UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 1 Examination in Engineering: July 2016

Module Number: ME1202 **Module Name: Fundamentals of Engineering Thermodynamics**

[Three Hours]

[Answer **all questions**, each question carries **twelve marks**]

Q1. Steam enters a steady flow turbine with a mass flow rate of 20 kg/s at 600 °C, a pressure of 5 MPa, and a negligible velocity. The steam expands in the turbine to a saturated vapour at 10 kPa.

a) If the turbine is adiabatic, determine the work done by the steam during this process.

[8 Marks]

b) Show the process on a T – v diagram.

[4 Marks]

Q2. a) A frictionless piston – cylinder device undergoes a polytropic compression process from a given thermodynamic state 1 to a final thermodynamic state 2. If the boundary work done is W, then show that,

$$W = \frac{1}{(1-n)}(P_2V_2 - P_1V_1)$$

[3 Marks]

b) For the process given in Q2. a) above, show that,

$$(T_2/T_1) = (P_2/P_1)^{[(n-1)/n]}$$

[3 Marks]

c) A frictionless piston – cylinder device contains 2 kg of Nitrogen (N_2) at a pressure of 100 kPa and a temperature of 300 K. Nitrogen is now compressed slowly according to the relationship "$PV^{1.4}$ = Constant". The final temperature at the end of the compression process is 360 K. Calculate the work done on the working fluid N_2. [R_u = 8.314 kJ/kg.K, M_{N2} = 28]

[6 Marks]

Q3. An ideal gas is subjected to an expansion process in an adiabatic turbine operating under steady state conditions. If m is the mass flow rate of the gas,

a) Show that, $W = m\, c_p(T_1 - T_2)$ [Consider the difference in inlet and outlet velocities of the gas to be negligible]

[3 Marks]

..... Question Q3. is continued on Page 2

Question Q3. is continued from Page 1 ....

b) Show that, $V_1 = (mR_iT_1)/(P_1)$ where V_1 is the volumetric flow rate of the gas at the inlet.

[3 Marks]

c) An ideal gas expands in an adiabatic turbine from a temperature of 1200 K and a pressure of 900 kPa to 700 K. Determine the turbine inlet volume flow rate of the gas, in m^3/s, required to produce turbine work output at the rate of 350 kW. The average values for the specific heats for this gas over the temperature range and the specific gas constant for the ideal gas are c_p = 1.13 kJ/kg.K, c_v = 0.83kJ/kg.K and R_i = 0.30 kJ/kg.K.

[6 Marks]

Q4. a) State the Clausius statement of Second Law.

[2.0 Marks]

b) What are the irreversibilities occurring in a practical thermodynamic process?

[4.0 Marks]

c) The interior lighting of refrigerators is provided by incandescent lamps whose switches are actuated by the opening of the refrigerator door. Consider a refrigerator whose 40Wlightbulb remains "On" continuously as a result of a malfunction of the switch. If the refrigerator has a coefficient of performance (COP) of 1.3 and the cost of electricity is 8 Rupees per kWh, determine the increase in the energy consumption of the refrigerator and its cost per year if the switch is not fixed. Assume the refrigerator is opened 20 times a day for an average of 30 seconds.

[6.0 Marks]

Q5. a) Discuss on practical difficulties associate with Carnot vapor cycle.

[4.0 Marks]

b) A steam turbine working on Rankine cycle is supplied with dry saturated steam at 25 bar and the exhaust takes place at 0.2 bar. For a steam flowrate of 10 kg/s, determine,

i) Work ratio.
ii) Rankine efficiency.
iii) Heat flow in the condenser if $v_{f@0,2\ bar}$ =0.001017 m^3/kg.

[8.0 Marks]