She Solves Challenge

Produced in conjunction with

BAE SYSTEMS

She Solves

Introduction

What is engineering?

Engineering surrounds us all in our day-to-day lives – even if we don't always realise it. Although it is a field that is often overlooked, without engineering the iconic pyramids, Stonehenge and even the International Space Station would not exist. There are also applications of engineering on a much smaller scale – from computer chips to medicines, building aircraft to designing bionic limbs. The activities in this book are designed to show some of the exciting and useful applications of engineering.

Women in engineering

In January 2016 the Women's Engineering Society (WES) revealed that approximately 29% of all research scientists and engineers in Singapore are female. This gender gap is apparent within the engineering industry worldwide.

Despite this gender gap, women from all over the world have achieved some of the greatest engineering feats of all time. Have a look within each section for more information on female engineers and their achievements.

World Thinking Day Activity Pack

This pack contains a selection of activities from Girl Guides Singapore's new She Solves Engineering Badge! There are more activities to choose from in the complete pack, which you can find on the Girl Guides Singapore website. To complete the badge, you'll need to complete four activities.You must then pick the activity that you have enjoyed the most and produce a poster explaining what this type of engineering is all about. Show your poster to an adult leader or young leader and describe what it means.

You could include:
• An overall description of this type of engineering
• How this affects your day-to-day life
• Famous female engineers in this area
• Greatest achievements/challenges for this type of engineering
• Is this type of engineering project present in Singapore? If so, state how this engineering type has benefitted Singapore.

Mini Activities – Materials Engineering

Try two of the mini-activities below to complete this clause on materials engineering.

Build your own Lava Lamp

Equipment

- A clear jar or glass
- Vegetable oil

Estimated time: 15 minutes

Method

Fill the jar/glass about 2/3 full with water. Add a few drops of the food colouring to this water to give your lava lamp some colour. Next, fill the cup up almost to the top with vegetable oil. You should see that the oil sits on top of the water. Finally, add a teaspoon of salt on top of the vegetable oil, and watch your lava lamp work! When the lava lamp stops working, you can add more salt on top of the oil to start the process again.

- How do you think the lava lamp works?
- What do you think the salt does?
- Could you use other things instead of salt?

Does an orange float?

Equipment

- A deep container that you can fill with water
- An orange

Estimated time: 5 minutes

Method

Fill the container with water and place the orange on the surface of the water. Does the orange sink or float? Next take the orange out of the water and peel it, then place it back on the surface of the water. Does the orange sink or float now?

Did peeling the orange make any difference to the result?

Why do you think this was the case?

Mini Activities – Materials Engineering (cont.)

Make your own slime

Equipment

- A large plastic container
- Cornflour
- Water
- A spoon for mixing the ingredients

Estimated time: 15 minutes

Method

Put one cup full of cornflour in the plastic container and add half a cup full of water to it. Mix this up using the spoon – you could also add a few drops of food colouring to change the colour of your slime.

Try mixing the slime quickly and slowly – does this change the slime?

If you squeeze the slime hard in your hand is this different to letting it run through your fingers?

Why do you think the slime behaves differently?

Guidance for leaders/teachers

Try to encourage the girls to think of their own explanations as to why these materials act the way that they do. Ask them about how they think materials with these properties could be useful. The explanations for why each material acts the way it does are below:

- **Lava Lamp:** The oil and the water do not mix, so the oil will form a layer on the surface of the water. When you add the salt, the salt will dissolve in the water and sink to the bottom, carrying droplets of oil with it. When the salt is completely dissolved the oil will float to the surface again, giving the ‚lava lamp' effect.
- **Floating Orange:** The peel of the orange contains small air pockets, which allow it to float. When the peel is removed these air pockets are gone and the orange is denser than water so it will sink.
- **Slime:** When the cornflour and the water are mixed together, particles of cornflour are suspended in the water. They are packed very closely together, but when you stir the mixture slowly they can move past each other. If you put a sudden strain onto the mix, however, the water will move away but the cornflour particles stay still, because they don't have time to move past each other. This means that it seems like a solid

How this relates to engineering

Material engineers research, design and develop new materials to create new technologies and products. A materials engineer studies the different properties of materials and the different ways that they behave. As a materials engineer you could work in all sorts of different roles, from cutting edge medical research to sports, designing carbon limb replacements for people with disabilities.

