Royal Academy of Engineering

Employer Engagement Challenge

Toughbook

How can you protect your phone and electronic devices when dropped?

Ariennir gan Lywodraeth Cymru
Funded by Welsh Government

THIS IS ENGINEERING

Pupil comments

"I learned about different types of engineering, including various types of phone and notebook holders. I also learned about durability testing and the design of tablets and laptops, as well as how they function."

"I learned how to create a 3D design using software and gained insight into the wide range of job opportunities available in the field of engineering."

Teacher comments

"The pupils really enjoyed the creative side of the project and they put a lot of effort into their designs. The project was able to link engineering and manufacturing to real life using something that the pupils love – their phones."

"The project enthused lots of the pupils, especially the ones that like using the software."

Employer comment

"From a Panasonic perspective, the biggest success for us has been the overall engagement from the pupils and the staff at the schools. It was also a great opportunity for us to pass on our knowledge of pathways into engineering, including apprenticeship schemes to the younger generation."

Acknowledgements

The Royal Academy of Engineering thanks Abertillery Learning Community and Panasonic for developing this challenge resource.

They have helped to raise awareness of engineering among young people, improve STEM teaching in schools and created new career opportunities for STEM learners.

Panasonic

Panasonic is a global electronics company with a long history in Wales. It first opened a factory in Cardiff in 1974, and has since expanded its operations to include several other sites across the country.

Panasonic develops and manufactures a range of products, including home appliances and computer technologies such as televisions, laptops and microwave ovens.

The challenge

In this challenge, students will learn about the engineering behind Panasonic's Toughbook solutions. They will work in teams to design and make a resilient casing for a phone or electronic device capable of withstanding accidental drops.

The aim is to ensure that the encased device remains protected from damage, maintaining both its structural integrity and functionality. Furthermore, the device should incorporate an innovative feature enabling multiple viewing angles, enhancing the user experience.

By engaging in this challenge, students learn about the materials used in the manufacture of these rugged devices. The investigation and selection of appropriate materials, based on required properties, will be an important aspect of the challenge.

Students will design their Toughbook inspired product from an initial concept idea through to the final outcome. Teams will prototype and test models featuring a range of adjustable viewing angles and use computer-aided manufacture such as 3D printers and laser cutting to bring their computer-aided designs (CAD) designs to life.

This challenge is designed to support practitioners to follow Curriculum for Wales' careers and work-related experience guidance. It is supported by a set of videos that give an inside look at how engineers at Panasonic work, and introduces first-hand how the challenge is delivered in school.

The challenge is recommended for secondary school pupils and can be adjusted to match different age groups and abilities.

Here are some of the learning opportunities that the challenge provides:

- **Real-world relevance**
- **Collaborative teamwork**
- **Material investigation**
- **Creativity, design and building**
- **Persuasive presentation**

Challenge overview

Setting the class challenge

Welcome to the exciting world of design, technology and engineering!

Get ready to take part in the Toughbook challenge, where you will have the opportunity to create a rugged phone or electronic device holder capable of withstanding impacts when dropped.

This product will not only protect phones from cracked screens and breakage, but will also include an innovative feature that allows users to adjust the viewing angle for comfortable use.

You will design and build your device using CAD and use computer-aided manufacturing techniques to bring your ideas to life.

Plus, you will get to create a cool marketing campaign to showcase the end product and why it's a must have for anyone who wants to protect their phone.

The Progressing to be an Engineer cycle

By participating in this challenge, young learners will develop the skills and practices that engineers use every day in their professional lives.

Asking questions, imagining and planning ideas, creating and refining outcomes, while continuously reflecting on how things could be improved, are all 'Engineering Habits of Mind' as demonstrated in 'the Progressing to be an Engineer' cycle.

Learning opportunities	Core skills
■ Real-world relevance ■ Collaboration and teamwork ■ Innovation design and making ■ Material exploration ■ Testing and analysis	**Literacy:** Reading and technical vocabulary. Selective research. Writing and reporting. Presenting and communication. **Numeracy:** Data collection and analysis. Pattern spotting. Measurements and calculation. **Scientific:** Problem-solving and experimenting. Visual and special awareness. **Technical:** Systems thinking and problem-solving. Communication and teamwork.

