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Collision Conservation

Purpose: The purpose of this experiment is to assert whether or not momentum and/or kinetic energy are conserved throughout the system of two objects with different masses on a near friction-less surface during a recoil collision of an internal spring which pushes both apart and a stick-together collision where one object collides into another and attaches to it.

Materials:

- 2 Carts w/ Plunger & Velcro
- 7 Bars of 250g each
- 2 Photogates
- 2 Ring Stands
- 2 Index Cards
- 1 Ruler
- Tape

Procedure:

1. Gather supplies.
2. Mark index cards #1 and #2 and mark carts #1 and #2.
3. Measure and record the initial masses of both carts.
4. Measure the width of each index card with the ruler and use to calibrate corresponding photogates #1 and #2.
5. Set up carts such that their corresponding index cards are taped in such a way that they stick up lengthwise and face towards the side of the cart.
6. Set up photogates on ring stands over the path through which the carts will be moving through, and on the height where the corresponding index cards can be sensed.
7. Set up carts for collision #1 with cart #2 loaded with 1 250g bar and both carts attached to each other between the photogates, with the carts on the side of their corresponding photogates, attached to each other and primed for plunger activation.
8. Arm the photogates to collect data.

9. Release the plunger and record the data from each photogate, recording also the mass added to each cart.
10. Repeat steps 6-8 with each cart being loaded with different amounts of bars as follows, with cart #1 bearing the greater mass: (2-0, 2-1, 3-0, 3-1, 3-2, 4-0, 4-1, 4-2, 4-3, 5-0, 5-1, 5-2, 6-0, 6-1, 7-0).
11. Add the added mass of the bars on each cart to the initial mass of each cart to obtain each carts' total mass for each trial (in kg).
12. Calculate the momentum for each cart in each trial by multiplying the total mass of each cart by the recorded velocity for each cart from its corresponding photogate.
13. Calculate the % difference between the carts' momentums in each trial by taking the greater of the two quotients of the two momentums and multiplying by 100%.
14. Average the % difference across all trials and conclude whether or not momentum was conserved.
15. Calculate the kinetic energy for each cart in each trial by multiplying the total mass of each cart by the square of the recorded velocity for each cart from its corresponding photogate and halving it.
16. Calculate the % difference between the carts' kinetic energy in each trial by taking the greater of the two quotients of the two kinetic energies and multiplying by 100%.
17. Average the % difference across all trials and conclude whether or not kinetic energy was conserved.
18. Set up carts for collision #2 with cart #2 loaded with 1 250g bar and set in between both photogates and cart #1 set behind photogate #1.
19. Arm the photogates to collect data.
20. Gently push cart #1 towards cart #2 such that cart #1 collides into and attaches to cart #2 via Velcro causing both carts to pass through photogate #2 and record the data from each photogate, recording also the mass added to each cart.
21. Repeat steps 18-20 with each cart being loaded with different amounts of bars as follows, with cart #1 bearing the greater mass: (2-0, 2-1, 3-0, 3-1, 3-2, 4-0, 4-1, 4-2, 4-3, 5-0, 5-1, 5-2, 6-0, 6-1, 7-0).
22. Add the added mass of the bars on each cart to the initial mass of each cart to obtain each carts' total mass for each trial (in kg).

23. Calculate the initial momentum for cart #1 in each trial by multiplying the total mass of cart #1 by the recorded velocity for cart #1 from photogate #1 and the final momentum for the combination of both carts by taking the sum of the total masses of both carts and multiplying that by the recorded velocity of the carts from photogate #2.
24. Calculate the % difference between the initial and final momentums in each trial by taking the greater of the two quotients of the two momentums and multiplying by 100%.
25. Average the % difference across all trials and conclude whether or not momentum was conserved.
26. Calculate the initial kinetic energy for cart #1 in each trial by multiplying the total mass of cart #1 by the square of the recorded velocity for cart #1 from photogate #1 and halving it and the final kinetic energy for the combination of both carts by taking the sum of the total masses of both carts and multiplying that by the square of the recorded velocity of the carts from photogate #2 and halving it.
27. Calculate the % difference between the initial and final momentums in each trial by taking the greater of the two quotients of the two momentums and multiplying by 100%.
28. Average the % difference across all trials and conclude whether or not kinetic energy was conserved.
29. Clean up experimentation area.

Data Tables:

