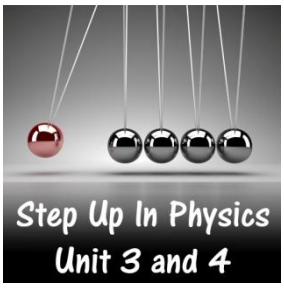
Satellite Motion

Problems Worksheet



Relevant Data	Gravitational Constant	$6.67 \times 10^{-11}\ m^3kg^{-1}s^{-2}$
	Mass of the Earth	5.97×10^{24} kg
	Mass of the Moon	7.35×10^{22} kg
	Radius of the Earth	6.38×10^{6} m
	Radius of the Moon	1.74×10^{6} m
	Mean Earth-Moon distance	3.84×10^{8} m

1. A satellite can theoretically remain above the surface of the Earth indefinitely without falling closer to the Earth despite being within the Earth's gravitational field. Describe how this is possible.

2. The centripetal force required for a satellite in a circular orbit is supplied by the gravitational field of the central body. Starting from this theoretical concept, show that the time for a satellite to orbit a central body of mass M is determined by $T = \sqrt{\frac{r^3 4\pi^2}{GM}}$.

3. Show that the Moon has an orbital period of approximately 27 days.

4. How fast would a cannonball fired horizontally across the surface of the Earth need to be moving to make it around the Earth without hitting the ground? You may ignore the effects of air resistance and assume the Earth is perfectly spherical.

5. A satellite is in a stable circular orbit around the Earth. It collides with a piece of space debris which reduces the satellite's current speed but not its current direction of motion. As time passes the satellite begins to pick up speed again. Explain why the speed of the satellite increases.

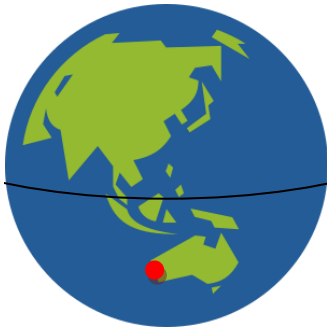
6. A satellite is orbiting along the equatorial plane and in the same direction as the surface of the Earth rotates around its axis. If this satellite starts over a city on the equator and passes over that city exactly twice more within a day, what is the altitude of the satellite?

7. A star's gravitational force acting on a planet in orbit around it is dependent on the mass of the star, the mass of the planet and the distance between them.
    a. How would the time it takes the planet to orbit the star change if the planet had a 10% larger mass? Justify your response with reference to a formula.

    b. How would the time it takes the planet to orbit the star change if the star had a 10% larger mass? Justify your response with reference to a formula.

    c. How would the time it takes the planet to orbit the star change if the planet orbited at a 10% larger distance? Justify your response with reference to a formula.

8. Explain, with the aid of the diagram, why a satellite cannot pass directly over Perth in Western Australia while it is in a geostationary orbit but can when in a geosynchronous orbit.



9. Many communication satellites are set up in geosynchronous orbits.
    a. Calculate the altitude of a satellite in a geosynchronous orbit around the Earth.

    b. If the Earth doubled in mass, how would this affect the distance required to maintain a geosynchronous orbit?

10. Can a person who does not live on the equator view geostationary satellites in the sky? Explain your answer.