THE MOON

I. In your pairs discuss the questions below (source: http://www.esldiscussions.com)

1. Is the Moon important in your culture?
2. What do you think about when you look at the Moon?
3. Would you like to visit the Moon?
4. Do you think there'll be cities on the Moon in the future with McDonalds and Starbucks?
5. What would happen to the Earth if the Moon disappeared?
6. What are the different phases of the Moon?
7. What would you do if you spent a day on the Moon? Why do some cultures say the Moon is made of cheese?
8. Why is it important to study the Moon?
9. Why can you sometimes see the Moon during the day?
10. What do you like doing by moonlight?
11. Why do you think people say the Moon landing didn't really happen, that it was just a hoax?
12. Someone once said, "Moonlight is sculpture; Sunlight is painting." What do you think?
13. What movies have you seen about the Moon?

II. Phases of the moon – match the names with their descriptions, then draw a picture of the moon in its particular phase.

Names: the crescent moon, the first quarter, the full moon, the gibbous moon, the last quarter, the new moon

Descriptions:
1. We see it when it is one quarter through its revolution around the Earth.
2. We see it between the quarter and full moon phases.
3. We see it when it is three quarters through its revolution around the Earth.
4. We see it between the quarter and new moon phases.
5. We see it when the Moon and the Sun are on opposite sides of the Earth, and the entire side of the Moon facing the Earth is lit up by the Sun.
6. When the Moon and the Sun are on the same side of the Earth, the dark side of the Moon faces the Earth and we don't see it at all.

III. Read the text about the moon and then decide whether the statements below are true (T) or false (F)

The Moon is the only natural satellite of the Earth, and the fifth largest satellite in the Solar System. It is the largest natural satellite of a planet in the Solar System relative to the size of its primary, having a quarter the diameter of Earth and $^{1}/_{81}$ its mass. The Moon is the second densest satellite after Io, a satellite of Jupiter. It is in synchronous rotation with Earth, always showing the same face; the near side is marked with dark volcanic maria among the bright ancient crustal highlands and prominent impact craters. It is the brightest object in the sky after the Sun, although its surface is actually very dark, with a similar reflectance to coal. Its prominence in the sky and its regular cycle of phases have, since ancient times, made the Moon an important cultural influence on language, calendars, art and mythology. The Moon's gravitational influence produces the ocean tides and the minute lengthening of the day. The Moon's current orbital distance, about thirty times the diameter of the Earth, causes it to appear almost the same size in the sky as the Sun, allowing it to cover the Sun nearly precisely in total solar eclipses.

The Moon is the only celestial body other than Earth on which humans have set foot. While the Soviet Union's Luna programme was the first to reach the Moon with unmanned spacecraft in 1959, the United States' NASA Apollo program achieved the only manned missions to date, beginning with the first manned lunar orbiting mission by Apollo 8 in 1968, and six manned lunar landings between 1969 and 1972, with the first being Apollo 11. These missions returned over 380 kg of lunar rocks, which have been used to develop geological understanding of the Moon's origins, the formation of its internal structure, and its subsequent history. It is thought to have formed some 4.5 billion years ago. One formation theory is a giant impact event involving Earth. The impact theory was called into question in 2012, after re-analysis of Apollo samples.


Full Moon as seen from Earth's northern hemisphere

1. The Moon is the densest satellite of the Solar System.
2. It rotates in the same direction as the Earth.
3. Moon's surface doesn't radiate light.
4. Its current orbital distance is 13x the diameter of the Earth.
5. Luna was the first mission with people to reach the Moon.
6. The specimens of lunar rocks are valuable source of information about the Moon.
7. It is not entirely clear how the Moon formed.

IV. Watch the video recording an interview with Neil Armstrong in 1970, and answer the questions below

1. What did the perception of colours on the Moon depend on? What range of colours could be observed there?
2. How were distances seen?
3. Why couldn't they see the real horizon?
4. What does the far side of the Moon look like?
5. What was Armstrong's opinion about building bases n the Moon?
6. What problems did he mention?
7. How did he compare building bases on the Moon to Antarctica?

V. Read one of the texts on missions to the moon and present your findings to the rest of the class

Missions to the moon (source: http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html)

I. Lunar Atmosphere and Dust Environment Explorer (LADEE) - Mar, 2013 - Lunar Orbiter

The Lunar Atmosphere and Dust Environment Explorer (LADEE) is currently under study for launch in 2012 on a Minotaur-V. LADEE is designed to characterize the tenuous lunar atmosphere and dust environment from orbit. The scientific objectives of the mission are: 1) Determine the global density, composition, and time variability of the fragile lunar atmosphere before it is perturbed by further human activity; and 2) Determine the size, charge, and spatial distribution of electrostatically transported dust grains and assess their likely effects on lunar exploration and lunar-based astronomy. further objectives are to determine if the Apollo astronaut sightings of diffuse emission at 10s of km above the surface were Na glow or dust and document the dust impactor environment (size-frequency) to help guide design engineering for the outpost and also future robotic missions.

