MARK HARTMAN: And you guys can use these sheets of paper to actually write these things down until you feel comfortable enough remembering all the steps to do it yourself. So question-- and I'm going to give you this question this time. Sometimes you have to come up with your own. We want to find out how-- what is the linear height?

Because what did we figure out? We did-- yeah, what is the linear height of the trash can? And again, this will be more exciting when, instead of measuring linear heights of trash cans, we're actually measuring linear heights of galaxies or things like that. What is the linear height of the trash can in the practice image? And you want to be as specific as you can, right?

What is the linear height of what-- of the trash can? Where? In the practice image-- that's why we gave you this printout of the image that's right there. You've already labeled it, OK?

So your question-- and actually I want you to physically write down the question, and nobody should be clicking on the computer. Jaylen, you shouldn't be using the computer at all right now. OK, so what is the linear height of the trash can in the practice image, that's what we're trying to get to. The next part is the diagram.

Let's draw a diagram. We already have the image. You can draw, and you can even, like Peter said, you could draw-- you know, here's a little picture of the trash can. We measured this. This is the angular height. This is the image. But we also want to draw a diagram.

So this is what the camera saw, and there is a ball here, and a couple of little other things, and the meter stick. Now that's what the image looks like. That's what we printed out. But to make it clear, we also want to draw the situation, remember, from the side.

We want to know this is a three-dimensional situation, so we also want to say, well, this is what it looked like from the camera's point of view. This is a side view. Side view, right? Here's our detector. Here's our camera, and then here's the board. And the trash can, it's kind of like this.

You can draw it three dimensional if you want. Well, if it's from the side, here's the board, here's the chalkboard, here's the trash can like that. And we know that this is the distance to detector.

If you think it's too hard to draw the side view, you can also draw a little perspective view, and you can say here's my camera. And then along the wall, I had the trash can. I had the ball. I had there was another thing. And again, this is still the distance.

So this is the distance to the detector. This, in the image, we said that was the angular height of the trash can. Now what is this if we could measure this quantity? Is it the angular height of the trash can if we're drawing this diagram?

In this case, if this is our side view, this is the distance to the detector. This is the linear height of the trash can. You want to label everything that you can. So here was our image, and we know that, in an image, we can only measure angular heights, or angular widths, from our side view-- or this is a perspective view. That's the distance to the detector.

This height right here is, again, the linear height of the trash can. I cannot overemphasize enough how important it is to try your best to draw these pictures, these little diagrams, because that's going to help you remember what did the situation look like? This is your kind of three-dimensional model of what you think is going on, the physical situation, that you want to apply your mathematical model to. OK? So there is a side view, there's the perspective view, there's the image. So now we've labeled everything. We know that we're going to worry about the distance to the detector. We know we're going to worry about the linear height of the object.

Next part. Next known-- what do we know about this situation? We've just labeled this situation. Do we know any of these quantities? What do we know, [INAUDIBLE]?

AUDIENCE: [INAUDIBLE]

MARK HARTMAN: We know what?

AUDIENCE: [INAUDIBLE] distance to the detector.

MARK HARTMAN: We know the distance to the detector, so we're going to say distance to detector is equal to, what, 10 meters. OK, good. Do we know anything else? OK, we know the angular height of the object-- so angular height of the trash can equals what?

AUDIENCE: 93.

MARK HARTMAN: What was it?

AUDIENCE: 93.

MARK HARTMAN: 93 is just a number. I'm looking for a quantity.

AUDIENCE: Then 93 phy.

MARK HARTMAN: OK, but phy is short for?

AUDIENCE: Physics--

MARK HARTMAN: Physical units. But we really mean pixels. That phy is pixels. So it's 93 pixels, OK? Do we know anything else?

Not really, right? I mean, we know which camera we're using, but want-- what do we want? What do we find out? In this point, always look back at the original question.

What do I want? What is the linear height of the trash can? So that's already also labeled in the diagram. You want the linear height of the trash can. All right. Do you want anything else? No, it's a very simple statement. What is the linear height of the trash can?

