

**PROFESSOR:** I think we've now reached our last problem. Let's do a time check. I need 6 more minutes, and boy, I have 6 minutes. It's perfect. 1.E.3 deals with a geosynchronous satellite.

Let's first consider a circular motion. Radius  $r$ . And there's an object going around with a constant speed. Speed is  $v$ . Here the speed is the same. That is  $v$ . But be careful. The velocity vector here is different from the velocity vector there, because the direction has changed. The magnitude, which we call speed, that is only the magnitude of the vector, but the direction of the vector is very important, and the direction changes. And so since the direction changes, there has to be an acceleration. Otherwise, the vector  $v$  could not possibly change.

In this situation, which I will give you without proof, the acceleration is always pointed towards the center. That's why we call it centripetal acceleration. It's therefore, also changing.  $a$  itself is not constant and  $v$  is not constant.  $a$  is pointing in this direction and  $a$  is pointing here.  $a$  is constant. The magnitude of the acceleration is constant. And that I will give you as our proof is  $v$  squared divided by  $r$ . And sometimes you see a little  $c$  here, which indicates centripetal. It's pointing towards the center of the circle.

Now, you can take an apple and swirl an apple above your head in more or less a horizontal plane. If you can do this at constant speed, then you have a situation like this.

A car that's going around in a circle, if the speed of the car were not changing, you would have a situation like this.

Take a satellite going around the earth, putting it in a circular orbit, you will have a situation like this.

Take a planet around the sun, put it in a circular orbit, you will have a situation like this.

And in your particular case, you're being asked to calculate the centripetal acceleration for a geosynchronous orbit. A geosynchronous orbit is an orbit whereby the satellite takes 24 hours to go around the earth. And if you launch that satellite in the plane of the Equator, then-- and you should think about that-- when you look from any point of earth at that satellite, it will not move relative to the rotating earth, because the earth rotates in 24 hours and the satellite rotates in 24 hours. So the satellite will appear to stand still in the sky relative to the earth. Of course, not relative to the stars. It has to be launched in the equatorial plane. You think about that. That's a must. Otherwise, it does not stand still in the sky.

Well, the orbital period is 24 hours and the radius of that orbit was given to you. There will be a time that you can calculate that. If you have Newton's laws and Kepler's laws, so the velocity will be  $2\pi r$  divided by 24 times 3,600. That would be in kilometers per second. And so the centripetal acceleration, which is  $v^2$  divided by  $r$ -- I think I found something like 0.2 meters per second squared. But you better check that.