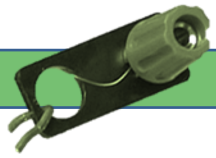

Muscle wire come sensore ed attuatore.

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Equipment

- muscle wire (L ~ 10 cm)
- cables
- battery (3V)
- switch
- graph paper
- wooden board (20 X 30 cm) with stand
- satchel + clips
- 10 grams masses
- 2 drawing pins
- ruler

Extremely thin Nitinol wires (∅ 100 μm or even less), better known ad muscle wires (actually there are many commercial names, Flexinol is one of them) are used in light weight micro devices acting as both sensors and actuators. It would actually be quite difficult to attain the same efficacy with traditional methods such as small motors or solenoids. .

As the 10 cm long wire contracts, the small movement and the big forced exerted by the wire are transformed into a larger movement thanks to particular configurations such as levers or even triangular actuators not needing any lever or pivot.

DO NOT exceed 3V and don't forget the switch on: the current passage should be strictly limited to a few seconds or even less.

Otherwise the wire may overheat and get irreparably damaged.

Do not exceed in the applied load well: max 30-35 g

Triangular actuator

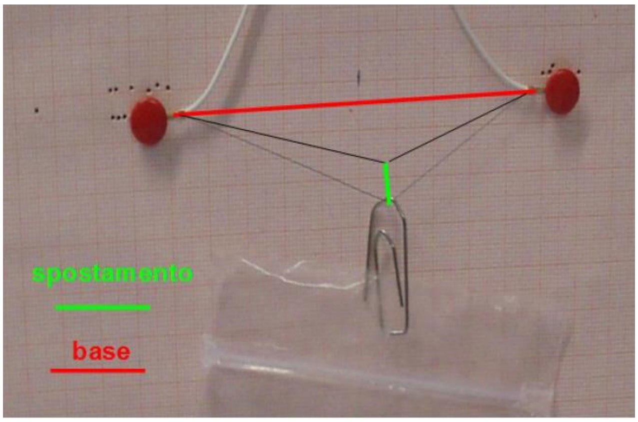
Activity 1

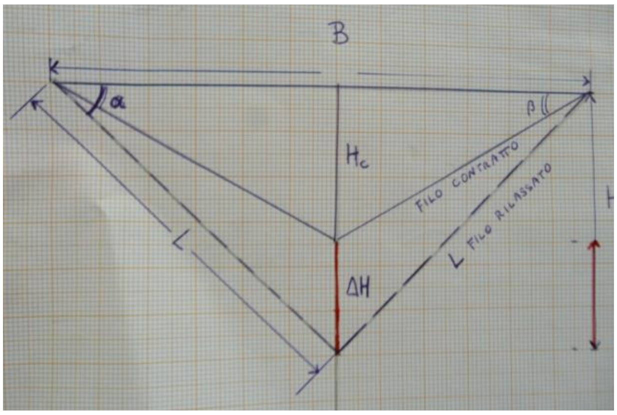
You will have to make some investigations investigate in order to answer to the following questions:

a) What happens if you **vary the length of the base in the triangular actuator?**
   a. Is there any relationship between the base length and the movement induced upon contraction (see fig.1)?
   b. Suppose you are interested in a 6 mm displacement: how large should the triangle base be?

b) Estimate the **amplification factor**: as the wire contract for a length X, a vertical movement Y of the load is produced , that means an amplification factor of ….. %

c) Estimate **efficiency**.
   a. Find a suitable way to estimate the efficiency of the triangle device
   b. Muscle wire efficiency is around 5%. 95% of energy is dissipated as heat However Nitinol finds ample application in robotics which are the advantages of such systems and devices?.





Procedure

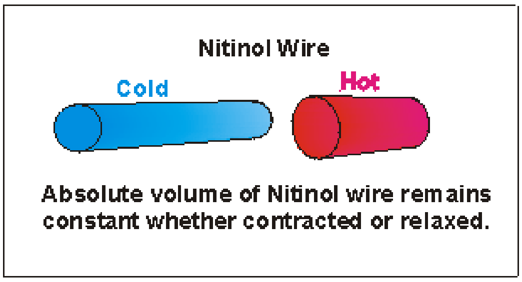
1. Change the length of the base B in the triangular actuator keeping the applied load constant (e.g. 30 g). The load should be hooked perfectly in the middle of the wire length (isosceles triangle). You may exploit the graph paper grid to reposition the drawing pin..
2. Take the height H of the triangle when the wire is "relaxed" (= no current going through).
3. Close the circuit switching the button on and make a pencil sign on the paper for the new height of the triangle upon the wire contracting . CAREFUL: **be** very **quick** to sign the new height reached **and immediately switch the current off ,** otherwise you will overheat and damage the wire. You will have ample time to actually measure Hc when no current is going through.
4. Calculate the vertical displacement of the load DH = H - H_c
5. Find the realationship, if any, between the base length B and the displacement DH
6. Suppose that for a project you need an x millimetre displacement, how long should the triangle base be for the actuator?

Activity 2 – Forces

1. Sketch a diagram of the apparatus in the two phases a)relaxedo b) contracted

2. Sketch a diagram of all the acting forces a) and b)
3. Find the relations between known data such as base length, wire length, weight of the applied load and unknown data : displacement upon contraction, force exerted by the wire in linear contraction; total and percentage wire elongation

Activity 3 – Dimensions varying



1. In the picture you may see a sketch of what happens to a Nitinol wire upon heating. Why this seems to be counterintuitive? ………………………………………………………………………………… ………………………………………………………………………………… ……………………

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2. What's the meaning of the linear expansion coefficient in a metal? …… …… ……

3. Sticking to the above definition would you be able to calculate the linear expansion coefficient in Nitinol? Why is this sort of "peculiar"?

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4. How could you possibly measure the wire diameter in the two phases?

A possible method is to use diffraction. Google for instance " *Measuring the Diameter of a Human Hair by Laser Diffraction.pdf*" or similar

Can you think of other ways?