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暨南大学本科实验报告专用纸

课程名称 Physics Experiment 成绩评定 ____

实验项目名称 Young's modulus 指导教师 Zhang

实验项目编号 EP 06 实验项目类型 ____ 实验地点 ____

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实验时间 2022 年 8 月 29 日 __ 午～__ 月 __ 日 __ 午 温度 __ ℃湿度 ____

OBJECTIVE:

1. To familiarize the student with the use of micrometer and reading ~~micrometer~~ microscope
2. To familiarize the student with the graphic method, and to measure the Young's modulus of steel using it.

THEORY:

The terms 'stress' and '~~stain~~ strain' are introduced which are used when referring to the deforming force and the deformation it produces.

Stress is the force (1N) acting on ~~the~~ unit cross-section area ($1m^2$). For a force F and area A we can write: stress = force / area. The unit of stress is the pascal (Pa) which equals one newton per square metre (that is, $1Pa = Nm^{-2}$)

~~Stain~~ Strain is the extension of unit length (1m). We can write: ~~stain~~ strain = extension/original length. ~~Stain~~ Strain is a ration without unit.

The stress required to produce a given ~~stain~~ strain depends on the nature of the material under stress. The ratio of stress to strain, or the stress per unit strain, is called an elastic modulus of the material. The larger the elastic modulus, the greater the stress needed for a given strain.

In the case in which the force causes elongation, ~~stree~~ stress is measured as the force per unit cross sectional area and strain is the increase in length of unit length. The modulus is then known as Young's modulus (E) and hence

$$E = \frac{\text{tensile stress}}{\text{tensile strain}} = \frac{F/S}{\Delta l/l} = \frac{F \cdot l}{S \cdot \Delta l} \qquad (1)$$

~~Whe~~ Where F is the force in N; S is the cross sectional area in m^2; Δl is the increase ~~is~~ in length (in m) ~~ca~~ caused by F; and l is the original length of the wire in m.

In the lab, F, S, l can be obtain easily, so how to measure Δl is the key.

Attach suitable hanger for weights and ~~cross~~ cross board for reading to the end of the wire (see fig 1). Adding weights (M), the force acting on the wire will increase by F

$$F = Mg \qquad (2)$$

and the wire elongate Δl, that is the tensile strain is Δl. At the same ~~#~~ time the cross-wire descend Δl, and Δl can be measured directly using the microscope.

