

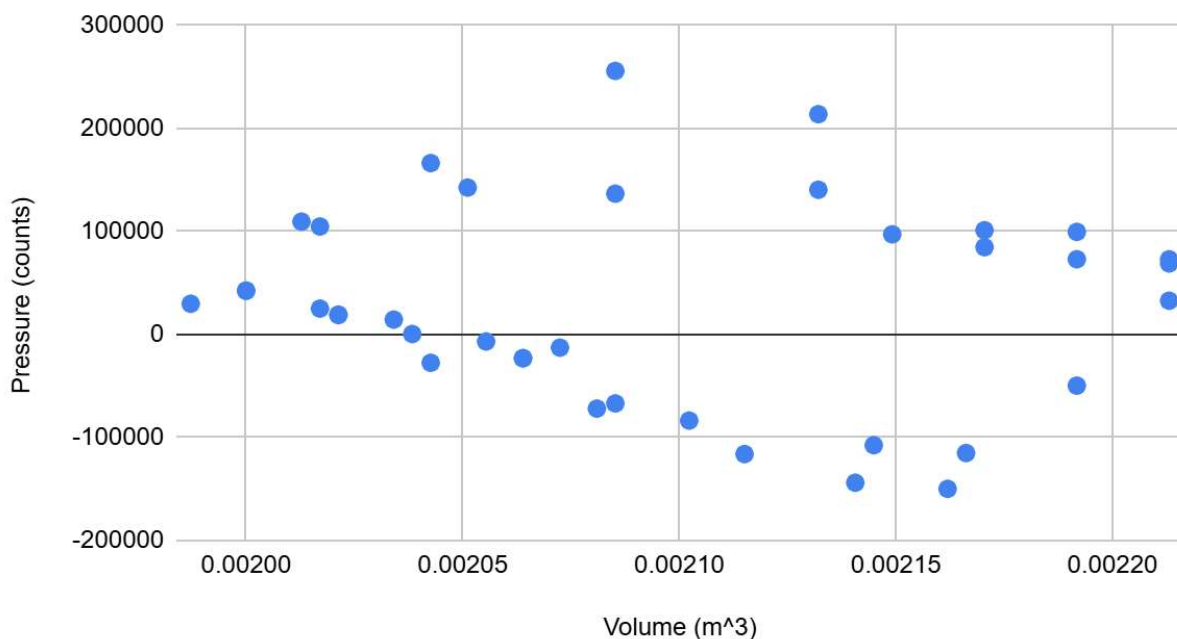
For the PV graph we generated, we collected the pressure and volume data for the piston system within two cycles, see data in the appendix.

For volume, we measured the height of the piston (in cm), added the bottle volume, and recorded its corresponding pressure (in counts) with an approximately 2-second time gap between each data collection point. We compiled a unit conversion for volume so that it is in  $\text{m}^3$  and kept the pressure unit in counts as outputted by the telemetry. In the future when we want to calculate the exact work output, it will be best for us to convert pressure into unit pascal, but since this graph is for observation purposes, we kept the count unit as it is.

The estimated amount of work output based on the weight and distance traveled is  $(0.5\text{kg})(0.05\text{m}) = 0.025\text{J}$ .

PV diagram generated:

### Pressure vs Volume



We do see that the graph we generated forms a closed cycle. Although the geometry is not perfectly aligned with that of the desired rectangle, we still generated relatively straight lines.

The magnitude of work loss is around 50% based on our data. Since this is the raw data without any optimization, some ideas we have to optimize work output are: aligning the tube to be straight so that the maximum amount of air can be exchanged, a good rate to be changing bath is to wait for it to be in complete thermal equilibrium with the surrounding, and find ways to minimize friction in the piston and gears.

## Appendix:

### Raw Telemetry Data:

<https://docs.google.com/spreadsheets/d/1xl7MIRon98mCqTg52ASjFhPwc5nxBvYq2AMr9LSbco0/edit?usp=sharing>

### Link to video:

[https://drive.google.com/file/d/1HEUmdCKdufmqx6-nOSjzEJ1dqJ9abi\\_v/view?usp=sharing](https://drive.google.com/file/d/1HEUmdCKdufmqx6-nOSjzEJ1dqJ9abi_v/view?usp=sharing)

### Data analyzed and calculated from Video and CAD:

Pressure (counts)	Height (cm)	Total Volume (m <sup>3</sup> )
-12797	1.7	0.002072443968
-6782	1.3	0.002055398329
14441	0.8	0.002034091279
25112	0.4	0.00201704564
42657	0	0.002
29808	-0.3	0.00198721577
109533	0.3	0.00201278423
142588	1.2	0.002051136919
255838	2	0.002085228198
140474	3.1	0.002132103707
97204	3.5	0.002149149346
84745	4	0.002170456396
73035	4.5	0.002191763445
72988	5	0.002213070495
-49688	4.5	0.002191763445
-115069	3.9	0.002166194986
-143920	3.3	0.002140626527
-116125	2.7	0.002115058067
-71974	1.9	0.002080966788
-23155	1.5	0.002063921148
432	0.9	0.002038352689
18847	0.5	0.002021307049
42309	0	0.002
104814	0.4	0.00201704564
166376	1	0.002042614099

136675	2	0.002085228198
213838	3.1	0.002132103707
101187	4	0.002170456396
99584	4.5	0.002191763445
68975	5	0.002213070495
32744	5	0.002213070495
-149853	3.8	0.002161933576
-107485	3.4	0.002144887937
-83598	2.4	0.002102273838
-66912	2	0.002085228198
-22869	1.5	0.002063921148
-27463	1	0.002042614099
19282	0.5	0.002021307049