PHYS 101 EXPERIMENT 3. CONSERVATION OF LINEAR MOMENTUM:COLLISIONS

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Data & Results: [45]

	Before the Collision			After the Collision		
	ΔR (cm)	Δt (ms)	V_{cm} ($\frac{cm}{ms}$)	ΔR (cm)	Δt (ms)	V_{cm} ($\frac{cm}{ms}$)
1	2	50	0.04	2	50	0.04
2	2	50	0.04	2	50	0.04
3	2	50	0.04	2	50	0.04
4	2	50	0.04	2	50	0.04

Table 1a: Collision with two steel disks (center of mass)

	Left Puck			Right Puck		
	ΔR (cm)	Δt (ms)	V ($\frac{cm}{ms}$)	ΔR (cm)	Δt (ms)	V ($\frac{cm}{ms}$)
1	2.5	50	0,05	2.6	50	0,052
2	2.5	50	0,05	2.6	50	0.052
3	2.5	50	0,05	2.6	50	0.052
4	2.3	50	0.046	2.2	50	0.044

Table 1b: Collision with two steel disks before the collision

$V_{avg\ left}$= 0.49 m/s	E_{left}= 0.0504	$V_{avg\ right}$= 0.5 m/s	E_{right}= 0,0525

$v_{avg} = 0.049 \frac{cm}{ms} = 0.49 \frac{m}{s}$ $\quad \frac{1}{2}\cdot(0.42)(0.49)^2$ $\quad v_{avg} = 0.05 \frac{cm}{ms} = 0.5 \frac{m}{s}$

$E_{initial}$= E_{left}+ E_{right}=

$E_{initial} = 0.0504 + 0.0525$

$= 0.1029$ j

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	Left Puck			**Right Puck**		
	ΔR (cm)	Δt (ms)	V ($\frac{cm}{ms}$)	ΔR (cm)	Δt (ms)	V ($\frac{cm}{ms}$)
1	2.6	50	0.052	2	50	0.04
2	2.6	50	0.052	2	50	0.04
3	2.6	50	0.052	2	50	0.04
4	2.6	50	0.052	1.9	50	0.038

Table 1c: Collision with two steel disks after the collision

$V_{avg\ left}$= 0.52 m/s	E_{left}= 0,0568	$V_{avg\ right}$= 0.395 m/s	E_{right}= 0,0328

$0.052\ \frac{cm}{ms} = 0.52\ \frac{m}{s}$ $\quad \frac{1}{2}\cdot(0.42)(0.52)^2$ $\quad 0.0395\ \frac{cm}{ms} = 0.395\ m/s$ $\quad \frac{1}{2}\cdot(0.42)(0.395)^2$

E_{final}= E_{left}+ E_{right}=

$E_{final} = 0.0568 + 0.0328$
$= 0,0896\ J$

E_{final} / $E_{initial}$ =

$= \frac{0.0896}{0.1029} = 0.8707$

Energy Loss % = $\frac{E_{initial} - E_{final}}{E_{initial}} \cdot 100 = \boxed{12,93\%}$

	Before the Collision			**After the Collision**		
	ΔR (cm)	Δt (ms)	V_{cm} ($\frac{cm}{ms}$)	ΔR (cm)	Δt (ms)	V_{cm} ($\frac{cm}{ms}$)
1	1.5	50	0.03	1.4	50	0.028
2	1.5	50	0.03	1.5	50	0.03
3	1.4	50	0.028	1.4	50	0.028
4	1.5	50	0.03	1.4	50	0.028

Table 2a: Collision with two steel disks & Velcro (center of mass)

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	Left Puck			Right Puck		
	ΔR (cm)	Δt (ms)	V (cm/ms)	ΔR (cm)	Δt (ms)	V (cm/ms)
1	1.9	50	0.038	1.8	50	0.036
2	1.8	50	0.036	1.8	50	0.036
3	1.8	50	0.036	1.8	50	0.036
4	1.5	50	0.03	1.6	50	0.032

