CENTRIPETAL FORCE & GRAVITATION Unit 14 & 8

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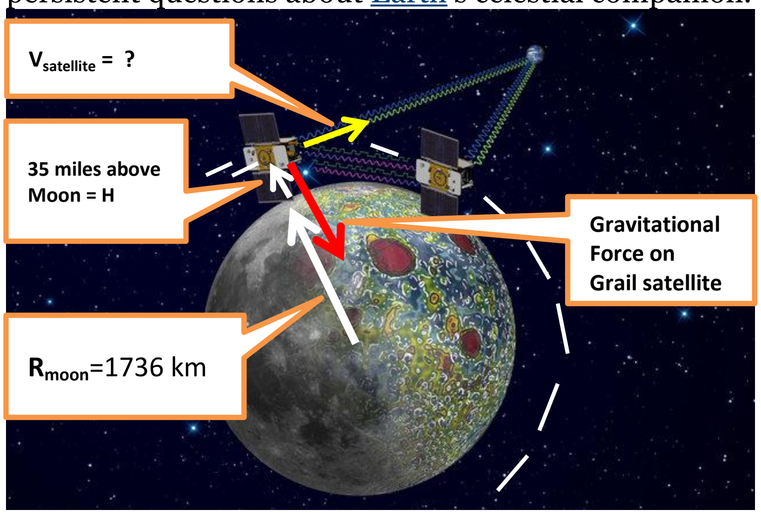
NASA Mission Will Look Beyond the Surface of the Moon

A pair of NASA spacecraft are slipping into orbit around the Moon this weekend to try to answer persistent questions about Earth's celestial companion.



An artist's rendering showing the two Grail spacecraft in orbit around the Moon. By collecting gravity data, scientists hope to get a better picture of the Moon's internal structure.

INTRODUCTION 1: **Gravity provides the centripetal force to keep objects on the surface of the moon and in orbit.**

$$G(M_{moon}m_{object})/R^2 = m_{object}V^2/R \qquad (1)$$

Thus: $$GM_{moon}/R = V^2 \qquad (2)$$

(2) can be used to find the speed of an orbiting satellite Where $R = R_{moon} + H$, H = height above surface. G = gravitational constant = 6.67×10^{-11} N m^2/kg^2

QUESTIONS: **Given the $M_{moon} = 7.35 \times 10^{22}$ kg. (a) Convert H = 35 miles into meters? (b) Find $R = R_{moon} + H$ = ? (c) Find speed(in m/s & mph) of Grail $V_{satellite}$ 35 miles above the moon? HINT 1.62 km = 1 mile, 2.237 mph/m/s**

ANSWERS: **(a) 40.5 km, (b) 1776.5 km, (c) 1.66×10^3 m/s , or 3717 mph.**

INTRODUCTION 2: **The weight of objects on surface of Moon is provided by gravity:**

$$m_{object}\, g_{moon} = G(M_{moon}m_{object})/R_{moon}^2$$

Thus, acceleration of gravity on moon surface is:

$$g_{moon} = G\, M_{moon}/R_{moon}^2$$

QUESTION(d): **Find g_{moon} ?**

ANSWER(d): **~ 1.62 m/s^2**

How did the Moon form? Is the lunar core still molten? And why is the Moon such an uneven lump? Over the decades, more than 100 spacecraft have gone to the Moon, "and yet we still don't know why the front side of the Moon looks different than the back side of the Moon," said Maria T. Zuber, the mission's principal investigator. The side of the Moon that faces Earth is flat and mostly smooth. The other side is mountainous. This $496 million NASA mission, called the Gravity Recovery and Interior Laboratory, or **Grail**, will conduct a single measurement: a map of the Moon's gravitational field. But it will do it with such precision that scientists will get a clear picture of the interior. Grail consists of two identical spacecraft that were launched side by side on a rocket on Sept. 10. Instead of taking a direct three-day trip to the Moon, they followed a longer, lower-energy trajectory that headed toward the Sun before looping back to cross paths with the Moon. Over the next couple of months, a series of shorter engine firings will nudge the spacecraft into circular orbits passing over the Moon's poles**,((34 miles)) above its surface.** In March, the spacecraft will begin **collecting the gravity data**. **Variations in density — for example, a mountain range or a clump of heavier metals below the surface — change the Moon's gravitational pull and create wobbles in its orbits, and the gravity map will be calculated from the changes in distance and speed between the two spacecraft.** For the near side, the data will be 100 times better than what scientists have now, Dr. Zuber said. For the far side, the improvement will be a factor of 1,000. That precision will allow the scientists to test, for example, predictions of a hypothesis that the Moon is actually an amalgamation of two moons that collided long ago, with the remnants of the smaller moon forming the far-side highlands. **Just as the Moon's gravity creates the rise and fall of ocean tides on Earth, so does the Earth's gravity slightly deform the shape of the Moon**. Measurement of this slight deformation will tell whether the Moon's core has cooled and turned solid. If it has, the deformation will be greatest when the Moon is closest to the Earth, the scientists said. (The Moon's orbit is almost, but not exactly, circular.) **But if part of the core is still molten, as is currently thought, the sloshing will delay the deformation to slightly after the closest approach.** The effect is so tiny that the scientists will first have to account for effects like the pressure of light from the Sun pushing on the Moon.