The current launch readiness date is May 2012 with launch windows opening any time after that. The nominal science orbit will last 100 days. The orbiter will carry a neutral mass spectrometer, an ultraviolet/visible spectrometer, and a dust detector. The total science payload mass must be less than 20 kg with normal power of 60 W and a 100 W maximum. There is also a technology demonstration, the Lunar laser Communication Demonstration.

Communications will be via S-band with a 10 Kbps science data rate. Total mass of the orbiter will be approximately 130 kg.

The instruments will detect and constrain the abundances of species expected to be prevalent at the 50 km altitude, due to the solar wind and its interactions with the surface, release from regolith, and radiogenic sources. The NMS is a quadrupole mass spectrometer designed ot detect species up to 150 amu and will look for CH4, S, O, Si, Kr, Xe, Fe, Al, Ti, Mg, OH, and H2O. The UV/Vis will detect Al, Ca, Fe, K, Li, Na, Si, T, Ba, Mg, H2O, and O and will monitor the dust composition.

Slated for launch in 2012 from Wallops Island on a Minotaur with a Star 37FM or FMV upper stage, LADEE will spend about 5 months reaching nominal lunar orbit and checking out systems before its 100 day science mission starts. The nominal science orbit will be a near-circular (about 50 km) retrograde equatorial orbit with a period of 113 minutes. The periselene will be over the sunrise terminator. After the science mission is complete the orbiter will be put into a higher elliptical orbit for the technology demonstration, which will last for about 9 months. Total mission cost is estimated at roughly $100 million.

II. Chang'e 2 - Oct 1, 2010 - Lunar Orbiter

Launched on 01 October 2010, the Chang'e 2 spacecraft is China's second lunar mission. Expanding on the goals of the Chang'e 1 mission, its will act as a technical test satellite for future Chinese lunar missions. Its principal objectives are to return high resolution images of the lunar surface to aid in selection of a future landing site for the Chang'e 3 lander and rover mission. A key technology for soft-landing on the Moon will also be tested.

Chang'e 2 was designed as a backup satellite for the Chang'e 1 spacecraft based on the DFH-3 Comsat bus. It has been modified for its current mission. The spacecraft will carry a CCD stereo camera with spatial resolution of 10 m from the nominal 100 km altitude. A laser altimeter with a laser pulse frequency of 5 Hz and a radial accuracy of 5 m will also be mounted on the spacecraft.

Chang'e 2 launched from Xichang launch site on a Long March 3C booster at 10:59:57 UT on 01 October 2010. A 5-day trans-lunar cruise was followed by insertion into a 12 hour elliptical lunar polar orbit at 03:06 UT on 06 October followed by lowering to a 100 km nominal science orbit. Towards the end of the mission the orbit will be lowered to 15 km x 100 km to test the tracking ability of a new X-band ground tracking system. The Chang'e program is named for a Chinese legend about a young fairy who flies to the Moon.

III. Chandrayaan-1 - Oct 22, 2008 - Lunar Orbiter

The Indian Space Research Organization announced on 31 August that the Chandrayaan 1 mission has been officially terminated after contact was lost abruptly at 20:00 UT on 28 August.

Chandrayaan-1 is an Indian Space Research Organization (ISRO) mission designed to orbit the Moon over a two year period with the objectives of upgrading and testing India's technological capabilities in space and returning scientific information on the lunar surface. The spacecraft bus is roughly a 1.5 meter cube with a dry weight of 523 kg (Launch mass of the system, including its Lunar Apogee Motor, LAM, is 1380 kg). It is based on the Kalpansat meteorological satellite. Power is provided by a solar array which generates 750 W and charges lithium ion batteries. A bipropellant propulsion system is used to transfer Chandrayaan-1 into lunar orbit and maintain attitude. The spacecraft is 3-axis stabilized using attitude control thrusters and reaction wheels. Knowledge is provided by star sensors, accelerometers, and an inertial reference unit. Telecommand communications will be in S-band and science data transmission in X-band.

