ÜBER PROBLEM – HAMSTER HUEY AND ALGEBRA ALEX

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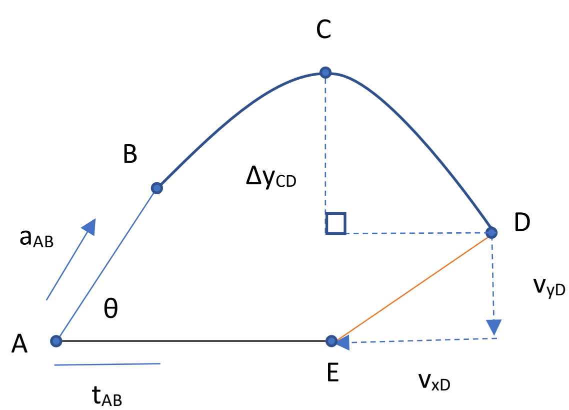
Description:

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 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 position.

Diagram:



Givens:

Launch Angle θ = 50°	v_{yD} = 7 m/s
t_{AB} = 6.6 s	v_{xD} = 20 m/s
a_{AB} = 5.6 m/s^2	a_g = -9.8 m/s
Δy_{CD} = 60 m	v_{iA} = 0 m/s
x_A = 0 m	$y_D = y_c - \Delta y_{CD}$
y_A = 0 m	

Strategy:

1. From position A to position B, find velocity at position B, diagonal distance between positions A and B, and the x and y displacements of position B from position A.
2. From position B to position D, find the time and height at which the rocket reaches position C (y_{max} of parabolic path between position B and position D). Next, find the y-displacement from position C to position D and find the time it takes for the rocket to reach position D. Then, find the x-displacement between position B and position D.
3. From position D to position E, find the time it takes for the rocket assisted by the parachute to hit the ground. Then, calculate the x-displacement from position D to position E.
4. Finally, take the 3 x-displacements (from position A to B, from position B and D, from position D and E) and find the sum to calculate the total x-displacement from the launch point to the landing point.

Process:

Stage A-B

$$v_B = at + v_a$$

$$v_B = 5.6 * 6.6 + 0$$

$$\underline{v_B = 36.96\ m/s}$$

$$\Delta_{AB} = \frac{1}{2}(v_B + v_A) * t_{AB}$$

$$\Delta_{AB} = \frac{1}{2}(36.96 + 0) * 6.6$$

$$\underline{\Delta_{AB} = 121.968\ m}$$

$y_B = \Delta_{AB} * \sin(50)$

$y_B = 121.968 * \sin(50)$

$\underline{y_B = 93.433\ m}$

X Dir: $\Delta x_{AB} = \Delta_{AB} * \cos(50)$

$\Delta x_{AB} = 121.968 * \cos(50)$

$\underline{\Delta x_{AB} = 78.3995\ m \text{ East}}$

Stage B-C

Y Dir: $y_c = \frac{1}{2}at^2 + v_{yB}t_{ymax} + y_B$

$y_c = \frac{1}{2}(-9.8)t_C{}^2 + (36.96)(\sin(50))t_{ymax} + 93.343$

$y_c = -4.9t_{BD}{}^2 + 28.313t_{ymax} + 93.343$

(This will be used shortly)

$$t_{ymax} = -\frac{b\ coefficicent}{2 * a\ coefficient}$$

$$t_{ymax} = -\frac{28.313}{-9.8}$$

$\underline{t_{ymax} = 2.89\ s}$

Y Dir: $y_c = -4.9t_{BD}{}^2 + 28.313t_{max} + 93.343$

$y_c = -4.9(2.89)^2 + 28.313(2.89) + 93.343$

$\underline{y_c = 134.332}$

Stage B-D

Y Dir: $y_D = \frac{1}{2}(-9.8)t_{BD}{}^2 + (36.96)(\sin(50))t_{BD} + 93.343$
(Same equation as y_C)

$134.332 - 60 = -4.9t_{BD}{}^2 + 28.313t_{BD} + 93.343$

$-4.9t^2 + 28.313t + 19.101 = 0$, solver (t)

$\underline{t_{BD} = 6.3884\ s}\ or\ \cancel{t_{BD} = -0.610198\ s}$

X Dir: $\Delta x_{BD} = v_{xB}t_{BD}$

$\Delta x_{BD} = (36.96)(\cos(50)) * 6.3884$

$\underline{\Delta x_{BD} = 151.772\ m \text{ East}}$

Stage D-E

Y Dir: $y_{DE} = v_{yD}t_{DE} + y_D$ (no acceleration due to constant velocity)

$y_{DE} = -7t_{DE} + 74.332$

$0 = -7t_{DE} + 74.332$

$\underline{t_{DE} = 10.6189 \text{ s}}$

X Dir: $\Delta x_{DE} = v_{xD}t_{DE}$ (no acceleration due to constant velocity)

$\Delta x_{DE} = -20 * 10.6189$

$\underline{\Delta x_{DE} = 212.378 \text{ m back towards the launch point}}$

(sub-answer is positive due to it being a vector)

Stage A-E

$\Delta x_{DE} = \Delta x_{AB} + \Delta x_{BD} + \Delta x_{DE}$

$\Delta x_{DE} = 78.3995 + 151.772 - (212.378)$

$\boxed{\Delta x_{DE} = 17.80 \text{ m East}}$