Table 2b: Collision with two steel disks & Velcro before the collision

$V_{avg\ left}$= 0.35 m/s	E_{left}= 0.0257	$V_{avg\ right}$= 0.35 m/s	E_{right}= 0.0257

$v_{avg} = 0.035 \frac{cm}{ms} = 0.35 \frac{m}{s}$ $\frac{1}{2} \cdot (0.42)(0.35)^2$ $v_{avg} = 0.035 cm = 0.35 m/s$ $\frac{1}{2}(0.42)(0.35)^2$

$E_{initial}$= E_{left}+ E_{right}= $2 \cdot (0.0257) = \boxed{0.0514 j}$

	Left Puck			Right Puck		
	ΔR (cm)	Δt (ms)	V (cm/ms)	ΔR (cm)	Δt (ms)	V (cm/ms)
1	1.3	50	0.026	1.4	50	0.028
2	1.5	50	0.03	1.5	50	0.03
3	1.3	50	0.026	1.4	50	0.028
4	1.3	50	0.026	1.5	50	0.03

Table 2c: Collision with two steel disks & Velcro after the collision

$V_{avg\ left}$= 0.27 m/s	E_{left}= 0.0153	$V_{avg\ right}$= 0.29 m/s	E_{right}= 0.0177

$\frac{108}{4} = 27 \Rightarrow 0.027 \frac{cm}{ms}$ $\frac{1}{2} \cdot (0.42)(0.27)^2$

~~$= 0.27 m/s$~~

E_{final}= E_{left}+ E_{right}=

$= 0.0153 + 0.0177 = \boxed{0.033 j}$

E_{final} / $E_{initial}$ =

$\frac{0.033}{0.0514} = 0.642$

Energy Loss % = $\frac{E_{initial} - E_{final}}{E_{initial}} \cdot 100 = \frac{0.0514 - 0.033}{0.0514} \cdot 100 = 35,80...$

$= \boxed{35,80\%}$

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Questions:

1. **[5]** If you are given a data sheet with only spark timer prints on it, can you distinguish between the initial and final states of the pucks?

If we ignore the energy loss caused by the system, we cannot distinguish the states of pucks in elastic collision since its motion will be symmetric with equal distances ⇒. However, inelastic collision can be distinguished by objects' motion, as their movement will differ. ⇒

symmetrical
final
initial
→ final
→ initial

2. **[5]** A particle collides obliquely with an identical particle initialy at rest. Assuming elastic collision, show that the two particles move at 90° from each other after the collision.

We know that systems preserves their momentum. Let v_1 be the velocity of the first particle. Then;
① $mv_1 + 0 = mv_1' + mv_2'$, where $\vec{v}_1'$ is the velocity of first particle, and $\vec{v}_2'$ is the velocity of second particle after the collision. Thus; ② $v_1 = v_1' + v_2'$. We also know that energy is also preserved: ③ $\frac{1}{2}mv_1^2 = \frac{1}{2}m(v_1')^2 + \frac{1}{2}m(v_2')^2 \Rightarrow$ ④ $v_1^2 = (v_1')^2 + (v_2')^2$
By combining ② and ④, we see that ⑤ $2 v_1' \cdot v_2' = 0$
Thus, since the scaler product of these velocities are 0, the angle between them must be 90°.

Conclusion: [15]

Purpose of this experiment was observing the states of momentum, collision types and their significances. To calculate precise results, airtable was used to reduce frictional force.

First, we observed elastic collusion as we used two identical pucks and collided them. We took the data of the distances between the center points, and the distance traveled by each pucks, before and after the collision for every 50 ms time interval. We then used this data to measure the velocity and the energy of the pucks. With measured energies, we then calculated the energy loss percentage. Since this system was not perfect, energy was not preserved. I found 12.93% energy loss due to possible conditions such as friction between the pucks and the air table or a small incline in air table.

Secondly, we repeated the same procedure, but with attaching velcro tapes to pucks so that they would unite and continue the motion together, allowing us to observe inelastic collision. We again took the data of multiple distances (same as the first part). At the end, we calculated the energy loss percentage which for my case was 35.80%. Yet again, possible reasons for such energy loss is due to the friction force, or an incline in the air table.