Yishun Junior College
Home-Based Learning
JC1 H1 Physics Worksheet 2016

Name: ……………………………… CTG: …………… Date: ……………

HBL Collision Carts Model **Total duration: 2h**

Instruction: Submit hardcopy of your completed worksheet to your H1 Physics tutor by 16 Nov 2016. You may print two pages on one page of paper to cut down on the use of paper.

Topic: Dynamics

Aim: Investigate momentum and impulse in elastic and inelastic collisions using Easy-Java-Simulation (EJS)

In this HBL activity, you will investigate different types of collision, namely elastic, inelastic and perfectly inelastic collision, using Easy-Java-Simulation "JC1 H1 Phy HBL - Collision Carts Model EJS". You will observe and explore the velocities and forces acting on two carts undergoing collisions.

A ***Getting to know the simulation (15 min)***

1. Open the simulation applet titled "JC1 H1 Phy HBL - Collision Carts Model EJS" as shown below.

2. Starting with the "**collision type**", click on the type of collision for analysis e.g. "elastic".

   "e" is the coefficient of restitution and it is the ratio of speeds after and before an impact, taken along the line of the impact (i.e. a measure of how much kinetic energy is lost).

3. For "**Cart 1**", check "**convention**" so that the velocity arrows can point according to sign convention of "Pointing to right as positive" and "Pointing to left as negative". Adjust the mass of cart 1, m_1 and its initial velocity u_1, by keying in the values and press 'Enter', or adjusting the sliders.

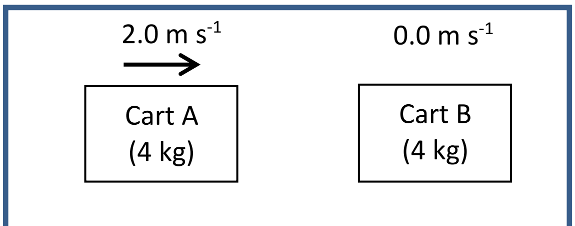
4. For “**Cart 2**”, make sure “**show**” is checked so that the velocity arrows are visible. Adjust the mass of cart 2, m_2 and its initial velocity u_2, by keying in the values and press ‘Enter’, or adjusting the sliders.
5. Once you are ready, click ▶ to start the motion of the carts according to your settings.

B ***Understanding the three different types of collisions (45 min)***

Now that you are familiar with the simulation, use it to explore the following collisions.

- ✓ Sketch the carts & indicate the direction and magnitude of their velocities after the collision.
- ✓ Fill in the respective values in the tables provided.

1. ELASTIC collision



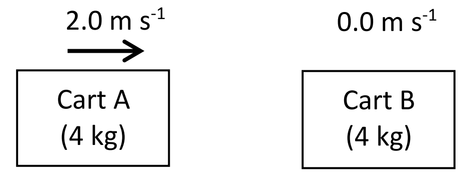
[Before ELASTIC collision]


[After ELASTIC collision]

Before collision			**After** collision			
Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	**Is there C.O.M.?**
Before collision			**After** collision			
Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	**Is there C.O.K.E.?**

C.O.M. *refers to Conservation Of Momentum*
C.O.K.E. *refers to Conservation Of Kinetic Energy*

2. <u>INELASTIC</u> collision

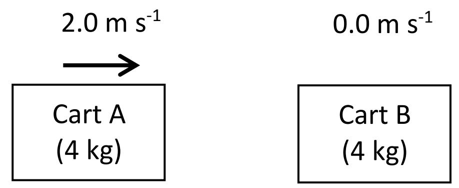


[Before INELASTIC collision]

[After INELASTIC collision]

Before collision			**After** collision			
Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	**Is there C.O.M.?**
Before collision			**After** collision			
Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	**Is there C.O.K.E.?**

3. <u>PERFECTLY INELASTIC</u> collision



[Before PERFECTLY INELASTIC collision]

[After PERFECTLY INELASTIC collision]

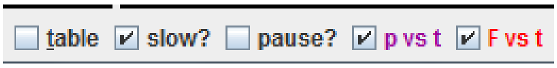
Before collision			**After** collision			
Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	**Is there C.O.M.?**
Before collision			**After** collision			
Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	**Is there C.O.K.E.?**

