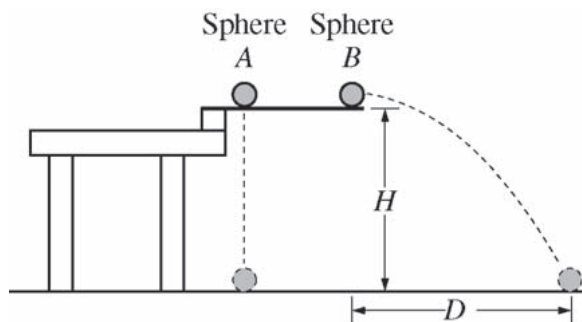




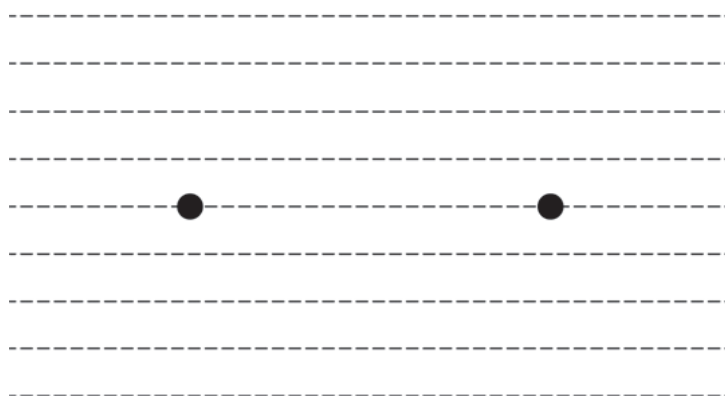
4. (7 points, suggested time 13 minutes)

Two identical spheres are released from a device at time $t = 0$ from the same height H , as shown above. Sphere A has no initial velocity and falls straight down. Sphere B is given an initial horizontal velocity of magnitude v_0 and travels a horizontal distance D before it reaches the ground. The spheres reach the ground at the same time t_f , even though sphere B has more distance to cover before landing. Air resistance is negligible.

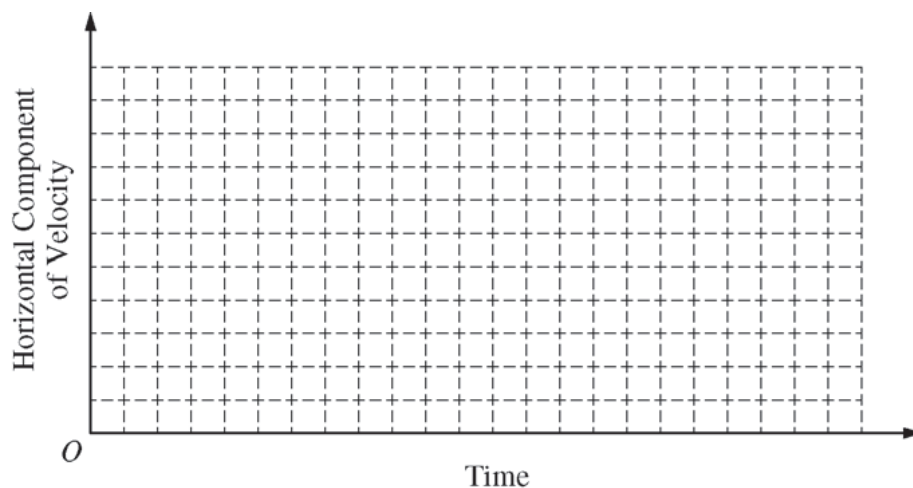
- (a) The dots below represent spheres A and B . Draw a free-body diagram showing and labeling the forces (not components) exerted on each sphere at time $\frac{t_f}{2}$.

Sphere A

Sphere B



- (b) On the axes below, sketch and label a graph of the horizontal component of the velocity of sphere *A* and of sphere *B* as a function of time.



- (c) In a clear, coherent, paragraph-length response, explain why the spheres reach the ground at the same time even though they travel different distances. Include references to your answers to parts (a) and (b).