

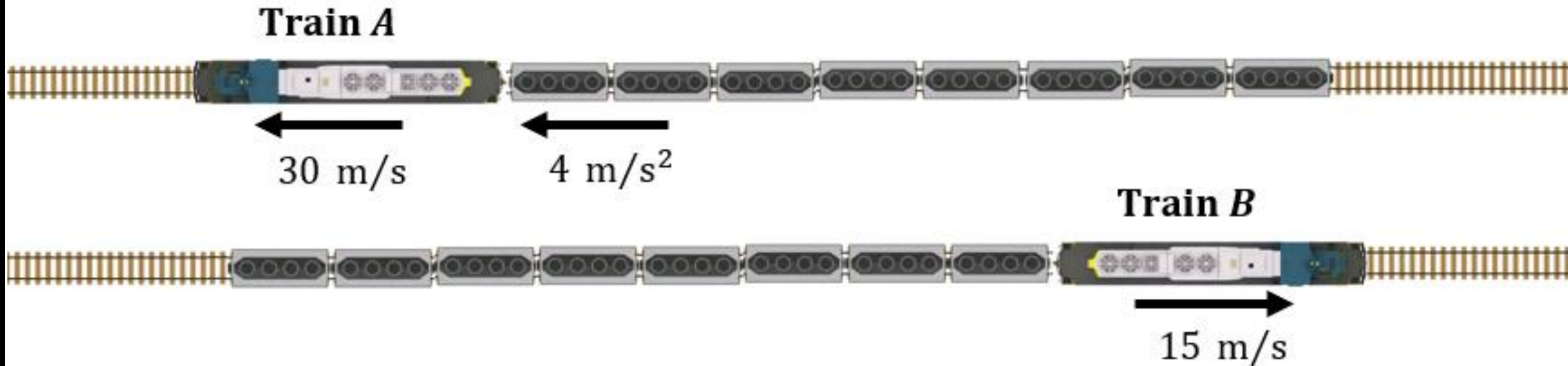
Kinematics of a particle

Tutorial 6

Relative motion

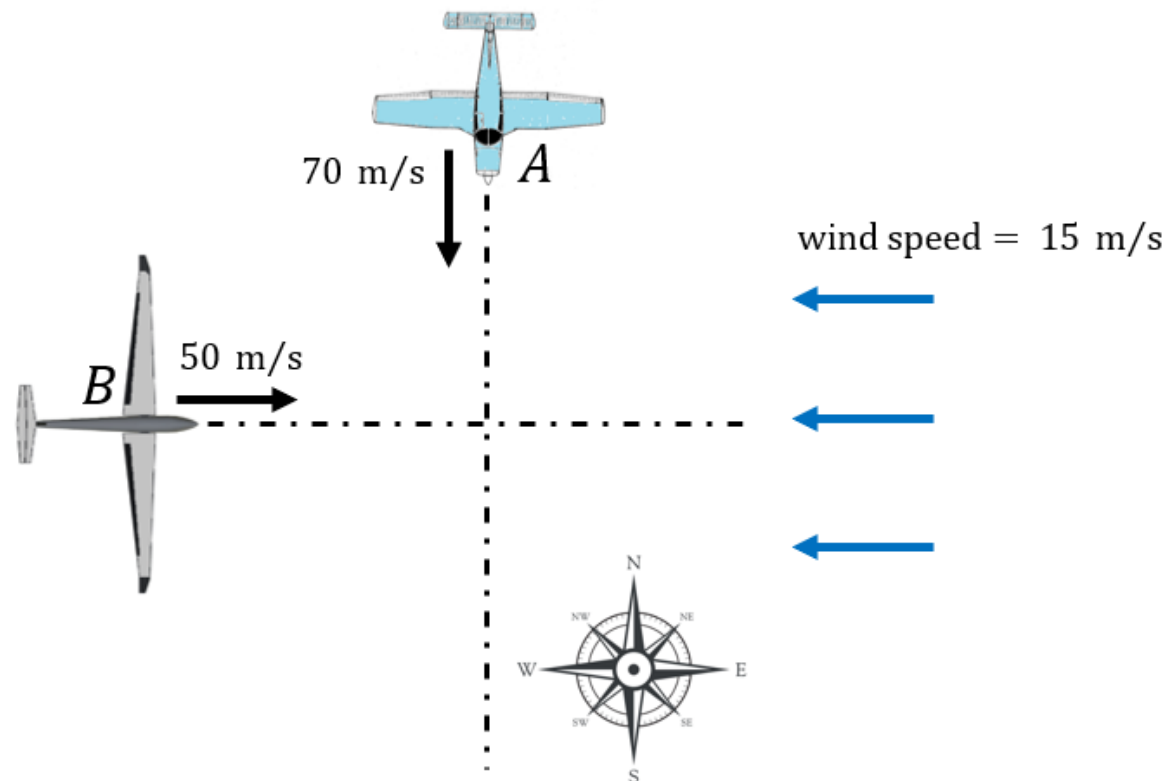
Question 6.1

Two diesel trains travel in opposite directions parallel to each other. At the instant shown train *A* has a speed of 30 m/s and is accelerating uniformly at 4 m/s^2 , and train *B* has constant speed of 15 m/s . What is the velocity and acceleration of train *B* relative to train *A*?



