How Are Rainbows Formed?

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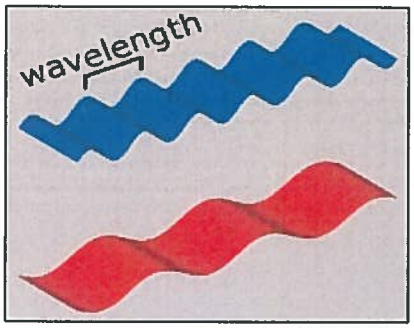
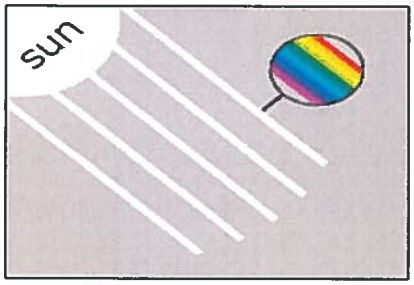
Sunlight is composed of light of varying wavelengths. Short wavelength light appears blue, violet and indigo, and long wavelength light appears red, orange and yellow. When sunlight enters a raindrop in the air, the light splits into a multitude of colors. This light then reflects off the back of the raindrop and re-emerges in the direction in which the light first entered. The light emerging from many raindrops creates a rainbow. Read on for a more detailed explanation.

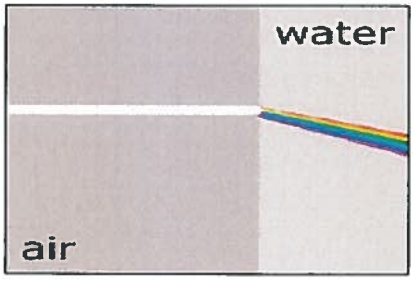
Fact 1. Light travels in waves. The light's wavelength determines its perceived color. Short wavelength light, for example, appears blue, and long wavelength light appears red.



Fact 2. Sunlight is composed of light of many wavelengths. In the range that we can see, this includes the colors of the rainbow.

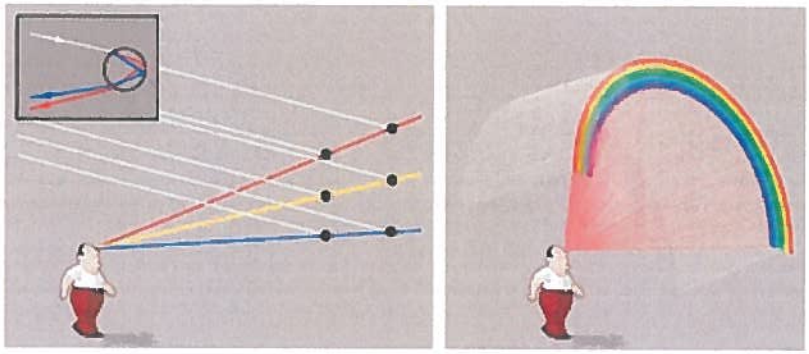


Fact 3. When light enters water, it bends (refracts). The amount of bending depends on the wavelength of light. As a result, the light splits into its component colors.



When a ray of sunlight enters a raindrop, it bends (refracts). The light then strikes the back of the raindrop, where some of the light passes through and some is reflected. As the light exits the raindrop, it is refracted again. The angle at which the light emerges depends on the wavelength of light. This path is illustrated in the small box below, where only the bending of two wavelengths (blue and red) are shown.

Consider now the diagram on the left. The sun is behind you (white rays) and there is rain in front of you (black dots). As the sunlight enters each raindrop, the light is refracted and reflected as described above. Because the sun is so far away, the rays of sunlight are nearly parallel to one another. As a result, the angle between the red line and each ray of sunlight striking a raindrop on that line will be the same. So, the light that reaches your eye along this ray will be of the same wavelength (color). The same is true for the yellow, blue, and intermediate lines corresponding to each color of the rainbow.



Consider now the diagram on the right which explains why the colors of a rainbow form an arc. The angle between the incoming rays of sunlight (white) and all of the red lines, forming a circular cone, have the same angle. As a result, the light that reaches your eye along these lines have the same wavelength (color). The same is true for each band of the rainbow.

The reason that rainbows are somewhat rare is that you will only see them when there is rain in front of you and somewhat in the distance, and the sun is behind you and fairly low on the horizon.

