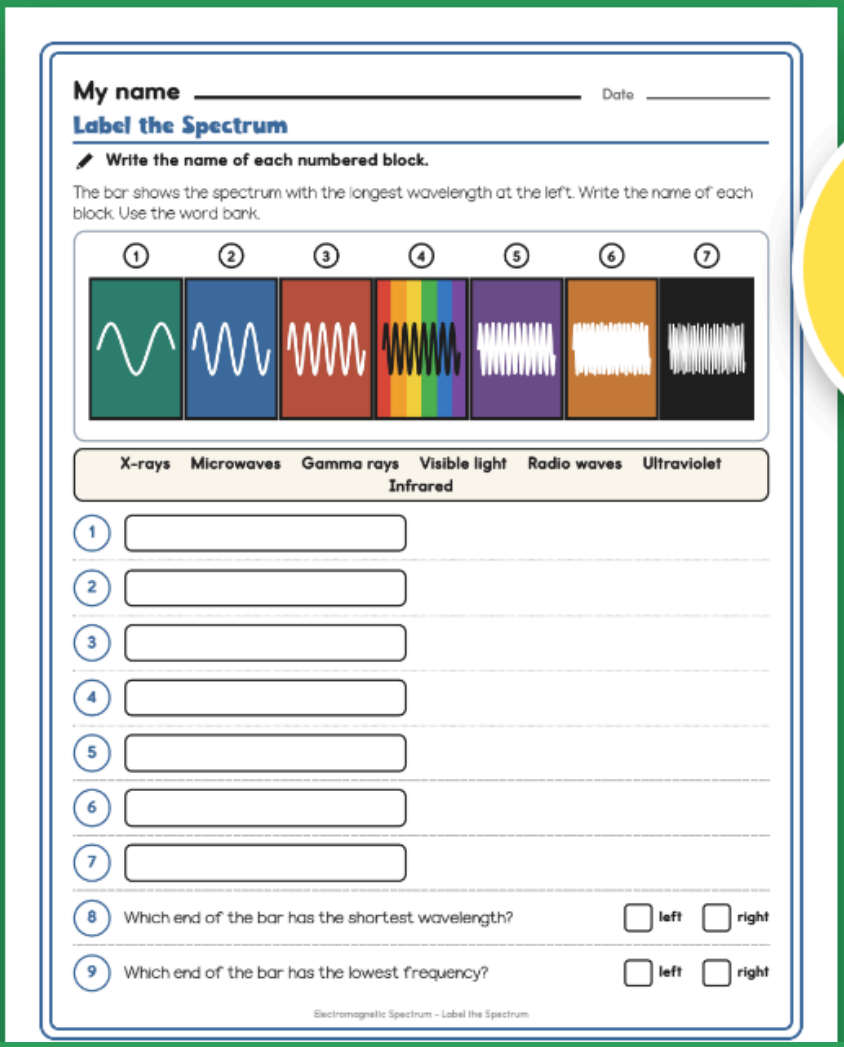
ELECTRO-MAGNETIC SPECTRUM

GRADES 8–10 · WORKSHEETS · ANSWER KEYS



My name _____ Date _____

Label the Spectrum

Write the name of each numbered block.

The bar shows the spectrum with the longest wavelength at the left. Write the name of each block. Use the word bank.

X-rays Microwaves Gamma rays Visible light Radio waves Ultraviolet Infrared

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 Which end of the bar has the shortest wavelength? ☐ left ☐ right

9 Which end of the bar has the lowest frequency? ☐ left ☐ right

Electromagnetic Spectrum – Label the Spectrum

19 STUDENT PAGES

Bright Path Sped

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This is a fillable PDF

- Open it in a PDF reader (Adobe Acrobat Reader, Preview, or your browser), click into a line or a box, type, and Save As.
- The name line, every answer box, every ruled work box and every check box on the student pages are type-in fields, and so are the tracker, class grid, team note and family page. You can also print any page and write by hand.
- It works offline. No account, no subscription, no internet connection needed after you download it.

Print at 100 percent

Turn off fit to page and shrink to fit so the ruled lines stay 0.34 inch apart. Every student page has a colored border and colored drawings, and it still reads when copied in black and white. The colors copy as shades of gray.

Student work

A filled-in tracker, class grid or team note carries a real student's name. Keep it in the data folder, and use a first name only on any page that leaves your hands.

Need help?

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PREVIEW

How To Read a Page

The parts of a student page, then the kinds of sheet in the order they come.

