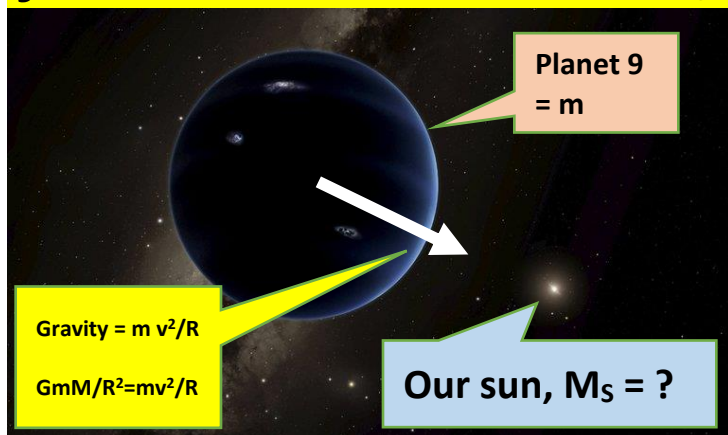


CENTRIPETAL FORCE FROM GRAVITY

Units 14 & 8

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& New York Times, October 20, 2016 by Nicholas St. Fleur, Dedicated to Tycho Brahe, Danish Nobleman and astronomer, 1546 – 1601. Known for his accurate and comprehensive astronomical and planetary observations without a telescope. Measurements done on his Danish island estate of Hven. This small island is not far from Copenhagen.

If Planet Nine Is Out There, It Tilts Our Solar System



INTRODUCTION: Purpose of this application is to find mass of our sun this ninth(?) planet orbits with provided data: $T(\text{period}) = \sim 17,117 \text{ yrs.}$, & from Wikipedia, perigee(closeness) = 200 AU, apogee = 1200 AU, AU = astronomical unit (distance earth-sun = $1.496 \times 10^{11} \text{ m}$). $R = \text{semi major axis} = (R_{\text{APOGEE}} + R_{\text{PERIGEE}})/2$
Equating gravity to centripetal force:

$$G m M_S / R^2 = m v^2 / R \quad \text{where } v = 2\pi / T \text{ yields}$$

$$M_S = (4 \pi^2 / G) (R^3 / T^2)$$

QUESTIONS: (a) Find R in meters?, (b) Convert $T = 17,117 \text{ yrs.}$ to seconds?, (c) Find M_{SUN} ?

An artist's rendering shows the distant view from Planet Nine back toward the sun

Most people think the eight planets in our solar system orbit the sun along a straight plane, like a disc on a record player. But actually, that plane is slightly tilted, and now astronomers think they know why: The elusive Planet Nine.

Earlier this year [Michael Brown](#), a professor of planetary astronomy at the California Institute of Technology, presented evidence that there may be a massive planet beyond [Neptune](#) orbiting the sun. The so-called Planet Nine is thought to be about **10 times the mass of Earth and about as large as Neptune.** At **(((its farthest point it is about 155 billion miles away from the sun.)))**

At that size and distance, this planet's mass would have large effects on the other planets orbiting the sun. **"It's so far away that it essentially gets this huge lever arm on the solar system, and it slowly tilts the planets in its direction."** Dr. Brown said Wednesday during a [joint meeting](#) of the American Astronomical Society's Division for Planetary Sciences and European Planetary Science Congress in Pasadena, Calif. "It can tilt the solar system." The eight planets (sorry, Pluto) orbit the sun along a plane. From our position on Earth, it appears as if the sun is tilted at a six-degree angle against that plane. But according to Dr. Brown, it's actually the planets that are tilted, because of Planet Nine's gravity. He said it was one of many effects that the elusive planet had on the solar system, and a clue to proving its existence. "It's really hard for me to think that the solar system could be doing all that it's doing without there being a massive planet out there," he said. [Renu Malhotra, a planetary scientist from the University of Arizona, also presented clues at the presentation that point to the existence of Planet Nine.](#) She said there are four objects deep in the Kuiper Belt, which is a minefield of ice and debris beyond Neptune, that orbit the sun in a synchronized pattern, or orbital resonance. Dr. Malhotra said the only way these extreme Kuiper Belt objects could orbit in the pattern that they do is if "they are in resonance with an unseen massive planet." Astronomers know that it takes those objects about 10,000 years to orbit the sun. If her findings are correct, that would mean that

(((Planet Nine orbits the sun about once every 17,117 years.))) Dr. Brown said he thinks **that Planet Nine is within the reach of giant telescopes and that astronomers will find it sometime soon.** "By the end of next winter," he said, "there will be enough people looking at it that I think somebody will track this down."

HINTS: $G = \text{gravitational constant} = 6.67 \times 10^{-11} \text{ N m}^2 / \text{kg}^2$, 365 days/yr., 24 hrs./day, 3600 s./hr.

ANSWERS: (a) $R = 1.047 \times 10^{14} \text{ m.}$, (b) $T = 5.4 \times 10^{11} \text{ seconds}$, (c) $M_{\text{SUN}} = \sim 2.33 \times 10^{30} \text{ kg.}$

COMMENT: Considering this is a hypothetical possible planet #9 circling our sun, our computed M_{SUN} is quite close to NASA or Wikipedia stated mass of our sun as $\sim 2 \times 10^{30} \text{ kg}$. Thus, the R and T of this hoped to be found planet number nine might be true. In the next few years the existence of this ninth planet will surely be proved.