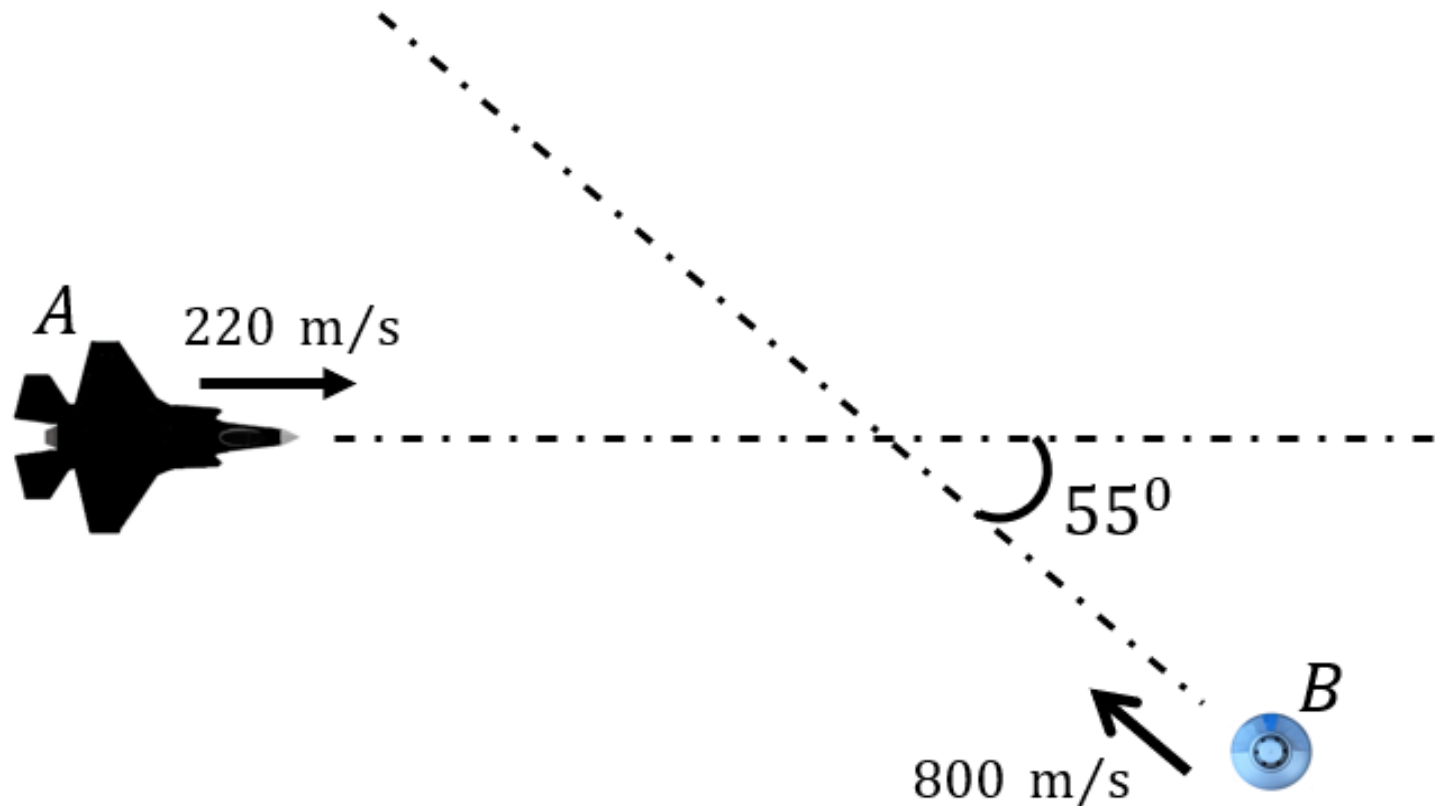
Question 6.2

The light aircraft at A is travelling south with a speed of 70 m/s relative to the ground before it encounters a crosswind from the eastern direction. Where the glider at B is flying east with an airspeed of 50 m/s and at almost the same altitude as aircraft A , determine the velocity aircraft A appears to have to the pilot in the glider at B when aircraft A encounters the crosswind.