Engineering design process		Activity	Success will look like
0–1 hour	Research the challenge	**Watch the challenge videos** – engineers films	Understand the aims and requirements of the challenge, as well as how engineering concepts relate to it. Gather relevant information and have a clear and comprehensive understanding of the challenge.
1–2 hours	Ask	**Time to investigate** – destructive and non-destructive testing **Time to question** – systems thinking	Identify problems and ask questions to understand how to resolve them. Explain how systems work while identifying ways they can be improved.
2–4 hours	Imagine Plan	**Time to imagine** – design and develop a CAD Toughbook **Time to plan** – modelling a card prototype of the Toughbook	Draw and label multiple design ideas, effectively communicating fitness for purpose and why certain ideas are better than others. Use simple annotated sketches to turn ideas into words and drawings. Plan a design that aims to solve a problem or task for a specific user, by transforming one idea into a better one.
4–6 hours	Create	**Time to create** – computer-aided manufacture of the Toughbook	Use knowledge of how systems and components work and interact to create a product that achieves a specific purpose. Evaluate the product's fitness for purpose and look to find ways to improve this based on observation and improvement.
6–7 hours	Improve	**Time to evaluate** – the manufactured outcome of the Toughbook **Time to reflect** – on experiences in relation to each stage of the challenge	Test the outcome for quality using a logical approach gathering evidence to make an informed decision. Evaluate how the product is working, identifying areas for improvement and describe possible changes that can enhance the design.
7–8 hours	Present the challenge	**Time to present** – create a marketing campaign for the Toughbook	Communicate ideas effectively and with confidence, making complex concepts understandable to the audience. Engaging interactions and making a lasting impression.

Research the challenge

Ask

Imagine

Plan

Create

Improve

Present the challenge

Time to start

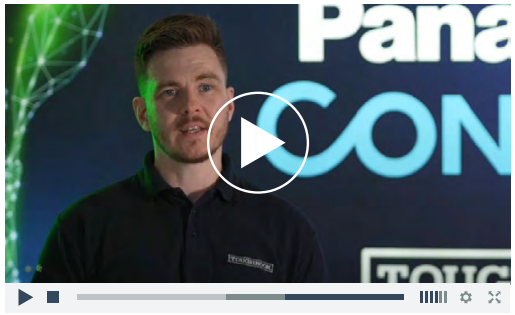
Begin by showing the class the set of three engineer videos that showcase the diverse range of engineering roles within the company. Each video is approximately three minutes long.

Go to **raeng.org.uk/wvep** or scan the QR code to watch the videos.

Ian: Electrical and mechanical engineering manager

Joy: Quality assurance engineer

Ross: Mechanical engineer



Time to ask

The aim of this first activity is to learn how testing a product before manufacture is an important part of the design process.

Begin by explaining that engineers undertake 'destructive and non-destructive' tests on products to ensure safety, reliability and durability before these are sold to consumers.

Products with electronic components are fragile and can easily break or be damaged if dropped or when transported. Therefore, designing and manufacturing protective casings is a preference for users of these devices.

Research the challenge

Ask

Imagine

Plan

Create

Improve

Present the challenge

Time to investigate

This destructive or 'hopefully' non-destructive activity illustrates real-world applications of protection through material choices.

Start with a brief discussion as to why an egg will break when dropped. Explain that the eggshell (like a phone screen) is relatively thin and brittle, which makes it susceptible to breaking upon impact.

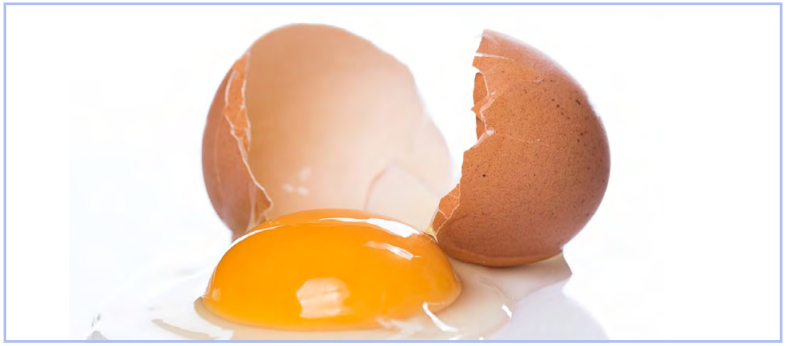
Divide the class into small groups and provide each group with an egg, bubble wrap sheets, tape and scissors.