Next part, relationships-- we want to look at the quantities that we know and the quantities that we want, and we want to think about is there a mathematical relationship or a mathematical model that describes how those are related. And there is.

AUDIENCE: [INAUDIBLE]

MARK HARTMAN: OK, so I actually want you to physically write that down, linear width. Well, in that case, we said width, but we could also say height, right? Linear height is just an up and down measurement.

So linear height is equal to angular height in radians times distance to the detector. OK, so that's it. State, in words, what these equations mean in terms of a physical situation. [INAUDIBLE] already did that for us before. He said, for objects farther from the detector, that must mean, if their angular height is the same, they must be a larger linear height. So you don't always have to write that down if you don't want to, but think about what this equation means.

It's not just, you know, some numbers to put together. And you notice that I'm not writing letters or anything. I'm just using the actual phrase for right now. Now the next thing is convert units.

This is what we learned how to do today, the unit conversion. We've been a lot of stuff today, so this is probably going to be one of the most intense days in the whole summer. From here on out, hopefully we won't be doing quite as much standing at the board. So convert the units. You guys have already done that, but if you were doing this for the first time then you'd say, oh, angular height in pixels but my relationship calls for angular height in radians. So I'm going to have to change my angular height from pixels to radians. And you would actually do that calculation right here.

Now we've already done it before, but we can now say angular height of trash can equals-- and what was it? 7.34 times 10 to the minus 2 radians, right? Now we converted the units. And now it says, now that you know all this, turn over and start calculating on the back. And it says, solve the equation for the quantity you want. Right now, it's already solved for linear height. Later on, we'll have to work with solving the equation for the right quantity.

Plug in the numbers with units and simplify. Make only one math step per line and rewrite the entire relationship on every line. So what I want you guys to do now with your group-- now that you filled out the front of this, I want you to rewrite this relationship on the back at the top, and then plug in those numbers that you've got, calculate what you end up getting for the-- well, actually let's just do this right here.

So we'd say linear height-- I want to go through this with you once-- equals angular height times distance to detector. All right, so we plug those values in. Our angular height, 7.34, times 10 to the minus 2 radians, times what's the distance to the detector? 10 meters. So then that gives us 7.34 times 10 to the minus 2 plus 1 radian meters. Nice. So 7.34 times 10 to the minus 2 plus 1 is minus 1 radian meters.

OK, here's where I have to just say a radian, because it's a unit of angle, doesn't quite work out to be the same way as other units. So when you have a radian times another quantity, you just end up with that quantity. Because our answer, we want it in linear height. A linear height is going to be measured in meters. So when you're working with radians, you can just drop those units out so long as it makes sense with what you're trying to end up with, the linear height. And the linear height's going to be measured in meters, so then if I rewrite this linear height as-- now if I multiply these out, 7.34 times 10 to the minus 1, that means I move the decimal point over 0.1, or I move the decimal point over one place.

So I've got 0.734 meters is my prediction for the linear height of the trash can. Predictions are not good unless they actually are somewhat close to reality, so what I want to do is ask [INAUDIBLE] if he could grab a meter stick. And I want you to measure how tall that trash can is. So measure from the bottom all the way to the top of the ridge. I think most people measured to the top of the curved part. There you go. What does it come out?

AUDIENCE: It's about 81.

MARK HARTMAN: How much?

AUDIENCE: 81.

MARK HARTMAN: About 81. So 81 what?

AUDIENCE: Centimeters.

MARK HARTMAN: 81 centimeters. So 81 centimeters is about 0.81 meters, and I'll let you guys do the factor label conversion on that. That's actually going to be one of your problems to work on.

So it's pretty close, but why is it not exact?

AUDIENCE: Rounded off.

MARK HARTMAN: OK, maybe we rounded off too much. Maybe our measurement of the-- it was hard to measure exactly where the top and bottom of that trash can were, right?