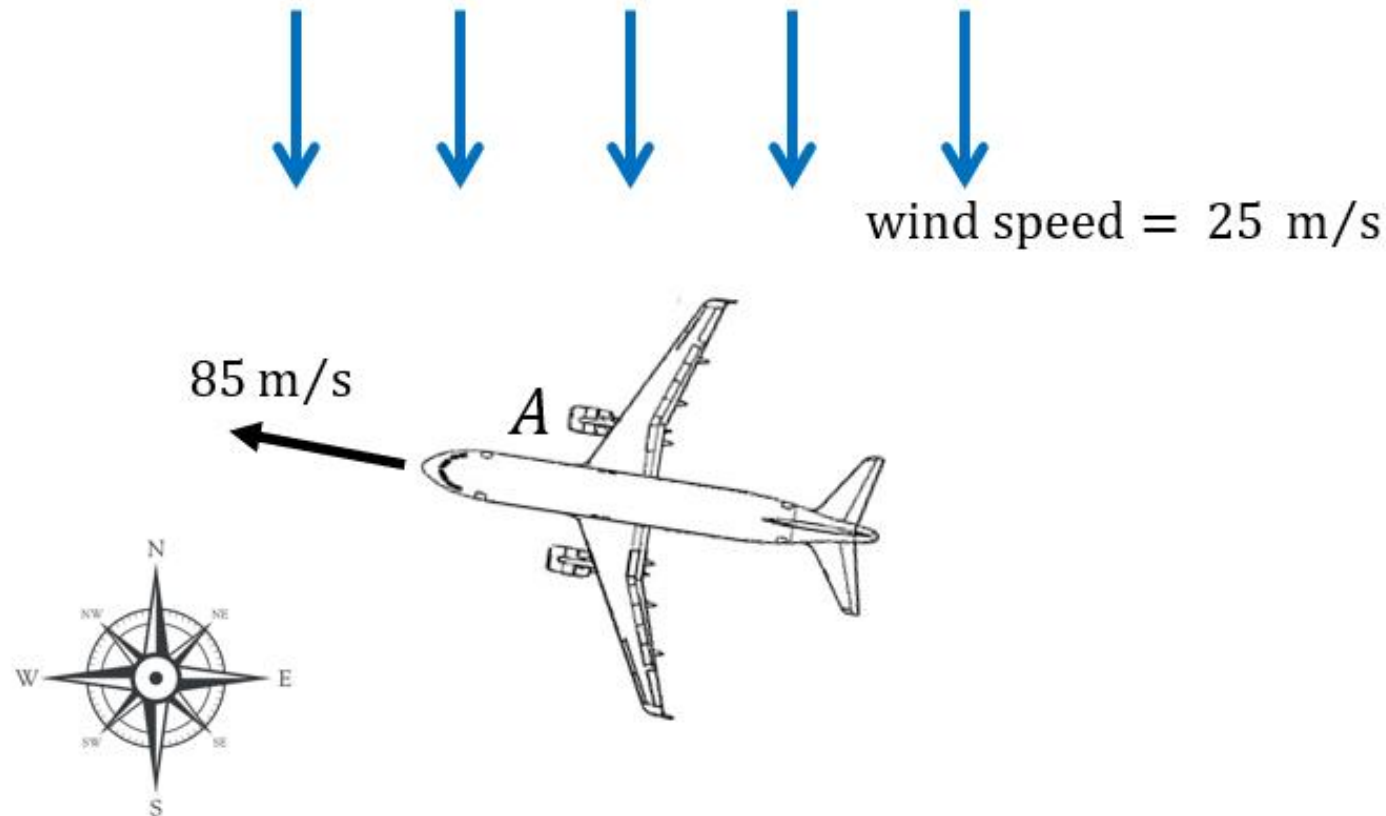
Question 6.3

A fighter jet at A is travelling east with a velocity of 220 m/s when a UFO at B passes ahead at the same altitude with a velocity of 800 m/s . If the angle between their straight line courses is 55° , what velocity does the UFO appear to have to the fighter pilot?



