F5a: Pressure & Volume

Introduction:

Boyle's Law describes the relationship between a volume of gas and its pressure when held at constant temperature. The pressure is inversely proportional to the volume. This means as the pressure increases the volume decreases or as the pressure decreases the volume increases. Another way to state this is; the product of the volume and the pressure is a constant. The data collected during this experiment will verify this relationship. A glass cylinder of variable length filled with air is pressurized. A computer monitors the air pressure inside the cylinder and the length of the cylinder during the pressurization.

Apparatus:

- Heat Engine / Gas Law Apparatus
- Rotary Motion Sensor
- Low Pressure Sensor (Differential)
- Computer, Interface & Software
- Laboratory Masses
- Laboratory Stand, Rods & Clamps

Figure 1

Please see the lab instructor for a briefing on the proper setup and usage of the apparatus before beginning.

Procedures:

1. Measure the masses that will be placed on the platform during the experiment. It is the accumulative mass that is needed for each trial not the individual masses.
2. Begin with the air tube clamp open, the piston at the bottom of the cylinder and no masses on the platform.
3. Start the computer data collection.
4. Raise the piston height to approximately 65 millimeters. While holding the piston at that position close the air tube clamp tight.
5. Watch the digital clock on the computer screen, when it reaches 30 seconds gently place the first mass on the platform.
6. Again watch the clock on the screen and when it reaches 40 seconds gently add the second mass to the platform.
7. Continue watching the computer screen clock and adding each additional mass in sequence to the platform at 10 second intervals.
8. Allow 15 seconds after the last mass is added to the platform and then stop the computer data collection.
9. Remove the masses from the platform and release the air tube clamp. The piston should slowly descend to the bottom of the cylinder.
10. Analyze the two computer graphs to obtain the length of the cylinder and the pressure inside the cylinder for each interval of different mass applied to the platform. Be certain to record the applied mass, the gauge pressure inside the cylinder and the length of the cylinder for each interval.

Data Analysis:

The first step in the data analysis is to determine, by calculation, the pressure inside the cylinder due to the masses placed on the platform. Since pressure is force per area, first calculate the cross sectional area of the cylinder (it correspond to the area of a circle). Next, calculate the net gravitational force for each trial due to the total combined mass (applied masses plus effective platform mass). Finally calculate the pressure by dividing the net gravitational force by the cross sectional area.

$$F = m_T * g$$

$A = \pi * r^2$ r = radius of cylinder, π = Pi (3.14159)

$$P_{calculated} = \frac{F}{A}$$

Next, determine the absolute pressure for each interval in units of Pascal. This can be done by using the following equation:

$$P_{absolute} = P_g + P_{atm}$$

P_g = gauge pressure
P_{atm} = 1.013 x 10^5 Pa (atmospheric pressure)

After calculating the total pressure, it is then necessary to determine the volume of the cylinder for each interval in units of meter^3. This can be done by simply making use of the formula for the volume of a cylinder; however, since the cross sectional area of the cylinder has been already calculated, it can be used directly to calculate the volume using the following equation:

$$V = A * l$$

V = volume of cylinder
l = length of cylinder

Once these two values have been calculated it is possible to calculate the constant value that is the product of the absolute pressure and the volume.

$$Constant = P_{absolute} * V$$

Finally, determine the mean and the standard deviation of the constant.

Experiment F5a: Pressure & Volume

Student Name_____

*Lab Partner Name*_____

*Lab Partner Name*_____

Physics Course_____

Physics Professor_____

Experiment Start Date_____

Lab Assistant Name	*Date*	*Time In*	*Time Out*

Experiment Stamped Completed

Data Sheets: F5a: Pressure & Volume

NAME: _____ DATE: _____

Piston diameter_____

Piston cross sectional area_____

Effective Platform mass_____

Applied Mass (Kg)	**Total Combined Mass** (Kg)	**Calculated Pressure** (Pascal)	**Length** (meter)	**Gauge Pressure** (Pascal)

Data Sheets: F5a: Pressure & Volume

NAME: _____ DATE: _____

Absolute Pressure **(Pascal)**	**Calculated Volume** **(meter^3)**	**Pressure * Volume** **(Pa m^3)**

Pressure * Volume: Mean_____

Standard Deviation_____