More marvellous magnets

Exploration with magnets is an exciting way to provide opportunities for learners to plan investigations and apply their knowledge to solve practical problems. In SSERC Bulletin 81 [1] we outlined a variety of ideas for practical science inquiry using magnetism as the focus.

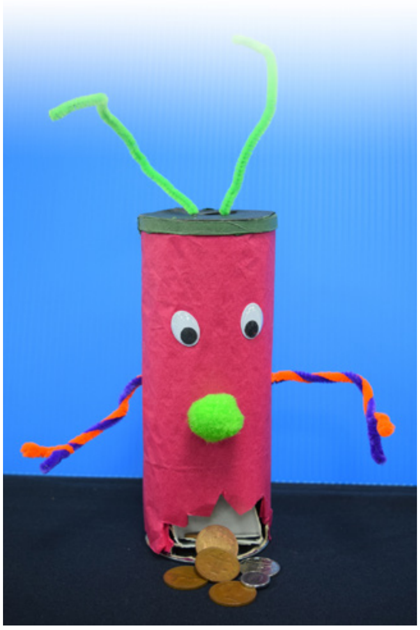

Figure 1 - The Marvellous Money Munching Monster.

In this bulletin we will provide additional ideas - all of which are designed to support CfE Sciences [2] and Technologies [3].

SCIENCES
Forces, electricity and waves

- Through everyday experiences and play with a variety of toys and other objects, I can recognise simple types of forces and describe their effects - *SCN 0-07a*.
- By exploring the forces exerted by magnets on other magnets and magnetic materials, I can contribute to the design of a game - *SCN 1-08a*.
- I have collaborated in investigations to compare magnetic, electrostatic and gravitational forces and have explored their practical applications - *SCN 2-08a*.

TECHNOLOGIES
Craft, design, engineering and graphics

- Design and Construct Models/ Product - *TCH 0-09a/1-09a/2-09a*.
- Exploring Uses of Materials - *TCH 0-10a/1-10a/2-10a*.

Once learners have explored magnets and magnetic materials and are familiar with the forces exerted by magnets on other magnets and magnetic materials they can start to contribute to the design of a game. We will outline several ideas for games and models using magnetic forces.

Make a Marvellous Money Munching Monster

This model appears to "swallow" some coins and "spit" out others - even though the coins appear to be made of the same material!

In Bulletin 81 we mentioned a change to the metals used to make coins in recent years and the effect this has had on whether 1p, 2p, 5p and 10p coins are magnetic or not. Since 1991 1p and 2p coins have been made from copper plated steel rather than bronze (a copper alloy) so these more recent coins are attracted to a magnet. Coins of this denomination that pre-date this change are not attracted to a magnet.

From 2011 5p and 10p coins have been made from nickel plated steel and are magnetic, in contrast to the older coins made of cupronickel (an alloy containing mainly copper and so non-magnetic). This change has been to save money, as the cost of the new material represents a significant saving. If you have a collection of older and newer coins learners will be able to use this interesting change in materials to make a money sorting model (see Figure 1).

Figure 2 - Inside the model - showing the magnets positioned on the cardboard chute.

Make sure you build up a collection of the older coins before they are removed from circulation. Learners could design ways to separate the mixture of coins – the money munching monster is just one possibility.

To make the model gather together: a tube or box - preferably with a lid or top, a piece of cardboard (to make a chute to fit inside the tube/box) and 10 ceramic magnets [4].

Learners can be shown a finished model and try to figure out how it works – after all it's not a magic monster! Learners could then be set a challenge to make their own versions.

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Figure 3 - Cardboard chute showing magnetic and non-magnetic coins.

Figure 4 - Cardboard chute showing spacing and position of magnets.

In our model the coins are posted through a slot in the lid and travel down a chute inside the tube. There are pairs of ceramic magnets placed down the sides of the chute. The magnets are placed far enough apart to allow non-magnetic coins to travel down freely (Figure 2), but positioned to ensure that all the magnetic coins are attracted to the magnets and are prevented from reaching the bottom of the chute (see Figure 3).

The chute will need to fit inside the tube/box at a steep enough angle to allow coins to travel down from top to bottom. We used the side of a cereal box cut to fit the length of the tube. We found that the optimum width for the chute was around 5 cm.

Learners can experiment to find the best number and position of the magnets to allow the sorting to take place consistently. We found that positioning pairs of magnets at 5.5 cm intervals along each edge of the chute and offsetting the magnets on either side of the chute by 2 cm on either worked well (Figure 4). Three or four coins (some newer and some older) can then be dropped down the chute, some will be attracted to the magnet and some will drop. If too many coins are dropped down at any one time then a blockage may occur further up the chute.

