Physics Invention Sequences Users' Guide: Density

DENSITY INVENTION SEQUENCE

Includes: *crowded clowns (clown density), crowded particles (particle density, crowded mass (mass density)*

Teacher Notes: Students unfamiliar with molar mass (PS level) should stop after crowded particles, and should not include the questions that use n as a value.

Levels: This sequence is appropriate for all levels, from middle school physical science (crowded clowns and crowded particles) through calculus-based physics (all three).

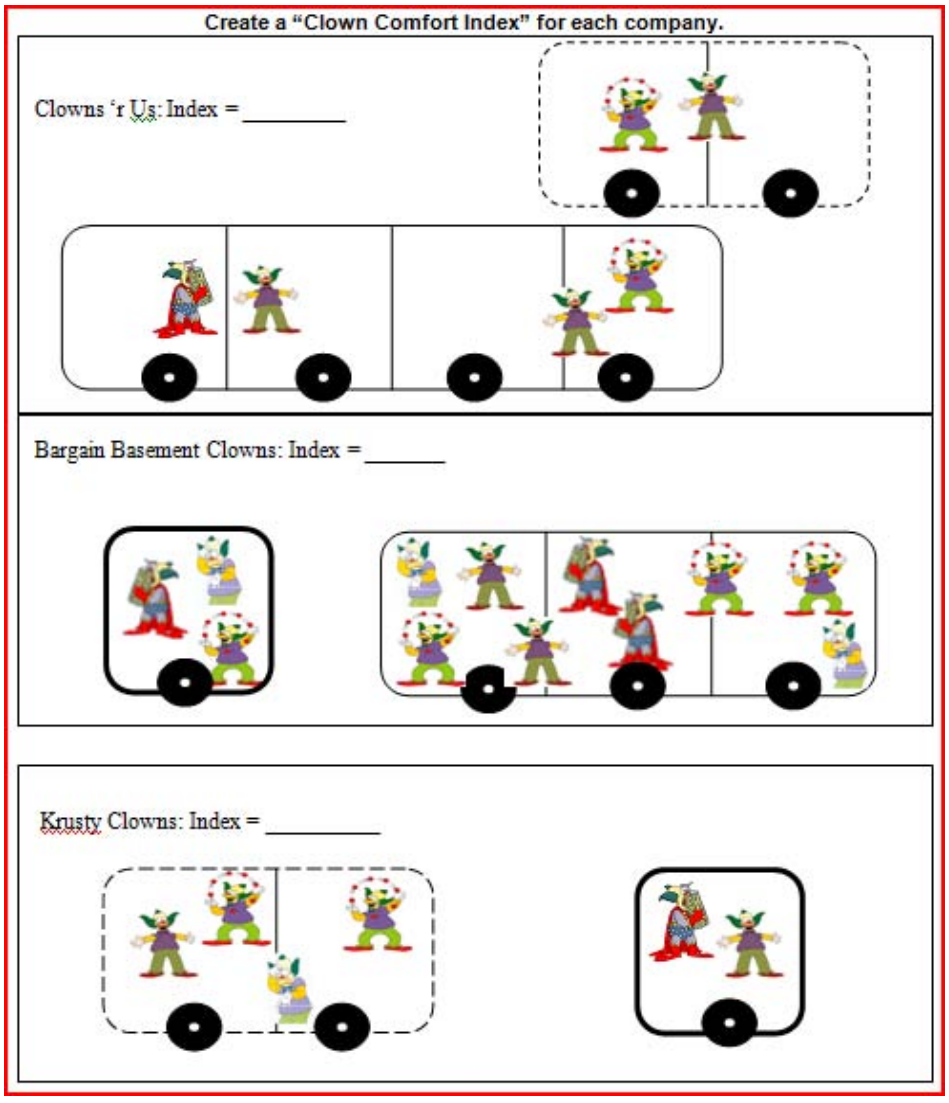
Crowded Clown Index

Companies send clowns to parties, circuses, amusement parks, sporting events and so on. To get the clowns to an event, each company packs the clowns into a bus. Some companies make the clowns more crowded than other companies. The more crowded the clowns are, the grumpier they will be.

