Exotrex2 Lesson Answer Key 2.2c: Titan Mission

Name: _____ Date:_____

Mission Notes: Record your notes on this handout as you complete the Titan Mission. Use this as a reference for your end-of-mission report to Dr. Burke.

Task #1 - Probe Lander: *Send your instruments to Titan's surface in order to study its composition.*

1) What are the three forces measured by your probe's computer systems?

a) Acceleration

b) Gravity 1.4 m/s^2

c) Speed

2) Which force (a, b or c from above) is the most important to control as you land? Speed or Acceleration

Why? Speed = Must maintain speed less than 20m/s or it will crash, control using thrusters.

Acceleration = Applying thrust increases acceleration and reduces/maintains speed to avoid crashes.

(Gravity = Players can't control gravity so no action can be taken)

3) What is the amount of gravitational force on Titan? 1.4 meters/second^2 (recorded in SI units)

4) How did you steer when landing the probe? Use thrusters to push against gravitational pull…

To move left, point thrusters to the right and fire thus demonstrating Newton's 3rd law of motion.

5) Which force above (a, b or c) changed the most when you steered? Acceleration

Why do you think it changed so much? The use of thrusters changes the acceleration significantly since it is an application of force that attempts to speed up the probe or change its direction.

Task #2 - Titan Rover: *Collect surface samples on Titan to analyze the planet.*

6) As you play Titan Rover, what causes the most damage to your rover? Falling into methane lakes or getting hit by oozing eruptions from cryovolcanoes.

7) Why do you think that causes so much damage? Liquid or slushy frozen methane can short the electrical circuitry onboard the rover.

Titan Rover Observations: Complete the following observations for your records. If you missed them, you can access them through the dashboard [ ] and then click on observations.

Methane is made of hydrogen and carbon and usually a gas, but on Titan it's a liquid due to the cold and pressure.

Titan Rover Observations *(Continued)*:

Titan's _cryovolcanoes_ don't erupt with _hot_ _lava_, but ooze a slushy combination of _water_, _methane_ and _ammonia_.

Titan's severe _atmospheric_ _pressure_ would make standing on Titan like standing at the bottom of a deep _swimming_ _pool_.

Titan is the only _moon_ in our solar system to have a _thick_ _atmosphere_. Most moons have little to no _atmosphere_.

Titan orbits _orbits_ about every _16_ _days_ and always _faces_ _Saturn_ the same way.

Task #3 – Methane Cycle Analysis: *Unscramble the content that you collected on Titan's surface.*

Methane in the atmosphere _condenses_ into _cloud_ formations.

Cryovolcanoes spew methane and other compounds into Titan's _atmosphere_.

Methane _rains_ down upon the surface, forming vast _lakes_ of _liquid_ methane.

Methane _evaporates_ from the surface and returns to the _atmosphere_.

8) How does the methane cycle on Titan compare to the water cycle on Earth? _____

Both cycles are virtually the same. Both water and methane in liquid form evaporate, condense into clouds, rain down and then evaporate again. Methane on Titan does ooze out of volcanoes which is different.

Task #4 - Conclusions: *You will need to share with Dr. Burke what you have learned but be prepared to answer this very important question:*

9) Would you recommend Titan for the future home of humanity? *Explain your answer*

Not a good alternative for humanity because:

-Titan is very cold (-290F) which is why there is liquid methane on its surface

-There is also a thick atmosphere which will put lots of pressure on humans

Presence of methane is promising since oxygen can be released if it is burned and it is a good fuel.

Exotrex2 Lesson 2.2c: Titan Mission Discussion Prompts

Debrief Game Play –

It is important that students see the cohesiveness of the Titan Mission as a series of three mini-games plus a reporting conversation with Dr. Burke. Ask students to explain what they had to do in order to fully explore Titan. Students should be able to sequence the following events:

a) Pilot and land probe successfully on Titan's surface
b) Collect samples from the surface while avoiding cryovolcanoes and liquid methane lakes
c) Unscramble the methane cycle puzzle
d) Report findings to Dr. Burke and make a recommendation on inhabitability of Titan for humanity

