**Worksheet 1.4 Part II -Vector Addition**

**The Change “∆” Of A Quantity a.k.a. Vector Subtraction**

This deals with the change of a quantity, which can be solved by vector subtraction. We will deal only with ∆v = vf – vi in these questions but the concept will appear several more times in this course. Remember that each term is a vector (therefore, do not expect to simply subtract the values!!)

Solve all problems on your own paper showing all work! ***Remember to draw a diagram!***

1. If a car that was originally going 40. m/s towards the east took 5.0 s to turn and go 30. m/s towards the south, what is the acceleration of the car? **∆v = vf – vi = 50 m/s therefore a = ∆v/∆t = 50/5 = 10. m/s2**
2. What is the acceleration of a car that changes from 60. m/s to the north to 60. m/s to an angle of 45o East of North in a time of 3.0 s? **∆v = vf – vi = 45.9 m/s therefore a = ∆v/∆t = 45.9/3.0 = 15.3 m/s2**
3. What is the acceleration of a bullet that was shot at 40. m/s in the horizontal and then changed to a velocity of 44.5 m/s at 26.1o below the horizontal in a time of 2.0 seconds?

**∆v = vf – vi = 19.5 m/s therefore a = ∆v/∆t = 19.5/2.0 = 9.75 m/s2**

1. What is the acceleration of a ball that bounces off a wall in 0.30 s if its incoming velocity is 60. m/s and its recoil velocity is 50. m/s? **∆v = vf – vi = 110. m/s therefore a = ∆v/∆t = 110/0.3 = 367 m/s2**
2. A car is traveling at 100 km/h **(27.8 m/s)**, due northwest. The driver puts on the brakes and turns the corner. Four seconds later, he is heading east at 50 km/h **(13.9 m/s)**. What is the average acceleration?

**Relative Velocity and Navigation -** Solve all problems on your own paper showing all work!

**The Across the River Problem**

1. A boat can travel 2.30 m/s in still water. If the boat heads directly across a river with a current of 1.50 m/s:

1. What is the velocity of the boat relative to the shore? **2.75 m/s**
2. At what angle compared to straight across is it traveling? **θ = 33.1°**
3. How far from its point of origin is the boat after 8.0 s? **22 m**

 **θ = 40.7°**,**1.74 m/s upstream**

**Vector Problems (Trig. Solutions)**

1. How far east has a person walked if he travels 350 m in a direction 25° E of N? **148 m**
2. What would be the resulting displacement if a snail crawls 2.0 m north and then 3.0 m east? What is the snail's direction from the starting point? **3.6 m & 33.7° N of E**
3. A boat travels east at 13 km/hr when a tide is flowing north at 1.2 m/s. Find the actual velocity and heading of the boat. **3.8 m/s at 18.4° N of E**
4. A person that swims at 3.2 m/s swims straight across a river with a current of 1.4 m/s. What is the resulting velocity of the swimmer (across and down stream)? At what angle compared to straight across is the swimmer moving? **3.5 m/s & 23.6°**
5. The swimmer above decides to swim into the current at such an angle that he will travel straight across. Find the angle (compared to straight across) at which he would have to swim. Calculate the velocity across the stream. **2.9 m/s & 25.9°**
6. If the river above is 1.58 km across how long will it take for each of the swimmers in question 5 & 6 to cross the river? How far downstream will the swimmer in question 5 land? **#5 8.2 min, #6 9.1 min, 690**
7. A plane with an air speed of 400.0 km/hr wants to go north but a wind of 70.0 km/hr is blowing west. What must be the plane's heading (to go north)? What will be its resulting ground speed? **10° E of N, 394 km/h**
8. A plane is traveling at 650. km/hr in a direction 37° east of north. Find the how fast the plane is traveling north and east. Find how far north and how far east it would travel in 90 minutes. **Velocity: 519 km/h North and 391 km/h East, Distances: 779 km North and 587 km East**
9. A boat has a speed of 9.0 km/hr, in still water and is traveling down a river with a current of 2.0 m/s. What will be its "riverbank" velocity going downstream? At what angle would this boat have to travel across the river in order to move straight across and what will be its resultant velocity as measured from the riverbank? **downstream = 4.5 m/s, upstream = 0.5 m/s, 53°**

**Vector problems (Component or Sine-Cosine Law Solutions)**

1. A seagull flying with an air speed of 10 km/h is flying north but suddenly encounters a wind of 5 km/h at 20° south of east. What will be the new direction and airspeed of the seagull? **9.53 m/s 60.5˚ N of E**
2. A pilot wishes to reach a city 600.0 km away in a direction of 15° S of W in two hours. **(v = 300 km/h at this same direction - this is the resultant vector in the vector diagram!)** If there is a wind of 70 km/h blowing at 10° W of S. What must be the heading and air speed of the plane? **Heading is 2˚ S of W at an airspeed of 278 km/h**
3. A plane that can fly at 250 km/h wishes to reach an airport that has a bearing of 25° W of N from its present location. If there is a 50.0 km/h wind blowing directly to the west what should be the heading of the plane. **14.6˚ W of N (set up vector diagram and then use Sine Law)** What will be its ground speed? **267 km/h** How long would it take to get to the airport if it were 560 km away? **2.1 hours**
4. A pilot of an airplane with an air speed of 300. km/h is on a heading of due north but finds he is actually traveling 350 km/h 8° W of N. What must be the wind velocity and direction? **67.4 km/h at 43.7˚ N of W**
5. A plane heading due north with an air speed of 250 km/h is blown off course by a wind blowing at 50 km/h to the NE. What will be the ground speed and direction of the plane? **288 km/h at 7.1˚ E of N**
6. A boat capable of 10.5 knots in still water wishes to cross a narrows at a bearing of 23° N of E. If the current in the narrows is at 3.7 knots at 8° E of S. What must be the heading of the boat and what will be its chart speed? **The trick is to draw the resultant vector then the two vectors that will add to this. Must use the sin law first to find the angle between the vectors (I found all three angles). The angle between the two vectors is 105˚. The velocity is 8.9 knots at 43˚ N of E.**

**Worksheet 1.4**

*Change in Quantity*

1) 10 m/s2 53o W of S 2) 15 m/s2 68o E of S 3) 9.8 m/s2 down 4) 367m/s2 back

5) 9.7 m/s2 30o S of E

*Across the River Problem*

1) a. 2.7 m/s 33o b. 33o c. 21.6 m

*Vector Problems(Trig)*

1) 148 m 2) 3.6m @ 56o E of N 3) 3.8 m/s @ 18o N of E 4) 23.6o 5) 2.9 m/s @ 26o upstream

6) swimmer 5: 494 s, ends up 693 m downstream, swimmer 6: 545 s 7) 394 km/hr @ 10.1o E of N

8) 587 km E and 779 km N 9) Riverbank velocity = 11 km/hr ; 8.8 m/s @ 12.8o upstream

*Vector Problems (Component or Sine/Cosine Law)*

1) 9.5 km/h @ 29.5o E of N 2) 278 km/hr @ 1.8o S of W

3) 267 km/h @ 14.6o W of N; 2.1 h 4) 67.4 km/hr @ 46.3o W of N

5) 288 km/h @ 8o E of N

6) The trick is to draw the resultant vector then the two vectors that will add to this. Must use the sin law first to find the angle between the vectors (find all three angles). The angle between the two vectors is 105˚. The velocity is 8.9 knots @ 43˚ N of E.