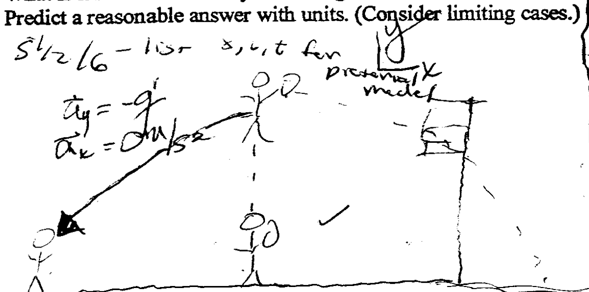
Solution to Test 3 Group Problem

Gather (from a group solution)

This is a pretty good G step. The only thing that could improve it would be to label the pictorial model with time, position, and velocity variables.

Gather information: (2 pts.)
What is known? What are you looking for?
Predict a reasonable answer with units. (Consider limiting cases.)



Guess — $\vec{v}_{ox}$ stud $= \vec{v}_{fx}$ stud & since the student weighs much more than the ball, his $\vec{v}_{ox}$ will be much less and no greater than 1 m/s ✓

Find ~ V_{xf} student

Known

Student – 40 kg
$\vec{a}_y = -g$
$\vec{a}_x = 0\ m/s^2$
$\vec{v}_{xo} =$ $\vec{v}_{xf} =$
$\vec{v}_{yo} =$ $\vec{v}_{yf} =$
$\Delta x = ?$
$\Delta y = 1.0\ m$
$\theta = 30°$

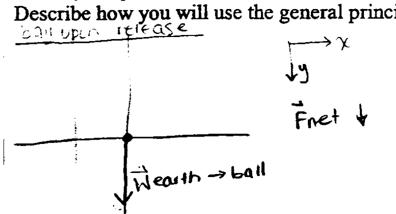
Ball – 0.80 kg
$V_{xo} = 20\ m/s$
$V_{xf} = 20\ m/s$
$\vec{V}_{yo} = 0\ m/s$ $V_{yf} = ?$
$a_x = 0\ m/s^2$
$\vec{a}_y = -g$
$\Delta x = ?$
$\Delta y = 1\ m$

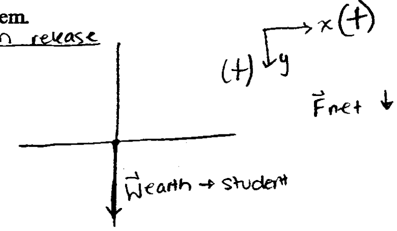
Organize (from a group solution)

This is a very good organize step (awarded 7 out of 7 possible points). Note that this group has included both Free-body diagrams and a good motion diagram. In addition, they have described how they are going to use conservation of momentum and the kinematics equations to solve the problem.

Organize your approach: (2 pts.)
Draw a diagram(s) labeled with variables from **G** step.
Classify the problem according to the general physics principle(s) used.
Describe how you will use the general principle(s) to solve the problem.

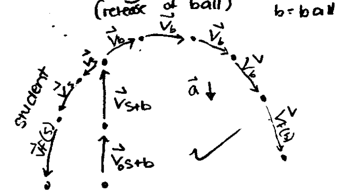
Free-body diagram





motion diagram (release of ball)

s = student
b = ball



Classification: motion/projectile ✓
conservation of momentum ✓

(ball's motion)

* $\Sigma \vec{p}_i = \Sigma \vec{p}_f$
  - p_i of ball & student before release equals zero

∴

$0 = \vec{p}_{f(ball)} + \vec{p}_{f(student)}$

$-\vec{p}_{f(ball)} = \vec{p}_{f(student)}$

good job

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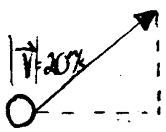
- $\vec{p} = m\vec{v}$
- Momentum is observed at the instant just before release and at the instant just after release ✓
- Momentum is conserved in the x-direction
- velocity will be constant in the x-direction b/c $a_x = 0\ m/s^2$ after the explosion

$\Delta x = V_{0x}(\Delta t) + \cancel{\frac{1}{2} a_x (\Delta t)^2}$

∴ $V_{0x} = V_{fx}$

therefore the velocity in the x-direction right after release equals the velocity in the x-direction before hitting the ground

Analyze



~~Is this the ball~~

$\vec{V}_y = |\vec{V}|\sin\theta$ //final velocity of the ball ✓ ok

$V_x = |\vec{V}|\cos\theta = \vec{V}_f^B$

$\Delta p_b + \Delta p_p = 0$ — where and when applied?

//conservation of momentum

$[m_b(\vec{V}_f^b - \vec{V}_i^b)] + [m_b(\vec{V}_f^p - v_i^p)] = 0$ // expand Δp for ball and player

$m_b(\vec{V}_{fb}) + m_p(\vec{V}_f^p) = 0$ // initial velocity for ball and person is 0

$$\vec{V}_f^p = -\frac{m_b(\vec{V}_f^b)}{m_p}$$

//equation for velocity final of
// the person in horizontal direction

$$\boxed{\vec{V}_f^p = -\frac{m_b[|\vec{V}|\cos\theta]}{m_p}}$$

//equation for final horizontal velocity
//of the person

$$\vec{V}_f^p = -\frac{(0.80kg)(20 m/s \cos 30^\circ)}{40kg}$$ ✓

$\vec{V}_f^p = -.35$ m/s ✓

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Learn (From a student solution)

Our answer certainly agrees with the G-step. (It would not hurt to say something here like, "From our solution we found that the x-component of the velocity was -0.346 m/s. This agrees with our prediction that this velocity would have a magnitude less than 1 m/s.) As the Algebra shows, all units cancelled out. (A unit check was performed explicity in the calculation of the final answer.) Since the ball left in the +x direction, the student travels in the -x direction. Therefore, a negative final velocity for the person is correct. All limiting cases make sense. [Equation 1: v(person xf) = - m(ball) v(ball) cos(theta) / m(person)]

- Had the person shot the ball straight up (theta = 90 degrees), he would have no horizontal velocity and landed in the same spot.
- If theta = 0 degrees, the person would have more horizontal velocity since cos (zero degrees) = 1 (*Cos max*).
- The lighter the ball, the slower the person would end up moving. As the person's weight decreases, our equation shows that he is easier to move.

If air resistance had been significant, he would have slowed down as he fell and landed with a horizontal velocity of smaller magnitude.

This problem was assigned to test us on taking a 2-D problem that can be simplified to 1-D. The problem is much like the other 1-D momentum problems.