Student Guide

Efficiency of Nitinol Wire

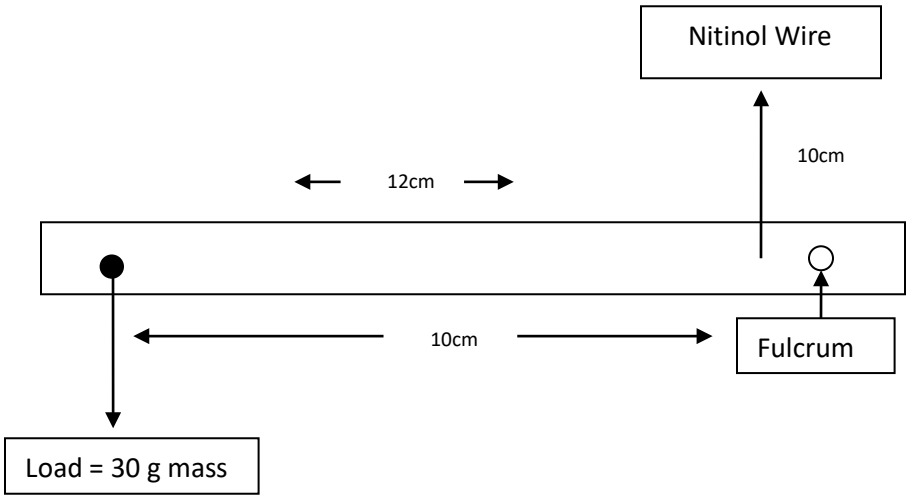
Shape memory alloy are a class of materials also referred to as smart materials. These alloys can be deformed when cold but are able to return to the pre-deformed shape when heated to a specific temperature. These alloys possess the ability to change crystal structure or phase at a distinct temperature. If the alloy is below the "transition temperature," it can be stretched and transformed without permanent damage. Once it is heated above the transition temperature, the alloy "recovers" and returns to the un-stretched shape.

Shape Memory Wire – a.k.a. nitinol or muscle wires can be used to lift a weight up a height. How does the work done lifting the load with the nitinol wire compare to the energy pumped into the wire by an electrical current? In this lab, you will calculate the work required to lift the load by measuring the change in potential energy and the energy input into the wire by measuring the voltage across the wire and the current through the wire. The time needed by the device to raise the load is also needed.

Materials: (per set up)

- Nitinol wire lever setup (specifications below).
- Nitinol wire (10-15 cm)
- Cardboard
- Dowel (lightweight) or balsa wood
- Voltmeter and Ammeter or a Voltage/Current Probe system (recommended)
- Metric ruler
- 2 AA batteries
- AA battery holder
- Alligator clips
- Crimp, tube or something to hold nitinol to cardboard
- Tack/push pin
- 30 gram mass – washers, nuts, bolts, pennies, dimes etc. in a small plastic bag
- Pasco or Vernier probe ware controller.

Schematic for set up:



The nitinol wire is connected a distance from the fulcrum of approximately 1 cm. The load is attached 10 cm from the fulcrum. The lever should be 12 cm long with the fulcrum placed 1 cm from the end of the lever. The load should be a 30 gram mass

Procedure:

1. You or your teacher will create the lever system to measure the time it takes for the nitinol wire to lift the load.
2. Once the lever system is constructed, connect the power supply to the each end of the nitinol wire with alligator clips.
3. Attach the leads of the voltmeter to the ends of the wire. Attach the leads to the alligator clips that are on the ends of the wire, not the wire itself.
4. You will want to measure the current in the circuit with an ammeter and the voltage across the wire.
5. Measure the time it takes for the load to rise. This can happen quickly, so use a motion detector or video camera and determine the time it is moving. Aim the detector at the load, and measure the time it takes for the system to change from one position to another. Use a ruler or the detector to measure the change in height.
6. Determine the time it takes for the load to rise.

Data:

Voltage:	
Current:	
Time:	
Mass of Load:	
Change in height:	

Input Energy = Power x time = Voltage x Current x time

Input Energy:	

Output energy = Mass x (acceleration due to gravity) x (change in height)

Output Energy:	

Efficiency of the machine = (Output energy / Input energy) x 100%

Efficiency	

Analysis and Conclusion:

Answer the following questions:

1. How does a nitinol wire get shorter when heated? Explain why this is unusual for a metal, and the reasons for this unusual behavior.

2. How efficient is the lifting process? How do you think this will compare to the efficiency of an electric motor?

3. How is the nitinol wire like a muscle? Can you make the wire stronger? Compare your method to how muscles are made stronger.

4. Where could nitinol wire be used that an electric motor could not be used? Remember that is heat, not the electricity that makes the wire expand.

5. How is nitinol related to nanotechnology?

6. How would you improve on the design?