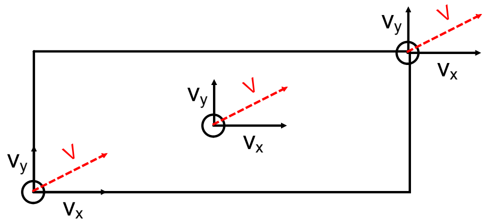
3.2 - Components of Motion

Ping Pong Time!

Mission: Two students must blow a ping pong ball from one corner of the table to the other with CONSTANT velocity.

- One blows in the x direction
- One blows in the y direction

Do this: draw labeled vectors showing the separate x and y component velocities of the ball as it moves across the table.

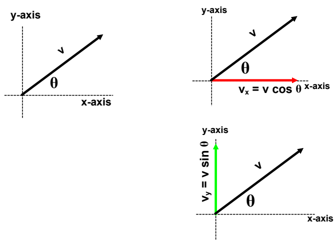


Components of Motion

Def: the separate x and y parameters of motion: position, velocity, and acceleration.
Time is always the same for x and y.

Decomposing vectors works the same regardless of physical quantity analyzed.

Ex: Velocity:



$$v_x = v\cos\theta$$
$$v_y = v\sin\theta$$

Components of Motion

The direction of the overall velocity vector is obtained the same as any other vector too:

$$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right)$$

Kinematics of Component Motion

For x and y components - use subscripts to show what's what.

Position: $x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$

$$y = y_0 + v_{y0}t + \frac{1}{2}a_y t^2$$

Velocity: $v_x = v_{x0} + a_x t$

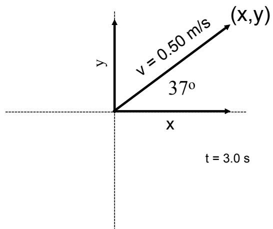
$$v_y = v_{y0} + a_y t$$

Example 1 - Position

Starting at the origin, a ball rolls at a constant 0.50 m/s velocity at a 37° angle.

Find its (x, y) coordinates after 3.0 seconds.

Strategy: Draw a picture, decompose velocity, then use the position equation (for x and y separately) to find its location.
What does constant velocity imply?



Example 1 - Position

Decompose velocity:

$$v_x = v\cos\theta = 0.50\frac{m}{s}\bullet(\cos 37^0) = 0.40\,m/s$$

$$v_y = v\sin\theta = 0.50\frac{m}{s}\bullet(\sin 37^0) = 0.30\,m/s$$

Example 1 - Position

Kinematics: use the position equation (acceleration drops out - constant velocity):

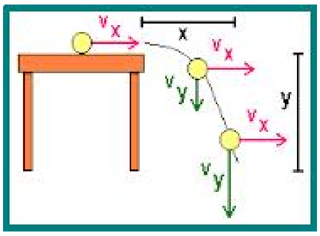
$$x = x_0 + v_x t = 0m + 0.4\frac{m}{s}\bullet 3.0s = 1.2m$$

$$y = y_0 + v_y t = 0m + 0.3\frac{m}{s}\bullet 3.0s = 0.9m$$

Coordinates = (1.2, 0.9)

Curvilinear Motion

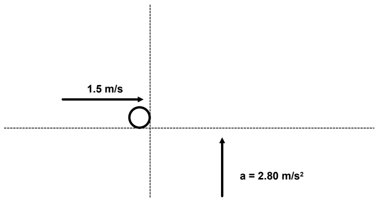
An object displays this when it's accelerated in a direction other than 0° or 180°.



Example 2 - Position

A ball rolling along the x axis at 1.50 m/s receives an acceleration of 2.80 m/s² in the positive y direction.
1. What is the position of the ball 3.0 seconds later?

Draw a picture:



Example 2 - Position

$$x = x_0 + v_{x_0}t + \frac{1}{2}a_x t^2$$

$$= 0m + 1.50m/s\bullet(3.0s) + \frac{1}{2}\bullet 0m/s^2\bullet(3.0s)^2 = 4.50m$$

$$y = y_0 + v_{y_0}t + \frac{1}{2}a_y t^2$$

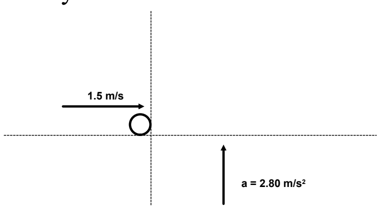
$$= 0m + 0m/s\bullet(3.0s) + \frac{1}{2}\bullet 2.80m/s^2\bullet(3.0s)^2 = 12.6m$$

Example 3 - Velocity

The same ball rolls along the x axis at 1.50 m/s with an acceleration of 2.80 m/s² in the +y direction.

What are the velocity & direction of the ball after 3.0 seconds?

Same picture:



Example 3 - Velocity

Find x and y component velocities, then find the vector sum of velocity:

$$v_x = v_{x_0} + a_x t = 1.50\,m/s + 0\,m/s^2 \bullet (3.0\,s) = 1.50\,m/s$$

$$v_y = v_{y_0} + a_y t = 0\,m/s + 2.80\,m/s^2 \bullet (3.0\,s) = 8.40\,m/s$$

$$v = \sqrt{v_x^{\,2} + v_y^{\,2}} = \sqrt{(1.5\,m/s)^2 + (8.40\,m/s)^2} = 8.53\,m/s$$

Are we done?

Example 3 - Direction

We have to determine the direction of motion:

$$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{8.40\,m/s}{1.50\,m/s}\right) = 79.9^0$$

Homework

Read 3.1 & 3.2 in your books
3.2 Problems in your Booklets
Due: Next Class