Additional science

I will investigate the factors that may affect the period of the pendulum. Each factor will be explored through the preliminary tests and a brief conclusion will be made. Afterwards, I will choose the factor which has shown the strongest results and do further investigations through the main experiment. The results will be recorded; spearman's rank calculations will be made for each preliminary and lastly, they will be all presented in a graph. Lastly, a conclusion and evaluation will be made based on the results at the end.

MY PRELIMINARY TESTS & RESULTS

Preliminary Test # 1:

In this preliminary test I will explore whether the angle at which the ball bearing is dropped affects the time of one period.

==> Independent Variable: The angle at which the ball bearing is dropped.

==> Control Variables: Material of ball, length of string, size of ball, time I start the stopwatch. These variables are kept constant so that the angle is pure reason as to why the times change for each angle, making the results more accurate.

Method:

1. With a bit of cello tape I stuck the protractor to the end of the retort stand so that it stays the same throughout the experiment.

2. Just over 30cm of string is measured and cut and a loop is made where the ball bearing will hook onto.

3. Then the string is attached to the retort stand.

4. Whilst looking at the protractor the ball bearing is hung at the specific angle, then the stopwatch starts when the ball is dropped.

5. The stopwatch is then stopped when one period is over.

6. Each angle is repeated 7 times for accuracy. All the results are recorded into a table and the averages are calculated afterwards with the calculator.

Angle it is dropped

(degrees)

1st time (secs)

2nd time (secs)

3rd time (secs)

4th time (secs)

5th time (secs)

6th time (secs)

7th time (secs)

Average (to 2. d. p)

180

1. 25

1. 10

1. 32

1. 32

1. 42

1. 10

1. 41

1. 34

170

1. 29

1. 27

1. 28

1. 24

1. 09

1. 24

1. 25

1. 26

160

1. 22

1. 22

1. 28

1. 25

1. 25

1. 27

1. 19

1. 24

150

1. 16

1. 15

1. 16

1. 26

1. 20

1. 22

1. 14

1. 18

Angle it is dropped (degrees)

Spearman’s rank

Average times (seconds & to 2. d. p)

Spearman’s rank

d^2

180

1

1. 34

1

0

170

2

1. 26

2

0

160

3

1. 24

3

0

150

4

1. 18

4

0

? dï¿½= 0

6 x 0 = 0

n(nï¿½-1) = 4(4ï¿½-1) = 60

= 1- (0/60)

Accuracy/Reliability:

I believe that these results are quite accurate, as I have learnt from the practise coursework that taping the measuring equipment will improve the accuracy of the results. Therefore, I taped the protractor onto the stand making it easier to read off. However, it was difficult to put the protractor on the stand, as it wasn’t exactly straight on the sand. Furthermore, I think that human error was quite a big concept in this preliminary test. We discovered

that we all had different perspectives of the ball bearing so one person would see that it was on 180 degrees whereas someone else would see 175 degrees. Therefore, the readings may be slightly wrong and inaccurate. To improve this test I would make sure that everyone would have their own jobs so that the results are collected through one person's eyes.

As you can see from the graph, that the relationship between the independent variable and the dependent variable would be that as the angle decreases and draws nearer to 90 degrees-which means that there is no swing-, the quicker the time.

Lastly, spearman's rank proves that there is a strong positive correlation, which means that the test has been done quite thoroughly and therefore has produced accurate data.

Preliminary Test # 2:

I will investigate the different sizes/mass of ball bearings by comparing the speeds of one period.

==> Independent Variable: Size/Mass of ball bearing.

==> Control Variables: Material of ball bearing, length of string, angle at which it's dropped, same time I start the stopwatch. These are kept the same so that none of the other factors, except for the size and mass, are affecting the outcome of the results.

Method:

1. I measure all 3 balls (25mm, 19mm, 13mm) on the electronic scales to find out what they weigh and record them in the table.

2. Now I hook the first ball onto the string of 30cm and attach it to the stand.

3. The stopwatch starts when the ball is dropped, from 180 degrees. Then the time is recorded.

4. This is repeated seven times for accuracy, and then the next two balls carry out steps 2, 3 and 4 again.

5. When the table is complete the averages are calculated with the calculator.

Mass (grams)

Size (mm)

1st time (secs)

2nd time (secs)

3rd time (secs)

4th time (secs)

5th time (secs)

6th time (secs)

7th time (secs)

Average (to 2. d. p)

68. 33

25

1. 36

1. 31

1. 35

1. 30

1. 30

1. 33

1. 34

1. 33

28. 53

19

1. 37

1. 38

1. 12

1. 31

1. 30

1. 34

1. 36

1. 34

12. 02

13

1. 22

1. 49

1. 49

1. 50

1. 47

1. 48

1. 46

1. 48

Size (mm, diameter)

