4.MOTION IN A PLANE

1. For the vectors $\vec{A}$ and $\vec{B}$ shown in fig.1, find the magnitude and direction of
   i) Vector sum $\vec{A} + \vec{B}$;
   ii) Vector difference $\vec{A}$ - $\vec{B}$.
   Using the answer to *ii*), state the magnitude and direction of $\vec{B} - \vec{A}$.

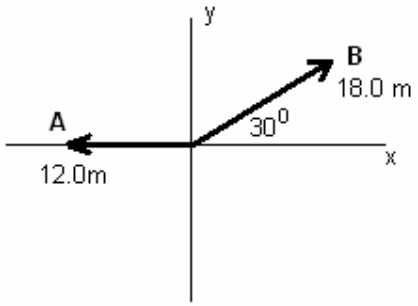


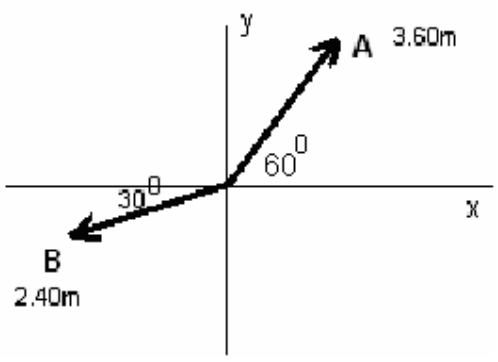
Fig.1

2. Write each of the vectors in fig. 1 in terms of unit vectors $\hat{i}$ and $\hat{j}$.

3. Find the magnitude and direction of the vector represented by each of the following pairs of components:
   i) A_x = 5.6 cm, A_y = -8.2 cm
   ii) A_x = -2.7 m, A_y = -9.45 m

4. Vector $\vec{A}$ has components A_x = 3.4, A_y = 2.25 cm
   Vector $\vec{B}$ has components B_x = -4.1 cm, B_y = 3.75 cm.
   Find *i*) the components of the vector sum $\vec{A} + \vec{B}$
   ii) the magnitude and direction of $\vec{A} + \vec{B}$
   iii) the components of the vector difference $\vec{A} - \vec{B}$
   iv) the magnitude and direction of $\vec{A} - \vec{B}$.

5. a) Refer to fig.2 and use unit vectors to express the vector $\vec{C}$, where
   $\vec{C}$ = 2.00 $\vec{A}$ – 5.00 $\vec{B}$.



   b) Find the magnitude of $\vec{C}$

Fig.2

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6. Find the angle between the following pairs of vectors:

i) $\vec{A}$ = -1.00 $\hat{i}$ + 6.00 $\hat{j}$ and $\vec{B}$ =3.00 $\hat{i}$ - 2.00 $\hat{j}$.

ii) $\vec{A}$ = -4.00 $\hat{i}$ + 2.00 $\hat{j}$ and $\vec{B}$ =7.00 $\hat{i}$ - 14.00 $\hat{j}$.

7. Is the direction of $\hat{i}$ x $\hat{j}$ into or out of the page in *i)* fig. 3 *ii)* fig. 4

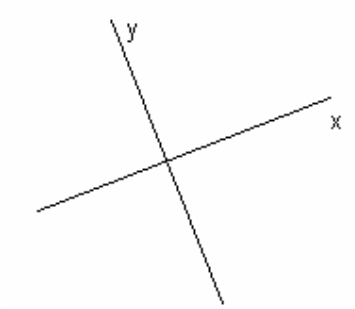

Fig. 3

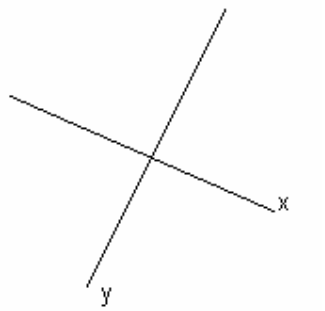

Fig.4

8. For the vectors $\vec{A}$ *and* $\vec{B}$ in fig. 5.
Find the magnitude and direction of $\vec{A}$ x $\vec{B}$ and $\vec{B}$ x $\vec{A}$

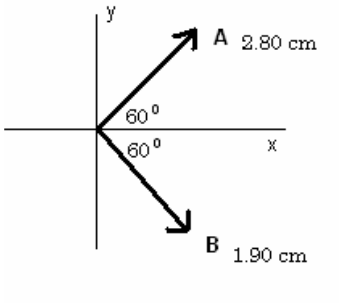

Fig.5

9. A motor cycle stunt rider rides off the edge of a cliff. Just at the edge of the cliff his velocity is horizontal, with magnitude 9.0 m/s. find the motorcycle's position, distance from the edge of the cliff and velocity after 0.50 s.

