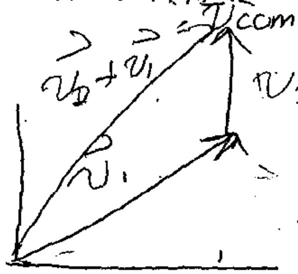
1/29/2018 LECTURE NOTES

NOW WE CAN ADD VELOCITIES LIKE WE DO POSITIONS TO SEE THE AFFECT OF VELOCITIES ON EACH OTHER

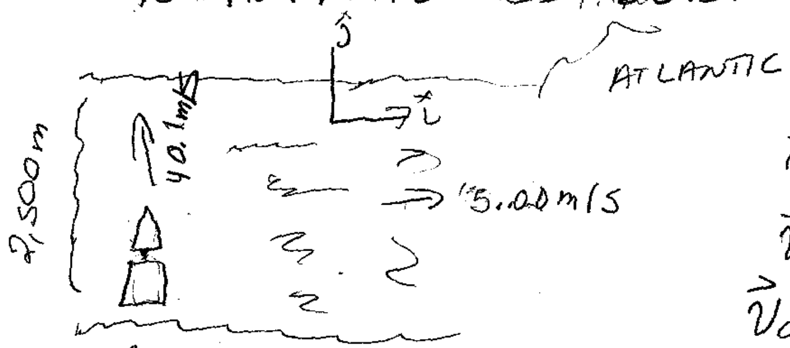


$\vec{v}_{comb} = \vec{v}_2 + \vec{v}_1$ or $\vec{v}_1 + \vec{v}_2$

- HEADWIND/TAILWIND
- WATER SPEED

EXAMPLE

PORT EVERGLADES IS APPROXIMATELY 2,500 m WIDE AT ITS ENTRANCE. A TUG IS PULLING A BARGE TO ITS BIRTH FROM ONE END TO THER OTHER IT HAS A SPEED OF 40.1 m/s (6 KNOTS) DUE NORTH AND THE WATER HAS A SPEED OF 5.00 m/s (6.2 KNOTS), DUE EAST. HOW FAR OFF TARGET WILL IS THE TUG AT THE END? HOW MUCH DOES THE TUG HAVE TO TURN TO KEEP DUE NORTH?

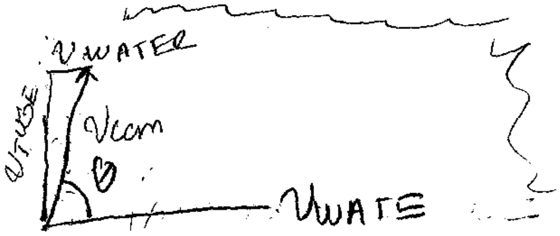


$\vec{v}_{TUG} = 40.1\,m/s\ \hat{j}$

$\vec{v}_{WATER} = 5.00\,m/s\ \hat{i}$

$\vec{v}_{comb} = \vec{v}_1 + \vec{v}_2$

$= 5.00\,m/s\ \hat{i} + 40.1\,m/s\ \hat{j}$



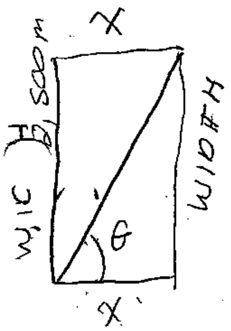
$\theta = \tan^{-1}\left(\frac{40.1\,m/s}{5.00\,m/s}\right) = 82.9°$

$v_{com}^2 = v_{TUG}^2 + v_{WATER}^2$

$|\vec{v}_{comB}| = \sqrt{v_{TUG}^2 + v_{WATER}^2}$

$= \sqrt{(40.1\,m/s)^2 + (5.00\,m/s)^2}$

$= \boxed{40.4\,m/s}$ TO AN OBSERVER ON SHORE



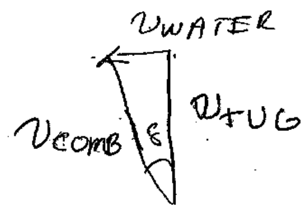
$$\tan\theta = \frac{\text{WIDTH}}{x}$$

$$\frac{x \cancel{\tan\theta}}{\tan\theta} = \frac{\text{WIDTH}}{\tan\theta}$$

$$x = \frac{\text{WIDTH}}{\tan\theta} = \frac{2{,}500\,m}{\tan(82.9)} = \boxed{311\,m}$$

