

# The Great *Exhibition* AT HOME

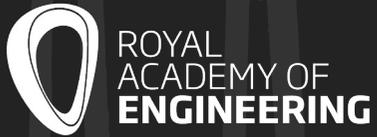


**BIG IDEAS**



ROYAL  
ACADEMY OF  
ENGINEERING

THIS IS  
ENGINEERING



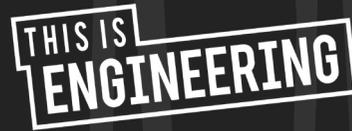
## The Royal Academy of Engineering

As the UK's national academy for engineering and technology, the Royal Academy of Engineering brings together the most talented and successful engineers to advance and promote excellence in engineering for the benefit of society.

We have three strategic priorities:

- Make the UK the leading nation for engineering innovation and businesses
- Address the engineering skills crisis
- position engineering at the heart of society.

We bring together engineers, policy makers, entrepreneurs, business leaders, academics, educators and the public in pursuit of these goals.



## This is Engineering

*This is Engineering* is a campaign to encourage more young people, from all backgrounds, to consider careers in engineering. Engineering is an exciting, varied, and rewarding career, and yet the UK has a shortage of young people applying for engineering courses and jobs. One of the reasons for this shortage is that many people hold outdated views of what engineering is, and what engineers do.

*This is Engineering* challenges these misconceptions by telling the story of real young engineers from a variety of backgrounds who are making a difference through engineering in a variety of ways. The campaign films and images bring engineering to life for young people across social media, and are free for anyone to use online, in the classroom and at events.

For more information about the campaign and to learn what engineering really looks like, visit the website and watch our short films at [www.thisisengineering.org.uk](http://www.thisisengineering.org.uk)

*This is Engineering* is led by the Royal Academy of Engineering in collaboration with Engineering UK and with the generous support of our partners.



## Royal Commission for the Exhibition of 1851

The Royal Commission for the Exhibition of 1851 awards some 35 postgraduate Fellowships and Scholarships a year, for advanced study and research in science, engineering, the built environment and design. It also makes a small number of Special Awards to support projects consistent with its overall aims. Many of these are focused on raising the awareness of the young to the opportunities presented by science and engineering.



## Big Ideas

Big Ideas creates programmes that encourage community participation, inclusion and cohesion across the arts, heritage, science and sport. We specialise in projects which bring groups together and create new experiences and relationships on a local, national and international scale. Change the way you see the world with Big Ideas.

# Foreword

The Great Exhibition of 1851 was an international celebration of innovation. To Prince Albert and his team of commissioners it was the ultimate demonstration of a modern world – fast moving and dynamic.

The Great Exhibition at Home Challenge is inspired by the wonder of such a momentous undertaking and the ambition of those involved. It provides an opportunity to connect schools and communities today in the spirit of the Exhibition of 1851, to look to the future and engineer a better world.

I'm looking forward to seeing what young people today make of Albert's story and the wonderful ways in which it will inspire them to create new inventions for 2020. We urgently need curious minds to address the challenges which we face today, none more urgent than the negative impact we are having on the environment.

Join us – and our friends at the Royal Academy of Engineering and Big Ideas – in activating and inspiring students across the country to get involved, and become a part of the legacy of the Great Exhibition of 1851.

**Nigel Williams**

Secretary, The Royal Commission for the Exhibition of 1851

## The Great Exhibition at Home partnership

The Royal Commission for the Exhibition of 1851 and The Royal Academy of Engineering have partnered to deliver The Great Exhibition at Home project with Big Ideas.

We would like to thank everybody who has been generous with their time and ideas during the development of this pack. We would particularly like to thank the fantastic engineers, who have allowed their work and research to be featured, and volunteered their time as part of a star prize for the competition winners.





Image: Interior view of Crystal Palace in South London. 1854.  
Delamotte, Philip Henry. © Victoria and Albert Museum, London.

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# The Great Exhibition at Home Challenge

Inspired by Prince Albert's original Great Exhibition, which showcased the most exciting technology and inventions from 1851, students across the country are invited to create a Great Exhibition in their own home! This year's challenge will address one of the big challenges we face...

## How can engineering help protect the planet?

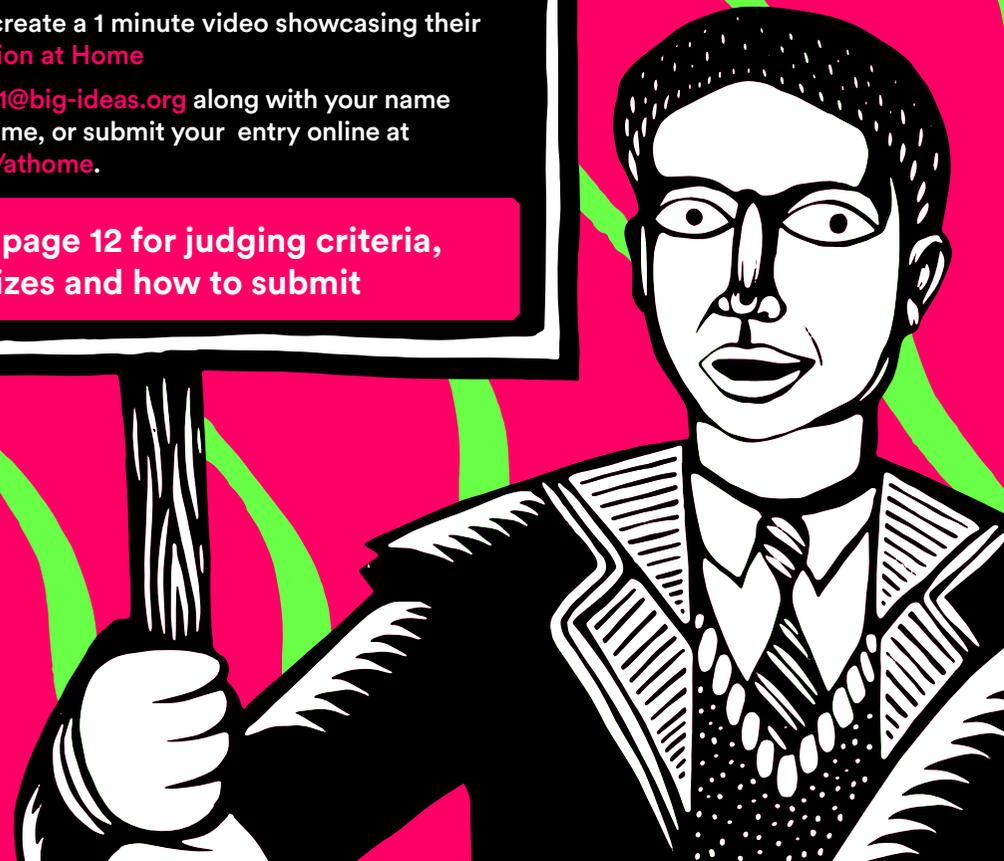
This resource pack contains information about the history of the Great Exhibition, the legacy of Prince Albert and some incredible engineering from 1851 and 2020. Use pages 1-13 to get an overview of the project and content, so that you can facilitate your students' learning – wherever your classroom may be! Pages 14-24 can be used as standalone pull out sheets, for students to work through. These provide further information and exciting activities.