The parts of a page

- **The answer box.** A bordered box for a letter, a number or a word. Click it to type, or print and write in it.
- **The ruled work box.** Lines 0.34 inch apart for sentences. Write one idea to a line.
- **The check box.** True or false, left or right, a wave name: click or mark.
- **The word bank.** A box of words to use. Each word in a bank is used one time unless the page says otherwise.
- **The cut line.** Pieces in a short grid, edge to edge: a few straight cuts across and down.

Kind of sheet	How many	What the student does
Readings and chart	3 sheets	Read, answer, and keep the chart to look things up.
Words and labels	3 sheets, 24 items	Match nine words, label a wave, name the blocks of the bar.
Table and compare	2 sheets, 26 items	Fill in frequency and energy rank, compare pairs of waves.
Wave math	1 sheet, 12 items	Find a missing wavelength or frequency, then name the wave.
True or false and mistakes	2 sheets, 12 items	Check sentences, fix false ones, find Mina's mistakes.
Writing	2 sheets, 5 questions	Short answers with ruled lines, then explain-it boxes with room to write.
Quizzes, exit tickets, sorts	12 items, 3 tickets, 15 pieces	Two quizzes, one exit sheet, two cut-and-paste pages.

Untimed, unscored on the page

No student page has a timer or a score on it. The keys and the tracker are for you. The answer keys are on pages 24 to 28.

Short answers and explain-its

Their keys (page 27) say what to look for, not one right sentence. Accept any answer that uses a fact from the readings or the chart.

Numbers on the math page

The speed of an electromagnetic wave in a vacuum is rounded to 3.0×10^8 m/s, and every key answer is rounded to two digits. Accept an answer that agrees with the key after rounding.

Printing and the type-in fields

Every page prints clean in black and white. The name line, every answer box, every ruled box and every check box are type-in fields in any PDF reader: click one, type, then save. This is a fillable PDF, not a slideshow or a word-processor file.

PREVIEW

Preview · Bright Path Sped

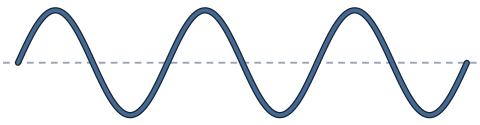
My name _____ Date _____

Reading 1: Waves of Energy

Read about waves. Then answer.

Waves, wavelength and frequency

A **wave** carries energy from one place to another. Look at a wave drawn on paper. The highest points are crests and the lowest points are troughs. The **wavelength** is the distance from one crest to the next crest. The **frequency** is the number of waves that pass a point each second. It is measured in **hertz**. Light, radio signals and X-rays are **electromagnetic waves**. They need no air or water to travel, so they can cross empty space. That is how sunlight reaches Earth. In empty space every electromagnetic wave moves at the same speed, about 300,000,000 meters each second. Speed equals wavelength times frequency. Because the speed stays the same, a longer wavelength means a lower frequency, and a shorter wavelength means a higher frequency.



A wave. The blue line is one wave drawn on paper.

Main idea: What is this reading mostly about?

Check what you read. Write the letter in the box.

1. What is wavelength?
   - **A** The number of waves each second
   - **B** The distance from one crest to the next crest
   - **C** The height of a wave above its rest line

2. Which unit measures frequency?
   - **A** Hertz
   - **B** Meters per second
   - **C** Kilograms

3. The speed stays the same and the wavelength gets longer. What happens to the frequency?
   - **A** It gets higher
   - **B** It stays the same
   - **C** It gets lower

4. How can sunlight reach Earth?
   - **A** Electromagnetic waves can travel through empty space
   - **B** Light needs air to carry it
   - **C** Sunlight is a sound wave

PREVIEW

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My name _____ Date _____

Spectrum Chart

Read the chart. Keep it all week.

The waves are in order from the longest wavelength to the shortest. 1 mm is one thousandth of a meter. 1 nm is one billionth of a meter.

