Circular Motion – Q1 [Problem/M](2/6/21)

Find the height above the earth's surface of a satellite in geostationary orbit (above the equator), using the following data:

radius of earth $= 6370$ km

mass of earth $\approx 6 \times 10^{24}$kg

$G \approx 7 \times 10^{-11}$

Gravitational force $= \frac{GMm}{r^2}$

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Solution

Steps:

(i) Set up F = ma

(ii) Establish ω

(iii) Solve for r

$\frac{GMm}{r^2} = m\omega^2 r$,

where M is the mass of the Earth, m is the mass of the satellite, r is the distance of the satellite from the Earth's centre, and ω is its angular speed

$\omega = \frac{2\pi}{24\times3600}\ rads^{-1}$

Hence $r^3 = \frac{GM}{\omega^2} \approx \frac{6.67\times10^{-11}\times5.98\times10^{24}\times(24\times3600)^2}{(2\pi)^2} = 7.5421 \times 10^{22}$

and $r = 4.22504 \times 10^7\ m$; ie $42250\ km$

Thus, height above Earth's surface is

$42250 - 6380 = 35900\ km\ (2sf)$