BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2004 – 2005
ESC U C112 THERMODYNAMICS TEST 1 (OPEN BOOK) Date: 31/10/04
DURATION: 50 MINUTES MAXIMUM MARKS: 20 WEIGHTAGE: 20%

NOTES:

1. Standard Thermodynamics tables are allowed.
2. Highlight all your answers by enclosing in boxes.
3. Assume any missing data suitably and mention the same at appropriate place in your answer.
4. All the parts of a particular question should be answered together.

Q1. Reproduce the following table in your answer sheet along with the given data. Fill the cells marked "?" with appropriate answers. **(20x0.5 = 10M)**

Substance	Temperature °C	Pressure k Pa	Specific Volume m^3/kg	Specific Internal Energy kJ/Kg	Phase	Quality (Give the value, if applicable. If the term quality is not applicable, clearly write "Not applicable")
Water	158.85	?	?	?	?	1
Water	600	46000	?	?	?	?
Nitrogen	?	1084.6	?	100	?	?
Methane	?	?	0.07717	202.09	?	?
R - 12	100	?	0.65	?	?	?

Q2. One Kg of air undergoes a thermodynamic cycle consisting of three processes. Process 1 – 2 is a constant specific volume process; Process 2 – 3 is an Isothermal expansion process; Process 3 – 1 is a constant pressure process. At state 1 the pressure and temperatures are 27°C and 100 kPa. At state 2 the pressure is 200 kPa. Represent the cycle on P – v diagram. Using the Ideal gas model determine the temperature at state 2. Determine the specific volume at state 3. Also find the work done in the individual processes and net work done in the cycle. **(7M)**

Q3. The piston of a vertical piston – cylinder device containing a gas has a mass of 60kg and a cross sectional area of 0.04 m^2. The local atmospheric pressure is 0.97bar and gravitational acceleration is 9.81m/s^2. (a) Determine the pressure inside the cylinder. (b) When some heat is supplied to the gas so that the volume occupied the gas is doubled. Find the new pressure. Write your comments based on the results of part (a) and part (b). **(3M)**

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2004 – 2005
ESC U C112 THERMODYNAMICS TEST 2 (CLOSED BOOK) Date: 12/12/04
DURATION: 50 MINUTES MAXIMUM MARKS: 20 WEIGHTAGE: 20%

NOTES:

1. Standard Thermodynamics tables are allowed.
2. Highlight all your answers by enclosing in boxes.
3. Assume any missing data suitably and mention the same at appropriate place in your answer.
4. All the parts of a particular question should be answered together.

Q1. Simplify the continuity equation and FLOT for the following two applications.
(a) The nozzle of a steam turbine
(b) Charging of an initially evacuated insulated tank, through an air pipeline connected to the tank by a valve. **[6M]**

Q2. In a steady flow apparatus, 135kJ of work is done by each kg of fluid. The specific volume of the fluid, pressure, and velocity at the inlet are $0.37m^3/kg$, 600kPa, and 16m/s. The inlet is 32m above the floor, and the discharge pipe is at floor level. The discharge conditions are $0.62m^3/kg$, 100kPa, and 270m/s. The total heat loss between the inlet and discharge is 9kJ/kg of fluid. In flowing through this apparatus, does the specific internal increase or decrease, and by how much? **[6M]**

Q3. A piston cylinder machine contains a fluid system, which passes through a complete cycle of four processes. During a cycle the sum of heat transfers is –170kJ. The system completes 100 cycles per min. Compute the missing values in the following table. Show all calculations clearly. Redraw the table in your answer book and write your answers in that table. Also find rate of work interaction per min.

PROCESS	Q kJ/min	W kJ/min	Change in internal energy kJ/min
A – B	0	2170	
B – C	21000	0	
C – D	-2100		-36,600
D – A			

[8M]

BITS, PILANI – DUBAI CAMPUS, KNOWLEDGE VILLAGE, DUBAI
FIRST SEMESTER 2004 – 2005
ESC U C112 THERMODYNAMICS
COMPREHENSIVE EXAMINATION (CLOSED BOOK)
DURATION: 180 MINUTES MAXIMUM MARKS: 40 WEIGHTAGE: 40%

NOTES:

1. Standard Thermodynamics tables are allowed.
2. Highlight all your answers by enclosing in boxes.
3. Assume any missing data suitably and mention the same at appropriate place in your answer.
4. **All the parts of a particular question should be answered together. Sub Questions answered at different locations in the answer sheet are liable to be ignored for evaluation.**

Q1. Refer **FigQ1**. Air at a temperature of 15°C passes through a heat exchanger at a velocity of 30m/s where its temperature is raised to 800°C. It then enters a turbine with the same velocity of 30m/s and expands until the temperature falls to 650°C. On leaving the turbine, the air is taken at a velocity of 60m/s to a nozzle where it expands until the temperature has fallen down to 500°C. The air mass flow rate through out is 2 Kg/s. Enthalpy of the air at any stage, follows the relation given by h = Cp* T where Cp is the specific heat at constant pressure whose value is 1.005kJ/kg K and T is the temperature. Without neglecting the velocity effects, calculate

(a) The total rate of heat transfer to the air in the heat exchanger.
(b) The total power output from the turbine assuming no heat loss
(c) The velocity at the exit of the nozzle, assuming no heat loss. **[8M]**

Q2. It is a proven fact that it is much more economical to use the high temperature heat produced by combustion in a heat engine and then to use the work so developed to pump heat from out doors to heat a house.

