ASTR 308 "Into the Final Frontier"

Project Apollo

1. Provide a brief description of the following maneuvers undertaken during an Apollo mission. Include a description of what parts of the rocket are involved (which part of the rocket fires its engines, etc). Rocket parts include: 1.the full Saturn V rocket, (2) the 2nd stage, (3) the 3rd stage (the S-IVB stage), (4) the "stack" (CSM docked to LEM), (5) the Service Module (SM) with SPS engine, (6) the command module (CM), (7) the full LEM, (8) the descent stage of the LEM, and (9) the ascent stage of the LEM

(a) When and where does TLI burn occur? Which part of the rocket is used for the "burn" and where is the rocket in its path to the moon and how is the rocket orientated. Draw a picture if it helps.

TLI is the Trans Lunar Injection Burn. It occurs while still in Earth orbit, specifically when the rocket is on the opposite side of the Earth relative to the moon. The rocket is pointing forward in its direction of motion and the thrust is used to increase the rocket's velocity (what they call Delta-v). At this point, the first and second stages of the Saturn V have been jettisoned because they have used all its fuel to get the rocket to orbit. It is the third stage of the rocket, or the S-IVB stage, that does the TLI burn (a J-2 engine).

(b) LEM/CSM docking maneuver. Explain where the rocket is in its path to the moon and explain the maneuver. Which part of the rocket is begin actively flown and which part is just coasting. What part of the rocket is discarded afterward.

The LEM/CSM docking takes place shortly after the TLI burn while the rocket is in a trans lunar trajectory (coasting between the Earth and the moon). The CSM actively separates from the S-IVB, which then is just coasting toward the moon. The CSM is turned around, docks with the LEM that is stationed in the upper part of the S-IVB and then extracts the LEM from the S-IVB. The S-IVB has now completed all its functions and is discarded (though it fires some small thrusters to ensure that it drifts way from the CSM+LEM stack.

(c) The LOR maneuver. Which part of the rocket (which engine) is used for the "burn" and where is the rocket in its path to the moon and how is the rocket orientated? Draw a picture if it helps. Answer the same for the TEI burn.

The LOR burn is performed as the stack goes around the far side of the moon for the first time. The Service Propulsion System (SPS) engine on the Service Module is the engine that is used. The stack is oriented backwards to its direction

of motion and the burn us used to decrease the stacks velocity so that it can be captured by the moon's gravity. After the LEM is discarded following the landing, the TEI burn (also using the SPS engine) is performed in lunar orbit to get the CSM on a trajectory back to earth. The burn happens on the far side of the moon with the rocket facing forward to its direction of motion so that the CSM velocity is increased so that it can escape the moon's gravity.

(d) When does the SM Jettison occur? What part of the rocket is left after SM Jettison and what is the next major event to take place in the flight plan after SM Jettison? Does the remaining part of the rocket have any major rocket engines on it?

The Service Module (SM), which provides power and oxygen to the Command Module (CM), is jettisoned at the very end of the trans lunar trajectory on the way back to earth just before reentry (only the CM enters the atmosphere). The CM does not have any major rocket engines; only small maneuvering thrusters to change its roll, pitch, and yaw. This means that the CM better be flying in the exact right trajectory because there are no second chances to correct any errors!

2. Apollo 8

(a) Provide at least two major reasons why Apollo 8 went to the moon… what were the reasons? Recall that Apollo 8 was not originally scheduled to go all the way out to the moon, but had a different original objective.

1. The LEM was not ready for testing, and the original plan was to test it before going to the moon. So, the entire program would have to be put on hold and we would be in trouble to meet the goal of landing on the moon by the end of the decade (this was in 1968!). So Apollo 8 had no LEM!

2. There was evidence that the Russians had tested a rocket capable of going to the moon with a man in it (the CIA had satellite photos). NASA did not want to be beaten by the Russians yet again! They wanted America to the first to send astronauts to the moon, even if it did not involve a landing.

(b) Name as many objectives as you can for the mission of Apollo 8.

The Apollo 8 mission was to send three astronauts all the way to the moon and have them orbit the moon 10 times. This required (1) a test of the computers, navigation and maneuvers to and from the moon, including TLI, LOI, TEI, and PTC, and the free return trajectory, (2) a test of the CMS and SPS engine in lunar orbit, and (3) a test of reentry at the extreme velocities of a returning moon ship (much higher than Gemini or Mercury!!!). The astronauts were given the goal of taking photos and looking for a good place for the first moon landing.

(c) What memorable event happened on Christmas Eve on the Apollo 8 mission? What were the names of the Apollo 8 astronauts? These were the first three people to leave earth and go to another astronomical body. They should be better remembered than Niel Armstong is!

On Christmas Eve 1968, while orbiting the moon, the Apollo 8 astronauts, Frank Borman, Jim Lovell, and Bill Anders took turns reading from the Book of Genesis in a radio and TV broadcast that was witnessed by millions of people on Earth.

3. Apollo 11

(a) Who flew on the Apollo 11 mission and what were their individual roles? What did they name the CM? What did they name the LEM? Where on the moon did they land? What call sign did they give this landing site once they landed there?

