Physics 3710 – Problem Set #7

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1. The orbital period of Moon about Earth is about 27.3 d, with a radius \( r = 3.85 \times 10^8 \) m.

(a) Calculate the centripetal acceleration of Moon (the orbit is almost circular).
(b) Compare that with the gravitational field strength of Earth at the center of Moon, given that \( M_{\text{Earth}} = 6 \times 10^{24} \) kg.
(c) Any comment?

2. Suppose a shaft could be drilled from the North Pole to the South Pole through the center of Earth. Use the expression \( g_{\text{inside}}(x) = \frac{g_E x}{R_E} \) (page 3, GR1) for the gravitational field strength in the shaft at a distance \( x \) from the center of Earth. (\( g_E \) = surface gravitational field strength = 9.8 m/s\(^2\), \( R_E \) = radius = 6.4\times 10^6 m)

(a) Calculate the time for the object to go from one pole to the other. (Hint: the motion is simple harmonic: \( a = -\omega^2 x \).)
(b) The orbital period of a satellite in low earth orbit is \( T_{\text{LEO}} = \frac{2\pi}{\sqrt{\frac{R_E^3}{GM_E}}} \). What is the relationship of the period of the oscillator found in (a) to \( T_{\text{LEO}} \)?

3. A pencil in the International Space Station (ISS) is displaced 1 cm from the center of the Station in the “normal” direction (\( s_n \)) as described GR2, p1. It subsequently moves relative to the center according to the oscillator equation \( \frac{d^2 s_n}{dt^2} = -\frac{GM_E}{r^3} s_n \). The pencil travels 4 cm in one complete oscillation. How far does the ISS travel in the same amount of time? Assume the ISS is in a circular orbit of radius equal to 6.8\times10^6 m. (Hint: the only difference between the LEO period and that of the ISS is the radii of the orbits.)