Initial Mass – RED = 257.9 g

Initial Mass – BLUE = 254.2 g

Collision #1

Total Mass - RED (kg)	Total Mass - BLUE (kg)	Velocity - RED (m/s)	Velocity - BLUE (m/s)	Momentum - RED (kg*m/s)	Momentum - BLUE (kg*m/s)	Momentum - DIFF (%)	Kinetic Energy - RED (J)	Kinetic Energy - BLUE (J)	Kinetic Energy - DIFF (%)
0.5079	0.2542	0.554	0.974	0.2813766	0.2475908	114%	0.077941318	0.12057672	155%
0.7579	0.2542	0.241	0.992	0.1826539	0.2521664	138%	0.022009795	0.125074534	568%
0.7579	0.5042	0.464	0.652	0.3516656	0.3287384	107%	0.081586419	0.107168718	131%
1.0079	0.2542	0.442	1.696	0.4454918	0.4311232	103%	0.098453688	0.365592474	371%
1.0079	0.5042	0.367	0.692	0.3698993	0.3489064	106%	0.067876522	0.120721614	178%
1.0079	0.7542	0.651	0.831	0.6561429	0.6267402	105%	0.213574514	0.260410553	122%
1.2579	0.2542	0.348	1.737	0.4377492	0.4415454	101%	0.076168361	0.38348218	503%
1.2579	0.5042	0.317	0.716	0.3987543	0.3610072	110%	0.063202557	0.129240578	204%
1.2579	0.7542	0.341	0.56	0.4289439	0.422352	102%	0.073134935	0.11825856	162%
1.2579	1.0042	0.578	0.71	0.7270662	0.712982	102%	0.210122132	0.25310861	120%
1.5079	0.2542	0.202	1.047	0.3045958	0.2661474	114%	0.030764176	0.139328164	453%
1.5079	0.5042	0.377	1.212	0.5684783	0.6110904	107%	0.10715816	0.370320782	346%
1.5079	0.7542	0.312	0.566	0.4704648	0.4268772	110%	0.073392509	0.120806248	165%
1.7579	0.2542	0.177	1.115	0.3111483	0.283433	110%	0.027536625	0.158013898	574%
1.7579	0.5042	0.237	0.777	0.4166223	0.3917634	106%	0.049369743	0.152200081	308%
2.0079	0.2542	0.161	1.132	0.3232719	0.2877544	112%	0.026023388	0.16286899	626%

Average Difference in Momentum = 109%

Average Difference in Kinetic Energy = 312%

Collision #2

Total Mass - RED (kg)	Total Mass - COMB (kg)	Velocity - RED (m/s)	Velocity - COMB (m/s)	Momentum - RED (kg*m/s)	Momentum - COMB (kg*m/s)	Momentum - DIFF (%)	Kinetic Energy - RED (J)	Kinetic Energy - COMB (J)	Kinetic Energy - DIFF (%)
0.5079	0.5042	0.336	0.215	0.1706544	0.108403	157%	0.028669939	0.011653323	246%
0.7579	0.7542	0.588	0.438	0.4456452	0.3303396	135%	0.131019689	0.072344372	181%
0.7579	1.0042	0.322	0.186	0.2440438	0.1867812	131%	0.039291052	0.017370652	226%
1.0079	1.0042	0.506	0.4	0.5099974	0.40168	127%	0.129029342	0.080336	161%
1.0079	1.2542	0.488	0.322	0.4918552	0.4038524	122%	0.120012669	0.065020236	185%
1.0079	1.5042	0.493	0.285	0.4968947	0.428697	116%	0.122484544	0.061089323	201%
1.2579	1.2542	0.395	0.324	0.4968705	0.4063608	122%	0.098131924	0.06583045	149%
1.2579	1.5042	0.392	0.279	0.4930968	0.4196718	117%	0.096646973	0.058544216	165%
1.2579	1.7542	0.574	0.359	0.7220346	0.6297578	115%	0.20722393	0.113041525	183%
1.2579	2.0042	0.61	0.352	0.767319	0.7054784	109%	0.234032295	0.124164198	188%
1.5079	1.5042	0.646	0.647	0.9741034	0.9732174	100%	0.314635398	0.314835829	100%
1.5079	1.7542	0.554	0.417	0.8353766	0.7315014	114%	0.231399318	0.152518042	152%
1.5079	2.0042	0.539	0.363	0.8127581	0.7275246	112%	0.219038308	0.132045715	166%
1.7579	1.7542	0.453	0.387	0.7963287	0.6788754	117%	0.180368451	0.13136239	137%
1.7579	2.0042	0.62	0.487	1.089898	0.9760454	112%	0.33786838	0.237667055	142%
2.0079	2.0042	0.548	0.488	1.1003292	0.9780496	113%	0.301490201	0.238644102	126%

Average Difference in Momentum = 120%

Average Difference in Kinetic Energy = 169%

Calculations:

$$\boldsymbol{m_t = m_i + m_A}$$

Ex: $m_{t\text{-}RED\text{-}1}$ = 0.2579kg + 0.250kg = 0.5079kg

$$\boldsymbol{P = m_t * v}$$

Ex: $P_{RED\text{-}1}$ = 0.5079kg * 0.554m/s = 0.2813766kg*m/s

$$\boldsymbol{KE = \frac{1}{2} * m_t * v^2}$$

Ex: $KE_{RED\text{-}1}$ = 0.5 * 0.5079kg * 0.554m/s * 0.554m/s = 0.077941318J

$$\boldsymbol{DIFF = \max(a/b|b/a)}$$

Ex: $DIFF_{P\text{-}RED\text{-}1}$ = 0.2813766 / 0.2475908 * 100% = 114%

Conclusions: In collision #1, the average multiplicative differences in momentum and kinetic energy were 109% and 312%, respectively, therefore it can be concluded that a recoil collision conserves momentum but does not conserve kinetic energy. In collision #2, the average multiplicative differences in momentum and kinetic energy were 120% and 169%, respectively, therefore it can be concluded that a stick-together collision conserves both momentum and kinetic energy, though the proof conservation of kinetic energy by the results of this experiments can be debated. Error may have been introduced by frictional forces on the surface, as well as sound, heat and other losses of energy.