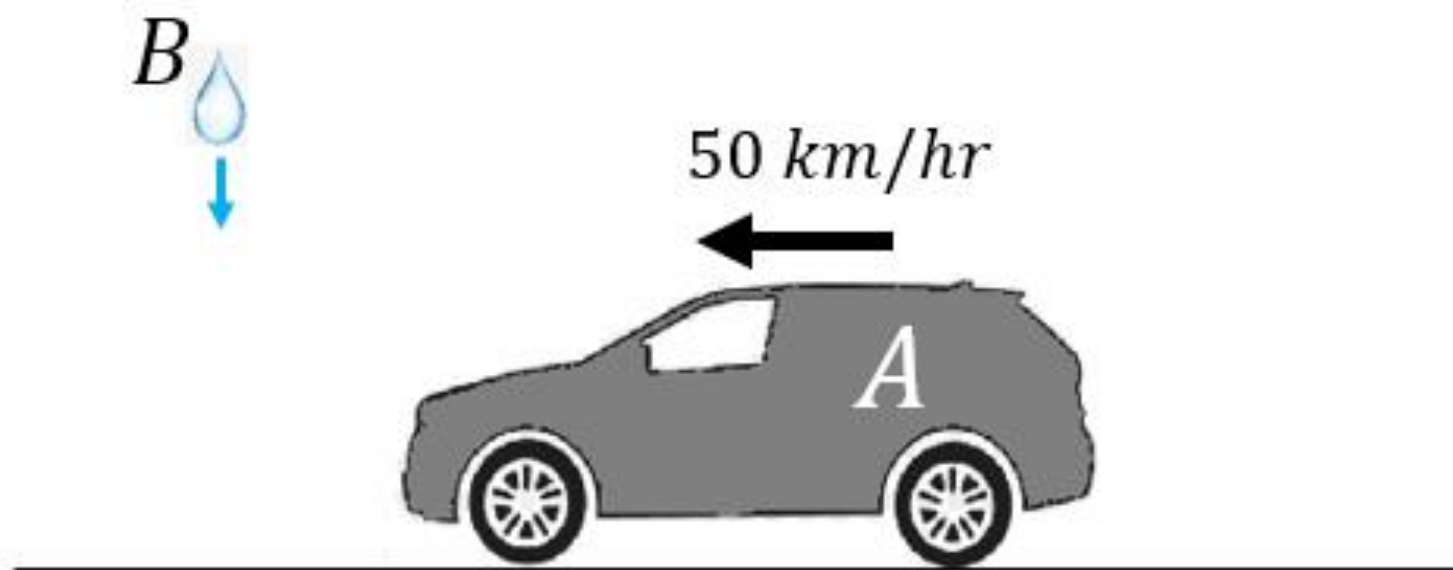
Question 6.4

A commercial jet with an airspeed of 85 m/s needs to fly west to be on the correct course. If there is a southern crosswind of 25 m/s , determine the direction the pilot should direct the jet to stay on the correct course. The pilots also want to know their ground speed, but there is a technical fault, find what it would be.



Question 6.5

The front passenger of car A observes a large water droplet B making an angle of 40° with the horizontal road as the car is travelling with a constant velocity of 50 km/hr . If the droplet falls from rest and hits the windshield from a height of 100m , what is the velocity of the droplet relative to the observing passenger? Assume the water droplet falls vertically.