Ask them to spend no more than 5 minutes creating a protective casing for the egg using the bubble wrap sheets.

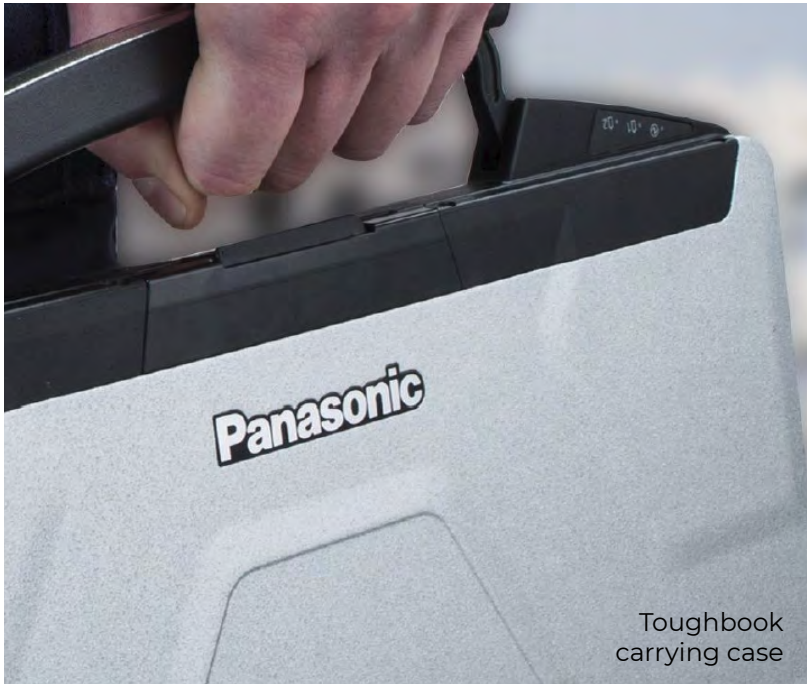
Once wrapped, instruct each group to drop their egg from a low height (no more than one metre) to minimise the likelihood of egg breakages.

After the drops, gather the students and their wrapped eggs and discuss the results as a class:

- Did the bubble wrap help the egg survive the drop?
- How did the bubble wrap absorb and distribute the impact force?
- How did the height of the drop affect the outcome?
- What other materials could be used to protect electronic devices such as phones and electronic notebooks from breaking when dropped?



Military grade phone case with adjustable viewing angles



Toughbook carrying case

Research the challenge

Ask

Imagine

Plan

Create

Improve

Present the challenge

Time to question

Systems thinking is "explaining how things work together and why each part is there".

The questions below encourage students to think critically about the complexities involved in designing and manufacturing a rugged Toughbook holder for a phone or notebook.

Discuss these questions as a group and facilitate the conversations in class.

Systems thinking questions	
1	How might the materials chosen for the casing affect its ability to withstand impacts and protect the device?
2	Whose preferences and needs should be taken into account when designing a rugged casing with a multi-viewing angle feature?
3	If the casing is too heavy and bulky, what impact could it have on the user's experience and the device's functionality?
4	How might the casing's protective features affect the user's opinion of the device's aesthetics?
5	What considerations are needed to determine the ideal price point for the Toughbook?
6	How might the addition of a multi-viewing angle feature affect the overall design and structure of the Toughbook?
7	How can the multi-viewing angle feature be designed to accommodate different device sizes and shapes, considering the diversity on the market?
8	What trade-offs might be necessary between the durability and ruggedness of the casing and the mechanisms required for the multi-viewing angle feature?

