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Margarine Tub Investigation

Aim

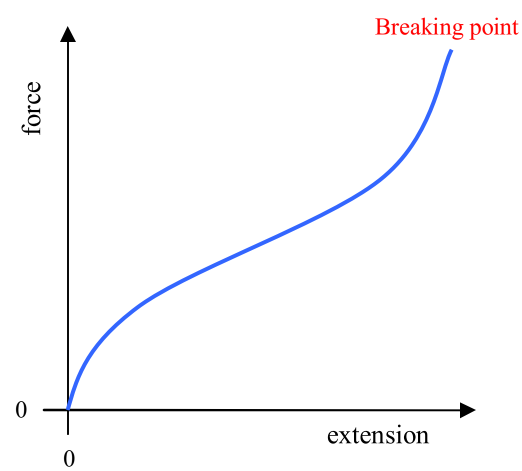
The target of this investigation is to find out how the force you exert on pulling back a rubber band, which will in turn catapult an empty margarine tub, affect the distance which the margarine tub will travel. We will not be changing any of the other factors of the experiment, only the force and extension of the rubber band, for that is the variable which we are investigating.

Prediction

I predict that the more force you exert, the further the margarine tub will travel, however, I think that the force and distance relationship will not increase evenly, instead it would first increase rapidly, then the increase will be less significant, and then rise slightly.

Scientific reason for prediction

Rubber is not a material which obeys Hooke's law and its extension doesn't increase uniformly. Some elastic materials are intended to absorb energy. The greater the force that is applied, more the rubber band is extended. The force in the rubber band is stored as potential energy which is reverted into kinetic energy once I have let go of it, this energy is transferred into the margarine tub as kinetic energy and therefore it moves. A stretched or compressed elastic band is capable of doing work when released. As the rubber band is released, the force that it exerts diminishes with distance.



Graph.1 This graph shows the behaviour of rubber when stretched.

Equipment

- Rubber band
- Chair/stool
- Rulers
- An empty margarine tub
- A newton meter that goes up to 10N

Procedure

- Loop the rubber band around the front legs of a chair.
- Place a margarine tub at the centre of it.
- Place 2 metre rulers in a row from the position of the margarine tub.
- Hook a newton metre on to the centre of the rubber band and pull it back in accordance with the required force.
- Release newton metre.
- Measure and record the distance travelled by the tub.
- Repeat for the other forces.

Diagram

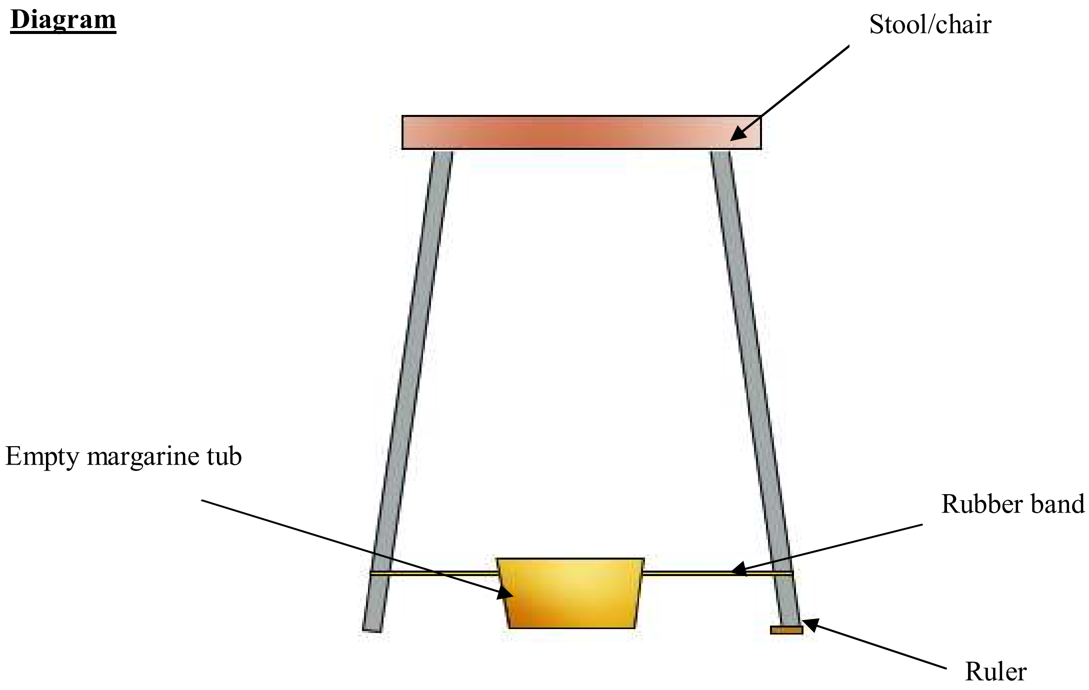


Fig.1 Front view of apparatus.