Radio waves		Wavelength: longer than 1 m Frequency: less than 3×10^8 Hz Energy: 1 (lowest). Use: carries FM radio programs through the air.
Microwaves		Wavelength: 1 mm to 1 m Frequency: 3×10^8 to 3×10^{11} Hz Energy: 2. Use: heats food in a microwave oven.
Infrared		Wavelength: 700 nm to 1 mm Frequency: 3×10^{11} to 4.3×10^{14} Hz Energy: 3. Use: lets a TV remote change the channel.
Visible light		Wavelength: 400 nm to 700 nm Frequency: 4.3×10^{14} to 7.5×10^{14} Hz Energy: 4. Use: lets you see colors.
Ultraviolet		Wavelength: 10 nm to 400 nm Frequency: 7.5×10^{14} to 3×10^{16} Hz Energy: 5. Use: makes a black light poster glow.
X-rays		Wavelength: 0.01 nm to 10 nm Frequency: 3×10^{16} to 3×10^{19} Hz Energy: 6. Use: shows a bone inside a hand.
Gamma rays		Wavelength: shorter than 0.01 nm Frequency: more than 3×10^{19} Hz Energy: 7 (highest). Use: sterilizes medical tools in sealed packages.

Which wave has the most energy? Tell how you can see it on the chart.

PREVIEW

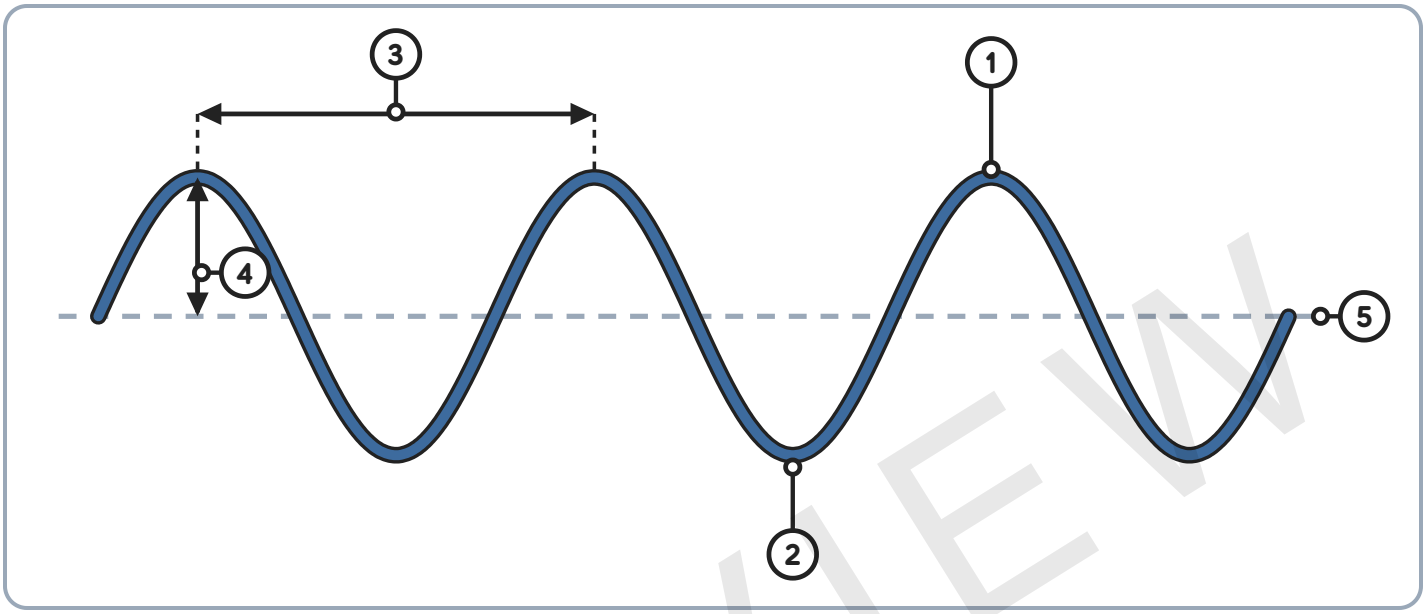
Preview · Bright Path Sped

My name _____ Date _____

Label the Wave

Write the name of each part of the wave.

Look at the numbers on the picture. Write each part's name. Use the word bank.



Amplitude **Rest line** **Crest** **Wavelength** **Trough**

1. _____

2. _____

3. _____

4. _____

5. _____

6. A wave with its crests closer together has a _____ wavelength.

☐ **shorter** ☐ **longer**

PREVIEW

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My name _____ Date _____

Fill In the Table

Fill in the frequency and the energy rank.

Use the Spectrum Chart on page 7. Pick each frequency from the bank. Then rank the energy from 1 (lowest) to 7 (highest).

