Conservation of Linear Momentum

Name_____ TA_____

Partners_____

Section #_____ Date_____

---

0.   Quiz before experiment (Please answer the questions before you do the lab.)

In this lab we are going to use the air track/glider system to investigate the conservation of momentum and kinetic energy during the collision of two objects.

To determine the velocity of the glider, we use a piece of tape as a "flag". If the flag width is L and flag blocks the photogate for a time period of T (called "time in gate" in the Science Workshop), we know the velocity V = L / T.

Momentum of a mass moving at velocity v is **P** = m**v**. For a system of multiple objects, the total momentum is the vector sum of the momenta of individual objects.

Kinetic energy of a mass moving at velocity v is E_k = ½mv^2. For a system of multiple objects, the total energy is the sum of the individual objects' energy.

During any collision, the system's total momentum is always conserved. Kinetic energy is conserved only if the collision is elastic. For inelastic collisions, part of kinetic energy is lost (converted to other forms of energy).

Question①: If the flag width is 0.0254 m and a time the flag blocks a photogate is 0.24 s, what is the velocity of the glider? v = _____ (m/s)
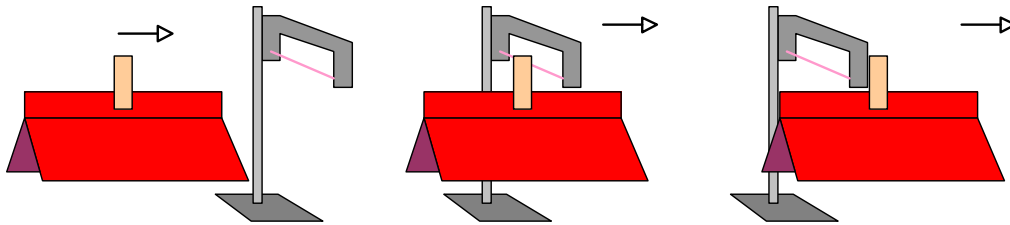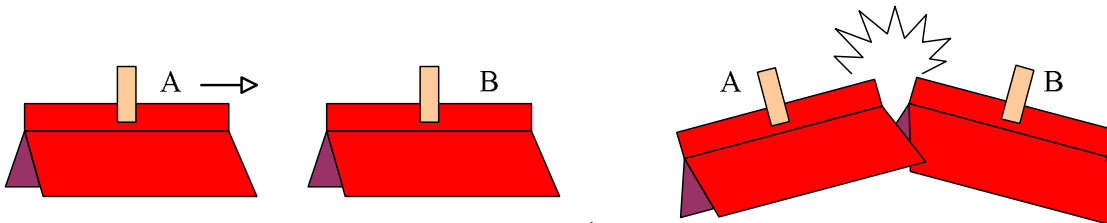

Question②: The objects A and B have <u>an equal mass</u>. B stays on the air track and A comes from left side. After hitting, what will happen?
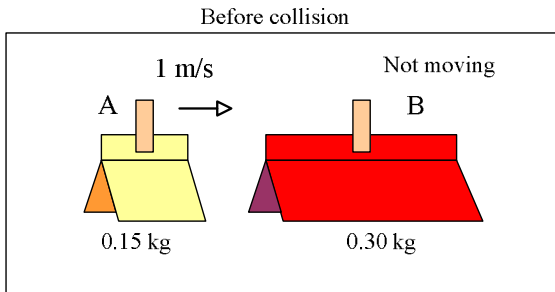(a) A and B recoil each other.
(b) A follows B at slower speed.
(c) A stops immediately after the collision.
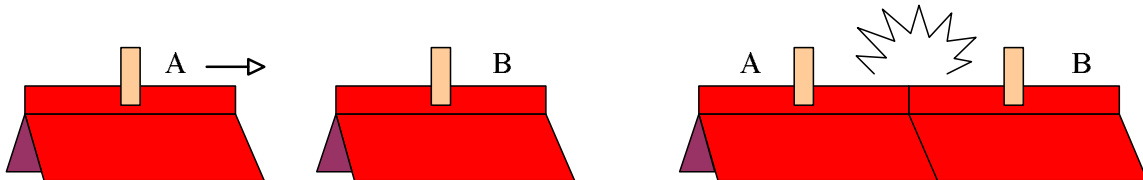
Question③: Even though the objects hit as shown below, you will obtain an expected result (momentum conservation). Is it True or False? _____

