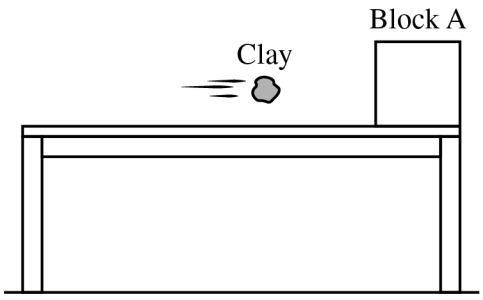
Begin your response to **QUESTION 4** on this page.

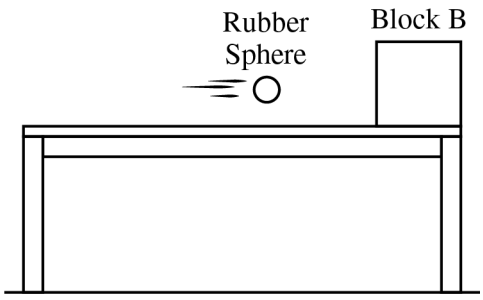
4. (7 points, suggested time 13 minutes)

A student has a piece of clay and a rubber sphere, both of the same mass. Both objects are thrown horizontally at the same speed at identical blocks that are at rest at the edge of identical tables, as shown, where friction between the blocks and the table is negligible. After the collisions, both blocks fall to the floor.

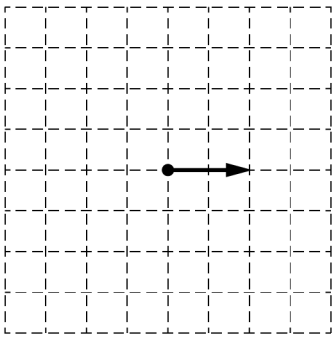
In Case A, the clay sticks to Block A after the collision. In Case B, the rubber sphere bounces off of Block B after the collision.



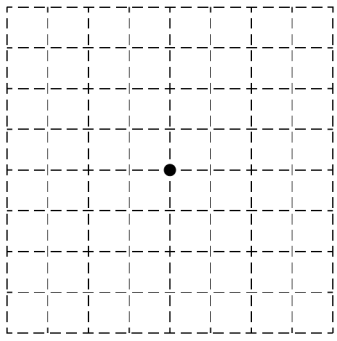
Case A: Clay and Block A
Before Collision



Case B: Rubber Sphere and Block B
Before Collision



Case A: Momentum of
Clay-Block System
Immediately After Collision



Case B: Momentum of
Sphere-Block System
Immediately After Collision

(a) In the figure at left above, the arrow represents the momentum immediately after the collision for the clay-block system in Case A. In the figure at right above, draw an arrow starting on the dot to represent the momentum of the sphere-block system immediately after the collision in Case B. If the momentum is zero, write "zero" next to the dot. The momentum, if it is not zero, must be represented by an arrow starting on, and pointing away from, the dot. The length of the vector, if not zero, should reflect the magnitude of the momentum relative to Case A.

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 4** on this page.

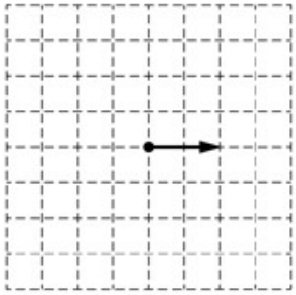
(b) After the clay and Block A collide, Block A lands a horizontal distance d_A from the edge of the table. Does Block B land on the floor at a horizontal distance from the edge of the table that is greater than, less than, or equal to d_A ? In a clear, coherent, paragraph-length response that may also contain equations and/or drawings, explain your reasoning. Neglect any frictional effects due to the table or air resistance.

GO ON TO THE NEXT PAGE.

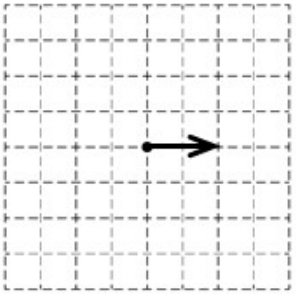
Question 4: Short Answer Paragraph Argument — 7 points

(a) For drawing an arrow representing the sphere-block momentum, two grid units in length and pointing to the right — **1 point**

Example Response



Case A: Momentum of Clay-Block System, Immediately After Collision



Case B: Momentum of Sphere-Block System, Immediately After Collision

Total for part (a) — **1 point**

(b) For indicating that momentum is conserved — **1 point**

For indicating **one** of the following: — **1 point**

- why a greater amount of momentum is transferred by the rubber sphere
- why the block in Case B has greater momentum than in Case A

For indicating that a larger momentum leads to a greater speed — **1 point**

For indicating the blocks fall for the same amount of time — **1 point**

For indicating that a block moving at a faster speed lands at a greater horizontal distance — **1 point**

For a logical, relevant, and internally consistent argument that addresses the required argument or question asked and follows the guidelines described in the published requirements for the paragraph-length response — **1 point**

Example Response

The momentum of the clay-block and sphere-block systems before the collision is the same for both cases and because momentum does not change in the collision; it is the same after the collision also. The sphere in Case B bounces off the block, so it has less (or negative) momentum after the collision than the clay in Case A. In order for the systems in both cases to have the same momentum after the collision, Block B must have greater momentum, and therefore greater speed, than Block A. The blocks take the same amount of time to fall, so the horizontal distance traveled by Block B (launch speed x time to fall) is greater than d_A.

Total for part (b) — **6 points**

Total for question 4 — **7 points**