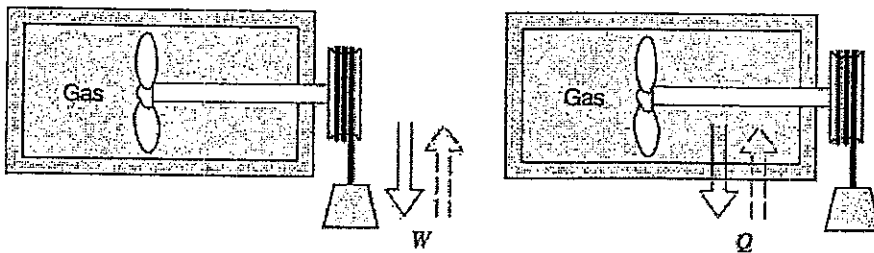※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

Given: air $C_{p0} = 1.004$ kJ/kg$-$K, $R = 0.287$ kJ/kg$-$K

1. Describe the two thermodynamic cycles (solid and dotted arrows) for the system shown below. 10%　Which one is not physically realizable? and why? 5%

2. Show that the work of a control mass system is reduced by an amount proportional to the entropy generation. $\delta W_{irr} = PdV - Td S_{gen}$ 12%

3. Derive $W = -\int_i^e vdp$. 16%　Hint: carefully list all assumptions made.

4. Show that isentropic pumping of liquid does not change the temperature. 11%

5. In a reversible process, air is compressed in a cylinder from 100 kPa and 20 °C to 500 kPa. During this compression process, the relation between pressure and volume is $PV^{1.3} = $ constant. Calculate the work (6%) and heat transfer (6%) per kilogram, and show this process on $P-v$ and $T-s$ diagrams (6%) qualitatively.

6. Air enters an automotive supercharger at 100 kPa, 300 K and is compressed to 150 kPa. The efficiency is 70%. What is the required work input per kilogram of air? What is the exit temperature? 16%

7. A room is heated with a 2000 W electric heater. How much power can be saved if a heat pump with a COP of 2.5 is used instead? 12%