LESSON MAKER PRO

Orbit Mission Planner

Predict how long objects take to circle the Sun.

HIGH SCHOOL · ESS.2.a

ESS.2.a "Use mathematics and computational thinking to predict the motion of natural and man-made objects in the solar system, using Kepler's laws, Newton's laws of motion, and Newton's gravitational laws."

NAME _____ DATE _____

KEPLER'S ORBIT RULE

For objects orbiting the Sun, $P^2 = a^3$, where P is the orbital period in Earth years and a is the semimajor axis in astronomical units (AU). Square the period or cube the semimajor axis, then use the positive value that makes the equation true.

WORKED EXAMPLE

A spacecraft has a solar orbit with a semimajor axis of 4 AU. Find its orbital period.

1. Use $P^2 = a^3$.
2. Substitute: $P^2 = 4^3 = 64$.
3. Find the positive value: P = 8.

Answer: 8 Earth years

PRACTICE 6 problems

1 A probe has a solar orbit with a semimajor axis of 9 AU. Find its orbital period.

ANSWER _____

2 An asteroid has a solar orbit with a semimajor axis of 25 AU. Find its orbital period.

ANSWER _____

3 A spacecraft orbiting the Sun takes 216 Earth years to complete one orbit. Find its semimajor axis.

ANSWER _____

4 A comet takes 343 Earth years to orbit the Sun. Find its semimajor axis.

ANSWER _____

5 A probe has a solar orbit with a semimajor axis of 1/9 AU. Find its orbital period.

ANSWER _____

6 A simulated object takes 1/125 Earth year to orbit the Sun. Find its semimajor axis.

ANSWER _____

APPLY IT Show your work

1 In a spaceflight game, you place a probe in a solar orbit with a semimajor axis of 36 AU. How long does one orbit take? How many complete orbits does the probe make in 432 Earth years?

WORK SPACE

ANSWER _____

2 A game designer wants a spacecraft orbiting the Sun to return to its starting point after 125 Earth years. What semimajor axis should the designer enter? How many complete orbits will the craft make in 375 Earth years?

WORK SPACE

ANSWER _____

CHALLENGE One step up

Two simulated probes orbit the Sun. The inner probe has a semimajor axis of 9 AU, and the outer probe has a semimajor axis of 81 AU. How many times longer is the outer probe's orbital period? Show how you know.

WORK SPACE AND ANSWER

ANSWER KEY

Orbit Mission Planner

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	A probe has a solar orbit with a semimajor axis of 9 AU. Find its orbital period.	**27 Earth years**
2	An asteroid has a solar orbit with a semimajor axis of 25 AU. Find its orbital period.	**125 Earth years**
3	A spacecraft orbiting the Sun takes 216 Earth years to complete one orbit. Find its semimajor axis.	**36 AU**
4	A comet takes 343 Earth years to orbit the Sun. Find its semimajor axis.	**49 AU**
5	A probe has a solar orbit with a semimajor axis of 1/9 AU. Find its orbital period.	**1/27 Earth year**
6	A simulated object takes 1/125 Earth year to orbit the Sun. Find its semimajor axis.	**1/25 AU**

PART 2 · APPLY IT

1. **216 Earth years per orbit; 2 complete orbits** Since $36^3 = 46{,}656$ and $216^2 = 46{,}656$, one orbit takes 216 years. Divide 432 by 216 to get 2 orbits.
2. **25 AU; 3 complete orbits** Since $125^2 = 15{,}625$ and $25^3 = 15{,}625$, the semimajor axis is 25 AU. Divide 375 by 125 to get 3 orbits.

CHALLENGE

27 times longer. The outer probe's semimajor axis is 9 times the inner probe's, so its period ratio squared is $9^3 = 729$; the period ratio is 27.

Accept equivalent fraction notation and units such as years for Earth years. All semimajor axes are measured from the Sun and stated in AU.