DENSITY

Experimental Density Calculation

In the lab, density of materials can be calculated using the following equation:

$$\rho = \frac{m}{V}$$

where:

ρ = density [kg/m^3]   m = mass [kg]   V = volume [m^3]

Equipment needed: (1) material sample/s, (2) scale/balance, (3) sample holder if using spherical samples

Information needed: sample dimensions/volume

Step 1: Prepare scale

Turn on scale and hit tare/zero to ensure a zero measurement before placing any material samples.

*if using a sample holder, make sure to zero balance of holder to ensure it does not impact sample measurement

Step 2: Measure sample

Place sample on scale, wait for value to equilibrate, and record the mass.

Remove sample, then place on scale a second time and record the mass a second time.

Take the average the two measurements to get the final value for the mass.

Step 3: Calculate density

Using the equation above, calculate the density of the sample.

Record the Density value in your Measurement Table for material ranking and chart step.

THERMAL CONDUCTIVITY

Experimental Thermal Conductivity Calculation

In the lab, thermal conductivity can be calculated using the following equation:

$$\lambda = \frac{QL}{A\Delta T}$$

where:

λ = thermal conductivity [W/(m·K)]* | Q = heat transfer rate [W] | L = material length [m]
A = material cross-sectional area [m^2] | ΔT = temperature difference across the material [K]

For our experiment, we will use an approximate measurement of Q as our thermal conductivity value

Equipment needed: (1) material sample/s, (2) infrared thermometer, (3) heating element/hot plate, (4) sample holder if using spherical samples

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Step 1: Initial Temperature Measurement

Turn on the heating element and give a few minutes to reach the desired temperature (to be determined by your instructor- do not exceed 50°C!!).

Place material sample on the heating element.

Record initial temperature value (T_1) of sample.

Step 2: Equilibrated Temperature Measurement

Allow sample to rest on heating element for an additional three minutes.

Record second temperature value (T_2) of sample.

Step 3: Calculate Heat Transfer Rate

Subtract T_2-T_1.

Record heat transfer approximation under "Thermal Conductivity" in your Measurement Table for material ranking and chart step.

ELECTRICAL RESISTIVITY

In the lab, we measure electrical ***resistance [R]*** (which is geometry dependent) from material samples using a multimeter and calculate electrical ***resistivity [ρ_e]*** (which is geometry *in*dependent) using the resistance.

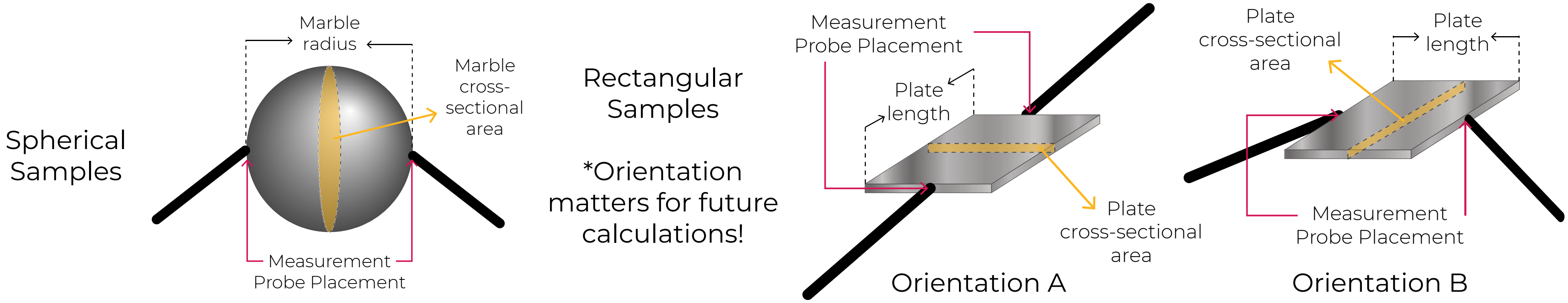
Equipment needed: (1) material sample/s, (2) multimeter, (3) sample holder (if using spherical samples)
Information needed: sample geometry

Step 1: Experimental Electrical Resistance Measurement

Select the Resistivity/Ω setting on the multimeter, then press measurement probes firmly on either side of the sample.