Students testing the gravitational pull of a tennis ball

Time to imagine

The aim of this activity is to design a robust and protective device from initial sketches to 3D CAD model.

Initial ideas

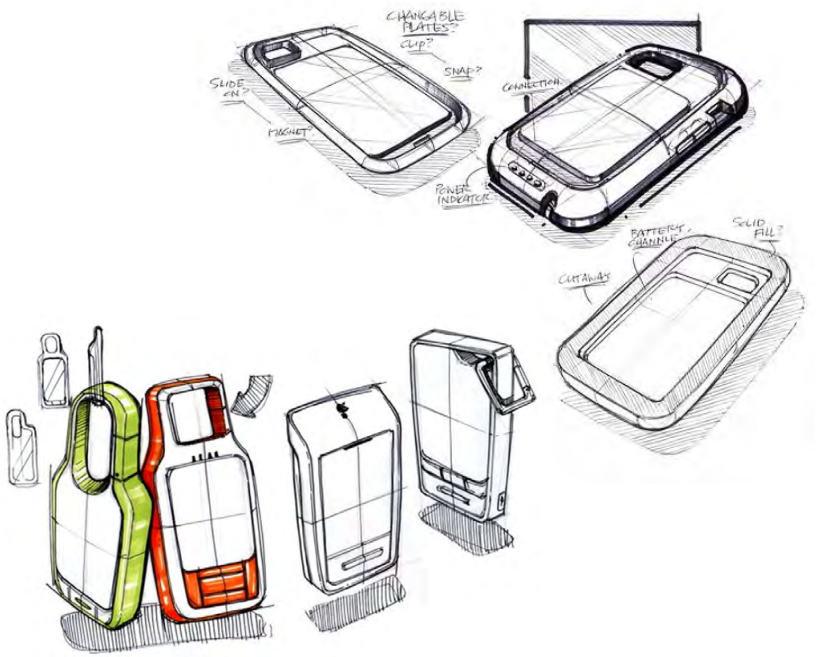
Start by asking teams to brainstorm ideas and sketch rough designs on paper. Encourage them to consider features such as multiple viewing angles and protection, as well as material selection and manufacturing techniques.

Emphasise the importance of annotating drawings with explanations for each design idea.

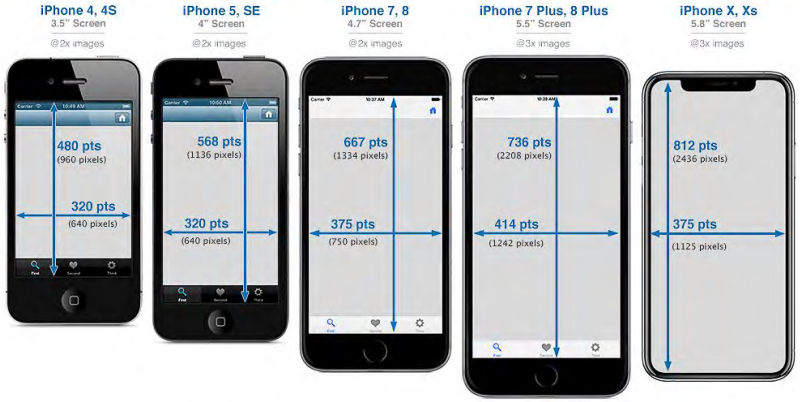
Development of ideas

Introduce the class to the basic principles of CAD.

Ask teams to design a three-dimensional model of their preferred ideas, refining details based on feedback they have received.