Spearman’s rank

Average times (seconds & to 2. d. p)

Spearman’s rank

d^2

25

1

1. 33

3

4

19

2

1. 34

2

0

13

3

1. 48

1

4

? dï¿½= 8

6 x 8 = 48

n(nï¿½-1) = 3(3ï¿½-1) = 24

= 1- (48/24)

Accuracy/Reliability:

I think that this experiment is fairly accurate, as there are only 2 outliers. However, one problem we had was that the balls would sometimes swing at an angle and maybe hit something, which could affect the time it comes back for its period. Furthermore, there could've been some human error especially when to know when to stop the stopwatch, as we would never know as humans when it would stop going up. We can only guess.

The graph shows a correlation, where as the size increases, the quicker the period is. I believe that if there were more sizes then we can show a strong correlation. Unfortunately, due to a lack of resources, we could not do more tests.

The Spearman's rank shows an indirect correlation, meaning that the larger the ball bearing, the shorter the time. This definite result shows that the tests have been accurate.

Preliminary Test # 3:

In this experiment I will investigate what kind of affect the length of string will have on the time it takes to perform one period.

==> Independent Variable: Length of string

==> Control Variable: size/mass of ball bearing, the angle at which it's dropped, material of ball bearing. They are kept constant so that the results are accurate and reliable to depend on this one factor, which is the length of string.

Method:

1. I cut out all the 4 sizes of string with the scissors and made sure that I cut a bit more than the actual size, for the loop, which I would hook the ball bearings onto.

2. I attached the first string onto the stand then at 180 degrees; I released then recorded the result.

3. This is repeated seven times with each length of string then recorded into the table.

4. Lastly, the averages are calculated.

Length of String (cm)

1st time (secs)

2nd time (secs)

3rd time (secs)

4th time (secs)

5th time (secs)

6th time (secs)

7th time (secs)

Average (to 2. d. p)

30

1. 34

1. 32

1. 27

1. 28

1. 26

1. 26

1. 31

1. 30

35

1. 31

1. 36

1. 29

1. 31

1. 28

1. 37

1. 33

1. 32

40

1. 45

1. 42

1. 49

1. 41

1. 46

1. 47

1. 38

1. 44

45

1. 59

1. 58

1. 56

1. 57

1. 58

1. 56

1. 58

1. 57

Length of string (mm)

Spearman’s rank

Average times (seconds & to 2. d. p)

Spearman’s rank

d^2

30

4

1. 30

4

0

35

3

1. 32

3

0

40

2

1. 44

2

0

45

1

1. 57

1

0

? dï¿½= 0

6 x 0 = 0

n(nï¿½-1) = 4(4ï¿½-1) = 60

= 1- (0/60)

Accuracy/Reliability:

This test was quite reliable, as there were no outliers or anomalies, which show that the tests have been done quite accurately. There is a clear correlation between the independent variable and the dependent variable. The correlation was, as the length of string got longer, the longer it took for the period to happen. The graph supports this also.

There could've been some faults whilst recording the data, as we had no control of the swing so sometimes it banged into an object. Furthermore, each time the ball was swung it might've not started on 180 degrees therefore, making the results unfair.

The spearman's rank calculation shows, the longer the string, the longer the time. This is definitely true as the final answer was +1.

Preliminary Test # 4:

I will try and find out whether; the material of the ball bearing affects the speed of the period.

==> Independent Variable: Material of the ball bearing.

==> Control Variables: Length of string, size/mass of ball, angle at which it is released, time the stopwatch starts.

Method:

1. Just over 30cm of string is hooked onto one of the ball bearings.

2. The ball is then hung at 180 degrees then released at the same time when the stopwatch starts.

3. The time is recorded and put into the table.

4. This is repeated, 7 times for both materials and an average is calculated with the calculator.

Material of Ball

1st time (secs)

2nd time (secs)

3rd time (secs)

4th time (secs)

5th time (secs)

6th time (secs)

7th time (secs)

Average (to 2. d. p)

Iron

1. 33

1. 40

1. 40

1. 31

1. 34

1. 31

1. 36

1. 35

Brass

1. 48

1. 34

1. 40

1. 35

1. 30

1. 42

1. 36

1. 36

Spearman’s rank correlation could not be used for this preliminary test as the material of the ball shows qualitative data; this means words are used. E. g Iron, Brass.

Accuracy/Reliability:

I think that this test has been quite limited due to resources therefore; you cannot gather much of a correlation between the material of the ball and the time because there are only 2 materials. Furthermore, the air resistance

could’ve affected the reliability or the friction of the string attached to the stand. However, this could’ve been a factor on each variable.