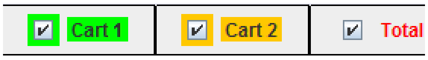
Conclusion:

Types of collision	**C.O.M.?**	**C.O.K.E?**
ELASTIC		
INELASTIC		
PERFECTLY INELASTIC		

C *<u>Understanding more about Newton's third law and C.O.M. (60 min)</u>*

1. Take note that the simulation ignores the effect of friction by the ground or air resistance, and the ground is perfectly horizontal.
2. Refer to the above **ELASTIC** collision again and set the mass and initial velocities of both carts to the same values as in **B.**
3. Click "slow?", "*p* vs *t*" and "*F* vs *t*" as shown below, so that (i) the motion will <u>slow down</u> during the interaction of the two carts; (ii) a graph of <u>momentum</u> against time and (iii) a graph of <u>force</u> against time will appear. Also click "Cart 1", "Cart 2" and "Total" to display the graphs of cart 1, cart 2 and the total system.





4. Click ▶ to observe the forces acting on each cart during the interaction and the graphs plotted.

<u>F vs t graph</u>

5. Sketch the graphs of <u>force</u> against time for (i) "cart 1"; (ii) "cart 2"; (iii) "total" in the same axes below and label the three graphs clearly *(if possible, use 3 different ink colours for "cart 1", "cart 2" and "total")*.

6. Did cart 1 exert a <u>constant</u> force on cart 2, and vice versa, throughout the interaction? If not, describe how the magnitude of force varies with time.

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____

7. What did you notice about the <u>magnitude</u> and <u>direction</u> of the forces acting on each cart?

____

8. What do we usually call these pairs of forces, according to Newton's 3rd law?

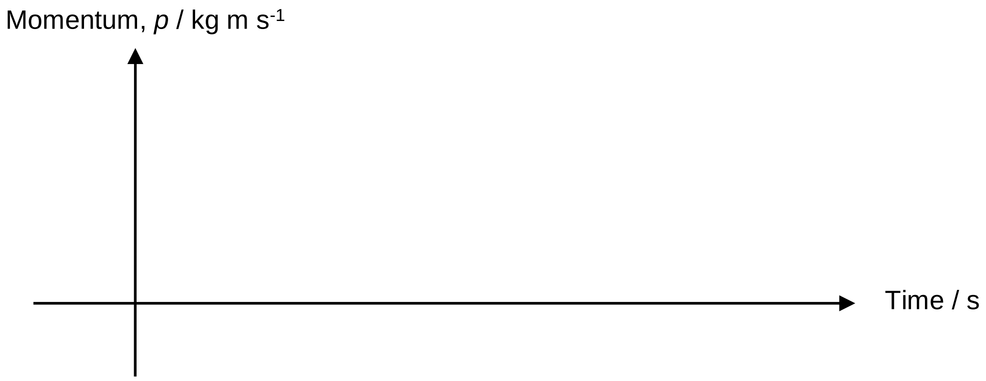
____

9. What did you notice about the total force acting on the system (which consists of the two carts)?

____

p vs t graph

10. Sketch the graphs of momentum against time for (i) “cart 1”; (ii) “cart 2”; (iii) “total” in the same axes below and label the three graphs clearly. *(if possible, use the same 3 different colours for “cart 1”, “cart 2” and “total”)*



11. Did the momentum of cart 1 remains constant? How about the momentum of cart 2?

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12. What did you notice about the total momentum of the system (which consists of the two carts)?

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13. Did the individual forces acting on each cart by the other cart affect the total momentum of the system? Explain your answer.

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14. Link your answer in Q13 to your previous table of momentum for ELASTIC collision and the concept of Conservation of Momentum (C.O.M.).

    Is C.O.M. referring to the momentum of cart 1, cart 2 or the total momentum? Explain your answer.

____

____

KE vs t graph *(Predict-Observe-Explain)*

15. Based on the "*p vs t*" graph sketched earlier, predict how the "*KE vs t*" graphs of cart 1, cart 2 and total *KE vs t* graph will look like and sketch your prediction below. Label the three graphs clearly.

