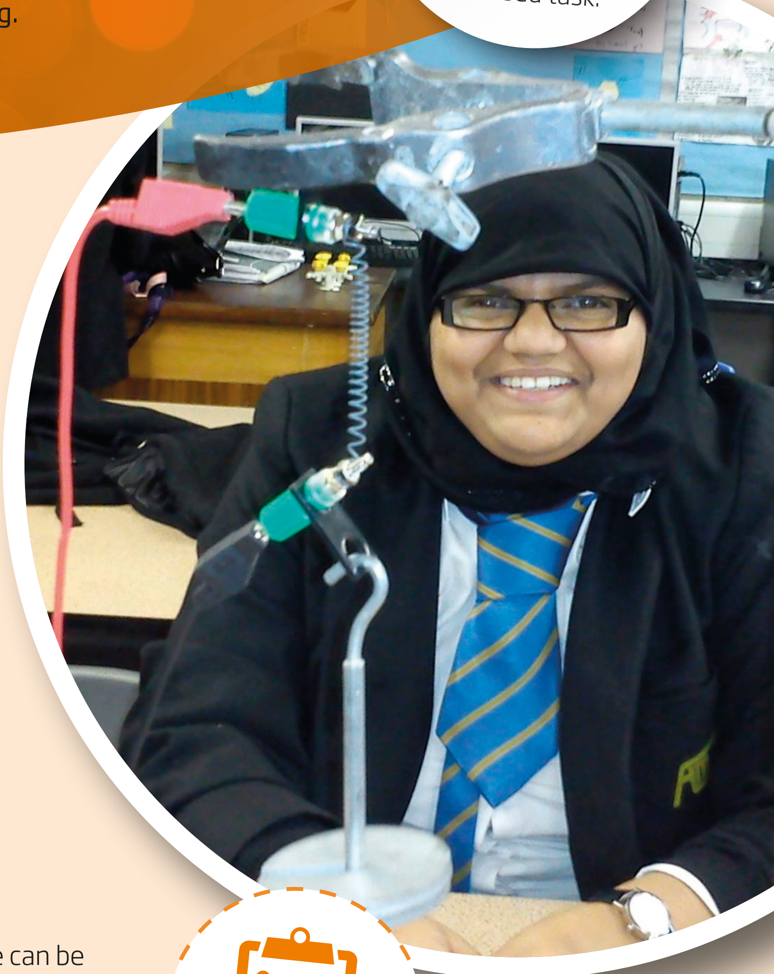
Smart **muscle**

As humans we are always evolving, especially when it comes to developing new technologies.

During this session, students will question the properties of materials and model a muscle based on a smart spring.

The initial experiment can be done in one session. The activity can be extended to several weeks by including the design and make focused task.



Adaptation

There are many instances of humans using technology to adapt their bodies.

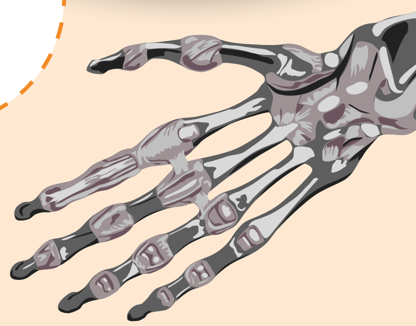
For example, Paralympic athletes have been able to use carbon fibre prosthetic legs to help them compete at a very high level.

Over 50,000 hip replacements and 70,000 knee replacements take place each year on the NHS. Many different types of joint are used depending on the size, age and activity of the patient.

We have even developed humanoid robots for example Asimo (**asimo.honda.com**). This resource looks at whether we can mimic human movement by using prosthetic technology to make a 'muscle' for a new generation of robots, so they can lift their arms and grab objects.

What you need

- A 'smart' spring and wire holders with posts (these can be purchased from **www.mindsetsonline.co.uk** product codes PAC SW3 and 211-011)
- Wires
- Boss, stand, clamp
- Stopwatch
- 6V power supply
- Masses (variety of sizes)



Note for STEM Ambassadors: schools will have many of the items you need, so check with the teacher before your session. A risk assessment should be done before starting this activity.

What to do

Use the diagram below to help you set up the experiment.

Attach your wire holders (and terminal posts) to each end of the spring (see photograph).