Name: _____ Date: _____

1. What is sunlight composed of?

A light of a single color
B light traveling at different speeds
C light of varying intensity
D light of varying wavelengths

2. What does the author explain in the first paragraph of the text?

A how light travels
B how a rainbow is formed
C why rainbows are shaped like an arc
D why rain causes light to split into separate colors

3. Read these sentences from the text.

"Sunlight is composed of light of varying wavelengths. [...] When light enters water, it bends (refracts). The amount of bending depends on the wavelength of light. As a result, the light splits into its component colors."

What can you conclude based on this evidence?

A Each wavelength of light bends the same amount when it enters water.
B When light enters water, its wavelength is altered.
C Each component color of light has a different wavelength.
D The component colors of light all have the same wavelength.

4. When would you be most likely to see a rainbow?

A in the evening on a partly rainy, partly sunny day
B in the morning on a bright, sunny day
C in the evening on a cloudy, rainy day
D at noon on a partly cloudy day

5. What is the main idea of this text?

A Sunlight is composed of light of varying wavelengths. Short wavelength light appears blue, and long wavelength light appears red.
B Rainbows form when sunlight enters raindrops, splits into different color components, and then re-emerges from the raindrops.
C The colors of a rainbow form an arc because of the angles at which light of different wavelengths reaches your eye.
D You will only see rainbows when there is rain in front of you and somewhat in the distance, and the sun is behind you and fairly low on the horizon.

6. Why might the author have chosen to list Facts 1, 2, and 3 separately instead of describing them in one paragraph?

A to emphasize the importance of these facts to the way rainbows form
B to show that these facts are not related to each other in any way
C to indicate that these facts do not affect the way rainbows form
D to make the explanation of how rainbows form seem more complicated

7. Choose the answer that best completes the sentence.

Light's wavelength determines its perceived color; _____, short wavelength light appears blue.

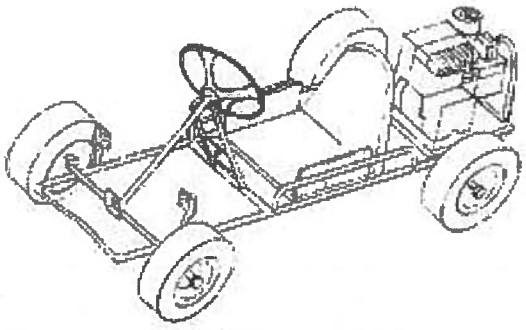
A initially
B for instance
C however
D similarly

8. When light enters water, it bends. What does the amount of bending depend on?

9. For a rainbow to form, sunlight needs to enter and then re-emerge from raindrops. Describe what happens to the light between when it first enters a raindrop and when it comes out of the raindrop. Support your answer with evidence from the text.

10. Why might you only see a rainbow when rain is in front of you? Support your answer with evidence from the text and images.

The Go-Kart



Michael and Sam had been neighbors for as long as they could remember, but they only just started loving go-karts a few months before. Sam's dad took the boys to the go-kart track for the first time as soon as school let out for the summer, and since then, they had been obsessed with getting their own go-kart. It would be a few years before Michael and Sam got their driver's licenses, and this seemed like the next-best thing. They would fantasize about go-karting down their block and into the main street, competing with taxis, speeding bikes, and other cars for room on the road. In these dreams they would wear old-fashioned brown helmets and vintage airplane goggles, like in old video footage of the people who got to drive the first-ever cars.

One evening, Sam was talking about it—again—over dinner. "Wouldn't it be great? We'd be low to the ground so we could even drive under big trucks! We'd go so fast, we'd be like a blur in all of the traffic. Can I get a go-kart for Christmas?"

Sam's mom rolled her eyes and set down a helping of spaghetti and meatballs on his plate. "I don't think so," she said. "Why don't you and Michael just build one?"

After dinner, Sam went over to Michael's house. "My mom had the best idea," Sam said. "We should build our own go-kart!"

Michael was also excited by the idea. His uncle John worked at an auto repair shop, and the boys called him right away to ask if he had any spare parts he would give them, and if he could help them: they had no idea how to build a car. John was thrilled that Michael and Sam were interested, and promised to talk the boys through it later in the week.

That weekend, John came by Michael's apartment with a bunch of different auto parts that they could use for a go-kart, like a steering wheel, brakes, and an ignition pedal, as well as a large poster board.

"The first thing we need to do is draw how you want the go-kart to look," John said. He laid the poster board flat on Michael's kitchen table and looked at the boys expectantly.

Michael and Sam both agreed that they wanted the go-kart to be extremely fast, but other than that, they had no idea how it should look. John showed them a few drawings. They decided that a four-wheeler would be the best, with a long nose and an open top.

John wrote a list of materials that they would need. "You can get this stuff at a hardware store," he said. "Let me know when you have everything, and you can come out to the shop to build it."

