**8.3(B) Satellite Motion and Kepler’s Laws**

**LEARNING TARGETS**

8.3 I can define, explain, and apply Kepler’s laws to solve problems involving satellite motion.

**REFERENCE PAGE**

Orbits of Planets and Satellites

A satellite is orbiting the Earth

\[ F_{net} = F_g \]

\[ \frac{m_s a_c}{G} = \frac{m_1 m_2}{r^2} \]

\[ \frac{V^2}{r} = \frac{G m_s}{r^2} \]

**Orbits of Planets and Satellites**

Speed of a Satellite Orbiting Earth \( v = \sqrt{\frac{GM}{r}} \)

The speed of a satellite orbiting Earth is equal to the square root of the universal gravitational constant times the mass of Earth, divided by the radius of the orbit.

**Geosynchronous Orbit**

The GOES-12 weather satellite orbits Earth once a day at an altitude of 35,785 km. The orbital speed of the satellite matches Earth’s rate of rotation. Thus, to an observer on Earth, the satellite appears to remain above one spot on the equator. Satellite dishes on Earth can be directed to one point in the sky and not have to change position as the satellite orbits.
Orbits of Planets and Satellites

\[ v = \frac{\text{circumference or orbit}}{\text{time to complete one revolution}} \]

\[ \sqrt{\frac{GM_e}{r}} = \frac{2\pi r}{T} \]

Mercury-Atlas 6 (MA-6) was the third human spaceflight for the U.S. and part of Project Mercury. Conducted by NASA on February 20, 1962, the mission was piloted by astronaut John Glenn, who performed three orbits of the Earth, making him the first U.S. astronaut to orbit the Earth.

A) What acceleration does he experience due to the earth's pull?

B) What tangential velocity must he possess in order to orbit safely (in m/s)?

C) What is his period (in hours)?

6. Glenn made three orbits of the Earth \((m_e = 5.98 \times 10^{24} \text{ kg})\) at a distance of 422 miles above the surface of the Earth \((r_e = 6.38 \times 10^6 \text{ m})\).

a) What acceleration does he experience due to the earth's pull?

\[ g = \frac{GM_e}{r^2} = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{(4.22 \times 10^6)^2} \approx 3.8 \times 10^{-18} \text{ m/s}^2 \]

b) What tangential velocity must he possess in order that to orbit safely (in m/s)?

\[ v = \sqrt{\frac{GM_e}{r}} = \sqrt{\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24}}{4.22 \times 10^6}} \approx 7760 \text{ m/s} \]

\[ T = 2\pi \sqrt{\frac{r^3}{GM_e}} \approx 5340 \text{ s} \approx 90 \text{ min} \]

Glenn made three orbits of the earth \((m_e = 5.98 \times 10^{24} \text{ kg})\) at a distance of 422 miles above the surface of the earth \((r_e = 6.38 \times 10^6 \text{ m})\).

a) What acceleration does he experience due to the earth's pull?

b) What tangential velocity must he possess in order that to orbit safely (in m/s)?

c) What is his period (in hours)?

\[ T = 2\pi \sqrt{\frac{r^3}{GM_e}} \approx 5900 \text{ s} \approx 1.6 \text{ hr} \]
PRACTICE
UNIT 8 PROBLEMS
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