Alternatively, you can spread the challenge over 7 weeks, culminating in our exciting video challenge with the chance of winning fantastic prizes. Go to our website [big-ideas.org/join1851/](http://big-ideas.org/join1851/) or sign up for our newsletter to access weekly challenge sheets.

## HOW TO TAKE PART

- All UK primary and secondary students and schools are welcome to take part in [The Great Exhibition at Home Challenge](#)
- The challenge is aimed at students aged 9 – 14, although younger and older children can be involved
- The challenge is suitable for wherever your classroom may be at this time, students can work alone or with friends.
- Participants take part in weekly engineering challenges using our digital, printable resources
- Participants create a 1 minute video showcasing their [Great Exhibition at Home](#)
- Submit to [1851@big-ideas.org](mailto:1851@big-ideas.org) along with your name and school name, or submit your entry online at [big-ideas.org/athome](http://big-ideas.org/athome).

Turn to page 12 for judging criteria, prizes and how to submit



# What was the original Great Exhibition all about?

In 1851, The Royal Commission, led by Prince Albert wanted to celebrate the global advances of the Industrial Age within the context of the British Empire and amongst the wider international community.

They decided to organise a worldwide showcase of modern technology, industry and design to be judged as part of a huge competition, named The Exhibition of the Works of Industry of All Nations, or The Great Exhibition.

Not only did they hope that such an exhibition would show that Britain had some of the leading engineers and innovators in the world, but also that the international exhibits would inspire and educate British manufacturers and the British public.

As the original World Trade Fair, The Great Exhibition is now considered one of the most memorable and influential cultural events of the 19th century.

Prince Albert  
championed the  
3 i's – innovation,  
inspiration  
and ideas

## PRINCE ALBERT FACT FILE

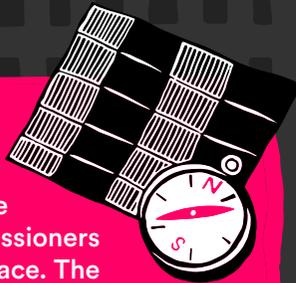
- Born in Germany **26 Aug 1819**
- Married to **Queen Victoria**
- **Loved photography**, Prince Albert's portrait from 1842 is the earliest surviving photograph of a royal family member



# Albert's Ingredients *for making a Great Exhibition*

## LOCATION, LOCATION, LOCATION!

There were no existing buildings large enough to house such a huge exhibition, so Prince Albert and his commissioners ordered the construction of the astounding Crystal Palace. The enormous glass structure was inspired by a greenhouse and designed by English gardener, Joseph Paxton. The entire Crystal Palace was erected in Hyde Park in under 5 months, an impressive feat of engineering. At 1,848 feet long, equivalent to 51 London buses, it became the largest building in the world at that time!



## WORLDWIDE WONDERS

Such an amazing space needed plenty of exhibits to fill it. By the opening ceremony on the 1 May 1851, over 100,000 exhibits from 13,937 exhibitors had been transported across land and sea from all over the globe. From a British printing press to a Canadian fire engine, guests to the Great Exhibition could marvel at materials, industry and inventions from far and wide. They were composed of four categories – Raw Materials, Machinery, Manufactures and Sculpture and the Fine Arts.



## CURIOUS CROWDS

More than six million people – equivalent to a third of the entire population of Britain at the time – visited the exhibition during its opening period between 1 May and 11 October 1851. The Exhibition attracted an average daily attendance of 42,831 with a peak of 109,915 visitors on 7 October 1851!



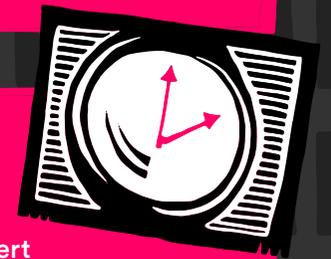
## ENGINEERING A BETTER WORLD

Visitors to the Great Exhibition marvelled at the cutting edge technology displayed, which hoped to revolutionise Victorian living. Prince Albert wanted his Exhibition to demonstrate how forward-thinking Britain was in 1851. He wanted to show how curiosity, research and progress could engineer a better world.



## BUILDING A LEGACY

The Exhibition was a great success, making a profit of £186,000 (equivalent to £159 million today)! Prince Albert and his Commissioners used this money to buy a large plot of land in South Kensington, at the time it was a market garden, and establish a cultural quarter in London. Nicknamed 'Albertopolis' by The Times, this iconic site still remains today. It includes world famous institutions such as The Royal Albert Hall, the Natural History Museum, the Science Museum, the V&A, as well as Imperial College London, the Royal Colleges of Art and Music and many more.

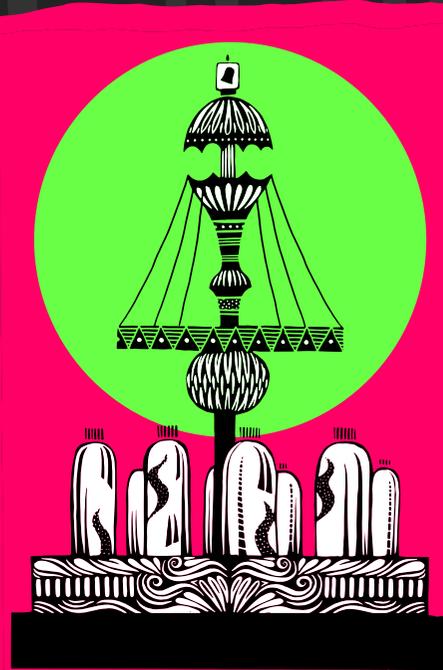


# Step inside the Crystal Palace

There were all manner of inventions, exhibits and curiosities shown inside the Crystal Palace. We have selected seven '1851ders' from more than 100,000 exhibits displayed at the original exhibition.

These inventions were cutting edge for their time and would have sought to tackle issues facing the Victorians. Take a look at the following exhibits and see examples of how participants can use these inventions from 1851 to think about one of the big challenges we face in 2020 - environmental concerns. These can act as a springboard for discussion, and a way to start thinking about the kinds of climate issues we are facing and how engineering can help.

For more information on each of the wonders Discover the Seven 1851ders on page 14



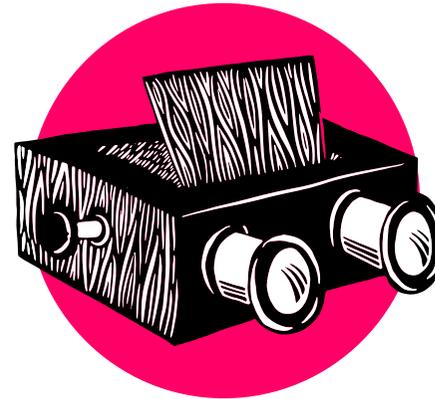
## TEMPEST PROGNOSTICATOR OR LEECH BAROMETER

*by George Merryweather*

Invention which used live leeches to predict the weather.

