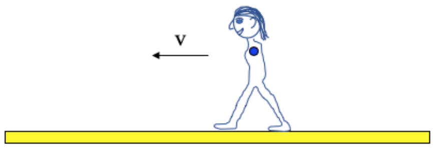
Off-the-wall question #1: A woman walking with constant velocity crosses a horizontal floor with a ball held at shoulder height out away from and to the side of her body. There is no stiff breeze blowing, and air friction is minimal (it's isn't Boston during the summer when you can cut the air with a knife due to humidity). At some point, as she is walking, she releases the ball, continuing to walk with constant velocity after the release.



a.) The ball lands:

____ in front of her __x__ next to her ____ behind her

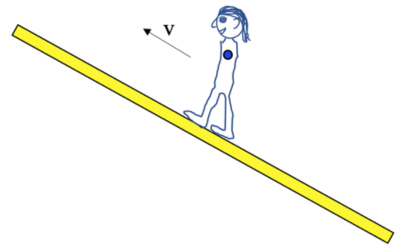
Justify your response using Newton's Laws.

--Newton's Second Law states that a body will accelerate in a particular direction if there is a net force acting on the body;
--there will be a force in the y-direction, so as time proceeds, the ball's motion in the y-direction will change and the ball will pick up speed downward;
--as air friction will be negligible, there is no force acting on the ball in the x-direction, so whatever velocity the ball had in that direction shouldn't change;
--conclusion, both the ball and the woman should continue moving in the x-direction with the same speed until the ball hits the ground, right next to the woman.

b.) Justify your response to the question in *Part a* in a second way.

--momentum in a particular direction is conserved unless there is an external impulse acting on a body;
--in the y-direction, the ball experiences an external impulse in the form of gravity, which means the ball's momentum in the y-direction changes with time until the ball hits the ground;
--in the x-direction, the ball experiences no external impulse, so momentum is conserved in the x-direction and the velocity of the ball does not change from its initial value;
--as the ball's initial velocity x-component was the same as the lady walking speed, the ball will hit the ground right next to her.

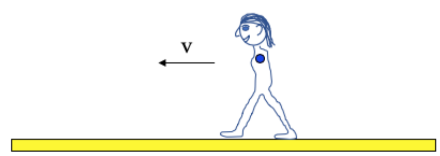
c.) The woman repeats the experiment, except now she is walking up an incline. She drops the ball as before, continuing to walk with a constant velocity. The ball lands:



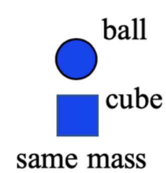
____ in front of her ____ next to her _ x behind her

Justify your response anyway you can.

--this is a bit tricky;
--when the woman was walking in the horizontal, the external force of gravity was perpendicular to the direction of the woman's motion;
--that meant that external impulse due to gravity didn't affect the ball's motion along the line of the woman's motion;
--in this case, there is a component of gravity along the line of the woman's motion;
--that means there is an impulse along the relevant line of motion, which means the velocity in that direction is going to change and the ball is going to land *behind* the woman.



The woman repeats the experiment with several big differences. She is back on the horizontal surface, walking with constant velocity, but now she is carrying a ball in one hand and a cube in the other. The ball and cube are of like dimensions (that is, the diameter of the ball is the same as the length of one side of the cube), and the two have the same mass. Additionally, even though she is able to power through it, maintaining a constant velocity, the woman is now moving through a viscous fluid that produces drag on objects that move through it.



d.) She releases the ball and the cube at the same time. Where will the ball and cube land? Justify your response.

--the prediction is that both will land behind the woman, but the ball will be closer to her.
--if both objects fell for the same amount of time, the object that produced the least drag would be in the air the least amount of time and would travel the farthest before hitting the ground;
--in that case, the ball would land closest to the woman;
--the problem is that because the drag happens in both the x and y-directions, the ball will feel less drag but it will travel for less time, which means the cube (traveling at a slower rate but for a longer time) *may* travel the same distance before hitting the ground;
--bottom line: all that is clear is that both will hit behind the woman;