The Sounds of Racing

The NASCAR garage is a pretty loud place. There are 43 engines going and none of them have mufflers. (You can learn more about why NASCAR cars have no mufflers in ***Race Gear: Mufflers***.) The sound intensity level can easily reach 100-130 dB if you're working around the cars, or even just watching the mechanics from outside the garage.

You are chatting with a couple mechanics and the car owner in-between practice sessions. One of the mechanics pulls out a brochure. "Someone sent this to me," he says, "They say that I'm possibly doing serious damage to my ears if I don't buy their earplugs. They say that their earplugs have a NRR of 33 dB. I don't even know what a NRR is, but my current earplugs say NRR 21. That doesn't seem like much of an improvement. They're custom molded, but they're also fifty bucks more expensive than the ones I use now." Another crew member suggests that he just put toilet paper in his ears to block the sound.

"NRR is noise reduction rating," your owner tells him. That's how much they cut they sound." He opens up the tool chest and pulls out some earplugs. "We bought these a while ago to give to people who were visiting and didn't know to bring their own. They say NRR 20. I wonder if we're giving our guests enough protection when they're in the garage for a couple of hours. On the other hand, they're less than a dollar apiece. The ones I bought for myself were about forty bucks."

The owner asks you to look into the earplug question. How much better are the earplugs from the mechanic's brochure than the earplugs he's using now? Are the earplugs your owner bought to give to guests sufficient for protecting their ears during the time they're in the garage?

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Pre-Race Prep

Clap your hands softly. Explain how the sound gets from your hands to your friends' ears.

If you clap your hands harder, your friends hear a louder sound. Why?

Do louder sounds transmit more energy? Explain why or why not.

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How do loud sounds affect our hearing?

List as many ways as you can to protect your hearing.

Which of these solutions are feasible for the race car driver during practice or a race?

How do the things you detailed above work? How do they decrease the amount of sound that reaches your ears?

PIT STOP: ***Have your instructor check your answers and/or compare with other students' answers before proceeding.***

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Start Your Engines

One of the tools you have in the hauler is a "sound-level meter," which is a device that responds to sound and provides a reading either with a needle indicator or an electronic digital display that corresponds to the "loudness" of the sound. When your driver gets in his car for practice and starts his engine, you measure a sound intensity-level of 110 dB. How loud is that? Measure some soft and loud sounds around your classroom so that you have some reference s. Create a table of situations below.

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Compare your table with those of other students in the classroom. Discuss your results. Are there any cases in which you made measurements of the same thing, but the values differed?

Look at two levels from your table, one of which is twice as many dB as the next. Is the louder sound twice as loud as the quieter sound?

Get a copy of a sound intensity level table from your instructor before continuing.

The OSHA (Occupational Safety and Health Administration) develops guidelines for how long you can safely listen to noises at different sound intensity levels. Are you around some sounds longer than you should be according to the table?

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The Noise Reduction Rating (NRR) is how much the earplug decreases the sound intensity level (which you'll measure in decibels). Does the largest NRR mean those earplugs are the most effective?

Explain how you would design an experiment to determine which earplugs are the most effective.

PIT STOP: Have your instructor approve your experimental design before continuing.

Take a careful look at the earplugs you have. Which ones do you expect would be most effective? Explain why.

Carry out your experiment. Make a table to record your data below. (If you have time, you can test the crew member's hypothesis that sticking toilet paper in your ears would be just as effective!)

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Did your measurements agree with your initial perceptions of how effective the different earplugs were? Can you explain any differences in what you thought would happen compared to what you measured?

Using your table of sounds and your measurements, what can you tell the crew member about the relative merits of the 33 dB NRR earplug would be relative to a 21 dB NRR earplug?

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If the people visiting your team are there for two hours or less and the average sound level is 110 dB, how high a NRR should the earplugs you provide for them have?

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Extension A: Cost vs. Benefit

Your teacher has information about how much each of the pairs of earplugs costs. Revise your recommendations to your owner about earplugs for the crew and for visitors (who are only in the garage for a short time) in light of the new information about cost.

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Extension B: Sound as Kinetic Energy

Is sound a type of kinetic energy? Explain why or why not.

Extension C: Earmuffs

Many race fans wear ear phones connected to a radio that can pick up the radio transmissions between the driver, the crew chief, and the spotter. Most of these ear phones fit over your ears and substantially reduce the sound level from the cars and fans that reaches your inner ear. Look at some of these ear phones or equivalent ear protection (like that you might wear in a wood shop or when operating a leaf blower or lawn mower) and figure out how they reduce the sound energy that reaches your ears. What kinds of materials are used in the ear protectors?

Do the earmuffs minimize sound the same way earplugs do? Are there advantages to the earmuffs?

Does combining earmuffs and earplugs give you better noise reduction?

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Extension D: Can You Hear Without Ears?

When your ears are clogged up, or when you're wearing earplugs, you can still hear sounds. How?

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Extension E: Earphones as a Source of Sound

Many race fans wear earphones connected to a scanner that picks up the radio transmissions between the driver, the crew chief, and the spotter. Some earphones fit over your ears and some have ear buds that fit inside your ears, like an iPod. Get an iPod or other sound source and adjust the volume to where you normally would listen. Then use your sound meter to measure the sound intensity level.

Then play some music at full volume and insert the iPod ear bud into the tube attached to the sound-level meter. (Don't put the ear bud into your own ear!) What sound level reading do you get?

If you're going to be at the track for four hours, what is the safest maximum sound intensity level you should experience? What volume setting would that correspond to on your radio?

Extension F: Sound and Distance:

You've probably noticed that the sound intensity level drops as you move away from the noise source. Does this happen in a predictable way? Devise an experiment that will allow you to make a graphical representation of how sound intensity level changes as you move away from a sound. Have your procedure approved by your teacher before proceeding.

Carry out the measurements. Make a table and then a graph of your results.

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Write in words what your graph tells you about how the sound intensity level varies with distance from the source.

Use your graph to determine how far away you would have to get from a 130-dB stock car to get the noise down to less than 90 dB without using earplugs.

Extension G: Sound and Distance (Advanced)

The driver doesn't have many options in terms of how close to the source of sound he is located, since he's got to be in the car. How does the sound level change for a race fan in the stands?

Devise an experiment to see whether this law holds when you measure a sound in your classroom.