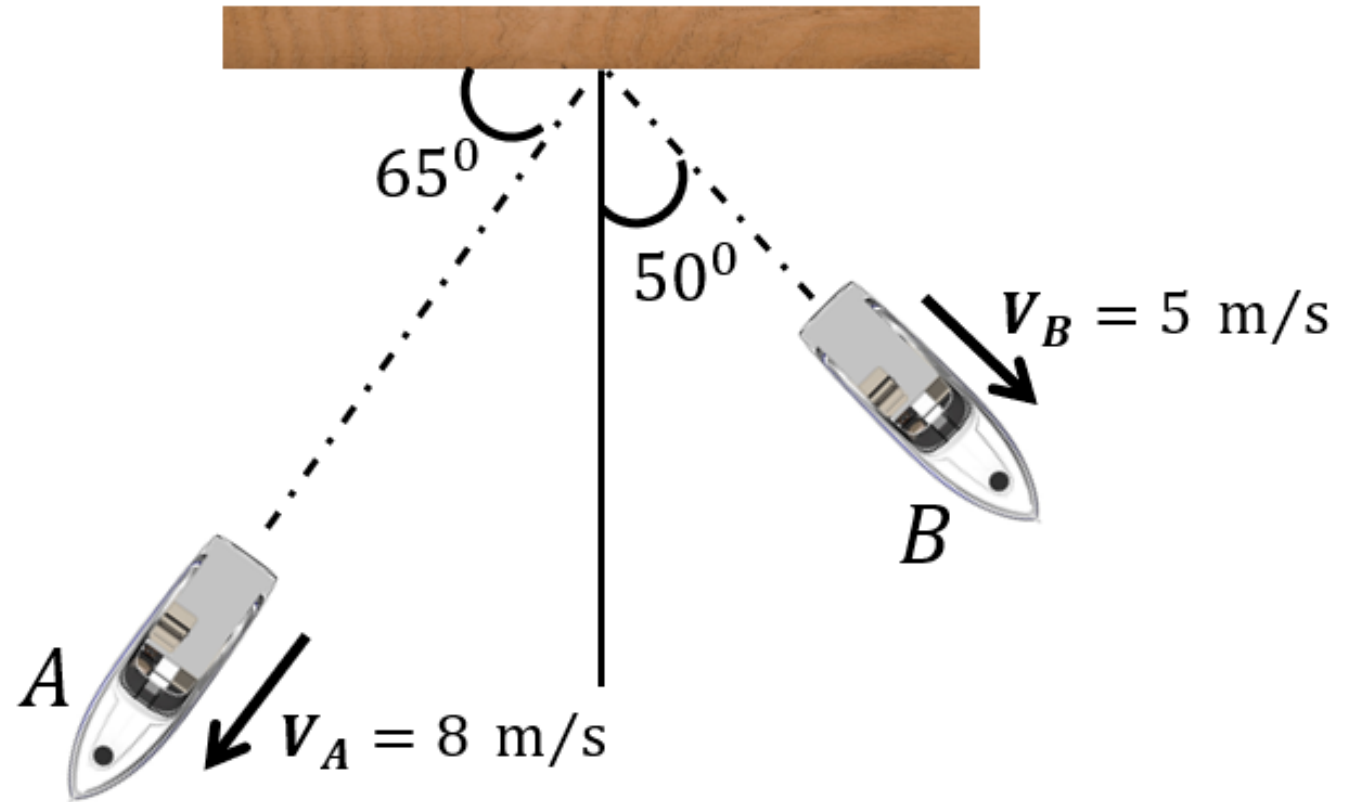


Question 6.6

Two rescue boats are dispatched from the dock at the same time, both travelling with constant velocity. The velocity of the boat A is $V_A = 8 \text{ m/s}$ and the velocity of the boat B is $V_B = 5 \text{ m/s}$.

Determine:

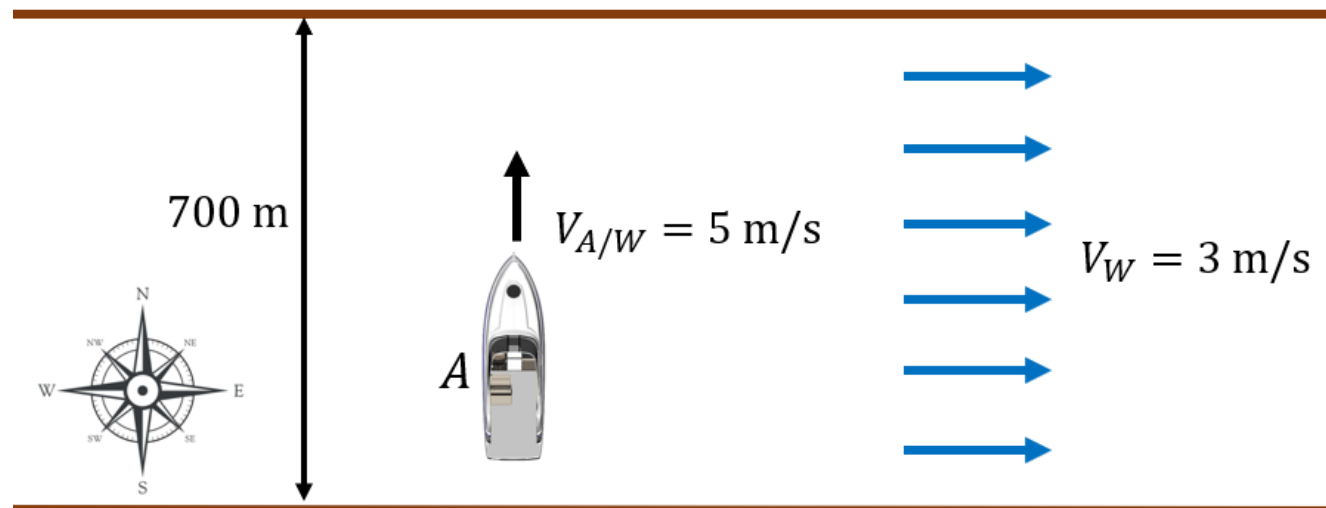
- The velocity of boat B relative to boat A .
- The velocity of boat A relative to boat B .
- How far apart the boats are after 25s.



