Using the definitions of sine and cosine, the vector components of $\vec{A}$ can be written as

$$\boxed{A_x = |\vec{A}| \cos\theta = A\cos\theta}$$

$$\boxed{A_y = |\vec{A}| \sin\theta = A\sin\theta}$$

Likewise we can express the magnitude and direction of $\vec{A}$ as

$$\boxed{A = |\vec{A}| = \sqrt{A_x^2 + A_y^2}}$$

$$\boxed{\tan\theta = \frac{A_y}{A_x}}$$

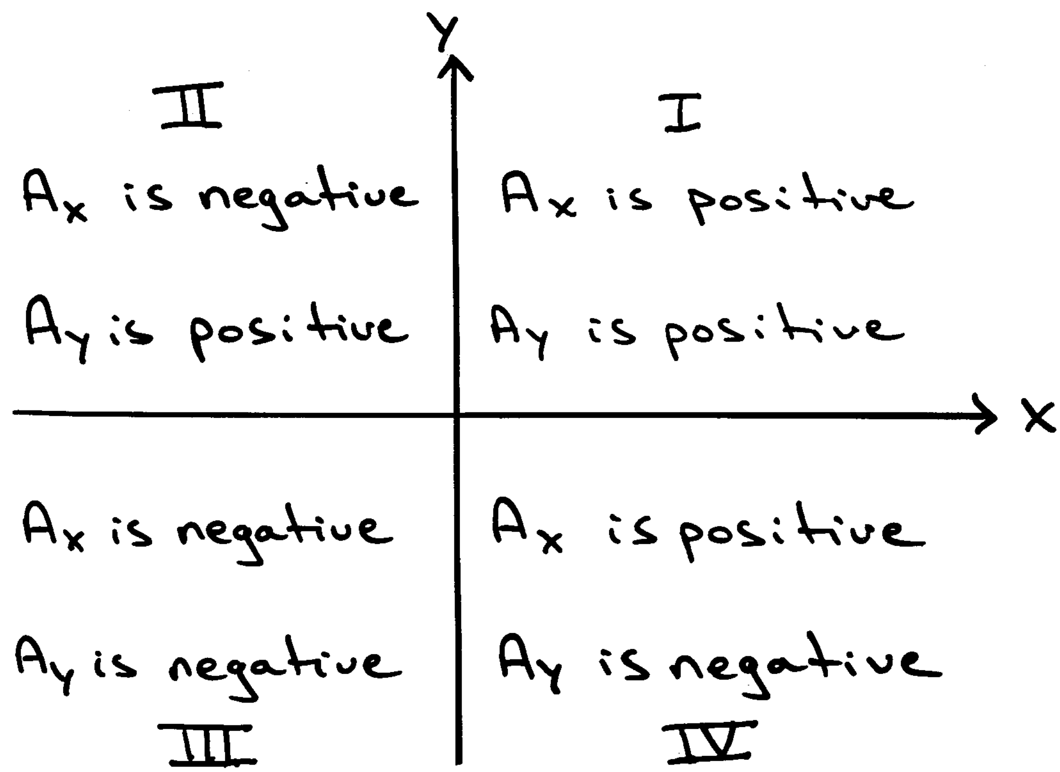
Note: If a coordinate system other than the one shown previously is used, then the above equations must be modified accordingly.

To properly solve for θ:

1. Use the equation

$$\tan \theta = \frac{A_y}{A_x}$$

2. Note the signs of the x and y components. This will tell you what quadrant the vector is in.



Convention: The positive direction is taken as counterclockwise from the +x axis.

Example: A disoriented physics professor walks 4.92 km east, 3.95 km south, and then 1.8 km west.

Find the magnitude and direction of the resultant displacement.

<u>Answers</u>

$|\vec{R}| = 5.03$ km

$\theta = -51.7°$

Problem-Solving Strategy

Adding Vectors

1. Select a coordinate system.

2. Sketch the vectors that are to be added (or subtracted). Label each vector.

3. Find the x and y components of all vectors

4. Find the algebraic sum of the components (the resultant) in both the x and y components

5. Use the Pythagorean theorem to find the magnitude of the resultant vector.

6. Use a suitable trigonometric function to find the angle the resultant vector makes with the x axis.

Projectile Motion

Consider an object moving in both the x and y directions simultaneously. This particular form of two-dimensional motion is called projectile motion.