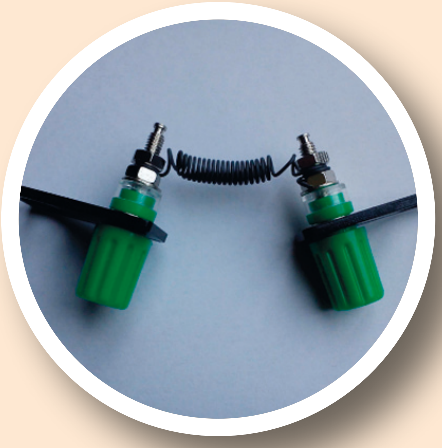
When you complete the circuit, allowing the current to flow, you will see that the masses are raised by the spring.

- Q Is the speed at which the spring contracts affected by the amount of mass?
- Q Use a stopwatch to measure the time taken for the spring to contract with various masses.

Does the spring always go back to its original shape or does it become permanently deformed? Does the spring become more extended?

By lifting the mass when there is an electrical stimulus, the smart spring is acting like an artificial muscle, perhaps in an arm. How could we use this idea to make an artificial muscle for robots?

Ask your group to design a robot with an artificial muscle. What will it be used for, who will buy it? Ask them to present their ideas on a poster.



Curriculum links

Using this activity you can discuss:

England

Science: Current electricity

D&T: Design

Scotland

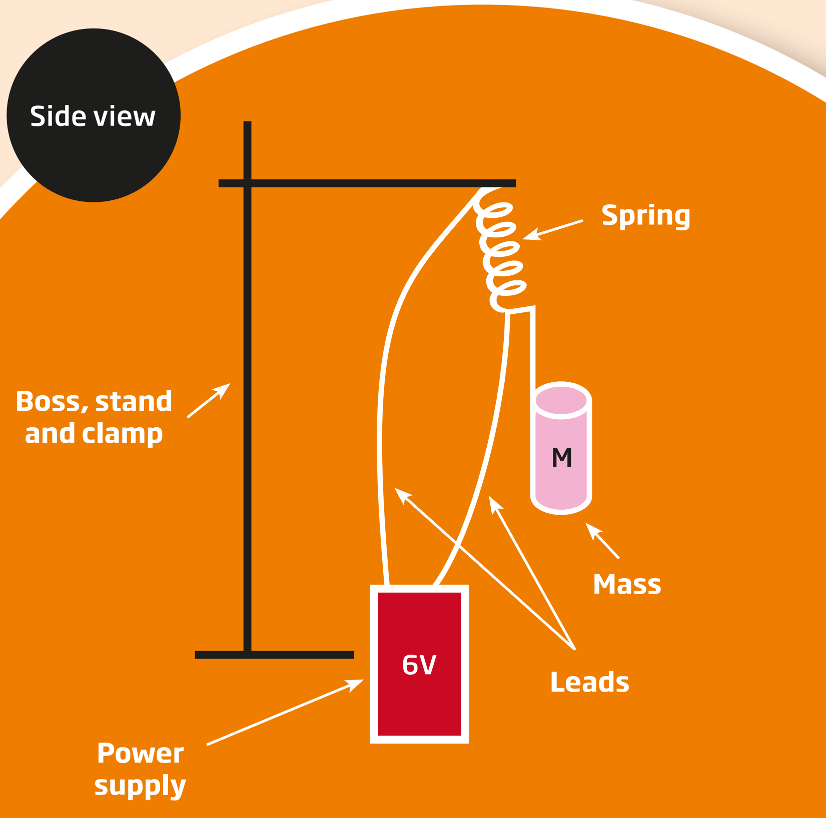
Science: Forces: 2-07a, 3-07a, Electricity 2-09a, 3-09a, Technological developments in society

Some extras...

Could you design and build an actual prototype of a robot forearm muscle? Any SAFE idea is fine, remember you will need extra materials. This could be part of an advanced Design and Technology project.

This type of spring could also be useful for opening doors or closing boxes. Can your group design and make a box that uses a Niti spring when closing?

This session could also be a starting point for discussions about biomimicry. Can the club think of examples where engineers have taken inspiration from nature? Perhaps a visit from a STEM Ambassador could help, speak to your local STEMNET contract holder to arrange.
www.stemnet.org.uk/regions



! Take care not to exceed the maximum voltage. Remember the spring will get **HOT** so don't touch, and if the mass is too heavy the spring will deform permanently!

Photograph used with kind permission of *Touch Bionics*

Explanation

This activity uses a *smart 'Niti' spring* made of an alloy of nickel and titanium.

When a current flows through the stretched spring, the metal is heated. The temperature change causes the spring to 'remember' the shape it had before it was stretched.

