Exotrex2 Answer Key Lesson 2.2a: Mercury Mission

Name: _____ Date:_____

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

Task #1 - Probe Lander: *Send your instruments to Mercury'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 3.7 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 Mercury? 3.7 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 - Mercury Rover: *Collect surface samples on Mercury to analyze the planet.*

6) As you play Mercury Rover, what causes the most damage to your rover? Exposure to the sun.

7) Why do you think that causes so much damage? The atmosphere of Mercury is too thin to offer protection against the Sun. High temperatures can melt the rover's electrical circuits.

Mercury 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.

Mercury has many craters from meteorites that couldn't be slowed down down by the planet's thin atmosphere.

Mercury Rover Observations *(Continued)*:

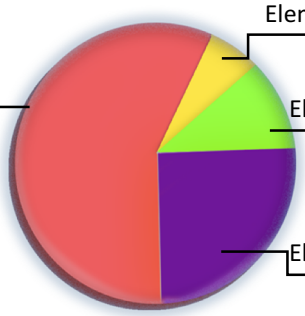
Mercury's thin atmosphere means nights are deathly cold and days are extremely hot.

Even though Mercury is the closest planet to the Sun, ice is found deep in dark craters that never see the Sun.

Mercury orbits the Sun four times by the time Earth completes one orbit.

Mercury is the smallest planet with a weak gravitational pull which is why there is such a thin atmosphere.

Task #3 - Particle Analysis: *Determine what you collected on Mercury's surface.*



8) Explain how you would use at least one of the elements on Mercury if you decided to settle there:
Iron can be used to produce metal for building structures. Magnesium can be used in fertilizer.

Silicate can be used to conduct electricity. Trace elements included H_20 which is essential for life.

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 Mercury for the future home of humanity? *Explain your answer*

Not a good alternative for humanity because:
-surface temperatures are too hot in the sun
~~- Thin atmosphere means wide temperature swings, very cold when not facing the sun~~
-Atmosphere is too thin to protect humans from space elements (meteorites)
-weak gravitational pull

Exotrex2 Lesson 2.2a: Mercury Mission Discussion Prompts

Debrief Game Play –

It is important that students see the cohesiveness of the Mercury 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 Mercury. Students should be able to sequence the following events:

a) Pilot and land probe successfully on Mercury's surface
b) Collect samples from the surface while avoiding spending too much time in direct sunlight
c) Analyze the elemental composition of collected samples to discover available resources
d) Report findings to Dr. Burke and make a recommendation on inhabitability of Mercury for humanity

Comparing Probe Lander Games-

Students will play the Probe Lander game while exploring Mercury and Titan. 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**. Mercury is generally darker in color with reds and browns as the prevalent color scheme and some rock/crater formations on the surface. 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.
- **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. Mercury is pulling at 3.7 m/s^2 which is more than twice as strong as Titan which is pulling at 1.4m/s^2 (in SI units).

> **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 2.2a: Mercury Mission Discussion Prompts *(continued)*

Mercury Rover Game –

Debrief the Rover Game to emphasize that an atmosphere is very important for sustaining life on a planet. Unfortunately, Mercury has a very thin atmosphere which means that it is uninhabitable. Use the following questions to highlight the effects of a thin atmosphere on a planet or moon.

Why does the sun do so much damage to the rover?

- Students may state that Mercury is the closest planet to the Sun which is why there is such intense and damaging heat but the main reason surface temperatures are so high is due to a thin atmosphere. A thicker atmosphere can mitigate temperatures and protect from wide swings in temperature ranges. The thin atmosphere of Mercury is why days are extremely hot and nights are deathly cold.

Why are there so many craters on Mercury's surface?

- Students should be able to refer back to the thin atmosphere of Mercury. Atmospheres also protect a planet from meteorites which cause craters. Mercury does not have this protective layer which is why there are so many craters.

Why is ice found inside craters even during the hot day?

- Craters create shadows and, on Mercury, any shadow means a dramatic drop in temperature since there is no atmosphere to trap heat.

Why does Mercury have such a thin atmosphere?

- Students can review their observational notes to share that Mercury is the smallest planet which causes it to have a weak gravitational pull. Refer to the discussion prompts about the Probe Landers to build on the idea that mass of a planet affects its gravitational pull.

Particle Analysis Game –

Discussion should be built off of the answers that students found for the percentages of elements as well as to how students would use them. Encourage students to do research on the chemical composition of Earth as a reference point. Additionally, some students may be confused by the mechanics of sample collection. Remind them that Fiona explained that the rover was not sending samples back to the space ship. The rover is equipped with lasers that can pulverize samples and analyze them for chemical composition. This data is recorded and sent to the player on the space ship. Actual samples are not returned nor is the rover. This game is played under the premise that rovers are sent and never returned which mimics the experience of early rovers on Mars.

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 Mercury look to you while you were driving around your probe?
- What elements did you find in your collected samples?
- Do you think Mercury should be considered for humanity's next home?
- What are the reasons why Mercury would not make a good home for humans?