DOWN TARGET

NOW v_{TUG} IS UNKNOWN



$$v_{COMB}^2 = v_{WATER}^2 + v_{TUG}^2$$

$$\sqrt{v_{COMB}^2 - v_{WATER}^2} = \sqrt{v_{TUG}^2}$$

$$v_{TUG} = \sqrt{v_{COMB}^2 - v_{WATER}^2}$$

$$v_{TUG} = \sqrt{(40.4\,m/s)^2 - (5.00\,m/s)^2}$$

$$= \boxed{40.B\,m/s}$$

$$\sin\delta = \left(\frac{v_{WATER}}{v_{COMB}}\right) \Rightarrow \delta = \sin^{-1}\left(\frac{3.00\,m/s}{40.4\,m/s}\right)$$

$$\delta = \boxed{7.11^\circ}$$

INSTANTANEOUS RADIAL VELOCITY (FROM LECTURE 1/23)

$t_1 = 2.30s$; $t_2 = 6.50s$ CONTINUATION OF ANGULAR VELOCITY

$$\vec{v}_1 = \frac{\vec{r}_1}{t_1} = \frac{12.5m}{2.30s}\hat{i} + \frac{21.7m}{2.30s}\hat{j} = 5.43 m/s\,\hat{i} + 9.43 m/s\,\hat{j}$$

$$|\vec{v}_1| = \sqrt{(5.43m/s)^2 + (9.43m/s)^2} = \boxed{10.9 m/s} = v_1$$

$$\theta_1 = \tan^{-1}\left(\frac{9.43m/s}{5.43m/s}\right) = 60.0^\circ$$

$$\vec{v}_2 = \frac{\vec{r}_2}{t_2} = \frac{-12.5m}{6.50s}\hat{i} + \frac{21.7m}{6.50s}\hat{j} = \boxed{-1.92 m/s\,\hat{i} + 3.34 m/s\,\hat{j}}$$

$$|\vec{v}_2| = \sqrt{(-1.92m/s)^2 + (3.34m/s)^2} = \boxed{3.85 m/s} = v_2$$

$$\theta_2 = \tan^{-1}\left(\frac{3.34m/s}{-1.92m/s}\right) = -60.0^\circ$$

$$\bar{v} = \frac{v_1 + v_2}{2} = \frac{10.9m/s + 3.85m/s}{2} = \boxed{7.37 m/s}$$ AVERAGE LINEAR VELOCITY

COMPARE TO ANGULAR VELOCITY

$$\bar{v} = \frac{l}{t} = \frac{26.2m}{4.20s} = \boxed{6.26 m/s}$$ AVERAGE LINEAR VELOCITY

$$t = t_2 - t_1 = 4.20s$$

NOW ARISTOTLE THOUGHT MOTION TO MOMENTUM HE DEFINED IT AS $\vec{p} = m\vec{v}$ (MOMENTUM = MASS • VELOCITY) MANY PHYSICIST HAVE DEALT WITH IMPULSE $\Delta\vec{p}$.

$$\Delta\vec{p} = \Delta(m \cdot \vec{v})$$
$$= \underset{①}{\Delta m} \cdot \vec{v} + m \underset{②}{\Delta\vec{v}} \quad kgm/s$$

IN A RELATIVISTIC SYSTEM ($\vec{v} \sim c$ (SPEED OF LIGHT)) WE NEED TO USE BOTH TERMS. BUT IN MOST SYSTEMS $\Delta p = m\Delta\vec{v}$.

ALSO WE CAN MULTIPLY VELOCITIES AS WELL. FROM THE IMPULSE WE CAN MEASURE THE ENERGY, KINETIC ENERGY. WE WILL SEE THE DERIVATION LATER IN THE SEMESTER. WE DEFINE KE AS

$$KE = \tfrac{1}{2}(m\vec{v} \cdot \vec{v}) = \tfrac{1}{2}mv^2 \; ; \quad \frac{p^2}{m} = \frac{m^2v^2}{m}$$

$$KE = \tfrac{1}{2}mv^2 = \frac{p^2}{2m} \quad (kgm^2/s^2) \qquad \frac{p^2}{m} = mv^2$$

EXAMPLE

WHAT IS MOMENTUM AND KINETIC ENERGY OF THE ABOVE TUGBOAT (19,200 kg).

$$\vec{p} = m\vec{v} = m\vec{v}_{comB} = (19{,}200\,kg)(5.00\,m/s\,\hat{i} + 40.1\,m/s\,\hat{j})$$
$$= 96{,}000\,kgm/s\,\hat{i} + 770{,}000\,kgm/s\,\hat{j}$$

$$p^2 = \sqrt{(96{,}000\,kgm/s)^2 + (779{,}000\,kgm/s)}^2$$
$$= \boxed{6.02 \times 10^{11}\,kg^2m^2/s^2}$$

$$KE = \frac{p^2}{2m} = \frac{(6.02 \times 10^{11}\,kg^2m^2/s^2)}{2(19{,}200\,kg)} = \boxed{1.57 \times 10^7\,kgm^2/s^2}$$