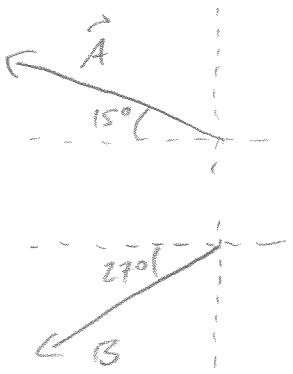
Physics 10154 - Exam #1B

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (30 pts) A boat crossing a wide body of water is attempting to get to a small island that is 357 miles due West from its initial location. The boat travels 192 miles in a direction 15.0° North of West, then 218 miles in a direction 27° South of West. What must the final straight line displacement of the boat be in order to find the island?



$A_x = -|\vec{A}| \cos 15^\circ = -185.46$

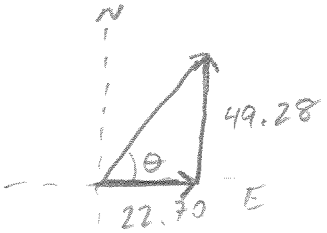
$A_y = +|\vec{A}| \sin 15^\circ = 49.69$

$B_x = -|\vec{B}| \cos 27^\circ = -194.24$

$B_y = -|\vec{B}| \sin 27^\circ = -98.97$

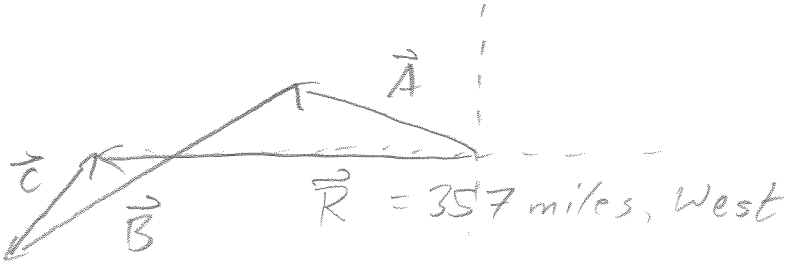
$A_x + B_x + C_x = -357 \Rightarrow C_x = +22.70$

$A_y + B_y + C_y = 0 \Rightarrow C_y = +49.28$



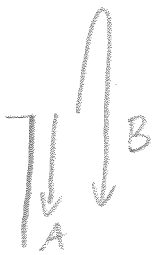
$|\vec{C}| = \sqrt{C_x^2 + C_y^2} = \boxed{54 \text{ miles}}$

$\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = \boxed{65^\circ \text{ N of E}}$



2. (35 pts) A person standing on a cliff fires a pellet gun A straight down toward the ground with an initial speed of 20.8 m/s. Pellet A hits the ground 1.62 seconds after it was fired.

If a second identical pellet gun B fires a pellet upward with a speed of 20.8 m/s at the same time as pellet A is fired downward, how many seconds after pellet A hits the ground does pellet B hit the ground?



Short way: when B reaches cliff edge on way down, further motion is identical to pellet A. Extra time is just time it takes for B to return to original position.

pellet B: $\Delta y = 0$, $v_0 = 20.8$, $v = -20.8$, $a = -9.8$, $t = ?$

$v = v_0 + at$

$-20.8 = 20.8 - 9.8t$

$t = \frac{-41.6}{-9.8} = 4.24\text{s}$

Long way:

pellet A: $\Delta y = ?$, $v_0 = -20.8$, $v = ?$, $a = -9.8$, $t = 1.62\text{s}$

$\Delta y = v_{0y}t + \frac{1}{2}a_y t^2$

$= (-20.8)(1.62) + \frac{1}{2}(-9.8)(1.62)^2$

$= -33.696 - 12.860$

$= -46.56\text{ m}$

pellet B: $\Delta y = -46.56$, $v_0 = +20.8$, $v = ?$, $a = -9.8$, $t = ?$

$v^2 = v_0^2 + 2a\Delta y$

$v^2 = (20.8)^2 + 2(-9.8)(-46.56)$

$v^2 = 1345$

$v = \pm 36.68$, use -36.68 since it is moving down

$v = v_0 + at$

$-36.68 = 20.8 - 9.8t$

$t = \frac{-57.48}{-9.8} = 5.86\text{s}$

$\Delta t = 5.86 - 1.62 = 4.24\text{s}$

Note answer is independent of initial height!

3. (35 pts) A rocket is fired at a speed of 53.0 m/s from ground level, at an angle of 61.0° above the horizontal. You may assume the rocket is in free fall for the entire problem. The rocket is fired toward a 72.0-meter high wall, located 42.5 meters away horizontally from the launch point.

a) Does the rocket get over the wall or hit the wall?
b) By how many meters does the rocket miss the top of the wall?
c) What is the rocket's velocity when it reaches maximum height?

a)

x	y
$\Delta x = 42.5\,m$	$\Delta y = ?$
$v_{ox} = 25.69\,m/s$	$v_{oy} = 46.35\,m/s$
$v_x = 25.69\,m/s$	$v_y = ?$
$a_x = 0$	$a_y = -9.8\,m/s^2$
$t = ?$	$t = ?$

Let Δx be 42.5m & find Δy at that horizontal distance.

$\Delta x = v_{ox}t + \frac{1}{2}at^2$

$42.5 = 25.69t + 0$

$t = 1.654\,s$

$\Delta y = v_{oy}t + \frac{1}{2}a_y t^2$

$= (46.35)(1.654) + \frac{1}{2}(-9.8)(1.654)^2$

$= 76.66 - 13.41 = 63.3\,m$

b) No, it hits wall (72.0 − 63.3 = 8.7 m below top

c) At max height, $v_y = 0$, but v_x same as v_{ox}

so ($v = 25.7\,m/s$, +x direction)