Question 6.7

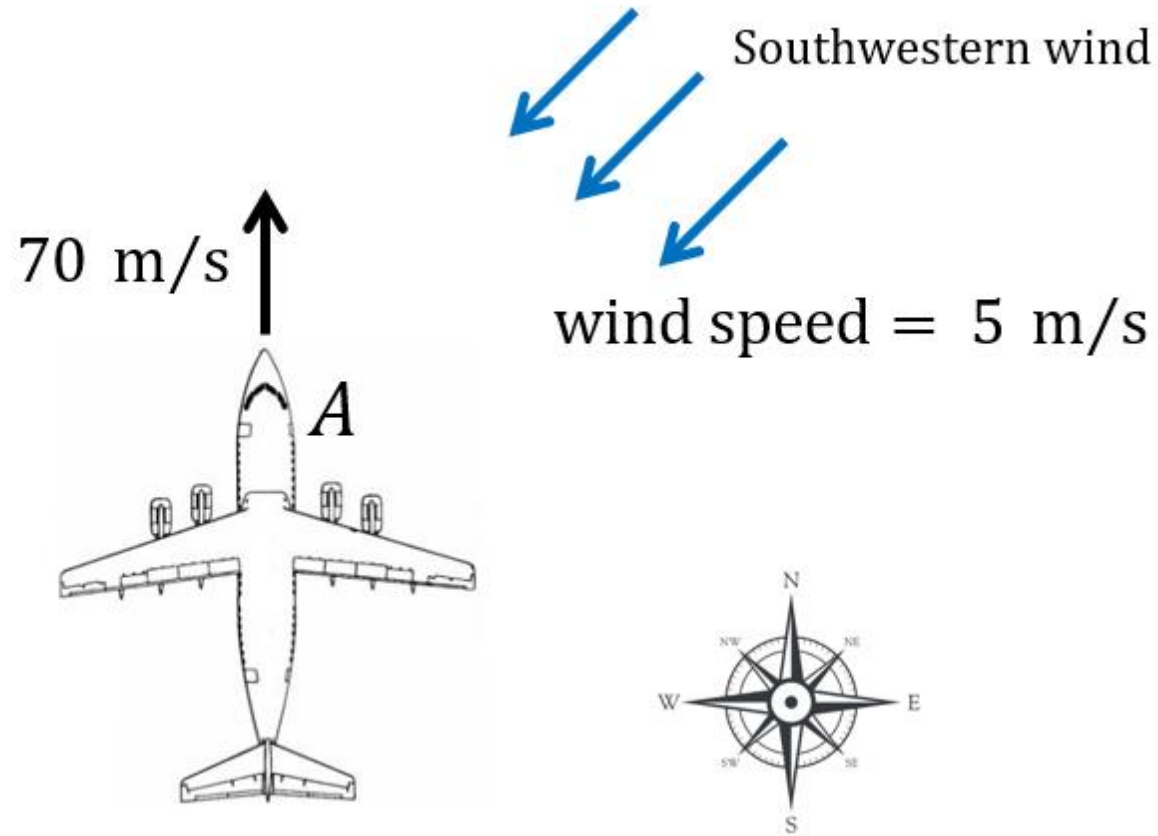
A river 700 m wide is flowing east with a velocity of $V_W = 3 \text{ m/s}$. One of the rescue boats at point A from question 6.6 is steered across the river starting from one side of the bank with a velocity relative to the water of $V_{A/W} = 5 \text{ m/s}$ due north. Determine:

- The velocity of the boat as seen from a stationary observer.
- How long it takes for the boat to cross the river.
- How far east from the starting point would the boat reach the opposite side.
- In which direction should the boat head to reach a point directly north on the opposite side of the river from the starting point.
- The velocity of the boat that is now seen from a stationary observer when the boat heads in this direction.
- How long it takes the boat to cross the river when the boat heads in this direction.



