Eye Spy – Exploring Saturn's Dust Ring

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.

Problem 1 – Using Scientific Notation, and the fact that 1 kilometer = 1.0x10^5 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 x 10^{18} kg and Saturn has a mass of 5.68 x 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 x 10^{11} kg. The mass of Saturn’s famous ring system is about 3.6 x 10^{19} kg. If the volume of the Phoebe ring is 8.1 x 10^{20} km^3, and Saturn’s rings is 8.5 x 10^{14} km^3, which ring system has the highest density?

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?
**Problem 1** – Using Scientific Notation, and the fact that 1 kilometer = 1.0x10⁵ centimeters, what is the distance between Saturn and its moon Rhea if Rhea is located 466,400 km from Saturn?

Answer:  
Distance = 4.664 x 10⁵ km x (1.0x10⁵ cm/1km) = 4.664 x 10¹⁰ cm.

**Problem 2** – The moon Phoebe has a mass of 4.0 x 10¹⁸ kg and Saturn has a mass of 5.68 x 10²⁶ kg. How many Phoebes could be made from the mass of Saturn?

Answer: Number = 5.68x10²⁶ kg / 4.0x10¹⁸ kg = 1.42x10⁸ times the mass of Phoebe.

**Problem 3** – The mass of the Phoebe Dust Ring is estimated to be 3.0 x 10¹¹ kg. The mass of Saturn’s famous ring system is about 3.6 x 10¹⁹ kg. If the volume of the Phoebe ring is 8.1 x 10²⁰ km³, and Saturn’s rings is 8.5 x 10¹⁴ km³, which ring system has the highest density?

Answer: Density of Saturn Rings = 3.6 x 10¹⁹ kg / 8.5 x 10¹⁴ km³ = 4.2x10⁴ kg/km³.

Density of Phoebe Ring = 3.0x10¹¹ kg / 8.2 x 10²⁰ km³ = 3.7x10⁻¹⁰ kg/km³

So Saturn’s famous rings have a much higher density by about a factor of 4.2 x 10⁴ / 3.7x10⁻¹⁰ = 1.1x10¹⁴ 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/m³. 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 3.0x10¹¹ kg, so at a density of 1000 kg/m³, the volume of water ice needed is about 3.0x10⁸ meters³. The volume of a cylindrical crater is just V = π R² H, and since H = 50 meters, the volume of the crater is just V = 1.57x10² R² meters³. But we know that the required crater volume is just 3.0x10⁸ meters³, so 3.0x10⁸ = 1.57x10² R² and solving for R we get a crater radius of 1.382x10³ 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!