Problem Set: Vectors

*Complete all the problems in this set in an organized fashion, showing ALL necessary WORK. Problems with only answers may be considered incorrect and lower your grade. Clearly indicate your answers by underlining or circling the final answer to each problem. #4, 10, 15, 17-18 are optional enrichment involving non-right triangle problems for Honors students.*

1. A car is driven 125 km due west, then 65 km due south. What is the magnitude of its displacement?

2. A shopper walks from the door of the mall to her car 250 m down a lane of cars, then turns 90º to the right and walks an additional 60 m. What is the magnitude of the displacement of her car from the mall door?

**3. A hiker walks 4.5 km in one direction, then makes a 45º turn to the right and walks another 6.4 km. What is the magnitude of her displacement?**

*4. What is the magnitude of your displacement when you follow directions that tell you to walk 225 m in one direction, make a 90º turn to the left and walk 350 m, then make a 30º turn to the right and walk 125 m?*

5. A car moving east a 45 km/h turns and travels west at 30 km/h. What are the magnitude and direction of the change in velocity?

6. You are riding in a bus moving slowly through heavy traffic at 2.0 m/s. You hurry to the front of the bus at 4.0 m/s relative to the bus. What is your speed relative to the street?

7. A motorboat heads due east at 11 m/s relative to the water across a river that flows due north at 5.0 m/s. What is the velocity of the motorboat with respect to the shore?

8. A boat is rowed directly upriver at a speed of 2.5 m/s relative to the water. Viewers on the shore find that it is moving at only 0.5 m/s relative to the shore. What is the speed of the river? Is its moving with or against the boat?

9. An airplane flies due north at 150 km/h with respect to the air. There is a wind blowing at 75 km/h to the east relative to the ground. What is the plane’s speed with respect to the ground?

*10. An airplane flies due west at 185 km/h with respect to the air. There is a wind blowing at 85 km/h to the northeast relative to the ground. What is the plane’s speed with respect to the ground?*

11. What are the components of a vector of magnitude 1.5 m at an angle of 35º from the positive x-axis?

12. A hiker walks 14.7 km at an angle 35º south of east. Find the east and north components of this walk.

13. An airplane flies at 65 m/s in the direction 149º counterclockwise from east. What are the east and north components of plane’s velocity?

14. A golf ball, hit from the tee, travels 325 m in a direction 25º south of the east axis. What are the east and north components of its displacement?

*15. A powerboat heads due northwest at 13 m/s with respect to the water across a reiver that flows due north at 5.0 m/s. What is the velocity (both magnitude and direction) of the motorboat with respect to the shore?*

16. An airplane flies due south at 175 km/h with respect to the air. There is a wind blowing at 85 km/h to the east relative to the ground. What are the plane’s speed and direction with respect to the ground?

*17. An airplane flies due north at 235 km/h with respect to the air. There is a wind blowing at 65 km/h to the northeast relative to the ground. What are the plane’s speed and direction with respect to the ground?*

*18. An airplane has a speed of 285 km/h with respect to the air. There is a wind blowing at 95 km/h at 30º north of east with respect to Earth. In which direction should the plane head in order to land at an airport due north of its present location? What would be the plane’s speed with respect to the ground?*

19. A car moves 65 km due east, then 45 km due west. What is its total displacement?

20. Graphically find the sum of the following pairs of vectors whose lengths and directions are shown. a) D and A b) C and D d) C and A d) E and F

B (3)

A (3)

E (5)

D (4)

F (5)

C (6)

21. An airplane flies at 200.0 km/h with respect to the air. What is the velocity of the plane relative to the ground if it flies with: a) a 50 km/h tailwind? b) a 50 km/h head wind?

22. Graphically add the following sets of vectors using the vectors shown in question 20:

a) A, C and D b) A, B and E c) B, D and F.

23. Path A is 8.0 km long heading 60.0° north of east. Path B is 7.0 km long in a direction due east. Path C is 4.0 km long heading 31.5° counterclockwise from east.

a. Graphically add the hiker’s displacements in the order A, B, C.

b. Graphically add the hiker’s displacements in the order C, B, A.

c. What can you conclude about the resulting displacements?