Question④: Calculate the following initial and final momenta. (Momentum = Mass × Velocity)
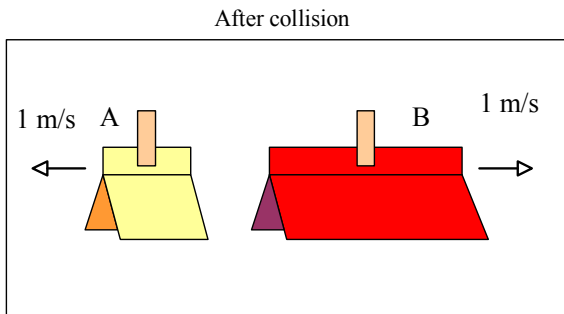
Before collision

Momentum of A: P_A(ini.)=_____kg·m/s

Momentum of B: P_B(ini.)=_____kg·m/s

Total momentum of this system:
P_{ini} (total)=_____kg·m/s

After collision

Momentum of A: P_A(fin.)=_____kg·m/s

Momentum of B: P_B(fin.)=_____kg·m/s

Total momentum of this system:
P_{fin} (total)=_____kg·m/s

Is the momentum conserved? _____

◆ – ◆
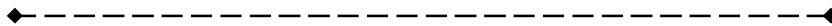
1. **Collision of two objects of equal mass**

Use the two large gliders. Place glider #2 between the two photogates. Push the glider A against B. Let them collide by the leaf springs with no Velcro.

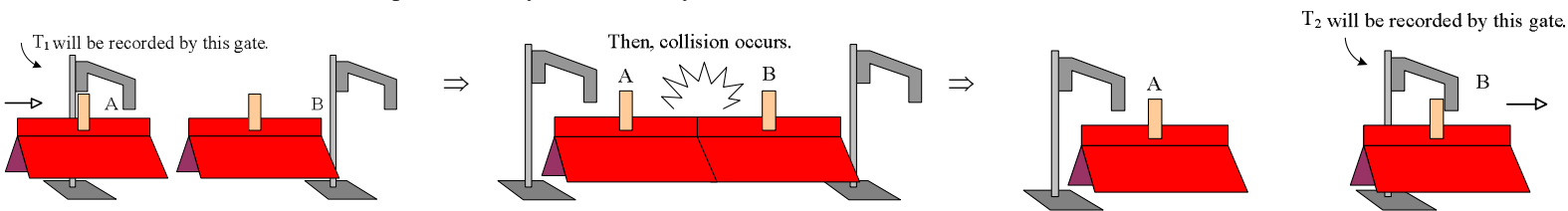Our system (the two gliders) should have momentum conserved, which means during the collision, 100% of glider A's momentum P_1 should be transferred to B. However due to various reasons P_1 and P_2 you obtain from the experiment may not be exactly the same.

Flag width L_1 _____   Flag width L_2 _____

m_1 _____ m_2 _____

Trial #	T_1	T_2	V_1	V_2	P_1	P_2	% difference
1							
2							
3							

Find the percentage difference $\dfrac{|P_1 - P_2| \times 100}{(P_1 + P_2)/2}$ (%)   for each value.

Is the momentum conserved?
2. Collision of two objects of unequal mass

Use the one large and one small glider. Place glider B between the two photogates. Push the glider A against the B. Let them collide by the leaf springs with no Velcro. Notice that this time the glider A will not stop after the collision. So you need to determine the final velocity of A glider as well.

Our system (the two gliders) should have total momentum conserved, which means the initial total momentum of the system should be the same as final. Test both cases: small hits large and large hits small.

