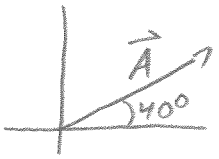
Physics 10154 - Exam #1 C

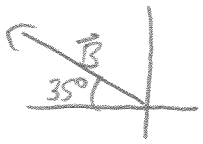
Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work (or if some parts are incorrect) even if you get the right answer. Clearly indicate your answer with a circle or box and remember to include correct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

1. (30 pts) A boat 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?



$A_x = |\vec{A}| \cos 40° = 2.413$

$A_y = |\vec{A}| \sin 40° = 2.025$

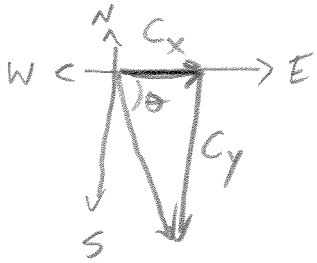


$B_x = -|\vec{B}| \cos 35° = -4.276$

$B_y = |\vec{B}| \sin 35° = 2.994$

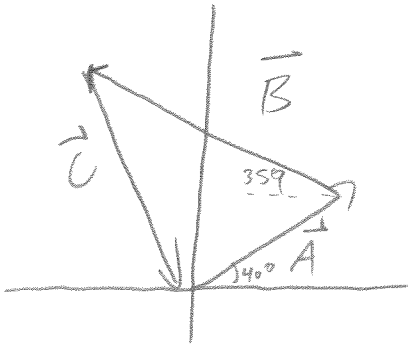
$A_x + B_x + C_x = 0 \quad C_x = -2.413 + 4.276 = 1.863$

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



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

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



2. (35 pts) A diver springs upward with an initial speed of 2.55 m/s from a board that is 3.20 meters above the water.

(a) Find the velocity (magnitude and direction) with which the diver strikes the water.

(b) If a stone is thrown downward with a speed of 2.55 m/s at the same instant the diver jumps upward, how much time elapses between the time the stone hits the water and the time the diver hits the water?

a) $\Delta y = -3.20\,m$
$v_0 = +2.55\,m/s$
$v = ?$
$a = -9.8\,m/s^2$
$t = ?$

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

$v^2 = (2.55)^2 + 2(-9.8)(-3.2)$

$= 69.22$

$v = \pm 8.32 \rightarrow \boxed{v = -8.32\,m/s}$

since diver moving downward

b) Short way: motion of diver + stone is identical (including time + v_0) once stone passes initial location on way down, so just find up/down time.

$\Delta y = 0$
$v_0 = 2.55\,m/s$
$v = -2.55\,m/s$
$a = -9.8\,m/s^2$
$t = ?$

$v = v_0 + at$

$-2.55 = 2.55 - 9.8t$

$t = \frac{-5.1}{-9.8} = \boxed{0.520\,s}$

Long way: Find each time separately + take difference.

Diver (from part a): $v = v_0 + at$

$-8.32 = 2.55 - 9.8t \rightarrow t = \frac{-10.87}{-9.8}$

$= 1.109\,s$

Stone: $\Delta y = -3.20\,m$
$v_0 = -2.55\,m/s$
$v = ?$
$a = -9.8\,m/s^2$
$t = ?$

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

$= (-2.55)^2 + 2(-9.8)(-3.2) \Rightarrow v = -8.32$

$v = v_0 + at$

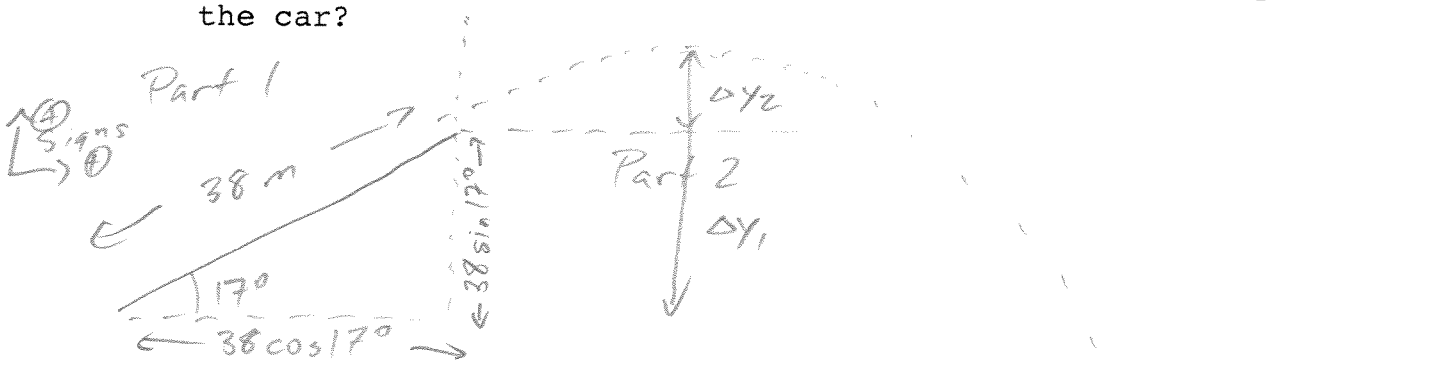
$-8.32 = -2.55 - 9.8t \rightarrow t = \frac{-5.77}{-9.8} =$

$= 0.589\,s$

$\Delta t = 1.109 - 0.589 = \boxed{0.520\,s}$

3. (35 pts) A race car starts from rest and accelerates up a 38.0 meter long ramp at a rate of 22.0 m/s². The ramp is elevated 17.0° above the horizontal. Upon leaving the ramp, the car is in free fall.

a) What is the magnitude and direction of the velocity of the car when it reaches its maximum height above ground level?
b) What is the maximum height above ground level achieved by the car?



Part 1

$\Delta s = 38.0$
$v_0 = 0$
$v = ?$
$a = 22.0\ m/s^2$
$t = ?$

$v^2 = v_0^2 + 2a\Delta s$
$v^2 = 0 + 2(22)(38) = 1672$
$v = 40.89$ ← use as v_0 for part 2

Also, $\Delta y_1 = \Delta s \sin 17° = 11.11\ m$

Part 2 (end of ramp → max height)

$\Delta x = ?$
$v_{0x} = 40.89 \cos 17°$
$v_x = 40.89 \cos 17°$
$a_x = 0$
$t = ?$

$\Delta y_2 =$
$v_{0y} = 40.89 \sin 17° = 11.96\ m/s$
$v_y = 0$ (at y_{max})
$a_y = -9.8\ m/s^2$
$t = ?$

a) $v_x = 39.1\ m/s$
$v_y = 0$
$\vec{v} = 39.1\ m/s$, +x dir

b) $v_y^2 = v_{0y}^2 + 2a_y\Delta y_2$
$0^2 = (11.96)^2 + 2(-9.8)\Delta y_2$
$\Delta y_2 = 7.30$

$\Delta y_1 + \Delta y_2$
$11.11 + 7.30 = 18.4\ m$