Name: _____ Date: _____

The Blue Dot and the Clocks

Reading level 10 (6th grade) · 746 words

Nia is halfway up a hiking trail when the path splits in two, and the only signpost has lost its arrows. She pulls out her phone. A small blue dot appears on the map, right where she is standing. That is strange, when you stop to think about it. Her phone has no eyes. It does not need to send anything to a satellite, and nobody told it where she was. So how does it know? The answer comes from the sky, and it starts with a clock.

High above Nia, about 20,200 kilometers up, a fleet of satellites circles the Earth. That is far higher than any airplane flies. Each satellite goes all the way around the planet twice a day. Here is the surprising part: they do not know that Nia exists. They mostly just broadcast, over and over, the time and where they are. A satellite works like a lighthouse, shining for anyone who looks, and it cannot tell who is looking.

Nia's phone listens, and its first trick is to measure how long each signal took to arrive. The message says when it left the satellite, and the phone knows when it came in. Radio signals travel at the speed of light, so even a tiny delay turns into a distance. For a satellite straight overhead, the trip takes less than a tenth of a second. The phone does the same sum for every satellite that it can hear, and every sum is another clue.

One distance alone is not enough. If Nia is a long way from one satellite, she could be anywhere on a giant ball around it. A second satellite gives her a second ball, and where the two balls cross, they make a circle. A third ball cuts that circle at just two points, and one is far out in space. Finding a place from distances is called trilateration. It is like drawing circles on a map, but in three dimensions.

So why does a phone need four satellites? The reason is the clock. A satellite carries an atomic clock that is almost perfect, but a phone's clock is not. Light moves so fast that a mistake of one millionth of a second would put the phone about three hundred meters off. So the phone uses three satellites to find where it is, and it uses the fourth to fix its own clock. The sky is built so that at least four satellites can be seen from anywhere on Earth.

Now comes the part that sounds like science fiction. Albert Einstein showed that time does not tick at the same speed everywhere. A satellite zooms along fast, and fast clocks run a little slow. But a satellite is also high above the Earth, where gravity is weaker, and clocks up there run fast. The two effects mostly fight each other, but the fast ticking wins. Each day, a clock in orbit gets ahead of a clock on the ground by about thirty-eight millionths of a second.

That sounds like nothing, but the engineers who built the system knew it was not. If nobody fixed it, the blue dot would slide away from the truth, and the mistake would grow by about ten kilometers every day. So before the satellites were launched, the engineers did something

clever. They made the clocks tick a little slow on purpose, so that up in orbit, they would run just right. You do not have to understand Einstein to find your way, but the dot only works because somebody did.

So how good is the dot? Under open sky, a phone is usually right to within about sixteen feet, or five meters. That is close enough to find the right block, which is the whole point. Of course, it is not perfect. Near tall buildings, bridges and trees, the signals bounce and the dot wanders. But for a system that works by listening to clocks in space, it is remarkably good.

Back on the trail, Nia looks at the screen. The blue dot sits beside the left fork. Far above her, satellites have told the time, and her phone has measured the delays, fixed its own clock, and crossed its spheres. The answer is one small dot, and she never said a word to the sky. She turns left, and the dot moves along with her. Twenty thousand kilometers overhead, the clocks keep ticking, a little fast, a little slow, and just right.

Questions

1. What do the GPS satellites mostly broadcast?

A. Maps of the trails
B. The time and where they are
C. Nia's name

2. Why does Nia's phone need a fourth satellite?

A. To fix its own clock
B. To make the screen brighter
C. To call for help

3. What does "trilateration" mean here?

A. Finding a place from distances
B. Flying very fast
C. Drawing a triangle in the sand

4. Why is a tiny clock mistake such a big problem?

A. Phones break
B. Light travels so fast that a tiny time error becomes a long distance
C. Batteries run out

5. What did the engineers do to the clocks before launch?

A. Made them tick a little slow on purpose
B. Painted them blue
C. Switched them off

6. How close is a phone usually, under open sky?

A. About sixteen feet

B. About sixteen miles

C. About sixteen inches

Words to know

satellite: orbiting machine

broadcast: send to everyone

trilateration: finding by distances

sphere: round ball shape

signal: message in waves

orbit: path around

Answer key: The Blue Dot and the Clocks

1. B. The time and where they are
2. A. To fix its own clock
3. A. Finding a place from distances
4. B. Light travels so fast that a tiny time error becomes a long distance
5. A. Made them tick a little slow on purpose
6. A. About sixteen feet