Inspiring Female Engineers:

Stephanie Kwolek

- Stephanie Kwolek was born in 1923 in Pennsylvania. When she was 23 years old she graduated with a degree in Chemistry.
- After nine years working as a research chemist she made a huge breakthrough, with the discovery of Kevlar. She was initially trying to find a material to be used in car tyres – but Kevlar turned out to be so much more than that.
- Kevlar is strong but also lightweight, which makes it the perfect material for protective clothing, such as bulletproof vests.
- Today, Kevlar has all sorts of applications, but its use in body armour is arguably the most important. Countless lives have been saved all as a result of the discovery that Stephanie Kwolek made.

Stephanie Lacour

- Stephanie Lacour is a research project manager based at Cambridge University.
- Before this, she was a researcher at Princeton University, where she developed semiconductors which are able to stretch. Semiconductors are small electronic devices, and this was a breakthrough in research to create „electronic skin".
- There are hopes that her research could help create implants which surgeons can use to repair nerve damage, for example if someone was paralysed.
- There are also hopes that these semi-conductors could be used to create a skin which could cover prosthetic limbs. This skin could be connected to the person's nerves, allowing them to feel the limb again.

Build a Mechanical Hand – Biomechanical Engineering

Equipment

- A piece of cardboard (one each) around the size of an A4 piece of paper
- 5 straws each
- Scissors
- String
- Stickytape

Estimated time: 30 minutes

Method

Using the materials above you are going to design a simple mechanical hand, which works in a similar way to your own hand. Firstly, place your hand on the piece of cardboard and draw around it. Then use the scissors to cut out the shape you have drawn. Looking at your own hand, decide where you think the fingers should bend and draw lines where you think these bends should be. You should expect to draw three lines on each finger and two lines on the thumb.

Using the scissors, score along each of the lines you have drawn to allow the paper to fold. Lay a straw along each of the fingers of the cardboard hand and cut the straw into sections which will fit between the score lines. Also cut a larger section of straw which runs from the bottom of the finger to the wrist.

Once you are happy with the size and position of the straws you can use sticky tape to stick them to the cardboard hand. Finally, cut five pieces of string which are about twice as long as your hand. Using one piece of string for each finger, thread the string through the straws on the finger. Tape the top of the piece of string to the top of the finger, to stop it from pulling through.

Once all of the pieces of string are threaded through the straws, you can tie all of the pieces of string together near to the wrist.

Your mechanical hand is now complete! Try pulling on the string to make the fingers bend.

What do you think the straws represent?

What do you think the strings represent?

What problems would there be if one of the straws or the pieces of string broke? What do you think this would mean if it happened in real-life to someone's hand?

Guidance for leaders/teachers

If you think this activity might be too difficult for your brownies, you could adapt the activity slightly. Instead of the strings, you could print out a diagram of the bones and tendons in a hand. Get them to cut out the shape of their hand from cardboard and draw on the bones and tendons, then decorate the hand as they like. Talk to them about what the bones and tendons do, and how we are able to move our hands.

How this relates to engineering

Biomechanical engineering is all about understanding systems within the body, and applying an understanding of mechanical engineering to these systems. For example, understanding how the hand works, and the engineering principles behind tendons, bones and skin allows biomechanical engineers to help figure out solutions when things go wrong.

Cipher Wheel – Cyber Security Engineering

- Printed cipher wheel template
- Split Pins
- Coded message print-out
- Blue tack
- Paper
- Pens

Estimated time: 1.5 – 2 hour

Method

Next page!

