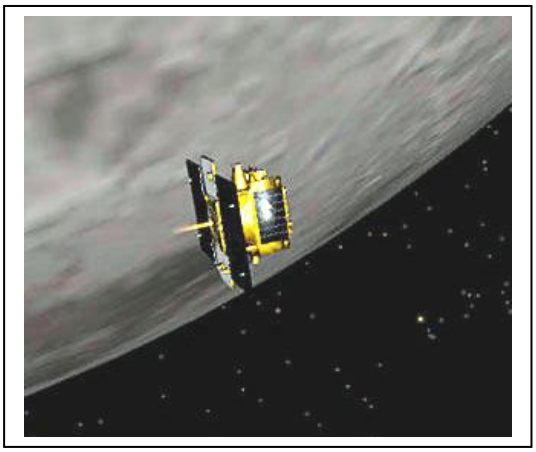


On May 31, 2012 the Grail 'Ebb' spacecraft and the Lunar Reconnissance Orbiter (LRO) will come very close to each other in their orbits around the moon. LRO is in a polar orbit, while Grail Ebb is in an equatorial orbit. Although there is no scientific value in the encounter, it does represent one of the first times that two NASA spacecraft orbiting the same astronomical body have passed so close to each other, and with the capability of actually seeing each other.

The table to the left gives the encounter times in the afternoon (Eastern Standard Time in hours, minutes and seconds) and distances (in kilometers) between the spacecraft.

Time	Distance	Time	Distance
4:00:38	190	4:01:23	110
4:00:42	180	4:01:35	105
4:00:46	170	4:01:46	110
4:00:51	160	4:01:56	120
4:00:56	150	4:02:03	130
4:01:01	140	4:02:09	140
4:01:07	130	4:02:14	150
4:01:14	120	4:02:20	160

Problem 1 – At what time were the spacecraft at their closest distances from one another?

Problem 2 – About how fast, in kilometers/hour was the distance between them changing just before closest approach?

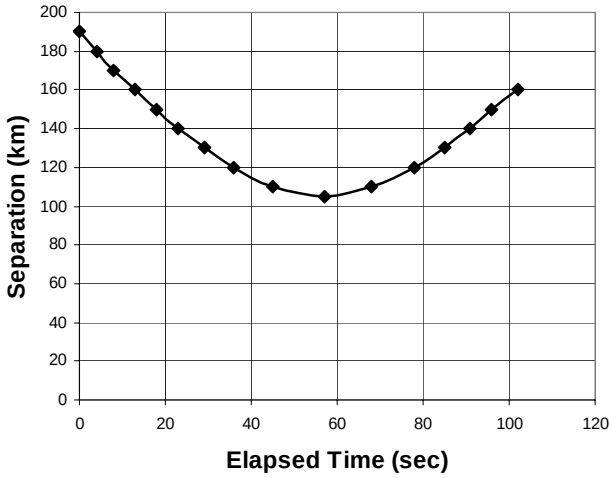
Problem 3 - Calculate the elapsed time of the encounter since 4:00:38 in seconds. Graph the tabular data in terms of elapsed time in seconds and distance in kilometers. What shape does the plotted curve resemble?

Problem 4 - The Grail 'Ebb' spacecraft will attempt to take a picture of LRO. At a distance of 50 kilometers, Grail/Ebb can just resolve an object if it is 8-meters across. That means that the angle corresponding to 8 meters at a distance of 50 kilometers is just large enough to be discerned by Grail. The LRO spacecraft is about 4 meters across. Using simple proportions, and the fact that the angular size of an object is inversely proportional to its distance, will Grail be able to see any details on the LRO spacecraft at the time of closest approach?

Problem 1 – At what time were the spacecraft at their closest distances from one another? Answer: This would be at **4:01:35** at a distance of 105 kilometers.

Problem 2 – About how fast, in kilometers/hour was the distance between them changing just before closest approach? Answer: Speed = distance/time. Distance = 110-105 = 5 km; time = 4:01:35 – 4:01:23 = 12 seconds so speed = 5km/12sec = 0.417 km/sec. In terms of km/hr, speed = 0.41 km/s x (3600 sec/1 hr) = **1500 km/hr**.

Problem 3 - Calculate the elapsed time of the encounter since 4:00:38 in seconds. Graph the tabular data in terms of elapsed time in seconds and distance in kilometers. What shape does the plotted curve resemble? Answer: **A parabola!**



Problem 4 - The Grail 'Ebb' spacecraft will attempt to take a picture of LRO. At a distance of 50 kilometers, Grail/Ebb can just resolve an object if it is 8-meters across. That means that the angle corresponding to 8 meters at a distance of 50 kilometers is just large enough to be discerned by Grail. The LRO spacecraft is about 4 meters across. Using simple proportions, and the fact that the angular size of an object is inversely proportional to its distance, will Grail be able to see any details on the LRO spacecraft at the time of closest approach?

Answer: At their closest separation, 105 kilometers is about twice as large as 50 km, and so for the same angle as seen by an 8 meter object at 50 km, the object would have to be about 8 x 105 km/50 km = 16.8 meters long in order to be seen by Grail. But LRO has a maximum size of only 4 meters, so that means Grail will only see LRO as an unresolved 'dot' of light as it passes by.

Note: Explore the encounter by using NASA's Eyes on the Solar System orbit simulator. Select the Moon, and the date and time of the encounter, then manipulate the scene until the two spacecraft orbits are highlighted. Step the time forward until you come to the encounter scene. To jump to this scene from here click on this link after first setting up EOSS to run on your computer: **http://1.usa.gov/LoD2YE**