PHYS3710 Short experimental projects I

Department of Physics

The Chinese University of Hong Kong, Hong Kong

Topic: Heat Engine & Peltier Device

designed by

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Topics you should know first:

Seebeck effect, Peltier effect & heat engine efficiency.

Objectives:

1. Understand the principle of a heat engine and a heat pump (Peltier cooler).
2. To measure the heat engine efficiency properly.
3. To measure Seebeck coefficients as a function of temperature.

Check-list for the project:

1. Try to understand the structure of the Peltier device.
2. Read references 1 & 2. Work out the required equations for the calculation of heat engine efficiency.
3. Do all five experiments listed in Ref. 2. You can work on Exp. 1 & 2 at the same time. Get more data for Exp. 2. Do analysis as suggested in Ref. 1 & 2. Plot graphs like those in Ref. 1.
4. Make a Type T thermocouple, attach it to the Peltier device and check the accuracy of the thermistor by plotting thermocouple temperature vs. thermistor reading.

References:

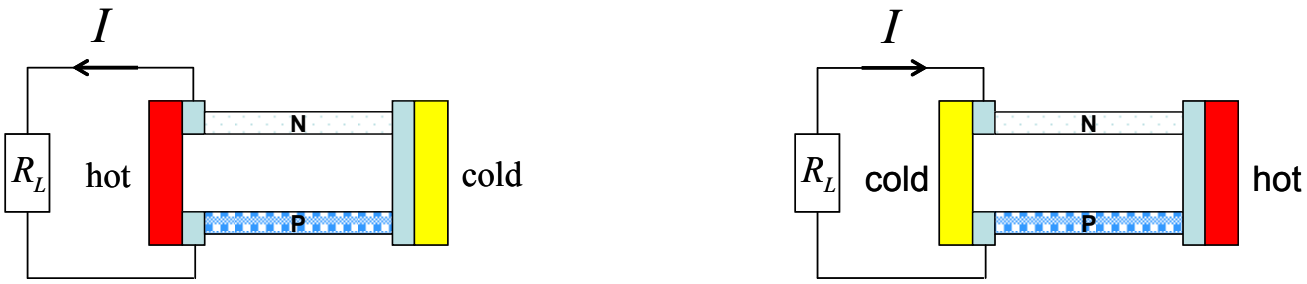
1. V.K. Gupta et. al., "Experiment to verify the second law of thermodynamics using a thermoelectric device", Am. J. Phys. **52**, 625 (1984) (available through UL).*
2. Manual for Thermal Efficiency Apparatus (PASCO model TD-8564)* (available on Course Web Page).
3. M. Cvahte & J. Strnad, "A thermoelectric experiment in support of the second law", European Journal of Physics, vol. 9, pp.11-17 (1988)

Reference folder is available.

* See Notes on next page.

Notes on Peltier device as a heat engine

(A) The two configurations are identical:



(B) Comparison of symbols in Ref. 1 & Ref. 2:

	Ref. 1	Ref. 2
Load resistance (~ 1 Ω)	R_L	R
Internal resistance of device	R	r
Current through the load resistor	I	I_W
Voltage across device with $I \neq 0$	V	$V_W = I_W R$
Work done by device	VI	$P_W = I_W^2 R$
Seeback emf (voltage across device with $I = 0$ (open circuit))	E	V_s
	$E = V + IR$	$V_s = I_W R + I_W r$
Input power (close circuit)	P_1	$P_H = V_H I_H$
Input power (open circuit)	P_2	$P_{H(open)}$
Total work done	EI	$P'_W = V_s I_W = \frac{V_W^2}{R} + I_W^2 r$
efficiency	η	e
	$\eta = \frac{EI}{P_1 - P_2 + \frac{1}{2} I(E-V)}$	$e = \frac{P'_W}{P'_H} = \frac{\frac{V_W^2}{R} + I_W^2 r}{P_H - P_{H(open)}} = \frac{\frac{V_W^2}{R} + (\frac{V_W}{R})^2 r}{P_H - P_{H(open)}}$
Temperature of hot reservoir	T_h	T_H
Temperature of cold reservoir	T_c	T_c

Typo errors in Ref. 2 (PASCO manual):

1. On. p.6, R_1 should be R.
2. On p.6, $V_s = IR + Ir$ should be $V_s = I_W R + I_W r$.
3. On p.16, $r = \left(\frac{V_P - V_W}{V_W}\right) R$ should be $r = \left(\frac{V_S - V_W}{V_W}\right) R$.