Physics 1135 Homework for Recitation 4: 2-d Kinematics with constant acceleration


1. A trebuchet was a hurling machine built to attack walls of a castle under siege. The machine was not placed near the wall, because then arrows could reach it from the castle wall. Instead, it was positioned so that the stone hit the wall during the second half of its flight.
A stone is launched from a trebuchet with initial speed 30.0m/s at angle 40° above the horizontal. It hits the castle wall when it has descended to half its maximum height.

a) Find the maximum height reached by the stone.
b) What are the x- and y-components of the stone's velocity at the highest point of its trajectory?
c) What are the x- and y-components of the stone's velocity just before it hits the castle wall?
d) Sketch, qualitatively, x-t, y-t, v_x-t and v_y-t graphs for the stone's motion.

2. One of the first "rocket scientists", Robin Hood, knew that if he shot an arrow at some angle θ above the horizontal it traveled a horizontal distance R. (See left figure.)
a) Find the arrow's initial velocity V_o . Note: The equation for the horizontal range of a projectile is not a starting equation and must be derived.

b) If he shot the same arrow straight up with the **same** initial speed, what maximum vertical height H would it reach? (See right figure.) Derive an expression for the height H **in terms of R, θ and constants**
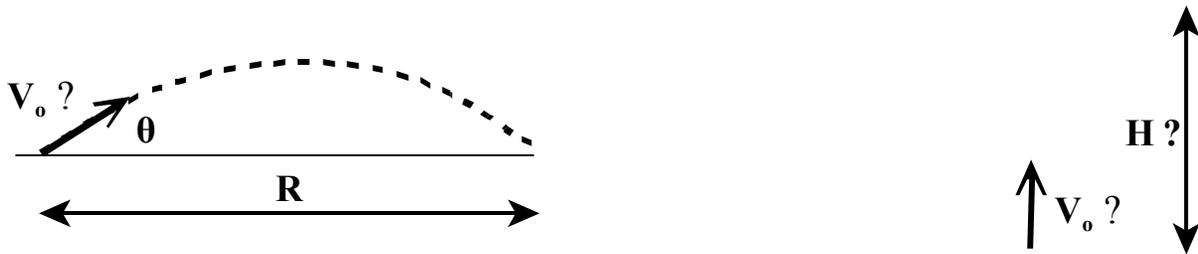
3. In a lecture demonstration, the instructor aims a blow gun directly at Barney, a stuffed purple dinosaur, who is suspended from the ceiling at a vertical height H above the muzzle of the blow gun, a horizontal distance D away. At the instant she launches a dart with speed v_0, Barney is released from rest.
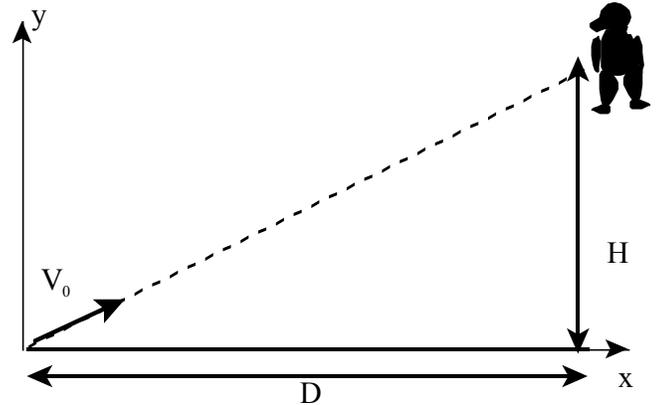
a) Derive an expression, in terms of system parameters, for the **dart's vertical position** when the dart has covered the horizontal distance D.

b) Derive an expression, in terms of system parameters, for **Barney's vertical position** at the instant the dart has the covered the horizontal distance D.

Hint: The angle θ between initial velocity and the horizontal is **not given**, but you can find $\sin\theta$, $\cos\theta$ and $\tan\theta$ from the given distances.

4. Jill is sitting on top of an overhanging cliff at height D above the ground. She wants to throw a water bottle to Jack who is sitting on the ground directly under her. In addition to the **vertical component** of acceleration due to gravity, a strong wind gives the bottle a **horizontal component** of acceleration of magnitude $\frac{1}{2}g$ toward the cliff. Jill throws the bottle horizontally with speed V and the bottle hits the ground right where Jack sits. Derive an expression for V.