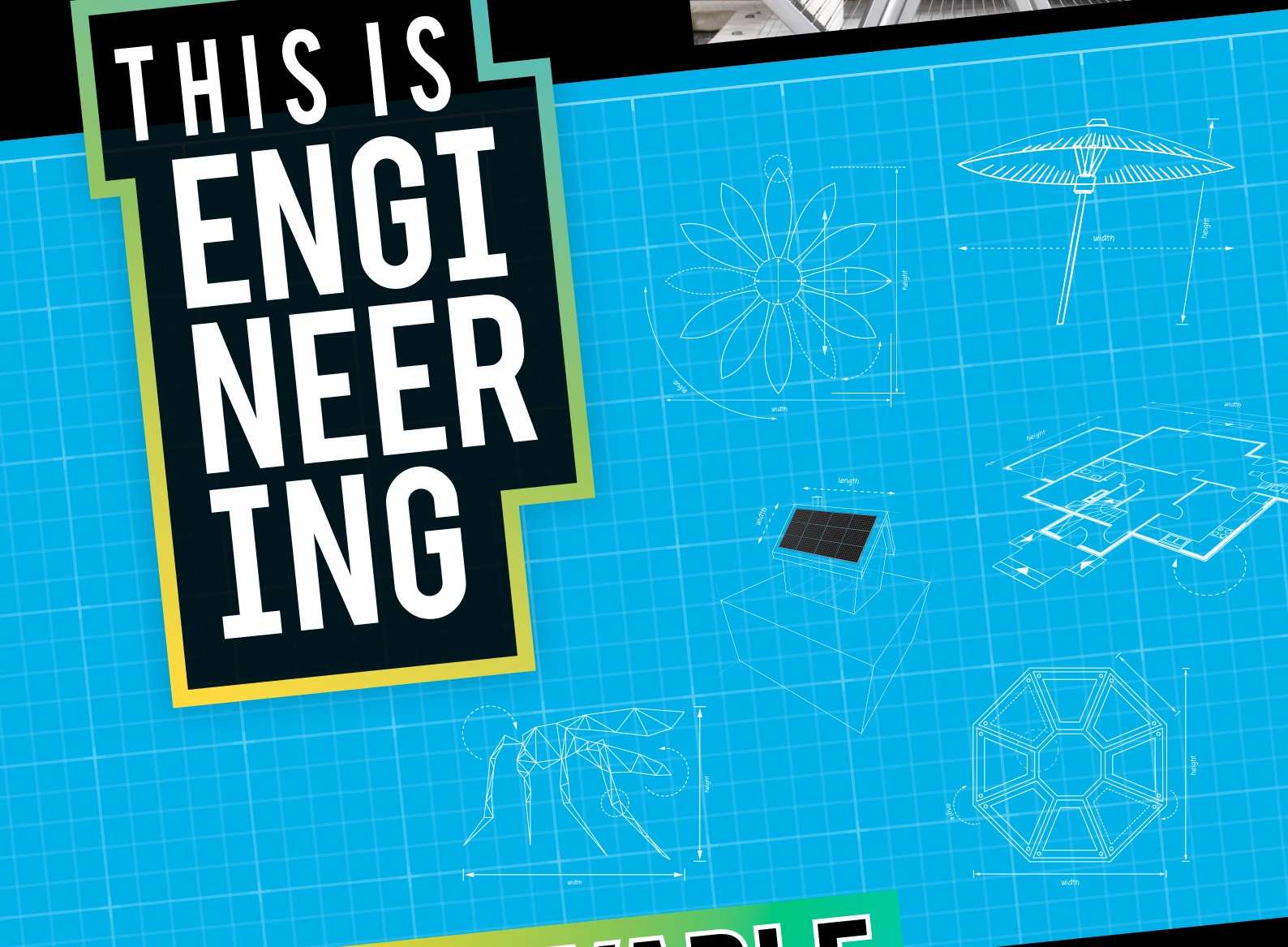
Royal Academy of Engineering

THIS IS ENGINEERING



DEPLOYABLE STRUCTURES

Teacher guide

INTRODUCTION TO THE RESOURCES

The purpose of these resources is to help students link the ideas they see in the maths classroom with applications in real world engineering.

The resources cover the broad topic of *deployable structures* which are structures that open up (deploy) into something of use. An obvious example would be an umbrella.

There are also case studies of two engineers involved with two different types of deployable structures.

