Motion in Space

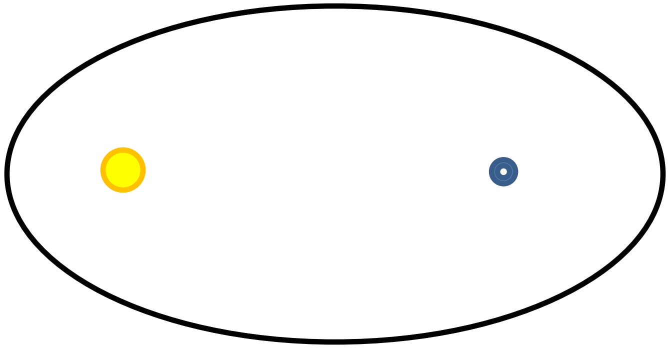
7.3

Objectives

- **Describe** Kepler’s laws of planetary motion.
- **Relate** Newton’s mathematical analysis of gravitational force to the elliptical planetary orbits proposed by Kepler.
- **Solve** problems involving orbital speed and period.

Kepler’s Laws

- Kepler discovered the laws that describe the motions of every planet and satellite.
- **Kepler’s first law** states that the paths of the planets are ellipses, with the Sun at one focus.

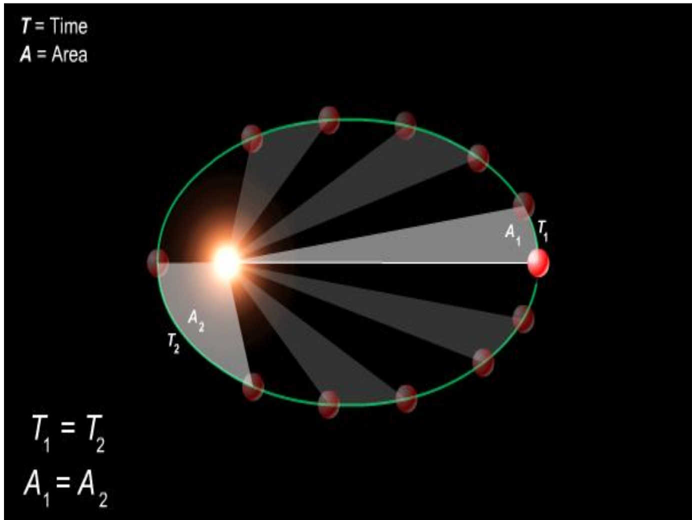


Kepler's Laws

- Kepler found that the planets move faster when they are closer to the Sun and slower when they are farther away from the Sun.
- **Kepler's second law** states that an imaginary line from the Sun to a planet sweeps out equal areas in equal time intervals.

So, if it takes longer, the planet is…

(closer, farther)



Kepler's 2nd Law

- Equation

$$\frac{{T_1}^2}{{T_2}^2} = \frac{{r_1}^3}{{r_2}^3}$$

OR

$$\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$$

Kepler's Laws

- **Kepler's third law** states the square of a planet's orbital period (T^2) is proportional to the cube of the average distance (r^3) between the planet and the sun.

Orbital Period: $T^2 = \left(\frac{4\pi^2}{Gm}\right) r^3 \longrightarrow T = 2\pi\sqrt{\frac{r^3}{Gm}}$

Orbital Speed: $v_t = \sqrt{G\frac{m}{r}}$

Planetary Info.

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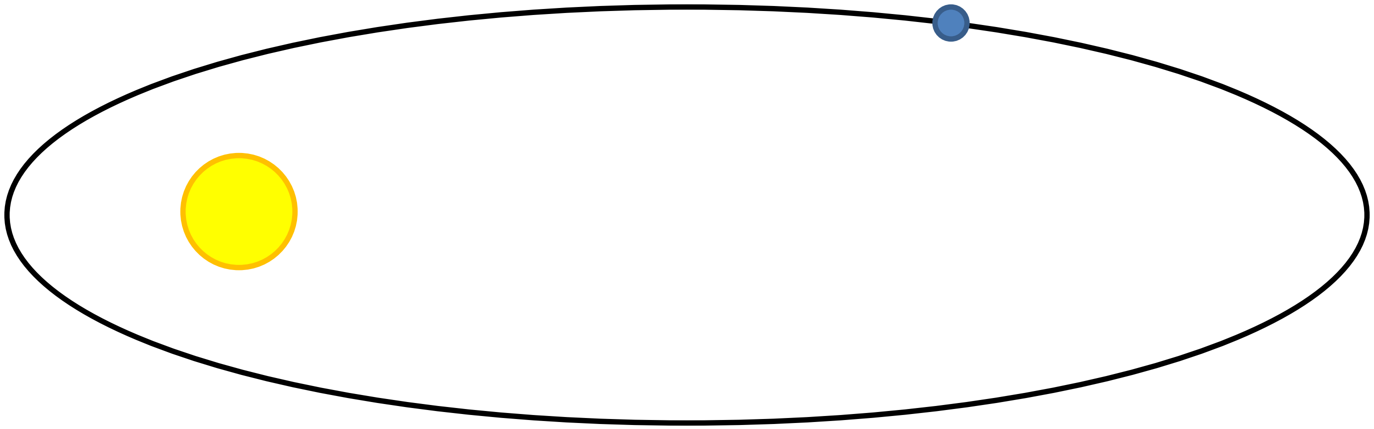
Table 1 Planetary Data

Planet	Mass (kg)	Mean radius (m)	Mean distance from sun (m)
Earth	5.97×10^{24}	6.38×10^{6}	1.50×10^{11}
Earth's moon	7.35×10^{22}	1.74×10^{6}	—
Jupiter	1.90×10^{27}	7.15×10^{7}	7.79×10^{11}
Mars	6.42×10^{23}	3.40×10^{6}	2.28×10^{11}
Mercury	3.30×10^{23}	2.44×10^{6}	5.79×10^{10}

Planet	Mass (kg)	Mean radius (m)	Mean distance from sun (m)
Neptune	1.02×10^{26}	2.48×10^{7}	4.50×10^{12}
Saturn	5.68×10^{26}	6.03×10^{7}	1.43×10^{12}
Sun	1.99×10^{30}	6.96×10^{8}	—
Uranus	8.68×10^{25}	2.56×10^{7}	2.87×10^{12}
Venus	4.87×10^{24}	6.05×10^{6}	1.08×10^{11}

Make sure to watch the Period and Speed of Orbiting Objects Math Help Video



Weight and Weightlessness

- What is apparent weightlessness?
- So, are astronauts really weightless?
- Give an example of something that is weightless.

Assignment

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