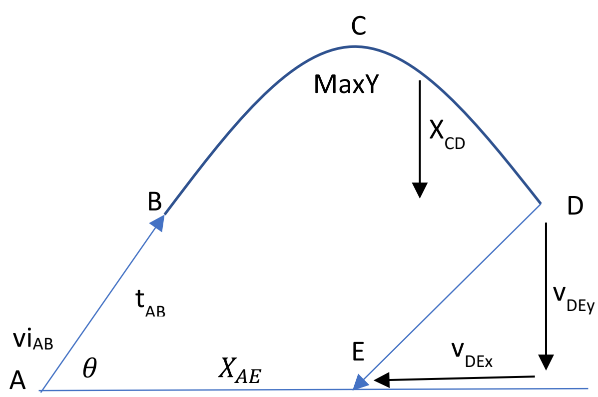
Über Problem - Hamster Huey and Algebra Alex

Asya Litvak Section Q 10/4/21

Description:
One breezy afternoon Algebra Alex decides to launch Hamster Huey into the air using a model rocket. The rocket is launched over level ground, from rest, at a specified angle above the East horizontal. The rocket engine is designed to burn for specified time while producing a constant net acceleration for the rocket. Assume the rocket travels in a straight-line path while the engine burns. After the engine stops the rocket continues in projectile motion. A parachute opens after the rocket falls a specified vertical distance from its maximum height. When the parachute opens the rocket instantly changes speed and descends at a constant vertical speed. A horizontal wind blows the rocket, with parachute, from the East to West at the constant speed of the wind. Assume the wind affects the rocket only during the parachute stage.

Diagram:



Givens:

Launch Angle	50 deg
Engine Burn Time	7.7 sec
Net Acceleration with Engine on	5.8 m/s^2
Vertical distance before parachute opens	71 m
Constant Parachute vertical speed	9 m/s
Constant Parachute Horizontal speed	16 m/s

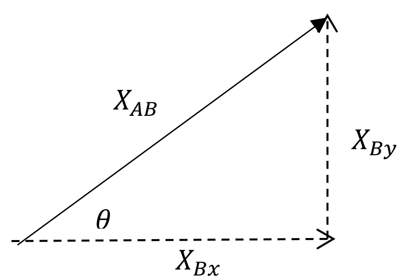
Step 1:
I found the diagonal distance of line AB.

$X_{AB} = \frac{1}{2}\, a_{AB}\, t_{AB}^2 + vi_{AB}\, t_{AB} + x_A$

$X_{AB} = \frac{1}{2}\,(5.8)_{AB}\,(7.7)_{AB}^2 + (0)_{AB}\,(7.7)_{AB} + (0)_A$

$\underline{X_{AB} = 171.941\ m}$

Step 2:
I used the distance of the diagonal to find the y distance and x distance using sin and cos



$X_{AB} cos\theta = X_{Bx}$

$171.941(cos50°) = X_{Bx}$

$\underline{110.522\ m = X_{Bx}}$

$X_{AB} sin\theta = X_{By}$

$171.941(sin50°) = X_{By}$

$\underline{131.714\ m = X_{By}}$

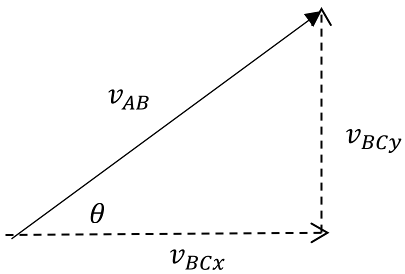
Step 3:
To find the initial velocity for stage BC I first must find the velocity throughout AB.

$vf_{AB} = a_{AB} t_{AB} + vi_{AB}$

$vf_{AB} = 5.8(7.7) + (0)$

$\underline{vf_{AB} = 44.66\ m/s}$

Step 4:
Knowing the velocity, I can find the x and y velocity by using cos and sin



$v_{AB}cos\theta = v_{BCx}$
$44.66(cos50°) = v_{BCx}$
$28.7069\, m/s = v_{BCx}$

$v_{AB}sin\theta = v_{BCy}$
$44.66(sin50°) = v_{BCy}$
$34.2115\, m/s = v_{BCy}$

Step 5:
At max height the velocity is 0 m/s so I didn't need to find the final velocity of stage BC. However, I do have all the components to find the max height
$vf_{BCy} = vi_{BCy}^2 + 2(a_{BCy})(\Delta y)$
$(0) = (34.2115^2) + 2(-9.8)(\Delta y - 131.714)$
$0 = 34.2115^2 - 19.6y + 2581.59$
$-3752.02 = -19.6y$
$y_{maxC} = 191.429\, m$

Step 6:
Since I know the max height and the height the hamster falls, I need to find the height where the parachute opens.
$y_D = y_{maxC} - \Delta y_{CD}$
$y_D = 191.429 - 71$
$y_D = 120.429\, m$

Step 7:
I have all the components now to find the time it took for the projectile to get to this height all the way from point B
$y_D = \frac{1}{2}a_{BDy}t_{BD}^2 + vi_{BCy}t_{BD} + X_{By}$
$120.429 = \frac{1}{2}(-9.8)t_{BD}^2 + (34.2115)t_{BD} + 131.714$
$-11.285 = -4.9t_{BD}^2 + (34.2115)t_{BD}$
$0 = -4.9t_{BD}^2 + 34.2115t_{BD} + 11.285$
$0 = t_{BD}^2 - 6.98194t_{BD} - 2.303$
$0 = (t - 7.2975)(t + 0.31559)$
$t_{BD} = 7.2975\, s$ ~~, $t = -0.31559\, s$~~

Step 8:
The next step is to find the horizontal distance it took to get from point B to point D
$xDir\text{: } vavg_{BD} = \Delta X_{BD}/t_{BD}$
$28.7069 = \Delta X_{BD}/7.2975$
$\Delta X_{BD} = 209.474\, m$

Step 9:
Since in the givens I have the constant vertical velocity I can find the time it took to get from point D to point E
$yDir\text{: } vavg_{DEy} = \Delta y_D/t_{DE}$
$9 = 120.429/t_{DE}$
$t_{DE} = 13.381\, s$

Step 10:
Knowing the time it took to reach the ground and the given constant horizontal velocity I can now find the x position I traveled backwards
$xDir\text{: } vavg_{DEx} = \Delta X_{DE}/t_{DE}$
$16 = \Delta X_{DE}/13.381$
$\Delta X_{DE} = 214.096\, m$

Step 11:
Now I have all three horizontal distances I traveled. I need to add them and subtract them as fit. The first two will be added since I am going west, the last distance is subtracted since I moved east.
$\Delta X_{AExx} = \Delta X_{AB} + \Delta X_{BD} - \Delta X_{DE}$
$\Delta X_{AEx} = 110.522 + 209.474 - 214.096$
$\boxed{\Delta X_{AEx} = 105.9\, m}$