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Loudness, pitch, and Feynman’s ear

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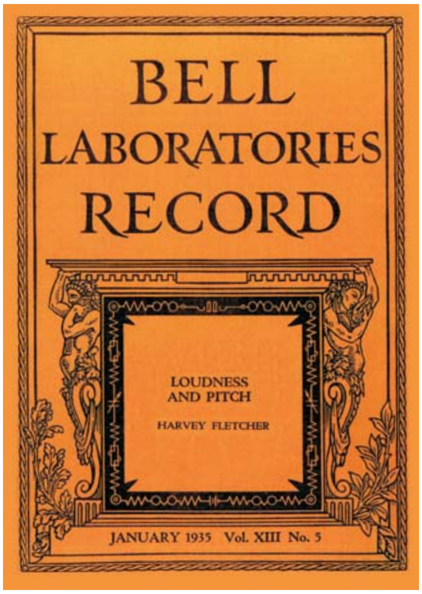
Loudness, pitch, and Feynman's ear

Seventy-five years ago a seminal article described how perceived musical pitch for two cases—pure tones and harmonically rich ones—depends not only on the actual pitch but also on intensity.[1] Many readers, including Ralph Leighton (PHYSICS TODAY, June 2010, page 8), are probably not aware of those surprising psychological phenomena, which are also little known to musicians and music lovers in general. Richard Feynman's close friend, amanuensis, and musical duet partner, Leighton offered as one example of Feynman's tone-deafness his misinterpretation of notes played louder as being higher in pitch. Most musicians obviously learn to correct themselves for those effects, or no music, solo or ensemble, would ever sound in tune.



BELL LABORATORIES RECORD

LOUDNESS AND PITCH

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Reference

1. H. Fletcher, *Bell Lab. Rec.* **13**(5), 130 (January 1935).

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The lowdown on siphons

The important point to be made in a revised definition of "siphon" (see PHYSICS TODAY, August 2010, page 28) is that the length of the pipe, hose, or other conduit on each side is not what matters, but that the level of the outflow side must be lower than the inflow side. Since the tube doesn't have to be vertical, either side may be longer or shorter, depending on slope.

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Smarter use of rare earths

David Kramer's report about China's rare-earths dominance (PHYSICS TODAY, May 2010, page 22) caught my interest. Our collective US ignorance about the rare earths and magnets is causing us to overlook one important area as we try to find a national strategy for securing rare earths and any raw material that is not being produced domestically.

For the past 25 years or so, the rare-earth element dysprosium has been added to neodymium iron boron magnets to increase their resistance to demagnetization. Historically, the improvement came at a relatively low cost, so most designs used a bit of extra dysprosium as a safety factor. The resultant overuse of dysprosium has forced up its price to the point where it may be harder to acquire than neodymium.

Trying to find new materials is all well and good, but we should devote a comparable amount of energy to being smarter with what we already have. For example, NdFeB magnets in hard disk drives over the past couple of decades have decreased in size with each succeeding generation. Although a small part of the change is that magnet properties have gradually improved, the primary reason for the reduction is that engineers have learned how to do more with less material. The same effect will occur with hybrid vehicles and wind turbines; it is inevitable.

If we were smarter about our use of magnets—in materials selection, design, and recycling—we would be in a much better position on rare earths than we are today.

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A brief lesson in viscosity

I welcomed the article "What Black Holes Teach About Strongly Coupled Particles," by Clifford Johnson and Peter Steinberg (PHYSICS TODAY, May 2010, page 29), as I hoped to learn something about black holes and particle interactions.

But I was shocked when reading about viscosity in the first paragraph. I presumed that viscosity relates to forces between adjacent particles and that weak interactions would thus correspond to low viscosities. Imagine my surprise at reading that "low shear viscosities indicate significant interaction strength." I would appreciate being corrected if I hold a misconception about the relation between interaction strength and viscosity.

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Johnson and Steinberg reply: In particle physics, viscosity is rarely discussed at the microscopic level, and many in the field are similarly surprised by the counterintuitive relationship between shear viscosity and interaction strength. In kinetic theory, shear viscosity typically scales in inverse proportion to the cross section; that is, the larger the cross section, the smaller the shear viscosity. Furthermore, the quantity of direct interest, the ratio of shear viscosity to entropy density, turns out to be proportional to the mean free path of the system constituents. Thus it is the smallest for systems with the strongest interaction. In such systems, disturbances—imagine putting an oar in water—are propagated nearly perfectly without dissipation. As the interactions between constituents become weaker, dissipative effects become more dominant, damping out local disturbances. As a system with noninteracting particles, an ideal gas has essentially an infinite viscosity, since there are no interactions to propagate disturbances.

We emphasize the ratio of shear viscosity to entropy density, which typically scales with the density of particles in the system, since the absolute scale of shear viscosity itself does not lead to meaningful comparisons between different materials. The absolute shear viscosity of the quark–gluon plasma is estimated at 5×10^{11} Pa · s, while pitch has a shear viscosity of 2.3×10^{8} Pa · s (both numbers are from http://en.wikipedia.org/wiki/Viscosity). The difference in how the two systems flow is not just about the interaction strength but about the densities and temperatures involved.

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Correction

August 2010, page 69—In the second column, the formula for capacitance should be $C = Q/V$. ■