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|  | **Year 11 Physics**  Investigation: Investigation of sticky collision compared to mass |

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| **Name: Thomas** | **Partner/s:** | **Mark / 60** |

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| **Background information** |
| *Sticky collision is a form of inelastic collision and is sometimes referred to as “perfect inelastic collision” in regard to a transfer of motion when after the collision the two objects remain in contact with each other and travel at the same relative velocity this is achieved as during the collision momentum is conserved while kinetic energy. the velocity is found by:*    Where v is the final velocity, u is the initial velocity.  M is the mass of the moving glider  m is the velocity of the stationary glider  u is the initial velocity of the incoming cart  This is relevant to the experiment as the stationary velocity will affect the velocity and therefor the kinetic energy will be affected. |
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| **Research Question** |
| What is the effect of the mass of a stationary object compared to the final speed as a result of sticky collision which indicates whether the increase of mass on a stationary object decreases final velocity. |

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| ***Hypothesis*** |
| *It is predicted that as the mass of the hit (stationary glider increases) the velocity because of the collision between the two gliders would be lower as force transferred from the incoming glider remains the same whilst the mass of the stationary glider increases. Newton’s second law of motion (F = m\*a) would show that as a result the acceleration of the glider would be lower resulting in a lower speed.* |
| **Definition of variables** |
| **Independent variable**  The independent variable is the mass of the stationary glider this is a component of the sticky collision formula and in Newton’s second law with the relation of mass, force and acceleration. The values were from 0.2 to 0.6 kg in 0.1 increments. |
| **Dependent variable**  The dependent variable is the final velocity of the two gliders after they have collided it takes the time the photogate sees darkness and multiplied by the length of the card in meters (being 0.40 meters) |
| **Controlled variables**  *List at least three variables that must be controlled (stay the same) – include the value that was used*   1. The incoming velocity of the cart 2. The weight of the incoming cart 3. The surface the carts moved along |

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| **Materials and equipment** | | |
| **Quantity / volume required** | **Apparatus / material** | **Uncertainty of apparatus** |
| 2 x | Gliders, same mass | ± 0.05 |
| 1 x | Compression Spring | N/A |
| 2 x | Photogates and Event Timer | ± 0.005 N |
| 1 x | Air track | N/A |
| 2 x | 50 g weights | ± 5 |
| 4 x | 100g weights | ± 5 |
| 1 x | 40 mm card | N/A |
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| **Method** |
| 1. Placed Photogates a set distance apart 2. Secured the compression spring to the end of the AirTrack 3. Inserted Velcro weights onto the carts to allow for joining 4. Placed one cart in between the two photogates and one cart next to the spring 5. Pull cart into the spring and release 6. Record time on the event timers 7. Repeat 2 more times 8. Increase weight by the interval 9. Repeat steps 4-8 till all data is collected   **Risk Assessment:**  There is no inherent risk during the experiment as all moving parts are confined to the AirTrack and no hazardous materials are used.  **Diagram:** |

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| **Quantitative data table** | | | | |
| Mass of Stationary Glider (kg) | Velocity of Combined Gliders (m/s) | | | *Average Velocity of combined* |
| Trial 1 | Trial 2 | Trial 3 |
| 0.2 | 0.643 | 0.617 | 0.664 | 0.6416 |
| 0.3 | 0.528 | 0.552 | 0.514 | 0.5317 |
| *0.4* | 0.396 | 0.395 | 0.451 | 0.4141 |
| *0.5* | 0.424 | 0.391 | 0.396 | 0.4036 |
| *0.6* | 0.354 | 0.324 | 0.362 | 0.3465 |

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| **Graph of quantitative data** |
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| **Analysis and discussion of results** |
| During the experiment the mass of the stationary cart was steadily increased this corelated with a strong negative correlation in the average speed of the two combined carts after undergoing sticky collision the relation is of for every increase in the mass of a stationary cart there is a 0.2632x-0.557 decrease in the final velocity of the two carts  The trend of the graph contains a high degree of precision with a coefficient of determination percentage of 97.9% across the data however the accuracy is partially off what was expected where the expected power value was **–1** due to when the sticky collision formula is simplified 1/The mass of the stationary glider becomes evident and the reciprocal power is -1.  The results of sticky collision follow the sticky collision formula where this is supported by theories including perfect inelastic collision where momentum is preserved between the two objects in an isolated collision would still loose kinetic energy despite the constant momentum. |

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| **Evaluation – To be completed in class under test conditions** |
| **Error Source 1: Incline of the AirTrack** |
| **Error Type (systematic/random): Systematic** |
| **Effect on results:**  **A tilt in the AirTrack would mean the path travelled is not level. If the path is not level the cart may undergo acceleration not intended by the original parameters of the experiment as there would have been acceleration between the recording of the speed into the stationary glider and the impact with the stationary cart.** |
| **Suggested improvements/ways to minimise:**  Ensure that the AirTrack is as level as feasibly possible at the beginning of the test, make sure both gliders are released at the same time as such any tilt in the track would affect both gliders equally. |

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| **Evaluation – To be completed in class under test conditions** |
| **Error Source 2: Cardboard cards being not fully upright** |
| **Error Type (systematic/random): Systematic** |
| **Effect on results:**  **The cardboard that is attached to the glider is controlled at 40mm but the card may have tilted during the experiment increasing the perceived size of it to the photogate, a factor that would not have been corrected in calculations this would’ve resulted in perceived slower speeds for the glider through the photogate as the time taken to clear the light would have been higher.** |
| **Suggested improvements/ways to minimise:**  Make sure that the card stands upright throughout the experiment. Alternatively installing a frame onto the glider and using more rigid materials for the card such as plastic or metal would greatly reduce the deformation and change in size from occurring during the experiment trials |

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| **Conclusion – To be completed in class under test conditions.** |
| As observed in the experiment there is a strong correlation between the mass of a stationary object and the final velocity of the two combined gliders. The hypothesis provided that if an increase in stationary mass occurred there will be a decrease in final combined velocity due to newtons second law (F = M\*A). The experiments results support this hypothesis as the averaged final velocity results show a negative correlation with the mass of the stationary glider. Several other studies co-operate these findings. The high precision of the experiment support the idea that any random errors in the experiment would have taken a non-influential role in the results while the moderately high accuracy shows that systematic errors may have had an influence in the final results. |

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| **References** |
| GeeksforGeeks 2024, Inelastic Collision, GeeksforGeeks.  Wikipedia Contributors 2020, *Inelastic Collision*, Wikipedia. |