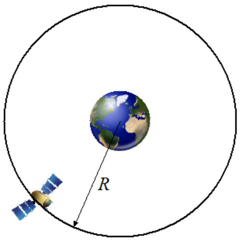
Announcements

HOMEWORK	LABS	TEST
Unit 8 Practice Problems (1-8)	• Gravitation Interactive (RSVCP) • Orbital Motion Interactive (RSVCP)	Unit 8 Test Thursday Dec.20

8.3 Satellite Motion

LEARNING TARGETS

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



REFERENCE PAGE

Universal gravitational constant, $G = 6.67 \times 10^{-11}\ \text{m}^3/\text{kg}\cdot\text{s}^2$ $\frac{N\,m^2}{kg^2}$

Acceleration due to gravity at Earth's surface, $g = 9.8\ \text{m/s}^2$

f = frequency

$$a_c = \frac{v^2}{r}$$

$$\left|\vec{F}_g\right| = G\frac{m_1 m_2}{r^2}$$

$$\vec{g} = \frac{\vec{F}_g}{m}$$

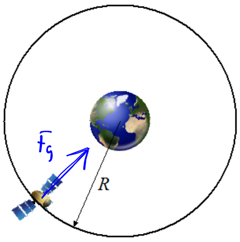
Orbits of Planets and Satellites

A satellite is orbiting the Earth

$$F_{net} = F_g$$

$$m_s a_c = G\frac{m_s M_E}{r^2}$$

$$\frac{v^2}{r} = G\frac{m_E}{r^2}$$



Orbits of Planets and Satellites

Speed of a Satellite Orbiting Earth $v = \sqrt{\frac{Gm_E}{r}}$

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.

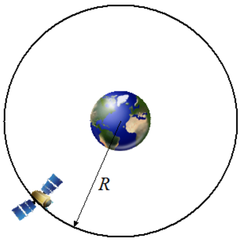
Geosynchronous Orbit

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

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

$$\sqrt{\frac{GM_E}{r}} = \frac{2\pi r}{T}$$



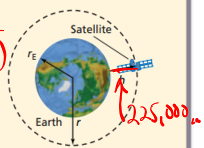
Orbits of Planets and Satellites

Period of a Satellite Orbiting Earth $T = 2\pi\sqrt{\frac{r^3}{Gm_E}}$

The period for a satellite orbiting Earth is equal to 2π times the square root of the radius of the orbit cubed, divided by the product of the universal gravitational constant and the mass of Earth.

EXAMPLE Problem 2

Orbital Speed and Period Assume that a satellite orbits Earth 225 km above its surface. Given that the mass of Earth is 5.97×10^{24} kg and the radius of Earth is 6.38×10^{6} m, what are the satellite's orbital speed and period?



$$V = \sqrt{\frac{GM_E}{r}} = \sqrt{\frac{(6.67\times10^{-11})(5.97\times10^{24})}{(6.38\times10^{6}+225{,}000)}}$$

$$V = 7760 \text{ m/s}$$

$$T = 2\pi\sqrt{\frac{r^3}{GM_E}} = 5340\text{ s} \approx 90\text{ min}$$

Name the Astronaut

Glenn Orbits the Earth

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.


"All the News That's Fit to Print"
The New York Times
LATE CITY EDITION
GLENN ORBITS EARTH 3 TIMES SAFELY; PICKED UP IN CAPSULE BY DESTROYER; PRESIDENT WILL GREET HIM IN FLORIDA

Glenn Orbits the Earth

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

422mi × 1600 m = 675,200m

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

$$g = \frac{GM_E}{r^2} = \frac{(6.67\times10^{-11})(5.98\times10^{24})}{(6.38\times10^{6}+675{,}200)^2} = 8.01 \text{ m/s}^2$$

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

$$V = \sqrt{\frac{GM_E}{r}} = 7520 \text{ m/s}$$

c) What is his period (in hours)?

$$T = 2\pi\sqrt{\frac{r^3}{GM_E}} \quad 5900\text{ s} \approx 1.6\text{ hr}$$

PRACTICE

UNIT 8 PROBLEMS (9-15)