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Physics 117

Quiz 3 (3/3/2003)

(Consider the surface gravitational acceleration on Earth $g_{\oplus}$=10 m/s^2)

A) The planet Venus has a radius of about 0.8 Earth radii and a mass of 0.95 Earth masses.
Q-A1: *Estimate g on Venus*
Q-A2: *If an object has a 100 Kg mass, what is its weight on Venus?*

A-A1: This is conceptually identical to Exercise 17 of the homework set 4.
We know from the text that M_{Venus}=0.95 M_{Earth} and R_{Venus}=0.8 R_{Earth}

$$g_{Venus} = \frac{GM_{Venus}}{R^2_{Venus}} = \frac{GM_{Earth}0.95}{R^2_{Earth}(0.8)^2} = g_{Earth} \times 1.48 \approx 14.8 \ \ m/s^2$$

Note: The real Venus has a radius of 0.95 Earth radii and a mass of 0.8 Earth Masses. So the Venus discussed in this exercise must be considered an imaginary planet.

A-A2:

The weight on Venus is just the mass times the gravitational acceleration on the surface of Venus.

$$W_{Venus} = mg_{Venus} = 100 \ \ Kg \times 14.8 \ \ m/s^2 = 1480 \ \ N$$

B) A 550 Kg geosynchronous satellite orbits at a distance from Earth's center of about 6.6 Earth's radii.
Q-B1: *What gravitational force does the Earth exert on the satellite?*
Q-B2: *Assume that the satellite orbit is circular. What is the speed of the satellite along its orbit?* (Consider the Earth radius to be approximately 6400 Km)

A-B1:

$$F_{gravity} = \frac{GM_{Earth}m_{sat}}{R^2_{sat}} = \frac{GM_{Earth}m_{sat}}{(6.6)^2 R^2_{Earth}} = g_{Earth}\frac{m_{sat}}{(6.6)^2} = 10 \ \ \frac{m}{s^2} \times \frac{550 \ \ Kg}{43.56} \approx 126 \ \ N$$

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A-B2:

If the satellite is in geosynchronous orbit the satellite time of revolution, *T* , is 24 hours as it is the Earth revolution around its axis. So

$$\mathrm{v}_{sat} = \frac{circumference}{period\ \ of\ \ revolution} = \frac{2\pi R_{sat}}{T} = \omega_{sat} R_{sat} = 7.27 \cdot 10^{-5}\ \ s^{-1} \times 6.6 \times 6400\ \ Km \approx 3\ \ \frac{Km}{s}$$

ALTERNATIVE PATH TO ANSWER

On a circular orbit

$$a_{sat} = \frac{\mathrm{v}^2}{R} \qquad \text{so} \qquad \mathrm{v} = \sqrt{a_{sat} R_{sat}} = \sqrt{a_{sat} \times 6.6 \times R_{Earth}}$$

The acceleration of the satellite must be the acceleration due to the gravitational attraction of the Earth. So it is simply

$$a_{sat} = \frac{F_{grav}}{m_{sat}} = \frac{g_{Eart}}{(6.6)^2} = 10\ \ \frac{m}{s^2} \times \frac{1}{43.56} \approx 0.23\ \ \frac{m}{s^2} = 0.23 \cdot 10^{-3}\ \frac{Km}{s^2}$$

Knowing both the acceleration and the radius of the satellite orbit we get

$$\mathrm{v} = \sqrt{a_{sat} R_{sat}} = \sqrt{0.23 \cdot 10^{-3}\ \ \frac{Km}{s^2} \times 6.6 \times 6400\ \ Km} \approx 3\ \ \frac{Km}{s}$$