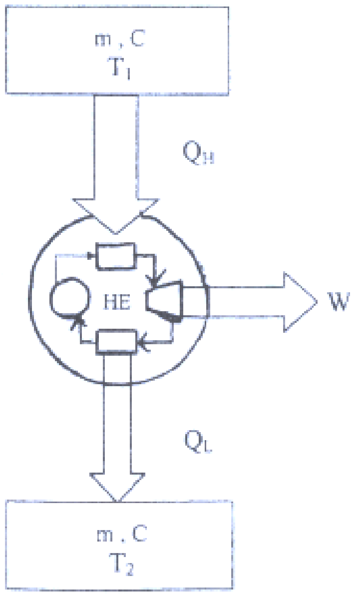
1. (25%) Starting from the first and second laws of thermodynamics, Derive and show that for a reversible and incompressible duct flow, the fluid pressure p, velocity v and elevation height z satisfy the Bernoulli equation.

2. (25%) Consider two bodies of identical mass m and specific heat C used as thermal reservoirs (source and sink) for a heat engine. The first body is initially at an absolute temperature T_1 while the second one is at a lower temperature T_2. Heat is transferred from the first body to the heat engine, which rejects the waste heat to the second body. The process continues until the final temperatures of the two bodies T_f become equal. Show that $T_f = (T_1 T_2)^{1/2}$ when the heat engine produces the maximum possible work.



(背面仍有題目,請繼續作答)

3. A large stationary air Brayton cycle gas-turbine power plant delivers a power output of 100 MW to an electric generator. The minimum temperature in the cycle is 300 K, and the maximum temperature is 1600 K. The minimum pressure in the cycle is 100 kPa, and the compressor pressure ratio is 14 to 1. Assume constant specific heats for the air, $C_v = 0.717 kJ/kg\text{-}K$ and $C_p = 1.004 kJ/kg\text{-}K$. Calculate the power output of the turbine. What fraction of turbine output is required to drive the compressor? What is the thermal efficiency of the cycle? (25 %)

4. Consider a simple compressible substance and its Maxwell relations

$$\left(\frac{\partial T}{\partial v}\right)_s = -\left(\frac{\partial P}{\partial s}\right)_v$$

$$\left(\frac{\partial T}{\partial P}\right)_s = \left(\frac{\partial v}{\partial s}\right)_P$$

$$\left(\frac{\partial P}{\partial T}\right)_v = \left(\frac{\partial s}{\partial v}\right)_T$$

$$\left(\frac{\partial v}{\partial T}\right)_P = -\left(\frac{\partial s}{\partial P}\right)_T.$$

Use Maxwell relations to derive (a) a general relation for the change of internal energy and (b) a general relation for the change of entropy. Either one of the relations only includes the properties P-v-T and the specific heat, C_v. (25 %)