4.3×10^{14} to 7.5×10^{14} **less than 3×10^{8}** **3×10^{16} to 3×10^{19}** **3×10^{11} to 4.3×10^{14}**
more than 3×10^{19} **3×10^{8} to 3×10^{11}** **7.5×10^{14} to 3×10^{16}**

Wave	Wavelength	Frequency (Hz)	Energy rank
Radio waves	longer than 1 m		
Microwaves	1 mm to 1 m		
Infrared	700 nm to 1 mm		
Visible light	400 nm to 700 nm		
Ultraviolet	10 nm to 400 nm		
X-rays	0.01 nm to 10 nm		
Gamma rays	shorter than 0.01 nm		

What happens to the frequency and the energy as the wavelength gets shorter?

PREVIEW

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My name _____ Date _____

Wave Speed Math

Use the speed rule. Find the missing number.

The speed rule

speed = wavelength x frequency, so wavelength = speed / frequency and frequency = speed / wavelength. The speed of every electromagnetic wave in a vacuum is about 3.0×10^8 m/s.

Example: The frequency is 1.5×10^8 Hz. Find the wavelength. Wavelength = 3.0×10^8 / 1.5×10^8 = 2.0 m.

1 The frequency is 1.0×10^8 Hz. Find the wavelength.

wavelength = _____ **m**

This is _____

2 The frequency is 3.0×10^9 Hz. Find the wavelength.

wavelength = _____ **m**

This is _____

3 The frequency is 6.0×10^{14} Hz. Find the wavelength.

wavelength = _____ **m**

This is _____

4 The wavelength is 2.5×10^{-6} m. Find the frequency.

frequency = _____ **Hz**

This is _____

5 The wavelength is 3.0×10^{-3} m. Find the frequency.

frequency = _____ **Hz**

This is _____

6 The wavelength is 2.0×10^{-8} m. Find the frequency.

frequency = _____ **Hz**

This is _____

Show your work for one problem here.

PREVIEW

Preview · Bright Path Sped

My name _____ Date _____

Find the Mistake

Find the mistake. Then fix it.

Mina is made up for practice. Each sentence has one mistake.

1 **Mina wrote:**

"Microwaves have a shorter wavelength than X-rays."

What is wrong?

Write it the right way.

2 **Mina wrote:**

"A wave with a high frequency has a long wavelength."

What is wrong?

Write it the right way.

3 **Mina wrote:**

"Light needs air to travel from the Sun to Earth."

What is wrong?

Write it the right way.

4 **Mina wrote:**

"Visible light is the whole electromagnetic spectrum."

What is wrong?

Write it the right way.

PREVIEW

My name _____ Date _____

Explain It

Explain your thinking in sentences.

Use what you know about waves and the spectrum. Say why.

Start with: I know that ____ because ____.

1. A student says X-rays are slower than radio waves because X-rays have more energy. Tell what is wrong with the idea.

2. Radio waves have a wavelength of 3.0 m. The waves in a microwave oven have a wavelength of about 0.12 m. Which has the higher frequency? Explain how you know.

PREVIEW

My name _____ Date _____

Quiz B

Pick the best answer. Write its letter.

Take your time. Guess if you are not sure.

7 Which wave has the longest wavelength?

A X-rays
B Radio waves
C Ultraviolet

8 From radio waves toward gamma rays, what happens to frequency?

A It increases
B It decreases
C It stays the same

9 A wave has a wavelength of 3.0 m. The speed is 3.0×10^8 m/s. What is its frequency?

A 9.0×10^8 Hz
B 3.0×10^8 Hz
C 1.0×10^8 Hz

10 Which wave shows bones in a picture?

A X-rays
B Microwaves
C Radio waves

11 Which part of the spectrum is between infrared and ultraviolet?

A Microwaves
B Visible light
C X-rays

12 What is true of all electromagnetic waves in a vacuum?

A They have the same wavelength
B They have the same frequency
C They move at the same speed

PREVIEW

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My name _____ Date _____

Check My Own Work

Check your own work. Mark yes or not yet.

1	I can name the waves of the spectrum in order.	☐ yes	☐ not yet
2	I can tell which wave has the longest wavelength and which has the shortest.	☐ yes	☐ not yet
3	I can say how wavelength and frequency are related.	☐ yes	☐ not yet
4	I can tell which waves have more energy.	☐ yes	☐ not yet
5	I can label the parts of a wave.	☐ yes	☐ not yet
6	I can use speed = wavelength x frequency to find a missing number.	☐ yes	☐ not yet
7	I can match a wave to one of its uses.	☐ yes	☐ not yet
8	I can explain why light can cross empty space.	☐ yes	☐ not yet

The part I can explain best is:

The part I still need help with is:

PREVIEW

My name _____ Date _____

Cut and Sort: What Is It Used For?

