

**Essays**

A few times through the semester I am assigning short essay questions on Titan and our exploration of the solar system. These essays should be at least 1000 words long and be themed to relate to subjects we are discussing in class at the time. You should include a short bibliography of sources. The essays should be typed and uploaded to Canvas.

Here are the topics:

**Exploring the Solar System – Due Midnight, March 17**

For this essay, each student will be assigned a specific spacecraft mission that has explored one or more worlds in our solar system. You should talk about how the spacecraft got to the world and how it landed, went into orbit, or flew past. What sort of instrumentation did it have and how did this help us understand this world better? What did it learn and what challenges did it face?

**Titan Essay: Select one of the following topics based on your Titan Mission Group – Due Midnight, April 28**

**Titan’s Surface**

Discuss what we currently know about the surface and interior of Titan. What can we tell about surface processes and surface age? What shapes the surface now and what can we tell about the history of Titan's surface? What are the current “big questions” about Titan’s surface?

**Titan’s Atmosphere**

Discuss what we currently know about the atmosphere of Titan. What can we tell about atmospheric processes? What shapes the atmosphere now and what can we tell about the history of Titan's atmosphere? What are the current “big questions” about Titan’s atmosphere?

**Liquids on Titan**

Discuss what we currently know about liquids (water and organics) on the surface and interior of Titan. What liquids exist and how do we know about them? How do they affects Titan’s surface and interior? How do the surface liquids cycle into and out of the planet’s atmosphere? What are the current “big questions” about liquids on Titan?

**Life on Titan**

Discuss what we currently know about the prospects for life on Titan. What environments have been suggested for life on Titan? What is known about the possibility of non-water based life on Titan? What are the strengths and weaknesses of having life in the interior of Titan? What other outer solar system moons might have life and how do they compare with Titan as a prospect for life?
Titan Mission Project

In this project I would like you to act as a team of scientists/engineers who are putting together a proposal for a robotic spacecraft mission to Titan. You will work in small groups on specific aspects of the mission, but you are all working on the same spacecraft so you will have to coordinate your efforts. I will make both class and group discussion boards available on Canvas so that you can share ideas and discuss the needs of your aspect of the mission.

There will be 3 graded parts to the assignment: writeup, presentation, and “discussion and decision making”.

1. Each group will do a 1500-to-2000-word write-up describing its focus in the mission. This write-up should outline the major science goals of your group, how you plan to accomplish these goals (what experiments you intend to do using what equipment in what locations), and the justifications for both of these.

2. The presentations will happen in the last week of the term. Each group will give a 20 minute presentation of their part of the proposal. There will be time at the end of each presentation for questions from the class and instructor. You can use any audiovisual tools you wish (e.g. Powerpoint or similar software, animations, music, etc.).

3. The discussion and decision-making part of the project will happen throughout the term. Here I will be using both the discussion-board posts and in-class discussions (including the question and answer part of the presentations) to judge how much the groups work with each other, share needed information and cooperate to allow everyone to develop their mission goals. I will also be looking at how well groups use scientific reasoning come to decisions.

Project Groups

You should divide up into groups of 3 or 4 people. Each group will be responsible for one aspect of the mission. The major divisions will be: geology, atmospheres, water, and life, but depending on the number of groups we may divide one or more of these topics into more specific areas of research (e.g. past vs. present life). Each group will have a unique set of questions to focus on, but each there are large areas of overlap between groups which will require coordination.

Geology

The geology group will try to address science questions related to the geologic state and history of the planet. The questions this group asks may relate to current geologic processes on the surface, surface mineralogy (types of rocks and minerals present, possibly including ones of economic interest), and the geologic history of the planet. This group will have to decide on an experiment(s) that can best address the questions they are interested in.

This topic may be divided into two groups. They may focus on different kinds of geologic processes (e.g. volcanism/tectonics vs. erosion) or they may divide up by current processes vs. geologic history.
Atmospheres
The atmospheres group will try to address science questions related to the current atmosphere of Titan and how it has changed over time. The questions this group asks may include climate questions (temperature structure, weather structure, seasons), meteorology questions (winds, temperature, moisture, dust content), chemical composition, climate variations over time, or habitability (preparing for human exploration). This group will have to decide on an experiment(s) that can best address the questions they are interested in. This topic may be divided between two groups. They may focus on current atmospheric processes vs. atmospheric history, or on upper vs. lower atmospheric processes.

