Order-of-Magnitude Physics – Problem Set 13

Problem 1. The Tuning Fork

A standard tuning fork consists of two tines each 8 cm long, 4 mm in diameter, and separated by 1.25 cm. It emits a nearly pure sine wave at 440 Hz.[1]

A tuning fork is struck hard, then allowed to radiate sound while suspended in free space (that is, it is not coupled to any sounding board). Does the kinetic energy in the tuning fork decay principally due to (a) acoustic radiation, (b) aerodynamic friction, or (c) inelasticity in the metal? Supply OOM arguments.

Problem 2. For Whom the Bell Tolls

Leslie observed that a bell sounds softer when immersed in air mixed with hydrogen.[2]

Estimate the factor by which the bell's acoustic power is reduced when immersed in hydrogen at STP versus air at STP (all other factors remaining the same).

Problem 3. The Burning Glass of the Siege of Syracuse, or "Keck Death Ray"

The Roman Fleet lay siege to the Greek port city of Syracuse in 214 BC. Legend has it that Archimedes devised a mirror that focused the Sun's rays to set fire to the Roman ships, "turning them to ashes at the distance of a bow-shot". Most people discount this story as myth, though it is probably fair to say that there is no definitive answer either way.

(a) We know from Diocles's treatise "Burning Mirrors" that Greeks in the late second century BC understood that parallel rays are focused to a point by a parabolic mirror. Suppose Archimedes wanted to use a single parabolic mirror. Estimate the diameter of the required mirror.

(b) Suppose Archimedes wanted to use instead the burnished, *flat*, bronze shields of Greek soldiers. Estimate the required number of shields.

Problem 4. Cavendish's Torsional Balance

See the description of Cavendish's celebrated experimental measurement of the force of gravity at en.wikipedia.org/wiki/Cavendish_experiment.

What the wiki page does not tell you is the radius of the wire used in Cavendish's

[1] The standard frequency for the note A was set at 440 Hz in 1953. In Mozart's day, the standard A was higher, more like 444 Hz.

[2] This experiment was explained by Stokes, and cited in great detail in Rayleigh's book, "Theory of Sound."

torsional balance. Deduce this radius using order-of-magnitude physics and the experimental parameters provided on this wiki page. Provide both a symbolic answer and a numerical estimate.

Hint: Begin by understanding the torsional stresses on the wire. The top cross-sectional face of the wire is cemented to the top of the apparatus, while the bottom face is free to rotate. Draw a line from the top of the wire to the bottom, parallel to the long axis of the wire. In the absence of a torque, this line is straight. In the presence of a torque, this line is bent.

Problem 5. Ask Your Own Question

Ask an OOM question of your own. You don't have to answer it.