Worksheet (Collision) Using Phet Simulation

**Dept. Physics and Astronomy Texas Christian University**

**Name:**

Instructions courtesy of: Nawal Nayfeh, University of Sharjah

This activity consists of two Parts

Part one: Collision in one Dimension.

Part two: Collision in two dimensions.

To be familiar with simulation setting and controllers used to set the velocity, momentum, mass, kinetic energy using Phet simulation open the following link and play with it.

<https://phet.colorado.edu/sims/collision-lab/collision-lab_en.html>

**Objectives**

1. Study collision in one dimension and collision in two dimensions.
2. Calculate the momentum and kinetic energy conservation in elastic and inelastic collisions.

**Theory**

The following experiment explores the conservation of momentum and energy in a closed physical system. In this lab, we will see in practice how the conservation of momentum and total energy relate various parameters (masses, velocities) of the system independently of the nature of the interaction between the colliding bodies.

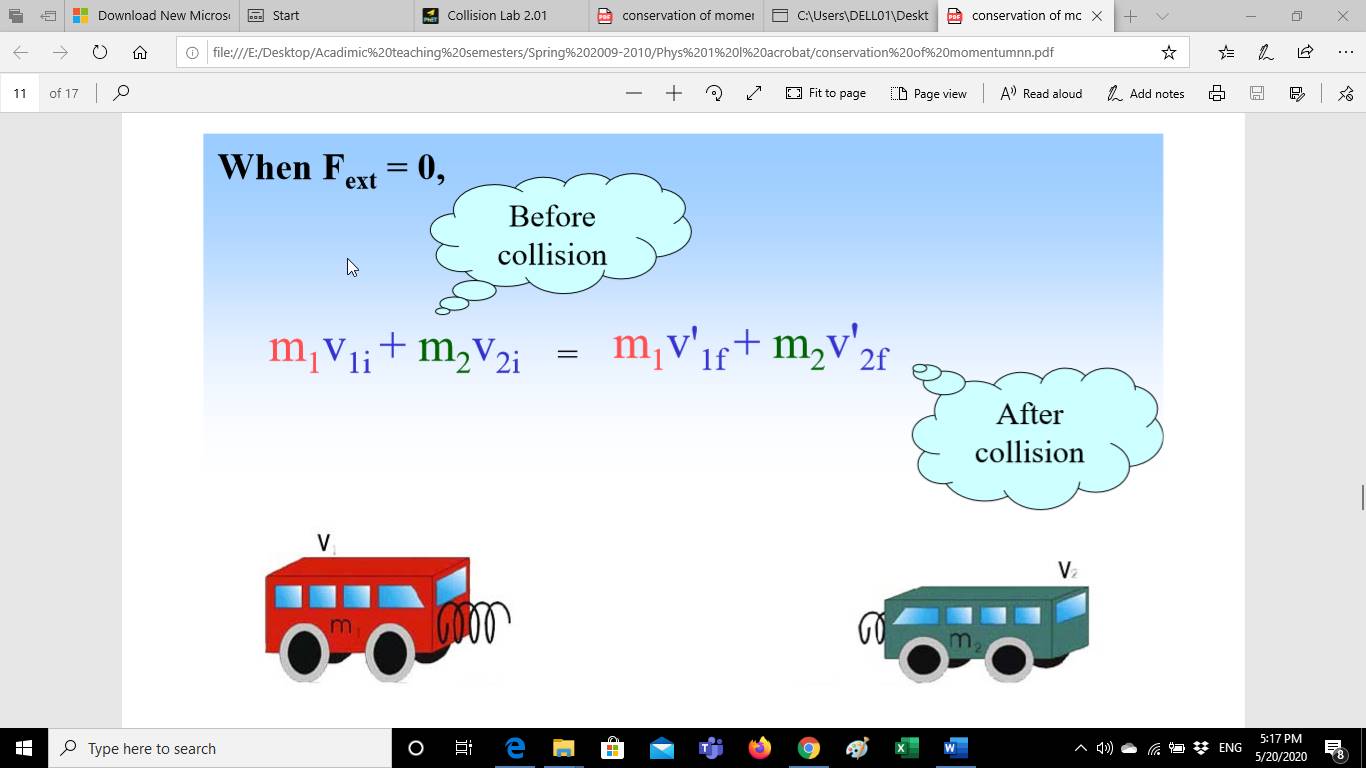
***Momentum:***

For a single object, momentum is defined as the product of the [mass](https://en.wikipedia.org/wiki/Mass) and [velocity](https://en.wikipedia.org/wiki/Velocity) of an object. It is a [vector](https://en.wikipedia.org/wiki/Euclidean_vector) quantity, possessing a magnitude and a direction. If *m* is an object's mass and **v** is its velocity (also a vector quantity), then the object's momentum is:  
