

Unit 4: Momentum and Force**Model/Approach: Momentum Conservation Model****Act-4.2.2 Momentum and Change in Momentum in One Dimension II (~50 min)**

Learning Goals:

- Get practice identifying momentum and change in momentum in simple 1-D collisions
- Get practice identifying impulse
- Get practice representing impulse, momentum, and change in momentum as vectors using the scaled-arrow representation
- Get practice defining and analyzing collisions/interactions, representing conservation of momentum using both the scaled-arrow and vector-equation representations

Act-4.2.3 Momentum and Change in Momentum in Two and Three Dimensions (~80 min)

Learning Goals:

- Get practice identifying momentum and change in momentum in two and three dimensions
- Get practice identifying impulse from the net force in multiples spatial dimensions
- Get practice representing impulse, momentum, and change in momentum as vectors using the scaled-arrow representation in more than one dimension
- Get practice defining and analyzing phenomena that occur in more than one dimension using the Momentum Conservation Model
- To understand that the net force causes changes in momentum.
- To understand that ΣF and Δp are parallel.

Announcements

- **Reading Assignment** - Read Summary and Review pages 96-101.
- **The first quiz will be during the lecture on Tues. Jan. 16.**

Momentum and Change in Momentum in One Dimension II

FNTs 3, 4, & 2 from DLM-2

In Your Small Group

Compare your responses to FNT 3 and 4 from DLM-2 with other members of your small group, come to a consensus on the appropriate momentum charts and answers, and put these on the board.

Added problem: Draw an appropriately scaled force diagram for some time during the interaction for each problem.

Whole Class Discussion

In Your Small Group

Repeat the exercise as stated above for FNT 2

Added problem: Draw an appropriately scaled force diagram for some time during the collision for each cart in part (a) and each cart in part (b).

Whole Class Discussion

Phenomenon: Collisions of 2 carts in one dimension, both elastic and inelastic collisions.

Finish Activity DLM-2 Activity 4.2.1 as directed by your DL instructor. Then use the Momentum Conservation Model discussed in 4.2.1 to analyze each of the collisions between two carts in the situations 1- 5 below. We treat the system made up of the two carts as a closed physical system because there is no net external impulse transferred to the system during the collision.

For each collision:

- a) Draw and fill in a momentum chart to help you describe momentum conservation in this closed physical system.
 - b) Write an algebraic vector equation, with appropriate subscripts on the symbols, to express what happened during the collision.
 - c) Draw a force diagram for each cart that shows the forces during the collision. Describe in words what physically happened and then how conservation of momentum applies in to each cart and to the system as a whole. Put your diagrams, equation, and word statement on the board.
 - d) Classify each case as elastic or inelastic.
- 1) Use two carts of equal mass arranged so the carts will bounce off one another. Start with **one cart stationary**.
 - 2) Repeat (1), but with the carts turned so the collision ends with the **carts locked**.
 - 3) Use two carts of equal mass carts initially **moving toward each other** with equal speed and still **ending with the carts locked**.

As you work through these scenarios, observe what is the same in the scenarios and what is different. What patterns can you observe? Describe any rules you come up with for the patterns.

Whole Class Discussion

(Optional, if time permits, else go to office hours if you have trouble working these on your own.)

- 4) Use two carts of **unequal mass** turned so the collision **ends with the carts locked** (again **one cart is stationary before the collision**).
- 5) Repeat (3), but with both carts initially **moving toward each other** with the same speed.

Momentum and Change in Momentum in Two and Three Dimensions

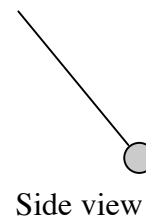
Phenomenon: You are going to observe, talk about in your group, and analyze motions in three dimensions. This will give you practice working with vectors and the concept of impulse in more than one dimension and practice determining the net force.

1) Compare with your group your responses to **FNT 5 from DLM –2**. Come to a consensus and put your response on the board.

2) **Mass swinging in a horizontal circle**

Arrange the weight and give it a push so it swings in a *horizontal* circle as in DLM 1. Focus on a small section of the arc of the circle.

- If we treat the moving mass as our physical system, is there a net impulse on the system? How do you know?
- What must be the direction of the total or net Impulse acting on the mass? How do you know this from the motion? Explicitly show the vectors \mathbf{v}_i , \mathbf{v}_f , and $\Delta\mathbf{v}$ on a diagram, drawn from above (looking down on the motion).
- What must the direction of the net force, $\Sigma\mathbf{F}$ be? How do you know this from the motion?
- Analyze the forces acting on the swinging object. What objects exert forces on the swinging mass? Remember, these could be contact forces or long-range forces. Now think about a side view of the swinging ball. Use what you know about the directions of these forces and the direction of $\Sigma\mathbf{F}$ to draw a force diagram of the swinging object in this **side view**. Be sure to label all forces with two subscripts and make their lengths appropriately scaled with respect to the each other. Show the net force separately with a double arrow.
- Write a few sentences explaining why the mass swings in a circle in terms of momentum, impulse and forces.
- Still treating our physical system as the moving mass, is mechanical energy conserved; that is, does the mechanical energy of the system remain constant? How do you know? You should answer this in terms of energy systems changing or not as well as whether energy is transferred as work.
- Is the net force more closely related to \mathbf{v}_i , \mathbf{v}_f , or $\Delta\mathbf{v}$?

