I have discussed several times the difference between angular velocity and angular frequency. And I would like to expand on that a little bit. And it's always a confusing thing because in physics we both give them the symbol omega.

Let's start again with a simple pendulum. A pendulum, which has length l and the object has mass m. And we are swinging it around. This is the maximum possible angle. I'll call this theta maximum. On the other side of course, there's also a theta maximum. I assume there's no damping. And let this angle here be theta.

The angular velocity for which we write omega in physics, I will in this exercise put an av there, so that you always know which omega I'm talking about. Angular velocity per definition is d theta dt. And this is in rays per second. The magnitude of this omega has a maximum, so it is the magnitude that I'm talking about now. The magnitude has a maximum when theta equals 0. When the object goes through equilibrium, then the angle changes the most per time unit delta t. The value equals 0 when theta equals theta maximum. Because then the object here and here stand still. So d theta dt is 0.

The angular velocity can be positive if d theta dt is increasing. So if it goes in this direction. And it can be negative when it goes in this direction. So the angular velocity can be larger than 0, can be equal to 0, and can be smaller than 0. The bottom line is, it is changing all the time. It can change sign and it changes magnitude.

Right here at this point the linear velocity is either in this direction or in this direction. I call that the linear velocity. And right here the linear velocity is either in this direction or it is in this direction depending upon whether it swings up or whether it swings down. You can do the same here. These linear velocities are l times s theta dt. And so they are l times the angular velocity. And you can immediately see if the angular velocity is 0, mainly here, that the linear velocity is 0. You can also see when omega changes sign that you can have a different sign for the linear velocity. This, for instance, could be called the plus and this would be a minus. This is a plus and this is a minus. And the magnitude can also greatly vary because when the angular velocity reaches a maximum where the object go through equilibrium, then of course, omega-- this omega, this angular velocity has reached a maximum value. d theta dt is maximum, so the linear velocity is a maximum. So much for the angular velocity.

Let us now think about the simple harmonic oscillation, which is to a good approximation the motion of this pendulum. In terms of theta, I can write down it's an approximate simple harmonic oscillation. theta equals theta max time the cosine. You may prefer the sine of omega t plus some face angle alpha. This omega has nothing to do with this omega. This is the angular frequency. This one is a constant. Omega angular frequency is a constant in time. It never changes. But this one changes.

The period of one oscillation of this simple harmonic oscillator, for which you can either write a T or you can write a P. I always prefer a P when I deal with strings because I want to avoid confusion with tension. That period for one oscillation, for a complete oscillation equals 2 pi divided by this angular frequency.

If you look at the theta, at the position of theta at time t1, at a random time t1, and you look again at time t1 plus 2 pi divided by the angular frequency, then the cosine function will repeat itself verbatim. That's why we call this the period. After so many seconds, the whole thing will repeat itself. So there's a huge difference between angular frequency and the angular velocity. Angular velocity changes in time. Angular frequency does not change in time.

Now I want to take a rotating disk. A disk that rotates uniformly, whereby omega is a constant. The angular velocity is a constant. Unlike in the case of the pendulum, whereby the angular velocity was not constant. It could also be a satellite going around the earth at a constant radius r. In other words, a circular motion.

Well, I could call this angle increased theta. I would have here a circumferential linear velocity v. It's tangential to the circle. Here the linear velocity and magnitude would be the same. But of course, not in direction. And this linear velocity-- I will write down linear-- equals r times d theta dt, which is r times the angular velocity. And you can see that the magnitude is constant everywhere because the angular velocity d theta dt is constant. Because this object rotates around with a constant angular velocity.

The time for one complete rotation-- just to remind you, the angular velocity equals d theta dt. The time for one complete rotation and you may call that period P or you call that T, whatever you prefer, equals 2 pi divided by the angular velocity. This is immediately obvious. One rotation is 2 pi radians. The object moves with the angular velocity, which is in radians per second. So to go 2 pi radians and you go with an angular velocity of omega radians per second, that would take so many seconds. So it's clear that this is the time that it takes for one complete rotation.

So this time is the time for a rotation. But remember, the time for one complete oscillation when we were dealing with a simple harmonic oscillator, that time for which we also wrote the letter capital T, that time T or in case of a pendulum you may prefer P, that time was 2 pi divided by the angular frequency. And the angular frequency comes in through the cosine term of the simple harmonic oscillation.

Now we talk about the frequency of a rotating disk, and that frequency then means rotations per second. So the word frequency, which now doesn't say angular frequency, simply frequency, is in the case of the disk, the number of rotations per second. We express that in terms of hertz. 400 hertz is 400 rotations per second. And that frequency is 1 divided by T. WE often call that F. And that would be the angular velocity divided by 2 pi. And this is in hertz.

But we also talk about the frequency of a simple harmonic oscillator. In which case, the frequency of a simple harmonic oscillator-- notice I simply use the word frequency-- is now how many oscillation per second it made? How many cycles per second, also in hertz? And that frequency 1 over T or if you prefer to write for that 1 over P, we also call that F. And that is the angular frequency divided by 2 pi. Look here. It was for a simple harmonic oscillator. In other words, you could argue though, this is perhaps a matter of semantics. That in the case of a uniformly rotating disk, or of a uniformly rotating satellite around the earth in a circular motion, that in that case the angular velocity is the same as the angular frequency. But as I said, this perhaps is only a matter of semantics. However, in the case of a pendulum, the angular velocity is very, very, very different from the angular frequency.