Brownies & Guides

1. Divide into small groups. Each group will need one of the coded message print-outs, and each of you will need three coding wheels – one of each size, a split pin and a small piece of blue tack.

2. Assemble each coding wheel by placing the largest wheel on a flat surface, then the smaller wheel on top of it. Pin them together through the centre of the wheels using the split pin.

3. The outer circle of this coding wheel represents the coded letters – and the inner wheel is the de-coded letters. These wheels can be used to code and decode messages – however first both the person sending and receiving the messages need to know how the wheels should be lined up. To do this, we use a ‚crib', which tells you which three letters should line up. All of the messages below are coded using the crib ‚NI'. To set-up your cipher wheel, make sure that the ‚N' on the outer wheel is lined up with the ‚I' on the inner wheel. Once you have correctly aligned the wheels use blue-tack to hold them in place.

4. As a group, use the aligned cipher wheel to decode the messages provided. Look at the letter you wish to decode on the outer wheel, and then look at the inner wheel to find out what the decoded letter is.

5. Once you have decoded your message have a go at choosing your own crib, and sending coded messages to each other. You could do this as a group, in pairs or individually.

Young Adults (Instructions for Young Adults):

1. Follow steps 1 – 4 of the guide activity listed above.

2. Imagine you have intercepted a secret message which you wish to read. You don't know what the crib is, but you need to figure out a way to decode the message. The message reads:

PGDUZS // FTQ // RUDEF // IADXP // IMD //, SUDXSGUPQE // IQDQ // QZFDGEFQP // ME // GZPQDOAHQD // EBUQE // FA // OMDDK // OAZRUPQZFUMX //, OAPQP // YQEEMSQE //. MF // RUDEF //, FTUE // FMEW // IME // SUHQZ // FA // FTQ // NAK // EOAGFE //, NGF // UF // EAAZ // NQOMYQ // MBBMDQZF // FTMF // FTQK // IQDQ // FAA // NAUEFQDAGE // MZP // FMXWMFUHQ // RAD // FTQ // FMEW

3. Try to figure out a method to decode the message. If you're struggling, here are a few hints:

- The most common letter in the English language is ‚E'
- Hint: Focus on two-letter words like ‚FA' and ‚UF' to figure out the crib!
- Cheat: Answer is at the bottom of the page if you get really stuck

(Continued over)

During the First World War, Girlguides were entrusted as undercover spies to carry confidential, coded messages. At first, this task was given to the boy scouts, but it soon became apparent that they were too boisterous and talkative for the task.

Cipher Wheel – Cyber Security Engineering (cont.)

How this relates to engineering

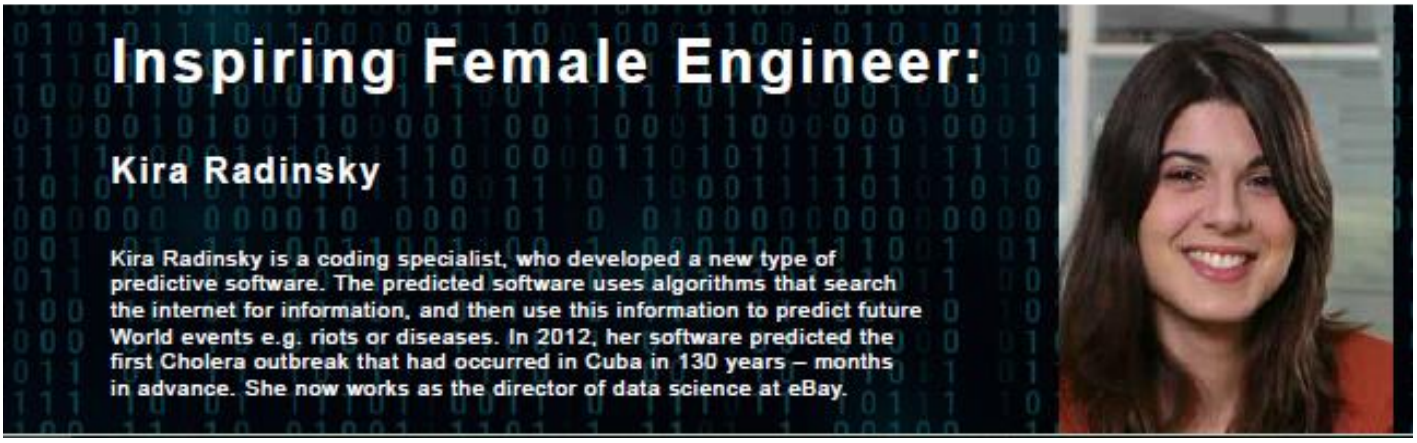
Cyber Security Engineers undertake many different tasks in their job. They are problem solvers, and use their problem solving skills to develop secure network solutions, protect against threats and manage security technology. This task is a basic step in understanding decryption and coded messages. This task helps to form a basic understanding of how letters and numbers can be used interchangeably in many ways to encrypt, store and transfer data.

