

Date of Lab 1/11/2017

Date of Submission \_\_\_\_\_

Laboratory Report

Title

表題 Thermal Properties of Gas, Heat Engine

Homeroom 11 E	Section 1	Name 氏名 Riyo Hatakeyama.
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Lab Partners  
共同実験者 \_\_\_\_\_

Summary

In this lab, we conducted 6 different tests to investigate the thermal properties of gas and heat engine. The tests used a pulse glass with volatile liquid, piston and a cylinder, a plastic bottle with cap, marble stirling engine, steam engine and a gasoline engine. As a result, we found out that during adiabatic compression, temperature of gas increases whereas during adiabatic expansion, temperature decreases.

- Meet a deadline
- Write logically
- Write clearly
- Write with your own words
- 締切り守って
- 論理的に
- わかりやすく
- 自分のことばで

Teacher Comments

2いねいかつわかり易くまとめている。

1	2	3	4	5	6	7	8	9
Due 提出期限	Summary 要旨	Intro. 序	Method. 方法	Results 結果	Table/Fig. 表/図	Discussion 考察	Clearness わかりやすさ	General 全般
+	+				+	++	++	++++

\* Write your report in Japanese or in English \* Use this form as a cover sheet.  
\* Submit your reports by the seventh day after your lab.

## <Objectives>

1. Understand the properties of gases (Expansion by increasing temperature, adiabatic compression, adiabatic compression)
2. Understand the structure of the engine and how it works
  - a) Marble stirling engine
  - b) Steam engine
  - c) Gasoline engine

## Theory:

- Boyle's Law  $P_1V_1=P_2V_2$

$P_1$ : Initial Pressure

$V_1$ : Initial Volume

$P_2$ : Final Pressure

$V_2$ : Final Volume

- Charles's Law  $V_1/T_1=V_2/T_2$

$V_1$ : Initial Volume

$T_1$ : Initial Temperature

$V_2$ : Final Volume

$T_2$ : Final Temperature

## <Experiment- Simple Experiment on the Properties of Gas>

Materials:

Test ① The pulse glass with a volatile liquid

Test ② Airtight piston and cylinder

Test ③ Plastic bottle with a cap and a pump

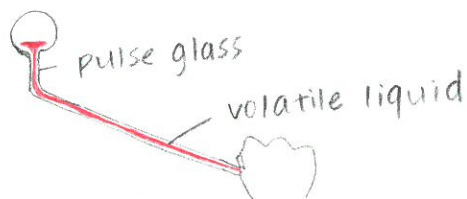
Test ④ Engine a- Marble, test tube, alcohol burner, syringe, piston, cork, wire

Test ⑤ Engine b- Jensen Steam Engine, coal, water

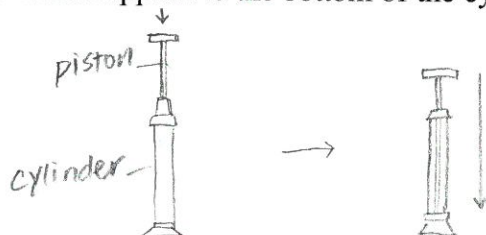
Test ⑥ Engine c- Gasoline engine

### Methods:

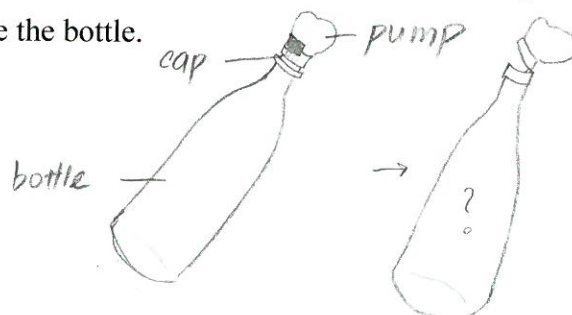
Test ① Hold one of the ends of the pulse glass with your hand and to warm it up and tilt it. See what happens to the red volatile liquid inside the glass.



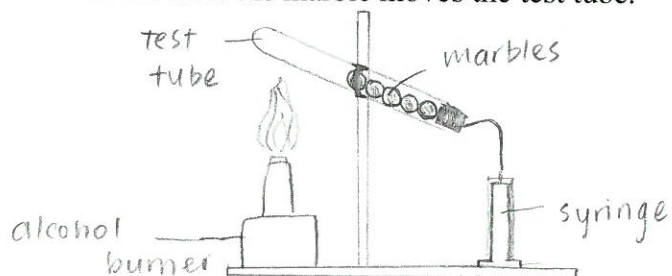
Test ② Push a piston into the cylinder as strong and fast as you can using your palm. Observe what happens to the bottom of the cylinder.



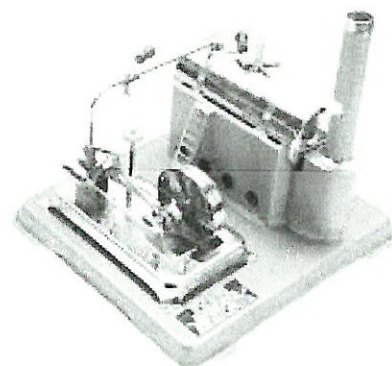
Test ③ Attach a cap with a pump onto a bottle. Then, push the pump approximately 30 times and expand the bottle with air. After that, remove the cap and let the air go out and see what happens inside the bottle.



Test ④ Put 5 marbles in a test tube and then close it with a cork. Attach a syringe with a piston to the cork and light the alcohol burner. Place the other end of the test tube on top of the flame and see how the marble moves the test tube.

