Special Problem 4: Sky Hook

a. A cable of constant mass per unit length λ points straight up, hovering over a point on the Equator. How is this possible? In terms of λ, Earth-parameters (mass, radius, and angular velocity of rotation), and Newton's constant of gravitation, calculate how long the cable has to be. (6)

Such a cable was proposed by Arthur C. Clarke, of science fiction fame (anticipated by Jack, of Jack and the Beanstalk fame) as a convenient step-ladder for taking cargo into space. Clarke called it a Sky Hook (Jack called it a beanstalk).

b. A related concept, very much in practical use, is the geosynchronous satellite. It stays in orbit over a fixed location on Earth. In terms of the same parameters, what is the height of a geosynchronous orbit? (1)

c. Evaluate these distances numerically. (1)

d. Identify the point of maximum tension in the Sky Hook. The tensile strength of a material is the maximum tension per (unit mass/unit length) it can bear before snapping. The largest known tensile strengths have values in the neighborhood of 2×10^6 N-m/kg. Is that enough? (2)