Physics Challenge for Teachers and Students

Solution to the February, 2017 Challenge**, Think inside the box!**

The heating of the left compartment increases its pressure until the volume expands to equilibrate to the pressure of the right compartment. Since the amount of gas is the same in both compartments, we can relate the final volume and pressure on both sides by using the ideal gas law: $PV = NkT$.

$$P_L = P_R \rightarrow \frac{T_L}{V_L} = \frac{T_R}{V_R}$$

Since the final temperature in the left compartment is twice that of the right compartment,

$$\frac{2T}{V_L} = \frac{T}{V_R} \rightarrow V_L = 2V_R$$

If the cross-sectional area of the container is A, then

$$A(\frac{L}{2} + l) = 2A(\frac{L}{2} - l) \rightarrow 3l = \frac{L}{2} \rightarrow l = \frac{L}{6}$$

where ℓ is the distance of movement of the insulating barrier due to the heating of the left compartment with respect to the center of the container. The two compartments have their length ratios equal to $2\,L/3 : L/3$.

As the left and right compartments change volumes, the center of mass of both compartments of gas shift to the right. Since there are no external, horizontal forces acting on the whole system, the location of the center of mass is conserved and the whole system moves left by a distance, x. The original center of mass was located at $L/2$.

$$\frac{L}{2} = \frac{M(\frac{L}{2} + x) + \frac{m}{2}(\frac{L}{6} + x) + \frac{m}{2}(\frac{L}{3} + \frac{L}{3} + x)}{M + m}$$

or

$$ML + mL = ML + 2Mx + m\frac{L}{6} + mx + m\frac{2L}{3} + mx$$

Solving for m,

$$2Mx = mL(1 - \frac{1}{6} - \frac{2}{3}) - 2mx = (\frac{1}{6}L - 2x)m$$

or

$$m = (\frac{12x}{L - 12x})M$$

(Submitted by Francisco Pham, Newman Smith HS, Carrollton, TX)

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Guidelines for contributors

- We ask that all solutions, preferably in Word format, be submitted to the dedicated email address *challenges@aapt.org*. Each message will receive an automatic acknowledgment.
- If your name is—for instance—Sean Spicer, please name the file "*Spicer17May*" (do not include your first initial) when submitting the May 2017 solution.
- The subject line of each message should be the same as the name of the solution file.
- The deadline for submitting the solutions is the last day of the corresponding month.
- Each month, a representative selection of the successful solvers' names will be published in print and on the web.
- If you have a message for the Column Editor, you may contact him at *korsunbo@post.harvard.edu*; however, please do not send your solutions to this address.

Many thanks to all contributors; we hope to hear from many more of you in the future.

As always, reader-contributed Challenges are very welcome.

--Boris Korsunsky, column editor