So I would like to now consider the wheel that is rolling without slipping.

And what I'd like to do is consider-- let's draw the wheel rolling without slipping.

And I'd like to consider the contact point between the wheel and the ground.

And I'd like to understand what the velocity of that contact point is.

And the result is surprising.

Now, we know by our law of the addition of velocities-- let's call that the point P-- that the velocity of P is the velocity of the center of mass, and that pointed this way, plus the velocity of the point P as seen in the center of mass frame.

And in that frame, every single point on the rim was just doing circular motion.

So that velocity is in the opposite direction.

And the vector sum is the velocity of this point P as seen in the ground frame.

So we want to consider the magnitudes of these two terms.

The velocity in the center of mass frame of a point on the rim has a magnitude equal to r omega.

And we said that the velocity of the center of mass, we call that V cm.

Now, the rolling without slipping condition was that these two magnitudes were equal.

V cm equals r omega, or the velocity of the point on the rim in the center of mass frame is equal to the center of mass velocity of the wheel.

And therefore, the velocity P, which is the sum of these two vectors for the contact point-- so that's when P is in contact with the ground-- is equal to 0.

So what we say is that the contact point is instantaneously at rest with respect to the ground.

And that's what really is the mystery of a wheel that's rolling without slipping-- that this contact point is the sum of these two vectors, and it's instantaneously at rest with the ground when the wheel is rolling without slipping.

The other points are certainly not.

Remember, up here, these two vectors pointed in the same direction, so that vector has twice the magnitude of either one.