scdi Scottish Council for Development and Industry

Young Engineers & Science Clubs Scotland

STEM in a Shoebox *on a* Shoestring

www.yecscotland.co.uk
@scdiYESC

STEM in a Shoebox

We are excited to present a series of practical STEM activities with a Shoebox, to complement our popular Pizza Box challenges.

The challenges each use a shoebox to introduce a range of Science, Technology, Engineering and Maths concepts. These can be run at a club or within the curriculum to suit the school. The activities support pupils to achieve the following first/second level outcome, although most of the activities can be easily adapted to suit groups at different stages, helping to develop problem solving and inquiry skills while working collaboratively.

> Through discovery and imagination, I can develop and use problem-solving strategies to construct models. TCH 1-14a / TCH 2-14a

Instructions are provided for each activity along with a list of the easily accessible resources required, in addition to the shoebox!

We would love to hear your feedback on the project, and see your own shoebox creations too! Please contact us by e-mailing: yesc@scdi.org.uk or tweet your photos to @scdiYESC

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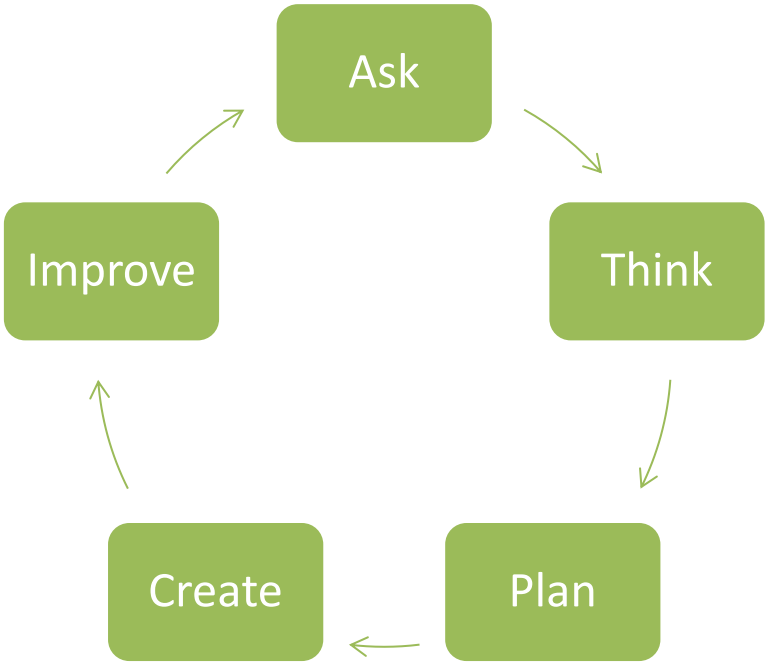
Engineering Design Process

Young Engineers are encouraged to develop their communication skills as they discuss ideas and design solutions to solve problems together.

A sample Engineering Report Sheet has been included for use with the relevant challenges. In general, Young Engineers should use the following steps when tackling an Engineering project:

1. Define the problem
2. Research/Consider several different ideas
3. Choose one and try it
4. Assess its performance
5. Consider improvements - Improve
6. If necessary, go back to step 2 and try a new design.



Health and Safety

Please note that it is teachers' responsibility to ensure activities are carried out safely within the club or class, and to complete a risk assessment in accordance with usual practice before undertaking any practical activities. A sample template has been provided and please do not hesitate to get in touch if you require any further guidance.
Throughout the Teacher's Notes you will find reminders of specific Health and Safety requirements relating to each activity or experiment, **highlighted in red.**

Challenge 1 - Coin sorter

Materials: Shoebox, cardboard, scissors, sellotape, ruler, spare change to be sorted!

- To sort the coins we first need to know their sizes. Looking at current British coins, you'll see that the sizes are not reflective of the value. Measure the diameter of each coin, then check your answers against the specifications on The Royal Mint website.

Coins sorted by value.

Coins sorted by size.

- Cut a hole in the top of the shoebox, at least the size of the largest coin.
- Fold a piece of cardboard into a cone and insert through the hole to act as a funnel. Secure in place with tape.
- Cut 7 pieces of cardboard the width and depth of the box.
- In one piece, cut around your 50p coin. This will be the first layer for the coins to filter through so by making the hole large enough for the 50p, that coin and any smaller will fit through, leaving the larger £2 coins to collect there.

