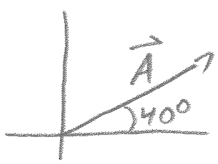
Physics 10154 - Exam #1A

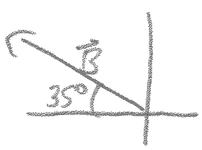
Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. <u>Clearly indicate your answer with a circle or box</u> and remember to include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

1. (30 pts) A boat race consists of three legs, defined by the displacement vectors A, B and C. The finish line is the same as the starting line, so the sum of the vectors A, B and C is zero. Vector A is 3.15 km in a direction 40.0° North of East. Vector B is 5.22 km in a direction 35.0° North of West. What is the magnitude and direction of vector C?



$A_x = |\vec{A}| \cos 40° = 2.413$

$A_y = |\vec{A}| \sin 40° = 2.025$

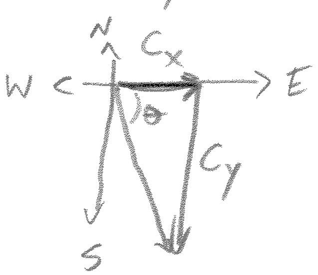


$B_x = -|\vec{B}| \cos 35° = -4.276$

$B_y = |\vec{B}| \sin 35° = 2.994$

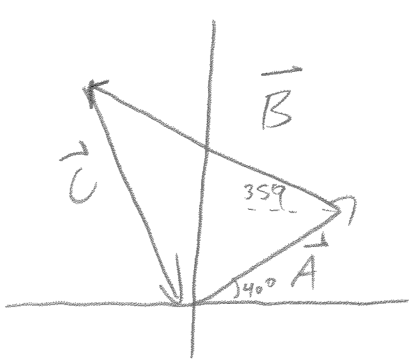
$A_x + B_x + C_x = 0 \quad C_x = -2.413 + 4.276 = 1.863$

$A_y + B_y + C_y = 0 \quad C_y = -2.025 - 2.994 = -5.019$



$|\vec{C}| = \sqrt{C_x^2 + C_y^2} =$ **5.35 km**

$\theta = \tan^{-1}\left(\frac{5.019}{1.863}\right) =$ **69.6° S of E**



2. (35 pts) A ball is thrown upward with some initial velocity. The ball spends a total of 4.32 seconds in the air before it is caught at the same place from which it was thrown. While the ball is in the air, it is in free fall.

a) To what maximum height does the ball rise?
b) At what altitude above its starting point is the ball's speed exactly 50.0% of its initial value?
c) What is the final velocity of the ball the instant before it is caught?

a) Entire motion

$\Delta y = 0$

$v_0 =$

$v =$

$a = -9.8\ m/s^2$

$t = 4.32\ s$

$\Delta y = v_0 t + \frac{1}{2} a t^2$

$0 = v_0 (4.32) + \frac{1}{2}(-9.8)(4.32)^2$

$-4.32 v_0 = -91.45$

$v_0 = 21.17\ m/s$

1st half

$\Delta y = ?$

$v_0 = 21.17$

$v = 0$

$a = -9.8\ m/s^2$

$t = ?$

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

$0^2 = (21.17)^2 + 2(-9.8)\Delta y$

$\Delta y = \frac{-(21.17)^2}{-19.6} = \boxed{22.9\ m}$

b) $v = 10.59\ m/s$ ($\frac{1}{2}$ of v_0)

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

$(10.59)^2 = (21.17)^2 + 2(-9.8)\Delta y$

$\Delta y = \frac{-336.13}{-19.6} = \boxed{17.1\ m}$

Note: KE is 25% so PE is 75% (height)

c) Since motion is symmetric, $\boxed{v = -21.2\ m/s}$

or going back to "Entire Motion" assumptions

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

$v^2 = (21.17)^2$

$v = \pm 21.2\ m/s$, choose -21.2 since ball moving downward

3. (35 pts) A disabled rocket is moving with a velocity of 245 m/s at an angle of 32.0° below the horizontal at an altitude of 1540 m. With the engines dead, the rocket is now in free fall. The rocket is currently over land, and monitors are hoping it reaches the water's edge before it hits, 2.00 km horizontally from the rocket's initial position.

a) What is the magnitude a direction of the rocket's velocity just before it hits the surface?

b) Does the rocket crash on land or on the water? Justify your answer mathematically.

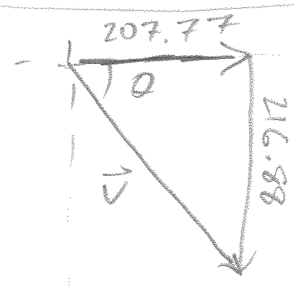
X	Y
$\Delta x = ?$	$\Delta y = -1540 m$
$V_{0x} = 245 \cos 32° = 207.77 \, m/s$	$V_{0y} = -245 \sin 32° = -129.83$
$V_x = 207.77 \, m/s$	$V_y = ?$
$a_x = 0$	$a_y = -9.8 \, m/s^2$
$t = ?$	$t = ?$

a) $v_y^2 = v_{0y}^2 + 2a_y \Delta y$

$= (-129.83)^2 + 2(-9.8)(-1540)$

$= 47640$

$v_y = \pm 216.88 = -216.88 \, m/s$



$|\vec{v}| = \sqrt{v_x^2 + v_y^2} = \boxed{300 \, m/s}$

$\theta = \tan^{-1}\left(\frac{216.88}{207.77}\right) = \boxed{46.2° \text{ below } +x}$

b) $v_y = v_{0y} + a_y t$

$-216.88 = -129.83 - 9.8t$

$t = \frac{-87.05}{-9.8} = 8.88 s$

$\Delta x = v_{0x} t + \frac{1}{2} a_x t^2$

$= (207.77)(8.88) + 0$

$= 1850 m < 2000 m$

so it $\boxed{\text{hits land}}$