{\displaystyle \mathbf {p} =m\mathbf {v} .}

**P**= m **V** ………Eq. 1

***Conservation of momentum:***

The conservation of momentum states that the total momentum of a system is constant if the net external force acting on the system is zero (in equation form **pi** = **pf**). When collisions occur the forces between objects are internal forces and do not affect the total momentum of the system (it does affect the individual momentums of the objects however). Thus, the conservation of momentum can also be stated this way: The total momentum before a collision is equal to the total momentum after a collision (or **pi** = **pf** where **pi** is the momentum before the collision and pf is the momentum after the collision). For two objects:

 **pi** = **p1i** + **p2i** & **pf** = **p1f** + **p2f**

thus **pi** = **pf** turns into

**p1i + p2i** = **p1f + p2f** and since **p** = m**v**

this turns into:

m1**V1i** + m2**V2i** = m1**V1f** + m2**V2f**

***Elastic collision:***

In perfectly elastic collisions objects bounce of one another when they collide. In this type of collision both momentum and kinetic energy are conserved (or **p**i = **p**f and Ki = Kf  ).

The momentum is given by: **P**= m **V**

The kinetic energy is given by: K= (1/2)mV2

***Inelastic collision:***

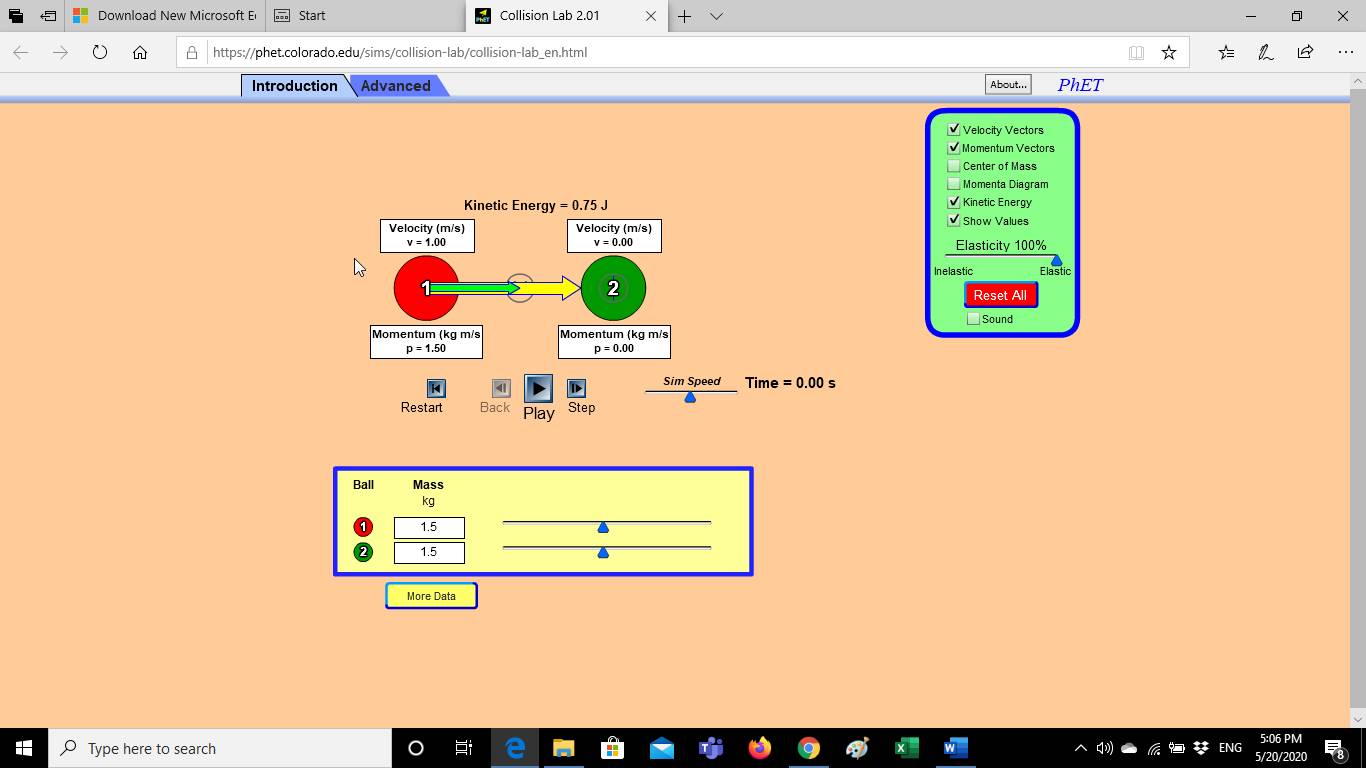
A perfectly inelastic collision is one in which the objects stick together and move as a single unit after the collision. In this type of collision momentum is conserved, but kinetic energy is not conserved.