Brownies & Guides Coded Message

1. RFWNJ // HZWNJ // BFX // YMJ // KNWXY // UJWXTS // JAJW // YT // BNS // YBT // STGJQ // UWNEX

2. FQNHJ // UJWWD // BFX // YMJ // KNWXY // BTRFS // YT // LWFIZFYJ // BNYM // F // IJLWJJ // NS // JSLNSJJWNSL // NS // YMJ // PF // - NS 1906!

1. Marie Curie was the first person ever to win two Nobel prizes, and created the theory of radioactivity
2. Alice Perry was the first woman to graduate with a degree in engineering in Great Britain, in 1906



Binary Activities – Cyber Security Engineering

Equipment

- Thread (you can use ribbon or string too)
- 16 beads – 2 packs of different colours
- Piece of paper
- 2 different coloured pens

Estimated time: 15-20 minutes

Method

In the diagram below, the black boxes represent 0s and the white boxes represent 1s (on and off signals). Each letter below has its own sequence of on and off signals within the binary alphabet.

Letter	Pattern	Letter	Pattern
A		N	
B		O	
C		P	
D		Q	
E		R	
F		S	
G		T	
H		U	
I		V	
J		W	
K		X	
L		Y	
M		Z	

On a piece of paper, write down your initials using the white and black boxes (binary code) above. For example, if your initials are LE then you will write it down as:

L		E	

Binary Activities – Cyber Security Engineering (cont.)

- You will need 16 beads in order to create your necklace.
- Choose one coloured bead to place on top of the black boxes and another coloured bead to place on top of the white boxes that spell out your initials.
- Place your different coloured beads on top of the white and black boxes on your piece of paper that spell out your initials.
- With your leader's help, measure a piece of thread that fits your neck comfortably for a necklace and cut it leaving a little extra in order to tie knots at both ends.
- Tie a knot at one end of thread and then thread the beads onto your piece of thread in the correct order to spell out both letters of your initials.
- After you've threaded all of your beads, ask your leader to help you with tying both pieces of thread together whilst you're wearing the necklace.

How this relates to engineering

Cyber Security Engineers undertake many different tasks in their job. They are problem solvers, and use their problem solving skills to develop secure network solutions, protect against threats and manage security technology. This task is a basic step in understanding decryption and coded messages. This task helps to form a basic understanding of how letters and numbers can be used interchangeably in many ways to encrypt, store and transfer data.

Inspiring Female Engineer:

Grace Murray Hopper

- Grace Hopper is often referred to as a 'pioneer computer scientist' who was known for creating COBOL (Common Business-Oriented Language) – the first computing language.
- She earned a PhD in Mathematics from Yale University, worked at the Havard University Computation Laboratory and went onto become a rear admiral in the Navy.
- In 1969, she was named 'Computer Science Man of the Year' by the Data Processing Management Association
- In 1991, she was the first woman to be awarded the National Medal of technology – the highest honour within engineering and technology in the United States.
- Throughout her life, she helped assemble computer compilers, systems which translate programming languages and codes. She spent her time trying to make programming more understandable to non-experts and as a result more businesses were able to utilise computer technology.

