Royal Academy of Engineering

THIS IS ENGINEERING

ENTERTAINMENT

Teacher Guide

Engineering is at the cutting edge: from artificial intelligence and gaming, to advanced sports equipment and creating the future of film and music.

Find stories of inspiring engineers and bring the work that they do into your home or classroom.

ABOUT THIS RESOURCE

THE THIS IS ENGINEERING: ENTERTAINMENT STEM (SCIENCE, TECHNOLOGY, ENGINEERING AND MATHS) RESOURCE EXPLORES THE ESSENTIAL ROLE THAT ENGINEERS PLAY IN THE ENTERTAINMENT INDUSTRY.

Engineering is at the cutting edge: from machine leaning, artificial intelligence and gaming, to advanced sports equipment, CGI, designing hi-tech sets and materials, and music production.

Engineers create incredible devices, software and systems that make the impossible possible. Using phones, apps, games or virtual reality, young learners can be part of how technology shapes the future.

Through a series of creative and collaborative challenges, students will develop enquiring minds and teamworking skills and are encouraged to find imaginative approaches to problem-solving, understanding the role STEM-based learning plays in real-world engineering scenarios.

***This is Engineering*: Entertainment** asks young learners to express and share their thoughts and ideas, to be curious, experiment, find their own passions and interests, and to understand, change and make a difference in the world around them.

Activities and challenges range from tracking sporting data, exploring the fourth dimension and creating light displays, to investigating synthetic beats and producing a scene from a horror film.

In response to COVID-19 and the changing needs of schools in this academic year, schools will be sent individual packs for students containing materials needed for the different challenges.

All activities will also be available for free on the Academy website and will be part of our STEM at Home series.

Tell us what you think...

Take our short survey for a chance to win £500 of robotics/coding equipment for your school.

Scan the QR code on your phone, or go to
stemresources.raeng.org.uk/teacher-survey

TEACHER NOTES

This resource is designed to provide practical and contextualised applications where students and teachers can see the role that STEM-based learning plays in real-world engineering scenarios.

Each of the activities and challenges have links across science, maths and design technology. However, some activities will be more heavily weighted towards one subject more than others.

Don't worry! Experience, or subject knowledge around engineering or any STEM subject is not required. The resource has been designed to allow students to learn independently and at their own pace, with your support as a facilitator not a subject expert.

Further investigation

We want to make the resource as inclusive and accessible as possible. Although we provide physical hands-on materials in each of the individual student packs, all the challenges can be adapted to use items that are easy to find around the house or in most classrooms.

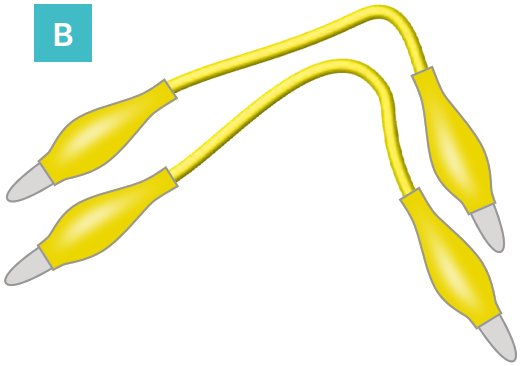
Both the student and teacher guide are available online for free:
stemresources.raeng.org.uk/this-is-engineering-entertainment

WHAT'S IN THE PACK?