Comparing Probe Lander Games-

Students will play the Probe Lander game while exploring Titan and Mercury. Once students have played both games, facilitate a conversation that compares and contrasts the probe landing on both of these locations. Here are some points that you will want to be sure that students are able to notice throughout this conversation

- **The mechanics of landing the probe are the same** in both locations. Players must pay attention to speed and acceleration and use thrusters to slow down and steer the probe.
- **The locations are visually different**. Titan is generally a much brighter color scheme with yellow and tan as predominate color scheme and the surface appears to be covered in a greenish body of liquid. Mercury is generally darker in color with reds and browns as the prevalent color scheme and some rock/crater formations on the surface.
- **Students should notice a significant difference in the speed at which the probes fall**. If students make this observation, prod them to hypothesize why this difference in speed exists. Highlight the fact that they are using the same Probe Lander so nothing has changed in terms of instrumentation. Push students to look at their notes to determine if there are any measurements which might be used to explain this difference in speed. The big difference is the **gravitational pull** of each location. Titan is pulling at 1.4m/s^2 (in SI units) which is less than half as strong as Mercury which is pulling at 3.7 m/s^2

> **Gravitational Force is determined by the mass of the celestial body**: In this instance the planet or moon with the greater mass will have a stronger gravitational pull. Even though Titan is larger than Mercury, it is still only half its mass so this results in a much weaker gravitational pull of 1.4 m/s^2. Refer students to Newton's Second Law of Motion: "The force acting on an object is equal to the mass of that object times its acceleration." Additionally, lead a discussion as to why the mass of Titan would be less than that of Mercury by hypothesizing the moon's composition. "Titan's mass is composed mainly of water in the form of ice and rocky material." https://www.space.com/15257-titan-saturn-largest-moon-facts-discovery-sdcmp.html

Exotrex2 Lesson 2.2c: Titan Mission Discussion Prompts *(continued)*

Titan Rover Game –
Debrief the Rover Game to emphasize that an atmosphere is very important for sustaining life on a planet. Titan has a very thick atmosphere which means that there will be different planetary characteristics that will make it uninhabitable. Use the following questions to highlight the effects of a thick atmosphere on a planet or moon.

What were the two main hazards you had to avoid while navigating Titan?
- Students should highlight cryovolcanoes as well as the liquid methane lakes.

Why do liquid methane lakes exist on Titan?
- Students may not be able to answer this solely from game-play. Titan has liquid lakes of methane due to high pressure from a thick atmosphere and very cold temperatures. The observational notes will highlight the heightened pressure but take an opportunity to emphasize how a high pressure and cold environment contributes to the formation of liquid methane.

If cryovolcanoes were a hazard, why are they dangerous? What do they do?
- Cryovolcanoes ooze a slushy frozen mixture of water, methane and ammonia which can be damaging to the rover's electrical components. They do not erupt like a volcano on Earth. The slushy mixture is further evidence of high atmospheric pressure and cold temperatures.

What does the atmospheric pressure on Titan feel like?
- Students can review their observational notes and share that it would feel like walking underwater in the deep end of a swimming pool. Highlight how the atmospheric pressure would be something that visiting humans would have to deal with (aside from deathly cold temperatures) and also how this high pressure has created the most unique planetary characteristics of Titan such as liquid methane.

Methane Cycle Puzzle –
Debrief student answers regarding the Methane Cycle Puzzle and review the answer for question #8. An important discussion extension is to prompt students to think about why Titan has similar cycles as Earth but different components. Also, challenge students to explore why planets have cycles at all! Students can begin to grapple with the idea that planets and moons are closed systems and that any cycle enables elements to be used and reused over time. In this case, the unique pressure and temperature have an impact on the cycles that exist on Titan.

Conclusions and Reporting to Dr. Estella Burke –
Students will have different experiences reporting to Dr. Burke so be sure to debrief their experiences and see if there were different outcomes for students. Here are the following questions that will be asked:
- How did the surface of Titan look to you?
- What is methane made of?
- Do you think Titan should be considered for humanity's next home?
- In your opinion, why would Titan not make a good home for humans?
- How do the volcanoes on Titan compare to the ones on Earth?