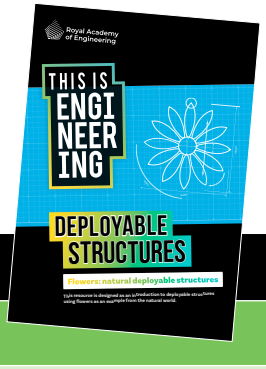
Each resource has a copy printed as a brochure **(remember to remove any answer pages before copying for students!)**.

All the resources are also available on our website. The resources can be used however you wish, but some initial explanation and guidance is given in this teacher's guide.

Royal Academy of Engineering

FLOWERS: NATURAL DEPLOYABLE STRUCTURES

Explanation:



This resource is designed as an introduction to deployable structures using flowers as an example from the natural world. It has activities associated with nets and density and discussion of a link to symmetry and transformations. There are also various practical suggestions (such as making a party blower) at the end which you could use.

Curriculum map:

Activity	Topic	National Curriculum
Time to think 3	Density – use of formula for density	*Ratio, proportion and rates of change:* use compound units such as speed, unit pricing and density to solve problems
Time to think 4	Nets of 3D shapes	*Geometry and measures:* use the properties of faces, surfaces, edges and vertices of cubes, cuboids, prisms, cylinders, pyramids, cones and spheres to solve problems in 3D
Time to think 5	Transformations of shapes and symmetry	*Geometry and measures:* identify properties of, and describe the results of, translations, rotations and reflections applied to given figures. Describe, sketch and draw using conventional terms and notations: points, lines, parallel lines, perpendicular lines, right angles, regular polygons, and other polygons that are reflectively and rotationally symmetric

Time:

The resource could be used in one 45-minute session or could take longer if you decide to use the practical suggestions at the end but these times are adaptable depending on how you use the resource.

Resources included:

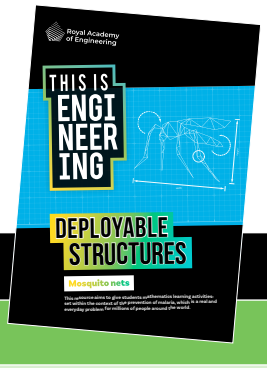
A packet of *Mimosa pudica* seeds have been included. When grown, this plant is a good example of a natural deployable structure.

Resources required:

None required for main activities other than writing space for students.

MOSQUITO NETS

Explanation:



This resource is based around the subject of nets to protect people from mosquitos which spread malaria. It includes various mathematical, discussion and design based exercises. The maths topics covered include nets, area, angles and scale.

Curriculum map:

Activity	Topic	National Curriculum
Activity 2 – parts 1 and 2	Nets, area and volume	*Geometry and measures:* derive and apply formulae to calculate and solve problems involving: perimeter and area of triangles, parallelograms, trapezia, volume of cuboids (including cubes) and other prisms (including cylinders). Use the properties of faces, surfaces, edges and vertices of cubes, cuboids, prisms, cylinders, pyramids, cones and spheres to solve problems in 3D
Activity 4	Scale drawings and scale factors. Solving problems Converting between units	*Ratio, proportion and rates of change:* use scale factors, scale diagrams and maps. Change freely between related standard units [for example time, length, area, volume/capacity, mass] *Working mathematically:* develop fluency and solve problems

Time:

The resource is adaptable in terms of the time required, but as a guide you should allow two hours to cover the main parts other than the design challenge.

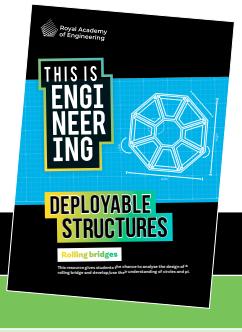
Resources included:

- A mosquito net (students could attempt to hang up a mosquito net or it could simply allow students to easily visualise what is being discussed).
- Plastic straws for activity 3. It has been assumed that students will work in pairs and there are up to 17 pairs in a class. Each pair requires four 7cm straws, two 9cm straws and two 6cm straws. The straws provided are around 20cm long, so three straws are required per pair when the first straw gives two 9cm straws and the other two each provide one 6cm and two 7cm straws. So for 17 pairs, 51 straws will suffice. Each pair will also require four of the corner connectors which gives 68 in total. In the box there are 150 straws and 68 connectors provided which should be enough for two classes working at the same time with room for mistakes with the straws. Additional straws and connectors are available from Cochranes of Oxford. Pipe cleaners or drinking straws and sticky tape could also be used as a cheap alternative to the straws and connectors.

Resources required:

- Writing space for students
- Activity 2 requires, glue, scissors and copies of the nets given in the activity
- The design challenge requires building materials to make a model of a frame. Pipe cleaners or drinking straws and sticky tape could be used for this. You might also have some of the straws from activity 3 left over.

