Experiment 8: Conservation of 2D Momentum

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PS181 Section 3

4/28/20

DATA:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **##** | Time (Sec) | **Puck 1 (LEFT)** | | **Puck 2 (RIGHT)** | |
| X (cm) | Y (cm) | X (cm) | Y (cm) |
| **01** | 0.000 | -33.23 | -37.52 | 35.38 | -39.67 |
| **02** | 0.042 | -26.80 | -28.95 | 26.80 | -31.09 |
| **03** | 0.083 | -20.37 | -20.37 | 18.23 | -20.37 |
| **04** | 0.125 | -11.79 | -11.79 | 11.79 | -11.79 |
| **05** |  |  |  |  |  |
| **06** | 0.209 | -8.58 | 2.14 | 9.65 | 7.50 |
| **07** | 0.250 | -11.79 | 9.65 | 13.94 | 20.37 |
| **08** | 0.292 | -16.62 | 23.59 | 20.37 | 39.67 |
| **09** | 0.375 | -19.30 | 32.16 | 24.66 | 50.39 |
| **10** | 0.417 | -21.44 | 38.59 | 28.95 | 60.04 |
|  |  | **Puck 1 (Mass)** | | **Puck 2 (Mass)** | |
|  |  | m1 (g): | **65** | m2 (g): | **45** |

Table 1: Positional Data of Pucks (mass included)

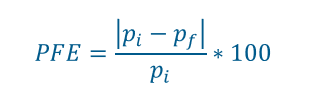
|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Puck 1 (LEFT) - BEFORE -** | | **INITIAL** |  |  | **Puck 1 (LEFT) - AFTER -** | | **FINAL** |
| X-Velocity | Y-Velocity | **Speed** |  |  | X-Velocity | Y-Velocity | **Speed** |
| **v1 , i, x** | **v1, i, y** | **v1, i** |  |  | **v1 , i, x** | **v1, i, y** | **v1, i** |
| (cm/s) | (cm/s) | (cm/s) |  |  | (cm/s) | (cm/s) | (cm/s) |
| 169.663296 | 205.659674 | 266.6112 |  |  | -59.791899 | 172.484236 | 182.5538 |
| **P1, i, ,x** | **P1, i, y** | **Angle** |  |  | **P1, i, ,x** | **P1, i, y** | **Angle** |
| (g-cm/s) | (g-cm/s) | (degrees) |  |  | (g-cm/s) | (g-cm/s) | (degrees) |
| 11028.11 | 13367.88 | 50.48 |  |  | -3886.47 | 11211.48 | -70.88 |
|  |  |  |  |  |  |  |  |
| **Puck 2 (RIGHT) - BEFORE -** | | **INITIAL** |  |  | **Puck 2 (RIGHT) - AFTER -** | | **FINAL** |
| X-Velocity | Y-Velocity | **Speed** |  |  | X-Velocity | Y-Velocity | **Speed** |
| **v2 , i, x** | **v2, i, y** | **v2, i** |  |  | **v2 , i, x** | **v2, i, y** | **v2, i** |
| (cm/s) | (cm/s) | (cm/s) |  |  | (cm/s) | (cm/s) | (cm/s) |
| -190.24533 | 226.224922 | 295.5859 |  |  | 89.0826328 | 243.035069 | 258.8470 |
| **P2, i, ,x** | **P2, i, y** | **Angle** |  |  | **P2, i, ,x** | **P2, i, y** | **Angle** |
| (g-cm/s) | (g-cm/s) | (degrees) |  |  | (g-cm/s) | (g-cm/s) | (degrees) |
| -8561.04 | 10180.12 | 130.06 |  |  | 4008.72 | 10936.58 | 69.87 |
|  |  |  |  |  |  |  |  |
| **- BEFORE -** |  | **INITIAL MOMENTUM** |  |  | **- AFTER -** |  | **FINAL MOMENTUM** |
| X-Total | Y-Total |  |  | X-Total | Y-Total |
| **Pi, x** | **Pi, y** | **Pi** |  |  | **Pf, x** | **Pf, y** | **Pf** |
| (g-cm/s) | (g-cm/s) | (g-cm/s) |  |  | (g-cm/s) | (g-cm/s) | (g-cm/s) |
| 2467.0744 | 23548.0003 | 23676.8827 |  |  | 122.2450 | 22148.0535 | 22148.3908 |
|  | Ptheta | 84.01906107 |  |  |  |  | 89.68376216 |

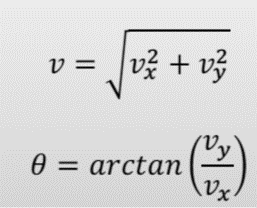
Table 2: Velocities, momentums, and angles calculated (before and after collision)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Final Results:** | |  |
|  |  |  |  |
|  | **Momentum (g-cm/s)** | |  |
|  | Pinitial | 23676.88 |  |
|  | Pfinal | 22148.39 |  |
|  | ΔP | 1528.49 |  |
|  | **Fractional Changes** | |  |
|  | FD (-): | 0.0646 |  |
|  | PFE (%): | 6.46 |  |
|  |  | |  |
|  |  |  |  |
|  | **Reference Variation** | |  |
|  |  |  |  |
|  | **Momentum (%)** | |  |
|  | Pinitial | 1.13% |  |
|  | Pfinal | 0.00 |  |
|  | ΔP | 0.21 |  |
|  | **Fractionals (%)** | |  |
|  | FD: | 19.74% |  |
|  | PFE: | 19.74% |  |
|  |  | |  |

Table 3: final results

CALCULATIONS:





Results:

The two pucks velocities pre-collision were calculated to be 266.6112 cm/s and 295.5859 cm/s at angles 50.48 degrees and 130.06 degrees, with a momentum of 23676.8827 g cm/s and . Post-collision the velocities were calculated to be 182.5538 cm/s and 258.8470 cm/s at -70 degrees and 69.87 degrees, with a final momentum of 22148.3908 g cm/s.

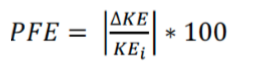
Discussion:

These results seem to be in line with what I would expect from the experiment, with a PFE of merely 6.46% it looks like the minor sources of energy loss we know we aren’t accounting for are not too significant. The biggest factor not accounted for is likely friction, as the surface is not truly frictionless. There is also likely some human error introduced by using the method used to find the center of the pucks in each frame, however I don’t believe that this would more less precise than the way the experiment was supposed to be done, and given the small difference between initial and final momentum, it seems this can be ignored.

Questions:

1. Q1
   1. Linear momentum is not conserved when there are external forces acting on a system
   2. This experiment does not account for friction, which is likely the biggest source of error in the experiment. Energy is also lost to sound, heat. Also since the pucks are likely spinning then we would also have to consider angular momentum.
   3. I would expect the initial momentum to be greater than the final momentum. Energy will be lost and converted to other types that are not being compensated for by the experiment.
   4. My prediction was correct, there was a loss of about 6%.
   5. Less measurements would reduce the number of times error could be introduced, however any basic errors like improper reading or calibration would remain and potential magnify
2. Q2
   1. 

0.4276 J

* 1. 
  2. 

39.415% =