- A Bumble Beep
- B Croc leads x two
- C Coin cell battery
- D Light dependent resistor
- E RGBug
- F Perspex sheet
- G Dowels x 15 and nuts x 30 (approx.)
- H Game tokens x six

A

B



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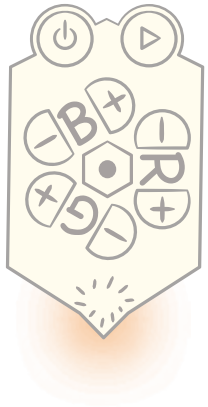

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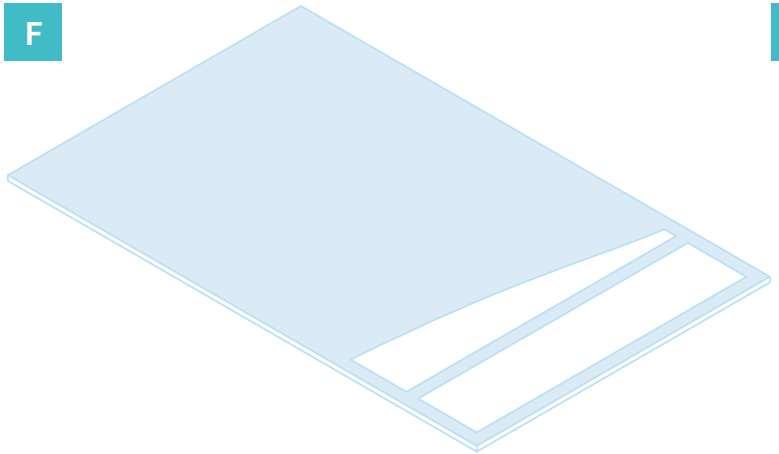

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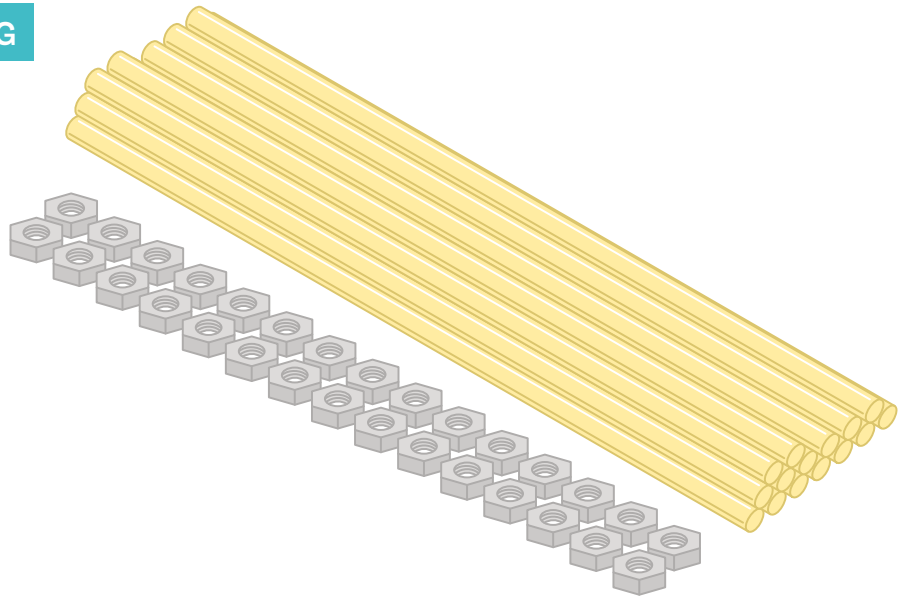

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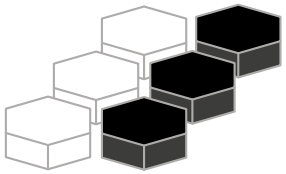
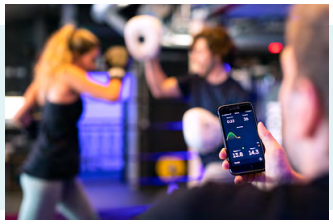


