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7<sup>th</sup> Grade: 2, 42 min periods

### The Ideal Gas Game

#### Goals:

- Students see how increasing temperature in a gas increases the pressure
- Students see how the number of particles in a gas increases the pressure
- Students view temperature as a measure of particle kinetic energy and speed
- Introduction to the ideal gas law that governs the thermodynamics of ideal gases
- Particles in a gas have an average speed reflected by the temperature and move in a random direction
- Using an average to translate a system of varying speeds to an equivalent one where every particle moves at the average speed

#### Objectives:

- Quantify gaseous dynamics as function of temperature, pressure, and particulate abundance by counting collisions while varying particle speed and number.
- Think about ways to generate a random number between [1,8] and [1,6]
- Calculate the probability that at any time a particle is moving in a given direction (2 dimensional grid)

#### Materials:

- Handout
- Pencil
- Graphing Calculator with "Probability simulator"
- "Ideal Gas Game" Mat

#### Prior Knowledge:

- Gas is matter
- The particles in a gas move freely and want to be spread apart

#### NJCCCS:

## Procedure:

1. Rules for the game:
  - a. Begin with 9 students spaced 3 squares apart from each other and from all boundaries.
  - b. Randomly assign an initial direction of motion using the probability simulator. Have the players record their initial direction on the game sheet.
  - c. Begin the game with turn 1.
  - d. Players move one square in their indicated direction.
  - e. Call for the next turn after 5 seconds.
  - f. Player takes another step in their current direction. If the player “collides” with a wall or another player, the player’s direction reverses. If there is a collision, the players mark a tally on their game sheet.
  - g. Repeat Steps (e, f) until 1 minute has passed.
  - h. Count the total number of collisions from all of the players.
2. Variations on the game:
  - a. Number of players:
    - i. Try the game with 6 players spaced 3 or 4 squares apart
    - ii. Try the game with 16 players spaced 2 squares apart
  - b. Speed of the particles (temperature):
    - i. Call for subsequent turns every 7 seconds
    - ii. Call for subsequent turns every 3 seconds
3. Discussion:
  - a. How did the number of particles affect how many collisions there were in the container? *More particles result in more collisions.*
  - b. How did the average speed of the particles affect the number of collisions? *More speed (more turns) result in more collisions*
  - c. In real life, not all particles move at the same speed. However, in our game, all of the particles moved at the same speed. Why is it okay to use the “average speed” as an estimate for the speed of all of the particles? *All of the particles moving at different speeds is equivalent to considering all of the particles moving at the same speed where the speed is the average of all of the different speeds.*
  - d. What would we have to change if our game board were made out of hexagons (6-sided polygons) instead of squares? *Probability changes from 1/8 to 1/6.*
  - e. What is the mathematics vocabulary word that describes when shapes can fully cover an area without any gaps and or any overlapping? *Tessellate (v.) /Tessellation (n.)*
4. The Ideal Gas Law: ( $pV=NkT$ )
  - a. The Ideal Gas Law is given by the following formula  
(pressure)\*(volume)=(number of particles)\*(constant)\*(temperature)
  - b. Using our data can we figure out what our constant (k) is?

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## The Ideal Gas Game

1. How did the number of particles affect how many collisions there were in the container?
2. How did the average speed of the particles affect the number of collisions?
3. In real life, not all particles move at the same speed. However, in our game, all of the particles moved at the same speed. Why is it okay to use the “average speed” as an estimate for the speed of all of the particles?
4. How would the rules of the game change if our game board were made out of hexagons (6-sided polygons) instead of squares?
5. What is the mathematics vocabulary word that describes when shapes can fully cover an area without any gaps and or any overlapping?