- On the second piece of cardboard, cut around a 2p coin.
- On the third piece of cardboard, cut around a 10p coin.
- On the fourth piece of cardboard, cut around a £1 coin.
- On the fifth piece of cardboard, cut around a 20p coin.
- On the sixth piece of cardboard, cut around a 1p coin.
- On the seventh piece of cardboard, cut around a 5p coin.
- Use tape to secure each layer across the width of the box, beneath the funnel. Position the cardboard layers with a dip in the middle to help the coins travel towards the hole.
- When all layers are secure, with the holes roughly beneath one another, close the door and tip your change in to be sorted! You may need to give it a gentle shake to move any large coins blocking holes to allow any smaller coins to get through!

- The smallest 5p coins should fall though all the holes and end up at the bottom of the box.
- The 1p coins will get as far as the seventh layer, above the 5p coins.
- The 20p coins will be on the sixth layer.
- The £1 coins will be on the fifth layer.
- The 10p coins will be on the fourth layer.
- The 2p coins will be on the third layer.
- The 50p coins will be on the second layer.
- The largest £2 coins will be on the first layer as they were too large to fit through any holes.

- What are the challenges with this design? For example, the coins can cover a hole, preventing other coins from getting through.
- What other designs can you think of? For example, could you create a system for the coins to roll down a ramp and fall through appropriately sized gaps, to ensure they would keep moving over holes that were too small and prevent a blockage?

Challenge 2 - Raft

Materials: Shoebox, strong tape (Duct tape/Parcel tape), floating materials (e.g. plastic bottles, balloons, polystyrene cups, bubble wrap), kebab skewers/straws to make a mast, paper/plastic bag to make sails, items as a load.

- Experiment to find the best material to waterproof your box. You could try covering smaller pieces of card in various waterproofing materials such as tape or polythene bags, and time how long it takes for each to get wet.
- Experiment to find materials that float well. Does your waterproofed box float well on its own, or would adding plastic bottles, balloons, polystyrene cups, bubble wrap or other materials to the base of the box to help it float? Remember to waterproof any other materials (e.g. ensure the bottle lids are sealed, or if using cups ensure they are sealed together or to the base of the box using tape.
- Test your raft in water!
- Try adding a load and record what weight it can comfortably carry. Think about where to position the load to keep the raft balanced.

- How could the raft travel across a tank of water? You could try adding a sail and use a fan or hairdryer to guide it along, or use some string, perhaps with a magnet, to drag it along the tank/bath. **Remember to keep all electricals out of contact with the water.**
- Investigate what speed your raft can travel. Does changing the weight of the load affect the speed?

Challenge 3 - Cable Car

Materials: Shoebox, scissors, coloured card/pens to design, drinking straw, sellotape, string, pulleys.

- Design your shoebox as a cable car. You'll need a door for passengers to get in and perhaps a window for them to see the views on their journey.
- Attach a drinking straw (or toilet roll tube) to the top of the box.
- Feed string through the straw/tube then secure the string to something stable (door handle, table leg) at either end of the room. By positioning one end of the string higher than the other, the cable car can travel downhill.
- Try it out and time how quickly you can travel along a set distance.
- Investigate what weight your cable car can safely hold. Does increasing the load affect the speed it travels?

- Now that you can travel downhill, investigate how you would travel uphill. Try creating a simple pulley system to hoist the cable car up.

Challenge 4 - Parachute

Materials: Shoebox, string, sellotape, balloons/plastic bags, padding materials (e.g. cotton wool, bubble wrap), eggs.

- Using string, attach a plastic bag to your shoebox to act as a parachute. You could also try tying inflated balloons to the box.
- Measure how long it takes for the box to fall to the floor, from a set height. Remember that the purpose of a parachute is to slow movement by creating drag, so the slowest is best!
- Compare using a shoebox with the shoebox lid. Which is more stable?
- Use padding materials to protect an egg within your box/lid.
- Investigate whether you can protect the egg in the shoebox/lid so it doesn't crack when dropped to the floor from a set height!

Challenge 5 - Maze

Materials: Shoebox, sprouting potato or onion, cardboard, sellotape, scissors.

