# Problem **20-R-KIN-DK-16**

In this video, you're pulling a cart that has a mass, and you're applying a 600 Newton force, all the dimensions are given and you're asked to find the normal forces at wheel a, and wheel B, you're given all of the dimensions of the cart. So, first of all, we're going to draw a diagram, a simpler diagram. And specifically, we're going to draw a freebody diagram in this case, so we're going to isolate the body, which is the cart. So our cart is going to be a rectangle. And we are going to add forces to it. So first of all, we're going to add our center of gravity, which is point G. And this will is where the mass force will act, this is going to be equal to mg. Or the this is where the weight is going to act or the force due to the mass. Next, we're going to add the to normal forces. And again, these forces act are going to act at the bottom of the wheels over here. Okay, so the wheels we're going to assume are attached to well, they are attached to the body. So we're looking at the bottom of the wheels, not the plate in the place where the wheels and the cart meet. So we're going to draw two forces here at the bottom, and we're going to name them an A and B. So this here is going to be this is point A, so where A meets the ground. And so this is going to be called NA, and then to the right, we have and B because this here is point B, or where B meets the ground. And then we the we have one more force, which is the tension force of that string you're pulling the cart with, and this is just going to be called F and it's equal to 600 Newtons that we're given. Okay. And then the last thing we have is an acceleration of the body. So I'm just going to draw it in and red this, the direction of this is not given, but we're going to determine the direction, this is going to be aG. Again, the acceleration is that the center of gravity at the center of mass, and we've assumed a direction. But again, there is we're going to determine the magnitude and the direction later. Okay. And again, everything else is drawn in the proper direction. Okay, so now that we have a freebody diagram, we're going to write out the equations of motion for the body and solve them. Again, I only have an x component of the acceleration, because again, this is rolling, so there's going to be no y acceleration. And also, this is the coordinate system we're going to use. So x is positive this way, y is positive up, and a rotation is positive when it's counterclockwise. Okay, so we're going to first take the sum of forces, both in the x direction in the y direction. So for, Okay, so first, we're going to start with the summer forces in the x direction. And this is going to be equal to the mass times the acceleration of the body. So again, there's two ways of figuring out the acceleration, because again, we're not given a direction. But again, there is an acceleration due to this force here. So the first method, which is the one that I'm going to use is scrapping this acceleration here, and summing up of these, all of these forces in the x direction, and then equating them to me, and that's going to give me my acceleration. Okay. On the other hand, I can apply an acceleration force to the body, okay, and the acceleration force is just the mass of the body times the acceleration of the body. And then if I sum up all of these forces, including that acceleration force, then I get a resulting acceleration. But that is going to be equal magnitude but opposite in direction to the actual acceleration because it's an acceleration force balancing the actual acceleration. Okay, so in this case, what I'm going to do is I'm going to equate the forces in the x direction to the mass times the accelerate Have the body in the x direction. Again, there's only an acceleration in the x direction because the wheels and light are on the bottom, there can't be an acceleration in the y direction. So if we implement this, we get that M, a of G in the x direction is going to be equal to f. And if we plug in numbers, we get that 160 kilograms times A g of x is equal to 600 Newton's. And so from this, we can derive a G is going to be equal to 3.75 meters per second squared. Next, we're going to take the sum of forces in the y direction. But this time, we're going to equate everything to zero because like I said, there is no acceleration in the y direction. So we're going to go back to the freebody diagram and take an A plus and B minus g is equal to zero. And if we plug in the actual values, we get an A plus and B, minus 160 kilograms, times 9.81 meters per second squared is equal to zero. So again, we can't solve for na, and NB because they're both unknown. So this becomes an equation. And then we have our last equation, which is the sum of moments. And that's going to give us our second equation. So two equations, two unknowns, we can solve for everything. So let's take the sum of moments. And in this case, we're going to take the sum of moments about a. But you can take this all moments about any point on the body, it's convenient to definitely pick a location with a force, because that it cancels out that force, that force doesn't have any doesn't have a line of action. So there's no moment created. So in this case, all the forces are either at vertical or horizontal, they're 90 degrees with respect to each other. So it's very convenient. But if there's slanted forces, usually it's easier to pick a point where that slanted forces act, and that slanted force acts so that you don't have angles. Okay. So in case if instead, this f was slanted, I would definitely take the sum of moments about this point. Since all of these are vertical, much, much easier to take a sum of moments, instead of doing a cross product or playing with angles where you might make a mistake. But in this case, we're gonna pick a as our Center for the sum of the moments. Okay? And again, in this case, so if you take the sum of moments, we have this acceleration, which again, is going to lead to an acceleration force, an opposing acceleration force. Okay, so this acceleration here, I'm going to take it into account. So I'm going to equate the sum of the moments to the force due to the acceleration, which is m A times again, that distance, which is the lever arm for that acceleration force. Okay, so if we implement this, we get the following. Am A times h, and that's a G is equal to, and this is going to have a negative sign. Negative g times dA. So this is the force due to the due to gravity. So da, again is this distance here. So that's the lever arm and the force is mg. And it's going to be negative, because again, it's clockwise, it makes it spin clockwise. Alright, next we have n b. So a and b times d A plus dB. Okay, again, this distance, the lever arm is this distance here. And that distance there, as you can see from the diagram is da plus DB So we're going to use that distance there. And then we have our last term, which is minus f times y plus two times R. And so f is the force due to the pulling. So again, the lever arm is this distance over here. And again, that distance over there is going to be equal to y plus two times the radius. Because this is a circle, so we have two radius or two times the radius on so that's why we have to R. And so this is our full sum of moments. And now we can plug everything in and get the following. I want to go on a new line. Okay, so again, 600, Newton's times 0.9 is F times y plus two r 1.28 is da plus dB. And this equation there is one unknown, which is NB. And remember, this 3.75 was the acceleration we found before. so we can directly solve for NB. So with this equation, we get that NB is going to be equal to 997.6 Newton's, okay, so that is the first part of the answer the normal force at B. And then with this NB, we can plug it into this equation here to solve for an A. Because again, it's an equation A and B and an A. So if we do that, we get that and a is equal to 572 Newtons. And that is the final answer. So again, just to clarify, you can think of this acceleration in two ways, either adding an acceleration force that is going to be opposing. So if we did that, you would you can assume a direction in that way. But since this force points to the right, this acceleration would point to the left. And that is the opposing acceleration force, the actual acceleration points towards the right. Okay. Or you can take the sum of forces and equated to the mass times the acceleration, which if this is on the opposite side of the equal sign positive, it will be a negative on the left, so that matches what I just said. And again, we also have to keep that in mind with the sum of moments. So with the sum of moments, we also have to keep into account which way this acceleration is turning the whole object. So that's where this negative sign comes into account. Because that this acceleration makes everything turn clockwise, it's negative on the acceleration force, which opposes would be positive. But again, that acceleration force would be positive on the right side of the equation. So it becomes negative on the left side of the equation. So everything checks out. Okay. Um, so yeah, so just picking a method and sticking with it. So either assuming an acceleration force that is in opposite direction and then flipping it to get the actual acceleration, or just writing the acceleration, in in the direction it is with an eat making it equal on the other side of the equation. Okay. And this is the problem.