10. You toss a water balloon from your window 8.0 m above the ground. When water balloon leaves your hand, it is moving at 10.0 m/s at an angle of 20° below the horizontal. How far horizontally from your window will the balloon hit the ground?

11. In a carnival ride, the passengers travel at constant speed in a circle of radius 5.0 m. They make one complete circle in 4.0 s. What is their acceleration?

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12. You are driving north on a straight two-lane road at constant speed of 88 km/h. A truck travelling at a constant speed of 104 km/h approaches you in the other lane.

    a) What is the truck's velocity relative to yours?
    b) What is your velocity with respect to the truck?
    c) How do the relative velocities change after you and truck have passed each other?

13. A model of a helicopter has 4 blades, each 8.2 m in length from the central shaft to the blade tip. In a wind tunnel, this model rotates at 600 rev/min,
    a) What is the linear speed of the blade tip in m/s?
    b) What is the radial acceleration of the blade tip expressed as multiple of the acceleration due to gravity, g?

14. An airplane pilot wishes to fly due north. A wind of 80.0 km/h is blowing toward the west
    a) if the air speed of the plane in still air is 240.0 km/h, in what direction should the pilot fly the plane?
    b) What is the speed of the plane? Illustrate with a vector diagram.

15. A man stands on the roof of a 30 m tall building and throws a rock with a velocity of magnitude 40.0 m/s at an angle of 30º above the horizontal. Calculate:
    a) maximum height above the roof reached by the rock
    b) the magnitude of the velocity of the rock just before it strikes the ground
    c) The horizontal distance from the base of the building to the point where the rock strikes the ground.

16. Consider two displacements, one of magnitude 3 m and another of magnitude 4 m. Show how the displacement vectors may be combined to get a resultant displacement of magnitude (*i*) 7m, *ii*) 1 m and c *iii*) 5 m.

17. The x component of vector $\vec{A}$ is -25.0 m and y component is 40 m. a) What is the magnitude of $\vec{A}$? b) What is the angle between the direction of $\vec{A}$ and the x direction?

18. Three vectors, $\vec{a}$, $\vec{b}$, $\vec{c}$ each have a magnitude of 50 m and lie in an **xy** plane. Their directions relative to the positive direction of the axis are 30º, 195º and 315º respectively. What are the magnitude and angle of $\vec{a} - \vec{b} + \vec{c}$? What are the magnitude and angle of a fourth vector $\vec{d}$ such that $(\vec{a} + \vec{b}) - (\vec{c} + \vec{d}) = 0$?

19. Show that $\vec{a} \times (\vec{b} \times \vec{a})$ is zero for all vectors $\vec{a}$ and $\vec{b}$.

20. A particle moves so that its position as a function of time is $\vec{r} = \hat{i} + 4t^2 \hat{j} + t \vec{k}$. Write expressions for (*i*) its velocity and (*ii*) acceleration as a function of time.

21. A rifle is aimed horizontally at a target 30 m away. The bullet hits the target 1.9 cm below the aiming point. What is the bullet's time of flight and its speed as it emerges from the rifle?

22. A stone is catapulted at time = 0, with an initial velocity of magnitude 20.0 m/s at an angle of 40°above the horizontal. What are the magnitudes of the horizontal and vertical

components of its velocity at t = 1.10 s? Repeat for the horizontal and vertical components at t = 1.80 s and at t = 5.0 s.

23. A ball is shot from the ground into air. At a height of 9.1 m, its velocity is observed to be $\vec{v}$ = 7.6 $\hat{i}$ + 6.1 $\hat{j}$ in meters per second (a) To what maximum height does the ball rise? (b) What total horizontal distance does the ball travel? (c) What is the magnitude of its velocity just before it hits the ground?

24. What is the magnitude of the acceleration of sprinter running at 10 m/s when rounding a turn with a radius of 25 m?

25. An astronaut is rotated in a horizontal centrifuge at a radius of 5.0 m. (a) what is the astronauts speed if the centripetal acceleration has a magnitude of 7.0 g? (b) How many rotations per minute are required to produce this acceleration? (c) What is the period of motion?

26.A boat is travelling upstream at 14 km/h with respect to the water of a river. The water is flowing at 9 km/h with respect to the ground. (a) What is the velocity of the boat with respect to the ground? (b) A child on the boat walks from front to rear at 6 km/h with respect to the boat. What is the child's velocity with respect to ground?

27.Ship A is located 4.0 km north and 2.5 km east of ship B. Ship A has a velocity of 22 km/h toward the south and ship B has a velocity of 40 km/h in a direction 37° north of east (a) What is the velocity of A relative to B? Assume $\hat{i}$ is towards the east. (b) Write an expression for the position of A relative to B as a function of t, where t = 0 when the ships are in the positions described above. (c) At what time is the separation between the ships least? (d) What is that least separation?