CHALLENGES

Sports and engineering

Track your skip



Sporting data

VR gaming and engineering

Enter the fourth dimension

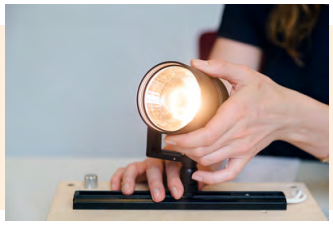
Computer always wins

Broadcasting and engineering

All about the sound

Synthetic beats

Lighting and engineering



Setting the mood

Visual effects and engineering

Creating a horror scene

The full production

CURRICULUM LINKS

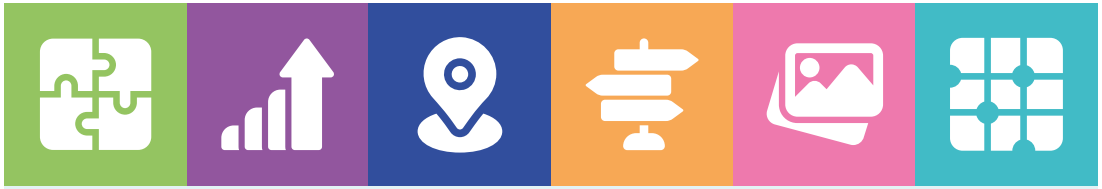
The activities and challenges bridge several subjects across the STEM curriculum. However, for ease of reference, these have been linked to one or two specialisms only.

Age group is given as a guide and activities can be extended or broken down depending on the group.

More information about the national curriculum in England **can be found here**.
More information about the Scottish Curriculum for Excellence **can be found here**.
More information about the Curriculum for Wales **can be found here**.
More information about the Northern Ireland Curriculum **can be found here**.

Activity	Subject	Age group	Curriculum link
Track your skip	*Maths*	11–14	I can display data in a clear way using a suitable scale by choosing appropriately from an extended range of tables, charts, diagrams, and graphs making effective use of technology.
Sporting data	*Maths*	7–14	I can interpret data using appropriate graphical methods. Having discussed the range of media used to present data, I can interpret and draw conclusion from information displayed, recognising that the presentation may be misleading.
Entering the fourth dimension	*Maths*	7–11	I can identify and describe the properties of 3D shapes, including the number of edges, vertices and faces.
		11–14	I can use the properties of faces, surfaces, edges, and vertices of cubes, cuboids, prisms, cylinders, pyramids, cones, and spheres to solve problems in 3D.
Computer always wins	*Computer science*	7–11	I understand how computers process information through simulating machine learning.
	Maths	9–14	By exploring algorithms I can build a machine-learning model.
All about the sound	*Science*	11–14	Investigating frequency and size of soundwaves and how it shows volume and pitch. Exploring reflection and absorption of sound.
Synthetic beats	*Science*	7–11	I can describe an electric circuit as a continuous loop of conducting materials and can combine components in a series circuit to make a model.
Setting the mood	*Science*	11–14	By exploring mixing of coloured lights, I can use my knowledge of the properties of light to show how it can be used in a creative way.
	Design technology	7–14	I can use graphic techniques to communicate ideas experimenting with colour to enhance my work.
Creating a horror scene	*Science*	7–14	By exploring reflections, I can use my knowledge of the properties of light to show how it can be used in a creative way.
The full production	*Design technology*	7–11	I can design and construct models and explain my solutions.