Cut out the pieces. Glue each one in the right box.

Each piece tells what a wave is used for. Think about which wave it is. Glue each piece in a box.

Radio waves and microwaves	Infrared and visible light	Ultraviolet, X-rays and gamma rays

Cut on the dashed lines: nine pieces, two cuts across and two cuts down.

Lets a heat camera show warm and cool objects	Sterilizes medical tools in sealed packages	Heats food in a microwave oven
Makes a black light poster glow	Sends phone signals between towers	Lets you see colors and read this page
Shows a bone inside a hand in a picture	Carries FM radio programs through the air	Lets a TV remote change the channel

Pick one piece. Tell which wave it is and how you know.

PREVIEW

Answer Key: Table, Compare, Math

The frequency bank is in a different order from the table.

Fill In the Table page 11

Wave	Frequency (Hz)	Energy rank
1. Radio waves	less than 3×10^8 Hz	1
2. Microwaves	3×10^8 to 3×10^{11} Hz	2
3. Infrared	3×10^{11} to 4.3×10^{14} Hz	3
4. Visible light	4.3×10^{14} to 7.5×10^{14} Hz	4
5. Ultraviolet	7.5×10^{14} to 3×10^{16} Hz	5
6. X-rays	3×10^{16} to 3×10^{19} Hz	6
7. Gamma rays	more than 3×10^{19} Hz	7

A note on the numbers

The lines between neighboring waves are conventions, and books draw them in slightly different places; accept a frequency that matches the chart. Energy rank follows frequency, so it goes 1 to 7 in the same order as the chart. The math answers use a speed of 3.0×10^8 m/s and are rounded. Wavelength times frequency comes back to the speed for every answer.

Higher or Lower? page 12

Pair	Longer wavelength	Higher frequency	More energy
1. Radio waves or X-rays	Radio waves	X-rays	X-rays
2. Visible light or Microwaves	Microwaves	Visible light	Visible light
3. Gamma rays or Ultraviolet	Ultraviolet	Gamma rays	Gamma rays
4. Infrared or Visible light	Infrared	Visible light	Visible light

Wave Speed Math page 13

Problem	Answer	This is
1. The frequency is 1.0×10^8 Hz. Find the wavelength.	3.0 m	Radio waves
2. The frequency is 3.0×10^9 Hz. Find the wavelength.	1.0×10^{-1} m	Microwaves
3. The frequency is 6.0×10^{14} Hz. Find the wavelength.	5.0×10^{-7} m	Visible light
4. The wavelength is 2.5×10^{-6} m. Find the frequency.	1.2×10^{14} Hz	Infrared
5. The wavelength is 3.0×10^{-3} m. Find the frequency.	1.0×10^{11} Hz	Microwaves
6. The wavelength is 2.0×10^{-8} m. Find the frequency.	1.5×10^{16} Hz	Ultraviolet

PREVIEW

Answer Key: Mistakes and Writing

The student in Find the Mistake is invented. Writing pages have no single right sentence: accept any answer that uses a fact from the readings or the chart.

Find the Mistake page 15

Item	What went wrong	Right sentence
15.1	X-rays are shorter.	X-rays have a shorter wavelength than microwaves.
15.2	At the same speed it is the other way around.	A wave with a high frequency has a short wavelength.
15.3	Electromagnetic waves need no air.	Light crosses empty space to reach Earth. Electromagnetic waves need no air.
15.4	It is only one small part.	Visible light is one small part of the spectrum, between infrared and ultraviolet.

Short answers: what to look for page 16

Item	Look for
16.1	When the wavelength gets longer, the frequency gets lower. When the wavelength gets shorter, the frequency gets higher. (Speed = wavelength x frequency, and the speed does not change.)
16.2	Radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays.
16.3	Accept any use that matches the wave on the chart or in the readings: radio (broadcasts), microwave (heating food, phone signals), infrared (remotes, heat cameras), visible light (seeing), ultraviolet (glowing materials), X-ray (pictures of bones), gamma (sterilizing tools).

Explain it: what to look for page 17

Item	Look for
17.1	In a vacuum all electromagnetic waves move at the same speed. X-rays have a shorter wavelength, a higher frequency and more energy, not more or less speed.
17.2	The microwaves. Their wavelength is shorter, and at the same speed a shorter wavelength means a higher frequency (3.0×10^8 divided by 0.12 is about 2.5×10^9 Hz; the radio waves are 1.0×10^8 Hz).

