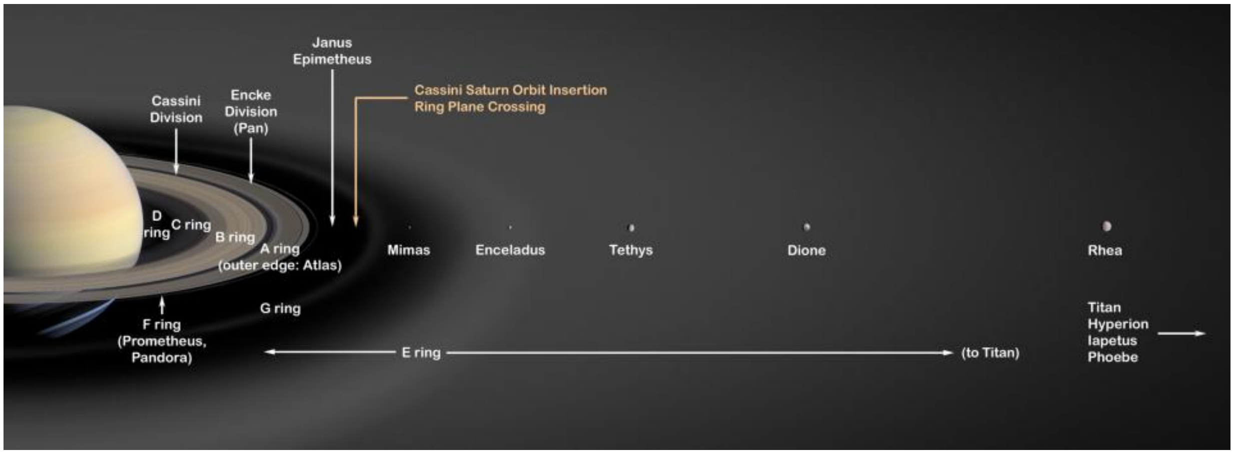

Saturn, the most beautiful planet in our solar system, is famous for its dazzling rings. Shown in the figure above, these rings extend far into space and engulf many of Saturn's moons. The brightest rings, visible from Earth in a small telescope, include the D, C and B rings, Cassini's Division, and the A ring. Just outside the A ring is the narrow F ring, shepherded by tiny moons, Pandora and Prometheus. Beyond that are two much fainter rings named G and E. Saturn's diffuse E ring is the largest planetary ring in our solar system, extending from Mimas' orbit to Titan's orbit, about 1 million kilometers (621,370 miles).

The particles in Saturn's rings are composed primarily of water ice and range in size from microns to tens of meters. The rings show a tremendous amount of structure on all scales. Some of this structure is related to gravitational interactions with Saturn's many moons, but much of it remains unexplained. One moonlet, Pan, actually orbits inside the A ring in a 330-kilometer-wide (200-mile) gap called the Encke Gap. The main rings (A, B and C) are less than 100 meters (300 feet) thick in most places. The main rings are much younger than the age of the solar system, perhaps only a few hundred million years old. They may have formed from the breakup of one of Saturn's moons or from a comet or meteor that was torn apart by Saturn's gravity.

Problem 1 – The dense main rings extend from 7,000 km to 80,000 km above Saturn's equator (Saturn's equatorial radius is 60,300 km). If the average thickness of these rings is 1 kilometer, what is the volume of the ring system in cubic kilometers? (use $\pi = 3.14$)

Problem 2 – The total number of ring particles is estimated to be 3×10^{16} . If these ring particles are evenly distributed in the ring volume calculated in Problem 1, what is the average distance in meters between these ring particles?

Problem 3 – If the ring particles are about 1 meter in diameter and have the density of water ice, 1000 kg/m^3, about what is the diameter of the assembled body from all of these ring particles?

Problem 1 – The dense main rings extend from 7,000 km to 80,000 km above Saturn's equator (Saturn's equatorial radius is 60,300 km). If the average thickness of these rings is 1 kilometer, what is the volume of the ring system in cubic kilometers? (use $\pi = 3.14$)

Answer: The area of a ring with an inner radius of r and an outer radius of R is given by $A = \pi (R^2 - r^2)$ and its volume for a thickness of h is just $V = \pi (R^2 - r^2)h$.

For Saturn's rings we have an inner radius r = 60300km+7000km =67300 km and an outer radius of R = 60300km+80000km = 140,300 km, and a volume of $V = 3.14 ((140300)^2 - (67300)^2) (1.0)$ = **4.75×10^{10} km^3**.

Problem 2 – The total number of ring particles is estimated to be 3×10^{16} . If these ring particles are evenly distributed in the ring volume calculated in Problem 1, what is the average distance in meters between these ring particles?

Answer: 4.75×10^{10} km^3 / 3×10^{16} = 1.6×10^{-6} km^3/particle, so each particle is found in a volume of 1.6×10^{-6} km^3. For two cubes next to each other each with a volume of $V = s^3$, their centers are separated by exactly s. The distance to the nearest ring particle is $D = (1.6 \times 10^{-6} \text{ km}^3)^{1/3}$ = 0.012 km, or **12 meters**!

Problem 3 – If the ring particles are about 1 meter in diameter and have the density of water ice, 1000 kg/m^3, about what is the diameter of the assembled body from all of these ring particles?

Answer: The volume of a single particle is $4/3\pi(1/2)^3$ = 0.5 meter^3. The total volume of all the 3×10^{16} particles is then $V = 1.5 \times 10^{16}$ meter^3. If this is a spherical body then $4/3\pi R^3 = 1.5 \times 10^{16}$ m^3, so R = 151185 meters or 150 kilometers in radius. The diameter is then **300 kilometers**.