To satisfy the objectives of this activity using Phet simulation, click on the link below and do the following steps

<https://phet.colorado.edu/sims/collision-lab/collision-lab_en.html>

*Part 1: Elastic collision*

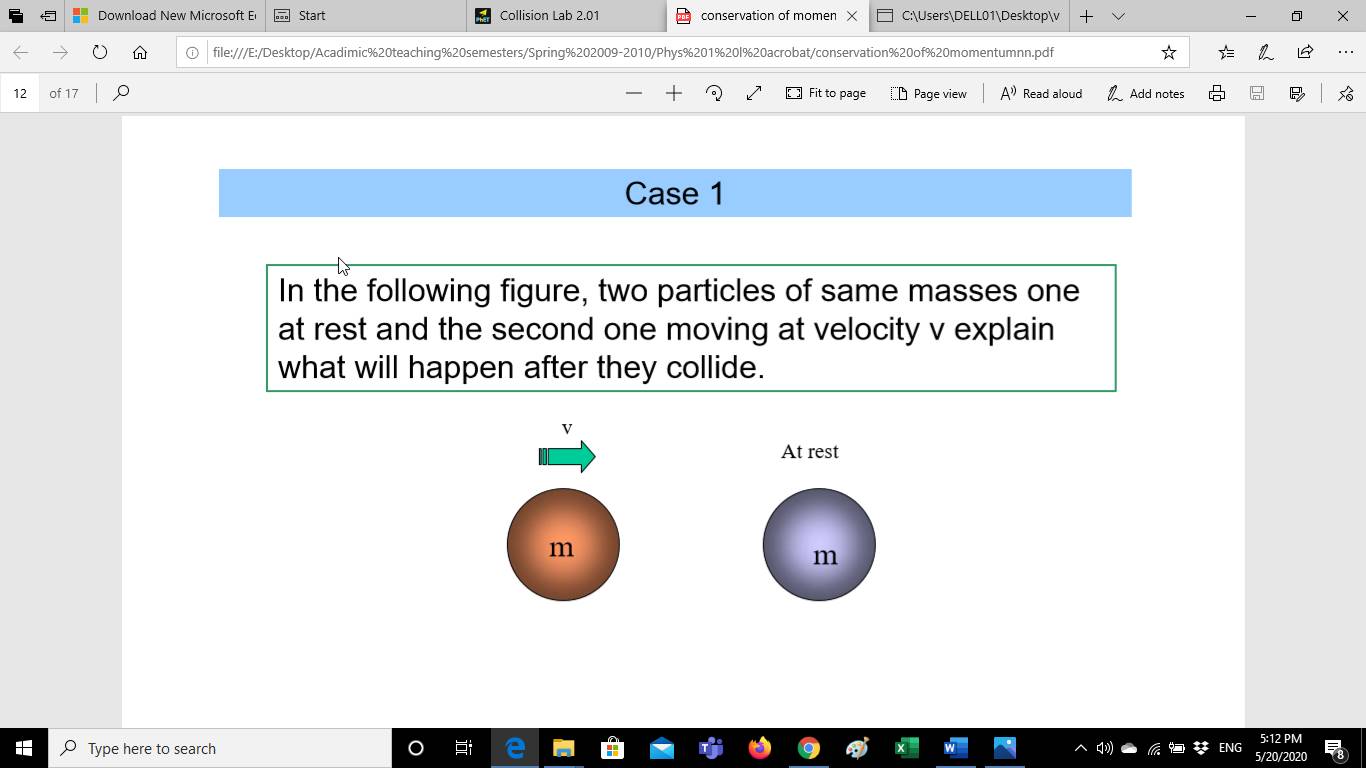
1. Open the link up (you will see a window like the side one), use the mass controller to control the mass of the balls (m1 and m2).