ENGINEERING HABITS OF MIND

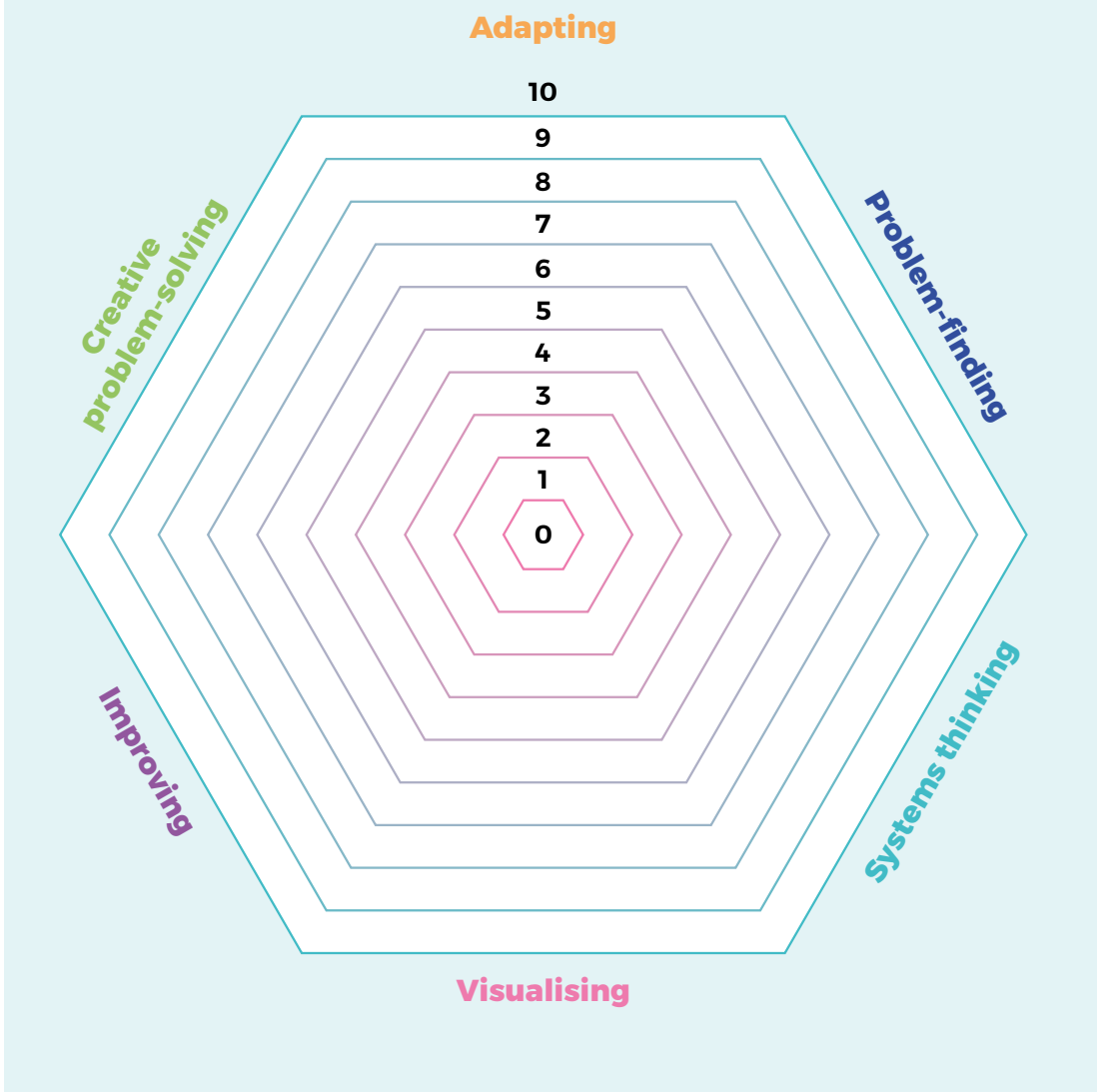


THE ACTIVITIES PRESENTED IN THIS RESOURCE ARE DESIGNED TO BE INTERACTIVE, OPEN-ENDED, ENCOURAGE DISCUSSION AND PROMOTE THE ENGINEERING HABITS OF MIND (EHOM).

The EHoM encourage the use of a pedagogical approach that cultivates problem-solving skills, creativity, making mistakes, reviewing, and planning.

There is no prescriptive teaching method, and it is up to you as a teacher, educator or STEM club leader to decide on which direction you wish to take each activity and where you may wish to spend more time.

Read the full report *Thinking like an engineer* here.



Engineering habits quiz

In the student booklet, we have called the EHoM 'engineering habits' and have included student statements that aim to bring the EHoM to life for young learners.

Students can take the engineering habits quiz to identify what engineering habits they are using, and perhaps ones they would like to work on.