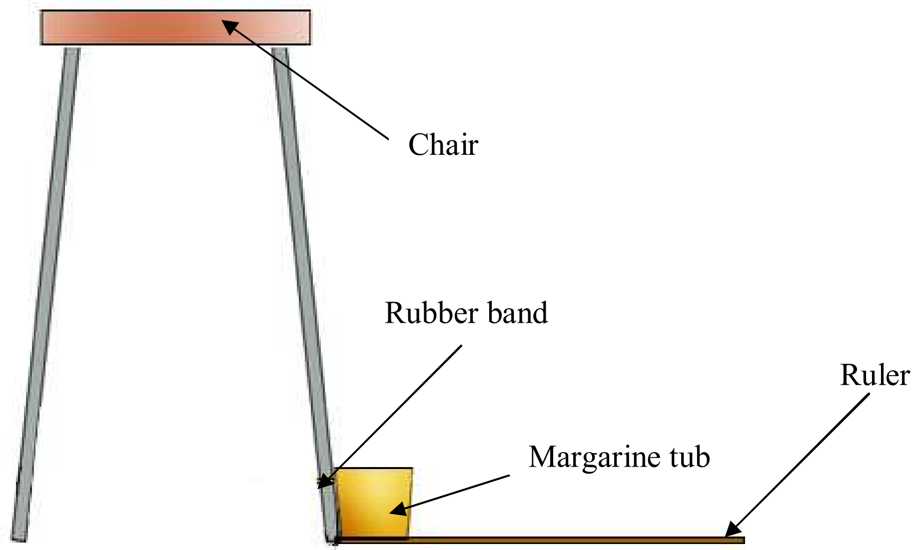


Fig.2 Side view of apparatus

Fair test

We made sure that it was a fair test by the following conditions:

- All tests were carried out on the same surface to minimise variations in friction, etc.
- All tests were carried out with the same rubber band; elasticity, energy storage potential, etc, may be different in various rubber bands.
- Use the same margarine tub for all tests or the mass, size and shape may vary.
- Always place the tub in the same position at the start of each experiment.
- Make sure that the newton meter is always hooked at the centre of the rubber band to avoid directional change of the tub after catapulting.
- Always newton meter around the same amount of rubber, eg, if the rubber band is looped around the stool, hook it around both lengths:

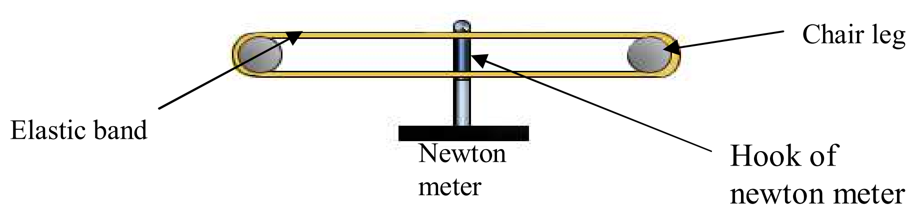


Fig.3 Correct method of latching

Results

(Anomalous results are highlighted)

	Distance travelled by margarine tub in cm			
Force in newtons	**Experiment 1**	**Experiment 2**	**Experiment 3**	**Average**
1	7	8	7	7.3
2	18	21	18	19
3	39	40	41	40
4	52	40	54	48.6
5	76	71	62	69.6
6	102	102	90	98
7	110	115	127	117.3
8	116	117	140	124.3
9	144	153	158	151.6
10	192	183	160	178.3

Table.1 Table of complete results

Analysis

Average distance travelled

7.3	19	40	48.6	69.6	98	117.3	124.3	151.6	178.3

11.7	21	8.6	21	28.6	19.3	7	27.3	26.7

Increase in distance from previous distance.

Table.2 Table to show increase in distances

From the average points, the graph shows a generally straight line of increase. As the force exerted increases, so does the distance which the margarine tub travels.

On average, the increase from each previous (i.e. one less newton) experiment is 18.77cm although there is a rather large difference in the range between experiments. The range of the largest increase and the smallest is 21.4cm; the smallest increase being 7N to 8N, which was only 7cm and the largest was from 5N to 6N; which was 28.4cm.

However, ignoring any anomalies, you can see that the increase in differences between distances are normally larger in the second half of the experiments with the larger forces, than the in the first half with the smaller forces.

One thing I noticed was the relationship between the distance travelled and the force exerted, there seemed to be a strong pattern forming; the distance of a certain force multiplied by 3 is more or less equal to the distanced travelled by the margarine tub at a force that is twice the size of the primary force. See Table 3.

