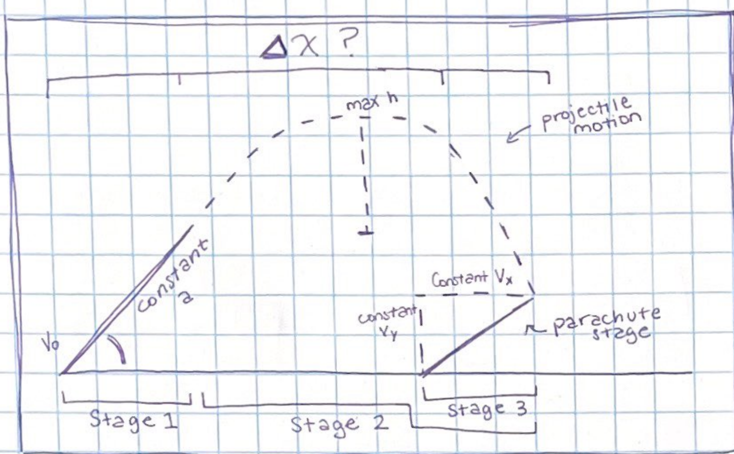
Kayla Vallecillo 9|27|23 Multi-Step Rocket Problem



◦ DIAGRAM ◦

Kinematic Equations:

$x = x_0 + V_0 t$ ← "no a"

$V = V_0 + at$ ← "no x"

$x = x_0 + V_0 t + \frac{1}{2} a t^2$ ← "no v"

$v^2 = v_0^2 + 2a(\Delta x)$ ← "no t"

◦ GIVEN ◦ → ◦ VARIABLES ◦

- launch angle = 53° → θ in part 1
- engine burn time = 7.1 sec → t in part 1
- net acceleration of rocket while engine burns = 6.9 m/s² → a in part 1
- vertical ~~[scribbled out]~~ distance rocket falls from max height before parachute opens = 86 m → ΔY_{fall} in part 2
- rocket w/ parachute constant vertical speed = 9.0 m/s → V_{0y} in part 3
- wind and rocket with parachute constant horizontal speed = 17 m/s → V_{0x} in part 3

◦ STRATEGY ◦

◦ PART 1 ◦ Engine burn

↳ use "no v" equation to find hypotenuse of travel path. With the hypotenuse, use trig skills to find Δx during stage 1.

◦ PART 2 ◦

↳ use Pythagorean theorem to find Δy from part 1. This will be Y_0 in part 2.

↳ use "no t" equation to find Δy. Find Y_{final} by subtracting Y_{fall}.

↳ Solve for t in no Δx equation. Plug t in in "no a" equation.

↳ Find Δx for stage 2.

◦ PART 3 ◦

↳ use "no a" for both x and y values seperately. Find t in Δy equation.

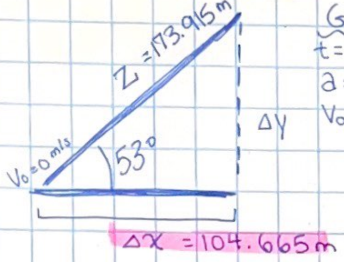
↳ plug t in on Δx equation to find Δx for part 3.

◦ FINAL STEP ◦

↳ add all Δx values to find x-displacement overall.

↳ last step: Celebrate! ☺

PART 1: ENGINE BURN



GIVEN
$t = 7.1$ sec
$a = 6.9\ m/s^2$
$V_0 = 0$ m/s

Step 1: find z (hypotenuse)

$z = V_0 t + \frac{1}{2}at^2$ ← "no V_0"
$z = \frac{1}{2}at^2$
$z = \frac{1}{2}(6.9)(7.1^2)$
$z = \boxed{173.915\ m}$ ← hypotenuse of triangle (path traveled)

Step 2: find Δx ⇨

$\cos(53°) = \frac{\Delta x}{173.915}$
$\Delta x = 173.915(\cos(53))$
$\boxed{\Delta x = 104.665\ m}$
horizontal Δx value during engine burn

PART 2: PROJECTILE MOTION

Step 1: find V_0, or Δy from part 1

$\Delta y = \sqrt{(173.915^2) - (104.655^2)}$
$\Delta y = 138.902$ m
Y_0 in PART 2: $\boxed{138.902\ m}$

Step 2: max height

$V = 0$ @ max height
$V_y^2 = V_{oy}^2 + 2a\Delta y$ ← "no t"
$0 = (48.99 \sin 53^2) + 2(-9.8)\Delta y$
$-1530.78 = -19.6\Delta y$
$\Delta y = \boxed{78.101\ m}$ ← MAX Δy

! to find V_0: $V = V_0 + at$
$V_0 = 0 \rightarrow V = at$
$V = (6.9)(7.1)$ ← from engine burn
$V = \boxed{48.99} \rightarrow V_0$ above!

Step 3: find Y_{final}

$Y_{final} = Y_0 + \Delta Y_{max} - \Delta Y_{fall}$ ← 86 m (given)
$Y_{final} = 138.902 + 78.101 - 86$
$Y_{final} = \boxed{131.003\ m}$

Step 4: find ΔX

x	y
$\Delta x = V_{ox} t$	$Y = Y_0 + V_0 t + \frac{1}{2}at^2$
$\Delta x = (48.99\cos 53)t$	$131.003 = 138.902 + (48.99 \sin 53)t - 4.9t^2$
$\Delta x = (48.99\cos 53)(8.182)$	$\underbrace{-4.9}_{a}t^2 + \underbrace{(48.99\sin 53)}_{b}t + \underbrace{7.901}_{c} = 0$
$\boxed{\Delta x = 240.786}$	* used polynomial solver *
Δx value in part 2	$t = 8.182$

PART 3: PARACHUTE

constant v = "no a"

$\Delta x = V_{ox} t$
$\Delta x = -17(t)$
$\Delta x = -17(14.556)$
$\boxed{\Delta x = -247.452}$
↑ Δx in part 3.

$\Delta y = V_{oy} t$
$Y = Y_0 + V_{oy} t$
$0 = 131.003 + (-9)t$
$-131.003 = -9t$
$\boxed{t = 14.556\ s}$

FINAL STEP

add Δx values from all 3 parts.

$104.665 + 240.786 - 247.452 = 98$ m

~~Δx = 98.8~~

$\boxed{\Delta x = 98\ m}$