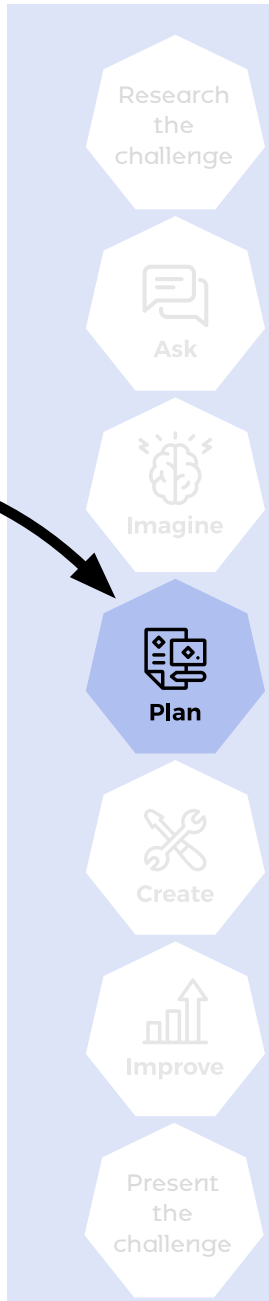
Students should examine the dimensions of their phone or device's height, width and thickness, when designing a casing, to ensure there is appropriate clearance and guaranteed comfortable fit.



It is important to observe these measurements when creating the CAD drawing. Additionally, consider the provision of access points for the charging lead and headphone socket, plus the multi-angled viewing feature.

Introduce the concept of iteration – refining and enhancing designs through multiple drafts.

Place a strong emphasis on accuracy, neatness and attention to detail.



Time to plan

The aim of this practical activity is to use recycled card and re-purposed materials to construct a scale model of the team's preferred design.

Begin by informing students that modelling (or prototyping) allows designers and engineers to visualise the product concept in a physical form. It provides a clear representation of the intended product, making it easier to understand and evaluate.

Teams start prototyping by creating a rough sketch of the chosen design on the recycled card, marking areas to be cut out.

Once this is complete, students cut and shape the card to create the basic structure. Remind them to refer to the measurements of their phone or notebook for accurate dimensions.

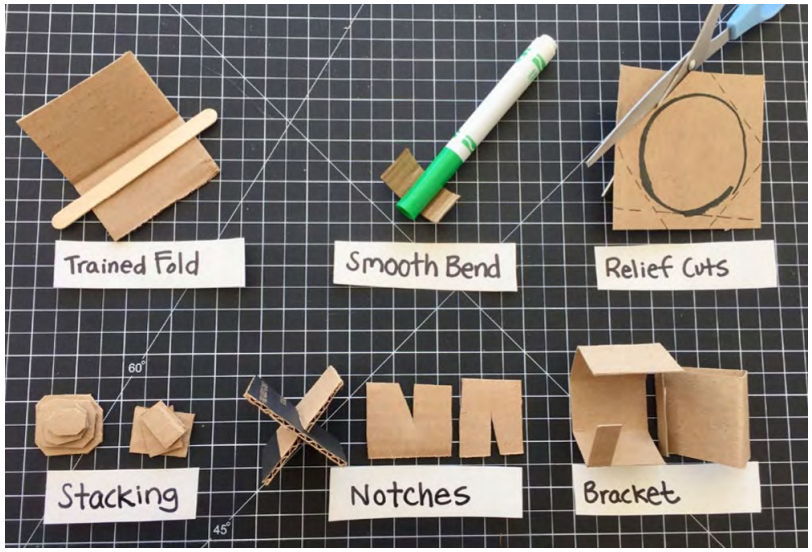
Assemble the card pieces using glue and tape, considering the need for a comfortable fit.

Ask teams to evaluate their prototypes once completed, identifying areas for improvement and refinement based on the following questions:

- Were there any sizing issues that prevented the device from fitting neatly into the prototype?
- Were the connection ports easily accessible?
- Did the multiple angle viewing feature work as intended?
- Were there any unexpected challenges encountered during the modeling process?

Materials

- Recycled cardboard and repurposed materials
- Craft knives, cutting mats, masking tape and glue guns
- Rulers, markers and pencils
- Phones and electronic notebooks



Research the challenge

Ask

Imagine

Plan

Create

Improve

Present the challenge

Time to create

The aim of this activity is to use computer-aided manufacturing to create a functional working prototype of the device.

In this activity, teams will manufacture and assemble their outcome, creating a functional product ready to be tested.

Instruct students to carefully consider the success of solutions from both the three-dimensional CAD modelling and the card prototyping activities.