Mass controller

Elasticity controller

1. Control the balls velocity by changing the length and the direction of the velocity vector. (press on the circle at the tip of the velocity vector and then drag to change its magnitude and direction).
2. For elastic collision use the elasticity controller (drag the blue triangle to the right ) to choose the collision type (elastic for this part).
3. Once you fix your variables, press on more data Potton to record your data before collision and then press play and then after the two balls collide, pause the simulation to record your data after collision, press on show values to get your data.
4. Fill tables 1(a), Table 1(b) and Table 1(c).



1 2

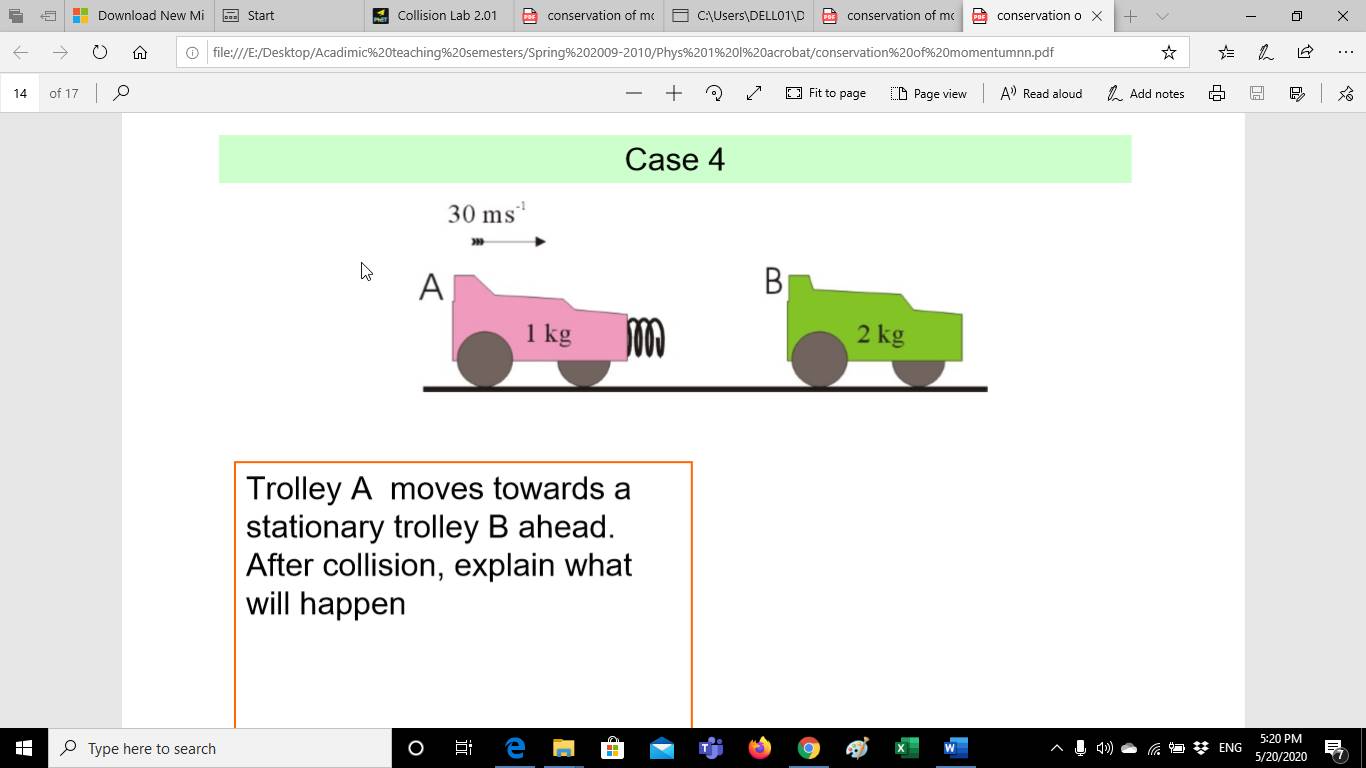
V1i

at rest

Table 1(a)

m1=m2=3kg

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1i  (m/s) | V2i  (m/s) | V1f  (m/s) | P1i  (m/s) | P2i  (kgm/s) | P1f  (kgm/s) | P2f  (kgm/s) | Pi  (kgm/s) | Pf  (kgm/s) | Ki  (kgm/s2) | KEf  (kgm/s2) |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |



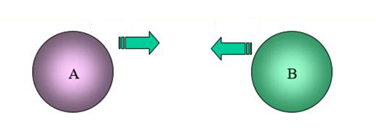
at rest

V1i

Table 1(b)

m1= 1kg and m2=2kg

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1i  (m/s) | V2i  (m/s) | V1f  (m/s) | P1i  (m/s) | P2i  (kgm/s) | P1f  (kgm/s) | P2f  (kgm/s) | Pi  (kgm/s) | Pf  (kgm/s) | Ki  (kgm/s2) | KEf  (kgm/s2) |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |



V1i V2i

m1

Table 1(c)

m1= 1kg, m2=3kg

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1i  (m/s) | V2i  (m/s) | V1f  (m/s) | P1i  (m/s) | P2i  (kgm/s) | P1f  (kgm/s) | P2f  (kgm/s) | Pi  (kgm/s) | Pf  (kgm/s) | Ki  (kgm/s2) | KEf  (kgm/s2) |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

Write your comments regarding the linear momentum and the kinetic energy of the three cases shown above for elastic collision.

Table 1 (a): Table 1 (b):

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Table 1 (c)

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*Part 1: Inelastic collision*

To satisfy the objectives of this Part using Phet simulation, click on the link below and do the following steps