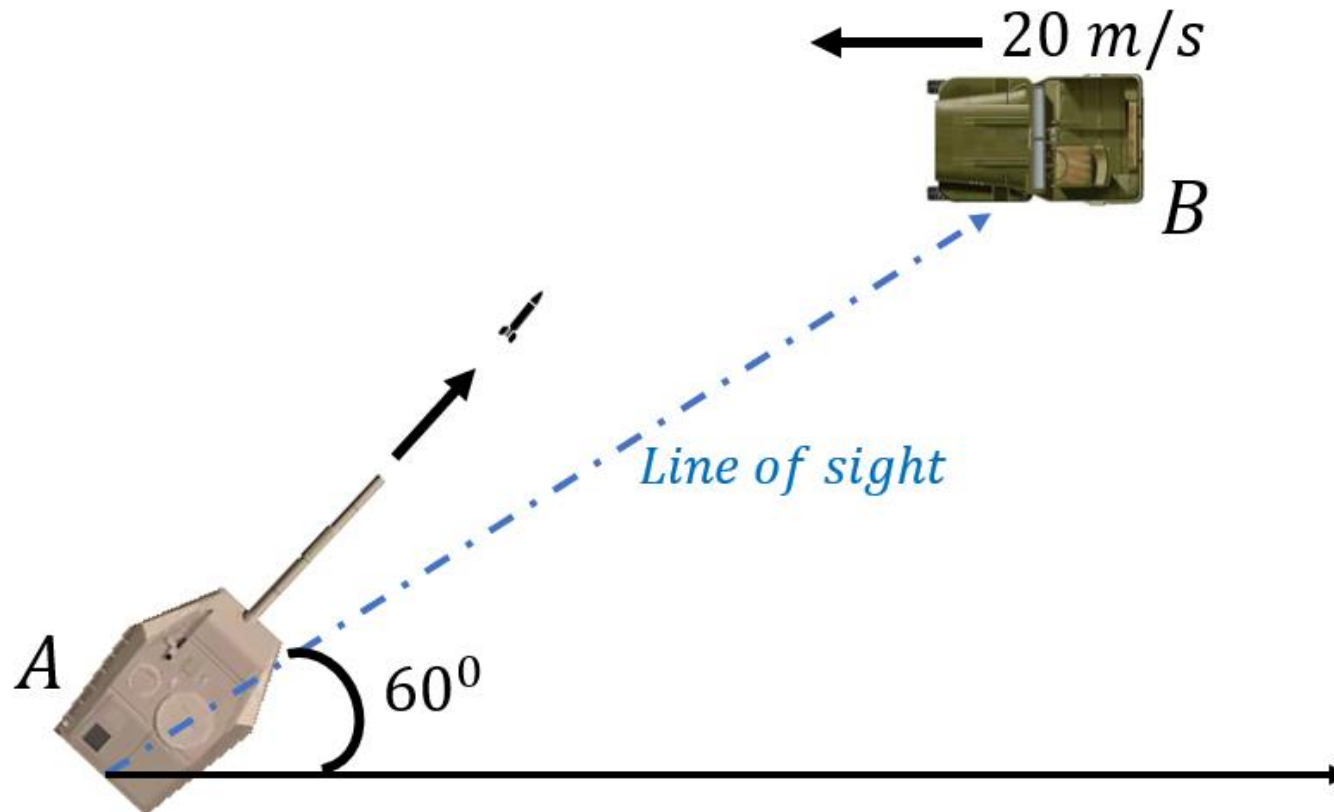
Question 6.8

The passenger jet at A is on its final approach, at this instant it has an airspeed of 70 m/s due north and is in a 5 m/s southwestern crosswind. What is the magnitude and direction of the jets velocity relative to a stationary observer on the ground?



