

Pressure and Volume

Using Boyle's Law to Comply with the BattleBots IQ Technical Rules and Regulations

BBIQ participant will apply fundamental math and science concepts in an effort to design and select High Pressure Storage Tank Systems that comply with the BattleBots IQ Technical Rules and Regulations.

Note: If you are not yet familiar with the BattleBot Rules and Regulations, **Section 8.0 Pneumatics**, then please download the .pdf file from the link in the learning section of this lesson and review the contents of that section.

Example Problem

A 47 cubic inch (ci) fiber wrapped paintball tank is filled with High Pressure Air. The tank pressure stabilizes at 2400 psi after filling. Approximately what volume of air, at standard temperature and pressure, is contained in this tank?

1.) Write out the equation for Boyles Law.

$$\begin{aligned} V_{\text{initial}} \times P_{\text{initial}} &= V_{\text{resultant}} \times P_{\text{resultant}} \\ \text{or} \\ V_1 \times P_1 &= V_2 \times P_2 \end{aligned}$$

2.) List the values you are given and the values you must determine.

$V_{\text{initial}} = 47 \text{ cubic inches}$

$P_{\text{initial}} = 2400 \text{ psi}$

$V_{\text{resultant}} = X$

$P_{\text{initial}} = 14.7 \text{ psi (Standard Atmospheric Pressure)}$

3.) Substitute the known and unknown values in the equation for Boyles Law.

$$\begin{aligned} V_{\text{initial}} \times P_{\text{initial}} &= V_{\text{resultant}} \times P_{\text{resultant}} \\ 47 \text{ ci} \times 2400 \text{ psi} &= X \times 14.7 \text{ psi} \end{aligned}$$

4.) Using basic algebra, solve for the unknown variable.

$$X = \frac{47 \text{ ci} \times 2400 \text{ psi}}{14.7 \text{ psi}}$$

$$X = 7,673 \text{ ci}$$

or

$$X = 4.4 \text{ cubic feet}$$

Name_____

Date_____

The following problems are typical of problems encountered in the design and construction of a BattleBot IQ Robot using pneumatic systems.

Directions: Read the problems carefully, then solve for the correct answer. Show all your work on the front and/or back of this paper.

Many engineering problems require multi-step solutions and parallel thought processes. It is often necessary to “See the path” to the solution. Some techniques that help you to “See the path” more clearly are:

- Re-phrasing the problem in a different way.
- Creating a similar problem.
- Sketching pictures of the problem and doodling.
- Breaking a complex multi step problem into smaller parts.
- Making an attempt to solve as much of the problem as you think you can.
- Risk solving it wrong, in order to think more deeply about the problem
- Guessing about what the answer might be, and then trying to see how close you came to a correct answer.

Problems

- 1.) A BattleBot IQ robot has one HPA storage tank on board. The interior volume of the tank is approximately 114 ci. What volume of air at standard temperature and pressure can this tank hold when filled to the maximum allowable pressure of 2500 psi?
- 2.) What is the minimum volume tank necessary to hold 12 cubic feet of air (at standard temperature and pressure) when filled to the maximum allowable pressure of 2500 psi?
- 3.) Which combination of 47 ci, 45 ci, 68 ci and 88 ci storage tanks could prove to be the BEST possible solution for an IQ BattleBot designer who hopes to make use of the entire 18 cubic feet of air allowed in the BattleBot IQ Technical Rules and Regulations? Justify your answer since there may be more than one combination.
- 4.) A BattleBot IQ Robot is designed to hold the maximum amount of air allowed for a robot with multiple storage tanks. The designer currently owns a paintball tank with an interior volume of 45 ci. How many more tanks of this size would be required in order to hold the maximum allowable volume, and what pressure (*equal for all tanks*) would be required in each tank?