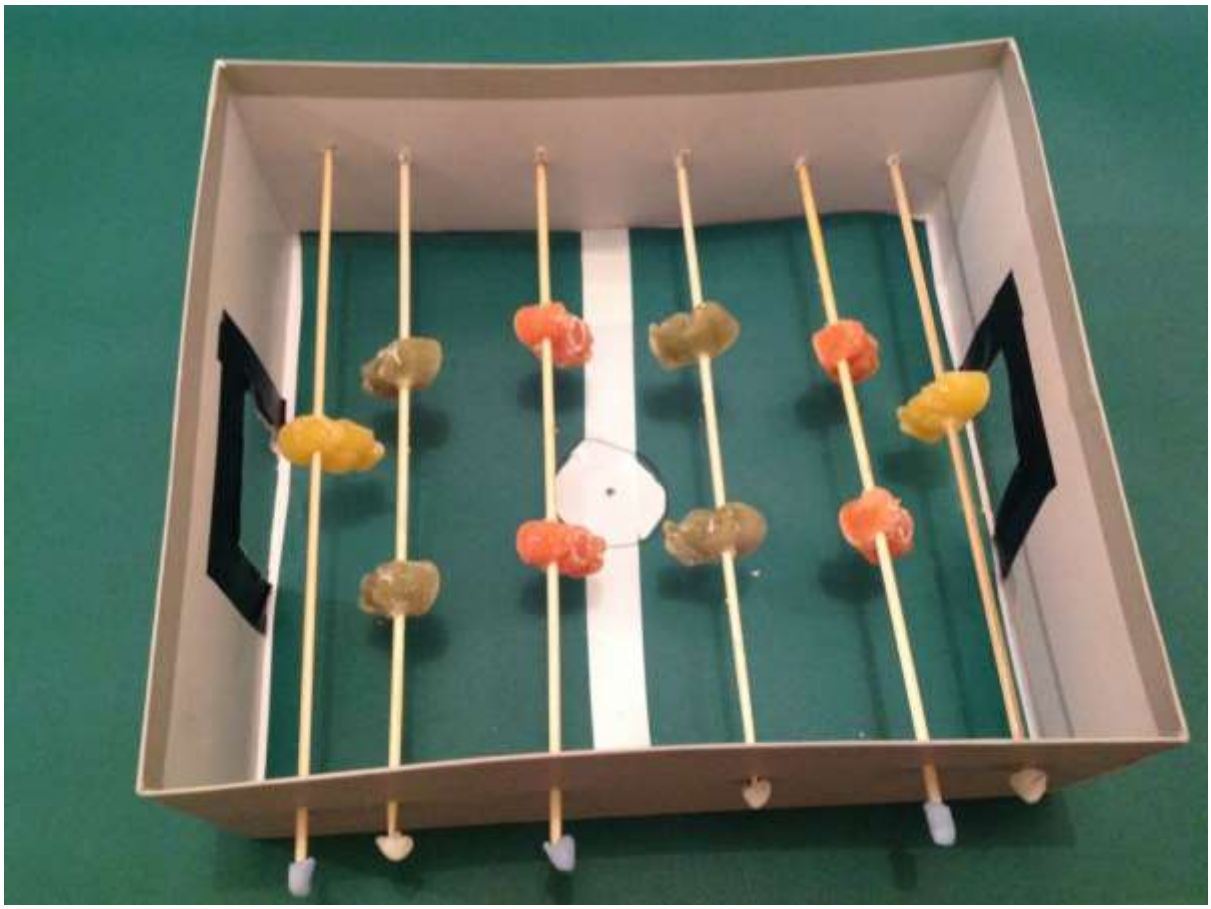
- Cut two pieces of cardboard the width and depth of the shoebox.
- Cut a hole in each piece, a few centimetre diameter.
- Tape these pieces into the box to create three compartments (see left image below).
- Or, rather than cutting holes you could use two pieces of cardboard about ¾ of the width of your box (see right image below).

- Cut a hole in one end of the shoebox, a few centimetre diameter.
- Place your sprouting potato or onion in the compartment at the end without a hole.
- Replace the lid and position the box on a sunny windowsill, with the hole directed to the sunlight.
- Check on your potato/onion every few days to monitor its progress through your maze. Record the time taken for the shoots to reach out of the box.
- Did the potato/onion follow the maze to reach the sunlight? Why is it useful for plants to be able to position themselves towards sunlight?