Force (N)	**Distance (cm)**		
1	7	8	7
1 x 3	21	24	21
2	18	21	18
2 x 3	54	63	54
4	52	40	54

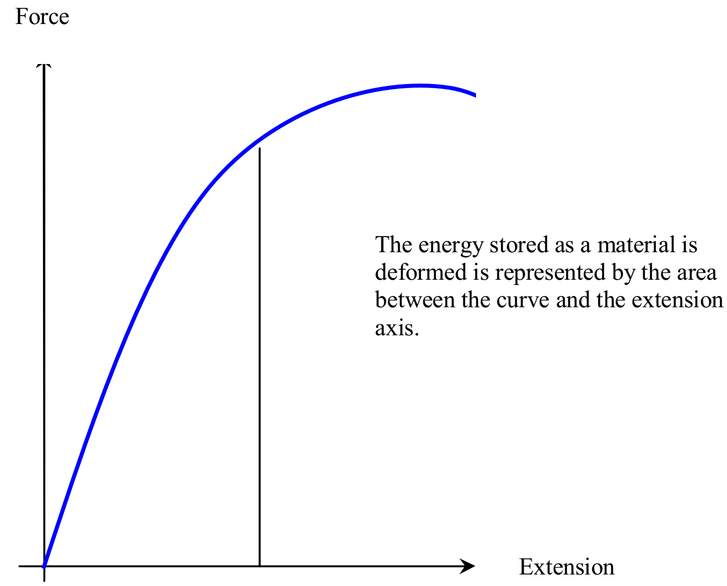
Table.3 The results show a strong relationship between each other, when the force doubles, the distance trebles.

I also noticed that the relationship worked very well for the first few values but not so fittingly for the later half (larger forces). This fits well with the Force/Extension law of rubber; if the pattern had occurs throughout the results then it would mean the relationship between force and extension could be plotted as a straight line, but that is not the case.

It was especially apparent with the largest results we had gained for each experiment; the line of best fit was a curved line. It does not fit my prediction because I had predicted that the increase of distance would get bigger for the larger forces, but then again, our range of forces wasn't exactly that large either.

Rubber is a polymeric substance and does not obey Hooke's law, force and extension of rubber is not a straight line and therefore the force that it exerts on the margarine tub does not increase evenly; force diminishes with distance and it remains elastic until it breaks.

The energy stored as a material is deformed is represented by the area between the curve and extension axis. See Graph 2.



Graph.2 Graph showing the amount of energy stored in proportion to extension.

Energy is never used up and in this case, it is transferred into the margarine tub, which in turn uses this energy to drive its movement.

In the law about the conservation of momentum, the resultant force is based on the initial forces of the two bodies, so my results suggest that the more force I exert on pulling back the rubber band, the faster it "recoils" and therefore increasing it's momentum, which in turn gives transfers it onto the stationary margarine tub.

My predictions

Evaluation

I think that my results are reliable because I had repeated each experiment three times and had gotten more or less similar results and it is probably accurate seeing as it fits into a pattern and the results show up as a relatively straight line. Also, we did not move the rulers during the experiment nor the newton meter.

There were anomalous results however, possibly caused by collision with dirt on the floor or an off centre impact with the tub; which may result in a change of direction or a different path of projection being taken.

If I was to do this experiment again, I would change the following things:

- The surface on which we were working; we were working in a rather crowded environment and the floor was not clean so there was lots of friction and this could have affected the results.
- The release mechanism; I think that the way we released the rubber band could have been improved, rather than letting the whole newton meter go, we could just have a detachable part for the device could have dragged across the floor and lengthened time of impact.
- I would mark out the centre of the tub so that I got it exactly centre each time rather than just estimating.
- I would mark out the centre of the rubber bad so that I got it exactly centre each time rather than just estimating.

In addition to this set of experiments, I would also like to measure the speed of the retraction of the elastic band and the extension of it so that I can incorporate it into some of the other rules of physics and see if it fits with my analysis. If I had those results I could introduce momentum into the analysis as well. I could also test out some larger forces to see if the pattern mentioned in Graph 1 actually applies in this case. The results I had attained did not quite show that pattern but it could have just been a small section of a bigger whole.

To measure the speed of the retraction, I would measure the distance of the extension and time the lapse between release of the rubber band and the impact with the tub and divide the distance by the time. See Fig.4.

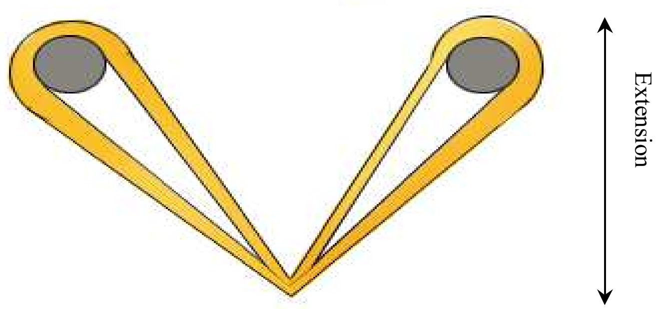


Fig.4 Measuring extension