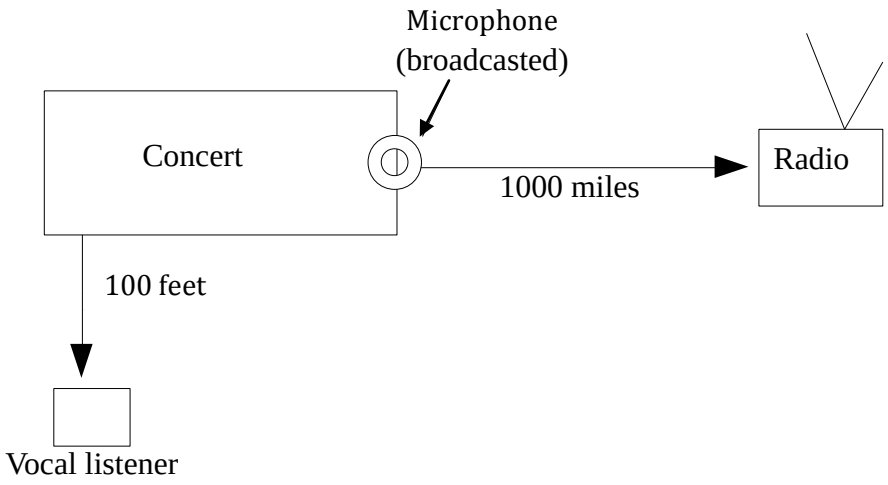
# Math at a Rock Concert

**Overview:** Here's an interesting math puzzle. If you're at a concert that's also being broadcast live on the radio, who will hear the music first? Will it be you, or people listening on the radio? I'll show you how to use the speed of sound versus the speed of light to find the answer.

**Materials**

- Pencil
- Paper

**Activity:** You've stood in long lines, paid for tickets, and now you're at a rock concert in the front row and get to hear it straight from the musicians themselves. This concert is so popular that they're also broadcasting it live to a radio station. The question is, do you get to hear the music first, or does the person listening on the radio?




The diagram above shows how things are set up: there's a live music performance at the concert. You're so close to the stage that you can hear their voices straight from their mouth. A listener on the radio is listening to a live broadcast from their radio at home. Let's figure out the difference between the time it takes the music to reach a listener 100 feet away via sound waves, and 1,000 miles away via electromagnetic waves.

Which do you think will be able to hear the music first?

As you make your guess, consider that 100 feet is a lot shorter than 1,000 miles! It seems obvious that the person who paid top dollar for those front row seats is going to get to hear it first.

But now consider this: Sound waves travel at around 750 miles per hour. That's the speed that the sound from the musicians travels at to get to you in the front row.

But what about the radio broadcast? Radios transmit electromagnetic waves, not sound waves. Electromagnetic waves travel much faster than sound waves: They speed along at 186,000 miles per second.

Write down your guess here: _____

Now let's figure this out:

Distance = 1,000 miles

Speed = 186,000 miles/sec

$$Time = \frac{Distance}{Time} = \frac{1{,}000\ miles}{186{,}000\ miles\ /sec} = \frac{1}{186} sec = 0.005\ 376\ sec$$

It takes 0.005 376 seconds for the music to go from the musician to the radio listener. That's fast!

Now let's take a look at the person in the front row.

Sounds travels at 750 mph, which is about 1,100 feet per second. The person in the front row is only 100 feet away.

$$Time = \frac{Distance}{Time} = \frac{100\ miles}{1{,}100\ miles\ /sec} = \frac{1}{11} sec = 0.090\ 91 sec$$

So it takes the sound 0.090 91 seconds to get to the listener in the front row.

The question is: which number is smaller? 0.053 76 seconds is less than 0.090 91 seconds, so the radio listener hears the music *before* the front-row person does!

**Exercises**

1. At what speed do electromagnetic waves travel?
2. What is the speed of sound though the air?
3. What is the relation between time, distance and speed?
4. A particle travels at a speed of 10 meters per second in the air for 20 seconds. Determine the distance that it covers.
5. Convert the answer from question #1 above to the units of minutes instead of seconds.
6. Convert the answer from question #2 above to the units of minutes instead of seconds.
7. A radio listener hears the news from her radio 12,000 miles away from the broadcasting center. Determine the time it takes to receive the sound.(Use the speed from #1 above)
8. A person attends a public rally at stand at 200 feet away from the stage so that they can hear the person's real voice without the use of speakers. Determine the time taken to hear the sound. (Use the speed from #2 above.)
9. In a phone conversation, it takes 1 second for a person to hear her friend from the other end. How far are these people from one another?
10. During a public lecture, a student at the back takes 0.1 seconds to hear what the lecturer is saying. What is the distance between the lecturer and the student?

**Answers to Exercises: Math at Rock Concert**

1. 1100feats/sec
2. 186,000miles/sec
3. Distance = speed  x time
4. 200m
5. 3100miles/min
6. 18.33feat/min
7. 0.0645sec
8. 0.1818sec
9. 186,000miles
10. 110feats