Collisions
A group of physics students are investigating the effect of the mass of two colliding carts upon their post-collision velocities. Being vectors, the velocities can be positive (for moving rightward) or negative (for moving leftward).

Experiment 1
In Experiment 1, the students place Cart B at rest on the track. They push Cart A towards it. The two carts are equipped with Velcro strips so that they stick together when they collide. The two carts collide and move together at the same speed after the collision. They use a motion detector to determine the velocity of Cart A before and after the collision. They conduct several trials while varying the mass of the two carts by adding bricks to them. Their data is shown in **Table 1**.

Table 1

Trial	Mass of A (kg)	Mass of B (kg)	Pre-Collision Velocity of A (cm/s)	Post-Collision Velocity of A (cm/s)
1	0.50	0.50	34	17
2	0.50	1.00	42	14
3	0.50	1.50	36	9
4	0.50	2.00	40	8
5	1.00	0.50	33	22
6	1.50	0.50	36	27
7	1.00	1.00	36	18

Experiment 2
In Experiment 2, the students arrange the carts so that magnets embedded in their ends repel each other before contact is made. Once again, they place Cart B at rest on the track and push Cart A towards it. After *the collision*, the carts move along the track at separate velocities. Their velocities are measured using motion detectors. Several trials are conducted using different mass combinations. Their data is shown in **Table 2**.

Table 2

Trial	Mass of A (kg)	Mass of B (kg)	Pre-Collision Velocity of A (cm/s)	Post-Collision Velocity of A (cm/s)	Post-Collision Velocity of B (cm/s)
8	0.50	0.50	32	0	32
9	0.50	1.00	36	-12	24
10	0.50	1.50	42	-21	21
11	0.50	2.00	38	-23	15
12	1.00	0.50	33	11	44
13	1.50	0.50	32	16	48
14	1.00	1.00	40	0	40

Questions
1. What is the purpose of these two experiments?
   a. To study general principles regarding collisions.
   b. To measure the post-collision velocity of the two carts.
   c. To determine the effect of cart mass upon the post-collision velocities.
   d. To investigate collisions in order to determine if the velocity is conserved.

2. Which of the following statements describe the effect of increasing the mass of Cart B as observed in **Experiment 1**?
   a. The mass of Cart A increases.
   b. The pre-collision velocity of cart A increases.
   c. The post-collision velocity of cart A increases.
   d. The post-collision velocity of cart A decreases.

3. A 2.0-kg cart moving at 60 cm/s approaches a 1.0-kg cart that is initially at rest. The two carts magnetically repel each other before actual contact is made. Which trial would provide sufficient evidence for predicting the post-collision speed of the two carts?
   a. Trial 2   b. Trial 5
   c. Trial 9   d. Trial 12

4. A 3.0-kg cart moving at 60 cm/s approaches a 1.0-kg cart that is initially at rest. The two carts magnetically repel each other before actual contact is made. What is the post-collision velocity of the two carts?
   a. Cart A: 40 cm/s;   Cart B: 20 cm/s   b. Cart A: 20 cm/s;   Cart B: 40 cm/s
   c. Cart A: -20 cm/s;   Cart B: 20 cm/s   d. Cart A: 30 cm/s;   Cart B: 90 cm/s

5. The collisions in **Table 2** are often referred to as perfectly elastic collisions. What mathematical equation accurately relates the pre- and post-collision velocities (v) of carts A and B for all the perfectly elastic collisions? NOTE: the ´ symbol indicates *after the collision*.
   a. $v_A = v_B{}'$ b. $v_A * v_A{}' = v_B{}'$
   c. $v_A + v_B{}' = v_B + v_A{}'$ d. $v_A + v_A{}' = v_B + v_B{}'$

6. Based on **Table 2**, which of the following conditions would result in the fastest post-collision velocity for Cart B?
   a. Cart A moves fast before the collision and is the less massive of the two objects.
   b. Cart A moves slowly before the collision and is the less massive of the two objects.
   c. Cart A moves fast before the collision and is many times more massive than Cart B.
   d. Cart A moves slowly before the collision and is many times more massive than Cart B.

Answers and Explanations

1. **Answer:** C
   Explanation: The purpose of an experiment is most often mentioned in the first paragraph of the passage. Here it states that the students are "investigating the effect of the mass of two colliding carts upon their post-collision velocities."

2. **Answer:** D
   Explanation: The first four trials of **Table 1** demonstrate the effect of increasing the mass of Cart B upon the post-collision velocity. The post-collision velocity decreases with each increase in Cart B mass. One must be a bit careful in jumping to this conclusion since the pre-collision velocity of Cart A is also changing from trial to trial. The way to reason around the effect of this velocity variable is to notice the ratio between the post- and the pre-collision velocities. In trial 1, the post-collision velocity is one-half the pre-collision velocity. In trial 2, the post-collision velocity is one-third the pre-collision velocity. In trial 3, the post-collision velocity is one-fourth the pre-collision velocity. And in trial 4, the post-collision velocity is one-fifth the pre-collision velocity. So if the pre-collision velocity were held constant, each increase in mass would result in a post-collision velocity that is a smaller fraction of the pre-collision velocity.

3. **Answer:** D
   Explanation: This question is referring to **Table 2** collisions since the two carts are magnetically repelling each other. This rules out choices A and B. In this question, Cart A has twice the mass as Cart B. This is consistent with the ratio of masses in Trial 12. The post-collision velocities for the collision described in this question could be determined by a comparison with the data presented in Trial 12.

4. **Answer:** D
   Explanation: This question is referring to **Table 2** collisions since the two carts are magnetically repelling each other. In this question, Cart A has three the mass as Cart B, identical to the conditions of Trial 13. In trial 13, the post-collision velocity of Cart A was one-half the pre-collision velocity. And the post-collision velocity of Cart B was one-half greater than its pre-collision velocity. One-half of the pre-collision velocity of 60 cm/s is 30 cm/s. And one-half greater than the pre-collision velocity of 60 cm/s is 90 cm/s. Choice D is the best answer.

5. **Answer:** D
   Explanation: This question is best answered using the process of elimination method. Data from each trial can be substituted into the equations provided for each choice until the equation fails to fit the data. Choice A can be eliminated since it is not consistent with Trial 9 and many other trials. Choice B can be eliminated since it is not consistent with Trial 8 nor any of the other trials. Choice C can be eliminated since it is not consistent with Trial 9 and many other trials. Choice D is consistent with all the trials and serves as the answer to this question.

6. **Answer:** C

Explanation: The largest values for the post-collision velocity of Cart B are observed in Trials 12 and 13 of **Table 2**. These are the only trials in both experiments in which the post-collision velocity of Cart B is greater than the pre-collision velocity of Cart A. The conditions that led to this were that the mass of Cart A was greater than the mass of Cart B. Since this condition leads to a post-collision velocity of Cart B that is greater than the pre-collision velocity of Cart A, the post-collision velocity of Cart B can be made even greater if Cart A is moving fast before the collision.