Science of Music: Problem Set 1

Due Monday Sept 2; Joseph Sepich (jps6444)

Directions: Save this worksheet with the filename "SOMProblemSet1-(lastname)". Enter your answers directly into the document and save, then upload it into Canvas. Clearly show your work. If you are using an equation, write the equation down, then plug in values you are using on the next line. When you are finished with a problem, draw a box around your final result or highlight it. Leave at least a couple of spaces on the paper before starting your next problem. Every answer should include the appropriate units. Remember to submit your homework by 10pm Monday. No homework will be accepted late, so get it done early.

A note about collaboration vs. plagiarism As with all homework assignments, you should work on each problem on your own. After having done that, you may seek guidance from other students or professors. But that help should come in the form of a discussion of the problem, not simply looking at the other person's work. You should then go and work the problem by yourself. You may compare final answers. Whenever you received significant assistance, it is your obligation to write a note on your solution to that individual problem that gives credit to that other individual.
Final note on collaboration: You may not get help from any written work of students that have previously taken this class. Of course this is on your honor... and it is our expectation!

1 Convert the following speeds into kilometers per hour (km/hr) from miles per hour (mph):

We know that the conversion rate from mile to kilometer is 1 mile to 1.60934 kilometers.

1.1 a) 35 mph

$$\frac{35mi}{1hour} * \frac{1.60934km}{1mi} = 56.3269mph$$

This means that 35 miles per hour is equivalent to **56.3269 kilometers per hour**.

1.2 b) 75 mph

We can once again multiply 75 by 1.60934 to get 75 mph to be equivalent to **120.701 kilometers per hour**.

1.3 c) 760 mph

We can once again multiply 760 by 1.60934 to get 760 mph to be equivalent to **1223.1 kilometers per hour**.

2 Convert the following speeds into meters per second (m/s):

We know that the conversion rate from mile to meters is 1 mile to 1609.34 meters. We also know that one hour is equivalent to 360 seconds. Let's use the same conversion method from before.

2.1 a) 35 mph

$$\frac{35mi}{1hour} * \frac{1609.34m}{1mi} * \frac{1hour}{3600sec} = \frac{35mi}{1hour} * 0.447 = 15.6464m/s$$

This means that 35 miles per hour is equivalent to **15.6464 meters per second**.

2.2 b) 75 mph

We can once again multiply 75 by 0.447 to get 75 mph to be equivalent to **33.528 meters per second**.

2.3 c) 760 mph

We can once again multiply 760 by 0.447 to get 760 mph to be equivalent to **339.75 meters per second**.

3 Problem 3

Pretend you are 6 kilometers (km) from where a lightning bolt strikes. The cracking sound produced will travel at the speed of sound, whereas the light will travel at the speed of light (300,000,000 m/s).

For this problem I will use the value of the speed of sound to be 343.6 m/s.

3.1 a) How long does it take the sound to get to you? (Assume that the speed of sound is the value given on page 9 of our text by Lapp for room temperature.)

Using our value for the speed of sound we know that the sound will travel 6 km at 343.6 m/s. This means that it will be travelling at 0.3436 km/s. Using our formula $d = rt$ we can calulate t (or time) by $t = \frac{d}{r}$. This will give us $\frac{6}{0.3436} = 17.4622$. The sound will take **17.4622 seconds** to reach you.

3.2 b) How long does it take the light to get to you?

Using the value of 300,000,000 m/s that is given we can change this to be 300,000 km/s. The light will travel at this speed for 6 km, so we can the equation again $\frac{6}{300,000} = 0.00002$. This means the light will get to you in **0.00002 seconds**. This is almost instantly versus the 17 seconds the sound takes.

4 Problem 4

A conductor taps on his music stand and hears an echo from the back of the auditorium 0.4 seconds later. Given the speed of sound, what is the length of the auditorium? (Assume that the room is dry and has a temperature of 20C – approximately "Room temperature.")

Given these assumptions we will once again use the speed of sound to be 343.6 m/s. We know the time and rate of the sound; however the time was an echo that travelled to the back and back up front, so we must divide by 2 in our equation assuming a constant speed in both directions. Let's setup and solve our drt equaiton.

$$d = rt$$

$$d = 343.6 * 0.4$$

$$d = 137.44$$

This means the total distance travelled was 137.44 meters, but we must remember that this is twice the length of the auditorium. This gives us the conclusion that the length of the auditorium must be **68.72 meters**.

5 Miscellaneous Questions

5.1 a) How many square inches are in a square foot?

A square foot is a 1 foot by 1 foot area. We know that a single foot is equal to 12 inches. That means that a square foot area is also 12 inches by 12 inches. If we multiply these values together we can conclude that one square foot is equal to **144 square inches**.

5.2 b) How many cubic centimeters (cm^3) in a cubic meter (m^3)?

A cubic meter is a 1 m x 1 m x 1 m volume. We know that a single meter is equal to 100 centimeters. That means that a cubic meter volume is also 100 cm x 100 cm x 100 cm. If we multiply these values together we can conclude that one cubic meter is equal to **1,000,000 cubic centimeters**.

5.3 c) How many milliliters (ml) in a liter (l)?

Using the prefix milli we know that a liter contains **1,000 milliliters**.

5.4 d) How many cm^3 in a ml?

A cubic centimer and a millitliter are the same unit of measurement. Therefore a ml contains **1 cm^3**.

5.5 e) How many liters in a cubic meter?

We declared int the last problem that a cubic centimeter is 1 milliliter. We also stated that 1 liter is 1000 mililiters, so 1 liter must be 1000 cubic centimeters. We also know that a cubic meter contains 1,000,000 cubic centimeters, so we can then conclude that 1,000,000 cubic centimeters / 1,000 cubic centimeters means a cubic meter contains **1,000 liters**.

6 Problem 6

The Blue Band drum major is standing with you in the end zone. He signals two drummers to start tapping the beat at the speed that he is indicating with his hands – one drumstroke per second. One drummer is right in front of you and the other one is 100 yards away from in the other end zone. So, given the relatively slow speed of sound, their tapping will sound out of phase to you. By how many milliseconds will the two placements of beats differ?

Once again let us use the speed of sound to be 343.6 m/s. We can convert the 100 yard distance to 91.44 meters, since 1 yard is 0.9144 meters. Knowing this we can use our drt formula to calculate the time delay of the further drummer to be $t = \frac{d}{r} = \frac{91.44}{343.6} = 0.266s$ or 266 milliseconds. If we can assume the first drummer has 0 delay then the beat placement will be off by **266 milliseconds** or roughly a quarter of a second.