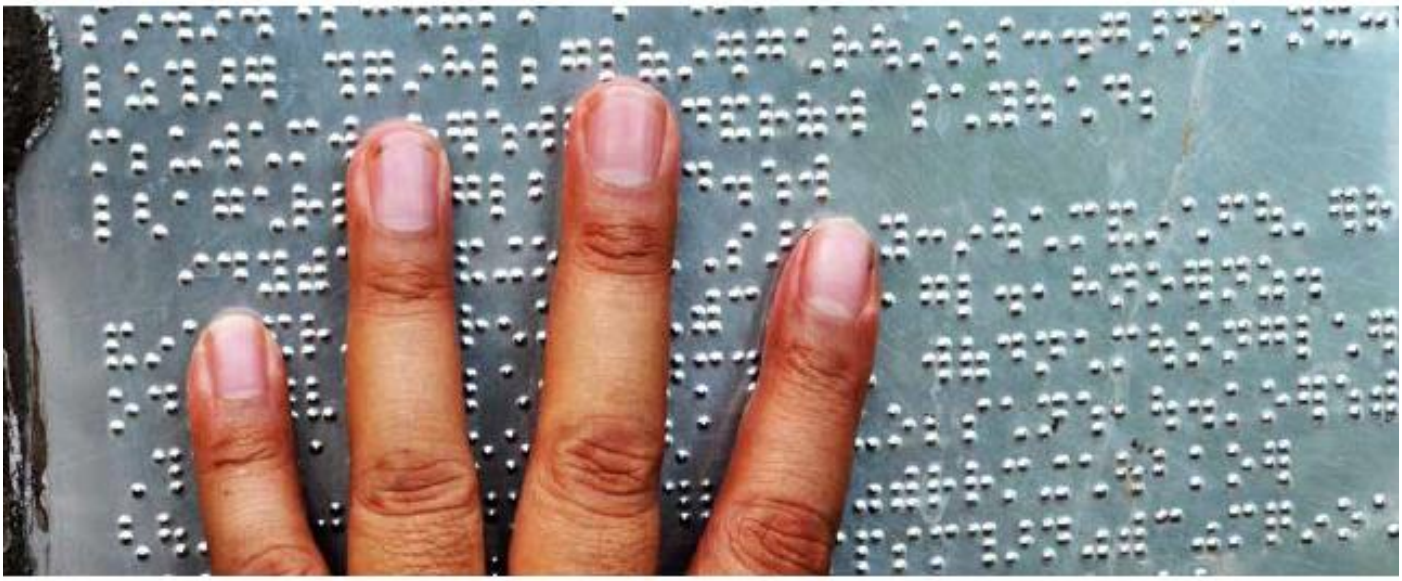
Binary Activities – Cyber Security Engineering (cont.)

