New Mexico High School
Supercomputing Challenge
Final Report

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Executive summary of the project

The air is filled with many gases, each with different properties. If we were to fill a regulation basketball with other types of gases, how would this effect the ball's bounce and weight, and what differences would occur during normal game play?

We attempted to simulate the changes influenced by variables, such as , different types of gases and temperature. What we found out so far is that if the same amount(in mass) of gas is put into the ball, the number of molecules will differ depending on the molar mass of the element. Which means that the gas with the lowest molar mass will have the highest pressure in a given volume. The higher the pressure is, the higher the ball will bounce. We worked on our program which will give us an estimation of how much pressure the ball will have.

This is the formula that we are using.

$$pV=nRT$$

p is the pressure
V is the volume
n is the number of moles,
R=0.0821 L atm mol-1 K-1 (that is, R is the gas constant)
T is the temperature in K (273 + temperature in Celsius).

The pressure we found by the program are :
He – 1.16332 atm
Ne – 0.230762 atm
Ar – 0.116571 atm
Kr – 0.0555 atm (atm stands for atmosphere. 1atm is the standard pressure)
Xe – 0.0355 atm
Rn – 0.02098 atm
N – 0.332461 atm
O – 0.291 atm

H – 4.62029 atm

Although we couldn’t relate the pressure inside the ball directly to the height the ball will bounce, we got the idea of which type of gas would make the ball bounce the highest. The gas that has the lowest molar mass will cause the ball to bounce the highest. What we would need to do in the future is to relate the pressure to the height the ball would bounce, try to verify the environmental conditions, and experiment with different types of balls.

Statement of the Problem

The air is filled with many gases, each with different properties. If we were to fill a regulation basketball with other types of gases, how would this effect the ball's bounce and weight, and what differences would occur during normal game play?

We attempted to simulate the changes influenced by variables, such as the height the ball is dropped from, how much pressure is used, and more, to try to find out if any gas has better attributes than what is normally used in basketballs today. Basically to make it more fun.

Description of the method

Gas pressure is the force of gas molecules striking the surface of a container. Four quantities describe gases : pressure, volume temperature, and quantity of a gas(moles). The first thing we had to decide was which variable we were going to set as a constant number. The constants in our project are the mass of gas put into the ball and the volume inside the ball. Then we had to get a relationship between the different types of gases to the pressure.

If the mass of the gas we use are always going to stay the same, the more the molar mass is, the less moles of gas that will be put into the ball. Also altering the temperature would make the gas expand, making the pressure inside go up. Pressure is directly proportional to the temperature and volume.

The formula for finding the pressure is $P = RnT/V$, This is the ideal gas law where P stands for pressure V is the volume, n is the number of moles, R=0.0821 L-atm/mole-K (that is, R is the gas constant), and T is the temperature in K.

We made a program that will calculate the pressure inside the ball. We used Helium, Neon, Argon, Krypton, Xenon, Nitrogen, Oxygen, Hydrogen, and Radon as variables for the program.

```
/* Basketball Physics
 * Project #34
```

```
 * Made By: Byung-Hwan Chu
 * Mentor: Greg Coffman
 */

/*************************************/
//Libraries///////////////////////////
/*************************************/

#include <iostream.h>   // input/output

/*************************************/
//Function Prototypes/////////////////
/*************************************/

int equ();                    // Equations
int ans();                    // Repeat Program
int quit();                   // Quit Program

/*************************************/
//Global Variables///////////////////
/*************************************/

int choice=0;           // dummy variable for
                              // choice selection
float
          bounce,       // bounce variable
          n=0,          // number of moles
          P=0,          // pressure
          V=11.494,     // volume in liters
          mass=2.21,    // mass of gas put into ball in grams
          R=0.0821,     // constant
          t=295;        // temperature

double  He=4.003,       // Element variables
            Ne=20.180,
            Ar=39.948,
            Kr=83.80,
            Xe=131.29,
            N=14.007,
            O=15.999,
            H=1.0079,
            Rn=222;

char exans;

/*************************************/
//Main Program///////////////////////
/*************************************/

int main()
{

      cout << "This is a program that will give you the pressure inside the ball
"
      << "when it is filled with different gases." << endl;
      cout << "1(He)  2(Ne)  3(Ar)  4(Kr)  5(Xe)\n"
           << "6(N)  7(O), 8(H) or 9(Rn)\n" << "Gas Number: ";
```

```
	cin >> choice;

	equ(); // Calls Equation Function

	cout << "The pressure is: " << P << " atm"<<endl;

	ans();

return 0;
}

/***************************************/
//Equation Function///////////////////
/***************************************/
// This function calculates the pressure
// using the different elements.

int equ()
{
	if (choice == 1)
		{
		n=mass/He;
		P = (R*n*t)/V;

		}
	else if (choice == 2)
		{
		n=mass/Ne;
		P = (R*n*t)/V;
		}
	else if (choice == 3)
		{
		n=mass/Ar;
		P = (R*n*t)/V;
		}
	else if (choice == 4)
		{
		n=mass/Kr;
		P = (R*n*t)/V;
		}
	else if (choice == 5)
		{
		n=mass/Xe;
		P = (R*n*t)/V;
		}
	else if (choice == 6)
		{
		n=mass/N;
		P = (R*n*t)/V;
		}
	else if (choice == 7)
		{
		n=mass/O;
		P = (R*n*t)/V;
		}
	else if (choice == 8)
		{
```

```
		n=mass/H;
		P = (R*n*t)/V;
		}
	else if (choice == 9)
		{
		n=mass/Rn;
		P = (R*n*t)/V;
		}
	else
		main();

}

/************************************/
//Repeat Function////////////////////
/************************************/
// This function asks the user if they
// want to run the program again.

int ans()
{
	cout << "Would you like to test another variable?(y/n): ";
	cin >> exans;
	if(exans=='y' || exans=='Y')
		main();
	if(exans=='n' || exans=='N')
		quit();
	else
		ans();
return 0;
}

/************************************/
//Quit Function//////////////////////
/************************************/

int quit()
{
	cout << "Exiting Program........";
return 0;
}

/************************************/
//Equations/////////////////////////
/************************************/

//P = (R*n*t)/V;
```

Results of our Study

As the formula P=RnT/V shows, the molar mass and the temperature are the key factors to the height the ball will bounce. Altering these values will have a direct effect on our experiment. The increase of the molar mass would decrease the number of moles that would be in a certain mass. The increase in temperature would cause the gas inside the ball to expand, therefore increasing the pressure inside the ball that has a specific volume.

The pressure we found are :
He – 1.16332 atm
Ne – 0.230762 atm
Ar – 0.116571 atm
Kr – 0.0555 atm
Xe – 0.0355 atm
Rn – 0.02098 atm
N – 0.332461 atm
O – 0.291 atm
H – 1.57 atm

Conclusion

Although we couldn't relate the pressure inside the ball directly to the height the ball will bounce, we got the idea of which type of gas would make the ball bounce the highest. The gas that has the lowest molar mass will cause the ball to bounce the highest. What we would need to do in the future is to relate the pressure to the height the ball would bounce, try to verify the environmental conditions, and experiment with different types of balls.

Significant Original Achievement

We found out that the increase of the molar mass would decrease the number of moles that would be in a certain mass. The increase in temperature would cause the gas inside the ball to expand, therefore increasing the pressure inside the ball that has a specific volume.

Mentors

Captain Mario Serna has been helping us out on the basic concepts of this project.
Greg Coffman helped us out with the programming.