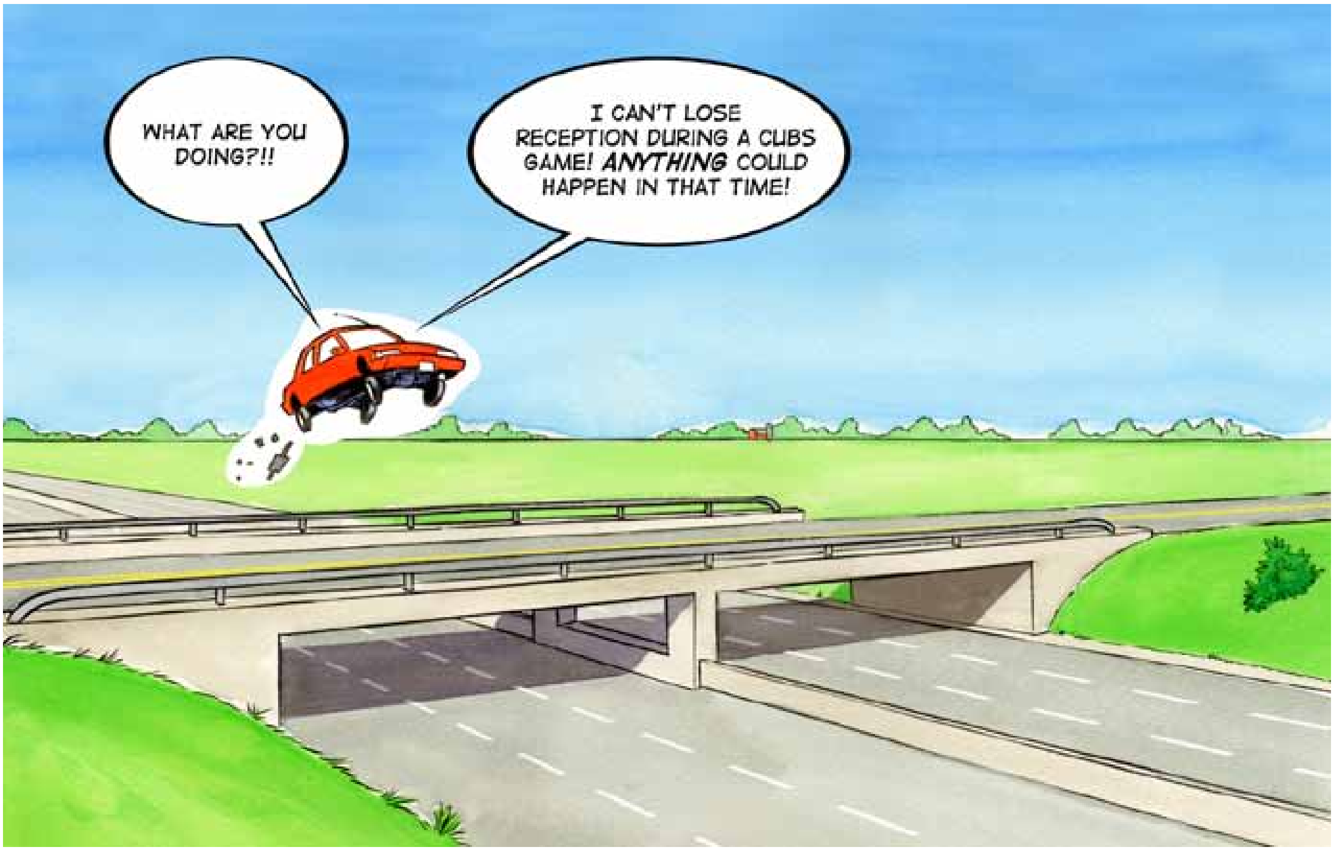
Q: Why do you lose AM radio reception when you go under an overpass?

By Bill Robertson

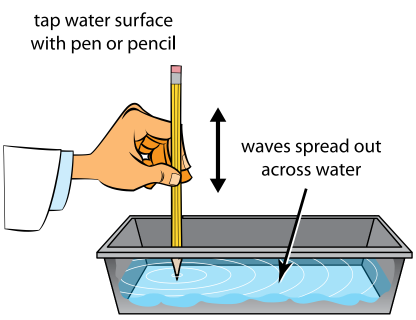


BRIAN DISKIN

A: Actually, it doesn't just happen under overpasses. It happens under bridges and sometimes when you drive over a bridge. You might also have noticed that AM reception goes away when you're inside a building. FM radio and satellite radio, along with phone reception, don't seem to have this problem as often.