*How can predicting the weather be helpful?*

*Think about natural disasters and how we might engineer solutions for flooding.*



## STEREOSCOPE

*by Jules Dubosq*

Transformed two dimensional pairs of images into three dimensional images before the viewer's eyes. The 'original' Virtual Reality.

*How can we use technology to help educate people about the environment?*

*Think about social media, VR and spreading the word!*



## THE YACHT PIANO

*by William Jenkins*

A folding piano complete with collapsible keyboard to squeeze into tight spaces such as a yacht, saloon or ladies parlour.

*How can we be more environmentally conscious with the way we travel?*

*Think electric cars, fast trains and city bike initiatives.*



## THE COMICAL CREATURES

by Hermann Ploucquet

A display of stuffed animals doing distinctly human things, such as a frog carrying an umbrella and a pair of sword fighting mice.

*Why are animals finding it increasingly hard to survive on the planet and what can engineers do to help?*

*Think about rising sea levels, deforestation and fires.*



## PERFUME FOUNTAIN

by Eugene Rimmel

A beautiful exhibit which allowed ladies to try 'Great Exhibition Bouquet' perfume by spritzing their handkerchief in the fountain.

*How can fashion and cosmetic brands be more sustainable?*

*Think about engineering new fabrics and using natural cosmetic ingredients.*



## ALARM BED

by R.W. Savage

A silent alarm bed which would tip a sleeping person out of bed at a time of their choosing.

*How can technology and gadgets help us be more eco friendly in our day to day lives?*

*Think about keep cups and public transport.*



## PAID FOR PUBLIC TOILETS

by George Jennings

For the first time ever, Great Exhibition visitors could pay one penny to gain access to individual cubicles with flushing toilets.

*Why is waste an issue in 2020 and how can engineers help?*

*Think about recycling and different types of biodegradable plastic alternatives.*

# Introduction to engineering

The engineers of the Great Exhibition in 1851 hoped their inventions would influence the future. This is still the case for engineers today.

Engineers find solutions to problems, make things work and then make them work better. They apply Science and Maths to find solutions and use practical skills that can be learnt in Design and Technology to achieve this. Engineers need to be problem finders and solvers, think creatively and work well in a team. They can adapt their ideas and learn by making mistakes. Engineering is diverse and cutting edge. Engineering shapes the world around us.

To learn what engineering really looks like visit [thisisengineering.org.uk](http://thisisengineering.org.uk)

Here are some examples of the types of engineers who are working to create a better world:

## MATERIALS ENGINEERING

As a materials maker you shape the products of the future. Working in manufacturing and materials engineering, you could work out how to get the best out of all the materials available to us in the greenest way possible, turning raw materials into finished products. *Meet our engineering trailblazer Lucy on page 18.*

## MECHANICAL ENGINEERING

As a mechanical marvel you keep the world in motion. You could work in the field of mechanical or biomechanical engineering. Your work might involve anything from designing Formula 1 cars and building planes to creating artificial heart valves and developing prosthetic limbs. *Meet our engineering trailblazer Halvard on page 23.*

## CHEMICAL ENGINEERING

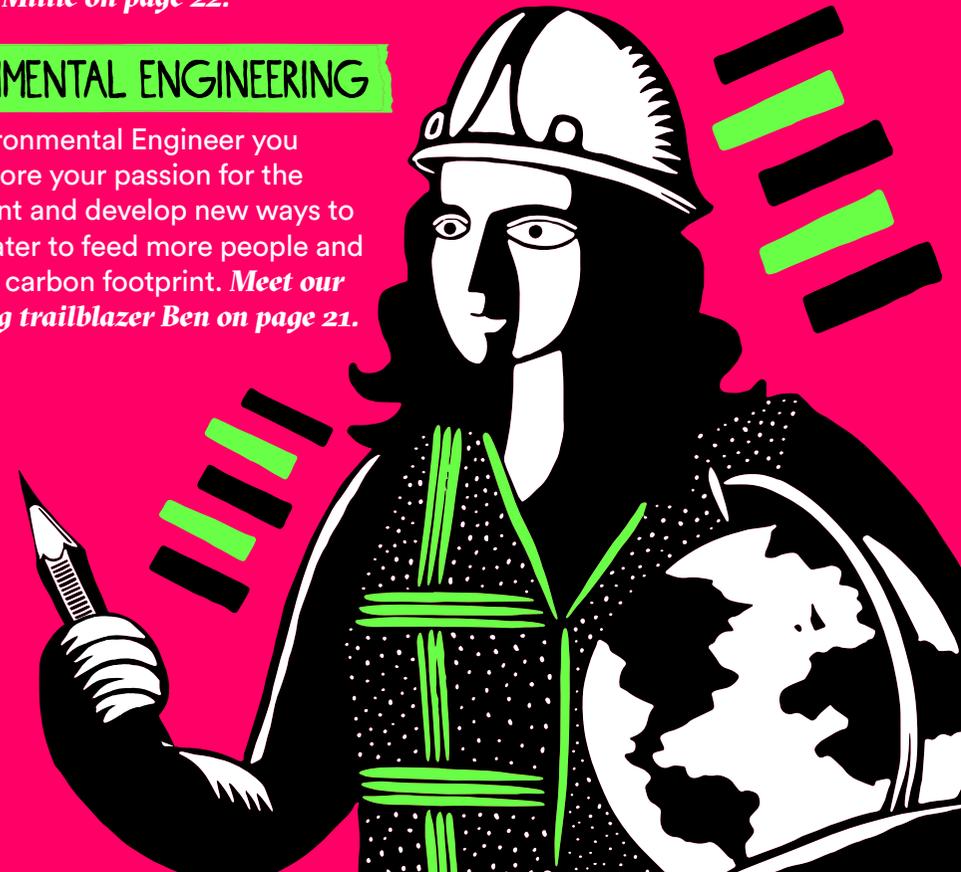
As an electron pioneer you improve every element of everyday life and turn raw materials such as oil into everyday products such as smartphones. You could be solving problems on a chocolate production line, creating new technologies to combat air and water pollution. *Meet our engineering trailblazer Enass on page 20.*

## CIVIL ENGINEERING

As a civilisation saver you create the cities of the future. You could use your civil and environmental engineering skills to keep us safe from flooding, design transport systems and construct hospitals, schools and sports arenas, while minimising the impact on our environment. *Meet our engineering trailblazer Millie on page 22.*

## ENVIRONMENTAL ENGINEERING

As an Environmental Engineer you would explore your passion for the environment and develop new ways to use less water to feed more people and reduce the carbon footprint. *Meet our engineering trailblazer Ben on page 21.*



# Engineering a better world

In the following table you can familiarise yourself with some inspiring engineers. Each of them is using engineering to address environmental issues. The table includes a summary of their work and their reasons for becoming engineers. From page 18 of this pack and in our student weekly worksheets, you will find profiles for each engineer. These will help participants learn about the engineers in more detail and provide activities to get them thinking.

