Planetary Transit Lab **Name: ___________________________** **Date: ____________**
Earth Science

Questions:

1. Define a planet:

2. Define a solar system:

3. Why do you suppose, to our knowledge, that life exists on Earth and none of the other planets in our solar system?

Introduction:

In August 2006, Pluto, the 9th planet in our solar system, was demoted. The downgrade to "dwarf planet" was made official by the International Astronomical Union (IAU), noting that Pluto did not "clear its region of neighboring objects" (LOC.gov). What did they mean? "Pluto and its moon Charon … now get demoted because they are part of a sea of other objects that occupy the same region of space. Earth and the other eight large planets have, on the other hand, cleared broad swaths of space of any other large objects." (Space.com)

Thus the definition of a planet became tightened (LOC.gov):

1. It is in orbit around the Sun.
2. It has sufficient mass to assume hydrostatic equilibrium (a nearly round shape).
3. It has "cleared the neighborhood" around its orbit.

Determining planetary criteria in our own solar system seems easy enough by observation if not by debate, but what about distant solar systems? How can we determine if all of the stars we see in the night sky are solar systems?

Any star other than our own is simply called a star, but any planet that orbits a distant star is called an "exoplanet". Depending on what excites you most, the first two exoplanets were discovered around a pulsar in 1992, or the first exoplanet was discovered orbiting a star like our own sun in 1995. (futurism.com) Since those discoveries, about 3500 exoplanets have been discovered thanks to various methods and telescopes.

Purpose:

Our activity is going to focus on the transit method for discovering exoplanets. A planet is difficult to detect, but stars are easy to see. We can detect exoplanets if one crosses in front of its star. This passage is referred to as a transit.

Transits are like fingerprints for exoplanets; the shape of them reveals characteristics about the planet. Your experiment will conclude what patterns scientists should look for in determining the size, speed of orbit, and distance an exoplanet is from its star.

During a transit, the amount of light visible to a sensor will slightly decrease. Features of exoplanets that you will investigate in this lab include relative size and orbital speed. Your group will conduct an experiment for each of these variables.

In your own words, what is a transit? What is the transit method?

Materials:

- Flashlight
- Spheres of assorted sizes
- Laptop with LoggerPro software
- Light sensor
- Plastic race track material
- Ring stand with C-clamp
- Meter Stick or wooden board
- Meter Stick

Pre-lab:
Sit down in front of the experimental setup. You will see, among other things, a secured light sensor on a textbook, various sized spheres, and a secured flashlight. What do each of these items represent for scientists discovering exoplanets?

Light sensor:

Spheres:

Flashlight:

Your teacher will now provide an overview of how to collect data using the light sensor and Logger Pro.

Hypotheses:
Your experiments will conclude what patterns scientists should look for in transit data to determine the (1) relative size, and (2) orbital speed. For each experiment, you will need to write a hypothesis.

Before we begin, what do we mean by "transit data"?

Experiment 1: Relating Transit Data to Planet Size
When comparing the transits of different exoplanets, how can scientists tell which planets are larger-sized and which ones are smaller? What specifically will be different about their transits?

Hypothesis 1: This should be phrased as "As the size of exoplanets increases, then the transit data will … because…"

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Experiment 2: Relating Transit Data to Orbital Speed of a Planet
When comparing the transits of different exoplanets, how can scientists tell which planets are moving faster in their orbit around their star? What specifically will be different about their transits?

Hypothesis 2: Use the same sentence structure that you used for your first hypothesis.

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Procedure:
You will now conduct two separate experiments to test each hypothesis. For each experiment, <u>be certain that you change only one factor to ensure it is a fully controlled experiment</u>. Right now, as a group, discuss how you will do this for each experiment before proceeding. For example, you only want to change sphere size for the first experiment. What other factors do you need to be certain remain constant throughout your data collection process for this experiment? Be sure to record in your notebook your thinking and any difficulties that arise.

<u>In each experiment you must change the factor three separate times</u>. For example, in Experiment 1 you are investigating planet size. You should use three different-sized spheres. You will conduct and record data for three trials each time you change the factor, and then average them for a single value.

