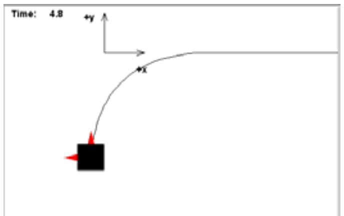
Worksheet for Exploration 3.4: Space Probe with Constant Acceleration



When you studied projectile motion, you learned that for projectile motion the x acceleration is zero and constant (which results in a constant x velocity) and the y acceleration is constant and downward toward Earth with a magnitude of 9.8 m/s^2. What mathematical curve describes the shape of the path of the projectile? Its shape is a parabola. It turns out that the shape of the path of any object that has constant acceleration and an initial velocity that is in a different direction than the acceleration is a parabola.

In the animation shown **(position is given in meters and time is given in seconds)**, a space probe has engines that can fire on all four sides. Two of the engines engage at t = 2 s. Restart. The acceleration is constant and zero before the engines engage, and it is constant (but not equal to zero) after the engines engage.

a. What is the direction of the x component of the acceleration after the engines engage?

   i. You can confirm your answer by measuring the x-component of the velocity at two different times after the rocket fires. Actually you can measure average velocity for a short time interval.

   ii. If you are not sure what to do, try measuring the x position at times 3.9s and 4.1s. Do this again for say 4.9 and 5.1s. Note that the average velocity for these time intervals is equal to the instantaneous velocity at the center time IF the acceleration is constant (it is here).

$X_{3.9}$=	$X_{4.1}$=	$X_{4.9}$=	$X_{5.1}$=	Δt=

v_{x4}=________

v_{x5}=________

b. What is the y velocity before the engines engage?

c. After the engines engage, how is the y velocity different?

i. Consider measuring the y component of acceleration.

ii. As you did above (for x) measure the y-component of the velocity at two different times after the rocket fires. That means you must measure an average velocity for a short time interval.

iii. If you are not sure what to do, try measuring the y position at times 3.9s and 4.1s. Do this again for say 4.9 and 5.1s. Note that the average velocity for these time intervals is equal to the instantaneous velocity at the center time IF the acceleration is constant (it is here).

$Y_{3.9}$=	$Y_{4.1}$=	$Y_{4.9}$=	$Y_{5.1}$=	Δt=

v_{y4}=________

v_{y5}=________

d. Now click here to view the velocity and acceleration vectors. Do they match what you predicted?

i. Use the information you collected above to determine the acceleration vector. Write out the definition of acceleration and then apply to each component below.

ii. First determine a_x. Then a_y (recall that acceleration is constant from the time the rockets fire on). You are calculating acceleration after the rockets fire (think about what a is before the rockets fire).

a_x=_______

a_y=_______

iii. Now convert each of the vectors you have (you have Cartesian components) to polar (magnitude and direction). Hint: you will need to use Pythagorian theorem and some trigonometry.

V_4=	θ_{v4}=
V_5	θ_{v5}
a	θ_a