Once students complete the quiz, they can see their results on the EHoM spider diagram and can easily pick out their engineering strengths.

Results are not fixed! We encourage young learners to complete the quiz several times.

They might find that different engineering habits are stronger depending on the type of activity or challenge they are doing.

We have included all the EHoM student statements for both you and young learners for reference and to use in different lessons and activities.

Find the engineering habits quiz on the *This is Engineering:* Entertainment page on our resource hub.

ENGINEERING HABITS – STUDENT STATEMENTS

I AM GOOD AT...

Creative problem-solving

- Coming up with lots of new and good ideas
- Working successfully in a group
- Taking on board other people's ideas and using them
- Making detailed mind maps
- Thinking first before doing something

Improving

- Making what I have done better
- Experimenting with things just to see what happens
- Working hard and practising to get better, even when it's tricky
- Working out what I need to do to improve
- Sticking at doing something until it's the best it can be

Problem-finding

- Thinking about the world around me and how it could be better
- Finding out why something does not work
- Finding mistakes in mine and other people's work
- Checking and checking again until I am happy
- Asking lots of questions to make sure I understand

Adapting

- Deciding how something could be done differently
- Explaining how well I am doing to my teachers or friends.
- Evaluating how good something is
- Behaving appropriately in different settings
- Sticking up for what I think when talking with other people

Visualising

- Thinking out loud when I am being imaginative
- Making a plan before I start work
- Practising something in my head before doing it for real
- Explaining my ideas to other people so they understand
- Making models to show my ideas

Systems thinking

- Spotting patterns and working out what comes next
- Using ideas from one subject in another
- Putting things together to make something new
- Spotting similarities and differences between things
- Working out the possible consequences of something before they happen

The quiz and student statements are based on EHoM research supported by the Royal Academy of Engineering and published in Hanson, J., Hardman, S., Luke, S., Maunders, P. & Lucas, B. (2018) **Engineering the future: training today's teachers to develop tomorrow's engineers**. London: Royal Academy of Engineering.

STEM BADGES

DIGITAL STEM BADGES REWARD LEARNERS FOR THEIR COMMITMENT TO STEM.

The activities in the student booklet require students to demonstrate their engineering habits such as problem-solving, working independently and in a team, communicating, investigating, reflecting, and evaluating.

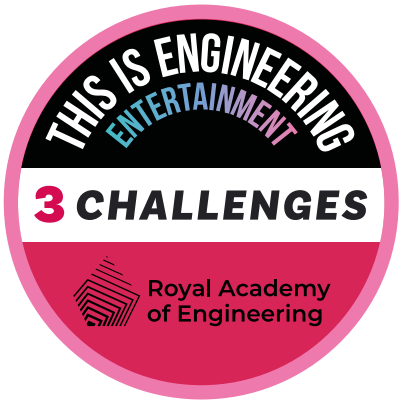
For each activity they complete from this booklet, we want them to think about which engineering habits they think they have been using and mark this out on our STEM badge tracker.

Once they have completed enough of the activities and challenges, they can cash them in for STEM badges!

The badges are digital meaning they can link them to their online profiles and applications and, best of all, they can't ever lose them!

By completing the 'This is Engineering' activities and claiming the badges your students can quickly progress to Global STEM Awards from STEM Without Borders.

More activities, pathways and information on progression at http://globalstemaward.org.



How do students collect badges?

For each challenge they are working on, mark up to three engineering habits they have been using on the STEM badge tracker. Once they have completed three activities, they can come and share what they have been working on with you, their teacher.

Then it's easy! Visit our online platform where you can tell us what challenges your students have completed and share one or two examples of their work with us.

Visit rae.mindsetsonline.co.uk to submit your students' work and apply for badges.

Assessment

The EHoM statements can be used as a guide for what we believe counts as engaging with, and positively contributing to, the challenges set.

Students can demonstrate these habits to you through:

- observation during time spent working on the challenges
- students presenting their work
- verbal feedback.

