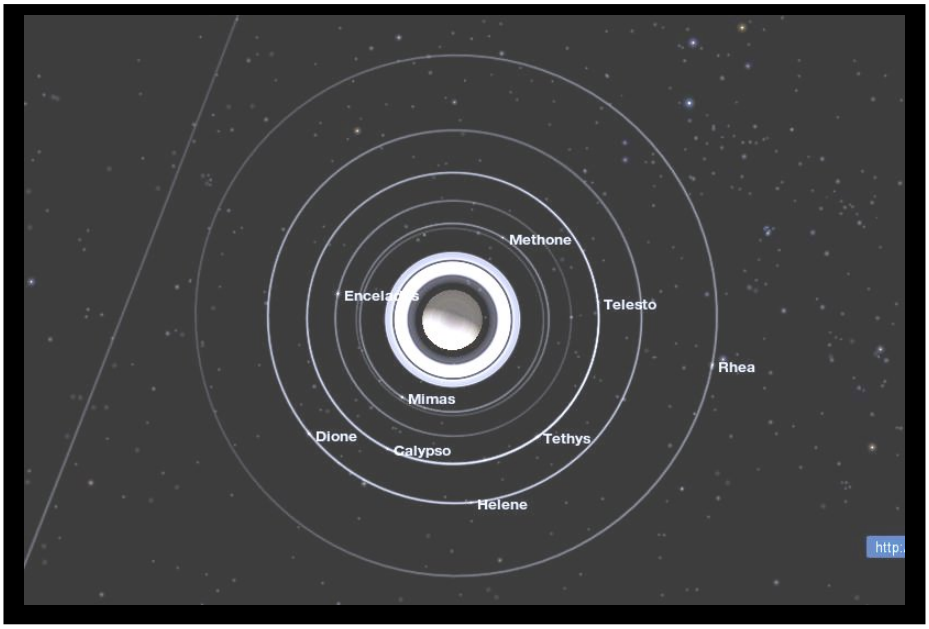
Eye Spy – Exploring Saturn's Dust Ring



Get the Data

Visit EOSS **http://1.usa.gov/Ne7b1b** to recreate the scene above. Recommended operating system: MS Vista or later; Browser: MS Internet Explorer 8 or later.

Step 1 – Click on the 'Visual Controls' tab and make sure that the following items are selected with a 'white spot': spacecraft, planets, labels, orbit lines, trails and metric.

Step 2 - Activate the Distance Measuring tool and measure the distance between the moon Helene and Saturn and confirm that it is about 315,000 kilometers.

Answering Questions

Problem 1 – Using Scientific Notation, and the fact that 1 kilometer = 1.0×10^5 centimeters, what is the distance between Saturn and its moon Rhea in centimeters if Rhea is located 466,400 km from Saturn?

Problem 2 – The moon Phoebe has a mass of 4.0×10^{18} kg and Saturn has a mass of 5.68×10^{26} kg. How many Phoebes could be made from the mass of Saturn?

Problem 3 – The mass of the Phoebe Dust Ring is estimated to be 3.0×10^{11} kg. The mass of Saturn's famous ring system is about 3.6×10^{19} kg. If the volume of the Phoebe ring is 8.1×10^{20} km^3, and Saturn's rings is 8.5×10^{14} km^3, which ring system has the highest density?

Math Challenge

Suppose that a crater on Phoebe could be approximated as a cylindrical disk with a depth of 50 meters. Suppose that the density of surface material on Phoebe is about that of solid ice or 1000 kg/m^3. What would be the radius of the crater that would produce the same amount of material as the mass of the new dust ring?

Answer Key

Problem 1 – Using Scientific Notation, and the fact that 1 kilometer = 1.0×10^5 centimeters, what is the distance between Saturn and its moon Rhea if Rhea is located 466,400 km from Saturn?

Answer: Distance = 4.664×10^5 km x (1.0×10^5 cm/1km) = **4.664×10^{10} cm.**

Problem 2 – The moon Phoebe has a mass of 4.0×10^{18} kg and Saturn has a mass of 5.68×10^{26} kg. How many Phoebes could be made from the mass of Saturn?

Answer: Number = 5.68×10^{26} kg / 4.0×10^{18} kg = **1.42×10^8 times the mass of Phoebe.**

Problem 3 – The mass of the Phoebe Dust Ring is estimated to be 3.0×10^{11} kg. The mass of Saturn's famous ring system is about 3.6×10^{19} kg. If the volume of the Phoebe ring is 8.1×10^{20} km^3, and Saturn's rings is 8.5×10^{14} km^3, which ring system has the highest density?

Answer: Density of Saturn Rings = 3.6×10^{19} kg / 8.5×10^{14} km^3 = 4.2×10^4 kg/km^3.

Density of Phoebe Ring = 3.0×10^{11} kg / 8.2×10^{20} km^3 = 3.7×10^{-10} kg/km^3

So Saturn's famous rings have a much higher density by about a factor of 4.2×10^4 / 3.7×10^{-10} = 1.1×10^{14} or 110 trillion times!

Challenge Problem: Suppose that a crater on Phoebe could be approximated as a disk with a depth of 2 kilometers. Suppose that the density of surface material on Phoebe is about that of solid ice or 1000 kg/m^3. What would be the radius of the crater that would produce the same amount of material as the mass of the new dust ring?

Answer: The Phoebe ring mass is 3.0×10^{11} kg, so at a density of 1000 kg/m^3, the volume of water ice needed is about 3.0×10^8 $meters^3$. The volume of a cylindrical crater is just $V = \pi R^2 H$, and since H = 50 meters, the volume of the crater is just $V = 1.57 \times 10^2 R^2$ $meters^3$. But we know that the required crater volume is just 3.0×10^8 $meters^3$, so $3.0 \times 10^8 = 1.57 \times 10^2 R^2$ and solving for R we get a crater radius of **1.382×10^3 meters.**

So, even though the volume of the new dust ring is enormous, all of the mass found there could have been excavated by the formation of a small crater (50 meters deep and just over 2.8 km in diameter) on the surface of the moon Phoebe!