Physics Invention Sequences Users' Guide: Pressure

PRESSURE INVENTION SEQUENCE

Includes: *hail intensity index* (particle pressure)

Teacher Notes: When teaching kinetic theory we assume students understand what is meant by particle density, and ask them to combine it with the momentum transfer per collision and create a quantity that is independent of both time and area. That is a lot to keep track of, and most students don't. We attempt here to break the thinking down into parts. This is still quite challenging; most students need considerable scaffolding.

Levels: This sequence is appropriate for college level that teaches kinetic theory.

Hail Intensity Index

You're on a team of scientists studying the effects of severe weather on food crops. In order to provide a useful early warning system to farmers, your team is devising an index that characterizes how intense a hailstorm will be.

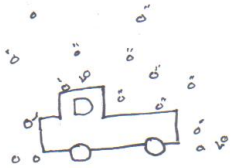
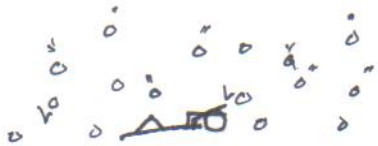
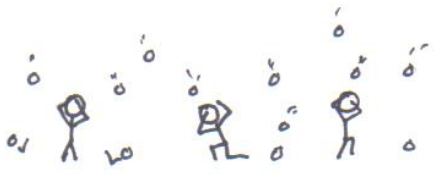
Some storms are severe enough to destroy entire crop beds (see computers):
http://www.youtube.com/watch?v=OFv2W7Duqiw

Storms summarized in the same row of the data table had the same intensity. Different rows represent storms that had different (and increasing) intensities. Note that the measurements were made using detectors with specified surface area.

There are two factors that contribute to the hail intensity:

- how frequently the crops were hit by hail and
- how much impulse each hailstone exerted on the plant (assume the plant stopped the hailstone)

Can you quantify those two factors then use them to create a *hail intensity index* that is the same for both storms in each row?

	Iowa	**New Mexico**	HAIL INTENSITY INDEX
Row 1	 #hailstones = 1200 mass of hailstones = 0.5 kg collection time = 1 s speed of hailstones = 0.2 m/s detector size = 2 m^2	 #hailstones = 2250 mass of hailstones = 0.2 kg collection time = 2 s speed of hailstones = 0.4 m/s detector size = 1.5 m^2	
Row 2	**Nebraska**	**Oklahoma**	
	 #hailstones = 2500 mass of hailstones = 0.7 kg collection time = 5 s speed of hailstones = 0.3 m/s detector size = 1.4 m^2	 #hailstones =750 mass of hailstones =0.4 kg collection time = 1 s speed of hailstones = .5 m/s detector size = 2 m^2	
Row 3	**South Dakota**	**Texas**	
	 #hailstones = 410 mass of hailstones = 0.6 kg collection time = 1 s speed of hailstones = 0.4 m/s detector size = 1.2 m^2	 #hailstones = 1845 mass of hailstones = 0.5 kg collection time = 5 s speed of hailstones = 0.8 m/s detector size = 1.8 m^2	

Follow up questions

1. Which quantities contribute to determining how frequently the crops are hit by hail?

2. Which quantities contribute to determining how much impulse each hailstone exerts on the plant?

3. The number of hailstones that hit each m^2 in each second can be called the hailstone **flux**. Determine the hailstone flux for each of the storms in row 1.

4. How would Texas' data have to be different if Texas and New Mexico were to have the same flux?

5. How would Iowa's data have to be different if Iowa and Oklahoma hailstones were to exert the same impulse?

6. Which is more important in determining hail intensity, the impulse or the flux? Explain your reasoning.

7. The New Mexico team realized that they had accidentally written down the wrong time interval for the data. They now report that the data was collected over an interval of 1 s, not 2 s. How does New Mexico's new Hail Intensity Index compare to its old one?

8. Of the microscopic quantities we've studied, which one do you think is most closely related to the hail intensity index- temperature or pressure?