Dyson outreach activity: Bioengineering

Introduction

My project is based on developing a tensile test device for soft biological tissues. However, it was not possible to design an outreach activity using soft tissue due to health and safety issues, as well as potential ethical issues. As a substitute for tissue, nitinol springs were tested in tension.

Part of the aim of my outreach activity was to introduce Bioengineering to the students, as students are unlikely to have encountered this topic during secondary school. The students were shown a presentation briefly covering the various types of bioengineering, and examples of projects a bioengineer would be involved in, for example: prosthetics, medical imaging devices and genetic engineering. Bioengineering was also highlighted as an option for students struggling to choose between engineering and medicine.

Shape memory alloys and their applications to bioengineering

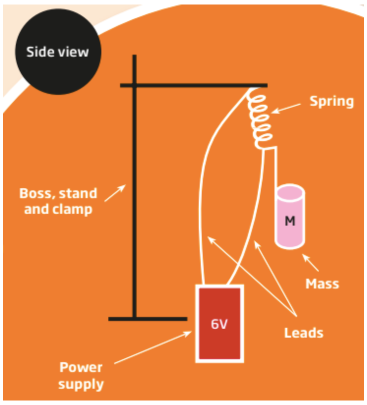
Shape memory alloys can be deformed when cold and will return to a 'remembered' shape when heated. This property can be exploited for multiple bioengineering applications such as robotics and dental braces. Shape memory springs were used for the outreach activity; the springs were extended by suspending masses from the end and then contracted to raise the mass. Links can be made between the contraction of a spring due to an electrical stimulus and human muscle contraction. These shape memory alloys have many potential applications, but particularly as lightweight actuators, as an alternative to hydraulic of pneumatic systems. Students were shown an example of a shape memory spring being used in a prosthetic hand to control movement of one of the fingers.

Outreach activity

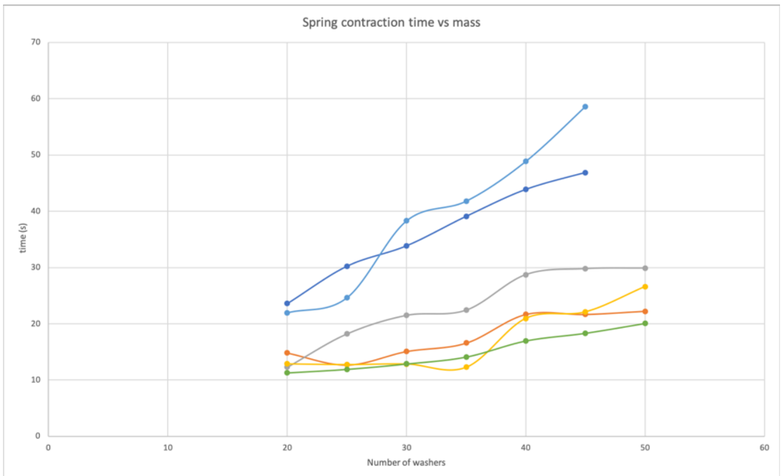
Equipment:

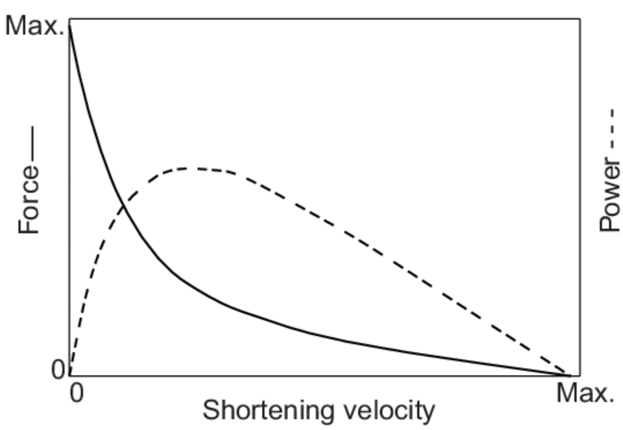
- Smart springs (1 per group)
- Wires with crocodile clips attached (2 per group)
- Masses and mass hanger
- 6V lantern battery
- Pens and paper
- Small screwdriver that was placed in a vice to support the spring
- Stopwatch (or students can use their phones)

A smart spring was suspended from one end and masses were hung from the free end, causing the spring to extend. When the spring was connected to a 6V lantern battery the current through the spring causes sufficient heating to cause contraction of the spring, raising a mass of up to 0.6Kg. The students used penny washers to load the springs, starting with 20 washers and increasing in increments of 5 to a total of 50 washers. The usable mass range was predetermined instead of letting the students decide as it was important the springs were not overextended by the addition of too much mass (if over extended the spring will not return to its remembered shape when heated). The students timed how long the spring took to contract under increasing load. While completing the measurements the students were encouraged to think about the following questions: does the spring always return to its original shape or does it become permanently deformed? Does the initial extension of spring or the amount of time taken to contract depend on how long the spring is allowed to cool down for between tests?



The results were plotted as a graph of number of washers (mass) against time taken to contract. This was then compared to the force velocity curve for human muscle.





All of the result collected by the students showed a positive correlation between mass and contraction time. However, there was significant variation between the times recorded by each group. This was due to ambiguity in when to stop the timer; some students stopped the timer once the spring stopped moving even if not fully contracted, however others let it run for longer if the spring had failed to fully contract. Groups noticed that the spring did not return to the fully contracted position at high mass. When the results are compared to the force velocity curve for muscle it is observed that the behavior of the spring is almost linear whereas muscles are highly non-linear. This is an important consideration if the springs are to be used to simulate muscles.

The second part of the outreach activity was to design a movable prosthetic limb using the springs. The students are encouraged to think about: who they are designing the limb for, what capabilities does that person need e.g. which features are most important, how many springs they will require (muscles work in pairs).

Reflection on outreach activity

The first part of the activity was successful, with the majority of the students able to collect data about the contraction times of the spring under the different loads. One group had a faulty spring therefore that pair had to be split and combined with another group. The activity took longer than anticipated due to the need to do a demonstration of setting up the equipment and then wait for all the students to set up their own. There were 7 data points to take measurements for and a few groups did not finish, despite running over on time. As a result, the second part of the activity was not completed therefore the students did not get as much of an idea of the potential uses of shape memory alloys as had been planned. The activity would have been more informative had it been able to be put into more context.

In order to speed up running of the activity the apparatus could be set up for the students ahead of time. However, it is not recommended to change the number of data points as they need to do enough to see the trend, therefore more time may be needed for this activity if it is performed again.

Risk assessment

It should be noted that the springs reach high temperatures when connected to the batteries so should not be touched during the experiment. Students should also be warned of the dangers of shorting the batteries and wear safety goggles just in case.