MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Physics Department

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Experiment 04: Momentum

Section and Group: 13A

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Each group need turn in only one report. Make sure that you each have a copy of your data, as you will need it for a problem on Problem Set 9. (You can find a copy of the problem at the end of the notes for the experiment.)

Part One: Inelastic Collisions
Enter your data for the three inelastic collisions into the table below. Include the velocity σ values from the fits and use them to estimate the error in $K_{A,1}$ and $K_{A,2}$

m_A	m_B	$v_{A,1}$ (m/s)	v_2 (m/s)	$K_{A,1}$ (J)	$K_{A,2}$ (J)
0.25 kg	0.25 kg	0.694 ±0.0013	0.337 ±0.003	0.060 ±0.001	0.014 ±0.005
0.25 kg	0.50 kg	0.948 ±0.0013	0.311 ±0.003	0.112 ±0.001	0.012 ±0.003
0.50 kg	0.25 kg	0.519 ±0.0012	0.339 ±0.003	0.067 ±0.001	0.029 ±0.001

Question 1: As the collisions are not elastic, the kinetic energy is not constant in these collisions. Where did this energy go? Is it a reversible process (i.e., can the energy be recovered as kinetic energy)?

The energy probably went several places. Some (probably most) would be used to deform the Velcro and hook the pads together and eventually be released as heat from the friction in the Velcro. Some energy would be radiated as sound (noise) during the collision.

None of this can be recovered as kinetic mechanical energy.

Part Two: Elastic Collisions

Enter the results measured by your group for elastic collisions into the table below.

If you assume that cart B collides elastically with the force sensor, then during the collision the momentum of cart B changes by $\Delta\vec{\mathbf{p}}_\mathrm{B} = -2m_\mathrm{B}\vec{\mathbf{v}}_{\mathrm{B},2}$. This change in momentum is the impulse that the force sensor exerts on the target cart B. Cart B therefore exerts an equal and opposite impulse on the force sensor; both have magnitude $J = 2m_\mathrm{B}v_{\mathrm{B},2}$. Measuring this impulse allows you to calculate the velocity of the target cart after the collision.

You were not asked to extimate errors from the standard deviations in the fit results, but I did it here just to indicate what they might be.

m_A	m_B	$v_{\mathrm{A},1}$ (m/s)	$v_{\mathrm{A},2}$ (m/s)	J (N s)	$v_{\mathrm{B},2}$ (m/s)
0.25 kg	0.25 kg	*0.487* $\pm$*0.0008*	$-$*0.009* $\pm$*0.002*	*0.235* $\pm$*0.0025*	*0.470* $\pm$*0.006*
0.25 kg	0.75 kg	*0.598* $\pm$*0.0010*	$-$*0.275* $\pm$*0.0004*	*0.431* $\pm$*0.005*	*0.287* $\pm$*0.004*
0.75 kg	0.25 kg	*0.375* $\pm$*0.0010*	*0.174* $\pm$*0.0015*	*0.277* $\pm$*0.0025*	*0.554* $\pm$*0.005*

Question 2: What is the impulse of cart A on cart B during each of the three collisions? While the carts were colliding, did the total kinetic energy change? If so, where did this energy go?

The impulse of cart A on cart B during each of the three collisions should be the change in momentum of cart A if the collisions are elastic. These changes are 0.124 ±0.001 Ns, 0.218 ±0.001 Ns, and 0.151 ±0.002 Ns, respectively in the three cases in the above table.

Each of these numbers should be equal to $m_B\, v_{B,2}$ *in the corresponding row of the table.*

Those numbers are 0.117 ±0.0015 Ns, 0.216 ±0.003 Ns, and 0.139 ±0.002 Ns, respectively. In all cases, they are a bit less than one would expect from the change in momentum of cart A. That suggests that some energy was lost as cart B rolled down the track and bounced off the spring. This energy went into a combination of friction on the track and energy lost to friction during the compression and expansion of the spring. On the force graphs you can also see that the spring is vibrating after the collision, so some energy went into that vibration.