Physics Investigation: Plastic Tub by Gareth Jones

Aim

To investigate how changing the weight in a plastic tub affects the distance it travels when it is propelled by an elastic band.

Prediction

I predict that the larger the number of masses placed inside the plastic tub is, the shorter the distance the tub will travel when propelled by an elastic band. I predict this will happen because the extra weight will slow down the plastic tub, as friction acts upon the tub. As the elastic band is stretched back, the elastic potential energy stored in the band increases. When the elastic band is released the elastic potential energy is released from the elastic band in the form of kinetic energy. As the band hits the plastic tub, some energy is released in the form of sound, but most of the energy transfers into kinetic energy moving the tub. As the elastic band hits the tub the forces become unbalanced and the tub moves. As the tub is pushed forwards friction acts upon it. This is because the two surfaces are not smooth. Many have very small bumps on the surface. The bumps on the top of the floor and those on the bottom of the plastic tub catch on each other, slowing the tub down. As a greater mass is placed inside the tub the surface of the floor and the bottom of the plastic tub are pushed closer together. This means that, with a greater mass inside, if the tub were to travel the same distance as with a smaller mass in the tub then a greater force would need to be exerted on the elastic band. In this experiment the force excerpted is going to be a constant 50N and so the tub will travel a shorter distance. Furthermore I predict that a mass of two times a previous mass will mean that when it is propelled by the elastic band it travels only half the distance. This however may not be exact due to our method, and inaccuracies. This is mentioned further in my evaluation.

Preliminary Experiments

From preliminary experiments I decided to vary the mass placed inside the plastic tub. This is a quantitative variable so we can measure it and draw numeral conclusions. We therefore decided that everything else in our experiment should remain the same, only the mass placed inside the tub changing. A number of constant variable need values addressing. The first is the force which we would pull back the elastic band with. A force which is too small will mean that the tub does not move enough, especially at higher masses there would be no discernible difference in the movement of the tub. Furthermore if the force applied to the elastic band was too large the band would become deformed, either loosing its elastic properties or snapping. A reasonable force was found during preliminary investigations to be approximately 50N. On a Newton meter this can be measured to ±5N. Another variable to which we needed to assign a value to during preliminary tests was the range of testing we would perform. An increase to small would result in too many experiments, or small inaccuracies being blown out or proportion as there would be little difference between the results. If the increase was too large then some experiments would travel a long way with others not moving. A reasonable range of results would be from 0N to 10N in 1N steps. We would test masses of 0g, 100g, 200g, 300g, 400g, 500g, 600g, 700g, 800g, 900g and 1000g. The tubs own mass does not need to be accounted for because it will remain almost exactly the same throughout the tests. The elastic band will be suspended 2cm above the floor so it hits in the same place ±0.2cm on the tub. The Newton meter will be attached to the elastic band upside down and twisted round. Preliminary investigation showed that the Newton meter could hit the tub and make it twist, adversely affecting our results.

Method

<u>Apparatus</u>

- Elastic Band
- Stool
- Plastic Tub
- Meter ruler

- 10 x 100g masses
- Newton Meter
- 50cm Ruler
- Student to apply pressure to chair

Diagram

Step by Step

- The stool will be placed on the floor and the elastic band stretched between the chair legs. It needs to be 2cm (±0.2cm because of the width of the elastic band and inaccuracy of the equipment) above the ground.
- A Student needs to sit on a stool so that the chair does not move. The student will sit still so they do not affect the results.
- Two one meter rulers need to be placed on the floor. They will touch and go in a straight line from the left chair leg. The plastic tub should be fired in a straight direction and so the measuring implements should not affect the results.
- A further 50cm ruler will be places in front of the chair so that the plastic tub can be lined up.
- A Newton meter will be attached to the elastic band, the elastic band pulled with a force of 50N, 2cm off the floor. (50N ±2N, 2cm ±0.2cm) masses of 0g, 200g.... in 100g increments to 1000g.
- The process will be repeated for each of the mass weights and the results drawn in a table.
- Each of the masses will be tested once, and then the experiment repeated twice. This allows for any anomalous results to be easily seen.

Fair Test

During our experiment it is important that certain values are kept the same throughout so that fair and reliable results can be obtained.

Constant Variables

These factors must remain constant throughout our experiment or our results will not be reliable.

- Amount of force applied to the elastic band - This must always be 50N ±2N because a greater force applied to the tub would mean that the tub would travel a different distance, and we would be changing two variables and so not be able to see clearly which was affecting the results. Too much force would result in the band loosing its elastic properties, and not being stretchy or snapping. Not enough will give a non discernible difference between maps.
- Height of the elastic band - This must always be kept 2cm ±0.2cm and the Newton metre must be kept 2cm ±0.2cm above the floor or it will not be fair. If this changes then the band may hit in a different place and mean that we the tub either flips or twists and so means that the tub will not travel in a similar fashion, and so no trends could be established.
- Same elastic band - The band must be kept the same so that when 50N of force (±2N) is excerpted upon it it stretches the same amount and applies the same amount of force on the tub. If a band snaps and needs to be replaced then a similar band needs to be used to replace it, one of equal length and girth. A band which does not display the same properties will invalidate some of the results, as it introduces a second variable which means you cannot discern what is affecting the results.
- Same Plastic Tub - A tub of different size of shape would have a different surface area in contact with the floor at different times in different places. This would mean that the mass was spread out differently and a different force applied on each part of the tub. If the tub is

different the masses placed inside will have a different effect, therefore it is necessary to use a tub of the same shape of size, if it is necessary for one to be replaced.