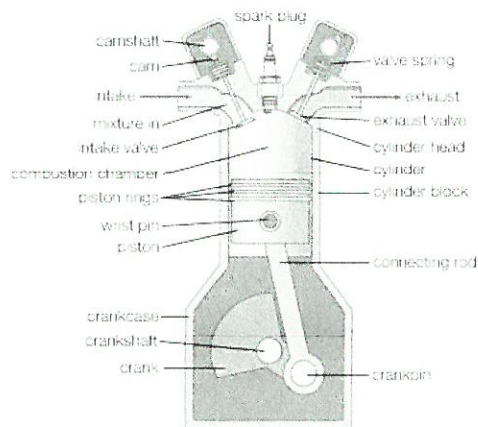


Test ⑤ Prepare a Jensen steam engine. Pour water into the boiler



and light the coal. Wait until the heat warms up the water and see what happens when the steam from the boiling water does to the wheel.

Test ⑥ Prepare a gasoline engine.

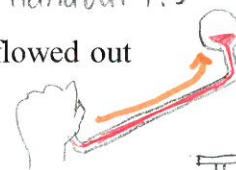


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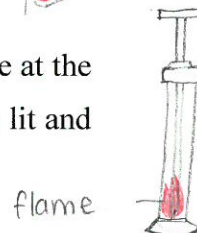
Physics Lab-024 Handout P. 3

<Results>

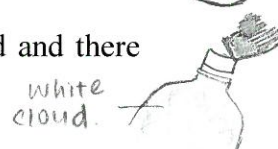
Test ① When the air inside the glass was heated up with my hand, the liquid flowed out of the bulb inside the hand and into the other side connected by a tube.



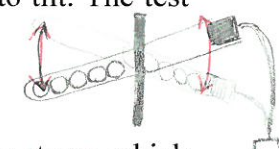
Test ② When the piston was pushed into the cylinder, it created a little bit of smoke at the bottom. As my group continued to push the piston several times, a the bottom of the lit and flame appeared for an instant.



Test ③ When the cap was removed from the bottle, it made a popping sound and there was a cloud formation inside the bottle. After a while, the cloud disappeared.



Test ④ When the air in the test tube was heated up by the alcohol burner, the marble rolled to the bottom of the test tube. Then, when the air was cooled down on the other side, the marble rolled back to the opening of the test tube, making the test tube to tilt. The test tube continued to move like this.



Test ⑤ When the water was heated up by the burning coal, it produced a steam which entered the valve. Because the air inside the valve was heated up, the air expanded, causing

the piston to move. When the piston moved, it pulled the connecting rod and made the flywheel turn quickly. As long as the water continued to produce steam, the flywheel kept turning and turning.

### <Discussion>

#### Test ①

- As the temperature increased with my hand, the vapor pressure in the bulb inside increased (according to Charles's Law,  $V/T = \text{constant}$ ), pushing volatile liquid out of the bulb and making it flow into the other end.

#### Test ②

- When the piston is pushed down very quickly, the air gets compressed (adiabatic compression) and the temperature rose sharply because in the beginning, the volume was larger and temperature was lower.
- When the temperature of the gas increased so fast, there is no time for the heat to flow out, causing a flame to appear.

#### Test ③

- By pumping air into the bottle, it expanded the air, increasing the pressure. This caused the temperature of the gas to increase (adiabatic compression).
- When the air is released out of the bottle, the pressure decreased rapidly causing the temperature of the gas to drop and producing water. (adiabatic expansion) This water created a cloud in the bottle

#### Test ④

- The alcohol burner heated up the air at the bottom of the test tube and because the air expanded, it entered the syringe and made the marbles roll to the bottom of the test tube.
- When the air was cooled down on the other side (where there is no source of heat), it contracted, as the temperature was lower.

- After the air contracted, the marbles rolled to the opening of the test tube. Once the air at the bottom got heated up again, it repeated the whole process again.

#### Test ⑤

- The coal heated up the water, causing it to produce steam. Since the air got expanded, when it entered the valve chest, it pushed the piston.
- When the piston reached the end, the valve shifted. This caused the steam to escape through the exhaust port and pushes back the piston.
- The warm steam entered the other side of the piston and pushed it. Then, the cold air escaped again and pushed back the piston.

#### Test ⑥

- First, the crankshaft pulled the piston towards it, bringing in the air as the left valve opened.
- When the valve closed, the crankshaft moved to push the piston up and compressed the air.
- When the piston reached to the top of the cylinder, it ignites the spark plug and an explosion occurred. The heat from the explosion expands the air and brought the piston back down, moving the crankshaft.
- After the piston moved back down, the exhaust valve (right) opened and pushed the air down.

### <Conclusion>

- When heat is added to a gas, the pressure increases.
- As the volume of the gas decreased and the pressure increased by adiabatic compression, the temperature increased.
- As the volume of the gas increased and the pressure decreased by adiabatic expansion, the temperature decreased.
- Engines effecticely apply the properties of gases including expansion by increasing temperature, adiabatic compression and expansion.



### <Opinion>

In this lab, we did 6 different experiments to understand the properties of gases and how engines work. The experiments were simple, but showed how gas is affected by temperature and pressure. It was interesting to observe how gasoline engines function using these properties because they are something that people use very commonly to drive a car.

A handwritten signature in red ink, appearing to be "John", is located in the lower right quadrant of the page.