D2 Measurong Young's modulus of copper(TAS)

Objective

In this experiment, The Young's modulus of copper will be mesured .

Apparatus

- copper wire   4m
- G-clamp
- polley on clamp
-2*Wooden block
- 2*rule (half meter and meter rule)
- slotted mass with hanger 15 * 0.1 kg
- adhesive label
-micrometer screw gauge
-safety goggles
-polystyrene board

(**Warning** : Wear safety goggles when doing this experiment)

Theory

When a spring is stretched or compressed by a force.The extension is directly proportional to the applied force.This relationship known as Hooke's law. Force=ke.However,the law is used when the proportional limit is not exceeded.To further investigate how the material behaves when it is stressed,we define:

The stress applied to the wire is defined as the force applied per unit cross-sectional area.

Stress = force per unit area =F/A

(where F is the force or tension in the wire, A is the cross-sectional area)

When the wire being stretched,it is under strain.The strain is defined as the extension per unit length.

Strain = extension per unit length = e/l

(where e is the extension and l is the unstretched length of the wire)

Withon the proportional limit,the ration **stress/strain** is a constant whose value depends on the material of the wire.
It is known as the **Young modulus** of the material

E = stress/strain = (F/A)/(e/l) = Fl/Ae

From this law,a material with larger Young’s modulus means a greater stress is required to produce the same strain than another material with smaller Young’s modulus gives how stiff a material is.

In this experiment, we will hang different loads (m) to one end of a copper wire of length l and diameter d. The extension (e) for each load is measured.
From the slope of the straight part of the m-e graph, Young’s modulus of copper can be

found.

Since F=mg and **A= cross-sectional area of the wire = $\pi(d/2)^2 = \pi d^2/4$**, Young's modulus of the copper wire is given by

$$E = Fl/Ae = mgl/(\pi d^2/4)e = m/e \times 4gl/\pi d^2 = \text{slope of graph} \times 4gl/\pi d^2$$

Procedure

1.To measure the diameter of the wire at two end and the center of the wire by using a micrometer screw gauge to take the mean value of the diameter.

2.The apparatus is seted on the bench as shown in Fig.D2.1.

3.Fix an adhesive label on the copper wire as a marker

4.Measure the unstretched original length of the wire before addong slotted mass to the wire (from the wooden blocks to the slotted mass)

5.The copper was loaded in steps and the extension produced was recorded. Steps were continued until the wire broke

Results

	1st measurement	2nd measurement	3rd measurement
Diameter d/m	0.00028	0.00028	0.000275

Mean diameter of wire d = 0.000278 m

Original length of wire l = 3.95 m

Load m/kg	0	0.1	0.2	0.3	0.4	0.5	0.6
Extension e/m	0	0.001	0.002	0.0025	0.0028	0.003	0.0038

0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	
0.0042	0.005	0.007	0.009	0.015	0.036	0.087	0.155	

Before the load increase to 0.7 kg.The extension is nearly proportional to the force .Also stress is nearly proprtional to strain.After the load is beyond 0.7kg,extension is not proportional to force and stree is not proportional to strain.The plastic deformation occur.The wire does not return completely to its original length .The wire broke whn the load is increase to 1.4 kg.

This part of graph obeys Hooke's law.

Fig. 4

% strain = extension / original length x 100%
= 0.0042/ 3.95x 100%
= 0.106%

Fig. 4 shows the best straight line through the points of the straight part of the graph.
Slope of load-extension graph = 189.72 kgm^{-1}

Young's modulus of copper
E = slope of graph x $4gl/\pi d^2$
$=189.72 \times 4(10)(3.95)/\pi(0.000278)^2$
$=123.46 \times 10^9$ Pa

Error estimation

Sraw lines of maximum and minimum slope through the points of the graph.
Find the slope and take the large deviation from the slope of the fitted graph as the error

Maximum slope = 208.77
Minimum slope = 163.15
Error in slope = ±26.57
→ % error in slope =14.00 %

Estimate the possible errors in l and d and express them as percentages
Error in l = 0.1cm/2 = ±0.05cm
% error in l =0.0127%
Error in d = ± 0.005mm
%error in d = 0.0180%
Hence, estimate the % error in E.
% error in E = % error in slope + % error in l + 2 × % error in d
= 14.00% + 0.0127% + 2 × 0.0180%
= 14.049%
→Error in E = ± 1.7345×10^{12}

Discussion

From the graph of Fig. 4 .The wire is undergo a proportional limit before the load increase to 0.7 kg.It's obeys Hooke's law.When the load is not reach to a yield point.The wire can returns to its original length when the load is removed.In this graph . The slope of the

graph of load against extension determines the Young's modulus.
When the load is beyond the yield point.The plastic deformation will occur.The wire does not return completely to its original length .It will contain a permanent extension.Then the load is added to the wire continuously.The extension of the wire is more signifiance..The wire narrows uniformly.
In our experiment,The maximum stress at the breaking point.Break is due to the wire narrows unevenly to form necks.

There are some precautions for this experiment.When we read the value of the length of the wire.It is more accuracy as we observe the value vertically.Moreover,when the load is add on the wire.It is more suitable to add slowly.This can avoid the force added by our hand.Besides,students should wear safety goggles when doing this experiment.It can protect our eye is hited by the wire.

Young's modulus is more useful than force constant because the Young's modulus depend on the force per unit cross sectional area.Also,the extension is per unit length.It is more accuracy than the force constant which is only depend on the relationship between the force and extension.

From the book called NEW WAY PHYSICS.the young's modulus of the copper is 124×10^9 Pa.

Also from **http://www.answers.com/topic/young-s-modulus.**
the Young's modulus is between110 to 130 $\times 10^9$ Pa.
Compare with our result.It is 124×10^9 Pa.The answer is very close to the reference answer.It is because we take all of the value very carefullyand seriously for decrease the error.

Conclusion

The Young's modulus is depend on the materials.The Young modulus of copper which measure by our group is 124×10^9 Pa