

Orbits

Some useful numbers for this sheet.

Mass of Earth: 6×10^{24} kg

Mass of Moon: 7.4×10^{22} kg

Distance Earth-Moon: 3.8×10^8 m

$G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$

Radius of Earth: 6.4×10^6 m

Radius of Moon: 1.74×10^6 m

Distance Earth-Sun: 1.5×10^{11} m

Concepts

1. Is an object in a perfect circular orbit with a constant speed accelerating? Explain.
2. Why is there a net force on a satellite that is orbiting the earth?
3. Why don't satellites simply fall and crash into the earth?
4. Using the terms "net force", "centripetal force" and "gravitational force" explain what has to happen for an object to be in a circular orbit.

Problems

1. Let's look at the orbit of the moon around the earth to go through the key ideas and steps in analyzing orbits.
 - a. What is the force of gravity between the moon and the earth?
 - b. Therefore, what is the centripetal force acting on the moon?
 - c. How fast is the moon traveling around the earth?
 - d. What is the period (in seconds) of the moon going around the earth?
 - e. How many days is that?

Orbits

2. A 10,000 kg satellite is in orbit 8×10^6 m away from the center of the earth.
- What is the force of gravity between the satellite and earth?
 - How fast is the satellite moving?
 - How many hours will it take the satellite to go around the earth?
 - If the satellite were 50,000 kg (5 times more massive) would your answers to *a*, *b*, and *c* change? Explain.
3. It turns out that you can figure out the mass of a planet by observing the motion of a moon going around the planet. Jupiter's moon Io goes around Jupiter in an orbit with a radius of 4.22×10^8 meters and a period of 1.77 days.
- How many seconds does it take Io to go around Jupiter?
 - How fast is Io moving around Jupiter?
 - What is the centripetal acceleration of Io around Jupiter?
 - What is the mass of Jupiter?

Answers: 1. a) 2.05×10^{20} N b) 2.05×10^{20} N c) 1026 m/s d) 2.33×10^6 s e) 26.9 days
 2. a) 62,560 N b) 7074 m/s c) 1.97 hours d) 5x the force of gravity, same speed, same period
 3. a) 153,000 s b) 17,340 m/s c) 0.71 m/s^2 d) 1.89×10^{27} kg