Effect of Angle of ramp on the acceleration of a Rolling Ball

# Rationale:

Energy is the capacity to do work (Britannica, 2021). Types of energy present during the experiment included gravitational potential energy, kinetic energy, sound energy and heat energy. Gravitational potential energy is defined as mass multiplied by gravitational field multiplied by height. Increasing any of the values will increase the total gravitational potential energy. In the experiment the mass and gravitational field are constant with the height of the ramp increasing therefore increasing one of the variables in the gravitational potential energy calculation. During the experiment this potential energy is converted to kinetic energy heat and sound energy.

Kinetic energy is the push and pull force on object and is the force of motion. It is the most interacted with energy and is essential to everything we as humans can do. Kinetic energy can be transformed from other types of energy including heat, electricity and gravitational potential energy. It can also be transferred to and from objects when colliding. Kinetic energy also commonly has by-products such as heat, and sound caused by friction in either other surfaces or air. This means that kinetic energy is lost when objects move. Due to the law of conservation of energy stating that energy can neither be created or destroyed this lost kinetic energy must be transformed into one or more of the aforementioned types of energy.

# Original experiment:

A cart was rolled down a ramp and timed with varying amounts of blocks under one end of the ramp to create slopes of different steepness. The acceleration of the cart with the most number of blocks was the greatest. The full original method can be found in appendix 1.

# Research Question:

Does an increase of the angle of a ramp increase the acceleration of a ball rolling down a ramp?

# Modifications to Original Experiments:

* A ball was used instead of a cart to reduce friction, instability and the randomness associated with the use of a more complicated system in the carts various parts, this created. This reduced the coefficient of variation of the trials.
* A camera was used to record the trials as this is more accurate than using a stopwatch and removes human error.
* The ramp’s steepness was measured with the angle to the ground and not height in blocks. This added consistency as the position of the blocks along the ramp greatly affected the steepness.

# Management of Risks:

The most dangerous equipment used during the experiment was the ball which could bounce unexpectedly into either people or knocking over objects. This was managed by using a stop at the end of the ramp to prevent the ball rolling off the table. Avoiding having the ball bounce entirely also stopped damage. The full risk asses can be found in appendix 3.

# Raw Data:

Table 1: Time taken for ball to reach end of ramp of varying angles.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Angle (Degrees) | Distance (m) | Mass (Kg) | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 |
| 2 | 2.50 | 0.05050 | 4.90 | 4.77 | 4.73 | 4.73 | 4.63 |
| 4 | 2.50 | 0.05050 | 3.30 | 3.43 | 3.43 | 3.40 | 3.40 |
| 6 | 2.50 | 0.05050 | 2.77 | 2.73 | 2.73 | 2.73 | 2.80 |
| 8 | 2.50 | 0.05050 | 2.37 | 2.37 | 2.37 | 2.37 | 2.43 |
| 10 | 2.50 | 0.05050 | 2.10 | 2.00 | 2.06 | 2.10 | 2.03 |

# Processed Data:

Figure 1: Acceleration of Ball Rolling Down a Ramp

Table 2: Average time, Average Velocity, Final Velocity and Average Acceleration of a Ball Rolling Down a Ramp

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Angle (degrees) | Average Time(s) | Average Velocity  (m/s) | Final Velocity (m/s) | Average Acceleration (m/s/s) | Standard Deviation | Coefficient of Variation |
| 2 | 4.75 | 0.53 | 1.05 | 0.22 | 0.10 | 2.05 |
| 4 | 3.39 | 0.74 | 1.47 | 0.43 | 0.05 | 1.58 |
| 6 | 2.75 | 0.91 | 1.82 | 0.66 | 0.03 | 1.16 |
| 8 | 2.38 | 1.05 | 2.10 | 0.88 | 0.03 | 1.13 |
| 10 | 2.06 | 1.21 | 2.43 | 1.18 | 0.04 | 2.13 |

Table 3: Sample Calculation of Ramp Angle of 2°

|  |  |
| --- | --- |
| **Formula used to process data** | **Sample calculation for ramp length of 1.20m** |
|  |  |
|  |  |
|  |  |
|  |  |

# Trends patterns and relationships:

Figure 1 shows a clear linear increase of acceleration when increasing the angle of the ramp. When the ramp was set to 2° the ball had an average acceleration of 0.22 m/s/s and at accelerated fastest at 10° with an acceleration 1.18 m/s/s. The coefficient of variation between trials was highest at ten° with 2.13. This is very small and is very precise. The average increase of acceleration was 0.236 m/s/s. The standard deviation of the average increase of acceleration was 0.035 m/s/s. This shows very little deviation between the trend line and the results in figure 1. This was observed because as the steepness increases the height increases. This greater height causes a greater gravitational potential energy. Because of this greater gravitational potential energy more kinetic energy is generated increasing the speed of the ball rolling down the ramp.

# Evaluation of Methodology:

The Method used in the experiment was valid but has some minor uncontrolled variables. The method of the experiment measured only the time for the ball to reach the end of the ramp. If the final speed was not double the average speed this would skew the results in an unpredictable fashion. The acceleration was then calculated by assuming that the final speed was the double the average speed which may not be the case. Variation on how the person released the ball could have changed the initial velocity and spin of the ball. This would change the measured time which is used to calculate the acceleration. Variation on how the ball is dropped could have been solved using an automated release mechanism such as a lifting bar Infront of the ball.

# Conclusion:

In conclusion the data recorded supports the research question of the experiment. This being does an increase in an angle of a ramp increase he acceleration of a ball rolling down that ramp. The data was very precise however the accuracy cannot be definitively stated.

# Reference List:

Britannica, T. Editors of Encyclopaedia (2021). energy. Encyclopedia Britannica. Retrieved from https://www.britannica.com/science/energy

Appendix 1

**Method**

1. Set up the ramp so that there is a gentle fall (approx. 2 blocks heigh). The ramp should be straight and not bent in the middle.
2. Place the cart so that the front of the cart is at the 2.5m mark.
3. Start the stopwatch as the car is released from the mark. Do not push the car.
4. Stop the stopwatch as it hits the end of the ramp.
5. Record the distance and time in the results table.
6. Repeat until 3 consistent measurements have been collected.
7. Repeat steps 3-7 for 3 and 4 blocks heigh.

Appendix 2

**Method**

1. Set up the ramp so that there is a gentle angle of 2 degrees. The ramp should be straight and not bent in the middle.

2. Place the ball so that the front of the ball is at the 2.5m mark.

3. Record the trials as the ball is released from the mark.

4. Repeat until 5 consistent measurements have been collected.

5. Repeat steps 1-4 for 4, 6, 7, 8 and 10 degrees.

6. Record the distance and time in the results table.

Appendix 3

Table

Description automatically generated