Find out more about our engineering trailblazers at [thisisengineering.org.uk](https://thisisengineering.org.uk)

ENGINEER	PROBLEM THEY HAVE TACKLED	SOLUTION THEY HAVE FOUND
<b>Lucy Hughes</b>	Plastic waste	Created a new plastic substitute from fish waste
<b>Laurence Kemball-Cook</b>	Non-renewable energy sources	Created a device to harness kinetic power from footfall
<b>Dr Enass Abo-Hamed</b>	Lack of power to countries without an electrical grid	Developing a hydrogen battery that would be able to store clean and renewable energy
<b>Ben Crowther</b>	Farming uses too much land and water	Created a new way to farm which uses less water and pesticides
<b>Milly Hennayake</b>	Flooding damaging homes and communities	Developing environmentally friendly drainage system to keep people safe from flooding
<b>Halvard Grimstad</b>	Lack of food for a growing population	Helps to build agricultural robots for growing food

# What will we be looking for?

To enter the challenge a parent or guardian must submit their participants 1 minute challenge video presenting their Great Exhibition at Home by email to [1851@big-ideas.org](mailto:1851@big-ideas.org) or online at [big-ideas.org/athome](http://big-ideas.org/athome).

Entries will be judged against the following criteria:

## UNDERSTANDING

*(Scored out of 25)*

How much have you learnt about the original Great Exhibition and the Great Exhibition at Home 2020 engineers? How well can you demonstrate this learning through your own work?



## ENGAGEMENT

*(Scored out of 25)*

How is your video engaging your audience? Is it accessible and exciting?



## CREATIVITY

*(Scored out of 25)*

How are your ideas and your Great Exhibition original? We want to see creative ideas, enthusiasm and energy.



## SIGNIFICANCE

*(Scored out of 25)*

Why is it important to use science and engineering to protect the environment?



## DOCUMENTING YOUR EXHIBITION

Participants will need to create a video, no more than 1 minute in length. The video should showcase their **Great Exhibition at Home** and explain how they think it will tackle this year's challenge question: 'how can engineering help protect the planet?'. Send this to [1851@big-ideas.org](mailto:1851@big-ideas.org) or submit online at [big-ideas.org/athome](http://big-ideas.org/athome).

For further guidance on how to create, edit and submit your video visit [big-ideas.org/teacher-support](http://big-ideas.org/teacher-support). If you are experiencing technical difficulties please feel free to get in touch.

## EXHIBITION INSPIRATION

When thinking about what a Great Exhibition in your Home might look like, always remember Albert's 3 i's - innovation, inspiration and ideas! A Great Exhibition can be whatever you want it to be, but here are a few ideas to get you started...

- Hold an Exhibition in your bedroom, your garden, even a shoebox!
- Create a display about one of our engineers
- Design or make your own own invention
- Conduct an experiment and display the results
- Create an animation about engineering and the environment
- Run a campaign to reduce plastic in your household
- Display posters in your window for the rest of your street

## PRIZES

**Three winning schools will receive:**

- £500, £300 or £100 worth of equipment to supersize STEM subjects in your school
- A 30 minute meeting or video chat with one of the inspiring engineers featured in this pack for your school

**Three runners up will receive:**

- A 30 minute meeting or video chat with one of the inspiring engineers featured in this pack for your school

More exciting prizes to be announced!

## GETTING STARTED

On the following pages you will find a selection of pull out sheets for students participating in **The Great Exhibition at Home**. These give information about the 1851ders and our inspiring engineers with activities, suggestions and questions along the way. Participants can work through the book at their own pace, or use our separate weekly challenge worksheets to take part. These worksheets guide a 7 week project in which students learn about 1 invention and 1 engineer each week. This can be a great way to build up exhibits for your students to display at their **Great Exhibition at Home** which is the final video challenge in week 7.

# Discover the Seven 1851ders

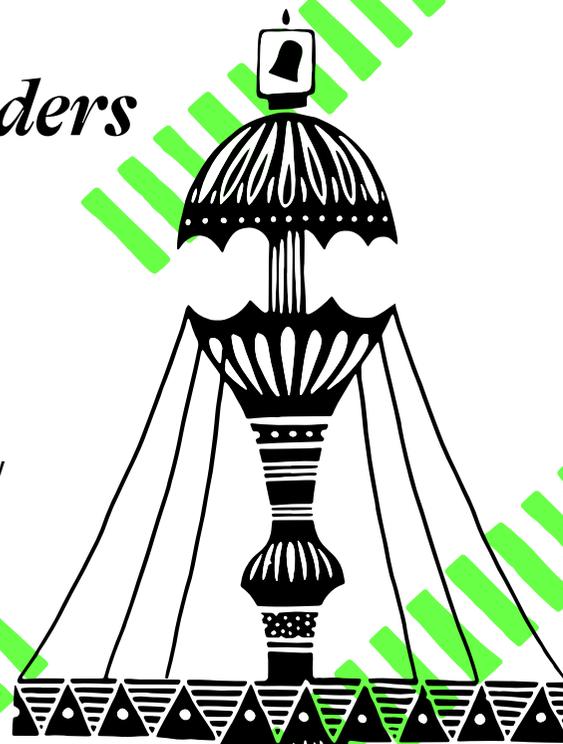
There were all manner of inventions, exhibits and curiosities shown inside the Crystal Palace - in fact there were more than 100,000 exhibits!

Victorian inventors of the day wanted to engineer exciting new ways to understand and improve the world. Use these seven '1851ders' from the Great Exhibition as a starting point to think about some of the environmental issues we face today and how we might use engineering to solve them...

1

## TEMPEST PROGNOSTICATOR OR LEECH BAROMETER

This invention by George Merryweather used live leeches to predict the weather. It worked by keeping twelve leeches inside twelve small bottles inside the device. When the leeches became agitated by an approaching storm they would attempt to wriggle up and out of the bottles, dislodging a piece of whalebone and triggering a small hammer to strike a bell. The likelihood of a storm could then be predicted by how many times the bell was heard.



Design a new invention to tackle extreme weather for your Great Exhibition!

Tell us about your invention. What is the name of your invention? What does it do? What is it made of? Why is it useful to people today?

Think about some of the extreme conditions we see in countries around the world, from flooding to fires.

Why is it helpful to predict the weather in 2020?

2

## STEREOSCOPE

The stereoscope was an exciting new device for viewing photography. It transformed 2D pairs of images into 3D images before the viewer's eyes. The 'original' virtual reality.

The original stereoscopic apparatus was invented in 1838 by Sir Charles Wheatstone, however it was not until the Great Exhibition that stereographs gained international recognition and became a real craze with the Victorians! Queen Victoria was said to be a great fan and was greatly impressed by the Stereoscope display by Jules Duboscq, a pioneering French photographer at the Great Exhibition. Stereographs of inside the Great Exhibition still exist today and allow us to imagine what it might have been like inside the Crystal Palace.



Yacht pianos gave Victorians a way to keep their travelling efficient and still be entertained.

Can you think of any exciting ways that people today can be more environmentally conscious in the way they travel?