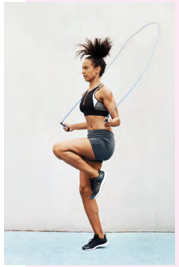
We have provided students with a set of questions to help them share their work with you and reflect on the engineering habits they have been using. Feel free to adapt these to suit your learners and the challenge they are completing.

- What problem did you solve?
- Which engineer or area of engineering does this challenge relate to?
- What did you discover from working on this challenge?
- Which engineering habits did you use?
- Did you work in a team or independently?
- What worked well?
- How could you improve this?

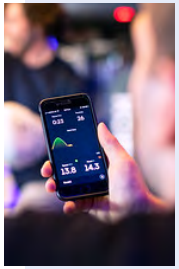
STEM BADGE TRACKER

Name:

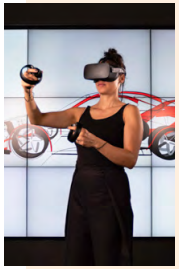
TRACK YOUR SKIP



SPORTING DATA



ENTER THE FOURTH DIMENSION

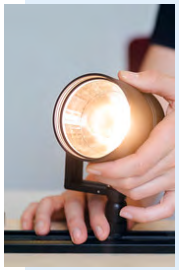


COMPUTER ALWAYS WINS

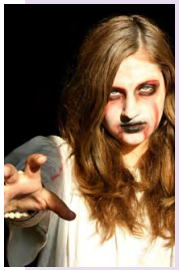
ALL ABOUT THE SOUND

SYNTHETIC BEATS

SETTING THE MOOD



CREATING A HORROR SCENE



THE FULL PRODUCTION

SOLUTIONS AND FURTHER INVESTIGATION

Track your skip

This activity asks learners to investigate how the length of a skipping rope affects their skipping using an accelerometer on their phones and how this information could be used to design an app that creates personalised training programmes.

The Science Journal App is available for free on Android or IOS. Students do not need to create an account to use the app.

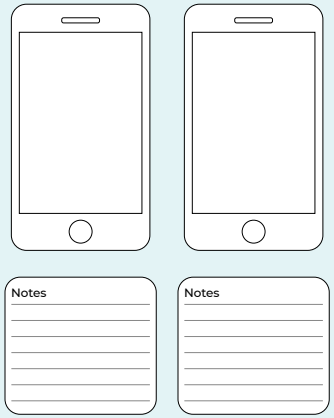
Further investigation

How else could students present their data?

Students can design an app that generates personalised plans for an activity of their choice.

What other data might they need to collect to develop their app?

Students can use the template below for their app design.



A copy of this template can be found on the *This is Engineering* page on our resource hub.

Sporting data

This challenge invites learners to consider some examples of representations from the world of sport, to make sense of the stories they tell, and to analyse whether the right representation has been chosen for the purpose.

We have given some prompt questions as a guide, but these can of course be adapted to suit your group's needs.

The questions are not necessarily intended for students to give exact answers to, but to think about what they think works and what story they think the graphic tells.

Shot comparison Map

- How many goals did Salah score?
  24 goals
- How many did Vardy score?
  25 goals
- Who saved the most shots?
  Leicester FC goalie
- Who missed the most shots?
  Salah

Spending on Olympic games

- Which country has the highest cost overrun?
  Canada in the 1976 summer games
- Which country was almost on budget?
  China in the 2008 summer games
- In which continent have most of the Olympic games taken place?
  Europe

Graphic showing the number of Grand Slams

- Who is the oldest player to win more than 300 Grand Slam matches?
  Navratilova at 41
- How old was Serena Williams when she won her first Grand Slam?
  17 years old
- Who was the youngest player to reach 200 Grand Slams?
  Graf
- How many players have won more than 250 Grand Slams?
  Five

Heat map showing the position of players in one team in a football match

- Which direction was the team playing?
  Up the pitch
- Did this team spend more time attacking or defending?
  Attacking
- Where was much of the game action focused?
  Most of the action seemed to take place in the opposing team's half of the pitch

Further investigation

Students can search for other examples of graphs or diagrams used in sport, or in wider contexts. Ask them to share why some representations are suitable or unsuitable for different purposes.