As shown in **FigQ2**, a boiler furnishes heat Q_1 at a high temperature T_1. This heat is absorbed by a heat engine, which extracts W work and rejects Q_2 in to the house at T_2. Work W in turn is used to operate a heat pump, which extracts Q_3 from out doors at temperature T_3 and rejects Q'_2 (where $Q'_2 = Q_3 + W$) in to the house. As a result of this cycle of operations, a total quantity of $Q_2 + Q'_2$ is liberated in to the house, against Q_1 which would be provided directly provided by the ordinary combustion of the fuel.

Considering that both the heat engine and the heat pump work on Carnot cycle,

(a) Represent Q_2 as a function of Q_1, T_1, and T2.
(b) Represent W as a function of Q_1, T_1, T_2.
(c) Represent Q'_2 as a function of Q_1, T_1, T_2, and T_3.
(d) If the relation $(Q_2 + Q'_2)/Q_1$ represents the heat multiplication factor, MF, represent MF as a function of T_1, T_2, and T_3.
(e) If T_1, T_2, and T_3 are 473K, 293K and 273K respectively, obtain the value of MF. **[8M]**

Q3. A fluid undergoes a reversible adiabatic compression from P_1 V_1 to P_2 V_2 according to the law $P V^n$ = Constant.

(a) Integrate the applicable Gibbs equation to show that

$$H_2 - H_1 = \frac{n(P_2V_2 - P_1V_1)}{n-1}$$

[PTO]

(b) If $P_1 = 0.5MPa$; $V_1 = 0.2m^3$; $V_2 = 0.05m^3$; and n= 1.3 find $P_2$and hence $H_2 - H_1$.
(c) Find $U_2 - U_1$ and $_1W_2$. **[8M]**

Q4. Refer **Fig Q4**. Steam at 0.8 M Pa, 250°C and flowing at a rate of 1kg/s passes in to a pipe carrying steam at 0.8M Pa, 0.95 dry. After adiabatic mixing the flow rate is 2.3kg/s. Determine the conditions of steam after mixing.

The mixture is now expanded in a frictionless nozzle isentropically to a pressure of 0.4M Pa. Determine the velocity of the steam leaving the nozzle. Neglect the velocity of steam in the pipeline. **[6M]**

Q5.
(a) Show that the entropy of a system is a property of the system.
(b) Explain the terms saturation temperature, saturation pressure, saturated solid
(c) Explain the construction and use of compressibility charts.
(d) Derive the two Gibbs equations.
(e) Write short notes on reduced pressure and reduced volume. **[5 X 2 = 10M]**

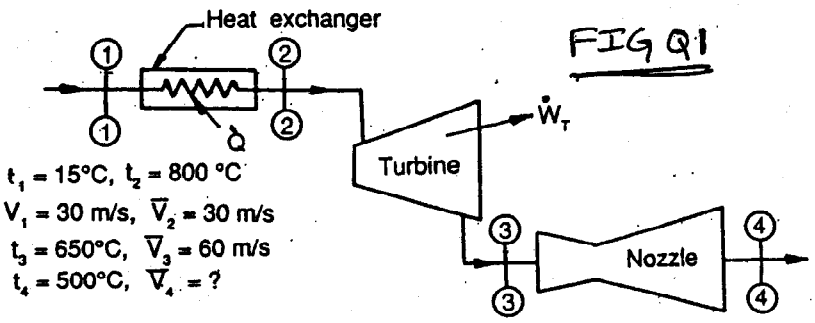

FIG Q1

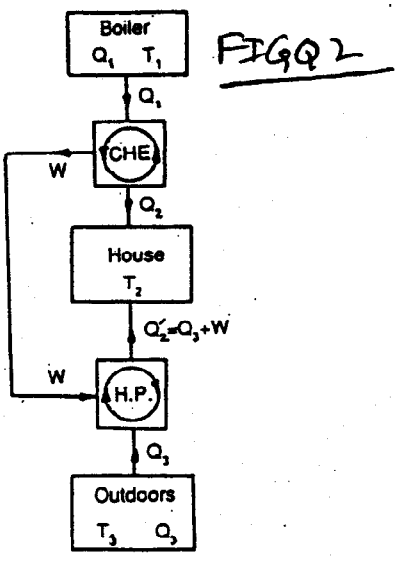

FIG Q2

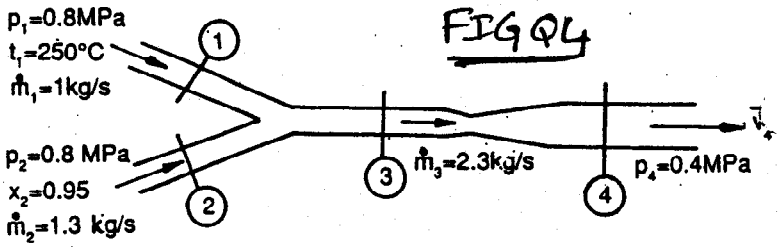

FIG Q4