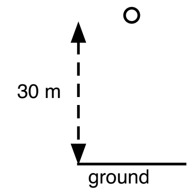
Coordinate Systems

The first step in doing a physics problem is to define your coordinate system. This means several things actually:

- Choose your origin. Be explicit about where zero is. It is almost always easier to make either the initial or the final position zero.
- Choose the directions of your axes. Be explicit about which way is positive. You have to be consistent with your signs when you do your math, so make sure you know what you are saying.
- Cartesian or polar coordinates (or something else.) In this class, cartesian will almost always be the prefered and easier choice. Polar coordinates comes up in more advanced problems that are typically above this level of physics.

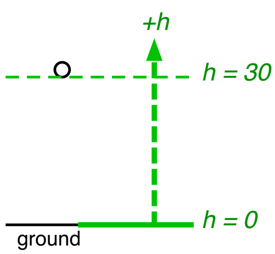
Even though it doesn't change the basic equation(s) you are using, your choice of coordinate system does dictate which values are zero and what is positive or negative. Let me illustrate this by solving the same problem a few different ways.

A rock is dropped from a height of 30 meters.
How long will it take to hit the ground? What is its final velocity?
(See diagram to the right.)



Coordinate System 1

We will use "h" to represent the height of the ball and call the ground a height of zero. That means the initial height of the ball is +30 meters. Since gravity is trying to accelerate the ball down, the acceleration due to gravity is –10 m/s^2.

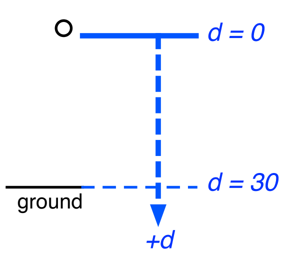


$$h = \frac{1}{2}at^2 + v_i t + h_i$$
$$0 = \frac{1}{2}(-10)t^2 + (0)t + 30$$
$$5t^2 = 30$$
$$t = \sqrt{6} = 2.45\ s$$

$$v = at + v_i$$
$$v = -10(2.45) + 0 = -24.5\ m/s$$

Coordinate System 2

We will use "d" to represent the distance the ball falls. That means the ball will hit the ground after it falls 30 meters and the initial "distance" of the ball is zero. Notice this means we are saying that down is positive! Since gravity is trying to accelerate the ball down, the acceleration due to gravity is +10 m/s^2.



$$d = \frac{1}{2}at^2 + v_i t + d_i$$
$$30 = \frac{1}{2}(10)t^2 + (0)t$$
$$5t^2 = 30$$
$$t = \sqrt{6} = 2.45\ s$$

$$v = at + v_i$$
$$v = 10(2.45) + 0 = 24.5\ m/s$$

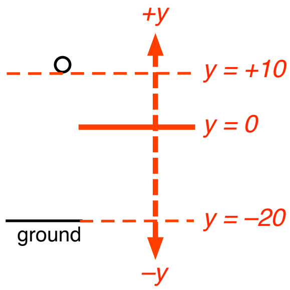
Coordinate Systems

Notice how both coordinates end up with the same time of 2.45 seconds Don't be fooled by the opposite signs of the final velocities! They are both saying that the object has a speed of 24.5 m/s and it is traveling down – so they are the same velocities, just expressed in different coordinates. The choice merely dictates how you get there. Either of those two coordinate systems would be fine, reasonable and easy to understand. When you are first learning physics, it may be easier to always choose the lowest position to be a height of zero, and so make all the heights positive and gravity negative (i.e. coordinate system 1). But as you gain fluency and confidence, feel free to choose a coordinate that is most convenient for the problem you are trying to do.

However, please do not choose a coordinate system that makes the problem more complicated or obfuscated, even though you get the correct answer. While the following choice is technically correct, please don't do something like this:

Coordinate System 3 (Bad, stupid, evil choice.)

We will use "y" to represent the coordinate of the ball. We will call positive y up, but for some inexplicable reason we will put the origin 10 meters below the starting position of the ball. That means the initial coordinate of the ball is +10 meters and the coordinate when it hits the ground is –20 meters. At least up is positive, so that gravity is $-10\ m/s^2$.



$$y = \frac{1}{2}at^2 + v_i t + y_i$$
$$-20 = \frac{1}{2}(-10)t^2 + (0)t + 10$$
$$5t^2 = 30$$
$$t = \sqrt{6} = 2.45\ s$$

$$v = at + v_i$$
$$v = -10(2.45) + 0 = -24.5\ m/s$$

It gave the correct answers, but you probably spent a lot of time looking at the picture going "huh?!" and "why would anyone do this??" Here is a pro tip for getting good grades or evaluations on your work: you don't want the person reading your work to say "huh??" or "why would anyone do this??"

Looking Ahead

In one dimension, all you are choosing is the origin and positive direction. Once we get into two (or more) dimensions, you have more choices. While it doesn't really come up in this class, there are problems that are much easier to do in polar coordinates rather than cartesian cooridinates. Something that will come up later on is using a rotated coordinate system. When dealing with an inclined plane, it is often easier to use a coordinate system that is parallel and perpendicular to the plane, instead of regular x and y coordinates. (Don't worry - that will actually make some sense when we get there.)