The magnets can be easily be used for other projects as they are not stuck to the chute. Once the chute is working well it can be placed in the tube/box and a slot carefully cut in the lid of the tube/box to allow the coins to be "posted" into the top of the tube. We secured the bottom of the chute in place with Velcro© to allow the chute to be removed easily to retrieve the magnetic coins. A hole can also be carefully cut into the bottom of the tube/box to allow any rejected coins to be "spat out" by the monster. The monster can then be "fed" a variety of coins and predictions/explanations sought from those observers unaware of the internal workings!

Make a Face (magnetic face matching game)

Based on the ever-popular "fishing" game this matching game uses inexpensive stick-on magnets [5] to enable learners to complete a matching face by fishing various facial features from inside a cardboard tube (Figure 5). There are some "red-herrings" in the mix so careful observation is needed!

We constructed a fishing rod from a paper straw by attaching two stick-on magnets to a piece of thread. Four adhesive magnets were stuck onto the tube to hold the chosen facial features, the tube also acts as receptacle for the features. A small steel paper clip is attached to each facial feature (Figure 6). We had to make sure that the magnets >>

Figure 5 - Make a face - magnetic fishing game.

Figure 6 - Completed Make a Face game.

Figure 7 - Magnetic Boat – showing drawing pins, mast and sail.

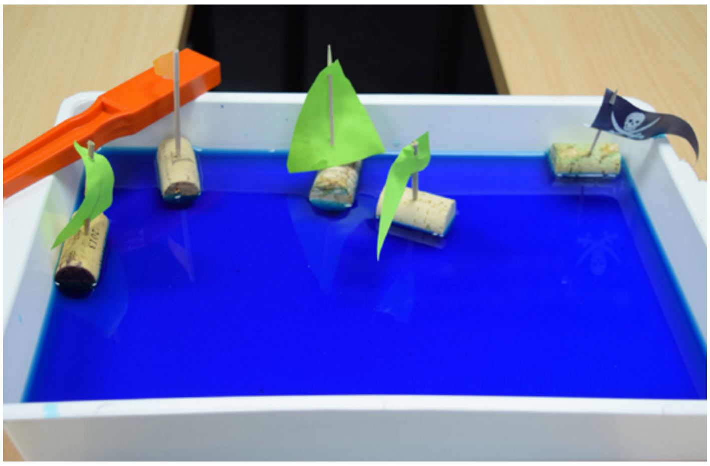

Figure 8 - Magnetic Boats floating in water tray between two tables. The magnet wand can be used to guide the boats from underneath the tray.

exerted a sufficiently weak force to allow only one facial feature to be attracted at once. Stronger magnets attracted too many facial features at once, making the game difficult to play. The number and complexity of the features chosen can adapted to challenge learners.

Magnetic boats

This idea is based on a game that has been around for a long time – it is included in the Ladybird Junior Book of Magnets, Bulbs and Batteries first published in 1962 [6]. Boats are constructed of corks with a keel of steel drawing pins. A mast can be added using a wooden skewer/toothpick and a sail made of paper (Figure 7). Once the boat is balanced on land it can be floated in a tray of water placed between two tables (Figure 8). A magnet wand (or other small easy-to-handle magnet) can be used to guide the boats from underneath the tray. A maze or obstacles can be placed in the water and boats can be guided or raced around the course. Learners can experiment with a variety of magnets and investigate the range of the magnetic force.

Figure 9 - Magnet maze on a plate with magnet wand.

Magnet maze

Designing a magnet maze to challenge even the most dexterous person is a great way to encourage creativity and demonstrate learners' understanding of magnetism. A variety of materials can be used to produce a magnet maze on a large or small scale. We have used a paper plate for a small scale maze, along with a magnetic marble and magnet wand (Figure 9) and for a larger scale maze a piece of cardboard/corriflute could be used [7]. All kinds of obstacles can be devised and constructed using easily sourced materials.

Maglev train

The ceramic magnets used in the Marvellous Money Munching Monster can also be used to construct a model Maglev (Magnetic Levitation) train. As learners will have discovered the like poles of two magnets repel each other. In this model magnetic repulsion lifts the train up above the tracks and thereby reduces friction as it travels along. We constructed the track using pieces of pine strip-wood – this is easily available from DIY stores. A single piece of wood 2.5 cm x 0.9 cm x 90 cm long was used for the base and two pieces 3.5 cm x 0.9 cm x 90 cm were used for the sides (see Figure 10).

Figure 10 - Track for Maglev train showing base and sides made from strip wood.

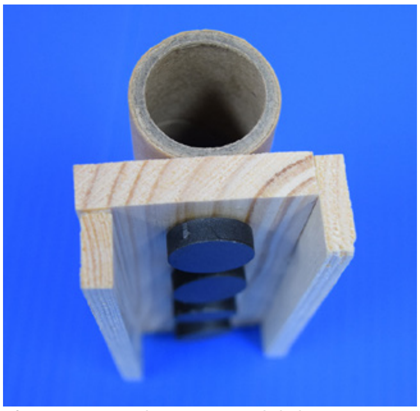

Figure 11 - Maglev Train model showing position of the pieces of wood and magnets.