The stereoscope helped to share the wonders of the Great Exhibition with Victorians who couldn't be there in person. Can modern technology help us educate people on environmental issues today in innovative ways?

## THE YACHT PIANO

Whatever the size of your yacht, it is not complete without a piano, or so William Jenkins, a British inventor and manufacturer, thought. His answer was to produce a folding piano complete with collapsible keyboard to squeeze into tight spaces. The clever design was exhibited at The Great Exhibition and inspired the manufacture of other Yacht Pianos to be stocked in London department stores. The first record player wasn't invented until 1877 so in 1851 musical instruments were an important source of entertainment – even at sea!

3

## Create your own Stereograph

Research different stereographs from the 1851 exhibition.

Create your own stereograph inspired by the topic of *the climate*. Send these to [1851@big-ideas.org](mailto:1851@big-ideas.org) for the chance to be featured on the 1851der app!

### How to create a stereograph

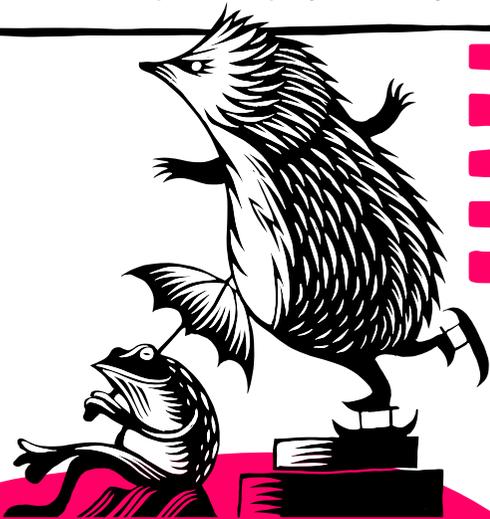
1. Stand with the camera pointed at the subject of choice and transfer the weight of your body to one leg
2. Take a picture
3. Keeping the camera pointed at the subject, transfer the weight of the body on to the other leg
4. Take another picture

For further instructions on how to create stereographs please visit [big-ideas.org/teacher-support](http://big-ideas.org/teacher-support).

4

## THE COMICAL CREATURES

A particularly strange exhibit found within the Crystal Palace was by German taxidermist Hermann Ploucquet. Visitors to the exhibition could peer at a display of stuffed animals doing distinctly human things, such as a frog carrying an umbrella, a pair of sword fighting mice and hedgehogs on ice skates! The display captured the imagination of the Victorians and even Queen Victoria herself described Ploucquet's display as "really marvellous".



Unfortunately even being able to sword fight wouldn't save animals from extinction in today's climate. See if you can find out more about why animals are finding it increasingly hard to survive on the planet. What can engineers do to help?

5

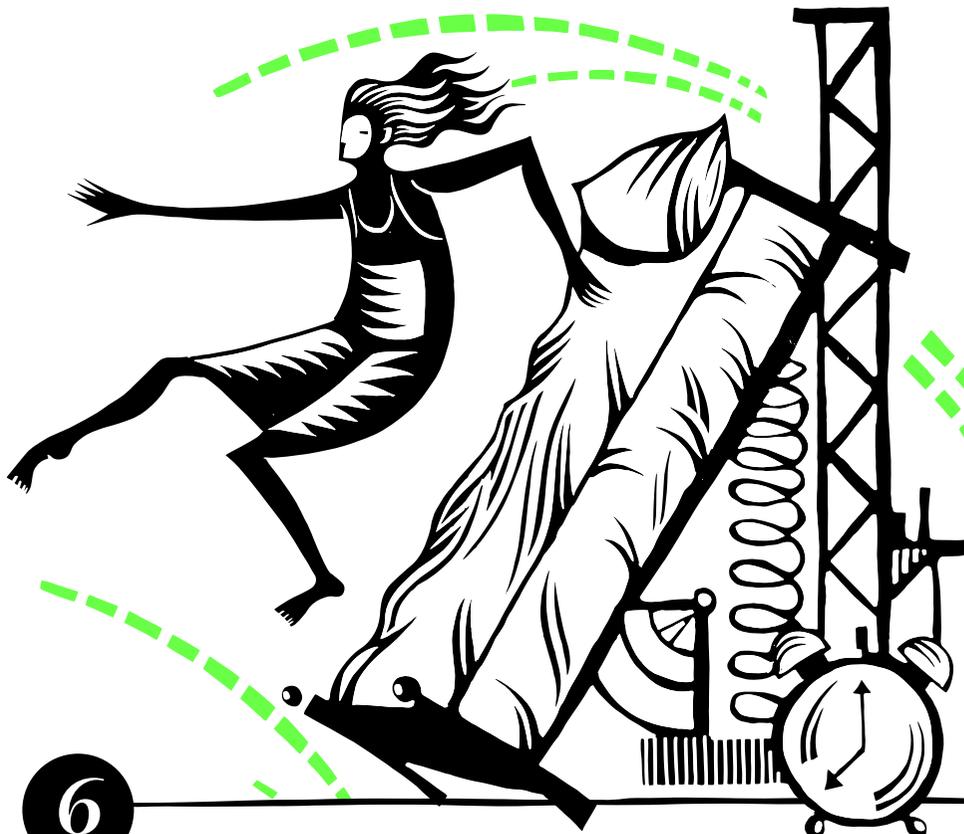
## PERFUME FOUNTAIN

Eugene Rimmel, a perfume maker, who was born in France but lived in England for most of his life, created a giant fountain for The Great Exhibition. The fountain sat on top of a splendid base featuring glass cases filled with bottles of 'Great Exhibition Bouquet' perfume. If the stylish bottles didn't convince customers, then ladies could try the perfume on their handkerchiefs – by asking for a spritz from the fountain itself!



You may recognise Eugene Rimmel's name. Although he died in 1887, the cosmetics brand that he created, Rimmel London, is still sold around the world today.

How can cosmetic brands be more sustainable? Chemical engineers are working to find Eco-friendly alternatives for beauty products. Can you create your own perfume using all non-toxic ingredients and 'waste smells'? For example, using discarded orange peel to create a citrus scent!



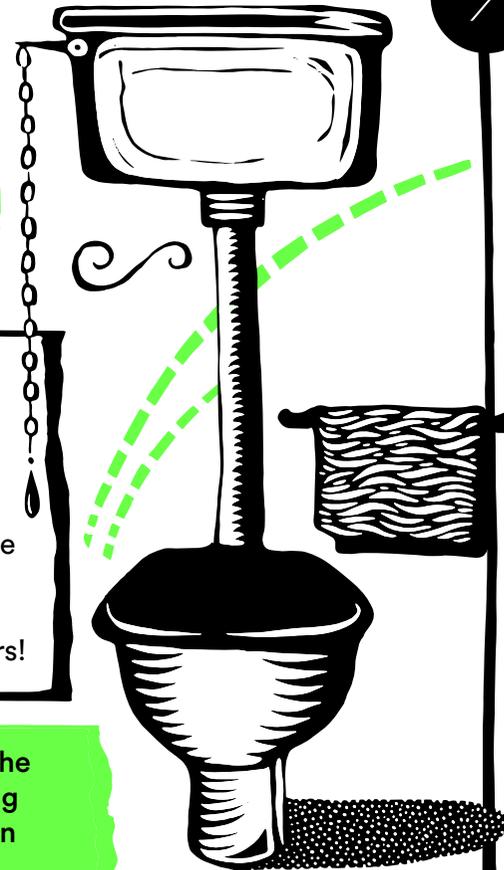
## ALARM BED

One of the most intriguing inventions at the Great Exhibition was a silent alarm bed. This contraption worked through a mechanism, that when connected to an alarm clock would tip a sleeping person out of bed at a time of their choosing. One suggestion by its inventor, R.W. Savage, was that the bed might tip people into a bath of cold water. This slightly soggy method wasn't actually tested in the Crystal Palace – a relief for unsuspecting visitors!

