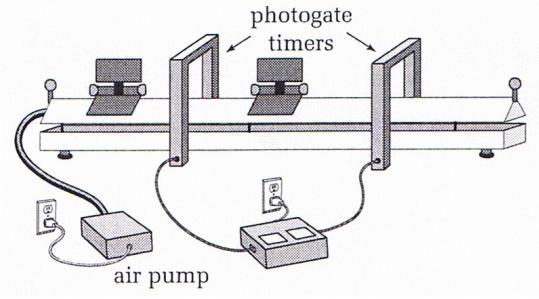
Problem

Are there characteristics that allow you to predict whether a collision will be elastic?

Background

- An air track similar to the diagram was set up and levelled.
- Two gliders (A and B), with velocity flags attached, were then placed on the track as shown.
- Glider A was set in motion while glider B remained stationary (i.e. the before velocity for glider B is always zero).
- The time for each velocity flag to go through the photogate timer was recorded.
- The experiment was repeated for (a) various masses of A and B and (b) elastic and inelastic collisions.



Notes

① The displacements "Δd" for each collision are given on the next page (i.e. they are the width of the velocity flags).

② The times for each collision will be given to you. "Δt Before" and "Δt After" represent the times that each glider's velocity flag took to pass through the photogate timers before and after the collision.

③ Since all of the motion will be in one dimension only positive and negative signs will be needed to indicate direction. Vector notations will not be necessary.

④ Since the values you will be working with are inherently small, it is important to express the answers to your calculations to 2 significant digits as requested (i.e. 3.2×10^{-3} or 3.2e-03). It is also important that you carry your answers through to ensure as much accuracy as possible is ensured. The % difference answers should be expressed to 1 decimal place as requested.

Calculations & Questions

1. Get your time data from the teacher and record it in the charts on the next page (page 2). Also be sure to indicate which time data you were given (i.e. the letter of your data) in the summary chart (page 3).
2. For each glider in each trial calculate the initial velocity (before the collision) and the final velocity (after the collision) from the displacement and the time interval (v=d/t). Be sure to include positive and negative signs. Express your answers to 2 significant digits (use scientific notation).
3. For each glider in each trial calculate the initial momentum (before the collision) and the final momentum (after the collision). Be sure to include positive and negative signs. Express your answers to 2 significant digits (use scientific notation).
4. For each trial calculate the total momentum of both gliders before the collision and the total momentum of both after the collision. Express your answers to 2 significant digits (use scientific notation). (NOTE: when the two gliders collide, stick together and move as a coupled pair use the displacement and time of the stationary glider to determine the "after" velocity of both gliders.)
5. For each trial calculate the % difference between the total momentum before and after the collision. Express your answers to 1 decimal place.
6. Describe how well the collisions demonstrated conservation of momentum. In any case for which momentum did not seem to be conserved, provide possible explanations for errors.
7. For each glider in each trial calculate the initial kinetic energy (before the collision) and the final kinetic energy (after the collision). Express your answers to 2 significant digits (use scientific notation).
8. For each trial calculate the total kinetic energy of both gliders before the collision and the total kinetic energy of both after the collision. Express your answers to 2 significant digits (use scientific notation).
9. For each trial calculate the % difference between the total kinetic energy before and after the collision. Express your answers to 1 decimal place.
10. Describe how well the collisions demonstrated conservation of energy. (Due to measurement errors, do not expect the kinetic energies to be identical before and afer a collision. Decide if the values appear to be close enough that the differences could be attributed to measurement errors.)
11. Examine the collisions. Look for a trend that would permit you to predict whether a collision would be elastic or inelastic. Explain your observations (i.e. which collisions are elastic or inelastic) and the trend.

