Old Dominion University

ODU Digital Commons

2023

Exploding Haystacks

John Adam
Old Dominion University, jadam@odu.edu

Fermi Questions

***John Adam,* Column Editor**
Old Dominion University, Norfolk, VA 23529;
jadam@odu.edu

Exploding haystacks

The picture above shows a cylindrical hay bale. Often, they will be snugly covered by black or white plastic, but as a boy in England, growing up on a farm, I saw haystacks in fields shaped like cylindrical houses with conical roofs. Elsewhere, they just consisted of bales of hay stacked in rectangular formations. No matter what the shape, if they are too large, they can self-ignite (and you thought spontaneous combustion was just an urban legend!). Note the following:

> "Every farmer has heard stories of someone affected by a hay fire. It certainly isn't a minor incident since it can damage property and threaten lives. While hay fires can occur during transportation, they are more likely to be caused by spontaneous combustion once the bales are at the farm …
> When the internal temperature of hay rises above 130 degrees Fahrenheit (55 °C) it provokes a chemical reaction producing flammable gases that can ignite."
> https://www.aimscentral.com/keeping-hay-fires-from-spontaneous-combustion

◗ Question 1:

An inexperienced farmer decided to save time and effort by storing his hay in one very large hemispherical hay-stack of radius R m instead of several smaller ones. Given the following information: (i) hay produces heat at a rate of b (J/h)/m³; (ii) the heat escapes at a rate of a (J/h)/m²; and (iii) there is no heat loss through the base,

   (a)   What is the maximum radius at which the haystack will become "pyrotechnically unstable" (i.e., heat produced exceeds heat lost)?

   (b)   What is the ***maximum safe radius*** of the haystack (i.e., the difference between heat lost and heat produced is a maximum)?

   (c)   Suppose $a = 100$ and $b = 30$ in the units stated above. What are the numerical values for the radii in parts (a) and (b)?

◗ Question 2:

Compare the answers to Question 1 with the corresponding answers for a cubical haystack of the same volume. Which shape of haystack is safer for the same volume?

> **Fermi Questions** *are brief questions with answers and back-of-the-envelope estimation techniques. To submit ideas, please email John Adam (jadam@odu.edu).*