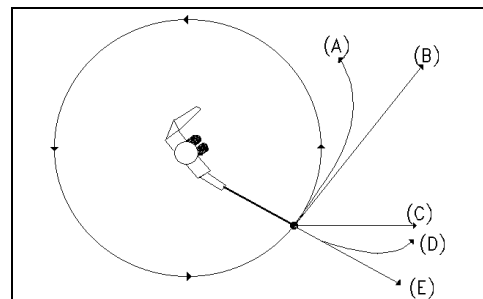


Put your responses on the board and be prepared to discuss them with the whole class.

Whole Class Sharing

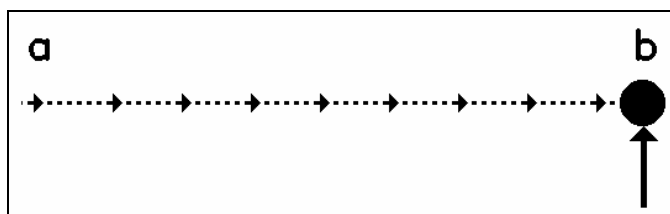
Refer to the Summary of Relationships in the Momentum Conservation Model on page 24 of the notes. Use these relationships first to analyze each physical situation and second to **make logical arguments that would convince another Physics 7 student of the correct response** to the following multiple choice questions. Remember that any conservation law requires you to compare a quantity at two times so you must always have in mind an initial time and a final time.

1) A heavy ball is attached to a string and swung in a circular path in a horizontal plane as illustrated in the diagram to the right. At the point indicated in the diagram, the string suddenly breaks at the ball. If these events were observed from directly above, indicate the path of the ball after the string breaks.

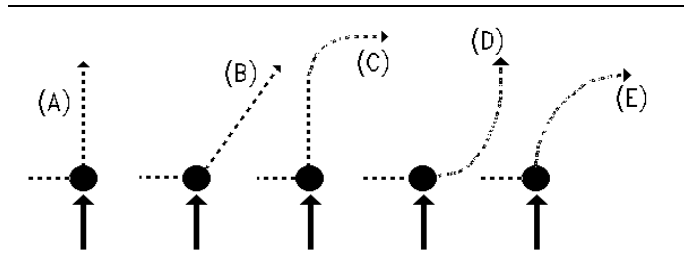


Use the statements and diagram below to answer the next four questions:

The diagram depicts a hockey puck sliding, with a constant velocity, from point "a" to point "b" along a frictionless horizontal surface. The picture is a view from above, looking down on the horizontal surface. When the puck reaches point "b", it receives an instantaneous horizontal 'kick' in the direction of the heavy print arrow.



2) Along which of the paths below will the hockey puck move after receiving the "kick"?



3) Along the frictionless path you have chosen, how does the speed of the puck vary after receiving the "kick"?

- (A) No change.
- (B) Continuously decreasing.
- (C) Continuously increasing.
- (D) Increasing for a while, and decreasing thereafter.
- (E) Constant for a while, and decreasing thereafter.

4) The main forces acting on the puck, after the 'kick', as the puck moves along the path you have chosen are:

- (A) the downward force due to gravity and the effect of air pressure.
- (B) the downward force of gravity and the horizontal force of momentum **in the direction of motion**.
- (C) the downward force of gravity, the upward force exerted by the table, and a horizontal force acting on the puck **in the direction of motion**.
- (D) the downward force of gravity and an upward force exerted on the puck by the table.
- (E) gravity does not exert a force on the puck, it falls because of the intrinsic tendency of the object to fall to its natural place.

5) When a rubber ball dropped from rest bounces off the floor, its direction of motion is reversed because:

- (A) energy of the ball is conserved.
- (B) momentum of the ball is conserved.
- (C) the floor exerts a force on the ball that stops its fall and then drives it upward.
- (D) the floor is in the way and the ball has to keep moving.
- (E) none of the above.

The following questions refer to a situation in which you are riding in a car that crashes into a solid wall. The car comes to a complete stop without bouncing back. The car has a mass of 1500 kg and has a speed of 30 m/s before the crash (this is about 65 mi/hr).

- 6) What is the car's initial momentum? What is your initial momentum? (Recall that the weight of one kilogram is 2.2 lbs) What is the change in the momentum of the car? What is the change in your momentum?
- 7) What is the net impulse that acts on the car to bring it to a stop? What is the net impulse that acts on you to bring you to a stop? Do these numbers depend on the details of the crash? Why? why not?
- 8) What object exerts the force that causes the impulse that brings the car to a stop? What object exerts the force that causes the impulse that brings you to a stop? Describe several scenarios that might exist here and describe the object in each case. One scenario should be that you remain buckled into the seat and that the seat remains attached to the center of the car (what happens to the length of the car between you and the front bumper?). Another scenario should be that you are not buckled into your seat.