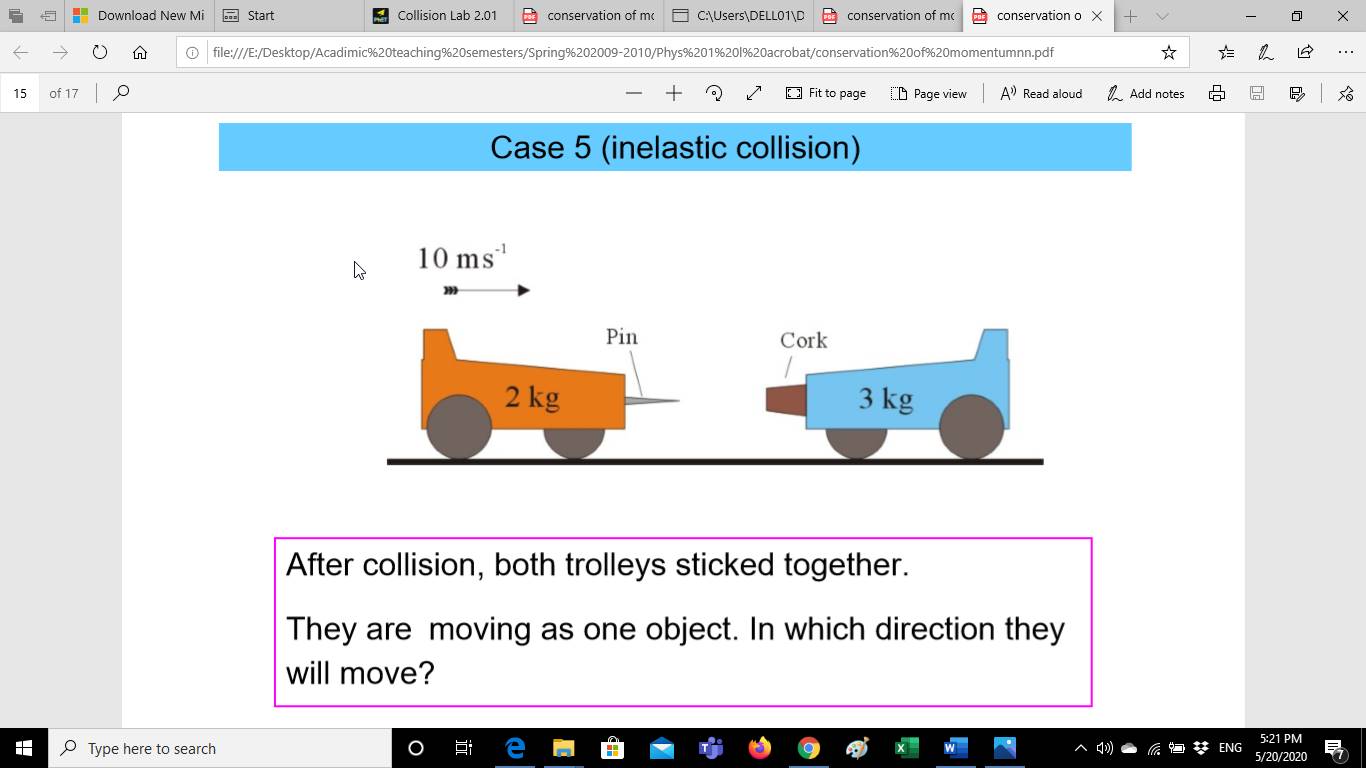
<https://phet.colorado.edu/sims/collision-lab/collision-lab_en.html>



Elasticity controller

Mass controller

1. Open the link up (you will see a window like the side one), use the mass controller to control the mass of the balls (m1 and m2).
2. Control the balls velocity by changing the length and the direction of the velocity vector. (press on the circle at the tip of the velocity vector and then drag to change its magnitude and direction).
3. For inelastic collision use the elasticity controller (drag the blue triangle to the left) to choose the collision type (inelastic for this part).
4. Once you fix your variables, press on more data Potton to record your data before collision and then press play and then after the two balls collide, pause the simulation to record your data after collision, press on show values to get your data.
5. Fill tables 2(a), Table 2(b).



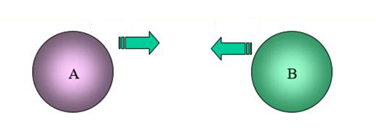
at rest

V1i

Table 2(a)

m1=2kg and m2=3kg

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1i  (m/s) | V2i  (m/s) | V1f  (m/s) | P1i  (m/s) | P2i  (kgm/s) | P1f  (kgm/s) | P2f  (kgm/s) | Pi  (kgm/s) | Pf  (kgm/s) | KEi  (kgm/s2) | KEf  (kgm/s2) |
|  | 0 |  |  |  |  |  |  |  |  |  |
|  | 0 |  |  |  |  |  |  |  |  |  |



V1i V2i

Table 2(b)

m1= 1kg, m2=3kg

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1i  (m/s) | V2i  (m/s) | V1f  (m/s) | P1i  (m/s) | P2i  (kgm/s) | P1f  (kgm/s) | P2f  (kgm/s) | Pi  (kgm/s) | Pf  (kgm/s) | Ki  (kgm/s2) | Kf  (kgm/s2) |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |

Write your comments regarding the linear momentum and the kinetic energy of the two cases shown above for inelastic collision.