ROLLING BRIDGES



Explanation:

This resource is based on Thomas Heatherwick's rolling bridge at Paddington Basin in London. There are exercises involving the mathematical analysis of the design and some basic construction of models of the bridge. The maths content covers circles and the use of pi for calculating the circumference of circles.

Curriculum map:

Activity	Topic	National Curriculum
Activities 1,2, and 3	Circles (including diameter, circumference and pi)	Geometry and measures: calculate and solve problems involving: perimeters of 2D shapes (including circles), areas of circles and composite shapes

Time:

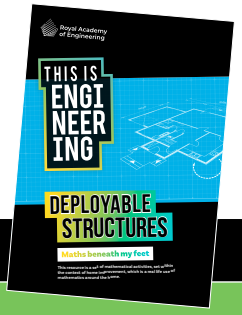
Again, the time required to complete the resource is adaptable but two hours should be allowed if the practical work and all tasks are to be completed.

Resources included: None

Resources required:

- Activity 1 requires A4 card, pencils, scissors and rulers.
- Activity 4 requires the students to research bridges so access to the internet would be useful.

MATHS BENEATH MY FEET



Explanation:

This resource is meant to give a very practical use of basic mathematics that might be used by a tradesperson in his/her work. The activity is based around carpeting/flooring rooms. It involves the use of area and lots of calculations which resemble the functional skills questions in GCSE maths exams.

Curriculum map:

Activity	Topic	National Curriculum
Activity 3	Area	*Geometry and measures:* derive and apply formulae to calculate and solve problems involving: perimeter and area of triangles, parallelograms, trapezia
Activities 4–6 and stretch and challenge activities	Solving problems	*Working mathematically:* solve problems

Time:

The main activities should take around an hour but the stretch and challenge activities will add time to this.

Resources included: None

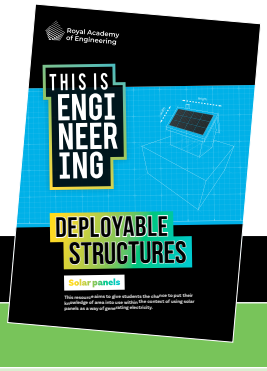
Resources required:

- Stretch and challenge activity 2 will require tape measures and/or metre rulers.

SOLAR PANELS

Explanation:

The solar panels resource starts with the same activities as the *Maths beneath my feet* resource but is set in the context of using solar panels for generating electricity. However, the questions in this resource become more difficult mathematically with activities requiring the calculation of complicated areas and using multiple bits of information to solve a problem.



Curriculum map:

Activity	Topic	National Curriculum
Activity 3	Area	*Geometry and measures:* derive and apply formulae to calculate and solve problems involving: perimeter and area of triangles, parallelograms, trapezia
Activity 4	Composite shapes and complicated area calculations	*Geometry and measures:* calculate and solve problems involving: perimeters of 2D shapes (including circles), areas of circles and composite shapes
Stretch and challenge activities 1 and 2	Solving problems	*Working mathematically:* solve problems. Select appropriate concepts, methods and techniques to apply to unfamiliar and non-routine problems.

Time:

This resource includes some difficult maths, so the time it takes to complete will depend on the mathematical understanding of the students.

Resources included:

None

Resources required:

None

GROUP UMBRELLA

Explanation:

This resource is a set of instructions for groups of six students to make a working umbrella mechanism out of simple materials. It is a completely practical activity with no formal maths content but it is very useful for linking the students' work on deployable structures to a real piece of engineering that they can work with themselves.

IMPORTANT SAFETY NOTICE

To make one of these umbrella mechanisms, twelve wooden coffee stirrers will need to be cut in two. This can be done with a craft knife and cutting mat or other suitable equipment. It is recommended that the teacher cuts the coffee stirrers before the activity begins in order to minimise the risk to students. Whether the teacher or the students cut the coffee stirrers, a **risk assessment** must be carried out to minimise risk or injury.

Time:

The time taken to make the umbrella will depend on the practical skills of the students and how much help they receive.

Resources included:

- Each umbrella mechanism requires 12 coffee stirrers. Presuming the students work in six groups of six, 72 coffee stirrers are required for a class. 170 coffee stirrers have been provided which should be enough for two classes with room for mistakes. The coffee stirrers used can be bought at **www.plastico.co.uk**

Resources required:

- Card
- Sticky tape
- A retractable craft knife and cutting mat (or other suitable equipment such as heavy duty scissors) to cut the coffee stirrers. **Read the safety notice above**.

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