16. Click "*KE vs t*" as shown below, so that a graph of kinetic energy against time will appear.

Sketch the graphs of kinetic energy against time for (i) "cart 1"; (ii) "cart 2"; (iii) "total" in the same axes below and label the three graphs clearly. *(if possible, use the same 3 different colours for "cart 1", "cart 2" and "total")*

--- End of worksheet ---

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Home-Based Learning
JC1 H1 Physics Worksheet 2016

Name: ………………………………   CTG: ……………   Date: ……………

HBL Collision Carts Model (Teacher) **Total duration: 2h**

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Topic: Dynamics

Aim: Investigate momentum and impulse in elastic and inelastic collisions using Easy-Java-Simulation (EJS)

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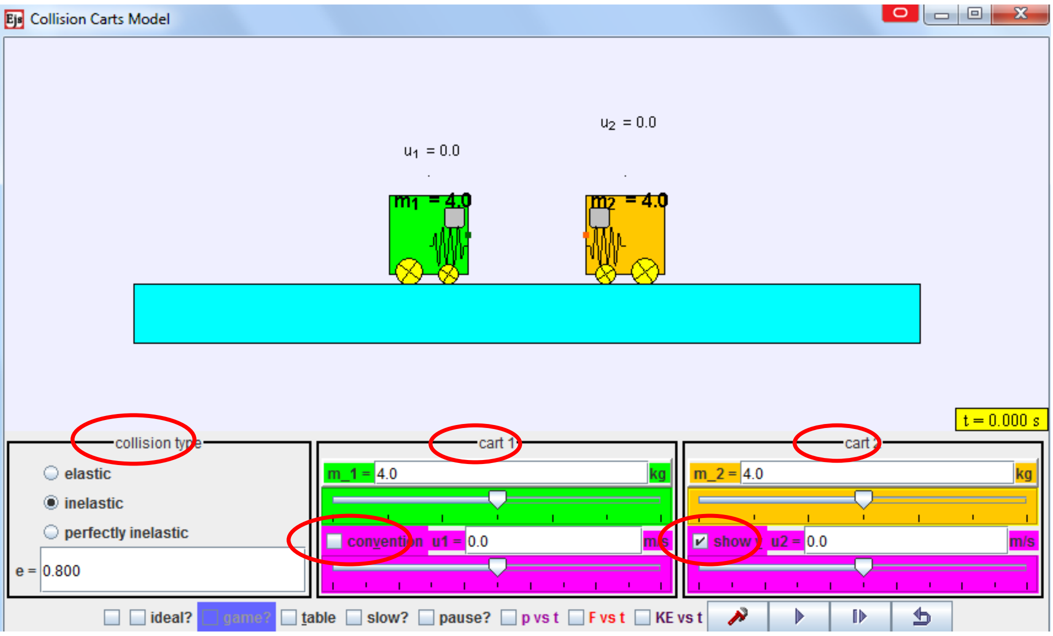
A *Getting to know the simulation (15 min)*

1. Open the simulation applet titled "JC1 H1 Phy HBL - Collision Carts Model EJS" as shown below.



2. Starting with the "**Collision type**", click on the type of collision for analysis eg "elastic".

   "e" is the coefficient of restitution and it is the ratio of speeds after and before an impact, taken along the line of the impact (i.e. a measure of how much kinetic energy is lost).

3. For "**Cart 1**", check "**convention**" so that the velocity arrows can point according to sign convention of "Pointing to right as positive" and "Pointing to left as negative". Adjust the mass of cart 1, m_1 and its initial velocity u_1, by keying in the values and press 'Enter', or adjusting the sliders.

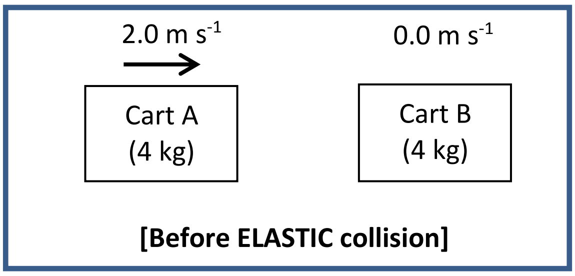
4. For "**Cart 2**", make sure "**show**" is checked so that the velocity arrows are visible. Adjust the mass of cart 2, m_2 and its initial velocity u_2, by keying in the values and press 'Enter', or adjusting the sliders.
5. Once you are ready, click ▶ to start the motion of the carts according to your settings.