People who order clowns want to know a company's crowded clown index. Invent a procedure for computing a crowded clown index for each company.

Rules for the Index

1. The same company always crowds the same amount, no matter how many clowns get ordered. So a company only gets a single crowded clown index.
2. You have to use the exact same procedure for each company to find its index.
3. A big index value should mean that the clowns are **more crowded**. A small index number should mean that the clowns are less crowded.



Follow Up Questions

1. You'd like 12 clowns at your party. How many compartments will each company need to send?

2. Krusty Clown sends a full bus that has 5 compartments. How many clowns show up?

3. Another clown company has an index of 2.5.

   a) What does the number 2.5 mean?

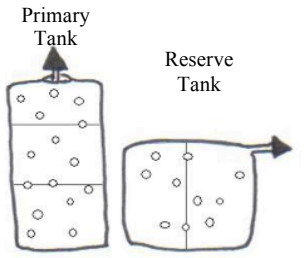
   b) Does it make sense? Sketch their bus to explain.

Crowded Particle Index

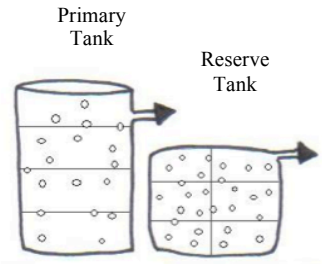
The clowns are arguing now. Their companies send them with helium tanks for blowing up balloons, but they disagree about who has the proper amount of helium in their tanks. It's important that the gas particles are not too crowded, because the tank can explode, but also that the particles aren't too sparse, or else they won't make it through the valve into the balloons. To make matters more complicated, the clown companies all send primary and reserve tanks of different sizes. Some are wide, short and fat, others are tall, wide and narrow etc.

In the drawings below, each dot represents a mole of particles. The lines on the diagrams indicate portions of the tank with a given volume, and all portions have the same volume (despite how they might look in this cross-sectional view).

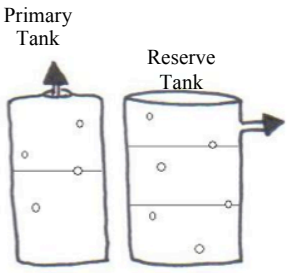
Can you come up with a *crowded-particle index* that characterizes how crowded the gas particles are in the tanks? The primary and reserve tanks for each clown company both have the same crowded-particle index. A bigger index means the particles are more crowded.



Clowns 'R Us



Bargain Basement Clowns



Krusty Klowns

crowded-particle index			

Follow up questions

1. Bargain Basement Clowns has a third tank in their truck that contains two portions of volume. How many moles of gas are in it?

2. Geeky Clowns is a new company entering the market. It uses helium that has a crowded-particle index of *n*.

a) What does *n* mean?

b) How many moles of helium are contained in a 4-portion tank used by Geeky Clowns?

c) They are planning a party that will require 8 moles of gas. How big will their tank have to be to hold the gas?

Crowded Mass Index

There's an international helium shortage, and some clown companies have had to make do with other elements to fill their balloons. Different elements have different masses, of course. Can you come up with a *crowded-mass index* that describes the "mass crowdedness" of the tanks for each clown company? The crowded-particle index for each clown company didn't change, just the type of gas.

- Clowns 'R Us replaced the helium with hydrogen (molar mass ~1g/mole)
- Bargain Basement Clowns actually used helium. (molar mass~4 g/mol)
- Krusty Klowns used neon (molar mass ~20g/mol)

	Clowns 'R Us	**Bargain Basement Clowns**	**Krusty Klowns**
crowded-mass index			

Follow up questions

1. Which tank has the largest crowded-mass index? How is this quantity different from mass of the gas contained in an individual tank?

2. Krusty Clowns buys a tank that has 10 portions. How many moles of neon will it hold? What mass of neon will it hold?

3. Another company, Tiny Clowns, uses a gas that has a crowded-mass index of 2.5.

   a) What does the number 2.5 mean?

   b) Being tiny, they are concerned about being able to lift their helium tank. What is the mass of the helium that is contained in a 12-portion tank used by Tiny Clowns?