QTC - Resistance Vs pressure

Equipment

For the **compressing apparatus**:

- 2 copper strips;
- Sellotape;
- vertical lab metal rod with stand;
- laboratory metal arm with pincers;
- disk plate + supporting holed cylinder;
- cardboard or not conductive hard substrate.

- QTC© pill, Velostat,(Eon-Tex)
- multimeter (as ohmmeter)
- two connecting "crocodile"wires
- paper glass + spoon
- chronometer
- scale (±0,1 gr)
- Lab masses, sand (~ 2 Kg)
- Beaker or bucket (>2L)

Procedure

The goal of this activity is to investigate how the resistance R varies with applied pressure, namely applied mass M, in the different piezoresistive samples. You will take direct measurements of R with an ohmmeter. Afterwards you'll look for the most appropriate models and best fitting curves.

Setup

1. Put the sample (QTC pill or Velostat) between the two electrodes (Careful! Check out that the strips are not touching in any way) .
2. Connect the metal strips to the ohmmeter with the two cables

Data collection

3. Decide what will be the increase in mass M at each step (for instance M = 100 g). This is the mass that you will add on the plate at each new measurement. If you resort to sand use the scale and a paper glass to weigh the due quantity.
4. Weigh the empty bucket plus the disk plate. Their total mass is M_0.
5. Progressively add M grams of sand each time. Do not take down the previous mass before adding the new one!
6. Measure the resistance R as soon as you have poured the sand (t = 0 sec) and also after 30 or 60 seconds (you choose the most appropriate time interval).
7. Write the collected data into the following table with the right units and uncertainties.

Total Mass: $M_0 + M$	R_0 (dopo 0 sec)	R_1 (dopo 60 sec)
(g) ±	(Ohm) ±	(Ohm) ±

Data analysis

1. Figure out the best fitting curve for each sample.
2. Discuss whether there are sections of the curves that should be investigated in more detail by collecting data with smaller intervals in mass increase. In case, set a new value for mass increase M (for instance 25 g) and repeat the data collection procedure. If time is short just stick to the interval in which you want to "zoom" and don't take data outside this range.
3. Plot all data in the same graph and find which is the best model for them.

Hints and tips

1. Settling time:
   - Are there any differences between the data collected respectively at 0 and 60 seconds?
   - Is 60 seconds a reasonable "adjustment" time? Do you think a different time interval would be more appropriate?
2. Mass increase
   - You've been directed to add progressively new masses without unloading the previous ones. Discuss pros and cons of the two different procedures (increasing mass with and without unloading)
3. Best-fitting curve:
   - Does the curve points to a direct proportionality? An inverse one? Other models? Why?

4. Mass in place of pressure :
    - You are actually measuring resistance VS mass instead of resistance VS pressure. Why is this reasonable? Which hypothesis justifies such a choice ?

Further research

5. Logarithmic scale:
    - Did you ever hear about **logarithmic and semilogarithmic scales**? What are they used for?
    - Would they be useful in this context? Why?
6. Alternative procedures to measure R:
    - Can you think of an alternative way to measure R ? (Just think of how you did use to measure R in wires and metal conductors)
    - Which are the pros/cons?
7. Quantum tunneling:
    - The conductive mechanism in QTC seems to be mostly based on **electrons quantum tunneling** through the polymer barriers in between the nickel particles. Which experimental evidence in your experiment supports such an hypothesis ?
8. QTC as pressure sensor:
    - Ultrathin films made of QTC have been used on the glove fingertips of Robonaut2, the NASA humanoid robot sent up to the ISS (International Space Station). Do you think that also the QTC pills can make a **good pressure sensor?** And what about the other samples? Which characteristics should they exhibit? Discuss in your group how to test them.