- Same Chair - A chair with different length between the legs will mean the elastic band is stretched differently and so a different force would be applied to the tub, in a different way. This would mean that the tub was being pushed forward differently and may travel in a different way depending on how far the band moves when a force of 50N (±2N) is applied.
- Same mass increments - It is important that only 100g increments are used so that trends can easily be spotted and results directly compared.

Results

Above anomalous results have been highlighted in red and were not included when the Average for each mass in the tub was calculated.

Analysis

From my experiment I have found that as you increase the mass the distance the plastic tub travels when propelled by an elastic band containing 50N elastic potential energy decreases. My graph clearly shows this trend as a curve slopes downwards. This is because the additional mass in the plastic tub increases the force of gravity acting upon the tub, and so brings it nearer to the floor. This means that the small bumps on the bottom of the tub and on the floor catch more frequently as illustrated in the Prediction. I can therefore conclude that my initial prediction was correct and that the greater the mass of the tub the shorter the distance it will move when propelled by an elastic band of fixed force. This is because an empty plastic tub is not as close to the floor as one with masses in it, due to gravity. This means it does not catch the bumps as frequently, or the small particles deposited on the floor. Therefore the tub can travel a further distance, as it can glide along the floor. A tub with a greater mass travels more slowly because it catches on small particles on the floor and the tiny bumps in the floor as it moves, which slow it down. The kinetic energy of the moving tub is lost in the forms of sound energy and the tub vibrates as it passes over the floor, heat as friction slows it down because the particles rub together and become hotter. My prediction said that the results would be directly proportional to each other, and that as the mass doubled the distance travelled by the tub when propelled by an elastic band would halve. This was not the case, and when mass is plotted against distance a curve in the form $y=k/x$ where k is a constant. Instead, to plot a linear graph you can plot 1/weight against the distance travelled by the tub.

Evaluation

Our method was inaccurate, as we had a number of anomalous results. It was a poorly carried out in that we did not obtain the most accurate and reliable results possible. This was due to some strange results that we obtained due to the inaccuracy of the method. These anomalous results were not included in the averages and have been circled on the table of results. When we repeated our experiment a number of anomalous results were found. This is due to inaccuracies in our method which are mentioned in more detail later. These anomalous results have been left out from our averaging and highlighted in the table so that they do not aversely affect our results. Each variable was measured to ±2N and the distance which the tub travelled to ±2cm. The height which the elastic band was placed above the floor was measured in cm to ±0.2cm. This means that there was margin for small error in our results being measured. When these errors combine this can lead to significant inaccuracies. However, this was not the feature that accounted for the greatest inaccuracies. Other features about the changing environment in which our experiment took place also attribute to anomalous results. These anomalous results have been highlighted in my table, and were not included when the averages were worked out. For example, as the tub moved along it was in contact with the floor. However, the floor varied a lot throughout the experiment. There were large differences between the areas on which the tub moved. At times the tub moved along the edge of the floor which had a large number of particles on the floor, and areas of the middle of the floor were wet. This meant that there was very little consistency in the floor on which the experiment was done. It was mainly flat, and vinyl. If the experiment were repeated a very useful improvement would be to make the floor surface consistent, so where ever the tub went the surface gave an equal resistance, so the floor would need to be cleaned and made sure that all the floor was even. Each time we repeated out experiment a lot of factors changed. The tub and elastic band had to be replaced a number of times during testing as they became unusable. Twice, the elastic band snapped and had to be replaced, which, although it was replaced by a band from the same pack was slightly different and interrupted testing. The tub also cracked as masses moved about inside it. This meant that the masses were not in the same place all the time, and, as the experiment was repeated the force was being applied to different areas. This meant that, because the way the centre of a plastic tub is raised, at sometimes the force would be being spread across all of the area in contact with the floor, but at others the masses would push down just on a particular area. To counter this the masses could be made the same size as the tub, and so they would not move. This would the mass was spread evenly across the area of the bottom of the tub. If the plastic tub were reinforced then the problem of splitting should not occur. As the Newton meter was released it hit the tub. Ideally this should not have happened, it led to inaccuracies in where the band hit the tub, and was responsible for hitting the tub and splitting it. Therefore, a simple improvement which would mean that the band was being measured more accurately, would be to find a place where the band reached when it was pulled back with 50N, and pull the band back with the finger to than point, meaning the height from the floor could be measured more accurately and the metal of the Newton meter would not damage the tub. Our results are reasonably reliable as the experiment was repeated three times, and an average measure made from at least two of these results, depending on the local reliability. If the experiment were re-examined then a larger number of repetitions may give more accurate results. At times anomalous results were found, which are highlighted in our results table. We cannot make too many precise commands given this inaccuracy in our method, revealed by the anomalous results. We can however draw general trends from our graph, which fit the scientific prediction and reasoning.