Use the tables below to record your data. The dependent variable to collect for Experiment 1 will be the change in lumens (the extent of the dip observed in the transit). The dependent variable to collect for Experiment 2 will be the duration of transit, in seconds.

For Experiment 2 you will control the speed of the spheres by rolling them down a track on a ramp from the same height for each set of three trials. There is a relationship between release height and speed of sphere at the base of the ramp. This model neglects the effects of air resistance and friction, but it is a reasonable approximation for how fast the spheres are moving once they reach the bottom of your ramp:

$$Speed\ of\ Sphere\ \left(\frac{cm}{s}\right) = 44.3\sqrt{h}$$

where h is the height above the table that you release the ball, measured in centimeters

Once you have understood and addressed all of the above considerations, lay out a procedure, step by step, in your notebook that describes how you will arrange the equipment and collect the data for each experiment.

Experiment 1: Identifying Patterns in Exoplanet Transit Data to Infer Relative Planet Size

Independent Variable: Sphere Diameter (cm)	Trial 1 (lm)	Trial 2 (lm)	Trial 3 (lm)	Dependent Variable: Average Change in Lumens (lm)

Notable factors held constant:

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Experiment 2: Identifying Patterns in Exoplanet Transit Data to Infer Orbital Speed

Release Height, above the table (cm)	Independent Variable: Orbital Speed (cm/s)	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Dependent Variable: Duration of Transit (s)

Notable factors held constant:

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Writing your Lab Report:
Header: (Only needs to be written at the top of the first page)

Your name: Due date:

Earth Science - Section #: Teacher's name:

Title:
Identifying Patterns in Transit Data to Predict Characteristics of an Exoplanet, Including Size and Orbital Speed

Introduction:
The introduction provides some background information, states the purpose of the lab, and states the hypotheses. The Introduction should be written in paragraph form. These sub-sections do not necessarily need to be written in this order, but must include:

Background information - should include information from the following:

- Sara Seager TED talk
- Class notes

→ No additional research is required.

Purpose of the lab

- Restate the purpose of the lab in your own words.

Hypotheses

- Both hypotheses that your group developed should be stated in this section.

Methods:
List all of the materials and equipment used. Then, briefly describe how you conducted the experiment. Provide instructions that would allow a fellow classmate to conduct your experiment, assuming they are familiar with all of the equipment, and how to use it. The Methods section should be written as a paragraph.

Results:
Data will be entered by each student in an independent Google Sheet.
Your lab report must include:

- a data table for all three experiments
- a graph for each experiment that only plots the averages
- a single annotated LoggerPro graph of your raw data

Be sure that all data tables and graphs have proper titles, labels, and include units.
Keep the data tables in a simple format! They should be clear, not overwhelming, and will be printed in black and white. Do not use different colors and fonts.

Conclusion/ Discussion:

Paragraph 1: Summarize your results
Questions to address: What did you discover for each factor that you examined? Review each of your hypotheses: did the data in each case support or refute your hypothesis? Was any experiment inconclusive? Explain.

Paragraph 2: Error Analysis
Questions to address: Was there anything about the experimental setup that is not an accurate **model** for how scientists detect exoplanets; did this lead to any possible error in your results? Explain.

Paragraph 3: Significance
Question to address: How are the results of your experiments useful or not useful for scientists exploring exoplanets? Explain this clearly for each experiment.

Paragraph 4: Future Experimentation
Questions to address: What other factor might you/scientists want to know about an exoplanet? Explain why you chose this factor. How would you propose to design an experiment to identify specific patterns in transit data that would reveal information about this factor?

Acknowledgements:
Your lab partners should be acknowledged at the completion of this report. Additional people, whether peers or someone outside of school, must also be acknowledged. You must clarify what they helped you with.

Sources use by teachers in preparation of this lab activity:

https://www.loc.gov/rr/scitech/mysteries/pluto.html
https://www.space.com/2791-pluto-demoted-longer-planet-highly-controversial-definition.html
https://futurism.com/the-first-exoplanet-was-discovered-25-years-ago-today