To investigate this question, you'll need an AM/FM radio, a cardboard box that will fit over the radio, enough aluminum foil to wrap around the box, and enough chicken wire to wrap around the box. Take the radio outside and find an AM station and an FM station that come in clearly. Place the cardboard box over the radio and see if that affects the reception on AM and FM. Next, wrap the cardboard box with aluminum foil, place the box over the radio, and see what that does to the AM and FM reception. Finally, remove the foil, wrap chicken wire around the box, and repeat. And in case you haven't figured it out, you have to change from AM to FM in between placing the box over the radio.

Figure 1.



I'm going to tell you what *should* have happened with the radio reception and the box, but you really should try this for yourself instead of taking my word for what happens. Nothing like directly observing something. Anyway, the cardboard box alone shouldn't have affected either the AM or FM reception. The aluminum foil (solid metal) should have blocked both the AM and FM signals. Radio waves are *electromagnetic* waves, meaning they consist of changing electric and magnetic fields. When electromagnetic waves encounter solid metal, the electrons in the metal (many of which are free to move around) respond to those waves. In fact, they respond in such a way as to create their own changing electric and magnetic fields that cancel out the effect of the radio waves. In short, no electromagnetic waves can travel through solid metal. Just for kicks, wrap your cell phone in aluminum foil and try to call it. Nada, because cell phone signals are transmitted via electromagnetic waves.

Now, the chicken wire should have blocked or severely interfered with the AM signal and not had much effect on the FM signal. This result alone tells us why bridges and overpasses generally interfere with AM signals but not FM signals. Both bridges and overpasses have a great deal of metal in them, but they're not solid metal. The metal in an overpass is "rebar" that forms a mesh throughout the structure, not unlike (but stronger than!) chicken wire. This mesh of wire blocks AM signals in the same way that chicken wire blocks AM signals. FM radio signals make it through the mesh of metal in an overpass just as they make it through chicken wire. In a bridge, the metal mesh is often just the overall structure of the bridge, but the concrete in the roadway also contains rebar as with an overpass.

Well, that's all fine and dandy, but what's really going on here? To answer that, you'll need a baking pan (metal or glass) that has water about 1 cm deep and a pen or pencil. Using the tip of the pen or pencil, tap the water at one end of the pan so you get waves that travel across the water in the pan (Figure 1).

First, tap the water about once every second and then tap the water about 10 times faster than that. You should see a difference in the wave patterns. When you tap slowly (this is tapping at a *low frequency*) the waves are farther apart, and when you tap quickly (this is tapping at a *high frequency*) the waves are closer together (Figure 2).

Next, find a few objects you can place in the water so as to form a small gap (about 2 cm or less) through which waves can travel. I used salt and pepper shakers, as shown in Figure 3. Using your pen or pencil, first tap out low frequency waves near the barrier and then tap out high frequency waves near the barrier. Look on the other side of the barrier each time and determine which waves (low frequency or high frequency) travel through the gap better. Look at Figure 3.

You no doubt noticed that the higher the frequency of the waves (tapping faster), the better the waves made it through the gap between the salt and pepper shakers. Low frequency waves don't make it through the gap so well. To investigate this further, you could try varying the size of the gap in the pan of water. If you make the gap really small, even the high frequency waves have trouble getting through. If the gap is large

Figure 2a.

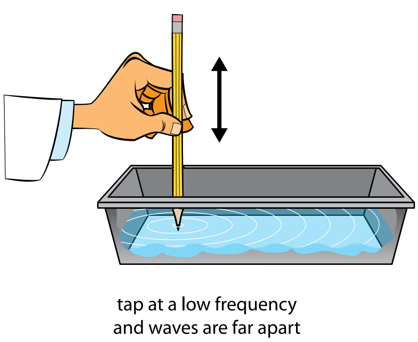


Figure 2b.

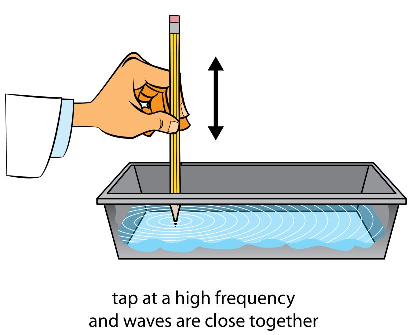


Figure 3a.

