discuss the brief and gather their initial thoughts about the project. They could consider filtering masks, air pollution removal devices or new forms of transport. Explain that they are going to produce a design specification for a product that would meet this brief. Ask students to work in their groups to produce a specification. Hand out **Worksheet 02: Specification**. Give them a limit on the number of criteria when completing the worksheet. You might like to decide on some criteria as a class and then allow the students to set a few more themselves. Explain to the students that they will refer to this specification throughout the designing and building process to make sure they are on track. They can then use the specification to test and evaluate their product once it is complete.
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. 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.

Wrap up: 5 minutes
Preparing to build a prototype

Learning objective	Activity
2	Explain to the students that in the next lesson they will complete the second part of the design process: Build. Ask the groups to identify what materials and equipment they will need, out of a list provided, to build a prototype of their design. Then they can make a plan for building their prototype in the next lesson, assigning roles and responsibilities.

LESSON 05
BUILDING A SOLUTION TO AIR POLLUTION

Duration: 1 hour

Learning objectives

1. Design and build a product to reduce air pollution.

Activity outcomes

Built prototype of a solution to air pollution

Presentation of prototype to the rest of the class

Things you will need:

A range of materials to construct prototypes

A range of adhesives to join parts together

A range of tools to cut up material and construct prototypes

Poster: The design process

Worksheet 02: Specification

Main: 50 minutes
Prototyping

Learning objective	Activity
1	Explain that in this lesson students will complete the second part of the design process: Build. Refer to **Poster: The design process.** Explain to students will work in their groups from the previous lesson to build a rough prototype of their design. Remind the groups to have their **Worksheet 02: Specification** to hand. Using their lists of materials and equipment compiled in the previous lesson, ask the students to gather what they need to build the prototype. Task each group to work as a team to build a prototype of their design using prototyping material and equipment provided. Remind the students that they don't need to produce a perfect model straight away. Encourage the groups to test their product as they go along, to understand how a user would interact with it and identify any design flaws. Remind them that the design process is a cycle. Encourage them to work together to modify and improve their design as they encounter difficulties.

Wrap up: 10 minutes
Evaluating

Learning objective	Activity
1	Ask each group to present their prototypes to the rest of the class, identifying the following: – The problem – The solution – How it works – Who will use it Ask the students to re-visit their **Worksheet 02: Specification** and compare it to their prototype considering any further changes that could be made to improve it. **[Optional] An alternative to student presentations 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 invite a local engineer to come in and meet the students – and even judge the best prototyped solution.**

WORKSHEET 01: YOUR JOURNEY TO SCHOOL

Map out your normal journey to school in the space below. Circle where you might be most exposed to air pollution.

What's causing this air pollution?

What actions could you take to reduce your exposure to air pollution during your journey?

Extension: On your computer you can research the concentrations of air pollution you're exposed to on your journey to school using air quality monitoring websites such as **breezometer.com** or **waqi.info.**

WORKSHEET 02: SPECIFICATION

Name (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...