Table 2 (a): Table 2 (b):

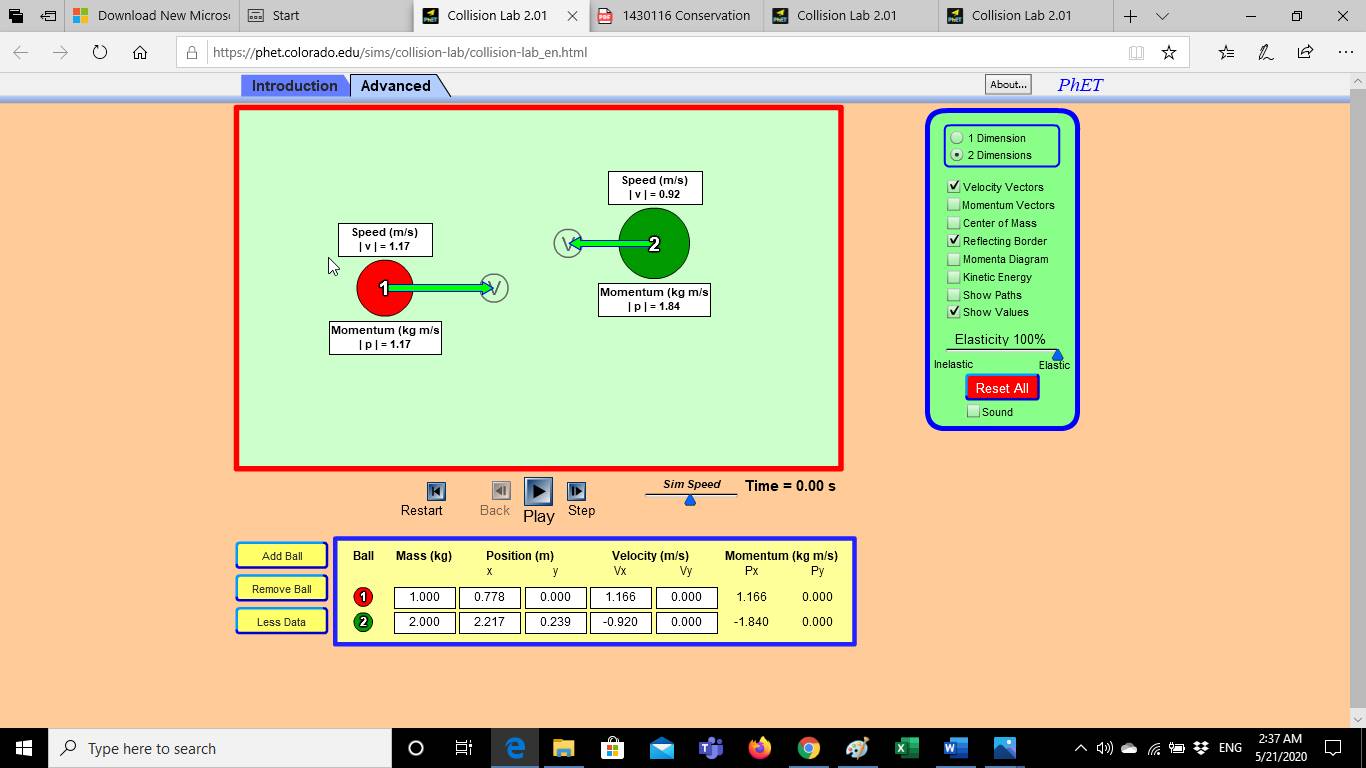
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*Collision in two dimensions*