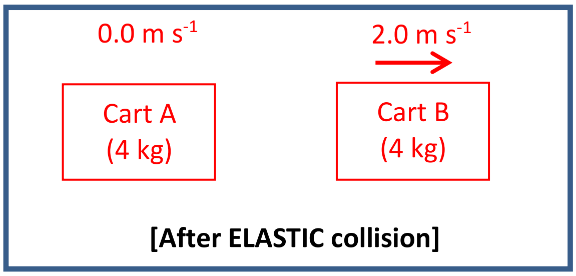
B ***Understanding the three different types of collisions (30 min)***

Now that you are familiar with the simulation, use it to explore the following collisions.

- ✓ Sketch the carts & indicate the direction and magnitude of their velocities after the collision.
- ✓ Fill in the respective values in the tables provided.

1. ELASTIC collision



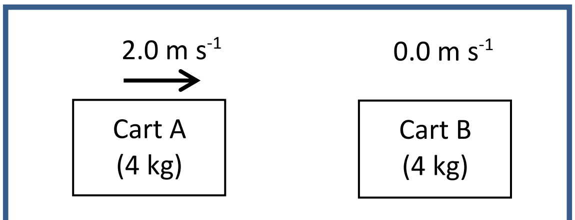


Before collision			**After** collision			
Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	**Is there C.O.M.?**
8.00	0.00	8.00	0.00	8.00	8.00	Yes

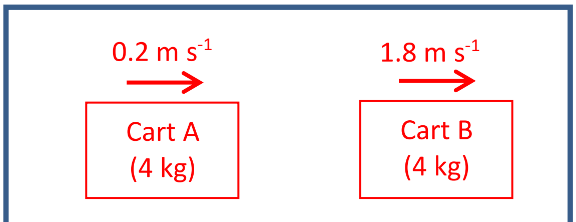
Before collision			**After** collision			
Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	**Is there C.O.K.E.?**
8.00	0.00	8.00	0.00	8.00	8.00	Yes

C.O.M. *refers to Conservation Of Momentum*
C.O.K.E. *refers to Conservation Of Kinetic Energy*

2. INELASTIC collision



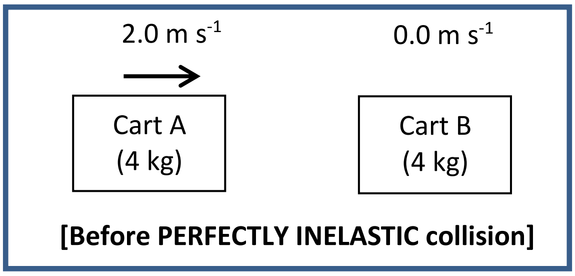
[Before INELASTIC collision]



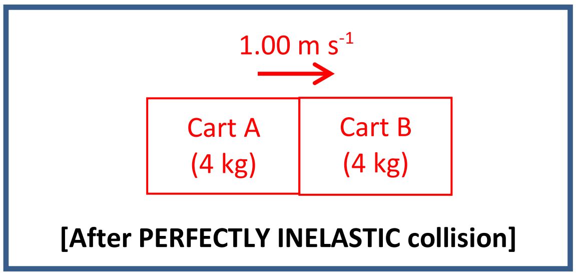
[After INELASTIC collision]

Before collision			**After** collision			
Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	**Is there C.O.M.?**
8.00	0.00	8.00	0.8	7.2	8.00	Yes
Before collision			**After** collision			
Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	**Is there C.O.K.E.?**
8.00	0.00	8.00	0.08	6.48	6.56	No

3. PERFECTLY INELASTIC collision



[Before PERFECTLY INELASTIC collision]



[After PERFECTLY INELASTIC collision]

Before collision			**After** collision			
Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	Momentum of **A**/ kg m s^{-1}	Momentum of **B**/ kg m s^{-1}	Total momentum of **A** & **B**/ kg m s^{-1}	**Is there C.O.M.?**
8.00	0.00	8.00	4.00	4.00	8.00	Yes