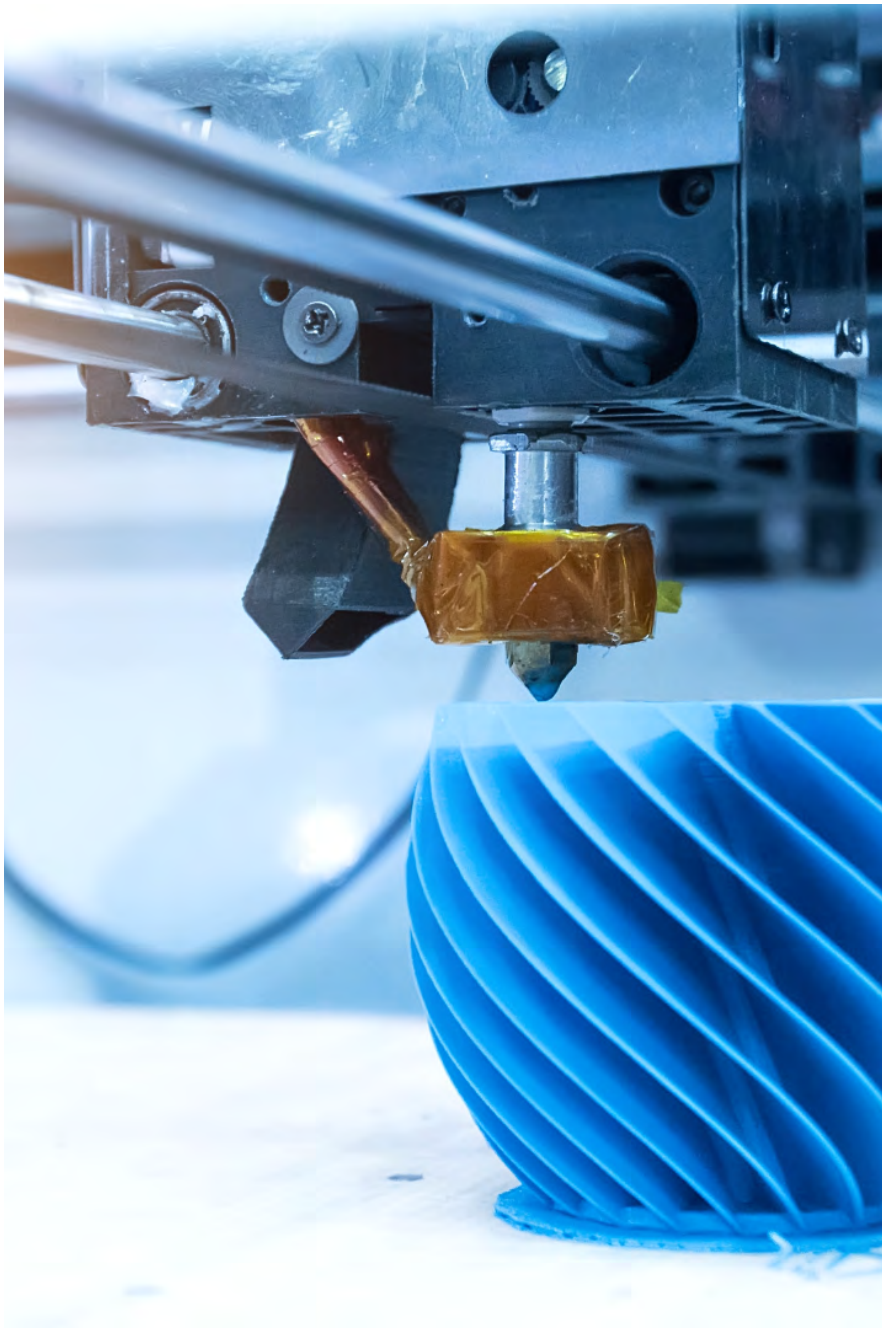
Computer-aided manufacturing

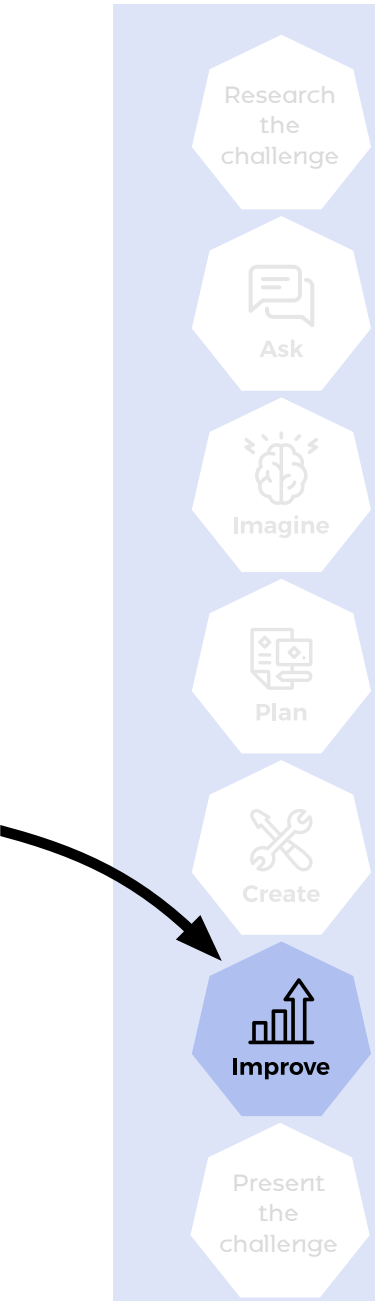
Familiarise students with the process of computer-aided manufacturing and provide them with an understanding of the processes involved in 3D printing and laser cutting.

Each team should be well prepared to adapt their CAD model for the manufacturing phase.

Once the assembly is complete, ask teams to test their devices for functionality (without causing any damage to their phones or other electronic devices).

This testing phase should also include ensuring that the charging and headphone points are correctly aligned, that phones and notebooks fit comfortably and securely, and the multiple viewing feature is fit for purpose.





Time to evaluate

Assemble the teams and provide them with the following questions to consider.

1. How well does your outcome align with your original CAD design?
2. Did the cardboard prototype effectively guide your final design? What changes did you make from the prototype to the final product?
3. How did your team ensure that electronic devices fit correctly within the final outcome?
4. What challenges did you encounter during assembly, and how did you overcome them?
5. How successful was your outcome in protecting phones and notebooks?
6. Did your team consider both the aesthetics and functionality in the design? Explain.
7. Reflecting on the challenge, what would you do differently if you were to redesign the product?

Within their respective teams, students should engage in discussions and collaboratively provide answers to each question based on their conversations.

Time to reflect

Success can be based on the skills students develop and the practices they acquire throughout each stage of the challenge.