These shape memory alloys have many potential applications, but particularly as lightweight actuators, as an alternative to hydraulic or pneumatic systems.

Who uses prosthetic technologies?

Hugh Gill

Director of Technology, *Touch Bionics*
(visit **www.touchbionics.com**)

My role at *Touch Bionics* is to oversee the research and development behind world leading prosthetic technologies like the i-LIMB Hand, the world's first bionic hand.

Engineering is vital to the success of a company like *Touch Bionics*. Our team consists of mechanical and electronic engineers, which reflects the electromechanical nature of the products that we design.

In addition, we have software engineers who work to develop the features and control technology for the devices.

The engineering team at *Touch Bionics* will be working on a wide variety of tasks from day to day. This may include testing and updating existing product lines, or working on the next exciting innovations to come out of the company.

The ability to think creatively is a must, and helps the company to build on the impressive level of inventive products that it has assembled over the years.

It is challenging work, but ultimately very rewarding when we get to see the impact our technologies have on the people whose lives are affected by limb loss.

Handy hints

Remember that the spring will never go back into a tight coil, so try not to over stretch it too much.

This could lead to a discussion about the lifetime of products. How long would a robot's muscle made like this last before it no longer works properly?

You could start a further discussion by comparing your robot muscle to a human's. Just like our spring, muscles can only pull in one direction, so in the body muscles come in pairs. When one muscle shortens causing movement, its opposite muscle is stretched. Muscles are stimulated by electrical impulses transmitted by nerves.

There are many different resources for **smart materials**. The SEP have some useful publications, particularly on metals and smart alloys:
www.nationalstemcentre.org.uk/sep

This is engineering

Understanding a vast range of smart materials and using them to find solutions to problems is just one dynamic aspect of engineering.

Engineers with an interest in design create the initial ideas and 'blueprints' for systems, structures and products, testing models rigorously to ensure they work, using computer aided design to help. Materials engineers develop new products and improve existing ones. Have a look at related university courses at **www.ucas.com**

Entry requirements include A Levels, Advanced Diplomas and Scottish Advanced Highers.

Related fields: Mechanical engineering

There are many apprenticeships in engineering and manufacturing technologies. It is a very broad field. Some of the main manufacturing industries covered include textiles, food, furniture, glass, metals and printing. Visit **www.apprenticeships.org.uk** for more details.

In Scotland visit **www.apprenticeshipsinscotland.com** and in Wales **wales.gov.uk/apprenticeships**

Extra maths

You have found the time it takes for the spring to contract at various masses.

Q Plot a graph of time taken against mass. Is there a pattern?

Next steps

Remember there are more resources at **networking.stemnet.org.uk**

For more on STEM Clubs visit **www.stemclubs.net**

To speak with your local STEMNET representative visit **www.stemnet.org.uk/regions**

Perhaps your students will be interested in a STEM Leaders qualification? **https://extra.shu.ac.uk/cse/slq**

CREST Awards are easy-to-run, encourage students to continue with STEM subjects, and add real value to UCAS applications. To link this activity's extra ideas to a CREST Bronze Award, contact your CREST Local Coordinator: **www.britishscienceassociation.org/crestcontacts**

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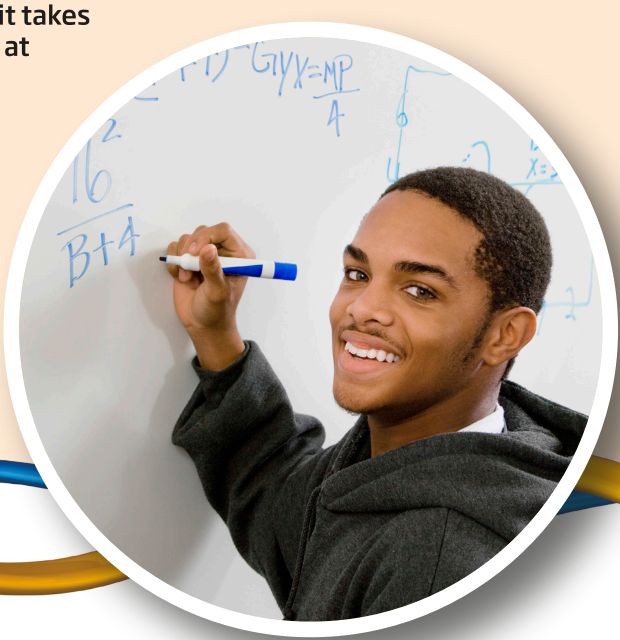

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