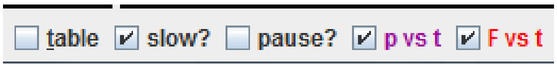
Before collision			**After** collision			
Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	Kinetic energy of **A**/ J	Kinetic energy of **B**/ J	Total kinetic energy of **A** & **B**/ J	**Is there C.O.K.E.?**
8.00	0.00	8.00	2.00	2.00	4.00	No

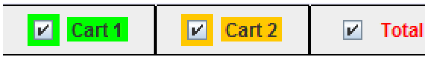
Conclusion:

Types of collision	**C.O.M.?**	**C.O.K.E?**
ELASTIC	Yes	Yes
INELASTIC	Yes	No
PERFECTLY INELASTIC	Yes	No

C *Understanding more about Newton's third law and C.O.M. (40 min)*

1. Take note that the simulation ignores the effect of friction by the ground or air resistance, and the ground is perfectly horizontal.
2. Refer to the above **ELASTIC** collision again and set the mass and initial velocities of both carts to the same values as in **B**
3. Click "slow?", "*p* vs *t*" and "*F* vs *t*" as shown below, so that (i) the motion will slow down during the interaction of the two carts; (ii) a graph of momentum against time and (iii) a graph of force against time will appear. Also click "Cart 1", "Cart 2" and "Total" to display the graphs of cart 1, cart 2 and the total system.



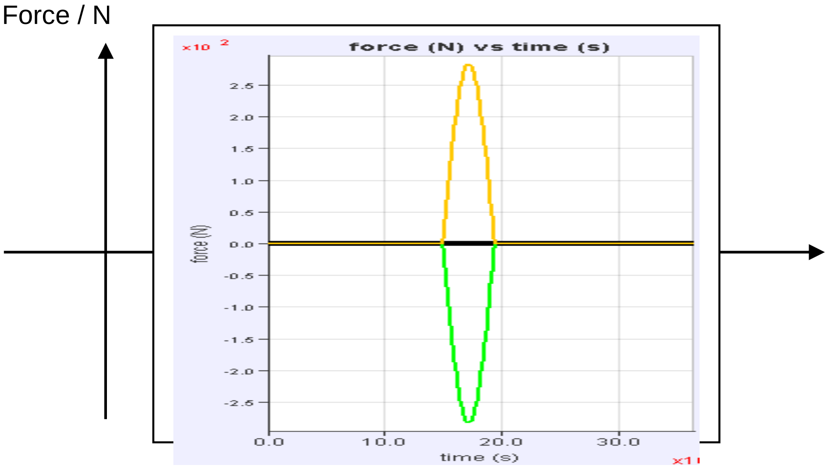


4. Click  to observe the forces acting on each cart during the interaction and the graphs plotted.

F vs t graph

5. Sketch the graphs of force against time for (i) "cart 1"; (ii) "cart 2"; (iii) "total" in the same axes below and label the three graphs clearly *(if possible, use 3 different ink colours for "cart 1", "cart 2" and "total")*.

Force / N



Time / s

6. Did cart 1 exert a constant force on cart 2, and vice versa, throughout the interaction? If not, describe how the magnitude of force varies with time.

No, the force is not constant. The magnitude increases to a peak and reduces back to zero.

7. What did you notice about the magnitude and direction of the forces acting on each cart?

The magnitudes of the forces are always the same but the directions are always opposite.

8. What do we usually call these pairs of forces, according to Newton's 3rd law?

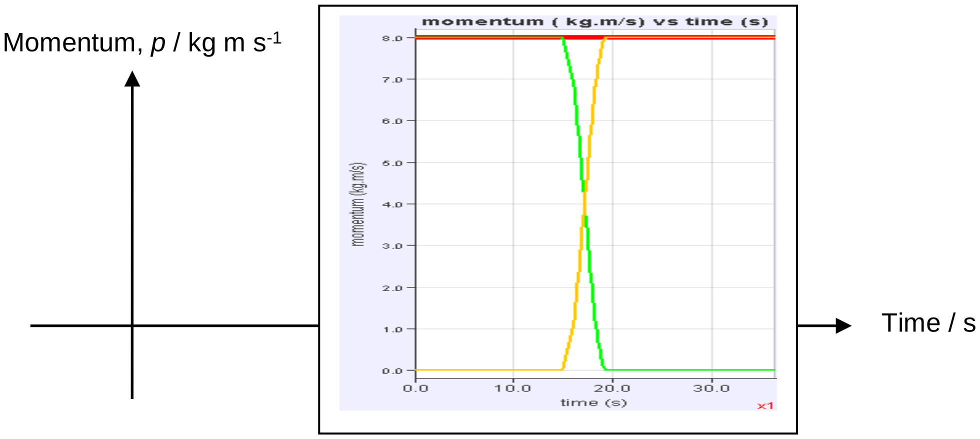
Action-reaction pairs

9. What did you notice about the total force acting on the system (which consists of the two carts)?

The total force is always zero, even when the individual forces are not zero. (momentum is conserved)