Record measured value for Step 2 calculation.

For the most accurate data, be careful with your probe placement! See some examples below for guidance.



Step 2: Intrinsic Material Property Electrical Resistivity Calculation

Using the measured resistance from Step 1, calculate the electrical resistivity using the below equation.

$$\rho_e = \frac{RA}{l}$$

where:

R = electrical resistance [ohms, Ω] | A = sample cross sectional area perpendicular to direction of current [m^2]*
ρ_e = electrical resistivity [Ω*m] | l = length of test sample [m]*

Record Electrical Resistivity in your Measurement Table for material ranking and chart step.

*This is why measurement probe placement matters!
Otherwise, the values for Area and Length are incorrect, leading to an inaccurate calculation

MECHANICAL LOSS COEFFICIENT

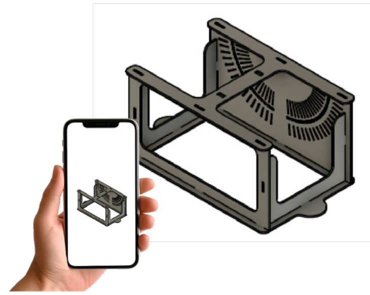
In the lab, we measure ***degree difference*** after two marbles of the same material collide. ***This is not the mechanical loss coefficient.*** However, the measured results should scale well with the actual loss coefficient values, leading to correct ranking values.

Equipment needed: (1) spherical material samples - two per material, (2) Newton's Cradle with sample holders, (3) Phone with slow-mo video capabilities, (4-optional but recommended) phone stand

Step 1: Experimental Setup

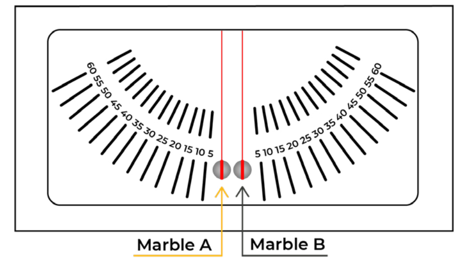
Step 1a:

Set up the Newton's Cradle and phone camera opposite the Cradle (camera should capture the entire cradle)



Step 1b:

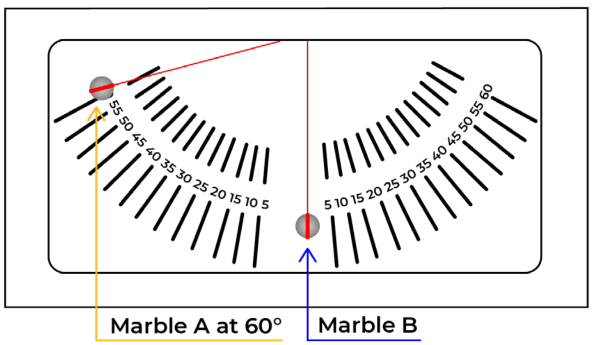
Place two marbles of the same material in the ring holders



Step 2: Run Experiment

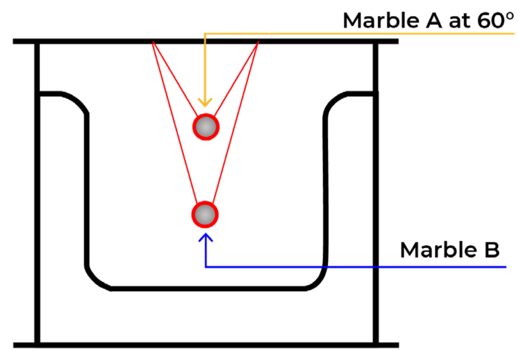
Step 2a:

Raise Marble A so the supporting string is aligned with the 60-degree line (make sure it is in camera view!)