A few weeks later, the boys showed up at John's auto shop with a cart full of materials to build the go-kart. They had bought most of the hardware with chore money, but had found some of it at a scrap yard by their school. They had tubing, plywood planks, bearings, bolts, and chains. John told them he would provide the frame, petrol tank, driving shaft, engine, and seat—all the objects they could get from an auto body shop. Michael, Sam, and John took over a corner of the shop and began to build.

Soon they had a prototype go-kart. "Let me try it first," Sam begged, grinning at Michael. He jumped into the shiny new go-kart and revved the engine. He pressed his foot down on the pedal, expecting the go-kart to shoot forward out of the garage and into the parking lot. Instead, it crept like a snail towards the open garage door.

"Woah!" Sam said. "This is way too slow." Sam stopped the kart and got out.

Michael nodded and said, "Yeah, I agree. Uncle John, how do we make it go faster?"

There were a few problems that the boys could fix, Uncle John said. First, the engine that Michael and Sam had chosen—the biggest one—took up a lot of space and was very heavy, so

it probably dragged the go-kart down. Second, the design they had chosen was not ideal for fast vehicles. Lastly, John said with a smile, it looked like Sam had forgotten to turn off the emergency brake.

So the three guys got back to work. They scoured the auto repair shop for a smaller engine, and found one in a small lawnmower that had been taken for disposal into the garage. They had fun taking the lawnmower apart to get to the small, powerful engine inside. The second problem was much more difficult to fix. Would they have to redesign the entire go-kart?

Together, they drew some other sample sketches that might make the go-kart less bottom-heavy, and even considered taking away one of the wheels so that it would be a three-wheel go-kart. Michael thought it would be a good idea to get lighter materials all around and keep their original design, but John didn't think that would work. Michael, Sam, and John needed to think about ways to maximize the go-kart for its speed: what aspects of their original design were unnecessary? The three of them came to the conclusion that it was probably the long nose. It looked cool, but ultimately, what was more important to Michael and Sam?

They had welded the nose to the frame, and used a grinder to break the metal away from the go-kart. When they were finally done, Michael stepped into the go-kart and put on the helmet he and Sam had found at a used-clothing store. He snapped on a pair of swimming goggles, revved the engine, and made sure to take the emergency brake off. All of a sudden, he sped out into the parking lot, and Sam ran after him with a big smile.

Name: _____ **Date:** _____

1. What do Michael and Sam build?

A) a fast car
B) a big truck
C) a go-kart
D) an engine

2. What problem do Michael and Sam face with their first go-kart prototype?

A) It is too slow.
B) It is too fast.
C) It is too small.
D) It breaks apart easily.

3. The second time Michael and Sam test their go-kart, they are satisfied with its speed. Which sentence supports this idea?

A) "Sam pressed his foot down on the pedal, expecting the go-kart to shoot forward out of the garage and into the parking lot."
B) "Michael, Sam, and John needed to think about ways to maximize the go-kart for its speed: what aspects of their original design were unnecessary?"
C) "Michael snapped on a pair of swimming goggles, revved the engine, and made sure to take the emergency break off."
D) "All of a sudden, Michael sped out into the parking lot, and Sam ran after him with a big smile."

4. Why might using a small engine instead of a large engine have increased the go-kart's speed?

A) The small engine was built for a go-kart, but the large engine was built for a lawnmower.
B) The small engine was easier for Sam and Michael to carry and work with than the large engine.
C) The small engine used more fuel than the large engine did.
D) The small engine did not weigh the go-kart down as much as the large engine did.

5. This passage is mainly about

A) how visiting a go-kart track can change someone's life
B) a mother who gives her son a piece of great advice
C) building a go-kart and then rebuilding it to make it faster
D) an uncle who lets his nephew and his nephew's friend play in his auto repair shop

6. Read the following sentence: "That weekend, John came by Michael's apartment with a bunch of different **auto** parts that they could use for a go-kart, like a steering wheel, brakes, and an ignition pedal, as well as a large poster board."
What does the word "**auto**" mean in the sentence above?

A) car
B) metal
C) cheap
D) simple

7. Choose the answer that best completes the sentence below.
The go-kart moves slowly _____ Michael and Sam rebuild it.

A) after
B) before
C) when
D) since

8. What does John say is the first thing that he, Michael, and Sam need to do in order to make the go-kart?

9. Why did Michael and Sam ultimately decide to shorten the nose of the go-kart?

10. If Michael and Sam were to make another go-kart, what might they do differently than what they did the first time? Support your answer with details from the story.