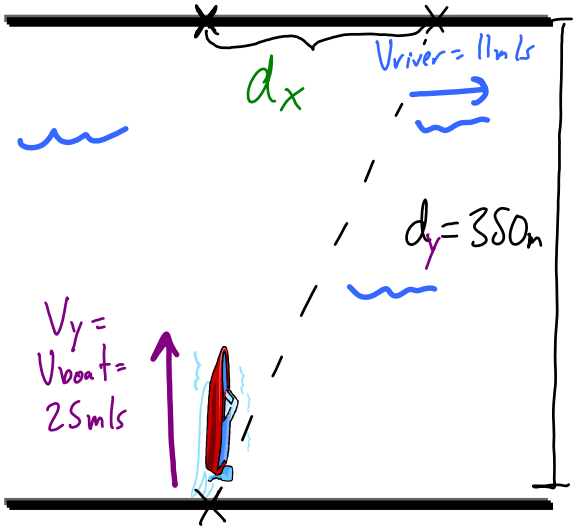
Unit 2: Kinematics in 2D

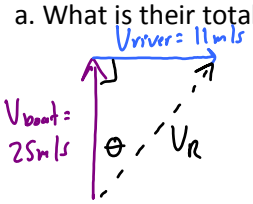
Independence of Perpendicular Vectors

Example: After escaping from a maximum security stockade, the A-Team is trying to travel north across a 350 m river in a speed boat. The boat can travel at a speed of 25 m/s in still water and the river flows to the east at 11 m/s.



Part 1: They point their boat directly north across the river.

a. What is their total (resultant) velocity?



$v_R^2 = v_{boat}^2 + v_{river}^2$

$v_R = \sqrt{25^2 + 11^2}$

$= 27.31 m/s$

$= \boxed{27 m/s \ 24° \ E \ of \ N}$

$\tan\theta = \frac{v_{river}}{v_{boat}}$

$\theta = \tan^{-1}\left(\frac{11}{25}\right)$

$= 24°$

b. How long does it take to cross the river?

$v = \frac{d}{t}$ $\quad t = \frac{d_y}{v_y} = \frac{350m}{25 m/s} = \boxed{14s}$

- Perpendicular vectors are... independent
- To find the total (resultant) vector we... do vector addition
- Don't forget that the resultant vector has... direction $\Rightarrow \theta$
- We don't use... + or − for direction

c. How far down-river do they end up?

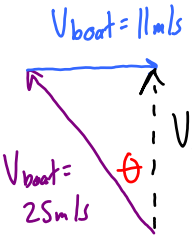
$v = \frac{d}{t}$ $\quad d_x = v_x \cdot t = (11 m/s)(14s)$

$= 154 m$

$= \boxed{150m \ E}$

Part 2: The Law has caught on to the boys and is waiting down river, on the other side.

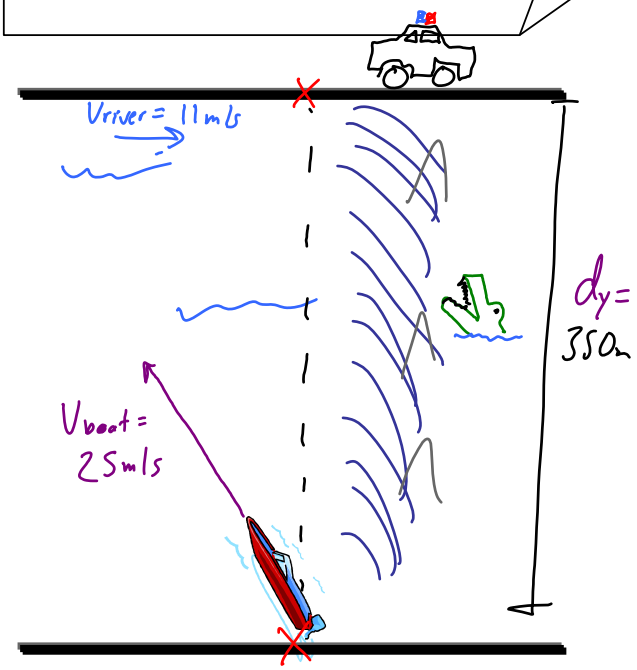
a. At what heading should they point the boat so that they land safely, DIRECTLY across the river?



$\sin\theta = \frac{11}{25}$

$\theta = \sin^{-1}\left(\frac{11}{25}\right)$

$= \boxed{26° \ W \ of \ N}$



b. How long will it take them to cross at this heading?

$v_y = \frac{d_y}{t}$

$t = \frac{d_y}{v_y}$

$= \frac{350m}{22.45 m/s} = \boxed{16s}$

$v_{boat}^2 = v_R^2 + v_{river}^2$

$v_R = \sqrt{25^2 - 11^2}$

$= 22.45 m/s$