Note: Momentum is a vector. In this one-dimensional problem, if the velocities are in different directions, be sure to use appropriate signs.

Draw the simple diagram as shown in the first part. Make sure which is T_1(initial), T_1(final), and T_2.
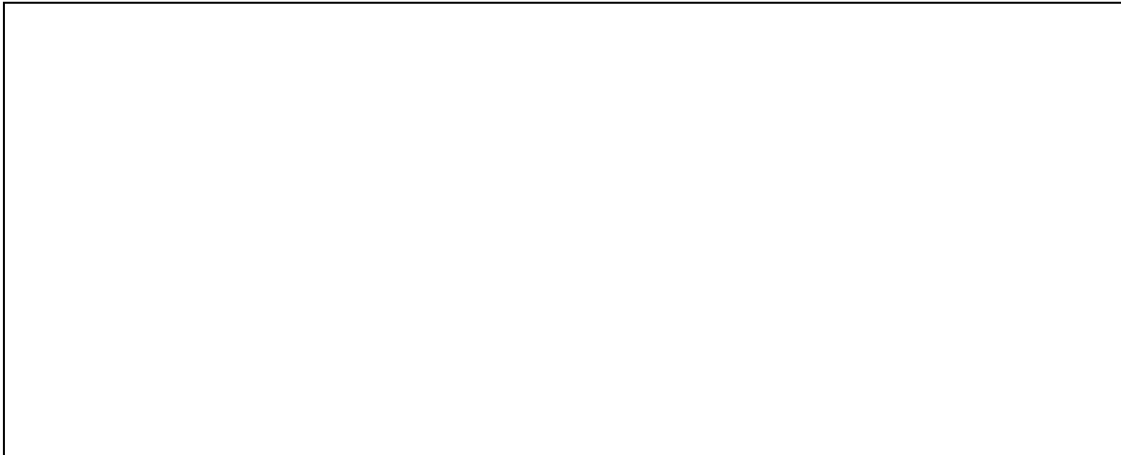
Flag width L_1 _____ Flag width L_2 _____

m_1 _____ m_2 _____

Trial #	T_1 initial	T_1 final	T_2	V_1 initial	V_1 final	V_2
1 large hits small						
2 small hits large						

Trial #	P_1 initial	P_1 final	P_2	(Total P) init	(Total P) final	% difference
1 large hits small						
2 small hits large						

Find the percentage difference $\dfrac{(\text{Total } P)init - (\text{Total } P)final}{((\text{Total } P)init + (\text{Total } P)final)/2} \times 100(\%)$ for each trial.

Is the momentum conserved?

3. Completely inelastic collision

Use the two large gliders. Place glider #2 between the two photogates. Push the glider A against the B. Let them collide by the leaf springs <u>with Velcro</u> so after collision they stick together.

Although the collision is completely inelastic, the total momentum is still conserved. However, 50% of the kinetic energy is lost, if the two masses are equal.

Draw the simple diagram as shown in the first part. Make sure which is T_1 and T_{1+2}.

Flag width L_1 _____ Flag width L_2 _____

m_1 _____ m_2 _____

Trial #	T_1	T_{1+2}	V_1	V_{1+2}	P_1	P_{1+2}	% difference $\frac{\left\lvert P_1 - P_{1+2}\right\rvert}{(P_1 + P_2)/2} \times 100$ (%)
1							
2							
3							

Is the momentum conserved?

Trial #	KE_1 $= \frac{1}{2}\, m_1 V_1^2$	KE_2 $= \frac{1}{2}\,(m_1 + m_2)V_{1+2}^2$	% difference $\frac{\left\lvert KE_1 - KE_2\right\rvert}{(KE_1 + KE_2)/2} \times 100$ (%)
1			
2			
3			

Is the energy conserved or not?

NOTE:
1. Use Kg for masses, m for lengths, kg·m/s or N·s for momentum in, and J for energy.
2. In your report be sure to write some comments on your results. If your results are different from what are predicted theoretically, discuss the possible reasons.