GRAVITY SUPPLYING CENTRIPETAL FORCE

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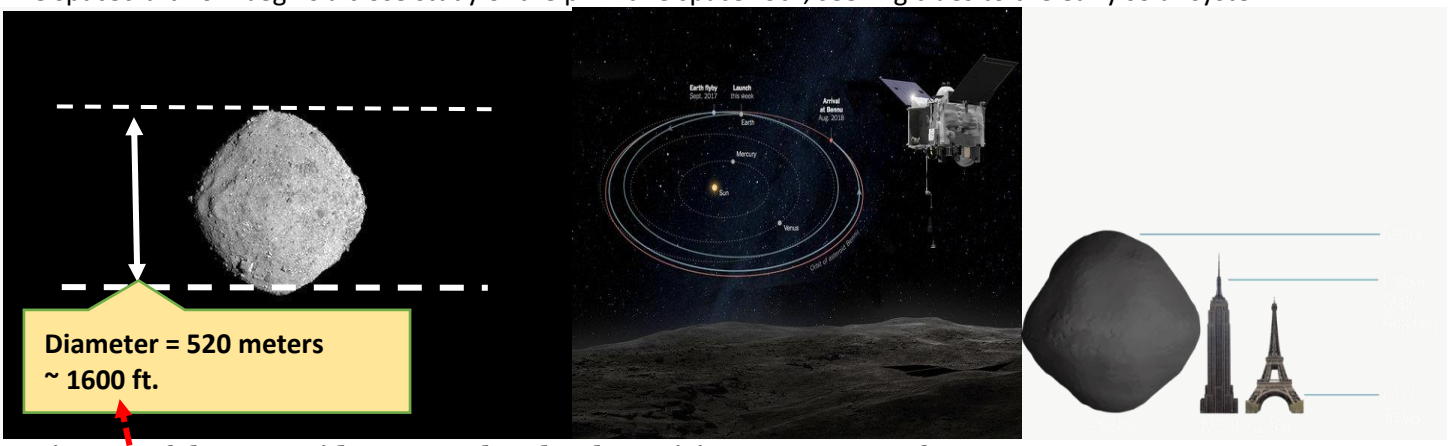
NASA's Osiris-Rex Arrives at Asteroid Bennu After a Two-Year Journey

The spacecraft now begins a close study of the primitive space rock, seeking clues to the early solar system.



An image of the asteroid Bennu taken by the Osiris-Rex spacecraft Nov. 16.CreditCreditNASA/Goddard

By Kenneth Chang Dec. 3, 2018 Launched two years ago, NASA's Osiris-Rex spacecraft pulled alongside the asteroid Bennu on Monday. Its mission is to survey the asteroid ahead of retrieving pristine bits of the solar system from the rock's surface and then bringing them back to Earth in the years ahead.With a short engine burn, the spacecraft matched the speed and direction of Bennu. A few minutes after noon, Javier Cerna, a communications systems engineer at Lockheed Martin, which built and operates the spacecraft, announced, "We have arrived."**What does NASA mean by "arrive?"** Osiris-Rex's arrival at Bennu was not like the landing of NASA's InSight spacecraft in one piece on the surface of Mars last Monday. (Happily, it landed flawlessly.)By contrast, Osiris-Rex pulled in at a modest speed, and the moment of arrival was somewhat arbitrary. The spacecraft started the approach phase of its mission in August when it was 1.2 million miles from Bennu. On Monday, it was just 12 miles away, although still too far away to orbit the asteroid. There was no drama, just a smooth transition to the next phase of the mission. **What happens next?** Osiris-Rex will make a series of passes over the asteroid at a range of 4.3 miles for an initial survey to better determine its mass, rate of spin and shape. In January, the **spacecraft will get closer to Bennu, between 0.9 and 1.2 miles,** and be drawn into orbit around the asteroid, which will be the smallest object ever to be orbited by a spacecraft. Osiris-Rex will then spend more than a year performing reconnaissance of Bennu, before attempting to bounce off the surface and collect a sample of the asteroid in mid-2020.**What can you tell me about Bennu?** Bennu, discovered in 1999, is a carbon-rich, almost black asteroid, about 1,600 feet wide. (That compares to the Empire State Building, which is 1,454 feet tall including the antenna at the top.) Scientists believe that it is a conglomeration of leftovers from the formation of the solar system, largely unchanged over the last 4.5 billion years. Bennu is categorized as a near-Earth asteroid, and scientists say there is a small chance it could slam into Earth, but not until the 22nd century if it happens at all. (It is not large enough to cause planet-wide extinctions, but it would be catastrophic at the point of impact.) By studying a primitive asteroid, scientists hope to get a better idea of what was around in the solar system's earliest days.

INTRODUCTION: Osiris-Rex spacecraft will orbit Bennu Asteroid with a period of 50 hrs.(data from NASA) at a altitude of 0.9 miles(see article above) above Bennu's surface. NASA's Bennu website (& Wikipedia) state Bennu's is 78 X 10^9 kg.. Purpose of this application is to first find mass of Bennu using Kepler's 3rd law $M = (4\pi^2/G)(R^3/T^2)$. Kepler's 3rd. law came from equating gravity as supplier of the centripetal force keeping Osiris-Rex in orbit around Bennu: $GmM/R^2 = mv^2/R$ Where $v = R\omega = 2\pi fR = 2\pi R/T$, Thus, $M = (4\pi^2/G)(R^3/T^2)$. Note R = 0.9 mi.(in meters) + radius of Bennu (255 m.).

QUESTIONS: (a) Convert 0.9 mi. to meters? (b)Find orbital distance R Osiris-Rex is from center of Bennu ? (c) Find period (in units of seconds)T of Osirix-Rex spacecraft orbiting Bennu? (d) Find mass of Bennu?, (e) Find acceleration due to gravity at surface of Bennu? Take mass of Bennu to be the NASA found mass of 78 X 10^9 kg.

HINTS: 16093.44 m./mi. , G = gravitational constant = 6.67 X 10^{-11} N $m.^2/kg.^2$, 3600 s./hr.

ANSWERS: (a) 1448 m., (b) R = 1703 m., (c) T = 1.8 X 10^5 s., (d) M = ~ 80.47 X 10^9 kg. (close to NASA stated 78 X 10^9 kg.,(e) g = 0.8 X 10^{-4} m/s^2 (close to NASA's Bennu surface g = 0.00009807 $m./s.^2$