EXPERIMENT: ONE-DIMENSIONAL COLLISIONS: ELASTIC

APPARATUS: One-dimensional air track, Photogate timing circuit, Balance

PROCEDURE:

In this experiment we will try to obtain an almost elastic collision of two carts on the air track. The main difference from the previous lab is that the carts move separately after the collision. The elastic bumper allows them to bounce off with almost no conversion of the kinetic energy into the other forms of energy.

As before, cart 2 initially stays at rest, and before the collision we have to measure only the velocity of the cart 1 v_{1i} (Figure 1). However, after the collision we have to measure the velocities of both carts, v_{1f} and v_{2f} (Figure 2). Thus, all in all we have to measure three times (t_{1i}, t_{1f}, t_{2f}), while the photogate system allows to simultaneously measure only two of them.

We can get out of this situation if, after the measurement of the initial time t_{1i}, but before the collision, we reset the timer. You have to make several practice trials to quickly remember and reset the contents of the timer before the carts collide. Then, we can again use the contents of the timer display and the memory to find t_{1f} and t_{2f}.

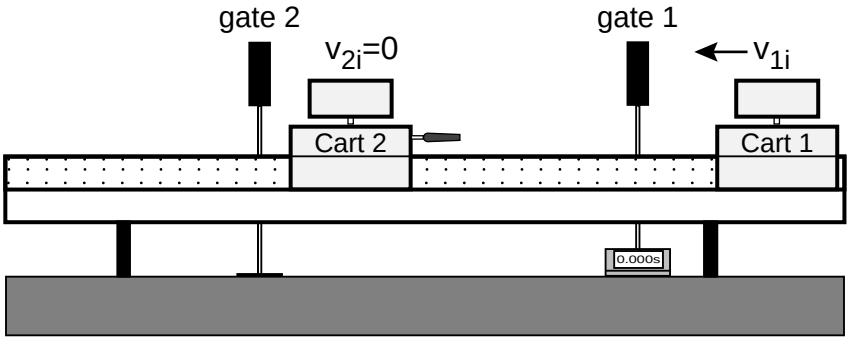

Figure 1: The initial state of the carts before collision.

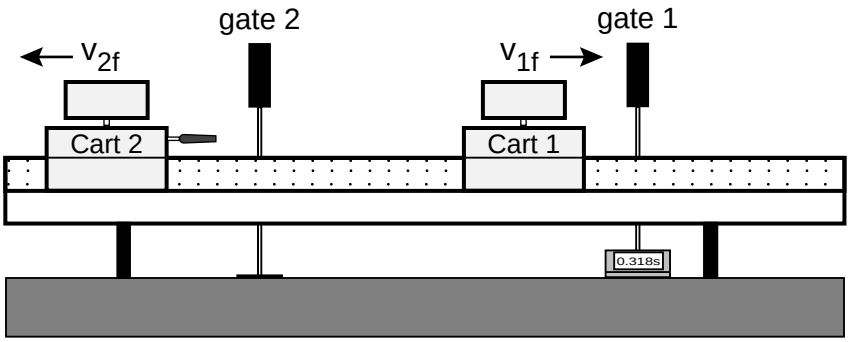

Figure 2: The final state of the carts after collision.

The plates on two carts have the same length (measure this length L_1 and L_2 on the track). The mass of the carts can be varied by adding masses (small metal disks) to them. The experiment will be done with cart2 initially at rest. So in the initial state we have :

Initial state: Cart1: has a mass m_1 and initial velocity v_1
Cart 2: has mass m_2 and is at rest, so v =0 cm/s

After the collision(final state): The two carts will be moving independently, in opposite directions.
The speed of the carts is $m_1 : v_{1f}$ and $m_2 : v_{2f}$

You will do 6 trials with the following m_1 and m_2 choices:
Trial 1+2: no mass disks on cart1, 2 mass disks on cart2, measure v_1 , v_{1f} and v_{2f}
Trial 3+4: 1 mass disk on cart1, 1 mass disk on cart2, measure v_1 , v_{1f} and v_{2f}
Trail 5+6: 2 mass disks on cart1 , no mass disk on cart2, measure v_1 , v_{1f} and v_{2f}

To measure these speeds you measure the following times: t_1, t_{1f}, t_{2f} Enter the data into the spreadsheet and calculate momenta and kinetic energy. Pay attention to the sign of the velocities, which depends on the direction of the motion of the cart. If the percentage change in momentum or kinetic energy before and after the collision is greater than 5%, repeat the measurement more carefully (collide slower/faster, etc.). Since the spreadsheet is set up it is easy to see whether momentum/energy is better conserved with every trial you do.

CHECKLIST:

Your lab report should include the following:

1) Several data runs with momentum and kinetic energy calculated for the system before and after the collision.

2) Calculations for percent changes in momentum and kinetic energy through the collision for the two sets of data specified above (change should be less than 5%). Describe what you changed to achieve changes less than 5%.

3) Conclusions, and possible explanations for any change in *KE*. and momentum.

4) Comment on the experimental uncertainties in the momentum and kinetic energy changes (do it like in the lab on inelastic collisions).

5) Comparison of the results of the Elastic collision and Inelastic collision experiments if you have done both.

Summary of formulae for momentum and kinetic energy:

Initial state:

Measure photogate time t_1, calculate v_1 and error on v_1 (called δv1 on spreadsheet)

Momentum: $P_i = m_1 v_1$ and kinetic energy: $KE_i = \frac{m_1 v_1^2}{2}$

Final state:

Measure photogate time t_{1f},t_{2f}, calculate v_{1f},v_{2f} and error in v_{1f},v_{2f} (called δv1f,δv2f on spread sheet)

Momentum: $P_f = P_{1f} + P_{2f} = m_1 v_{1f} + m_2 v_{2f}$ and kinetic energy: $KE_f = KE_{1f} + KE_{2f} = \frac{m_1 v_{1f}^2 + m_2 v_{2f}^2}{2}$

NOTE: Momentum is a vector quantity i.e. in one dimension it has a sign !!!

The difference between initial and final state is:
Momentum: $P_{diff} = P_i - P_f$ which is called Pdiff in spreadsheet.
Kinetic energy: $KE_{diff} = KE_i - KE_f$ which is called KEdiff in the spreadsheet.

Summary of errors:

You have to determine(=choose) the errors in the length measurement δL (dL)and the time δt (dt). Here we will neglect the error in the mass measurement. The error in the velocity is given by:

$\frac{\delta v}{v} = \left(\frac{\delta L}{L} + \frac{\delta t}{t} \right)$ resulting in $\delta v = v \left(\frac{\delta L}{L} + \frac{\delta t}{t} \right)$

The error in momentum is: $\delta P = P \frac{\delta v}{v}$ and in kinetic energy is: $\delta KE = KE \frac{2 \delta v}{v}$

The error in the differences for momenta and kinetic energies is the sum of the individual errors.