Let’s take a very simple situation and work our way up.

A ball is dropped from 10 meters above the ground, and as we’ll see later in the course, a falling object undergoes a constant acceleration of . We’ll discuss this in more detail later, and we’ll get into the physics of freefall at length, but for now, we’ll just show you how to run the mechanics of the simulation. How far above the ground is the ball 0.02 seconds later?

We’re dealing with very small amounts of time, so our assumption that things are constant will be true. To get started, we’ll set up a table:

|  |  |  |  |
| --- | --- | --- | --- |
| Time (t) | Position (x) | Velocity (v) | Acceleration (a) |
| 0 | 10 | 0 | -9.81 |
|  |  |  |  |
|  |  |  |  |

Our table has position, velocity, acceleration, and time, as these will all play into the motion of the ball. We’ll define the beginning of the drop at t=0, with an initial position of 10 meters, and the initial velocity of 0 m/s, as the ball isn’t moving at the very beginning of the drop. For the acceleration, as stated earlier, it’s . Again, don’t get too engrossed in the physics right now, we’ll talk about why it’s a negative and a positive much later. For now, I just want to go through the mechanics.

Now we’ll move on to some time later. We’re going to go some small amount of time later, so let’s pick our change in time to be 0.01, since it’s small and fits into 0.02 seconds nicely. Remember, this whole idea is predicated on the assumption that velocity and acceleration aren’t changing very much over the time, and the only way that can be true is if the time is small, so we need to take small time steps. For the next time step, the time is the previous time plus the change in time, or , which comes out to be 0.01. Acceleration won’t change, so we can leave that as is.

Now what about the velocity and the position? From above, we solved for final position and final velocity as

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We can use the initial position, initial velocity, and acceleration to solve for the final velocity and final position. Remember, since we’re taking a small time step, the velocity won’t change much, so we can replace the average velocity with just the initial velocity. Acceleration doesn’t change, so the average acceleration is just what it started as in the beginning. Plugging in the numbers gives us:

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We can use these numbers to continue our table:

|  |  |  |  |
| --- | --- | --- | --- |
| Time (t) | Position (x) | Velocity (v) | Acceleration (a) |
| 0 | 10 | 0 | -9.8 |
| 0.01 | 10 | -0.0981 | -9.8 |
|  |  |  |  |

We can repeat this process for the next step in time, using the values we found for the next time step as our new initial conditions. So, plugging in the numbers into the equations:

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And putting out new values into the table:

|  |  |  |  |
| --- | --- | --- | --- |
| Time (t) | Position (x) | Velocity (v) | Acceleration (a) |
| 0 | 10 | 0 | -9.81 |
| 0.01 | 10 | -0.0981 | -9.81 |
| 0.02 | 9.99902 | 9.99902 | -9.81 |

So the answer to our initial problem is that the ball is 9.99902 meters off the ground 0.02 seconds later.

The ball doesn’t move very far in the short amount of time; we could have figured that out probably by intuition. However, using simulations can better your understanding of concepts such as acceleration and velocity. For example, notice that the ball’s position doesn’t change in the first time step. Through this simulation, you can see that the acceleration does not result in a change in position immediately, but rather a change in velocity, and it’s this velocity that causes the change in position.