Challenge 6 - Table Football

Materials: Shoebox, kebab skewers, card, scissors, sellotape, ping pong ball.

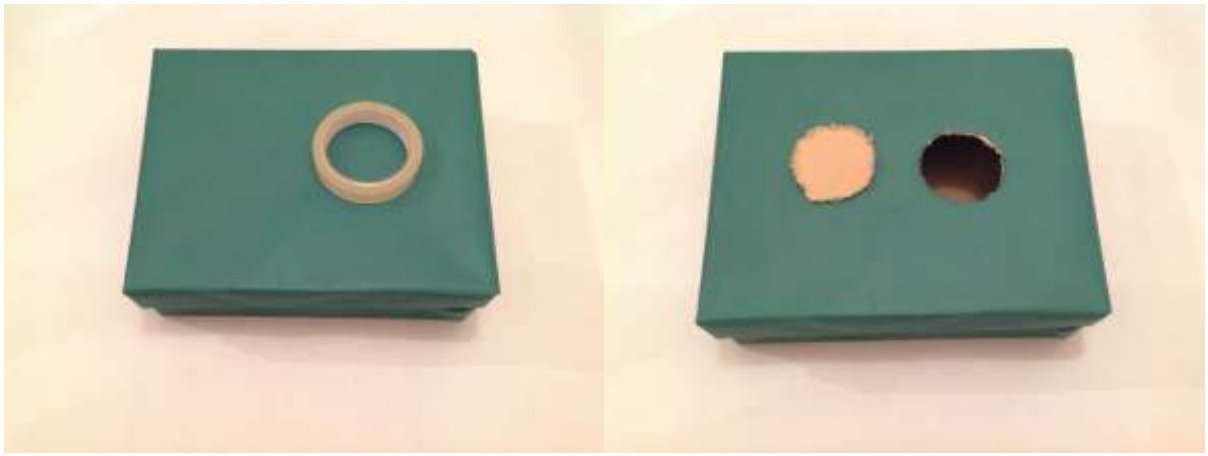
- Cut a rectangle as the 'goal' at either end of the box. Ensure they are the same size at either end, and big enough for the ball to fit in!
- Decorate the box as a football pitch, or your favourite sports ground (it is easier to do this before putting the kebab skewers in).
- Draw your players on card, or you may wish to use Jelly babies or small toys (Duplo figures are a good size). Think about what size they need to be to fit in the box.
- Use one of your figures to check what height you will need the kebab skewers to be, then pierce the kebab skewer through one side of the box, and out the other side, ensuring it is level.
- Cover the pointed ends of the skewers to help prevent injury. You could use two different colours of plasticine, one for each team.
- Attach your players to kebab skewers, ensuring there's an equal number of players on each team! Think about how many can fit in your box and how you'll position them to ensure the best chance of scoring goals.
- Use a ping pong ball, marble or other small ball appropriate to the size of your box and players, and see how many goals you can score!



Challenge 7 - Guitar

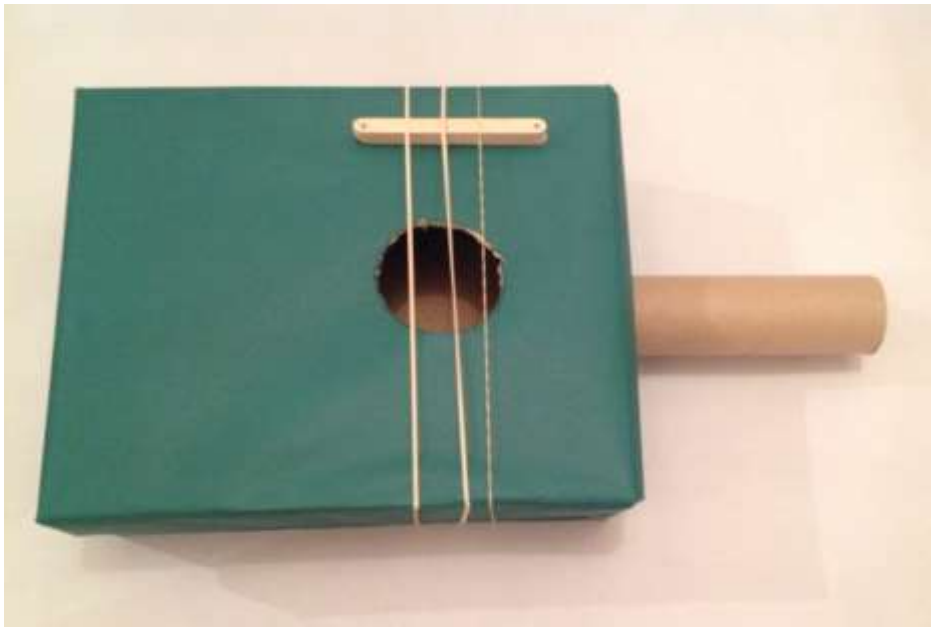
Materials: Shoebox, cardboard or kitchen roll tube, scissors, large elastic bands.