This 1851<sup>der</sup> didn't take off after the Great Exhibition but it captured the imagination of visitors. There are even more inventors in 2020 making weird and wonderful technologies to help improve our lives. How can these gadgets help us to be more eco-friendly day to day?

Although our services and hygiene have improved since 1851, waste disposal is still an issue we face today. From recycling to biodegradable plastic alternatives, engineers are working to reduce and reuse all the things we throw away.

Can you find a new use for rubbish waste in your school or home? Plastic bottles, tin cans, these are all materials which can be repurposed – what will you make?



## PAID FOR PUBLIC TOILETS

In 1851, for the first time ever, individual cubicles with flushing toilets became available for members of the public to use. Before then, flushing public toilets for men were not available and public toilets for women didn't exist at all! Engineer George Jennings, a plumber from Brighton, installed the first paid-for flushing public toilet at the Great Exhibition, where visitors spent one penny for the luxury of a clean toilet seat, a towel, a comb and a shoe shine. This was the start of the phrase 'spend a penny' – although records show that during the original Great Exhibition 675,000 pennies were spent, an expensive trip to the loo!

# Lucy Hughes

Lucy Hughes is a 24 year old engineer from the UK. While studying product design at the University of Sussex, she developed an exciting new material called MarinaTex, which is causing waves in the engineering industry.

## What is MarinaTex?

MarinaTex is a new material which could provide an alternative to plastic packaging. Unlike plastic, MarinaTex can biodegrade in just 4-6 weeks and does not give off harmful chemicals meaning it is suitable for home composting.

## How can MarinaTex help the environment?

Our current world is dependent upon single use plastic in our everyday lives. The lifespan of plastic is not suited for this purpose – it is estimated that a plastic bottle may take 450 years to biodegrade! With endless waste building up at landfill sites it is becoming more and more urgent to find new materials to replace plastic which do not have the same environmental footprint.

## What is MarinaTex made from?

It is made using 100% organic materials. The main components are sourced from the sea. This includes agar from red algae and proteins from fish processing waste. In the UK alone, 172,702 tonnes of fish waste is produced annually from land based processing. Repurposing waste in this way means MarinaTex aims to work within a circular economy rather than adding to the problem.

## How did Lucy create a new material?

Lucy noticed that there were lots of waste materials in the fish processing industry that were unused. She researched the different waste streams and she discovered that fish skins and scales had the most potential locked up in them, due to their flexibility and strength enabling proteins.

However, in order to give these proteins something to attach to and create a brand new material she had to find an organic binder. Keen to keep the solution local in order to reduce transportation, she looked to the Sussex coastline, experimenting with different organic marine binders before finally settling on agar. It took over 100 different experiments to refine the material and process, most of which she did on the kitchen stove of her student accommodation.

## NOW IT'S YOUR TURN

If you were designing a new material what would it be used for? How would it be environmentally friendly? What problem would it seek to solve?



# Laurence Kembball-Cook

Laurence founded Pavegen after graduating from Loughborough University. Since then his invention, which converts people's footsteps into energy, has captured over 1/2 billion footsteps.

## What is Pavegen?

Pavegen is a smart flooring system which harnesses the kinetic power of people's footsteps and converts it into off grid energy and personalised data.

## How does it work?

As people step on the top surface, their weight causes generators underneath the tiles to rotate, creating off-grid power via electromagnetic induction. Electromagnetic induction involves magnets moving around a coil of wire to create an electrical current. All magnets have a south pole on one end and a north pole on the other end. Poles which are the same repel and push away from one another whereas opposite poles attract, pulling towards each other. By alternating push and pull at timed intervals the magnets will rotate around the coil of wire producing an electrical current. It is this energy that can be harvested to power things such as lights!

Pavegen walkways also have integrated Bluetooth sensors built into their tiles that capture and analyse data such as the number of steps and energy harvested.

## How can Pavegen be used?

Pavegen has been installed over 200 times around the world, helping big and small communities with LED lighting, environmental sensors, and charitable donations from footsteps.

In 2019, Pavegen built an energy-generating running track in a Hong Kong office building. This meant that workers exercising during the day could help to power lights inside the office from their steps.

## How can Pavegen help the environment?

Not only are we running out of non-renewable energy sources such as fossil fuels, but changing our everyday behaviours to combat global warming with renewable energy is harder than ever. Consequently finding alternative ways to generate energy and change our habits takes a long time. Pavegen offers a smart energy that puts people at the heart of its technology, empowering citizens to make their city greener.

**NOW IT'S YOUR TURN**

**Can you think of a new way to generate renewable energy?  
Would it utilise weather, humans or machines?**



# *Dr Enass Abo-Hamed*

Enass, is an activist, business woman and entrepreneur from Palestine. She co-founded H2GO, an engineering company developing new ways to store clean energy at the age of just 28.

## **What is H2GO?**

H2GO power is an energy storage company that provides long term storage for renewable energy in the form of hydrogen. It provides an efficient and cost effective alternative to electrical and gas grid networks.

## **How does it work?**

H2GO Power's Plugnplay (PnP) units are the size of a standard shipping container which can be transported worldwide for use in permanent or temporary cases. Designed to take in renewable energy and store it as hydrogen for long duration (over 8hours), the PnP units then release power on demand (conversion using fuel cells or engines). AI algorithms then provide cost-efficient management and optimal storage/response operations.

Through the use of a water electrolyser, the unit splits water to produce hydrogen. The hydrogen is then stored until needed. During periods of unmet demand, the storage units release hydrogen to the fuel cell with its output being electricity and water as the only by-product.

## **Why does the world need H2GO?**

Over 1 billion people in the world don't have regular access to electricity. Being able to store energy for a long period of time allows people to keep a supply of energy to use when access fails. Without building new power stations or a power grid.