The scientific payload has a mass of 55 kg and contains three Indian instruments. The Terrain Mapping Camera (TMC) has 5 meter resolution and a 40 km swath in the panchromatic band and will be used to produce a high-resolution map of the Moon. The Hyper Spectral Imager (HySI) will perform mineralogical mapping in the 400-900 nm band with a spectral resolution of 15 nm and a spatial resolution of 80 m. The Lunar Laser Ranging Instrument (LLRI) will determine the surface topography. A fourth instrument, an X-ray flourescence spectrometer, will have three components: an Imaging X-ray Spectrometer (CIXS) covering 1 - 10 keV with a ground resolution of 10 km, a High Energy X-ray/gamma ray spectromenter (HEX) for 10 - 200 keV measurements with ground resolution of about 20 km, and a Solar X-ray Monitor (SXM) to detect solar flux in the 2 - 10 keV range. CIXS will be used to map the abundance of Si, Al, Mg, Ca, Fe, and Ti at the surface, the HEX will measure U, Th, 210Pb, 222Rn degassing, and other radioactive elements, and the SXM will monitor the solar flux to normalize the results of CIXS and HEX. The Sub-keV Atom Reflecting Analyzer (SARA) will map composition using low energy neutral atoms sputtered from the surface. The Moon Mineralogy Mapper (M3) is an imaging spectrometer designed to map the surface mineral composition. A near-infrared spectrometer (SIR-2) will also map the mineral composition using an infrared grating spectrometer. The Miniature Synthetic Aperture Radar (Mini-SAR) will perform radar scattering and imaging investigations at the poles in a search for water ice. A Bulgarian instrument, the Radiation Dose Monitor (RADOM-7), will also fly on the mission to characterize the local radiation environment.

Chandrayaan-1 will also carry a 35 kg Moon Impact Probe (MIP) designed to be released from the spacecraft and hit the lunar surface. The MIP carried a video camera, a radar altimeter, and a mass spectrometer. The side panels of the box-like probe were painted with the Indian flag.

The spacecraft launched on a PSLV C11 (Polar Satellite Launch Vehicle) from the Satish Dhawan Space Center in Sriharikota on the southeast coast of India on 22 October 2008 at 00:52 UT (6:22 a.m. local time). The PSLV injected Chandrayaan-1 into a 255 x 22860 km transfer orbit with an inclination of 17.9 degrees. Reaching lunar transfer trajectory involved five firings of the LAM increasing the eccentricity of the orbit around the Earth to a final apogee of 380,000 km on 4 November. On 8 November Chandrayaan was put into a 7502 x 504 km lunar polar orbit, and then lowered into a 100 km circular polar orbit. On 14 November at 14:36:54 UT the Moon Impact Probe was released and hit the lunar surface at 15:01 UT near the Moon's south pole. All three instruments returned data before the crash. The orbiter will return data for at least two years. Chandrayaan means "Moon Craft" in ancient Sanskrit. Total cost of the mission is estimated at INR 3.8 billion ($83 million U.S.).

IV. Lunar Prospector - Jan 7, 1998 - Orbiter

Launch Date: 7 January 1998 UT 02:28:44 (6 January 9:28:44 p.m. EST)
Launch Vehicle: Athena II
Launch Site: Kennedy Space Center
Launch Mass 296 kg (fully fueled), 158 kg (dry)
Power System: Body Mounted 202 W Solar Cells and 4.8 amp-hr NiCd Battery

The Lunar Prospector is designed for a low polar orbit investigation of the Moon, including mapping of surface composition and possible polar ice deposits, measurements of magnetic and gravity fields, and study of lunar outgassing events. Data from the 19 month mission will allow construction of a detailed map of the surface composition of the Moon, and will improve our understanding of the origin, evolution, current state, and resources of the Moon. The spacecraft is a graphite-epoxy drum, 1.37 meters in diameter and 1.28 meters high with three radial instrument booms. It is spin-stabilized and controlled by 6 hydrazine monopropellant 22-Newton thrusters. Communications are through two S-band transponders and a slotted, phased-array medium gain antenna and omnidirectional low-gain antenna. There is no on-board computer, ground command is through a 3.6 kbps telemetry link. Total mission cost is about $63 million. After launch, the Lunar Prospector had a 105 hour cruise to the Moon, followed by insertion into a near-circular 100 km altitude lunar polar orbit with a period of 118 minutes. In December 1998 the orbit was lowered to 40 km. The nominal mission ended after one year, at which time the orbit was lowered to 30 km. On 31 July 1999 at 9:52:02 UT (5:52:02 EDT) Lunar Prospector impacted the Moon near the south pole in a controlled crash to look for evidence of water ice - none was observed.

V. Luna 22 - Jun 2, 1974 – Orbiter

Luna 22 was a lunar orbiter mission. The spacecraft carried imaging cameras and also had the objectives of studying the Moon's magnetic field, surface gamma ray emissions and composition of lunar surface rocks, and the gravitational field, as well as micrometeorites and cosmic rays. Luna 22 was launched into Earth parking orbit and then to the moon. It was inserted into a circular lunar orbit on 2 June 1974. The spacecraft made many orbit adjustments over its 18 month lifetime in order to optimize the operation of various experiments, lowering the perilune to as little as 25 km. Maneuvering fuel was exhausted on 2 September and the mission was ended in early November.