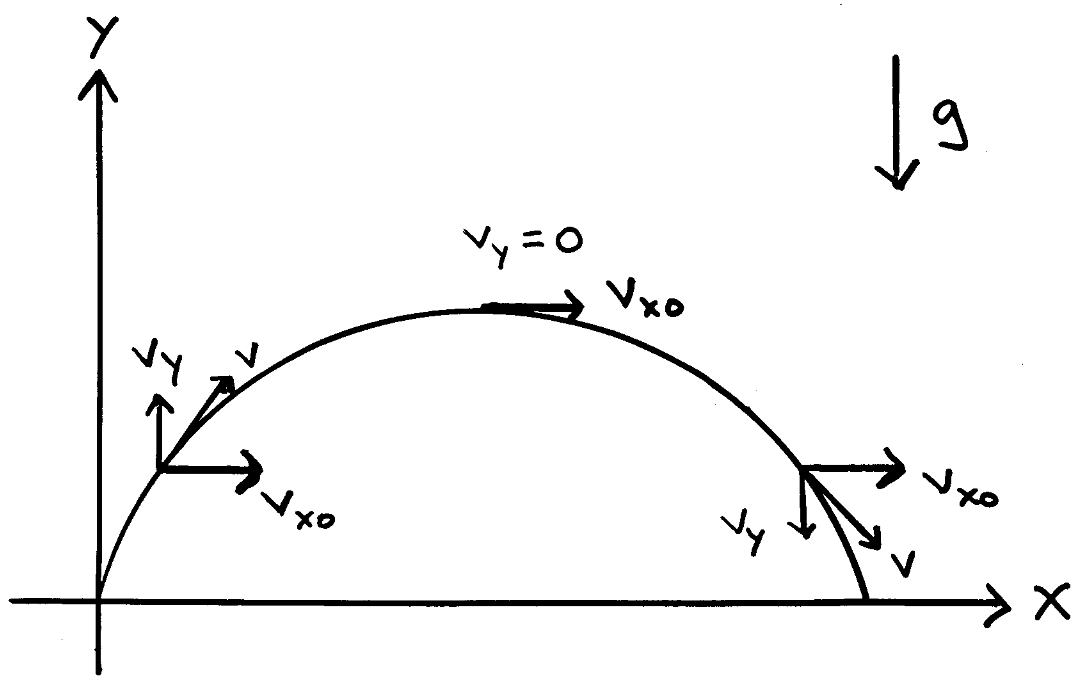
Three assumptions are made when dealing with this motion

1. The free-fall acceleration, g, has a magnitude of $9.8\ m/s^2$, is constant over the range of motion, and is directed downward.

2. Air resistance is negligible

3. The rotation of the Earth does not affect the motion

With these assumptions, the path of a projectile is a parabola



Notes

1. With the coordinate system shown, the acceleration in the y direction is $-g$, and the acceleration in the x direction is zero.

Therefore

$\boxed{a_y = -g}$ $\boxed{a_x = 0\ m/s^2}$ $\Rightarrow$ $\boxed{V_{ox} = V_x}$

2. Note the symmetry of projectile motion.

3. The magnitude of the velocity vector is a minimum when it reaches maximum height

4. At maximum height, the velocity in the y-direction is zero.

When dealing with problems in projectile motion, break the picture into x and y components. The unknowns can be solved for using the kinematic equations developed for motion with constant acceleration.

Example: A rescue plane drops a package to a party of explorers, as shown. The plane is traveling horizontally at 40 m/s at a height of 100 m above the ground.

(a) Where does the package strike the ground relative to the point at which it was released?

(b) What are the horizontal and vertical components of the velocity of the package just before it hits the ground?

Answers

(a) $x = 180.7$ m

(b) $v_x = 40$ m/s

$v_y = -44.3$ m/s

Problem Solving Strategy

Projectile Motion

1. Select a coordinate system and draw a picture

2. Resolve the initial velocity vector into x and y coordinates. Make a list of all known and unknown quantities.

3. Treat the horizontal motion and the vertical motion independently.

4. Provided $a_x = 0$, follow the techniques for solving problems with constant velocity to analyze the horizontal motion of the projectile.

5. Follow the techniques for solving problems with constant acceleration to analyze the vertical motion of the projectile.