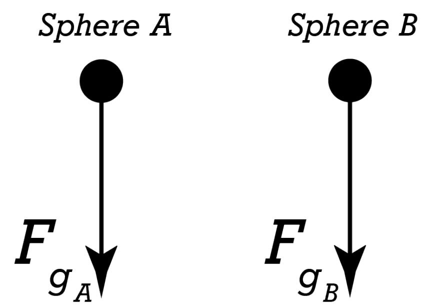
Free Response Question #4 - AP Physics 1 - 2015 Exam Solutions

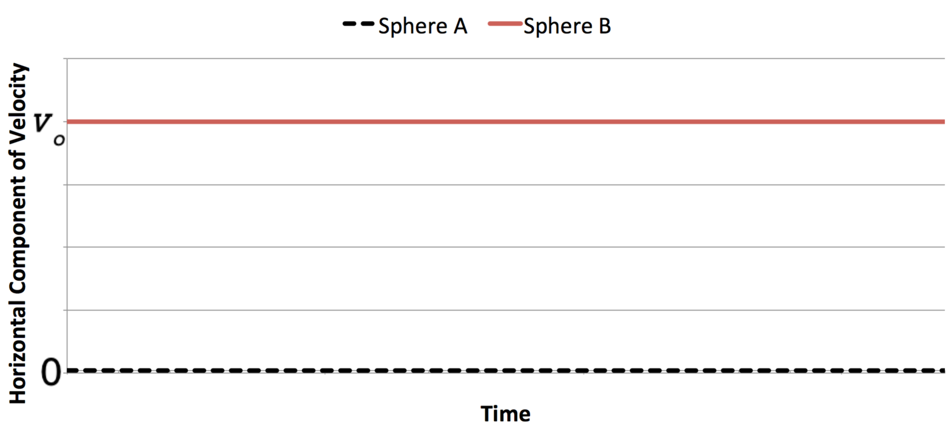
http://www.flippingphysics.com/ap1-2015-frq4.html

FYI: I have a video which shows and explains this demonstration: http://www.flippingphysics.com/bullet.html



Part (a): Both identical spheres are in projectile motion. The only force acting on them is the force of gravity, which is straight down. Because both spheres have the same mass, the force of gravity is identical.

Part (b): Neither sphere has any forces acting on it in the x-direction, therefore neither sphere will have an acceleration in the x-direciton, therefore neither sphere will have any change in its horizontal velocity. Sphere A has no initial horiztonal velocity and will therefore continue with no horizontal velocity. Sphere B has an initial horizontal velocity of v_o and will therefore continue to have a constant horizontal velocity of v_o.



Part (c): As shown in Part (a), the only force acting on each sphere is the force of gravity. Therefore each sphere will have an acceleration in the y-direction which will equal –g. There is no force in the x-direction on either sphere, so, as shown in Part (b), both spheres will have zero acceleration in the x-direction. And any motion in the x-direction will not affect how long it takes the spheres to reach the ground. The initial velocity in the y-direction for both spheres is zero. The displacement in the y-direction for both spheres is –H. Therefore we can use the uniformly accelerated motion equation $\Delta y = v_{iy}\Delta t + \frac{1}{2}a_y\Delta t^2$ to show that both spheres will reach the ground at the same time. We have shown that, other than the change in time, all of the variables in this equation are the same for both spheres, therefore the remaining variable, change in time, must be the same.

(the following is not a part of the solution necessary for the AP exam, however, I couldn't resist)

Knowns: $\Delta y = -H;\ a_y = -g;\ v_{iy} = 0;\ \Delta t = ?$ (all known values are the same the same)

$$\Delta y = v_{iy}\Delta t + \frac{1}{2}a_y\Delta t^2 \Rightarrow -H = 0\left(\Delta t\right) + \frac{1}{2}\left(-g\right)\Delta t^2 \Rightarrow H = \frac{g\Delta t^2}{2} \Rightarrow \Delta t = \sqrt{\frac{2H}{g}}$$ (for both)