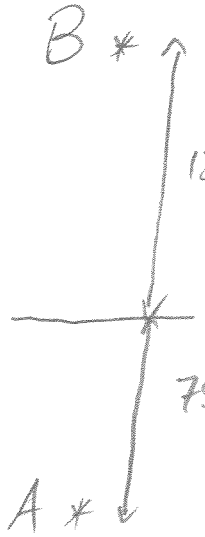
Physics 10154 - Exam #1a

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. Clearly indicate your answer with a circle or box and remember to include correct units and significant figures.

1. (30 pts) For the purposes of this problem, assume Fort Worth and Oklahoma city are connected by a straight North-South highway. Car A starts in Fort Worth, which is 75 miles South of the Oklahoma-Texas border, driving North with a constant speed of 53 miles/hour. Car B starts in Oklahoma City, 132 miles north of the Oklahoma-Texas border, driving South with a constant speed of 75 miles/hour.

How far North or South of the border do the cars pass one another? Give both a distance (in miles) and a direction.



$|\Delta x_A| = v_A t = 53t$

$|\Delta x_B| = v_B t = 75t$

$|\Delta x_A| + |\Delta x_B| = 132 + 75 = 207$

$53t + 75t = 207$

$t = \frac{207}{128} = 1.617\ hr$

$|\Delta x_A| = (53)(1.617) = 85.7\ mi = 86\ mi$

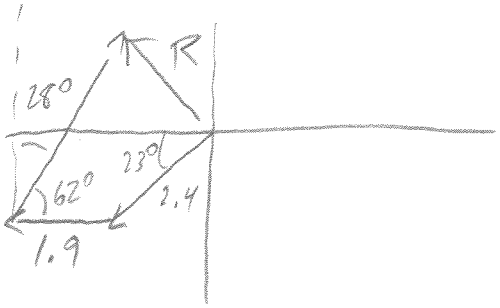
Cars meet 11 miles North of border

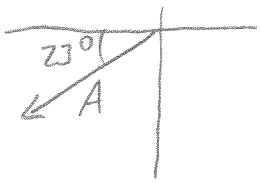
(86 − 75)

Check $|\Delta x_B| = (75)(1.617) = 121\ mi$, $132 - 121 = 11$

And $86 + 121 = 207$

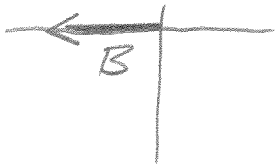
2. (30 pts) A hiker walks 2.4 miles in a direction 23° South of West, then 1.9 miles West, then 3.4 miles in a direction 28° East of North. What is the magnitude and direction of the total displacement for this hike?





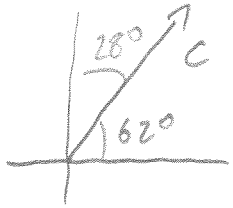
$A_x = -2.4 \cos 23° = -2.209$

$A_y = -2.4 \sin 23° = -0.938$



$B_x = -1.9$

$B_y = 0$

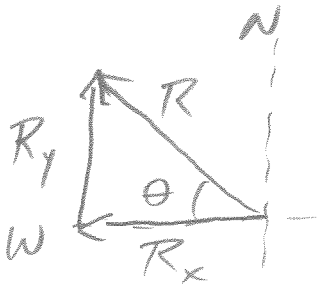


$C_x = 3.4 \cos 62° = 1.596$

$C_y = 3.4 \sin 62° = 3.002$

$R_x = -2.209 - 1.9 + 1.596 = -2.513$

$R_y = -0.938 + 0 + 3.002 = 2.064$



$|\vec{R}| = \sqrt{R_x^2 + R_y^2} =$ 3.3 miles

$\theta = \tan^{-1}\left(\frac{|R_y|}{|R_x|}\right) =$ 39° N of W

3. (40 pts) An electric toy car starts at rest and accelerates at a rate of 6.4 m/s^2 across a 2.5 meter long table. When the car reaches the edge of the table, it is 85 cm above the ground and moving horizontally. At that point, the horizontal acceleration stops and the car enters into free fall.

a) How far horizontally from the bottom of the table does the car land?

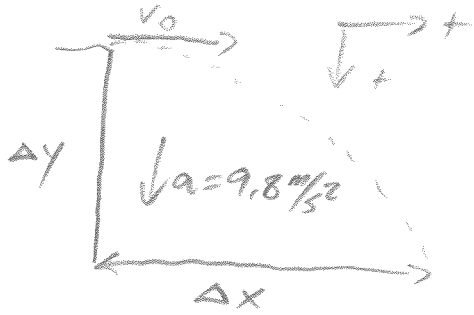
b) What is the magnitude and direction of the car's velocity the instant before it hits the ground?

Part 1 (horizontal)

$\Delta x = 2.5\ m$
$v_0 = 0$
$v = ?$
$a = 6.4\ m/s^2$
$t = ?$

$v^2 = v_0^2 + 2a\Delta x$
$v^2 = 0^2 + 2(6.4)(2.5) = 32$
$v = 5.66\ m/s$, $+x$ dir

Part 2 (free fall)

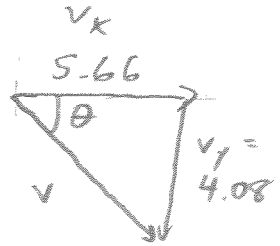


x	y
$\Delta x = ?$	$\Delta y = 0.85\ m$
$v_{0x} = 5.66$	$v_{0y} = 0$
$v_x = 5.66$	$v_y = ?$
$a_x = 0$	$a_y = 9.8\ m/s^2$
$t = ?$	$t = ?$

a) y: $\Delta y = v_{0y}t + \frac{1}{2}a_y t^2$
$0.85 = 0 + \frac{1}{2}(9.8)t^2$
$0.173 = t^2$
$t = 0.416\ s$

x: $\Delta x = v_{0x}t + \frac{1}{2}a_x t^2$
$= (5.66)(.416) + 0$
$= \boxed{2.4\ m}$

b) $v_y^2 = v_{0y}^2 + 2a_y\Delta y$
$v_y^2 = 0^2 + 2(9.8)(.85)$
$v_y^2 = 16.66$
$v_y = 4.08\ m/s$



$v = \sqrt{v_x^2 + v_y^2}$
$= \boxed{7.0\ m/s}$

$\theta = \tan^{-1}\left(\frac{4.08}{5.66}\right) = \boxed{36^\circ \text{ below } +x}$