Physics 1145 Homework for week 4: Motion in 2d. Circular motion

Problems 1-3 must contain fully labeled diagrams and must begin from kinematics starting equations. Derive symbolic answers before using numbers.
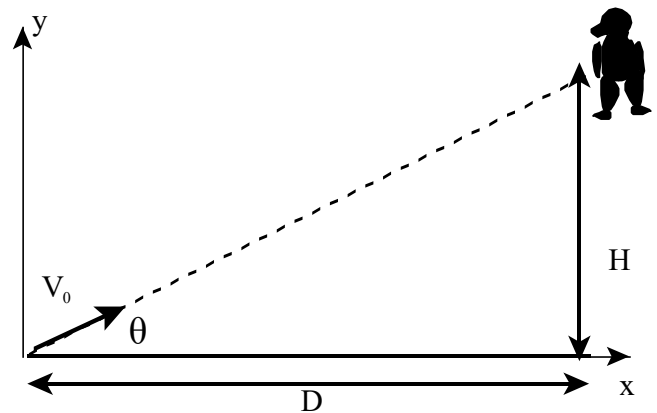
1. A cannon is fired from a castle wall at some unknown height above the ground. The cannonball leaves the cannon with speed 30.0m/s at angle 30° above the horizontal and hits the level ground at a horizontal distance 100m from the wall.

a) Calculate the time it takes the cannon ball to hit the ground.
b) Calculate the height of the castle wall.
c) What are the x- and y-components of the cannon ball's velocity at the highest point of its trajectory?
d) What are the x- and y-components of the cannon ball's velocity just before it hits the ground?
e) Sketch, qualitatively, x-t, y-t, v_x-t and v_y-t graphs for the cannon ball's motion.

2. A kangaroo jumping across flat ground is leaving the ground at an angle $\theta=30°$ with respect to the horizontal and lands a horizontal distance 10.0m from its takeoff point. Find the kangaroo's initial speed.

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 and angle θ above the horizontal, Barney is released from rest.

a) Derive an expression, in terms of D, v_0 and θ, for the time T it takes the dart to cover the horizontal distance D.

b) Derive an expression, in terms of system parameters, for the **dart's vertical position** y_D when the dart has covered the horizontal distance D. Use the expression for T you found in a).

c) Derive an expression, in terms of system parameters, for **Barney's vertical position** y_B at the instant the dart has the covered horizontal distance D. Use the expression for T you found in a).

d) Compare y_B and y_D. (Hint: aiming the blow gun directly at Barney means that D, H and θ are related!)

II. Circular Motion

4. A merry-go-round of diameter 6m is turning with a period of 4.0s.
a) What is the frequency of the rotation?
b) What is the speed of a child sitting at the rim?
c) What is the centripetal acceleration of a child sitting at the rim?
d) What is the speed of a child sitting half-way between the center and the rim?

5. A toy car moves in a circle of radius 2.0m. It takes 3.14 seconds to complete one revolution. Find the car's speed and centripetal acceleration.