

## Lesson Summary

In this activity, students are presented with a series of geometrical shapes, which they add and subtract like in an equation.

### Prior Knowledge & Skills

- Knowledge of basic geometry
- Ability to use a ruler
- Understand how graphs are used to represent physical data

Complete lesson (recommended):

- Star Light, Star Bright? Finding Remote Atmospheres

### AAAS Science Benchmarks

#### **The Nature of Mathematics**

*Mathematical Inquiry*

### NSES Science Standards

#### **Science as Inquiry**

*Abilities Necessary to do Scientific Inquiry*

#### **Physical Science**

*Transfer of Energy*

### NCTM Mathematics Standards

- **Algebra:** Understand patterns, relations, and functions

### Suggested background reading

*Light*

**Teaching Time:** One 30-minute period

### Materials

Each Student Needs:

- Copy of student directions
- 1 Ruler

### Advanced Planning

**Preparation Time:** 5 minutes

1. Make copies of the student pages.

### Why Do We Care?

During an occultation event, light from a background star shines through the atmosphere of a planet or body. The star, however, has its own spectrum because it is made up of different material. When we want to look at the spectrum of just the planet or body, we have to remove the spectrum of the star first!



# Solving a Mixed Up Problem

**Grade Level** 6-9

**Activity Dependency** Star Light, Star Bright? Finding Remote Atmospheres

**Group Size** 1-2

**Expendable Cost per Group** \$0

### Pre-Requisite Knowledge

Students should:

- Be familiar with simple geometry and using a ruler.
- Understand that graphs are used to represent physical data.

### Learning Objectives

After this lesson, students should be able to:

- Demonstrate how simple graphs could be added or subtracted
- Explain how geometry is used to analyze a plot

### Introduction / Motivation

Now that you know about stellar occultation events, you know how we could tell if a planetary body has an atmosphere or not. Then what? That doesn't give us that much information. What we want to know is: *What's in that atmosphere? Does it have water? Does it have oxygen? Could it support life, maybe? Would it be an interesting place for us to visit with a spacecraft?*

But we can figure out some of these things using a stellar occultation event. When light from a star is shining through the atmosphere of the planet scientists are studying, the spectrum from the star will combine with the spectrum of the planet. Then, they have to figure out how to remove the star's spectrum so they can study the spectrum of the planet. If we know the spectrum of the star, we can remove (or subtract) it from the spectrum of the planet's atmosphere. Today, you will be looking at plots and adding and subtracting them to see how this is done.

### Vocabulary / Definitions

Word	Definition
Occultation event	When an astronomical body crosses the line of sight between an observer and another astronomical body.

## Procedure

### Background

When light from a star passes behind a planet or body we are able to determine the nature of the planet's atmosphere based upon the combined spectrum of the star and the planet's atmosphere. The stellar spectrum is removed from the combined spectrum by observing the spectrum of the star prior to the occultation event. Typically, the combined spectrum is "divided" by the stellar spectrum using a computer algorithm, but simple subtraction is an acceptable analogy to this process, as the students will see in this activity.

The Cassini Spacecraft team has often adjusted Cassini's orbit with the appropriate geometry for a star to pass behind one of Saturn's moons. This has given us some surprising results about some of the moons, which the students will explore in the next lesson, "Enceladus, I Barely Knew You."

Incidentally, objects can occult our Sun. Planets pass between Earth and the Sun, and are easily observed using a telescope with a solar filter. These events are called transits, and are used to observe the interior planets (Mercury and Venus) and their atmospheres. Transits are also used to observe planets orbiting stars outside of our Solar System. The Kepler Mission is doing just that- observing planets transiting their parent star. The Kepler instruments do not collect spectra, but future spectroscopy missions will be able to observe the planets Kepler discovers to see if they have atmospheres that could support life!

### With the Students

1. Hand out student sheets and rulers.
2. Walk around the room to talk to individual students about the shapes from the student worksheet.
3. Discuss class results of the worksheet and then display answers.

## Assessment

### Pre-Activity Assessment

*Class Discussion:* Give students the following examples: *If you wanted to weigh your cat on your bathroom scale, but the cat won't stay still, how do you get an accurate weight for the cat?* (You would weigh yourself, then weigh yourself holding the cat and subtract your weight to get the weight of the cat.) *A 6 ft. tall man is standing on a building. The total height from the base of the building to the top of his head is 216 ft. How tall is the building?* (210 ft.) *If you take a spectrum of the Sun from Earth's surface, will you get only the spectrum of the Sun?* (No, the spectrum of the Earth's atmosphere will be superimposed and you can remove the Earth lines by taking a spectrum of the Earth's atmosphere alone and removing them from the combined spectrum).

## **Activity Summary Assessment and Extension Activity**

*Puzzles for Peers:* Students can create their own word or picture puzzles using some of the knowledge gained during this activity. Encourage creativity in the assignment, and look for students' concepts to include removing or adding something to another thing to create their puzzles. Students could even use color addition and subtraction to create new puzzles for peers. Choose the best puzzles and create a new problem set for homework.

## **Troubleshooting Tips**

Students with blindness can conduct this activity if the instructor prepares similar shape representations using craft wire.