Exit tickets

- Exit tickets (page 20): ticket 1 names a likeness (both are electromagnetic waves, both move at the same speed in empty space) and a difference (radio waves have the longest wavelength and the lowest energy; gamma rays have the shortest wavelength and the highest energy); ticket 2 says the wavelength gets shorter while the frequency and the energy go up; ticket 3 is open.

A quick check for any written answer

- Does it answer the question that was asked?
- Does it use at least one fact from the readings or the chart?
- Is it written in sentences a classmate could follow?

PREVIEW

Electromagnetic Spectrum Tracker

One student, every scored sheet. Filled example: page 33.

Student _____ Teacher _____ Month _____

Page	Page type and set	Items	Right	Date	Notes
5	Reading 1: Waves of Energy	4			
6	Reading 2: The Spectrum at Work	4			
8	Wave and Spectrum Words	9			
9	Label the Wave	6			
10	Label the Spectrum	9			
11	Fill In the Table	14			
12	Higher or Lower?	12			
13	Wave Speed Math	12			
14	True or False	8			
15	Find the Mistake	4			
18	Quiz A	6			
19	Quiz B	6			
22	Cut and Order: Longest to Shortest	6			
23	Cut and Sort: What Is It Used For?	9			

How to fill this in

Write how many items the student got right with no prompt, and the date. A blank means not tried yet, never wrong. There are 109 items on the 14 scored sheets. Answer keys: pages 24 to 28. Filled example: page 33.

This unit we are working on (your own standard or wording)

PREVIEW

Team Note

Use this page between team meetings or when a student moves classes, to hand off what changed without writing a note from scratch. Everything below is observable, with a blank for the number or the wording your team already uses.

Student _____ Team member _____ Date _____

Kind of sheet	Covered since last note (Y/N)	Items right	Still blank
Readings and words			
Labels			
Table and compare			
Wave math			
True or false, mistakes			
Quizzes			
Sorts			

What I saw (observable, not a conclusion)

- Filled in ___ of 14 table boxes (page 11).
- Named ___ of 9 items on the spectrum bar (page 10).
- Chose the right wave for ___ of 12 comparisons (page 12).
- Found the missing number in ___ of 6 wave-speed problems (page 13).
- Explained how wavelength and frequency are related in a complete sentence: yes / no / with a reminder.

Next step

- Next page or set: ___, because ___ (what you saw).
- What to try in another class or at home: ___.
- What to keep doing because it is working: ___.
- Anything for the team meeting to decide: ___ (this page records what happened, never a label or a plan).

Summary, in one or two sentences, for whoever reads this next

A filled-in line, for reference

"Got 8 of 12 items right on the wave-speed page on 10/15. Next step: reread the speed rule and do the example together." That is the level of detail this page is built for. It matches the filled example on page 33.

PREVIEW

Rowan's Tracker (Invented Student)

Rowan P. is invented; nothing on this page describes a real student. The blank tracker is on page 29.

Student: Rowan P. (an invented student)

Teacher: Ms. Patel (invented)

Month: October

Page	Page type and set	Items	Right	Date	Notes
5	Reading 1: Waves of Energy	4	3	10/6	Mixed up wavelength and amplitude
6	Reading 2: The Spectrum at Work	4	4	10/7	-
8	Wave and Spectrum Words	9	7	10/8	Swapped hertz and frequency
9	Label the Wave	6	5	10/9	Called the rest line a trough
10	Label the Spectrum	9	9	10/10	-
11	Fill In the Table	14	11	10/13	Ranked two energies backward
12	Higher or Lower?	12	10	10/14	Mixed up frequency and wavelength
13	Wave Speed Math	12	8	10/15	Missed an exponent
14	True or False	8	7	10/16	Thought sound is electromagnetic
15	Find the Mistake	4	-	-	-
18	Quiz A	6	-	-	-
19	Quiz B	6	-	-	-
22	Cut and Order: Longest to Shortest	6	-	-	-
23	Cut and Sort: What Is It Used For?	9	-	-	-

How to read it

Rowan P. has done **9 of 14** scored sheets and got **64 of 78** items right with no prompt. **2** sheets were all right and **7** carry a note. Every number comes from the table.

What the table points to

The lowest sheet is Wave Speed Math (8 of 12). That is where the next practice goes. The 5 sheets left blank are not tried yet, never wrong.

PREVIEW