## **How can a hydrogen battery benefit the environment?**

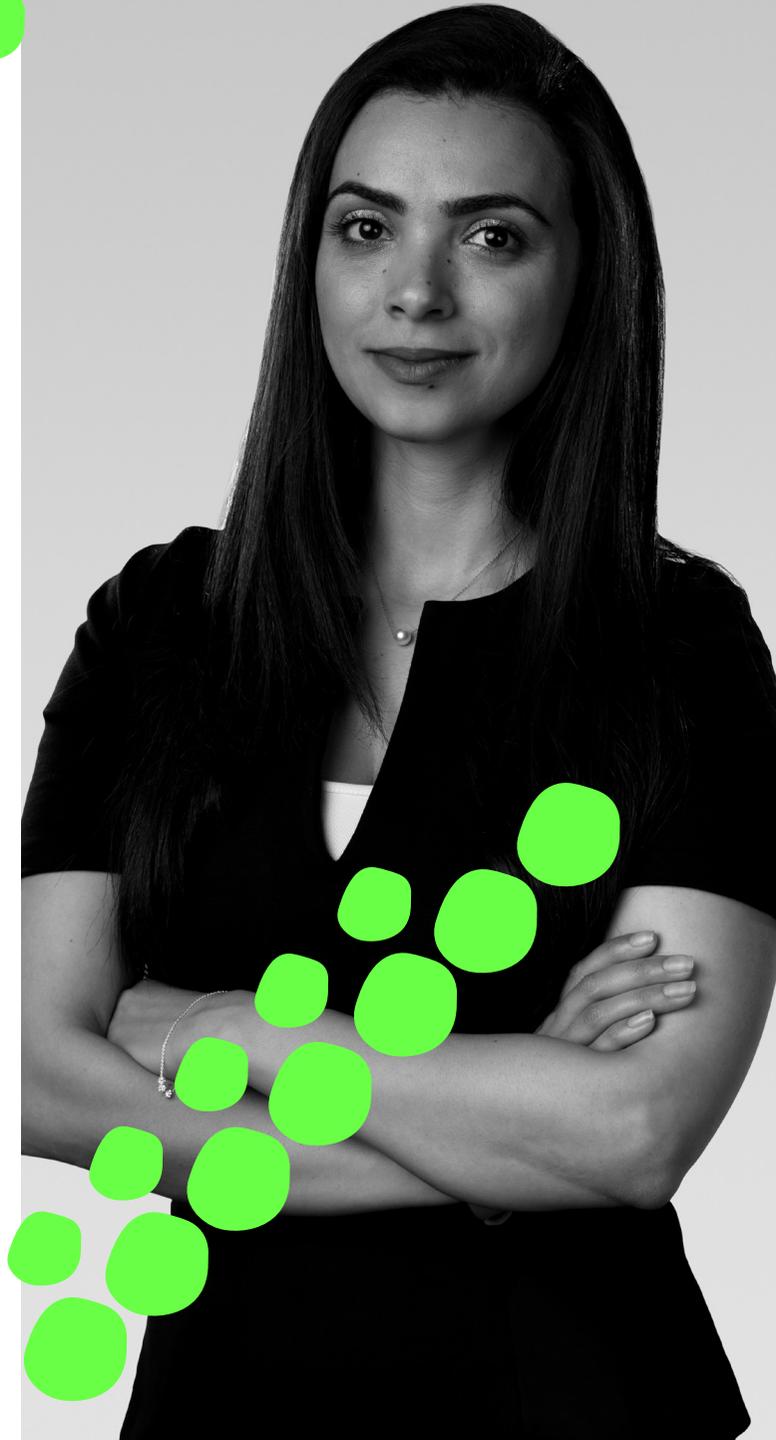
The only waste product of H2GO's hydrogen batteries is water. The waste products of many electricity sources are Carbon Dioxide and Nitrogen Oxide, which are toxic and contribute to global warming.

Enass believes that there is 'scope for hope' in the future, her engineering work focuses on sustainable energy solutions that are accessible for everyone.

*Learn more from Enass at [bit.ly/2TBKSun](https://bit.ly/2TBKSun)*

## **NOW IT'S YOUR TURN**

**Can you identify a climate issue in another country and engineer a sustainable solution? Do some research and get designing!**



# Ben Crowther

Ben is a young engineer from Reading who is passionate about the environment. After studying engineering design at the University of Bristol he co-founded LettUs Grow with two friends from university who were equally passionate about reducing food waste and CO2 emissions.

## What is LettUs Grow?

LettUS Grow is a company who have developed a new method of farming which uses less water, needs no pesticides and can be set up anywhere in the world: from cities to deserts.

## How does it work?

Instead of growing plants in soil, LettUs Grow cover the roots of their plants in a mist filled with nutrients. This means the plants need 95% less water to grow than traditional agriculture!

This unique style of growing means the beds can be placed under a light source of either the sun or LED lamps so it can be used in greenhouses or basements. The system dramatically reduces the operational cost of indoor agriculture, whilst delivering an average of a 70% increase in growth rate across a range of crop species.

## How can LettUs Grow help the environment?

This new style of farming helps to address some of the biggest environmental concerns facing our world – CO2 emissions, waste, ecosystem collapse and food security.

Due to our growing population food production needs to increase by 70% by 2050 to feed the nearly 10 billion people living on earth. As a consequence we must find new ways to grow food with less land and an unstable climate. LettUs Grow's methods are more efficient and sustainable than current methods and encourage people to grow their food locally rather than having food travel to get to plates.

*Learn more from Ben at [bit.ly/3asHglv](http://bit.ly/3asHglv)*

## NOW IT'S YOUR TURN

How could you tackle environmental concerns through food? Could you think of a new way to grow food, like Ben? Or experiment with growing something of your own. Why not try growing cress in your home – grab some soil, seeds and a plastic tub or pot!



# Milly Hennayake

Milly is a civil engineer who is passionate about using her skills to keep communities safe. Milly grew up living in Sri Lanka and the UK before going on to study Civil Engineering at the University of Cambridge. She is now a civil engineer in the water engineering team at Arup.

## What does Milly do as a civil engineer?

Milly works with other experts to manage flood risk to communities. As part of this, she designs drainage systems to stop water from building up, keeping people's houses safe and dry even after big storms. While doing this she ensures that her designs leave a minimal impact on the environment. In fact, Milly works with nature: from rivers and lakes, to trees protecting river banks to manage rainwater in storms.

## Why did Milly get into civil engineering?

Milly didn't always know she wanted to be an engineer. Growing up she considered going into medicine like her parents, however, she decided to pursue civil engineering when she realised that she would be able to make real impact on people's lives and the world around her.

Milly began by volunteering for a charity called Engineers Without Borders UK. It was here she discovered the ways in which engineers work in developing countries to help people access clean water and improve health with safe sanitation and drains, among many other things.

## Why is Milly's work important for the planet?

With extreme weather conditions worsening around the world, it is so important that engineers work together to keep our homes safe. As global warming causes ice caps to melt, our sea levels are rising meaning the risks of flooding are higher and Milly's work is becoming ever more important. Finding clever ways to work with nature and live alongside this weather without disruption will help us all live comfortably.

Learn more from Milly at [bit.ly/2ThzK76](https://bit.ly/2ThzK76)

NOW IT'S YOUR TURN

Can you think of a way that nature could help to solve a problem in your community sustainably?



# Halvard Grimstad

Halvard is a robotics engineer from Norway. He decided to study mechanical engineering because he loves putting things together and knowing how things work. Halvard now works for a company called Saga Robotics and is using his skills to create robots that will revolutionise farming.