This activity was adapted from an Nrich problem 'Charting Success'.

Entering the fourth dimension

Through investigating the number of vertices, edges and faces of all polyhedral shapes (that does not intersect itself), students might arrive at Euler's Formula:

Faces + vertices = edges + 2

Check out the resource ***Euler's Characteristic*** for more activity ideas relating to Euler's formula.

Compuer vs human - hexapawn

Hexapawn is intended to introduce learners to the idea of machine learning and artificial intelligence (AI). Find out more about the game and its links with computer science in **this article from the Royal Institute Christmas Lectures**.

A printable version of the 24 images of the possible moves in the hexapawn game is available to download on the ***This is Engineering:*** **Entertainment page on our STEM resource hub**.

An online version is also available at **www.greenfoot.org/scenarios/23788** and as an **Android App**.

All about the sound

Use your wave machine to show:

- ... a change of **volume/amplitude**.

Learners could try increasing or decreasing the size of their initial twist or the amount of pressure they are using.

- ... a change in **pitch/frequency** of sound.

Learners could try moving one of the dowels very quickly or very slowly a number of times before releasing.

- Use your wave machine to show a change in the speed in which the waves are travelling half way across your machine.

Learners could either remove the nuts from one half of their wave machine or increase the weight by adding more nuts.

- Use your wave machine to show how waves are not transmitted but reflected upon meeting a solid object.

Learners could hold still one of the rods approximately half way across the machine. This should stop the wave motion at this point and reflect the waves back in the opposite direction.

- Use your wave machine to show what happens when sound waves are partially transmitted and partially reflected through an object.

By increasing the number of nuts on two or three dowels halfway across the wave machine, learners should be able to replicate some waves being reflected and some waves being transmitted.

Synthetic beats

Share the story of **BBC Trailblazer, Delia Derbyshire** and how she revolutionised how we hear music on TV and film when she arranged the theme for one of the most famous TV shows: *Doctor Who*.

The final production

Students could use the **RGB**ug and the **Bumble Beep** to create the special effects for the horror scene.

Thank you

This STEM teaching and learning resource has been developed by the Royal Academy of Engineering as part of its national **Connecting STEM Teachers (CST)** programme.

CST is a support network 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. The programme operates across all regions of England, and in Scotland, Wales and Northern Ireland.

The programme, founded by the Royal Academy of Engineering, would not be possible without the generous support of its funders:

Special thanks to our strategic partner Shell, for significant support of the programme.

CST is also generously supported by: The Arthur Clements Fund, BAE Systems, Boeing, the estate of the late Mr John Gozzard, the Helsington Foundation and the Royal Air Force.

Royal Academy of Engineering

The Royal Academy of Engineering is harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone.

In collaboration with our Fellows and partners, we're growing talent and developing skills for the future, driving innovation and building global partnerships, and influencing policy and engaging the public.

Together we're working to tackle the greatest challenges of our age.

What we do

Talent & diversity

We're growing talent by training, supporting, mentoring and funding the most talented and creative researchers, innovators and leaders from across the engineering profession.

We're developing skills for the future by identifying the challenges of an ever-changing world and developing the skills and approaches we need to build a resilient and diverse engineering profession.

Innovation

We're driving innovation by investing in some of the country's most creative and exciting engineering ideas and businesses.

We're building global partnerships that bring the world's best engineers from industry, entrepreneurship and academia together to collaborate on creative innovations that address the greatest global challenges of our age.

Policy & engagement

We're influencing policy through the National Engineering Policy Centre – providing independent expert support to policymakers on issues of importance.

We're engaging the public by opening their eyes to the wonders of engineering and inspiring young people to become the next generation of engineers.

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