Answer on question #55019, Physics / Quantum Mechanics

Question A synchronous satellite circles the earth eastward above the equator once every 24hour and stays over the same spot on the earth because the earth is rotating at the same rate. What is the orbital radius and the velocity of the synchronous satellite?

Solution Angular velocity of this satellite is

$$\nu = \frac{2\pi}{T} = \frac{2\pi}{86400 \, s} = 0.0000727 rad/s$$

Centrifugal acceleration is equal to gravitational force:

$$\frac{v^2}{r}m = G\frac{mM}{r^2}$$

where $v = \nu r$ is velocity, m is mass of satellite and M is mass of Earth.

$$\nu^2 r = G \frac{M}{r^2}$$

From here we can find radius of orbit

$$r^{3} = \frac{GM}{\nu^{2}}$$
$$r = \sqrt[3]{\frac{GM}{\nu^{2}}} = \sqrt[3]{\frac{6.67 \cdot 10^{-11} \cdot 6 \cdot 10^{24}}{0.0000727^{2}}} \approx 4.23 \cdot 10^{7} \, m$$

This is the distance the satellite needs to be from the center of the Earth. Subtracting the Earths radius of $6.38 \cdot 10^6$ m we get radius of orbit $3.59 \cdot 10^7$ m. Velocity is

$$v = \nu r = 0.0000727 \cdot 4.23 \cdot 10^7 \approx 3075.21 \, m/s$$

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