Liquids
The liquids group will try to address science question related to liquids on the surface of Titan. These questions include what liquids exist now and on the surface and how these have changed over time, as well as how they cycle into and out of the atmosphere and affect the surface. These interests are likely to overlap substantially with the other science groups. This group will have to decide on an experiment(s) that can best address the questions they are interested in.

Life
The life group will try to address science question related to life on Titan. These questions include whether life ever developed on Titan and whether there is any life currently present on the world. As with the water group, the interests of the life group are likely to have a large overlap with the other science groups. This group will have to decide on an experiment(s) that can best address the questions they are interested in.

Mission Type
The first major decision the groups need to make is over which kind of mission they wish to use. Note that there is just 1 mission, so the different groups will have to agree on an overall mission design.

The total mass of the spacecraft will be 400 kg. The fraction of this available for science operations will depend on the early decisions you make regarding the type of mission you wish to pursue.

There are 3 basic types of planetary probes you will need to decide between: an orbiter, a stationary lander, and a surface rover, or some combination. There are pros and cons to each type:
1. **Orbiter**

Orbiters allow global surveys of planetary processes. Because they do not have to land on the surface, the requirements for mission operations are comparatively small so more spacecraft weight can be devoted to science operations. Up to half the mass of the spacecraft can be devoted to science instruments. However, an orbiter does not allow “close-up” views or studies: you can’t dig up a rock and hit it with a hammer. Also, the Titan atmosphere is opaque to visible light, so you can only observe the surface in other parts of the spectrum. Mission decisions will include shape of orbit (eccentric vs. circular), inclination (polar vs. equatorial) and altitude. Examples: Galileo, Cassini, Magellan, Mars Global Surveyor, Mars Reconnaissance Orbiter, Mars Express, Mars Odyssey

2. **Stationary Lander**

Stationary landers are spacecraft that land in one location on the surface and remain there for the duration of the mission. Landers allow you to do detailed studies of a single location. They are ideal for drilling below the surface and for long-term studies of one location. Since they have to land on the surface more of the spacecraft weight is devoted to mission operations than with orbiters. Less than 1/3 of the spacecraft mass can be instruments. However, they can devote more spacecraft weight to science than rovers. The main problem with type of spacecraft is that it is limited to just one location, so you cannot compare many different regions of the planet. The major mission decision will be location, since you only get 1 shot at it. Examples: Huygens lander, Viking landers, Phoenix Lander, Venera 9

3. **Surface Rover**

Surface rovers have wheels to move about the surface. Their range is generally limited by speed and the need to avoid breakdowns (repairs are not an option) as well as any barriers in the terrain that the rover can’t get past. In principle the rover can visit a wide range of terrains, though it may take considerable time to travel long distances. A large amount of spacecraft mass is devoted to operations to keep a rover operating, so this type of probe has the least mass available for
science payload (generally less than 20% of the mass). In addition, these are the most complex probes to they have the greatest chance of failure. As with the stationary lander, the biggest early mission decision will be landing location. Then you will have to decide which way to travel. Examples: Lunokhod, Pathfinder/Sojourner, Spirit, Opportunity, Curiosity

4. Other options: So far I have listed the sorts of things that have already been tried in our solar system. There are other possibilities to consider, including balloons, mini probes (many tiny probes scattered around the world), aircraft, boats (for the lakes), etc. It would be worth looking into some of the options and deciding if they would be worth trying.

Project Timeline

Begin Project: 3/27
Choose groups and project assignments: 4/1
Draft of scientific goals: 5/5
Determine mission type: 5/8
Define landing/orbit parameters: 5/15
Resolve conflicts over mission needs: 5/29
Final presentations and discussions: 6/3, 6/5
Final write-ups: 6/7

In addition to these deadlines, each group should plan on contributing regular comments on their progress, problems they are facing, and answers to other people’s concerns on the discussion board at least every week.

How to Get Started

There are several sources you can use for research, starting with your textbook (especially the chapters on solar system overview, geology and atmospheres) and lecture notes.

One of the best online sources of information on Titan is the NASA Cassini web site: saturn.jpl.nasa.gov

Mars is the most thoroughly explored world, so a good place to learn about planetary probes is the Mars exploration web site: mars.jpl.nasa.gov

Note: All images from NASA