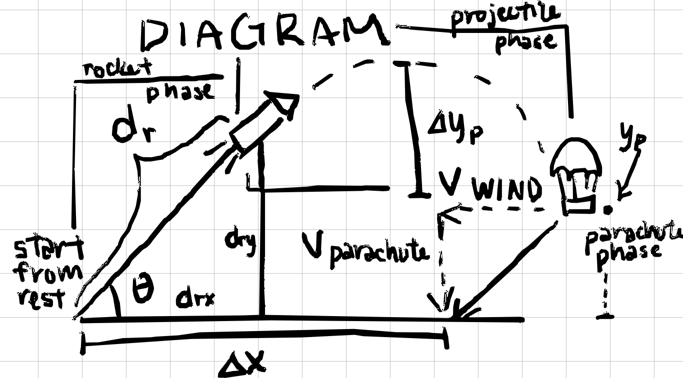
MULTI STEP ROCKET PROBLEM
due 9/25
Sophie

DIAGRAM



ROCKET PHASE

$\theta = 59°$
$t_r = 8.1s$
$a_r = 4.9 m/s^2$
$V_{ri} = 0 m/s$
$d_r = ?$
$\longrightarrow d_{rx} = d_r \cos\theta$
$d_{ry} = d_r \sin\theta$

$d_r = V_{ri} t_r + \frac{1}{2} a_r t_r^2$
$d_r = 0 + \frac{1}{2} \cdot 4.9 \cdot 8.1^2$
$d_r = 160.7445$

$d_{rx} = d_r \cos\theta = 160.7445 \cos 59$
$= 82.789537$
$d_{ry} = d_r \sin\theta = 160.7445 \sin 59$
$= 137.78492$

$V_{rf} = V_{ri} + a_r t_r$
$V_{rf} = 0 + 4.9 \cdot 8.1$ $\rightarrow V_{rf} = 36.69 m/s$

- used no-V_f-equation (Δy version) to solve for distance traveled by accelerating rocket, then broke the distance into x and y components
- calculated final velocity of accelerating rocket to find starting velocity of projectile phase (using no-Δy-equation)

PROJECTILE PHASE

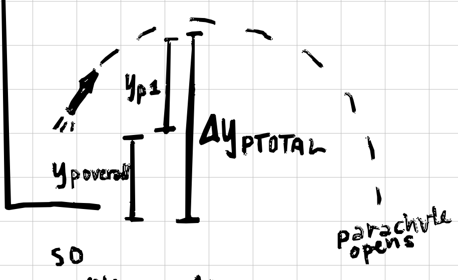
$V_{pi} = V_{rf} = 36.69$
$\theta = 59°$

	x	y
	$V_{px} = 36.69 \cos 59$	$V_{pyi} = 36.69 \sin 59$ m/s
	Δx_p	$a_p = -9.8 m/s^2$
	$t_p = \frac{\Delta x_p}{V_{px}}$	t_p
		$\Delta y_{po} = ?$ $\quad \Delta y_{pt} = -78m$

to reach max height,
$V_{pyf} = 0 m/s$

$V_{pyf}^2 = V_{pyi}^2 + 2a_p \Delta y_p$
$0 = (36.69 \sin 59)^2 - 19.6 \Delta y_{p1}$
$\Delta y_{p1} = -50.462707$
$\Delta y_{pt} - \Delta y_{p1} = \Delta y_{po}$
$-78 + 50.462707 = \Delta y_{po}$
$\Delta y_{po} = \underline{-27.537293 m}$

PROJECTILE PHASE DIAGRAM



so
$\Delta y_{pt} - \Delta y_{p1} = \Delta y_{po}$

- used no-t-equation to find the Δy from the start of the projectile to the max height (so $V_{pyf} = 0 m/s$)
- the overall Δy of the projectile phase only takes into account the change from the starting position, not the Δy from starting h to max h, so $\Delta y_{po} = \Delta y_{pt} - \Delta y_{p1}$ (refer to projectile phase diagram)

$\Delta y = v_i t + \frac{1}{2} a t^2$
$\Delta y_{po} = V_{pyi} \cdot \frac{\Delta x_p}{V_{px}} + \frac{a}{2} \left(\frac{\Delta x_p}{V_{px}}\right)^2$
$-27.5337293 = \frac{\sin 59}{\cos 59} \cdot \Delta x_p - 4.9 \frac{\Delta x_p^2}{(36.69 \cos 59)^2}$
$0 = -0.0137221444 \Delta x_p^2 + 1.6642794482 \Delta x_p + 27.537293$
$\Delta x_p = \underline{136.03602}$ m

- used no-V_f-equation (Δy version) to solve for Δx of the overall projectile, so Δy_{po} was used as the Δy

PARACHUTE PHASE

- the current y position is the sum of the overall Δys of the past two phases

$\underset{(rocket)}{d_{ry}} + \underset{(projectile)}{\Delta y_{po}} = y_{parachute\ initial}$
$137.78492 - 27.537293 = y_{ci}$
$y_{pi} = 110.24763 m$

- in order to get back to the ground ($y_f = 0$), the $\Delta y_{parachute}$ is $-110.24763 m$ (eq: $y_i + \Delta y = y_f$)

	x	y
	$\Delta x_c = ?$	$\Delta y_c = -110.24763 m$
	$V_{cx} = -17 m/s$	$V_{cy} = -7 m/s$
	$t_c = \frac{\Delta x_c}{V_{cx}}$	$t_c =$

$\Delta y_c = V_{cy} t$
$\Delta y_c = V_{cy} \frac{\Delta x_c}{V_{cx}}$
$-110.24763 = \frac{-7}{-17} \Delta x_c$
$\Delta x_c = \underline{-267.74424 m}$

- used equation for constant v and substituted $\frac{\Delta x_c}{V_{cx}}$ for t_c to solve for Δx_c using one equatio

FINAL ANSWER

- the overall ΔX will be the sum of all ΔXs from all three phases

$\underset{(rocket)}{d_{rx}} + \underset{(projectile)}{\Delta x_p} + \underset{(parachute)}{\Delta x_c} = \underset{(total)}{\Delta X}$
$82.789537 + 136.03602 - 267.74424 = \Delta X$
$\Delta X = -48.918683$
$\downarrow$
$\boxed{48.92m \text{ west}}$