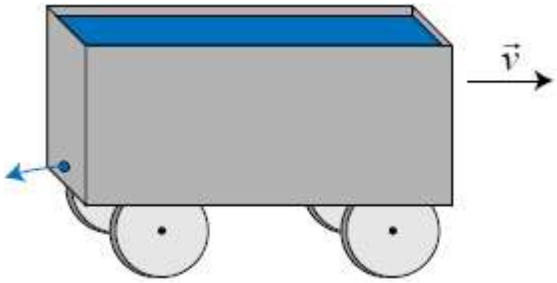
Big Ideas 1, 3, 4 & 5: Momentum 1 **AP Physics 1**

1. A cart full of water travels horizontally on a frictionless track with initial velocity **v**. As shown in the diagram, in the back wall of the cart there is a small opening near the bottom of the wall that allows water to stream out. Considering just the cart itself (and not the water inside it), which of the following most accurately describes the characteristics of the cart?



Speed	Kinetic Energy
(A) stays the same	stays the same
(B) increases	increases
(C) stays the same	increases
(D) increases	stays the same

2. A firecracker is launched with an initial velocity of 70 m/s at an angle of 73° with the horizontal. The firecracker explodes at its highest point, splitting into three equal pieces. One piece continues at its same horizontal speed, but moves vertically upward at 10 m/s immediately after the explosion. A second piece moves vertically downward at 10 m/s, but with a horizontal velocity of 30 m/s backward immediately after the explosion. Determine the speed of the remaining piece of the firecracker immediately following the explosion. Neglect air resistance.

(A) 0 m/s
(B) 10 m/s
(C) 70 m/s
(D) 90 m/s

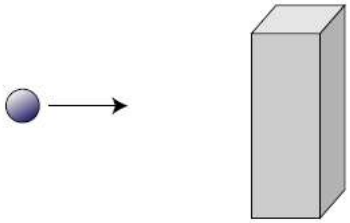
3. A cart traveling on a smooth track with velocity v collides and sticks to an identical cart on the track, initially at rest. What is the maximum percentage of the cart's initial kinetic energy maintained as kinetic energy in the two-cart system?

(A) 25%
(B) 50%
(C) 75%
(D) 100%

4. Identical bullets are fired into identical wood blocks in two different positions as shown in the diagram at right. In each case the wood block (with the bullet embedded) rises to a certain height before returning to the surface of the Earth. Assuming the bullets have the same initial velocities, which block will go higher, and why?

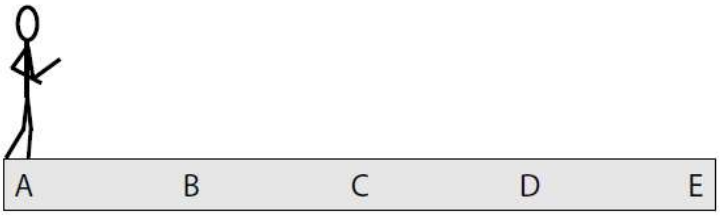
(A) Block A will go higher since all of the bullet's initial kinetic energy is transformed into gravitational potential energy (height) in scenario A, while some of the bullet's initial kinetic energy in scenario B is transformed into rotational kinetic energy, therefore B doesn't go as high.
(B) Block B will go higher since the rotational kinetic energy in situation B adds to the translational kinetic energy imparted by the bullet, while Block A doesn't receive this additional rotational kinetic energy.
(C) The blocks will reach the same maximum height due to conservation of linear momentum.
(D) The blocks will reach the same maximum height due to conservation of angular momentum.

5. Two small, uniform balls of identical density and size are fired from a toy gun toward a wooden block. Ball A is highly elastic and bounces backward after striking the block. Ball B is made of clay and sticks to the wooden block upon impact. Which of the following statements best describes the effects of the collision with the block?



(A) Ball A transfers more momentum and more energy to the block than Ball B.
(B) Ball A transfers more momentum and less energy to the block than Ball B.
(C) Ball A transfers less momentum and more energy to the block than Ball B.
(D) Ball A transfers less momentum and less energy to the block than Ball B.

6. An 80 kg student stands on the left end of a 240-kg log which is floating in the water (which you may treat as a frictionless surface). The student and the log are both initially at rest.

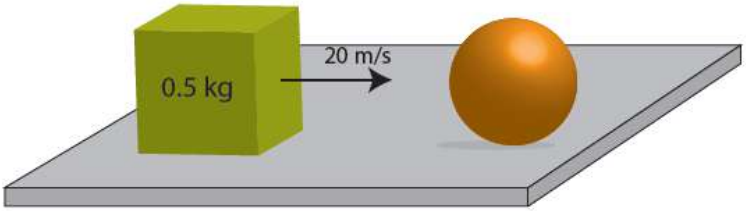


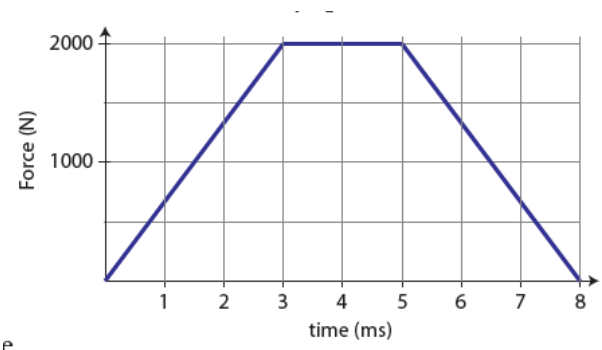
(a) Which point is the approximate center of mass of the student-log system?

(b) The student walks to the far end of the log at a constant speed of 2 m/s. As the student walks to the right, describe the motion of the log. Provide quantitative values wherever possible.

(c) What is the velocity of the center of mass of the student-log system while the student is walking?

7. A 0.5-kilogram block slides at 20 m/s on a smooth frictionless surface toward a stationary sphere, shown below below. The sphere is half the volume of the block, but is eight times as dense. The block strikes the sphere at time t=0. A plot of the force exerted on the cube by the ball as a function of time is shown above right.





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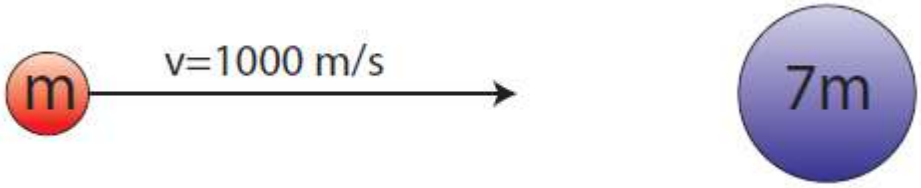
(a)What is the impulse applied to the block?

(b) What is the speed of the ball immediately following the collision?

(c) What is the velocity of the cube immediately following the collision? (State both direction and magnitude.)

(d) Is this an elastic collision? Justify your answer.

8. A proton (mass=m) and a lithium nucleus (mass=7m) undergo an elastic collision as shown below.



Find the velocity of the lithium nucleus following the collision.