Observations

TRIAL	Mass of gliders m (kg)		Displacement Δd (m)		Times recorded Δt (s)			Velocities of gliders v (m/s)		
	A	B	A	B	A		B	A		B
					Before	After	After	Before	After	After

#1 Glider A & Glider B Relatively Same Mass

Glider A moves to the right and collides with stationary glider B ✡ Glider A stops and glider B moves to the right (glider B seems to have relatively the same speed as glider A had initially).

	m_A	m_B	d_A	d_B	t_A	t_A'	t_B'	v_A	v_A'	v_B'
1	0.38	0.38	0.089	0.089					0.0000	

#2 Glider A Heavier Than Glider B

Glider A moves to the right and collides with stationary glider B ✡ Glider A and B both move to the right (glider B moves more quickly than glider A).

	m_A	m_B	d_A	d_B	t_A	t_A'	t_B'	v_A	v_A'	v_B'
2	0.38	0.18	0.089	0.089						

#3 Glider A Lighter Than Glider B

Glider A moves to the right and collides with stationary glider B ✡ Glider A rebounds to the left (negative displacement = negative velocity) and glider B moves to the right.

	m_A	m_B	d_A	d_B	t_A	t_A'	t_B'	v_A	v_A'	v_B'
3	0.18	0.38	0.089 (-0.089)	0.089					-ve	

NOTE: In the next 3 collisions glider A moves to the right and collides with stationary glider B ✡ Glider A sticks to glider B and both move as a coupled pair to the right. Use the displacement and time of the stationary glider to determine the "after" velocity of both gliders.

#4 Glider A & Glider B Relatively Same Mass

	m_A	m_B	d_A	d_B	t_A	$t_A' = t_B'$	t_B'	v_A	v_A'	v_B'
4	0.38	0.38	0.089	0.089						

#5 Glider A Heavier Than Glider B

	m_A	m_B	d_A	d_B	t_A	$t_A' = t_B'$	t_B'	v_A	v_A'	v_B'
5	0.38	0.18	0.089	0.089						

#6 Glider A Lighter Than Glider B

	m_A	m_B	d_A	d_B	t_A	$t_A' = t_B'$	t_B'	v_A	v_A'	v_B'
6	0.18	0.38	0.089	0.089						

TIME DATA: _____

NOTE: the BEFORE momentum and BEFORE kinetic energy for B are zero because the BEFORE velocity for B is 0

TRIAL	Momentum (kg·m/s)						
	A		B		Total		% Diff
	Before	After	Before	After	Before	After	
1			0				
2			0				
3		-ve	0				
4			0				
5			0				
6			0				
	2 significant digits (use scientific notation)						1 dec.pl.

TRIAL	Kinetic Energy (J)						
	A		B		Total		% Diff
	Before	After	Before	After	Before	After	
1			0				
2			0				
3			0				
4			0				
5			0				
6			0				
	2 significant digits (use scientific notation)						1 dec.pl.

SAMPLE MARKING SCHEME
(REFERENCE ONLY - DO NOT SUBMIT)

ENERGY & MOMENTUM: ANALYZING COLLISIONS

STUDENT: _____

Summary for Time Data _____ (Correct #s)	Average Momentum % Diff.		Average Kinetic Energy % Diff.	
	1,2,3	4,5,6	1,2,3	4,5,6
A moving glider and stationary glider of equal mass.				
A moving glider heavier than a stationary glider.				
A moving glider lighter than a stationary glider.				

STUDENT ANSWERS				
A moving glider and stationary glider of equal mass.				
A moving glider heavier than a stationary glider.				
A moving glider lighter than a stationary glider.				

% ERROR BETWEEN CORRECT #s & STUDENT ANSWERS				
A moving glider and stationary glider of equal mass.				
A moving glider heavier than a stationary glider.				
A moving glider lighter than a stationary glider.				

STUDENT MARK ☞ based on % error between theirs and accepted

< 20 %	☞	5/5
20 - 50 %	☞	4/5
50 - 100 %	☞	3/5
100 - 500 %	☞	2/5
>500 %	☞	1/5
TOTAL ÷ 2	=	/30

Sample calculations	☞	pick a trial & show your work	/7
Glider calculations	☞	2 significant digits (-1 for each omission)	/5
% Difference calculations	☞	1 decimal place (-1 for each omission)	/3
Answers to questions	☞	#6 (/3), #10 (/3), #11 (/4)	/10

TOTAL = /55