VI. Apollo 13 - Apr 11, 1970 - Crewed Landing (aborted)

Apollo 13 was intended to be the third mission to carry humans to the surface of the Moon, but an explosion of one of the oxygen tanks and resulting damage to other systems resulted in the mission being aborted before the planned lunar landing could take place. The crew, commander James A. Lovell, Jr., command module pilot John L. Swigert, Jr., and lunar module pilot Fred W. Haise Jr., were returned safely to Earth on 17 April 1970.

Apollo 13 was launched on Saturn V SA-508 on 11 April 1970 at 19:13:00 UT (02:13:00 p.m. EST) from pad 39A at Kennedy Space Center. During second stage boost the center engine of the S-II stage cut off 132 seconds early, causing the remaining four engines to burn 34 seconds longer than normal. The velocity after S-II burn was still lower than planned by 68 m/sec, so the S-IVB orbital insertion burn at 19:25:40 was 9 seconds longer than planned. Translunar injection took place at 21:54:47 UT, CSM/S-IVB separation at 22:19:39 UT, and CSM-LM docking at 22:32:09 UT. The S-IVB auxilliary propulsive system burned at 01:13 UT on 12 April for 217 seconds to put the S-IVB into a lunar impact trajectory. (It impacted the lunar surface on 14 April at 01:09:41.0 at 2.75 S, 27.86 W with a velocity of 2.58 km/s at a 76 degrees angle from horizontal.) A 3.4 second mid-course correction was made at 01:27 UT on 13 April.

A television broadcast was made from Apollo 13 from 02:24 UT to 02:59 UT on 14 April and a few minutes later, at 03:06:18 UT Jack Swigert turned the fans on to stir oxygen tanks 1 and 2 in the service module. The Accident Review Board concluded that wires which had been damaged during pre-flight testing in oxygen tank no. 2 shorted and the teflon insulation caught fire. The fire spread within the tank, raising the pressure until at 3:07:53 UT on 14 April (10:07:53 EST 13 April; 55:54:53 mission elapsed time) oxygen tank no. 2 exploded, damaging oxygen tank no. 1 and the interior of the service module and blowing off the bay no. 4 cover. With the oxygen stores depleted, the command module was unusable, the mission had to be aborted, and the crew transferred to the lunar module and powered down the command module.

At 08:43 UT a mid-course maneuver (11.6 m/s delta V) was performed using the lunar module descent propulsion system (LMDPS) to place the spacecraft on a free-return trajectory which would take it around the Moon and return to Earth, targeted at the Indian Ocean at 03:13 UT 18 April. After rounding the Moon another LMDPS burn at 02:40:39 UT 15 April for 263.4 seconds produced a differential velocity of 262 m/s and shortened the estimated return time to 18:06 UT 17 April with splashdown in the mid-Pacific. To conserve power and other consumables the lunar module was powered down except for environmental control, communications, and telemetry, and passive thermal control was established. At 04:32 UT on 16 April a 15 second LMDPS burn at 10% throttle produced a 2.3 m/s velocity decrease and raised the entry flight path angle to -6.52 degrees. Following this the crew partially powered up the CSM. On 17 April at 12:53 UT a 22.4 second LMDPS burn put the flight path entry angle at -6.49 degrees.

VII. Luna 1 - Jan 2, 1959 – Flyby

Luna 1 was the first spacecraft to reach the Moon, and the first of a series of Soviet automatic interplanetary stations successfully launched in the direction of the Moon. The spacecraft was sphere-shaped. Five antennae extended from one hemisphere. Instrument ports also protruded from the surface of the sphere. There were no propulsion systems on the Luna 1 spacecraft itself. Because of its high velocity and its announced package of various metallic emblems with the Soviet coat of arms, it was concluded that Luna 1 was intended to impact the Moon.

On 2 January 1959, after reaching escape velocity, Luna 1 separated from its 1472 kg third stage. The third stage, 5.2 m long and 2.4 m in diameter, travelled along with Luna 1. On 3 January, at a distance of 113,000 km from Earth, a large (1 kg) cloud of sodium gas was released by the spacecraft. This glowing orange trail of gas, visible over the Indian Ocean with the brightness of a sixth-magnitude star, allowed astronomers to track the spacecraft. It also served as an experiment on the behavior of gas in outer space. Luna 1 passed within 5995 km of the Moon's surface on 4 January after 34 hours of flight. It went into orbit around the Sun, between the orbits of Earth and Mars.

The spacecraft contained radio equipment, a tracking transmitter, and telemetering system, five different sets of scientific devices for studying interplanetary space, including a magnetometer, geiger counter, scintillation counter, and micrometeorite detector, and other equipment. The measurements obtained during this mission provided new data on the Earth's radiation belt and outer space, including the discovery that the Moon had no magnetic field and that a solar wind, a strong flow of ionized plasma emmanating from the Sun, streamed through interplanetary space.