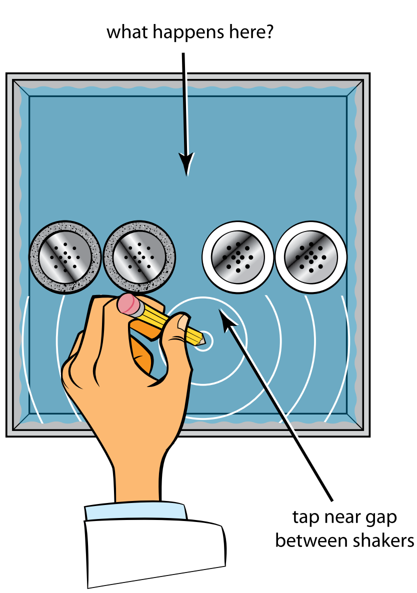
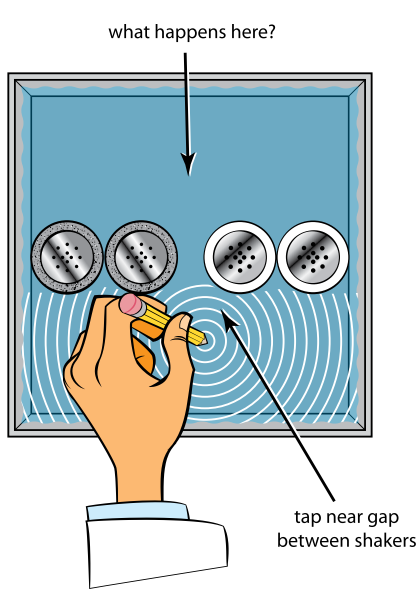


Figure 3b.



enough, both high and low frequency waves make it through okay. The neat thing for us is that water waves and gaps in solid barriers behave just like electromagnetic waves and gaps in metal. Salt shakers block water waves and metal blocks electromagnetic waves. If you have electromagnetic waves of low frequency, they will have trouble making it through gaps in metal. Electromagnetic waves of high frequency will be able to pass through gaps in metal. And of course, that statement depends on the actual frequencies and the sizes of the gaps.

To tie this all together, take a look at your AM/FM radio display. The units for the numbers on the AM display are KHz, and the units for the numbers on the FM display are MHz. KHz stands for one thousand cycles per second—the frequency of the AM electromagnetic waves. MHz stands for one million cycles per second—the frequency of the FM electromagnetic wave. So, for example, an AM radio station in nearby Denver operates at a frequency of 850 KHz, or 850,000 cycles per second. An FM station in Denver operates at 104.3 MHz, or 104,300,000 cycles per second. Both of these might seem like incredibly high frequencies, and they are, but 850 KHz is considerably smaller than 104.3 MHz. Thus, when I go underneath an overpass, the 850 KHz signal fades out while the 104.3 MHz stays with me. The FM signal is a high enough frequency that it passes right through the gaps in the metal mesh that supports the overpass. The AM signal is blocked by this mesh. My cell phone doesn't cut out underneath an overpass. Why? Cell phone signals are transmitted at an even higher frequency than FM radio waves. Same for satellite radio—very high frequencies.

Let's see whether all of this makes sense in everyday occurrences. I can get both AM and FM signals in my house with no problem. That's because the walls of my house don't have any metal other than the nails holding the wood together and some metal strips at the corners. If I go into my crawl space, which is below the foundation, I lose the AM radio. That's because there is a mesh of metal (rebar again) embedded in the concrete foundation. If I'm in a commercial building, I generally lose AM reception. That's because many commercial buildings have metal in the walls. Skyscrapers and large hotels definitely have lots of metal in their walls. Now, sometimes you can lose AM reception, FM reception, and even phone reception and satellite radio reception inside buildings. I can only surmise that such buildings have either solid metal or a metal mesh with very small gaps in their structure, making it impossible for even high frequency radio waves to get through.

To end, I want you to know that, as I looked across the internet before writing this column, I found the perfect fashion accessories for the alien-aware among us. You probably have heard of the "aluminum foil hat" crowd—people who wear aluminum foil hats to block electromagnetic waves coming from aliens or maybe even government sources. Well, it turns out there are entire websites devoted to wire mesh headbands, hats, dresses,and shirts. Now you can block electromagnetic waves from all sources while being stylish! ■

Bill Robertson (wrobert9@ix.net com.com) *is the author of the NSTA Press book series,* Stop Faking It! Finally Understanding Science So You Can Teach It.