How this relates to engineering

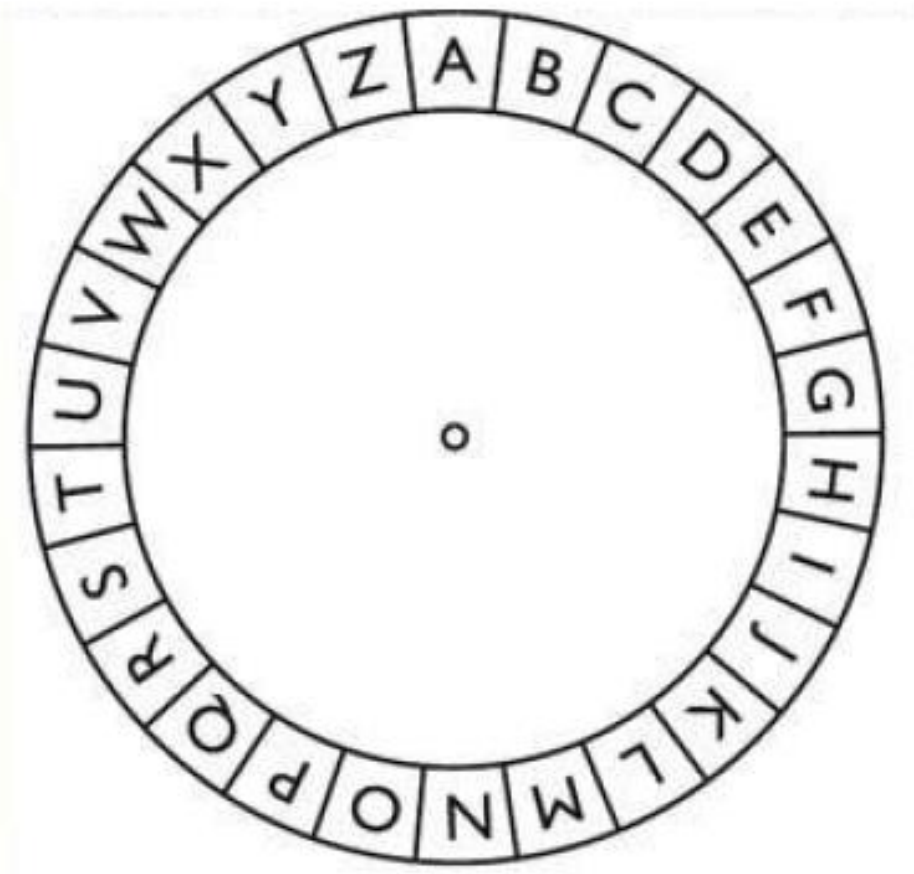
Computers are used to store and view data; they process data by using electrical signals which are either on or off. All of the data that needs to be processed by a computer must be converted into binary format; it's a language which the computers can understand.

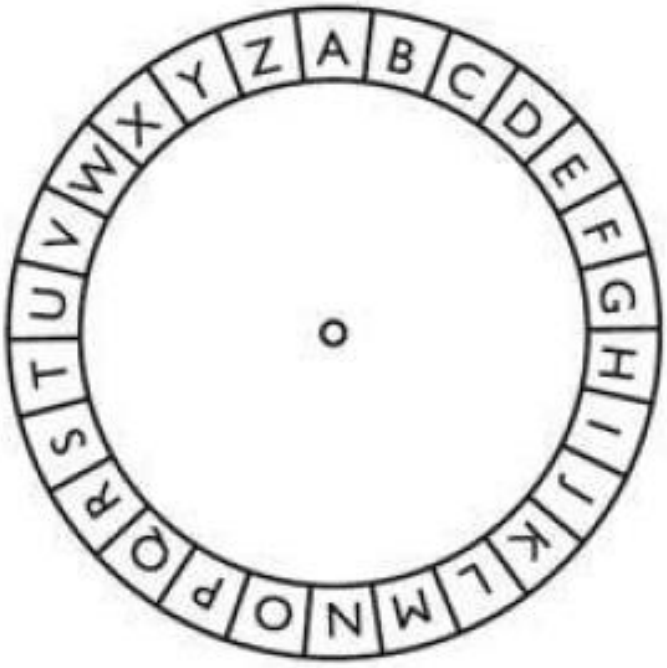
Binary code represents text, computer instructions or any other data using a two-symbol system (1s and 0s). The binary code assigns a pattern of binary digits, also known as bits, to each instruction.

Braille is a type of binary code that is widely used by blind people to read and write by touch, named for its creator, Louis Braille. This system consists of grids of six dots each, three per column, in which each dot has two states: raised or not raised which is similar to how binary code works for computers by being in an on or off state.



Appendix – Cipher Wheel Template





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