بسم الله الرحمن الرحيم

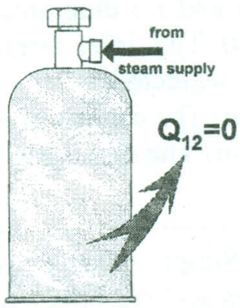
Mansoura University — **Thermodynamics I**
Faculty of Engineering — **Allowed Time: 3 hrs.**
1st Year Mechanical Power Engineering — **January 2009**

Steam Tables and Chart are allowed to be used.
Illustrate your answer with neat sketches, whenever it is possible.
Take for air: R = 0.287 kJ/kg-K, c_v = 0.718 kJ/kg-K

1.

a) Prove that, the first law of thermodynamics for unsteady open system process 1-2, is given by:

$$Q_{12} - W_{12} = \left[m_o(h_o + \tfrac{1}{2}c_o^2 + gz_o) - m_i(h_i + \tfrac{1}{2}c_i^2 + gz_i)\right] + \left[m_2(u_2 + \tfrac{1}{2}c_2^2 + gz_2) - m_1(u_1 + \tfrac{1}{2}c_1^2 + gz_1)\right]$$



b) A thermally insulated vessel of 0.1 m³ is connected to a supply of steam through a valve. The vessel is initially empty. The steam of the supply is at 10 bars and 250°C. Now, the valve is open and steam is allowed to enter the vessel till the pressure inside the vessel reaches 5 bars. At this instant, the valve is closed. Represent the filling process on *p-v* and *T-s* diagrams and then determine:

i) The thermodynamic properties of water at the end of filling process.
ii) The mass of water entering the vessel during filling process.

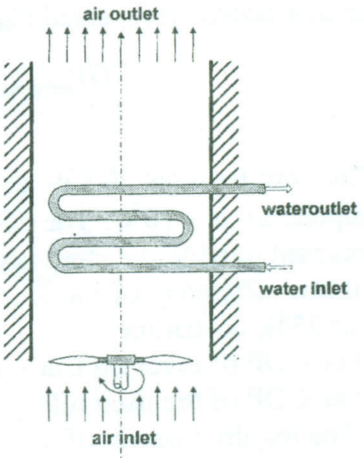
2.

a) Starting with the first law of thermodynamics applied to open system, prove that it takes the following form for heat exchanger:

$$m_c\ (h_{c,o} - h_{c,i}) = m_h\ (h_{h,i} - h_{h,o})$$

b) Prove that, the change of entropy through any process 1-2 and for perfect gas, is given by:

$$\Delta s = c_p \cdot \ell n\frac{v_2}{v_1} + c_v \cdot \ell n\frac{p_2}{p_1}$$



c) Atmospheric air at 10°C is heated to 20°C by flowing it over a steam coil. Water enters the coil as dry and saturated steam at 4 bars, while it leaves the coil at 4 bars and 35°C. Air has constant pressure of 1.0 bar as it flows through the heating duct. Represent on *T-s* diagram both of the air heating process and water cooling process and hence; neglecting the blower power, calculate:

i) The required mass of water per kg of air.
ii) The change of air entropy through the process.

(من فضلك اقلب الورقة) **Please Turn Over)**

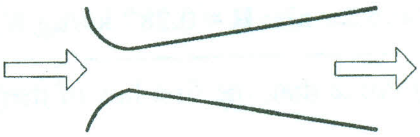
3.

a) Prove that, the internal energy (u) and enthalpy (h) of perfect gas, are given by:

$$u = c_v \cdot T \quad \text{and} \quad h = c_p \cdot T$$

b) Prove that, the viscosity and inertia cause internal irreversibility.

c) Air leaves a convergent divergent nozzle at 100°C and 1 bar with velocity of 450 m/s. If the flow through the nozzle is assumed to be irreversible adiabatic process with adiabatic efficiency of 90%, represent the process on *p-v* and *T-s* diagrams and determine:



i) The inlet temperature and pressure, if the velocity of approach (inlet velocity) is neglected.

ii) The change of entropy through the process.

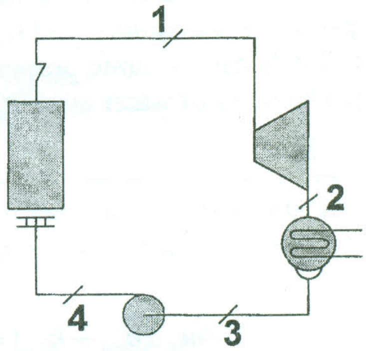
iii) The exit cross-sectional area per kg flow rate.

4.

a) Simple steam power cycle, the pressure of condenser is 0.2 bars and the boiler pressure is 60 bars. The steam enters the turbine at temperature of 500°C. Sketch the cycle on *T-s* diagram and determine for one kg:

i) The turbine work, **ii)** Heat added, **iii)** Heat rejected,

iv) The pump work, **v)** thermal efficiency of the cycle.



b) For the same temperature limits of the foregoing cycle, considering its minimum temperature and pressure as the condition of dead state, determine:

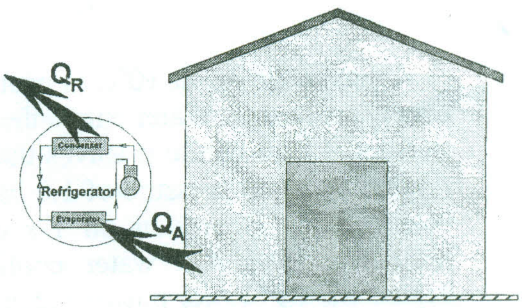
i) Thermal efficiency of Carnot cycle and hence second law efficiency of the foregoing cycle.

ii) For one kg, determine the available work, irreversible work and unavailable energy.

5.

a) Prove that the coefficient of performance of refrigerator based on reversed Carnot cycle is given by:

$$COP_{refrigerator} = \frac{T_{min}}{T_{max} - T_{min}}$$



b) Cold store requires 30 kW as cooling load to maintain its temperature at −10°C. The average temperature of the environment outside the store is estimated by 35°C. If the second law efficiency of the required refrigerating unit is taken as 35%, determine:

i) The COP of reversed Carnot cycle operates between the same temperature limits.

ii) The COP of the used refrigerating unit.

iii) The required power of the used unit.

(GOOD LUCK Prof. Dr. M. G. WASEL)