But what about objects that aren’t collections of point particles? Well, if the object is uniform, and this is a very important caveat, then the center of mass will be at the geometric center of the object. For example, if we have say a meter stick, then the center of mass will be at the 50-centimeter mark as that’s the middle of the meter stick. If I have a metal washer, then the center of mass will be at the geometric center, right in the middle. You can notice that the center of mass does not need to be inside the body of the object. It can in fact be some random point in space. The center of mass of the washer is not within the metal, it’s within the center of the hole.

But what about objects that are not uniform? Well, the answer in this case is divide the object up into uniform chunks, find the center of mass of each chunk, treat each chunk is a point particle located at the center of mass, and then calculate as usual.

So, here I have a nice example problem of a slab made of a light half and a heavy half, and let’s think about trying to find the center of mass of this object. Thinking ahead, I expect it to be on this side of the middle, because this is the heavier side of the object. Furthermore, I can already say from the symmetry of the problem that the center of mass is going to lie along this line, right in the middle, vertically, of the object.

Now we follow the same procedure with point masses. First, we establish a coordinate system; we’ll set the origin to be at the center of mass of the left chunk. This will simplify our calculation for reasons we’ll explore in a bit. We’ll also have to break down the problem into x and y coordinates. However, like earlier in this section, we can look at the symmetry of the problem to simplify it. You’ll notice that the object is symmetrical in the y direction, and therefore we can assume that the center of mass will be at y=0m. Next, we set up our center of mass calculations for each chunk. For the left chunk, we have:

Again, we take the position of the point mass and weight it with its mass over the total mass. Since the position is at 0m, however, we know it’ll go to 0; this is why we set the origin to be at the center of mass of one of the objects. Moving on to the right chunk, we’ll need to find the position of its center of mass. The center of mass of the object will be at its geometric center, and we can see that there’s 1 meter on each side of the center of mass, and 2 meters separating both center of masses. So, we have:

And the total weighted average of the center of mass will be:

Doing the calculation, we get 1.6m, so the center of mass will be just to the left of the center of mass of the right chunk.

So, that’s one part of the definition for center of mass, the mass weighted average position of the object. The center of mass is also the location where gravity can be said to act. As I said at the beginning of this video, when we discuss torque, we’ll be interested in where each force acts. For example, when I open a door, I tend to apply the force at the knob in the door. Gravity acts at the center of mass.

So, if we look at this chicken and we were to make a free body diagram, we would say there are two normal forces, one for each foot, and the weight force, but now we’re going to start thinking about where each force is being applied. The two normal forces are being applied one on each foot, so they’re being applied there, and the weight force is applied at the center of mass, or the center of gravity, remember that these are synonymous terms as far as this class is concerned, which is roughly in the middle of the chicken.

So, the normal forces get applied where the feet meet the ground and the weight force gets applied at the center of gravity, or the center of mass. So, this is the second part of the definition of center of mass. The center of mass is the point where gravity can be set to act. This part of the definition of center of mass has some consequences. The first piece is that if an object is suspended from a point, then the center of mass will be below the point from which it is hung.

So, let’s say we have some oddly shaped object, and I suspend it from a point like here, and I draw a nice line hanging straight down. The center of mass is somewhere on that line. Now, if I take this same object and hang it from a different point, I know that the center of mass is somewhere on this line. Where the two lines cross will be the center of mass. This technique is useful for finding the center of mass of irregular objects. Another consequence of the definition of center of mass as being the point where gravity is said to act means that the center of mass is what follows the parabolic path that we know and love for objects and projectile motion. So, this hammer follows a rather complicated path, but the center of mass, which is closer to the head of the hammer, follows a nice parabolic path just like a ball would.

A final consequence of the center of mass being the point which gravity said to act deals with the balance of an object. Now, if you hold an object under its center of mass, it will balance. So, for the hammer in the previous example, if I put my finger close to the head of the hammer, I can balance the hammer at that point. However, more complicated objects we’re usually interested in not balancing on a single point, so we need to define a quantity known as base of support, and the base of support is the region where the object contacts the ground, plus the space in between.

So, for the example of our chicken the base of support is this area between the feet of the chicken, or if you were to look at a person in some rather fancy shoes, the base of support is everywhere the foot contacts the ground, so, this line here connected by a line, plus all the region in between. All of this is the base of support. if the center of mass of an object is above the base of support, then an object will balance. We will explore this in a laboratory activity in class in more tail and become more comfortable with this idea. Right now, what I want you to take away from it is the definition of base of support, and the fact that center of mass sort of has an aspect of its definition, which is that if the center of mass is over the base of support than an object or balance.