The Space Shuttle – Fly me to the moon?

A common misconception shared by many students, and perhaps some members of the public, is that the Space Shuttle could have been used to travel to the Moon.

A few simple math problems will show that this could never have been a possibility, even if engineers had decided to 'upgrade' the Shuttle. Here are some basic facts:

Lunar distance :	384,000 km
Shuttle Orbital Speed :	17,500 miles / hr
Maximum cargo mass :	55,000 pounds

Astrodynamicists are physicists and engineers who calculate the trajectories and orbits for spacecraft throughout the solar system. Near Earth, we can think of successive orbits at increasing distance from Earth as representing a ladder. A spacecraft needs to expend more energy the higher up the ladder its orbit is from the surface of earth. This means that more distant orbits require larger launch vehicles and longer 'burn' times to get to them, than orbits close to Earth. Astrodynamicists think of the process of changing from one orbit to the other as a series of speed (velocity) changes. For example, the orbit of the Space Shuttle at an altitude of 380 km has an orbital speed of 7.68 km/s. The more distant orbits of the commercial geostationary communications satellites, located 35,800 km from Earth's surface, represent an orbital speed of 3.07 km/sec.

You might think that, since the GEO satellite orbit speed is slower than the Space Shuttle, all you have to do is 'slow down' the Space Shuttle by decreasing its kinetic energy, and it will move out to GEO satellite orbits. In fact, because of the way that kinetic energy changes in a gravitational field, you actually have to increase the kinetic energy of the Space Shuttle to make this orbit change. This is done by turning on its rockets for enough time to move it outwards from Earth. Once its orbit speed has dropped 4.61 km/s to the new value of 3.07 km/s, it will find itself at GEO orbit altitude.

Problem 1 – The Moon is 'located' at an orbit speed of 1.0 km/sec. What must be the Space Shuttle speed change to reach lunar orbit?

Problem 2 – When the Shuttle Orbital Maneuvering System (OMS) is turned on, it can cause a speed change of 0.6 meter/s for every second that the engines are burning. How many seconds would the OMS have to remain on in order for the Space Shuttle to build up the necessary velocity change to reach the Moon?

Problem 3 – The OMS can produce a maximum delta-V of 1,000 m/s before consuming all of its 9,700 pounds of fuel. How many pounds of fuel will the OMS have to expend to get to the Moon?

Problem 4 – Does the Space Shuttle have the payload capacity to carry enough extra fuel for this one-way trip?

Problem 1 – The Moon is 'located' at an orbit speed of 1.0 km/sec. What must be the Space Shuttle speed change to reach lunar orbit?

Answer: Delta-V = 1.0 – 7.68 = **- 6.68 km/sec**.

Problem 2 – When the Shuttle Orbital Maneuvering System (OMS) is turned on, it can cause a speed change of 0.6 meter/s for every second that the engines are burning. How many seconds would the OMS have to remain on in order for the Space Shuttle to build up the necessary velocity change to reach the Moon?

Answer: The delta-V to get to the moon is 6,680 meters/sec. The OMS can produce 0.6 m/s every second, so the total burn time would have to be T = 6,680 / 0.6 or about **11,000 seconds or 3 hours of continuous thrust.**

Problem 3 – The OMS can produce a maximum delta-V of 1,000 m/s before consuming all of its 9,700 pounds of fuel. How many pounds of fuel will the OMS have to expend to get to the Moon?

Answer: We need a total delta-V of 6,680 m/s, so 9,700 pounds x (6,680/1,000) = **64,796 pounds of fuel.**

Problem 4 – Does the Space Shuttle have the payload capacity to carry enough extra fuel for this one-way trip?

Answer: The maximum cargo mass is 55,000 pounds, so the OMS fuel would require 64,796 / 55,000 = 1.2 times the maximum load of the Space Shuttle cargo bay. **No, the Shuttle does not have enough capacity to lift all of the required OMS fuel to Earth orbit.**