<https://phet.colorado.edu/sims/collision-lab/collision-lab_en.html>



1. Open the link up (you will see a window like the side one), click on Advanced instead of Introduction (the one used for collision in one dimension), use the mass controller to control the mass of the balls (m1 and m2).
2. Control the balls velocity by changing the length and the direction of the velocity vector (press on the circle at the tip of the velocity vector and then drag to change its magnitude and direction).
3. For elastic collision use the elasticity controller (drag the blue triangle to the right) to choose the collision type (elastic for this part).
4. Once you fix your variables, press on more data Potton to record your data before collision and then press play and then after the two balls collide, pause the simulation to record your data after collision, press on show values to get your data. Fill table 3(a).
5. Repeat all the above for inelastic collision and record your data in Table 3 (b)

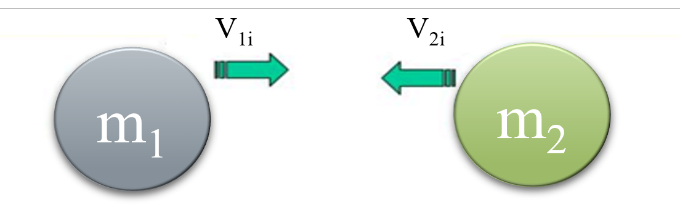
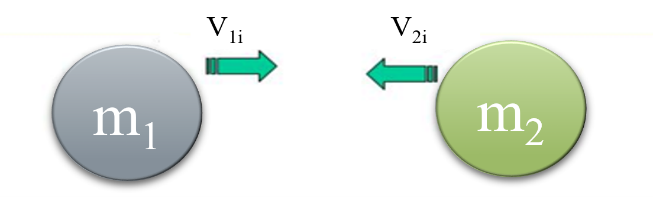


Table 3(a)

m1=1kg and m2=2kg

*Elastic* *Vector*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1xi  (m/s) | V2xi  (m/s) | V1xf  (m/s) | V2xf  (m/s) | P1xi  (m/s) | P2xi  (kgm/s) | P1xf  (kgm/s) | P2xf  (kgm/s) | Pxi  (kgm/s) | Pxf  (kgm/s) | **Pi**  (kgm/s) | KEi  (J) |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

*Vector*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1yi  (m/s) | V2yi  (m/s) | V1yf  (m/s) | V2yf  (m/s) | P1yi  (m/s) | P2yi  (kgm/s) | P1yf  (kgm/s) | P2yf  (kgm/s) | Pyi (kgm/s) | Pyf  (kgm/s) | **Pf**  (kgm/s) | KEf  (J) |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

Table 3(b)

m1=1kg and m2=2kg

*Inelastic* *Vector*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1xi  (m/s) | V2xi  (m/s) | V1xf  (m/s) | V2xf  (m/s) | P1xi  (m/s) | P2xi  (kgm/s) | P1xf  (kgm/s) | P2xf  (kgm/s) | Pxi  (kgm/s) | Pxf  (kgm/s) | **Pi**  (kgm/s) | KEi  (J) |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

*Vector*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V1yi  (m/s) | V2yi  (m/s) | V1yf  (m/s) | V2yf  (m/s) | P1yi  (m/s) | P2yi  (kgm/s) | P1yf  (kgm/s) | P2yf  (kgm/s) | Pyi (kgm/s) | Pyf  (kgm/s) | **Pf**  (kgm/s) | KEf  (J) |
|  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

Write your comments regarding the linear momentum and the kinetic energy of the two cases shown above for collision in two dimensions (elastic and inelastic collision).

Table 3 (a): Table 3 (b):

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**Report Questions:**

1. Compare total system KE for elastic and inelastic collisions. Was mechanical (kinetic) energy conserved in any of the situations? Which ones?
2. For 1D collisions, is momentum conserved? What about for 2D?
   1. In the 1D simulation click on the “Momenta diagram” check box. What can you say about the total momentum vector vs the momentum vectors for each ball immediately before and after the collision?
   2. Do the same for the 2D simulation. What are your observations?