- Secure the lid on then decorate the box (at least cover with coloured paper, which is easier to do at this stage, but further decorations can be added later).
- Cut a circle about a third of the way down the shoebox as the sound hole.



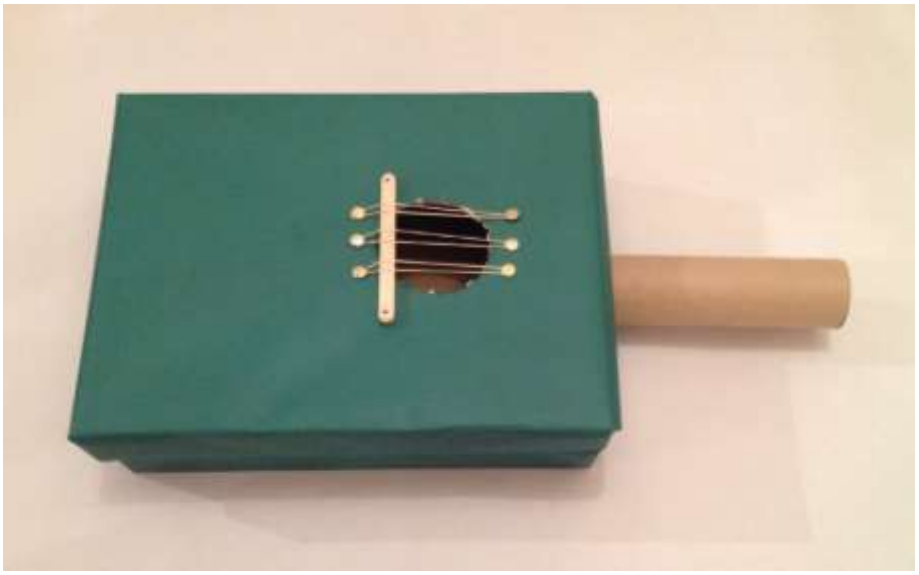
- Draw around the kitchen roll tube in the centre of the top of the shoebox. Then cut out this circle. If you cut the circle slightly smaller than drawn, the tube can fit in without needing glue or tape to hold it in position.

- Stretch the elastic bands over the box, ensuring they pass over the sound hole.
- Attach a long object such as a small pile of lollipop sticks or a pen, underneath the bands on one side.



- Now you are ready to make some music!

- If your elastic bands are not big enough to stretch over the length of the box, try putting them across the width of the box (see example above) or attach them across the sound hole using drawing pins or paper fasteners.



- Investigate whether positioning the bands in different places over the hole makes different sounds. Does the size of the sound hole affect the sound? Does the length of the tube affect the sound? What happens if you remove the pile of lollipop sticks?

Challenge 8 - Projector

Materials: Shoebox, magnifying glass, smartphone or small tablet, scissors, tape, plasticine.

- Draw around the magnifying glass at one end of the shoebox then cut out this circle.

- Attach the magnifying glass to the box with the flat side facing into the box.
- Position the box towards a blank projection screen or wall. Hold the smartphone in the box and move it closer or further from the magnifying glass to focus the image. This will test your patience but it is worth persevering!

- Once you have found the optimum position to project an image, note the distance the box is from the wall and the position of the smartphone within the box. You could then use plasticine to hold the smartphone in position.
- Remember that when light rays converge an inverted image can be produced, so if your image appears upside down, lock the rotation on the smartphone and have the image upside down before securing it with the plasticine, so that it will appear the correct way up on the screen/wall.

Engineering Report Sheet

The Challenge:	
Research sources including web links:	
Our design ideas:	
Our chosen design:	
What worked well?	
How could the design be improved?	