For this activity:

- Assume the baseline is zero.
- Shapes can be measured with a ruler to determine the final shape in the equation.
- A ruler may not be necessary for every problem.
- Small group discussion should be encouraged.
- Use problem one as an example.
- This activity may be challenging for some students. Note that it is meant to be like a puzzle, and should be a fun challenge. If students become frustrated, assist them as needed. The important part is that students gain a conceptual understanding of the processes involved when looking at spectra, and not that they get every problem right.

## **Activity Extensions**

Continue the spectroscopy unit by completing the associated activity, "Enceladus, I Barely Knew You."

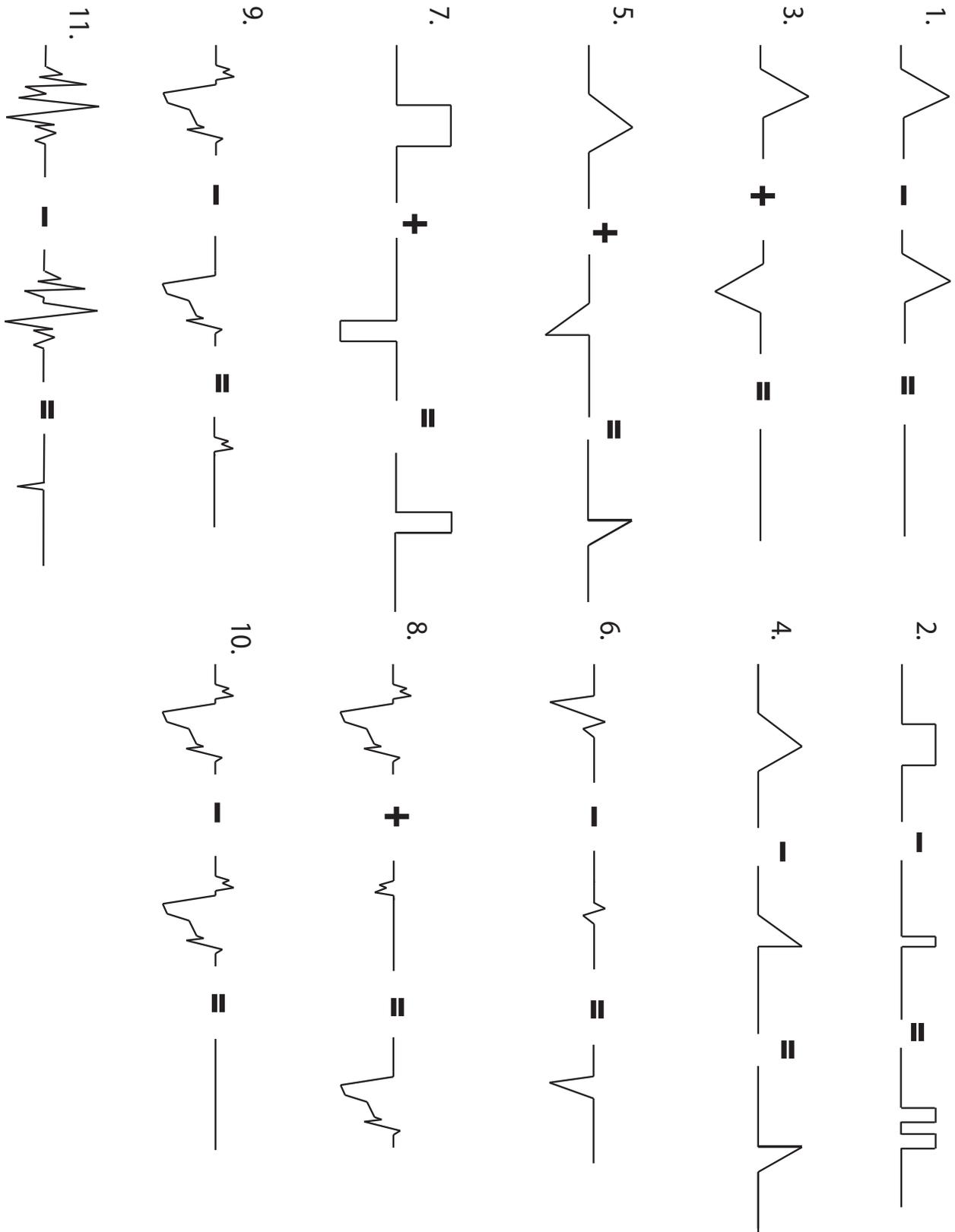
### **Owner**

Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder

### **Contributors**

Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder

**Solution Set**



Student Handout

Instructions: Draw the solution below each equation.

Name (s):

1.  -  =

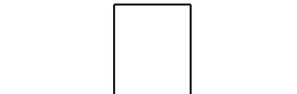
2.  -  =

3.  +  =

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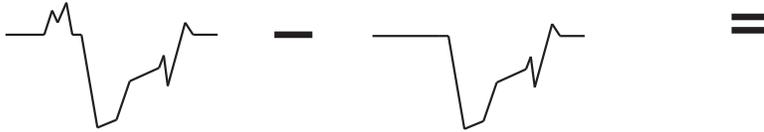
5.  +  =

6.  -  =

7.  +  =

8.  +  =

9.



10.



11.