Double-sided sticky tape was used to hold the pieces together. The model can be easily dismantled after use. We spaced the ceramic magnets out evenly along the base using blu-tac - 1 cm apart ensuring the magnets all face the same way up in terms of polarity (test this with another magnet). The magnets can easily be repositioned/reused.

The train itself is made from a piece of strip wood 4.5 cm x 0.9 cm x 11.5 cm – forming the base with one side piece 2 cm x 0.5 cm 11 cm and the other side piece 1.5 cm x 0.5 cm x 11 cm. Once again, the pieces of wood are fixed with double-sided tape. The way the pieces are arranged to make the train are shown in Figure 11. This configuration allows the model to fit over the track and keeps it stable as it moves along the raised track. We added a cardboard tube on the top to provide stability – this can then be painted to complete the model.

Magnets are placed on the underside of the train (Figure 12). Ensure that the magnets are placed so that they are repulsed by the magnets on the track. The train will be raised off the wooden rails by the repulsive force of the like poles and when pushed along the track it will move more easily due to the reduction in friction (Figure 13). We used magnets on half the track and left the other half without magnets to compare the force needed to propel the train along the track in each case. This technology is used by Japanese bullet trains and Maglev trains are currently in development that have documented record-breaking speeds of up to 603 km/h [8].

Figure 12 - Maglev train underside showing position of magnets.

Constructing a Maglev train model could support learners as they progress through CfE in Sciences [2] and Technologies [3].

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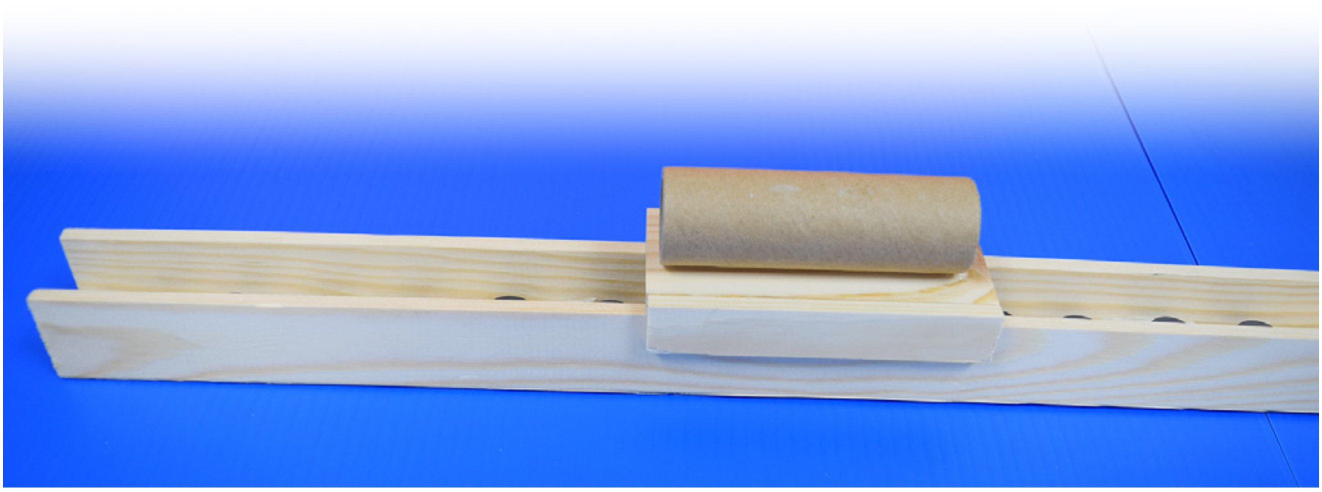

Figure 13 - Maglev train model on track.

Using magnets safely

Avoid using very small magnets, especially with young children as they could pose a choking hazard.

Children should be warned about the possibility of strong magnets moving together and pinching the skin. This is particularly important if you have the very powerful rare earth metal magnets (e.g.neodymium).

Strong magnets should not be used near anyone who has a pacemaker. <<

More Experiences and Outcomes

Forces, electricity and waves

- By investigating how friction, including air resistance, affects motion, I can suggest ways to improve efficiency in moving objects - *SCN 2-07a*.

Craft, design, engineering and graphics

- I can design and construct models and explain my solutions - *TCH 1-09a*.
- I can extend and enhance my design skills to solve problems and can construct models - *TCH 2-09a*.
- I can recognise a variety of materials and suggest an appropriate material for a specific use - *TCH 1-10a*.
- I can recognise basic properties and uses for a variety of materials and can discuss which ones are most suitable for a given task - *TCH 2-10a*.
- I explore and discover engineering disciplines and can create solutions - *TCH 1-12a*.
- I can extend my knowledge and understanding of engineering disciplines to create solutions - *TCH 2-12a*.

References

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