Question 6.9

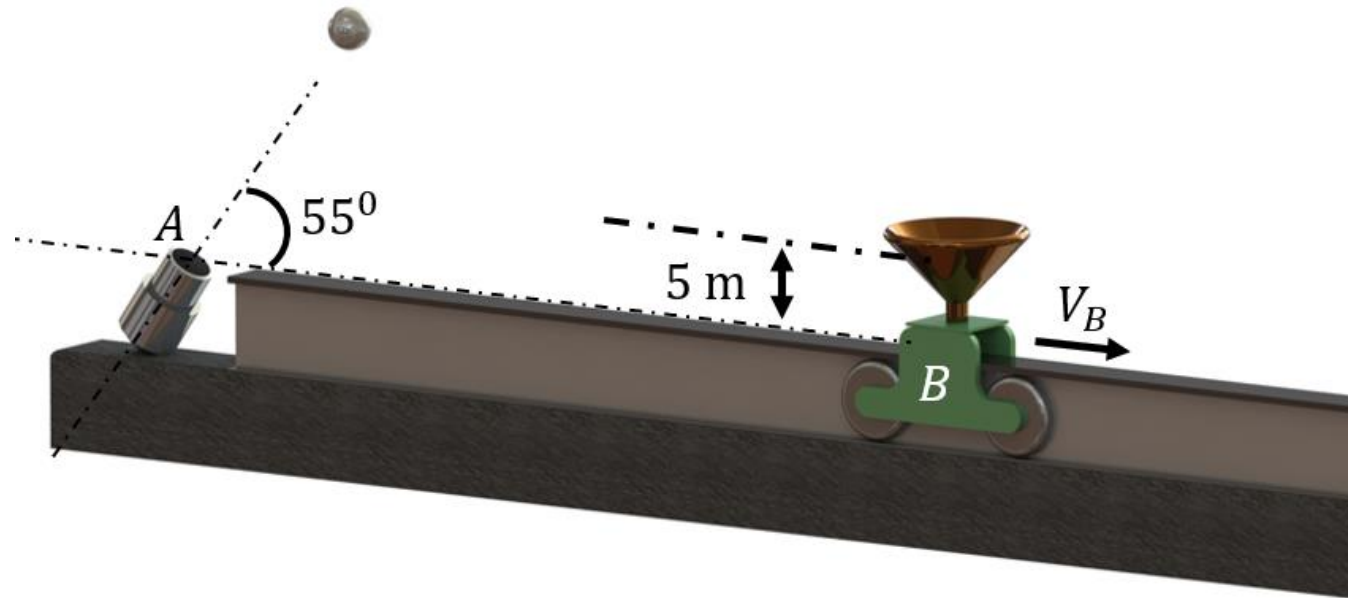
The stationary turret at A is trying to hit the moving target at B . By what angle should the turret be offset from the line of sight of the operator to hit the target? The turret is capable of launching the missile with velocity of 200 m/s .



Question 6.10

A projectile is launched at A with a velocity $v = 30 \text{ m/s}$ with the sliding cart B located 3 m ahead prior to launch. If the cart begins motion at the same time the projectile is launched, determine:

- The constant velocity V_B the cart must have to catch the projectile.
- The velocity of the projectile relative to the cart at the instant the projectile is caught.
- The acceleration of the projectile relative to the cart at the instant the projectile is caught.



Question 6.11

A passenger boat is traveling upstream on a canal when a passenger suddenly falls overboard and gets carried by the current. The crew realize the passenger is missing 10 minutes later and by that time the boat has travelled 300 m, at this point the boat turns around and heads downstream. The boat eventually catches up with the passenger 600 m downstream from where the boat had turned around. Assume constant power consumption from the engine of the boat throughout and a 15 second turnaround time.

Determine:

- a) The current velocity in the canal.
- b) The velocity of the boat if the water was still (no current).

Answers are shown on the next page

Answers

Question 6.1

$$V_{B/A} = 45 \text{ m/s}$$

$$a_{B/A} = 4 \text{ m/s}^2$$

Question 6.2

$$V_{B/A} = 83.22 \text{ m/s}$$

Question 6.3

$$V_{B/A} = 943.55 \text{ m/s}$$

Question 6.4

$$\theta = 17.1^\circ / \text{bearing: } 287$$

$$V_A = 81.24 \text{ m/s}$$

Question 6.5

$$V_{B/A} = 71.51 \text{ m/s}$$

Question 6.6

- a) $V_{B/A} = 8.34 \text{ m/s}$
- b) $V_{A/B} = -8.34 \text{ m/s}$
- c) $s_{B/A} = 208.5 \text{ m}$

Question 6.7

- a) $V_A = 5.83 \text{ m/s}$
- b) $t = 140 \text{ s}$
- c) $S_E = 420 \text{ m}$
- d) $\theta = 59.05^\circ$
- e) $V_A = 4 \text{ m/s}$
- f) $t = 175 \text{ s}$

Question 6.8

$$V_A = 66.55 \text{ m/s}$$

$$\theta = 3.05^\circ$$

Question 6.9

$$\theta = 4.97^\circ$$

Question 6.10

- a) $V_B = 16.58 \text{ m/s}$
- b) $V_{P/B} = 22.51 \text{ m/s}$
- c) $a_{P/B} = -9.81 \text{ m/s}^2$

Question 6.11

- a) $V_W = 0.25 \text{ m/s}$
- b) $V_B = 0.75 \text{ m/s}$