

## One-Dimensional Collisions



Every type of collision can be classified according to its elasticity. A **perfectly elastic collision** is one in which none of the initial momentum or kinetic energy is lost during the collision. An inelastic collision is one in which no momentum is lost, but some of the kinetic energy is converted to other forms of energy. A **perfectly inelastic collision** is one in which the maximum kinetic energy as is possible to lose is converted to other forms of energy while keeping momentum conserved.

When two objects collide in one dimension, each object can either move to the left ( $\leftarrow O$ ), move to the right ( $O \rightarrow$ ), or become/remain stationary ( $O$ ). In addition to these individual movements, it is also possible for the two objects to stick together and move together to the right ( $OO \rightarrow$ ), move together to the left ( $\leftarrow OO$ ), or both become stationary ( $OO$ ). A systematic analysis of these outcomes reveals eleven

outcome possibilities for the pair of objects after the collision. (There are actually twelve total possibilities, but having both stationary and having both stationary and stuck together describe the same physical situation.)

The goal of this activity is for you to discover the initial conditions that determine which of these outcome possibilities can actually occur when the collision is either perfectly elastic or perfectly inelastic.

Go to the simulation web site at <http://www.sciencejoywagon.com/explsci/media/airtrack.htm>.

Set the masses and initial speeds of each cart in order to see which outcomes are possible when the two objects collide if **1) a moving object hits a stationary object**, **2) two moving objects collide head-on**, and **3) a moving object catches up and strikes another moving object from behind**.

Fill in the eleven outcome possibilities in the "Outcomes" column. For each chart, run the simulation in order to try to obtain each of the possible outcomes. When an outcome is obtained, record the initial conditions that led to those final conditions. If any situation is impossible, write "impossible" across the "Outcome Conditions" columns on that row and leave the "Initial Conditions" blank.

Air Track by Raman Pfaff (pfaff@ExploreScience.com)

$e =$   1.00

$dt =$   1.0

total time (sec) 28.0

vel (m/s)  5.0

mass (kg)  0.5

$i =$   1.0

vel (m/s)  0.0

mass (kg)  2.0

momentum values	Initial	Final
V	5.0	-12.600
P	2.500	-6.300
V	-6	-1.600
P	-12.000	-3.200
tot P	-9.500	-9.500

units: P in kg\*m/s<sup>2</sup>, V in m/s

1. Object A, moving to the right, collides with stationary Object B

Initial Conditions						Elastic or Inelastic?	Outcomes	Outcome Conditions					
Object A			Object B					Object A			Object B		
Mass	Vel.	Mom.	Mass	Vel.	Mom.			Mass	Vel.	Mom.	Mass	Vel.	Mom.
							$\leftarrow O \ O \rightarrow$						
							$O \rightarrow \ O \rightarrow$						
							$O \ O \rightarrow$						
							$\leftarrow O \ \leftarrow O$						
							$O \rightarrow \ \leftarrow O$						
							$O \ \leftarrow O$						
							$\leftarrow O \ O$						
							$O \rightarrow \ O$						
							$OO$						
							$OO \rightarrow$						
							$\leftarrow OO$						

2. Object A, moving to the right, collides with Object B, moving to the left.

Initial Conditions						Elastic or Inelastic?	Outcomes	Outcome Conditions					
Object A			Object B					Object A			Object B		
Mass	Vel.	Mom.	Mass	Vel.	Mom.			Mass	Vel.	Mom.	Mass	Vel.	Mom.
							$\leftarrow O \ O \rightarrow$						
							$O \rightarrow \ O \rightarrow$						
							$O \ O \rightarrow$						
							$\leftarrow O \ \leftarrow O$						
							$O \rightarrow \ \leftarrow O$						
							$O \ \leftarrow O$						
							$\leftarrow O \ O$						
							$O \rightarrow \ O$						
							$OO$						
							$OO \rightarrow$						
							$\leftarrow OO$						

3. Object A, moving to the right, collides from behind with Object B, also moving to the right.

Initial Conditions						Elastic or Inelastic?	Outcomes	Outcome Conditions					
Object A			Object B					Object A			Object B		
Mass	Vel.	Mom.	Mass	Vel.	Mom.			Mass	Vel.	Mom.	Mass	Vel.	Mom.
							$\leftarrow O \quad O \rightarrow$						
							$O \rightarrow \quad O \rightarrow$						
							$O \quad O \rightarrow$						
							$\leftarrow O \quad \leftarrow O$						
							$O \rightarrow \quad \leftarrow O$						
							$O \quad \leftarrow O$						
							$\leftarrow O \quad O$						
							$O \rightarrow \quad O$						
							$OO$						
							$OO \rightarrow$						
							$\leftarrow OO$						

As you examine what you have discovered in this activity, you should see some obvious generalities that can be made. Make statements summarizing any of the obvious patterns that you have discovered.