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Fermi Questions, Question 1: Air Pressure on Waves; Question 2: Weight of Toner

Larry Weinstein

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- ***Intermediate Level –*** Provide the students with an Excel file containing a thundercloud model and have them vary the parameters (size, total charge, distance above Earth) to answer fundamental questions. As an example, they might try to design a "safe thundercloud," i.e., one that produces almost no surface charge density anywhere on Earth (which would minimize lightning strikes). This type of "cloud engineering" provides a natural bridge to studies in atmospheric science where clouds are classified by their properties.
- ***Advanced Level –*** If the students have some proficiency in writing code as well as a solid grasp on the derivation above, they could model more complex cloud shapes, examine edge effects near to a cloud, or even simulate a small group of thunderclouds and create the corresponding electric potential/surface charge density maps. This would definitely challenge their understanding of the physics as well as the details of numerical simulation in general.

Conclusion

We produced realistic electric potential and surface charge density maps near a hypothetical thundercloud with minimal resources and with relatively simple physics. With very basic geometry and knowledge of introductory electrostatics, it is possible to build models that yield good approximations of the electric potential surrounding thunderclouds and the effect that the charged cloud has on Earth underneath. This modeling process could be leveraged in the classroom to create activities that highlight electrostatic physics as well as our ability to numerically simulate it. In this way, students with varying levels of familiarity with the subject matter can be engaged and encouraged in their learning.

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Matthew Neel *is a physicist, researcher, and data scientist with special interests in plasma physics and quantum optics. He earned a BA in physics from Whitman College, an MS in physics from Oregon State University, and a Professional Certificate in Data Science from the University of Washington. He currently works for the Bonneville Power Administration in Seattle, WA. Contact him by email at* **msn2700@gmail.com**, *or visit his professional profile at* **www.linkedin.com/in/mattneel.**

Fermi Questions

Larry Weinstein, **Column Editor**
Old Dominion University, Norfolk, VA 23529;
weinstein@odu.edu

Question 1: Air pressure on waves

When the wind is blowing, what is the difference between the air pressure at the crest and at the trough of an ocean wave due to the Bernoulli effect?

Question 2: Weight of toner

How much heavier is a 100-page printed document than 100 blank pages? (*Thanks to Emily Kandel of Scarsdale, NY, for suggesting the question.*)

Find answers at *TPT Online;* tpt.aapt.org.

Question suggestions are always welcome!

For more Fermi questions and answers, see *Guesstimation 2.0: Solving Today's Problems on the Back of a Napkin,* by Lawrence Weinstein (Princeton University Press, 2012).

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