These include the ability to ask questions, imagine and plan ideas, create and refine outcomes, while continuously reflecting on how things could be improved.

Engineers also demonstrate the following practices as part of their day-to-day activities.

- Problem finding and creative problem-solving
- Systems thinking and visualising
- Adapting and improving
- Teamwork and collaboration
- Project and time management

At the end of the challenge, gather teams for a post-challenge debrief. Encourage them to reflect on their experiences and assess their personal growth in relation to the skills they have developed and practised throughout the challenge.

Research the challenge

Ask

Imagine

Plan

Create

Improve

Present the challenge

Present the challenge

Time to present

The aim of this final activity is to create and present a marketing campaign for the sale of the product.

In their teams, ask students to brainstorm and discuss the following considerations.

- Who should the product be aimed at and why?
- What are the advantages of using their product?
- What makes their product better than others?

Ask teams to discuss and plan the pricing for their product. Encourage them to consider effective marketing strategies and create a basic outline of their marketing plan.

Then, ask them to create their marketing presentation. Why not develop a TV commercial or a radio ad? Alternatively, they can create a website or social media posts.

Encourage each team member to participate in some way and let each team decide on their preferred method of presentation.

Allow time for questions and feedback after each team has presented their marketing campaign to the class.

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.

Royal Academy of Engineering
Prince Philip House
3 Carlton House Terrace
London SW1Y 5DG

Tel: +44 (0)20 7766 0600
www.raeng.org.uk
Registered charity number 293074