## What do these robots do?

The agricultural robots which Halvard works on help to do farming work to grow our food. They are complex mechanical structures who can do a variety of agricultural tasks such as ploughing and weeding, to picking strawberries and testing the soil. They are also designed to work on lots of different terrain and can be quickly customised to work in various environments such as greenhouses, tunnels, open fields or orchards!

## How does Halvard help to make them?

As a robotics engineer, Halvard's work is different every day. He helps to design sensors and gadgets and gets to help build the robots in the workshop as well as test them out in the field. One day he will be in the lab and the next out at a school talking to children about robots!

## How can agricultural robots help the environment?

Halvard's work uses robots that are able to farm in an effective and sustainable way by precisely measuring water and soil. With the world's population growing rapidly we need to find ways to grow more food! Farming is a difficult skill, and the better we are at using the land and growing sustainably the healthier our fields will be.

*Learn more from Halvard at [bit.ly/zvzLybU](http://bit.ly/zvzLybU)*

## NOW IT'S YOUR TURN

Think about the sustainability of your meals. Is there a way to minimise waste in your school or home kitchen? Can you calculate the food miles of your lunch this week by finding out where your food has come from?

Find out more about all our engineering trailblazers  
at [www.thisisengineering.org.uk](http://www.thisisengineering.org.uk)

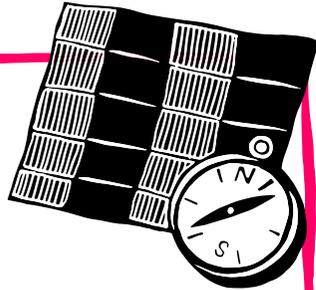


# How to make your own Great Exhibition at Home!

Now you have learnt all about our inspiring engineers and the original Great Exhibition it's time to start thinking about making your own, to present for your 1 minute film entry. Use Albert's key ingredients to make your exhibition truly Great!

## LOCATION, LOCATION, LOCATION!

You may not be able to build your own Crystal Palace but think carefully about where you would want to hold your exhibition – you could hold it in one room, across lots of rooms in your home, in a garden or even design a new fantasy space!



## TICKET

### CURIOUS CROWDS

The Victorians were truly amazed by everything they saw at The Great Exhibition. Think about who you could share yours with – you could video call a classmate, or family member and present your exhibition to them. Think about Curious Crowds when submitting your video entry - the judges will be excited to hear from you!

### A LASTING LEGACY

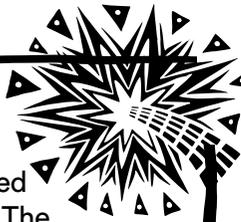
Engineering is all about working to build a better future. The Great Exhibition had a huge and lasting impact and our engineers are working hard today for a better tomorrow. Consider what the impact of your Great Exhibition is, for you, your school and for the planet!



## WORLDWIDE WONDERS

Prince Albert's exhibition included exhibits from all over the world. The different exhibits reflected the various skills, materials and resources of each nation.

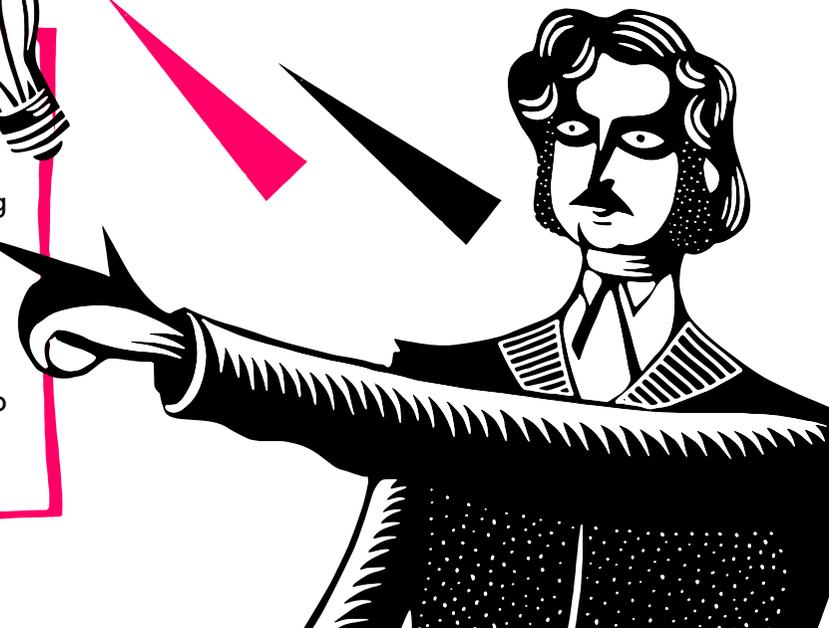
You could even consider how engineering is used to address the different climate issues faced in different countries around the world.



## ENGINEERING A BETTER WORLD

The original Great Exhibition was all about progress, developing technologies and using engineering to tackle problems of the day. Use your exhibition to create innovative solutions to one of the biggest challenges that our world faces today, climate change.

Learn more about trailblazing engineers who are already developing sustainable solutions in this pack.





# Take this further...

## Stay Connected

The Royal Academy of Engineering's Connecting STEM Teachers programme aims to create a national network of support for teachers across all STEM subjects, ensuring they have the knowledge and confidence to engage a greater number and wider spectrum of school students with STEM. Central to the success of the programme is the work of the Academy's Teacher Coordinators (TCs) who lead support networks for local STEM teachers across the UK.

To find out more about the benefits of joining the network and the location of your closest TC visit [tinyurl.com/STEM-Teachers](https://tinyurl.com/STEM-Teachers)

## STEM Project resources

Our resources have been developed by teachers and engineers to be used in schools for pupils aged 9-14. The resources provide thematic learning activities to support and add context to the national curriculum. They can also be used in STEM clubs or school challenge days. An important aim of each resource is to enable teachers and STEM leads to engage their students with STEM through hands-on activity and stimulating engineering content. You can download these at [stemresources.raeng.org.uk](https://stemresources.raeng.org.uk)

To join the network and receive free training and resource boxes contact [education@raeng.org.uk](mailto:education@raeng.org.uk)

## Big Ideas

To get involved with more exciting educational projects visit [big-ideas.org](https://big-ideas.org)

## The Engineers

Listen to interviews with three of the world's greatest engineers recorded with public audiences. Search "[The Engineers The World Debate BBC](#)" to find links to programmes exploring civil engineering, robotics, genetic engineering and engineering space flight. The Engineers is a partnership between the BBC World Service and The Royal Commission for the Exhibition of 1851.

## The Royal Commission for the Exhibition of 1851

To learn more about the history of the Great Exhibition and its legacy today visit [royalcommission1851.org](https://royalcommission1851.org)

## This is Engineering

Join the campaign and share *This is Engineering* films and case studies with pupils in your school. Watch the films and visit the website at [thisisengineering.org.uk](https://thisisengineering.org.uk)

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© Big Ideas – you are welcome to use and copy all the materials in this resource pack to take part in the project





**BIG IDEAS**



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