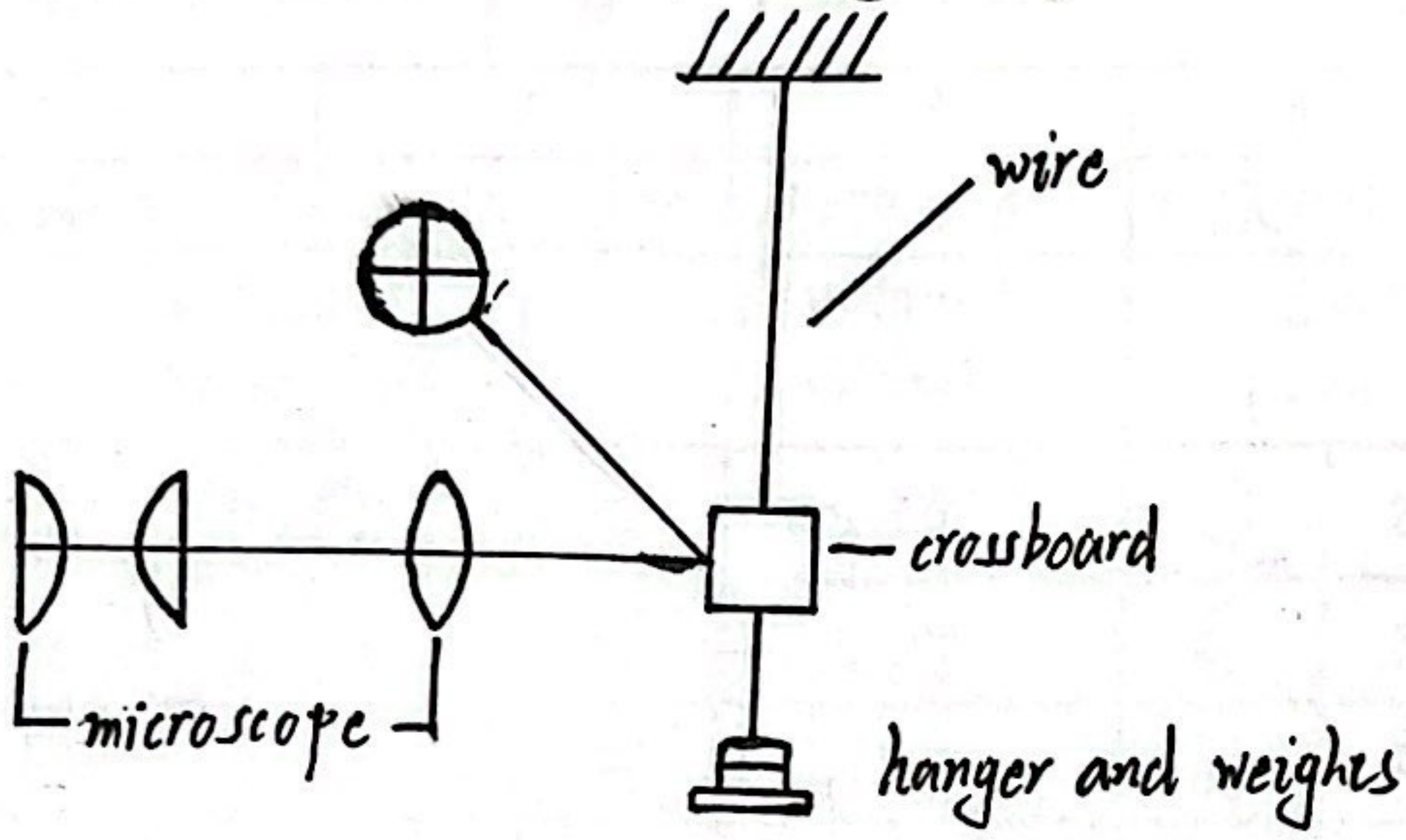

Figure. 1 the principle of the lab

If the ~~valute~~ value of the diameter of the wire, is d, the cross sectional area equal to $\frac{1}{4}\pi d^2$, so

$$E = \frac{F \cdot l}{S \cdot \Delta l} = \frac{4Mgl}{\pi d^2 \Delta l} \qquad (3)$$

Where g (acceleration of gravity) = 9.788 m/s² in Guangzhou, l, M, are given in the lab. if Δl is ~~mea~~ measured, E can be obtained.

PROCEDURE:

(1) Measure the diameter of the wire at five different points along its length and find a mean value. This measurement must be done carefully with a micrometer caliper.

(2) Adjust the screws under the base until the base is level, at that time the frame is parallel to the wire, and the scale seen in microscope is parallel to "|" of the cross board.

(3) Adjust the ocular of the microscope until the scale is clear. Move slightly the base until the image of the cross is clear seen from the microscope, then lock the base. Use the fine adjustment to ascend or descend until some reticule in the scale coincides with "——" in the cross, read the readings on the scale, that is C_0.

(4) Load the weights one by one on the hanger nine times (every time the weight added is 0.200 Kg). Take the corresponding readings ~~at each stage, that is $C_i'(i=8,7,\cdots,1,0)$, then $\bar{C_i} = \frac{C_i + C_i'}{2}$ $(i=8,7,\cdots,1,0)$~~ after each addition, that is $C_i(i=1,2,\cdots,8,9)$

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(5) Upload the weights one by one, take the corresponding reading ~~after each addition, that is C_i~~ ~~C_i~~ at each stage, that is C_i' ($i=8, 7, \cdots, 1, 0$), then $\bar{C}_i = \frac{C_i + C_i'}{2}$ ($i=8, 7, \cdots, 1, 0$)

(6) $\Delta l_i = \bar{C}_i - \bar{C}_0$ ($i=0, 1, 2, \cdots, 8$)

DATA RECORDING AND PROCESSING

micrometer caliper: zero reading d_0(m) = -0.010×10^{-3}, length of the steel wire $l = 0.75$m

d(m)	1	2	3	4	5	average
	0.180×10^{-3}	0.182×10^{-3}	0.174×10^{-3}	0.175×10^{-3}	0.178×10^{-3}	0.178×10^{-3}

mi(Kg)		ci(load) ($\times10^{-3}$m)		ci' (unload) ($\times10^{-3}$m)		$\bar{c} = (c_i + c_i')/2$ ($\times10^{-3}$m)		$\Delta l = \bar{C}_i - \bar{C}_0$ (m)	
m_0	0	c_0	2.85	c_0'	2.84	$\bar{c}_0$	2.845		
m_1	0.200	c_1	2.50	c_1'	2.49	$\bar{c}_1$	2.495	Δl_1	4×10^{-04}
m_2	0.400	c_2	2.25	c_2'	2.24	$\bar{c}_2$	2.245	Δl_2	6×10^{-4}
m_3	0.600	c_3	2.03	c_3'	2.00	$\bar{c}_3$	2.015	Δl_3	8.3×10^{-4}
m_4	0.800	c_4	1.81	c_4'	1.77	$\bar{c}_4$	1.790	Δl_4	1.055×10^{-3}
m_5	1.000	c_5	1.59	c_5'	1.56	$\bar{c}_5$	1.575	Δl_5	1.27×10^{-3}
m_6	1.200	c_6	1.38	c_6'	1.35	$\bar{c}_6$	1.365	Δl_6	1.48×10^{-3}
m_7	1.400	c_7	1.19	c_7'	1.15	$\bar{c}_7$	1.170	Δl_7	1.675×10^{-3}
m_8	1.600	c_8	0.99	c_8'	0.95	$\bar{c}_8$	0.970	Δl_8	1.875×10^{-3}
m_9	1.800	c_9	0.75						

Since $E = \frac{4Mgl}{\pi d^2 \Delta l}$, so $\Delta l = \frac{4Mgl}{\pi d^2 E}$, a graph of Δl against M will be a straight line and its gradient will be $k = \frac{4gl}{\pi d^2 E}$, from the equation, E can be obtained.

The corrected value of $d = 0.188\times10^{-3}$m,

Using computational software we got the M-Δl image on the right and the slope $k = 1.127\times10^{-3}$.

Therefore, $E = \frac{4gl}{\pi d^2 k} = \frac{4\times9.788\times0.75}{\pi\times(1.88\times10^{-4})^2\times1.127\times10^{-3}}$

$= \cancel{2.34}\ 2.35 \times 10^{11}\ N/m^2$