Commander (CM): Niel Armstrong, command the mission, fly the LEM
Command Module Pilot: Michael Collins, fly and maintain the CM
Lunar Module Pilot: Buzz Aldrin, co-pilot and maintain the LEM

The CM was named Columbia. The LEM was named Eagle. They landed on a flat smooth area called Mar Traquillitatus (the Sea of Tranquility). Once they landed, Armstrong called it Tranquility Base.

(b) In Chaiken, he describes a few problems had with the LEM during the descent. What were at least two major and alarming problems they had such that landing was not so smooth of an endeavor and that they might have aborted? (You also learned about one of these in the movie "To the Moon".)

During the descent phase of the landing, they experienced several "1201" alarms. This meant that the computer was overloaded with too many tasks to compute and was starting over. It happened because Aldrin left the rendezvous radar on when he was only supposed to have the landing radar on! They almost had to abort. The other problem was that the LEM was flying too fast (almost to the abort limit) and because of this was going to navigate them to the wrong spot, and this spot was a boulder field! Armstrong had to take the controls and find a smooth area. It was so close that they had less than 15 seconds of fuel left in the descent stage when they landed!

(c) For roughly how long did the Apollo 11 astronauts walk on the moon and what goals did they accomplish? (see Chaiken)

Roughly, Armstrong and Aldrin walked on the moon for about 2 hours. They measured and tested their ability to walk around. They gathered some rocks, set up some experiments, and planted the American flag (and talked with Nixon!).

(d) What did the astronauts have to do for 30 days after the mission was completed and why? (see Chaiken)

The astronauts were quarantined for 30 days with their lunar booty. The US government had a lot of pressure to protect the peoples of Earth from any possible biological contamination that might have been present on the moon. [BTW, this happened for Apollo's 12 and 14 too; Apollo 15 was the first to not have to be quarantined.]

4. Apollo 15

(a) Who flew on Apollo 15 and what were their roles? What did they name the CM? What was the CM named after? What did the name the LEM? Where on the moon did they land?

CM: Dave Scott
CMP: Al Worden
LMP: Jim Irwin

The CM was named Endeavor, after Captain Cook's ship (the first ship of exploration!). The LEM was name Falcon. They landed in a valley amongst the Apennine Mountains near a place called Hadley Rill just to the edge of Mar Imbrium.

(b) Why does Chaiken say that Apollo 15 is the first real Apollo mission for scientific discovery? What were different about its objectives than previous missions?

Apollo 15 was the first all out geological survey mission on the moon in which the astronauts applied the field survey techniques of geologists. Proper geology requires knowing the context of a rock, which requires documenting its location and orientation on the ground and it location with respect to the mountains and valleys. No previous moon mission did this kind of work.

(c) For roughly how long did the Apollo 15 astronauts walk on the moon and what goals did they accomplish? Did they do more than one moonwalk? What special contraption did they use in order to go long distance on the moon? (see Chaiken)

One of the main objectives was to find anorthosite, a white crystalline rock believed to be what the moon's original crust was made of. They found a particularly large one and it has been dubbed the "Genesis Rock". In the words of Dave Scoot when he saw it- "I think we found what we came for!" They did three moonwalks and stayed on the moon 2 days 18 hours and 55 minutes. To go far distances on the moon, they used the Lunar Rover (they were the first), a small 4 wheel vehicle that they drove around Hadley Rill and all.

(d) When the astronauts returned to earth, they got in some trouble with NASA. What did the astronauts do that was considered unethical? (see Chaiken)

Upon their return from the moon while flying back to Hawaii, the astronauts signed first day cover issues of stamps they had taken to the moon with them. They did this so that they could make money; in particular they wanted to start college funds for their children. The story broke and NASA took the heat (so did the astronauts).

5. Apollo 17

(a) Who flew on the Apollo 17 mission and what were their roles? What did they name the CM? What did they name the LEM? Where on the moon did they land?

CM: Gene Cernan
CMP: Ron Evans
LMP: Harrison "Jack" Schmidt

The CM was named America. The LEM was named Challenger. They landed at Taurus-Littrow, a valley in the highest mountains yet explored on the moon.

(b) What was unique about the Lunar Module Pilot on this mission? What were the circumstances and for what reasons were the original CMP taken off the flight and this guy put on the flight?

The LMP, Dr. Jack Schmidt (aka. Dr. Rock) was the first scientists on the moon, in particular he was the first professional geologist to practice his art on a different astronomical body (and he is still the only one to have done so!). NASA was pressured to send a geologist/scientists to the moon, and "Dr. Rock was the only geologist trained as an astronaut. The decision was made to take the original LMP off the mission just as the crew assignment was made for Apollo 17.

(c) Who was the last man to set foot on the moon and what did he say to humanity (you can quote it) just before he stepped off the moon?

Apollo 17 CM Gene Cernan was the last man to leave the moon (Schmidt got back in the LEM before Cernan did. His challenge to future generations were: "Bob, this is Gene, and I'm on the surface; and, as I take man's last step from the surface, back home for some time to come - but we believe not too long into the future - I'd like to just (say) what I believe history will record. That America's challenge of today has forged man's destiny of tomorrow. And, as we leave the Moon at Taurus-Littrow, we leave as we came and, God willing, as we shall return, with peace and hope for all mankind. Godspeed the crew of Apollo 17. (I grabbed this from http://en.wikipedia.org/wiki/Eugene_Cernan)