Experiment 18

Elastic Modulus of Rubber

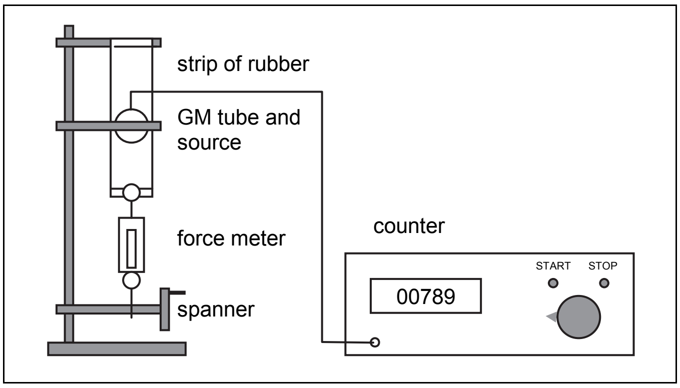
Name:
……………………………………………...

Aim

To measure the elastic modulus of rubber.

Set-up

The set-up consists of a strip of rubber, clamped to a force meter and a spanner (for stretching the strip of rubber). A source of strontium-90 (^{90}Sr) and a Geiger-Müller tube are mounted on opposite sides of the strip of rubber. The GM tube is connected to a pulse counter.



Read the introduction on page 22 of the booklet *ISP Experiments* about the way to measure the elastic modulus.

Measurements

With the equipment set-up the elastic modulus *E* of rubber can be determined by measuring the force *F* on and the elongation $\Delta\ell$ of the strip of rubber, in combination with the cross-section area *A* and the original length ℓ_0 of the strip. Determining the cross-section area *A* requires measuring the width *w* and thickness *d* of the strip of rubber. This thickness *d* is measured through the absorption of β-radiation in the strip of rubber. The measured intensity of the transmitted radiation and the calibration graph on the other side of this worksheet allow the reading of the thickness *d*. All other quantities can be measured directly by means of a force meter and a ruler.

1 Measure the length ℓ_0 of the strip of rubber (without stretching) between the fixed end points.

ℓ_0 = ……… cm

2 Set the force meter to 20 N with help of the spanner. Measure the length ℓ and the width *w* of the strip of rubber. Record your measurements in the table below. Measure the intensity *I* (in pulses per 50 s) of the transmitted radiation. Do this by measuring the number of pulses in 10 s five times without resetting the counter. Record your measurement in the table below.

3 Repeat this for the other values of the force *F* as indicated in the table.

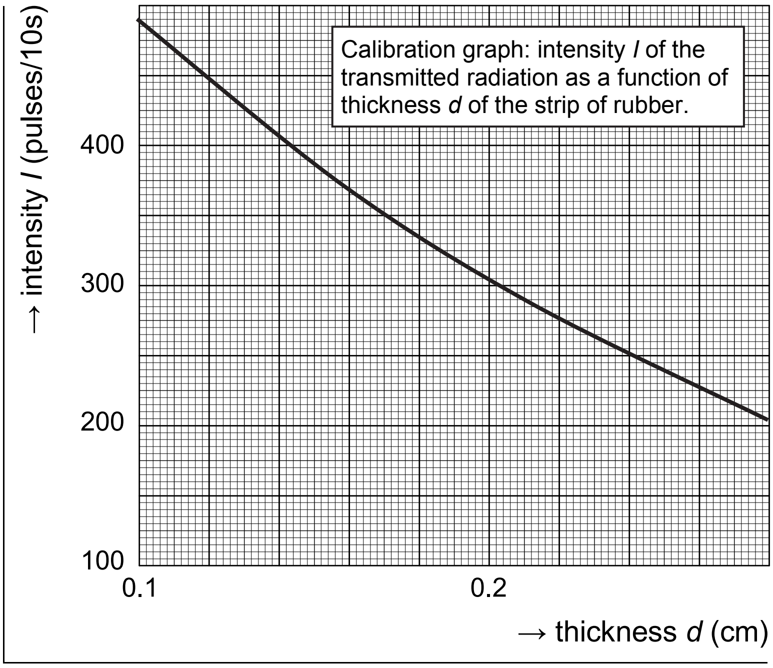
F (N)	ℓ (cm)	*w* (cm)	$\Delta\ell$ (cm)	*I* (pulses/50s)	I_{avr} (pulses/10s)	*d* (cm)	*A* (cm^2)	$A\cdot\Delta\ell$ (cm^3)
20								
15								
10								
5								

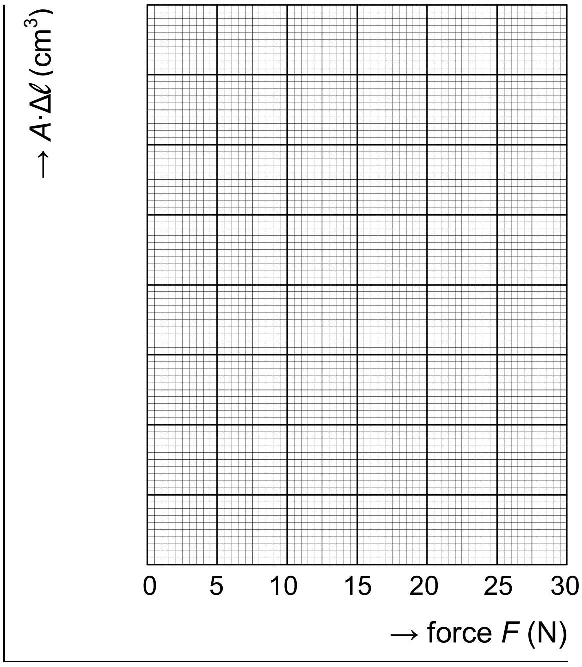
Assignments

1 For each of the values of the force *F* on the strip of rubber, calculate the elongation $\Delta\ell$ ($\Delta\ell = \ell - \ell_0$), and record the results in the table above.

2 For each of the values of the force *F* on the strip of rubber, calculate the average intensity I_{avr} of the transmitted radiation in pulses per 10s. Then use the calibration graph at the other side of this worksheet to determine the corresponding thickness *d* of the strip of rubber. And finally, calculate the corresponding values of the cross-section area *A* of the strip of rubber and the product of *A* and $\Delta\ell$. Record all results in the table above.

3 Plot the force *F* as a function of the product $A\cdot\Delta\ell$ in the graph on the other side of this worksheet (right).





4 As you can see from the graph, the quantities F en $A \cdot \Delta \ell$ are proportional. Or, in other words: the value of $F/(A \cdot \Delta \ell)$ is a constant. From the graph, determine the value of this constant.

$\frac{F}{A \cdot \Delta \ell}$ = ... N/cm^3

5 Calculate the elastic modulus E of rubber by using the answer of Assignment 4 and the formula that gives the relationship between the force F and the elongation $\Delta \ell$ of the strip of rubber (see the booklet *ISP Experiments*, page 22):

$$F = \frac{E \cdot A \cdot \Delta \ell}{\ell_0}$$

Hint: First write this formula in the form E = …

E_{rubber} = ……… N/cm^2