Names: ______________________ ______________________

______________________ ______________________

Teamwork (5)	Discussion (5)	Completeness (5)	Correctness (5)	Total (20)

Exoplanet Discovery

A house of wood in a hidden place,

Built without nails or glue.

High above the earthen ground,

It holds pale gems of blue.

What is it?

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Pre-Lab Quiz

Record you team's answers as well as your reasoning and explanations.

1.
2.
3.
4.

Part 1: Sizes of Exoplanets

1. Explain your group's method for determining the **size** and **position** (distance from the Sun) of Jupiter in the classroom scale model. Be prepared to share your thoughts / work with the class.

Part 2: Transit Method

1. Sketch a graph of the output from the photometer used in the transit demonstration. Label the axis `(time, intensity)` and indicate where the planet

   a) is not in front of the star

   b) is traveling over the limb (edge) of the star

   c) is completely in front of the star

2. If a sphere with half the diameter of the first is passed in front of the light source, how will this affect the light curve? Explain your prediction below and try to quantify it.

3. Did the second demo verify your reasoning? What does this mean for the kind of exoplanets that are likely to be discovered using the transit method?

4. In this problem we're going to derive the relationship between the radius of the planet r_p, the radius of the star $r_\star$, and the dip in the star's brightness. Partnering with another group, on a white board work though the following steps:

1. The star's normal brightness $B_\star$ is given by the area that we see (a circle with radius $r_\star$) multiplied by the star's surface brightness density $S_\star$. Write down the equation for the brightness $B_\star$ in terms of $r_\star$ and $S_\star$.

2. When the planet is completely in front of the star, the area that we see is the area of the star $A_\star = \pi r_\star^2$ minus the area blocked by the planet $A_p = \pi r_p^2$. Write down the equation for the brightness B when the planet is completely in front of the star in terms of r_p, $r_\star$, and $S_\star$.

3. The relative brightness of the dip to the star's normal brightness is $B/B_\star$. Write down this ratio and use your expressions from (1) and (2) to form an equality and simplify the expression.

4. You should now have the expression

$$\frac{B}{B_\star} = \frac{r_\star^2 - r_p^2}{r_\star^2} \tag{1}$$

   Split the right side into two parts to remove the radius of the star in the numerator, then solve for the ratio $r_p/r_\star$.

Go over your work with your TA and have them mark below once complete. Record the relationship for $r_p/r_\star$ as we'll be using it in the next part.

TA	

Part 3: Detecting Alien Worlds

The star `XO-1` is a G1V star, making it similar to our Sun (G2V). The presence of an exoplanet around this star has been confirmed though the use of the radial velocity and transit methods. In this part we'll calculate the size of the orbiting exoplanet.

- In Maxim, under **Analyze** click **Photometry**
  - Click `Add Files` and open all the files in the indicated directory below
    - `labimage → Exoplanets → XO-1`
  - Under the `Match` tab, set the mode to `Auto - star matching`
  - Under the `Identify` tab, expand the list in the left panel and select an image to display it. Identify the star `XO-1` and the reference star from the provided image in the online manual. Then under `Tag Mode`
    - Select `"New Object"` and click on the star `XO-1`
    - Select `"New Reference Star"` and click on the reference star in the image. Enter the magnitude into the `Mag` column (hit the tab key once after selecting the star, otherwise trying clicking into the cell).
  - Right-click on the image and adjust the radius of the inner circle `(aperture)` so that it collects all the light from the object and the outer circle `(annulus)` so that no background sources (e.g. stars) and present in the image. Once complete, click on the `Graph` tab.

If m denotes the magnitude during the transit and $m_\star$ the magnitude of the star, then the ratio of brightnesses can be found from

$$\frac{B}{B_\star} = 100^{(m_\star - m)/5} \tag{2}$$

1. Optionally working with another group, calculate the fractional change in brightness $B/B_\star$, the radius of the exoplanet relative to the host star $r_p/r_\star$, and the exoplanet radius r_p in Jupiter radii. Show your work on a white board.

TA	