



In 2011, the Kepler observatory detected a Saturn-sized planet orbiting the binary stars Kepler 16A and Kepler 16B. Nicknamed 'Tatooine', the view from this planet of its twin suns would be spectacular. The smaller star, Kepler-16B orbits once every 41 days at a distance of 30 million km from the larger star Kepler 16A, and the planet is in a circular orbit 108 million km from Kepler 16A which takes 229 days to complete. As seen from 'Tatooine', the small orange star Kepler-16B never gets more than 18 degrees from the much larger, yellow star Kepler 16A.

Predicting when Kepler 16B will pass across the face of Kepler 16A, called a transit, is made a bit more difficult because Tatooine is also moving along its orbit while Kepler 16B is in motion around the main star. To see a transit, Kepler 16B and Tatooine must be located in their orbits so that a line through their centers passes through the center of Kepler 16A at the center of the orbits. The time it takes this to happen is called the Synodic Period and is calculated using the formula

$$\frac{360}{t} - \frac{360}{T} = \frac{360}{P}$$

In our problem  $t = 41$  days and  $T = 229$  days so  $P = 50$  days.

**Step 1 - Draw a circle representing the orbit of Tatooine.**

**Step 2 - Place a dot on the circle to mark the location during the planet's orbit when the first transit was observed. Label this dot A**

**Step 3 - Place a second dot, B, at a position 50 days later where the next transit would be observed.**

**Problem 1 -** How many days will elapse before someone on Tatooine sees a transit within 10 days of the first dot, A, that you placed on the circle?

**Problem 2 -** How many days will elapse before someone on Tatooine sees a transit within 5 days of the first dot that you placed on the circle?

**Problem 3 -** How many days will elapse before someone on Tatooine sees a transit within 1 day of the first dot that you placed on the circle?

**Problem 4 -** How many days will elapse before someone on Tatooine sees a transit on the same day as the first dot that you placed on the circle?

**Problem 1** - How many days will elapse before someone on Tatooine sees a transit within 10 days of the first dot that you placed on the circle?

Answer: Students will need to compare two number series, one in intervals of 229 the orbit period of Tatooine, and one with a period of 50 days, which is when transits will occur.

229, **458**, **687**, 916, 1145, 1374, 1603, 1832, 2061  
50, 100, 150, 200, 250, 300, 350, 400, **450**, 500, 550, 600, 650, **700**, 750, 800, 850, 900, 950

We see that 458 and 450 are within 8 days of each other, while the next match, 687 and 700 are 13 days apart, so after **458 days or two Tatooine 'years'** a transit will happen within 10 days of Point A.

**Problem 2** - How many days will elapse before someone on Tatooine sees a transit within 5 days of the first dot that you placed on the circle?

Answer: Using the same method as in Problem 1, students should find the first such event after 1145 days when the two series yield 1150 and 1145. This will happen after 5 Tatooine years.

**Problem 3** - How many days will elapse before someone on Tatooine sees a transit within 1 day of the first dot that you placed on the circle?

Answer: The first time this happens is after 4351 days, which is 19 Tatooine years.

**Problem 4** - How many days will elapse before someone on Tatooine sees a transit on the same day as the first dot that you placed on the circle?

Answer: This requires that students solve  $M \times 50 = N \times 229$  to find N.

The first time this happens is after 11450 days where  $N = 50$  and  $M = 229$  transits. **So, a transit will occur on the same day of the year on Tatooine every 50 years!**

This can be done by finding the Least Common Multiple...since 229 is a prime number, the LCM is just  $50 \times 229 = 11450$ .