Step 2b:

Double check marble alignment from side view (marbles should be on the same path)



Step 2c:

Begin slow-mo video recording

Step 2d:

Release Marble A

Step 2e:

Stop recording once marbles have completed 2-3 swings

Flip page for Steps 3 & 4 →

MECHANICAL LOSS COEFFICIENT

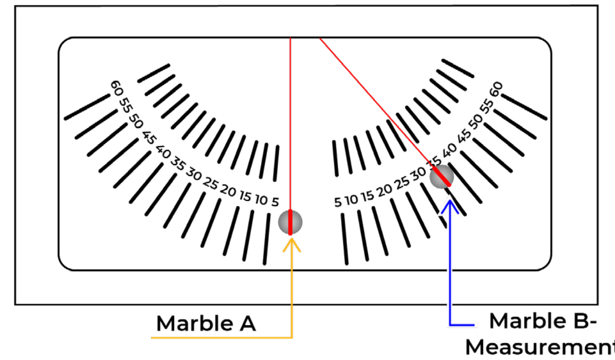
Step 3: Gathering Information via Video

Step 3a:

Scroll through video recording to find the highest point Marble B reached after collision (figure →)

Step 3b:

Record the degree line value*
*If string is between two lines, make an estimate!



Step 4: Determine degree difference

Step 4a:

Subtract 60°-measured degree value to get the degree difference.

Step 4b:

Use this value to rank materials

A low number of degrees lost corresponds with a low mechanical loss coefficient (less energy lost upon collision)

CAPACITANCE

For this experiment, we are measuring "*capacitance*" of our material. Because this measurement is done outside of a capacitor (see Property Definition Card for more details), the measured property is **technically not the dielectric constant**. However, the measured results should scale well with the material's real dielectric constant value, meaning our ranking results are still correct.

Equipment needed: (1) material sample/s, (2) capacitance meter with leads, (3) sample holder (if using spherical samples)

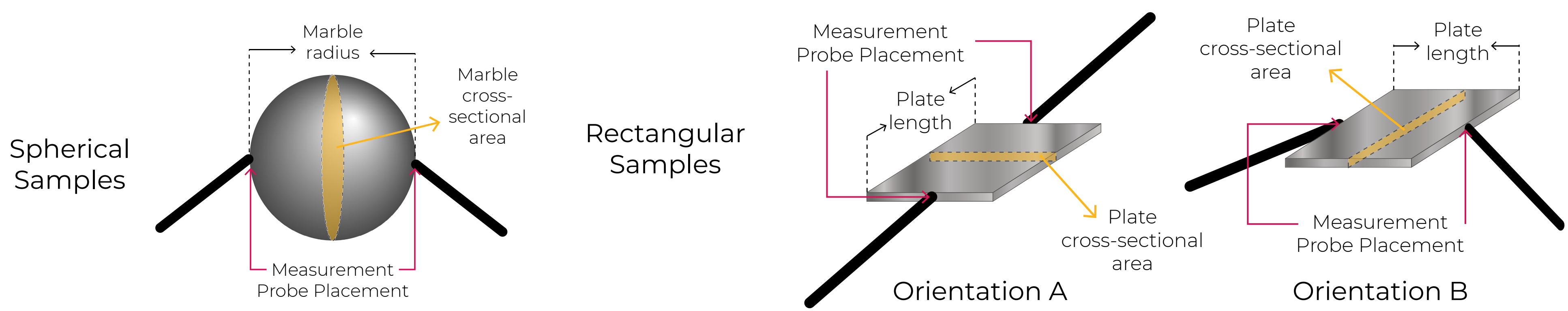
Step 1: Experimental Setup

Check the capacitance meter scale (start with pF and increase if needed). Connect the multimeter leads to color-coded positions on the back.

Step 2: Take Capacitance Measurement

Press leads to the two opposite sides of the sample.

For the most accurate data, be careful with your probe placement! See some examples below for guidance.



Wait until the number stabilizes (adjusting scale as needed)

Record measured value and use to rank materials