Overall, in this test, it has not been successful, due to lack of resources.

REVIEW OF PRELIMINARIES:

Generally I think that the tests have gone well since I haven’t got massive ranges from my results although I did collect some outliers in the process of it. Moreover, all of my spearman’s rank calculations have shown a definite direct correlation of indirect correlation which shows that my they have been successful. The reliability of the tests is reflected through this calculation. I think that my methods of doing the experiment was quite accurate as I have learnt some lessons from my practise coursework such as sticking the measuring equipment onto the retort stand to make the readings more precise. Nevertheless, I can point out some improvements such as having better equipment. An example could be the retort stand, where sometimes, it was not long enough so we had to hang it over the table, where there was more chance of it hitting the table. I also think that if we had more time to do the preliminaries, then we could’ve gathered more results that would make the mean of the results more accurate. However I am pleased that we did each test 7 times which made my preliminaries more reliable.

INFLUENCES FROM THE PRELIMINARIES TO MY MAIN EXPERIMENT:

For my main experiment I have chosen to investigate further on the variable of the lengths of string based on the accuracy of the preliminary results (as there are no outliers) and the simplicity of method. I have also based my

choice on the Pendulum Law, where Galileo found out that the period of a pendulum was not dependent on the material or its weigh but on the length of string. He found out that the longer the string, the longer the period of the pendulum. What I have learnt from the preliminaries is that it is best for one person to keep a job for the whole experiment as our reaction times vary for different people. Therefore, everyone on the team had they’re own role in the main experiment therefore, keeping human error to a minimum.

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THE MAIN EXPERIMENT.

Hypothesis: I think that there will be a direct relationship between the length of string and time it takes for one period to happen. (This means, the longer the string, the longer the period.)

Collecting Data:

When I am conducting the experiment I will have to consider human error, because of the reaction times due to human reflexes so we decided to use the same person to use the stopwatch so that the reaction times will be similar.

The Equipment:

* 1 retort stand

* String (25cm, 30cm, 35cm, 40cm, 45cm, 50cm, 55cm, 60cm)

* 1 iron ball bearing, size: 19mm(diameter)

* Protractor

* 30cm Ruler

* Stopwatch

* Scientific calculator

* Scissors

* Cello tape

Method:

1. Everyone on the team was allocated a certain role in the experiment, whether it was the person releasing the ball to the person recording the results.

2. All the sizes of string were cut with the scissors, with loops at the end of them for the ball bearing to hook onto. Also, the protractor is cello taped firmly onto the clamp.

3. The ball bearing is then hooked onto the first length and is hung at 180 degrees, then the stopwatch starts when the ball is released. This is done 10 times for accuracy.

4. The times are recorded into a table.

5. Steps 3 and 4 are repeated with the next 7 lengths then, the mean is calculated with the calculator -excluding the outliers- to find the averages.

6. The mean is rounded off to 3 decimal places.

Length of String (cm)

1st time (secs)

2nd time (secs)

3rd time (secs)

4th time (secs)

5th time (secs)

6th time (secs)

7th time (secs)

8th time (secs)

9th time (secs)

10th time (secs)

Average (3. d. p)

25

1. 37

1. 24

1. 14

1. 12

1. 19

1. 15

1. 18

1. 16

1. 16

1. 14

1. 164

30

1. 28

1. 25

1. 24

1. 26

1. 27

1. 21

1. 20

1. 20

1. 20

1. 26

1. 247

35

1. 31

1. 35

1. 34

1. 34

1. 34

1. 38

1. 39

1. 35

1. 35

1. 32

1. 347

40

1. 47

1. 44

1. 45

1. 49

1. 41

1. 41

1. 45

1. 42

1. 40

1. 45

1. 439

45

1. 49

1. 53

1. 52

1. 52

1. 55

1. 54

1. 54

1. 57

1. 55

1. 77

1. 534

50

1. 62

1. 65

1. 56

1. 70

1. 62

1. 64

1. 66

1. 64

1. 64

1. 60

1. 633

55

1. 68

1. 81

1. 88

1. 87

1. 89

1. 88

1. 86

1. 82

1. 87

1. 86

1. 860

60

1. 98

1. 97

1. 99

1. 91

1. 99

1. 98

1. 93

1. 93

1. 97

1. 98

1. 963

Results Table:

Length of string (mm)

Spearman’s rank

Average times (seconds & to 2. d. p)

Spearman’s rank

d^2

25

8

1. 164

8

0

30

7

1. 247

7

0

35

6

1. 347

6

0

40

5

1. 439

5

0

45

4

1. 534

4

0

50

3

1. 633

3

0

55

2

1. 860

2

0

60

1

1. 963

1

0

* ? dï¿½= 0

* 6 x 0 = 0

* n(nï¿½-1) = 8(8ï¿½-1) = 504

* = 1- (0/504)

Now we compare what we should’ve got by using the Pendulum formula:

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>

>

>

>

>

>

>

INTERPRETING & EVALUATION

From the data I have collected you can see that my prediction was correct, where longer strings meant a longer/slower period. There is a 0. 799 difference between the largest result and the smallest results, which shows

the small scale of my experiment. If we had more time to look at more extreme lengths we would've had a better variety of results. However, it is clear that my results are reliable as each length is repeated 10 times which is more than the preliminaries and also, it shows a clear relationship between the time and the length of string as shown in the graph and spearman's rank calculation.

