

2023

Exploding Haystacks: Solutions for Fermi Questions, March 2023

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Original Publication Citation

Adam, J. (2023). Exploding haystacks: Solutions for Fermi questions, March 2023. *The Physics Teacher*, 61(3), A236. <https://doi.org/10.1119/5.0141361>

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Solutions for Fermi Questions, March 2023

Exploding Haystacks



► Solution to Question 1:

- (a) Suppose $D_1(R) = \text{“heat lost – heat produced.”}$ Clearly, $D_1 = 2\pi R^2(a - bR/3)$, so D_1 is zero when $R = 3a/b$.
- (b) Elementary calculus shows that D_1 is a maximum when $R = 2a/b$.
- (c) $R = 10$ m and 7 m, respectively.

► Solution to Question 2:

For equal volumes, the cube side $L = (2\pi/3)^{1/3}R \approx 1.28R$. Correspondingly, for a cube of this size,

- (a) $D_1(L) = 5L^2(a - bL/5)$, so D_1 is zero when $L = 5a/b$, or $R \approx 3.9a/b$.
- (b) D_1 is a maximum when $L = 10a/3b$, or $R \approx 2.6a/b$.

Therefore, the cube is the safer shape for the farmer to use. This is basically because, in the same units, the surface area-to-volume ratio for the cube is $5/L \approx 3.9/R$, which exceeds the same ratio for the hemisphere, namely $3/R$. (Again, it is assumed there is no heat lost through the base.)