24. A river flows toward the east. Because of your knowledge of Physics you head your boat 53° west of north and have a velocity of 6.0 m/s due north relative to the shore.

a. What is the velocity of the current?

b. What is your speed relative to the water?

25. You walk 30 m south and 30 m east. Find the magnitude and direction of the resultant displacement both graphically and algebraically.

26. A ship leaves its home port expecting to travel to a port 500.0 km due south. Before it moves even 1 km, a severe storm blows it 100.0 km due east. How far is the ship from its destination? In what direction must it travel to reach its destination?

27. A descent vehicle landing on Mars has a vertical velocity toward the surface of Mars of 5.5 m/s. At the same time, it has a horizontal velocity of 3.5 m/s.

a. At what speed does the vehicle move along its descent path?

b. At what angle with the vertical is this path?

28. You are piloting a small plane, and you want to reach an airport 450 km due south in 3.0 hours. A wind is blowing from the west at 50.0 km/h. What heading and airspeed should you choose to reach your destination in time?

29. A hiker leaves camp and, using a compass, walks 4 km E, then 6 km S, 3 km E, 5 km N, 10 km W, 8 km N, and finally 3 km S. At the end of three days, the hiker is lost. By drawing a diagram, compute how far the hiker is from camp and which direction should be taken to get back to camp.

30. You row a boat perpendicular to the shore of a river that flows at 3.0 m/s. The velocity of your boat is 4.0 m/s relative to the water.

a. What is the velocity of your boat relative to the shore?

b. What is the component of your velocity parallel to the shore? Perpendicular to it?

31. A weather station releases a balloon that rises at a constant 15 m/s relative to the air, but there is a wind blowing at 6.5 m/s toward the west. What are the magnitude and direction of the velocity of the balloon?

32. An airplane, moving at 375 m/s relative to the ground, fires a missile forward at a speed of 782 m/s relative to the plane. What is the speed of the missile relative to the ground?

33. A rocket in outer space that is moving at a speed of 1.25 km/s relative to an observer fires its motor. Hot gases are expelled out the rear at 2.75 km/s relative to the rocket. What is the speed of the gases relative to the observer?

**Appendix B**

1. Bob walks 81 m and then he walks 125 m.

a. What is Bob’s displacement if he walks east both times?

b. What is Bob’s displacement if he walks east then west?

c. What distance does Bob walk in each case?

2. A cross-country runner runs 5.0 km east along the course, then turns around and runs 5.0 km west along the same path. She returns to the starting point in 45 minutes. What is her average speed (speed = distance/time)? Her average velocity?

3. Car A is traveling at 85 km/h while car B is at 64 km/h. What is the relative velocity of car A to car B under the following conditions:

a. If they are both traveling in the same direction?

b. If they are headed toward each other?

4. Find *θ* for each of the following:

a. tan *θ* = 9.5143 d. tan *θ*  = 0.1405

b. sin *θ* = 0.4540 e. sin *θ* = 0.7547

c. cos *θ* = 0.8192 f. cos *θ* = 0.9781

5. Find the value of each of the following:

a. tan 28º d. tan 58º

b. sin 86º e. sin 40º

c. cos 2º f. cos 71º

6. You walk 30 m south and 30 m east. Draw and add vectors representing these two displacements.

8. A plane flying at 90º at 1.00 x 102 m/s is blown toward 180º at 5.0 x 101 m/s by a strong wind. Find the plane’s resultant velocity and direction.

9. A man hops a freight car 15.0 m long and 3.0 m wide. The car is moving east at 2.5 m/s. Exploring the surroundings, the man walks from corner A to corner B in 20.0 s; then from corner B to corner C in 5.0 s as shown. With the aid of a vector diagram, compute the man’s displacement relative to the ground.

A

B

C

east

10. A plane travels on a heading of 40.0º for a distance of 3.00 x 102 km. How far north and how far east does the plane travel?

11. What are the *x* and *y* components of a velocity vector of magnitude 1.00 x 102 km/h and direction of 240º.