I have also used the formula of the pendulum and have discovered that my results I have collected are slower than what it should be, from using the formula. The differences between the numbers grow whilst the length of string gets longer. I believe that this has happened as we only presumed when it visually looked like one period was over. Furthermore, the time that " stop" is said then the stopwatch is stopped is probably why there has been these extra seconds. Therefore, having a computerised stopwatch would definitely make the results much more accurate and closer to what the times should be.

Outliers

For the main experiment, I have set a boundary of 0. 15 seconds away from the median to class as a an anomaly. However, in the preliminaries, my boundaries were 0. 2 seconds. The reason for this was because I knew that the results I would get would be much more accurate than the preliminary results, so I set the boundaries higher to really mark out the outliers in my data.

In the results above I have encountered 3 anomalies…

25cm ==> Median = 1. 16, so the boundaries would be 1. 01 – 1. 31. Therefore, 1. 37 would definitely be an outlier. This might have occurred because 25cm was the shortest length of string, therefore, the shortest time compared to the rest of the results. It was probably due to human error where the human reflexes were a bit slower.

45cm ==> Median = 1. 64, so the boundaries would be 1. 39 – 1. 69. Therefore, 1. 77 is classed as an outlier probably due to human error again or might have been swung just a bit off course for that time.

55cm ==> Median = 1. 87, so the boundaries are 1. 72 – 2. 02. So, 1. 68 would be an anomaly. The reason could be because the stopwatch was stopped to early, because we can only estimate visually when the ball bearing will start moving back down for its next period.

The overall reasons for the outliers are from human error, so maybe to improve the equipment; I could have a computerised machine that tells us the exact times from the experiment. Furthermore, having a better stand for the experiments could have improved the accuracy of the results because it was difficult to swing the ball bearing directly straight, so having a guide from the stand would help immensely.

Science

When the pendulum is at the top of its swing it is momentarily stationary. It has zero kinetic energy and maximum gravitational potential energy. As the pendulum falls the potential energy is then transferred to kinetic energy. As the pendulum falls, the speed increases as it reaches the maximum at the

bottom of the swing. The speed and kinetic energy are at its maximum, and the potential energy is a minimum. As the pendulum rises the kinetic energy is transferred back to potential energy. The speed of the pendulum decreases and falls to zero as it reaches the top of its swing, with the potential energy a maximum again.

There are 2 main forces involved in the swing, which are, gravity, pulling it down and the tension of the string resists this. The only time when the forces are equal is when it is at the middle of its swing, otherwise they are unbalanced. The longer the string, the longer the time will be, as there would be more air resistance the ball will have to go through to reach the end of one period. For example, 60cm of string had more air resistance therefore had the longest time. Also, when you compare this to the shortest length of 25cm and the time of 1. 164 seconds it is evident that air resistance is definitely one factor which affects the time of the period.

Improvements

Improvements on nearly all the equipment would have make the overall results very reliable and accurate. An example would be to have a ruler which measures in millimetres to get an accurate reading rather than the centimetres. Furthermore, there could have been some parts of the method, which could have been changed such as having the same amount of string as an excess to attach it onto the retort stand. This is because more knots and therefore, string would have had created more friction between the stand and the string which would have impacted on the results in general. Lastly, improvements like having a data log or a computerized stopwatch will

always polish my results, as the data collected from this would be precise. These little improvements would definitely make all the results just that bit more accurate where there wouldn’t be as many anomalies.

What I have learnt from this is that the only way to get thorough results is to do more tests and get an overall average from that. This would be an advantage as you have more results, which could affect the overall trend or the line of best fit in the graph.

CONCLUSION:

All in all, I think that this experiment has proved my hypothesis very well but I do think that it could have been a better experiment with more reliable results and no anomalies. To back and extend my hypothesis further, I would do more tests on different kinds of weights to see whether this affects the time of the period or whether it is purely up to the length of string.

Due to lack of resources and time, the techniques and apparatus I have used could have been improved to make the results perfect and make the ranges tighter however, I am very pleased with the results I have collected and calculations I have made.