p vs t graph

10. Sketch the graphs of momentum against time for (i) "cart 1"; (ii) "cart 2"; (iii) "total" in the same axes below and label the three graphs clearly. *(if possible, use the same 3 different colours for "cart 1", "cart 2" and "total")*



11. Did the momentum of cart 1 remains constant? How about the momentum of cart 2?

No, neither the momentum of cart 1 nor the momentum of cart 2 remains constant.

12. What did you notice about the total momentum of the system (which consists of the two carts)?

The total momentum of the system remains constant.

13. Did the individual forces acting on each cart by the other cart affect the total momentum of the system? Explain your answer.

No, the forces acting on each cart are always equal in magnitude and opposite in direction.

Hence resultant force acting on the system is always zero which results in no change in total momentum.

14. Link your answer in Q13 to your previous table of momentum for ELASTIC collision and the concept of Conservation of Momentum (C.O.M.).

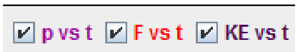
Is C.O.M. referring to the momentum of cart 1, cart 2 or the total momentum? Explain your answer.

C.O.M. is referring to the conservation of total momentum, as the system of the two carts is a closed system where resultant force is zero. (Not the individual cart.)

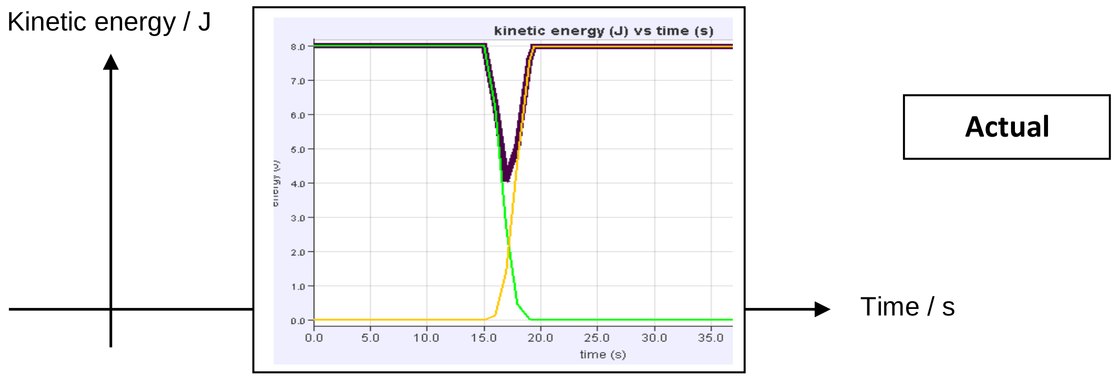
KE vs t graph *(Predict-Observe-Explain)*

15. Based on the “*p vs t*” graph sketched earlier, predict how the “*KE vs t*” graphs of cart 1, cart 2 and total *KE vs t* graph will look like and sketch your prediction below. Label the three graphs clearly.

16. Click “*KE vs t*” as shown below, so that a graph of kinetic energy against time will appear.



Sketch the graphs of kinetic energy against time for (i) “cart 1”; (ii) “cart 2”; (iii) “total” in the same axes below and label the three graphs clearly. *(if possible, use the same 3 different colours for “cart 1”, “cart 2” and “total”)*



Extension (teacher):

17. Compare the actual *KE vs t* graphs with your prediction and reflect why they are different (if they are different).

18. Since kinetic energy is conserved in Elastic Collision, suggest why there is a drop in the total kinetic energy during the collision.

Some of the total kinetic energy is converted to potential energy in the carts when the carts collided, before converting back to kinetic energy when the carts separated.

--- End of worksheet ---

