Name ____ Section ___

Multi-Step Rocket Problem

A 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 stage.
Givens for your individualized problem:

Launch angle	51	deg
Engine burn time	9.0	sec
Net acceleration of rocket while engine burns	5.9	m/s^2
Vertical distance rocket falls from max height before parachute opens	63	m
Rocket with parachute constant vertical speed	8.0	m/s
Wind and rocket with parachute constant horizontal speed	20	m/s

Calculate the x-displacement of where the rocket lands relative to the initial x-position.

Your written work, which may be hand-written, must include:

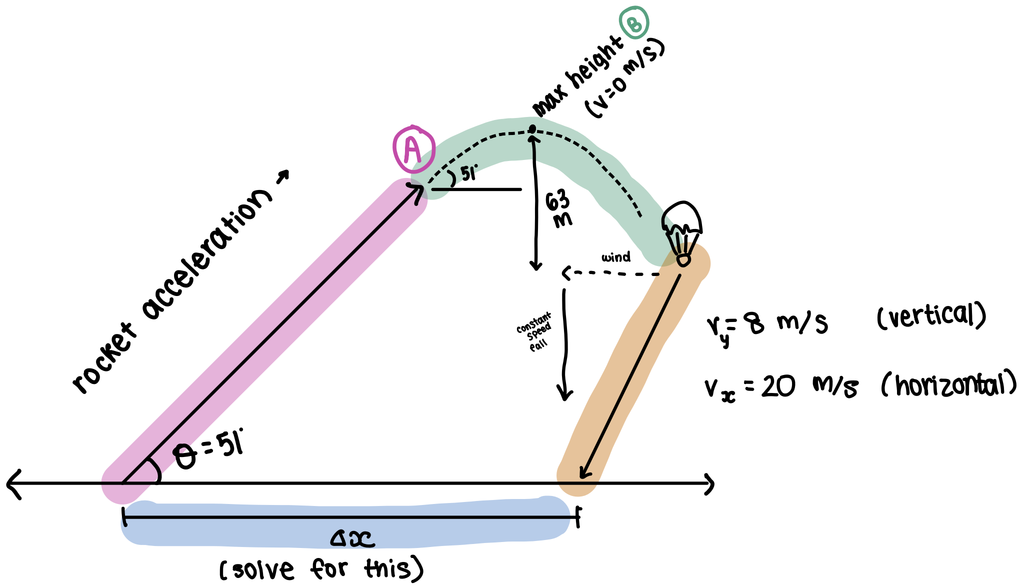
- Your given values including units, and the variable names you've assigned them
- A clear diagram with each variable labeled (no values)
- Description of your strategy in a step-by-step sequence. This can be a bulleted list. For each step, tell what you are solving for and what equation or concept you are using to solve it. An example based on our work to place the hoops:
    - Solve for the time it takes to reach the hoop given the horizontal velocity and horizontal distance, assuming it travels at constant velocity horizontally.
    - Use the no-v kinematic equation to find the height at that time given the initial height and initial y-velocity.
- Your work shown for each part of the solution including:
    - the equations before any substitutions
    - a clear substitution step
    - the work shown to get a numerical solution
- Your circled final answer to 4 sig figs with units. Include the magnitude and direction of the displacement.

The assignment is worth 10 points:

5 points for correctness (partial credit is awarded)
5 points for the level to which your work is shown as described above.

Given information

51	deg
9.0	sec
5.9	m/s²
63	m
8.0	m/s
20	m/s



Part 1: Before the Projectile (up to point (A))

1. use the given information to calculate Δx and Δy in this section

$$\Delta x = V_0 t + \tfrac{1}{2}at^2$$
$$= 0 + \tfrac{1}{2}(5.9\cos 51)(9^2)$$
$$\Delta x = 150.3761 \text{ m}$$

$$\Delta y = V_{0_y} t + \tfrac{1}{2}at^2$$
$$= 0 + \tfrac{1}{2}(5.9\sin 51)(9^2)$$
$$\Delta y = 185.6990 \text{ m}$$

2. use Δx and Δy to find the x and y velocities

(a, a_y, a_x)

$$V_x^2 = V_{0_x}^2 + 2a\Delta x$$
$$= 0 + 2(5.9\cos 51)(150.3761)$$
$$V_x = 33.4169 \text{ m/s}$$

$$V_y^2 = V_{0_y}^2 + 2a\Delta y$$
$$= 0 + 2(5.9\sin 51)(185.6990)$$
$$V_y = 41.2664 \text{ m/s}$$

Part 2: Projectile Motion

1. solve for Δy from point (A) to max height (B)

$$V_y^2 = V_{0_y}^2 + 2a\Delta y$$
$$0 = 41.2664^2 + 2(-9.8)\Delta y$$
$$19.6\Delta y = 41.2664^2$$
$$\Delta y = 86.8835 \text{ m}$$

2. Add this Δy to height at point (A) to find height at max point (B), then subtract vertical distance rocket falls from max height before parachute opens

$$185.6990 + 86.8835 = 272.5825$$
$$272.5825 \text{ m} - 63 = 209.5825 \text{ m} \rightarrow y$$

3. Use that information to find Δx during this part of the problem

x	y
$\Delta x = V_x t$	$y = y_0 + V_{oy} t - \frac{1}{2}at^2$
$\Delta x = 33.4169\,(7.7965)$	$y = y_0 + v\sin\theta t - \frac{1}{2}at^2$
$= 260.5349$ m	$209.5825 = 185.6990 + 41.2664t - 4.9t^2$
	$-4.9t^2 + 41.2664t - 23.8835 = 0$
	$t = 7.7965$ sec

$V_{o_x} = 33.4169$ m/s
$V_{o_y} = 41.2664$ m/s
$X_o = 150.3761$ m
$Y_o = 185.6990$ m
$a = -9.8$ m/s²

Part 3: Parachute to ground

1. Find Δx during this part of the problem

x	y
$\Delta x = V_{o_x} t$	$y = y_0 + V_{oy} t - \frac{1}{2}at^2$
$\Delta x = -20(26.1978)$	$0 = 209.5825 - 8t + 0$
$= -523.956$ m	$t = 26.1978$ sec

make 20 negative since rocket is moving left

$y_0 = 209.5825$ m
$y = 0$ m
$V_x = 20$ m/s
$V_y = 8$ m/s

Part 4: Find final x-displacement relative to initial x-position

$260.5349 + 150.3761 - 523.9560$
$= -113.0450$ m

↓

113.0450 m west