



REDSHIFT



STUDY GUIDE



This guide contains all the background knowledge you need for the competition.

1. Understanding Light Spectra

Stars emit light across all colors (a full rainbow spectrum). When this light passes through gas elements such as hydrogen or helium, certain colors are absorbed, creating thin dark lines in the rainbow spectrum. These are called **absorption lines**. Each element absorbs at specific positions, which act like a “fingerprint.”

You will be given:

- A rainbow strip labeled from 0 to 10 (0 = red, 10 = violet)
- A reference absorption chart listing elements and the scale positions where they create dark lines
- A star classification chart along with their light spectrum containing several dark lines
- A questionnaire whose answers will tell which elements are blocked.

Your task:

Match the dark lines on your mystery spectrum to the correct elements in the reference absorption chart.

This will allow you to determine the **star type**.

2. Light Curves & Planet Transits

When a planet passes in front of its star, it blocks a small portion of the star’s light. This creates a dip in the brightness of the star.

If you plot the star’s brightness over time, you get a light curve.

You will be given:

- A list of 40 coordinates
- (Time, Relative Light Intensity)
- A blank graph paper template

Your task in **Round 2:**

1. Plot all the given points carefully.
2. Identify the dip(s) in brightness.
3. Observe the depth and shape of the transit.

This graph represents the planet passing in front of the star.

3. Finding the Orbital Period

The orbital period is the time it takes for the planet to orbit its star once. You find this by measuring the time between the deepest points of two dips.

Formula:

$$P = t_2 - t_1$$

Where:

- t_1 = time of first deepest dip
- t_2 = time of second deepest dip

You will write this value in your Discovery Report.



4. Calculating the Planet Radius

The depth of the dip tells us how large the planet is compared to the star.

Transit Depth Formula:

$$\frac{\Delta F}{F} \approx \left(\frac{R_p}{R_*} \right)^2$$

Where:

- $\Delta F/F$ = drop in brightness
- R_p = planet radius
- R_* = star radius (this will be provided)

Steps you will follow:

1. Identify the baseline brightness (usually 1.00).
2. Identify the minimum brightness during the dip.
3. Compute the dip depth:

$$\Delta F = \text{baseline} - \text{minimum}$$

1. Take the square root:

$$\frac{R_p}{R_*} = \sqrt{\Delta F}$$

1. Multiply by the star radius:

$$R_p = R_* \cdot \sqrt{\Delta F}$$

This gives the planet's radius in solar radii.

5. Calculating Escape Velocity

Escape velocity is the speed needed for an object to escape a planet's gravity.

You will calculate this using the simplified formula, which avoids needing the planet's mass:

Escape Velocity Formula:

$$v_{esc} = \sqrt{2gR}$$

Where:

g = surface gravity (this will be provided)

R = planet radius you calculated

v_{esc} = escape velocity

Steps:

1. Convert radius into meters if needed.
2. Substitute radius and gravity into the formula.
3. Calculate the square root.
4. Write your escape velocity in m/s and km/s.

This helps determine if the planet is small, large, dense, or similar to a gas giant.

6. Discovery Report

Fill your discovery report sheet by answering all questions with the answers you have deduced up until now



Example Calculations from the Light Curve

1. Find the Orbital Period

- Look at two consecutive dips.
- First dip at Day 5, next at Day 15.
- Period $P=15-5=10$, $P = 15 - 5 = 10$, $P=15-5=10$ days.

2. Measure Transit Depth (ΔF)

- Out-of-transit brightness (baseline): 1.000
- Minimum brightness in transit: 0.980

Transit depth:

$$\Delta F = 1.000 - 0.980 = 0.020 = 2\%$$

3. Calculate Planet/Star Radius Ratio

Formula:

$$\frac{R_p}{R_s} = \sqrt{\Delta F}$$

Substitute values:

$$\frac{R_p}{R_s} = \sqrt{0.020} \approx 0.141$$

So, the planet's radius is 14.1% of the star's radius.

4. Convert to Planet Radius in Earth Units

- Assume from Round 1 that this is a G-type star, radius $\sim 1.0 R_\odot$
- 1 solar radius $R_\odot \approx 109 R_\oplus$ (Earth radii).

Planet radius:

$$R_p = 0.141 \times 109 R_\oplus \approx 15.4 R_\oplus$$

5. Classify the Planet

$$15.4 R_\oplus / 109 = 0.14 R_\odot$$

So, $0.14 R_\odot$ = larger than Jupiter, a gas giant.

Final Result from This Light Curve

- Orbital period: 10 days
- Transit depth: 2%
- Planet radius: 15.4 Earth radii
- Planet type: Gas giant (larger than Jupiter)



6. Convert the planet's radius into meters

Solar radius:

$$R_{\odot} = 6.96 \times 10^8 \text{ m}$$

Given:

$$R_p = 0.14 R_{\odot}$$

So:

$$R_p = 0.14 \times 6.96 \times 10^8 \text{ m} = 9.744 \times 10^7 \text{ m}$$

7. Use the escape velocity formula

We use the simplified version:

$$v_{esc} = \sqrt{2gR}$$

Given surface gravity:

$$g = 15 \text{ m/s}^2$$

8. Substitute values

$$v_{esc} = \sqrt{2 \times 15 \times 9.744 \times 10^7}$$

Compute inside the square root:

- $2 \times 15 = 30$
- $30 \times 9.744 \times 10^7 = 2.9232 \times 10^9$

So:

$$v_{esc} = \sqrt{2.9232 \times 10^9}$$

9. Take the square root

$$v_{esc} \approx 5.40 \times 10^4 \text{ m/s} \quad v_{esc} \approx 54,000 \text{ m/s} \quad v_{esc} \approx 54 \text{ km/s}$$