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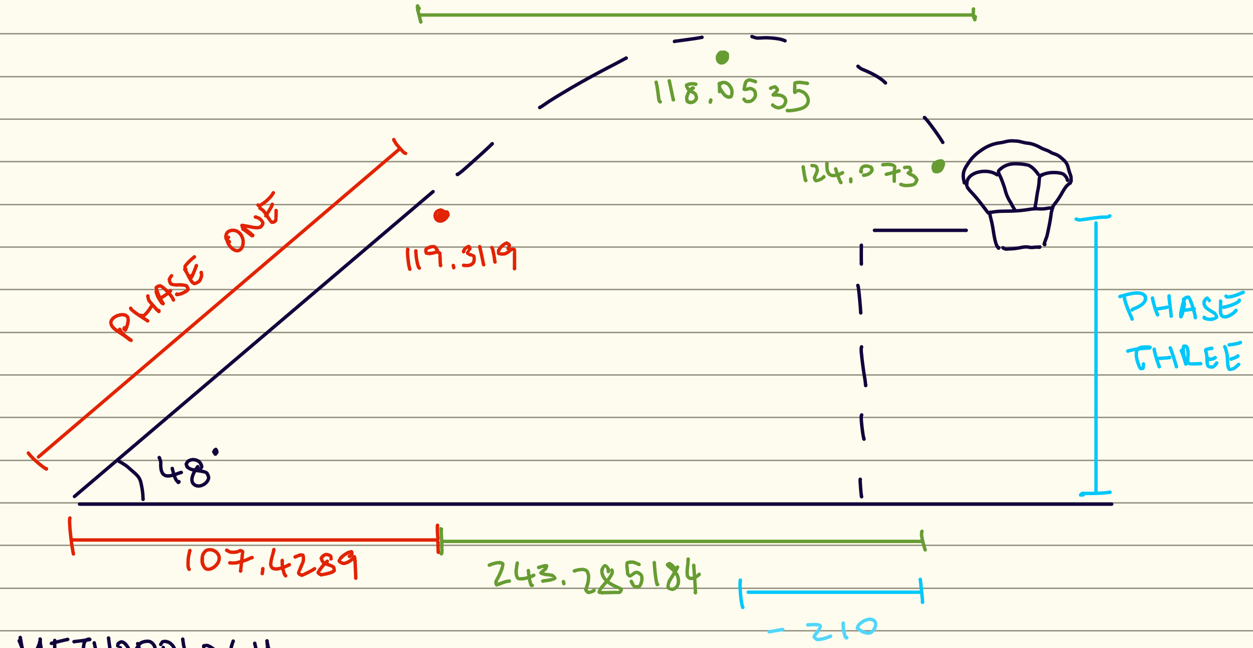
Multi-Step Rocket Problem



METHODOLOGY

Phase One

- use "no v" kinematic eq. to find hypotenuse of phase
- use calculus to find vertical & horizontal displacements
  - ↳ vertical displacement will be y_0 in Phase Two
- find final velocity of phase using "no x" kinematic equation
  - ↳ this will be initial velocity in Phase Two

Phase Two

- use "no t" equation to find Δy of the phase
- find final height of phase by adding Phase Two Δy with y_0 from Phase One
- use "no x" kinematic equation to solve for time in seconds for phase
- substitute t into "no a" kinematic equation to help find Δx for Phase Two

Phase Three

- use "no a" kinematic equation for both x and y.
  1. y will return time
  2. Substitute time from y to find Δx in Phase Three

Final Step!

The wind blows rocket back, therefore Phase Three Δx is negative while Phase One Δx & Phase Two Δx are positive. Add all three together to find total x displacement! :)

Given:

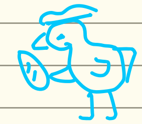
Launch angle = 48°

Engine burn time = 6.5 s

Net accel. of rocket while engine burns = $7.6\,m/s^2$

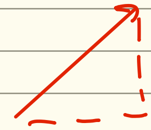
Rocket w/ parachute constant vertical speed = $8.0\,m/s$

Wind & rocket w/ parachute constant horizontal speed = $14\,m/s$



PHASE ONE

angle = 48°
accel = 7.6 m/s^2
time = 6.5 s
V_0 = 0 m/s

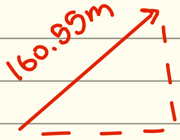


$R_y = R\sin\theta$
$R_x = R\cos\theta$

① To find hypotenuse

$y = y_0 + V_0 t + \frac{1}{2}at^2$
$y = 0 + 0 + 1/2\, 7.6(6.5)^2$
$y = 160.55\text{m}$

② To find legs



160.55m

vertical Δy value

$R_y = 160.55\sin 48$
$\Rightarrow 119.3119\text{m}$

$R_x = 160.55\cos 48$
$\Rightarrow 107.4289\text{m}$
↑ horizontal Δx value

③ To find final velocity of engine burn time

$V = V_0 + at$
$V = 0 + 7.6 \cdot 6.5$
$V = 49.4\text{s}$

PHASE TWO

① To find max height

$V_y^2 = V_{0y}^2 + 2a\Delta y$
$V_y^2 = (49.4\sin 48)^2 - 19.6\Delta y$
$\Delta y = 68.7614\text{m}$

② To find final height of phase 2

$y\text{ final} = y_{max} + y_0 - 64$
$\Rightarrow 119.3119 + 68.7614 - 64$
$\Rightarrow 124.073\text{m}$

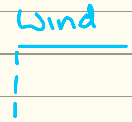
③ To find Δx of phase 2

$X = X_0 + V_0 t \rightarrow \Delta x = V_{0x} t$
$\Delta x = 49.4\cos 48 \cdot t$
$\Delta x = 49.4\cos 48 \cdot 7.36$
$\Delta x = 243.2851824$

$y = y_0 + V_0\sin\theta - 4.9t^2$
$124.073 = 119.3119 + 49.4\sin 48 t - 4.9t^2$
$-4.9t^2 + 36.711t - 4.7611 = 0$
$t = 7.36$

PHASE THREE

V_{wind} = 14 m/s
$V_{parachute}$ = 8.0 m/s



To find Δx in phase 3

$\Delta X = V_{0x} t$
$\Delta X = -14t$
$\Delta X = 217$

$\Delta y = V_{0y} t$
$y = y_0 + V_{0y} t$
$y = 124.073 + (-8)t$
$t = 15.5$

FINAL STEP

$107.4289 + 243.2851824 - 217$
$\Rightarrow$ 133.7140824 East