BITS, PILANI DUBAI CAMPUS
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
Second Semester 2013-2014

Course: BITS F111 Thermodynamics

Comprehensive Examination [Closed Book]

Max. Marks: 80
Weightage: 40 %

Date: 26-05-2014
Time: 3 hours

COMMON TO ALL BRANCHES

*Note: (i) Answer all Questions in a sequence (ii) Assume suitable value if required (iii) Thermodynamics Data book is provided (iv) Answer Every Question on a fresh page (v) Answer the questions of **Part A , Part B and Part C separately***

PART A

1. A sealed rigid vessel of 2 m^3 contains a saturated mixture of liquid and vapor R-134a at 10°C. If it is heated to 50°C, the liquid phase disappears. Find the final pressure and the initial mass of the liquid. **(6 M)**

2. Consider a piston/cylinder with 0.5 kg of R-134a as saturated vapor at -10°C. It is now compressed to a pressure of 500 kPa in a polytropic process with n = 1.5. Find the final volume and temperature, and determine the work done during the process. **(6 M)**

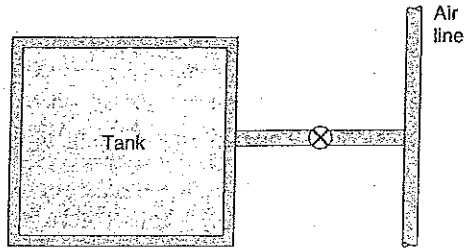
3. A piston/cylinder arrangement contains water of quality x = 0.7 in the initial volume of 0.1 m^3 where the piston applies a constant pressure of 200 kPa. The system is now heated to a final temperature of 200°C. Determine the work and the heat transfer in the process. **(6 M)**

4. Superheated refrigerant R-134a at 20°C, 0.5 MPa is cooled in a piston/cylinder arrangement at constant temperature to a final two-phase state with quality of 50%. The refrigerant mass is 5 kg, and during this process 500 kJ of heat is removed. Find the initial, final volumes and the necessary work. **(6 M)**

5. A 1-m^3 rigid tank with air at 1 MPa, 400 K is connected to an air line as shown in Fig. The valve is opened and air flows into the tank until the pressure reaches 5 MPa, at which point the valve is closed and the temperature inside is 450 K.

a. What is the mass of air in the tank before and after the process?

b. The tank eventually cools to room temperature, 300 K. What is the pressure inside the tank then? **(6 M)**



PART B

1. What is the difference between a nozzle flow and a throttle process? **(2 M)**

2. Assume a cyclic machine that exchanges 12kW with a 250 °C reservoir and has $\dot{Q}_L = 2$ kW, $\dot{W} = 4$ kW and Q_L is exchanged with a 30 °C ambient. What can you say about the process if the machine is a heat engine? **(2 M)**

3. Consider the four cases of a heat engine given below and determine if any of those are perpetual machines of the first or second kind.

a). $\dot{Q}_H = 6$ kW, $\dot{Q}_L = 4$ kW, $\dot{W} = 2$ kW; b.) $\dot{Q}_H = 6$ kW, $\dot{Q}_L = 0$ kW, $\dot{W} = 6$ kW

c) $\dot{Q}_H = 6$ kW, $\dot{Q}_L = 2$ kW, $\dot{W} = 5$ kW; d.) $\dot{Q}_H = 6$ kW, $\dot{Q}_L = 6$ kW, $\dot{W} = 0$ kW **(4 M)**

4. A proposal is made to use a geothermal supply of hot water to operate a steam turbine, as shown in ***Fig.1***. The high-pressure water at 1.4 MPa, 150°C, is throttled to 400 kPa into a flash evaporator chamber, where the liquid and vapor at a pressure of 400 kPa are separated. The liquid is discarded while the saturated vapor feeds the turbine and exits at 10 kPa, 90% quality. If the turbine should produce 1 MW, find the required mass flow rate of hot geothermal water and also find the quality of feed water into the flash evaporator. **(5 M)**

Fig-1

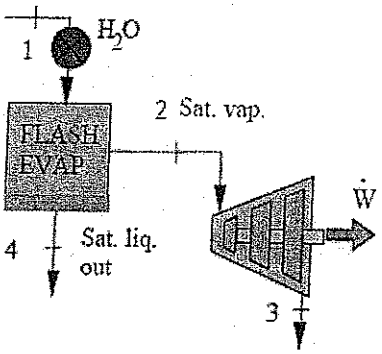
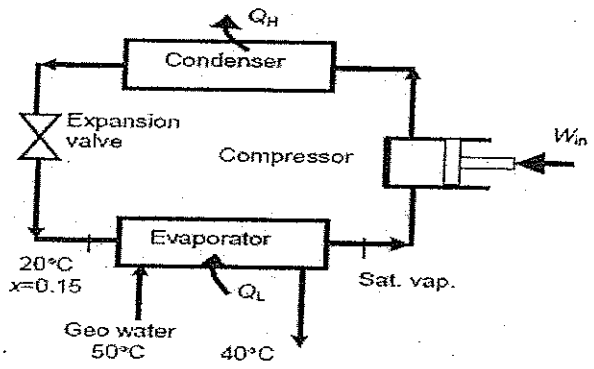


Fig-2



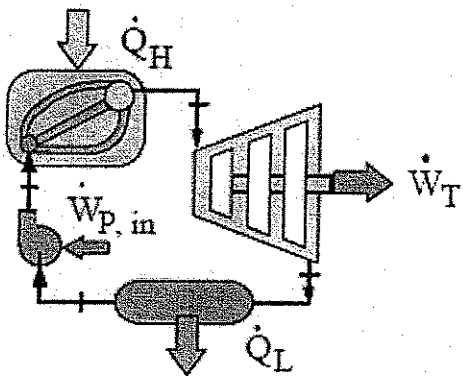
5. A heat pump shown in ***Fig-2*** with R-134a as the working fluid is used to keep a space at 25 °C warm. It absorbs heat from geothermal water that enters the evaporator at 50 °C at a rate of 0.065 kg/s and leaves at 40 °C. Refrigerant enters the evaporator at 20°C with a quality of 15% and leaves at the same pressure as saturated vapor. If the compressor consumes 1.2 kW of power, determine (a) the mass flow rate of the refrigerant (b) the rate of heat supplied to the room (c) the

Coefficient Of Performance and (d) the minimum power input to the compressor for the same rate of heat supply. **(12 M)**

PART C

1. At a constant pressure of 100 kPa, 1 kg of air at 500 K is mixed with 1 kg air at 600 K through an adiabatic process. Find the final T and the specific entropy generation in the process. **(5 M)**

2. In a steam power plant, 1 kW is added in the boiler, 580 W is taken out from condenser and



the pump work is 20 W. The boiler is at 700 °C and the condenser is at 40 °C. Does that satisfy the inequality of Clausius? Justify. Repeat the question for the cycle operated in reverse as a refrigerator. **(5 M)**

3. Steam enters a turbine at 3 MPa, 450°C, expands in a reversible adiabatic process and exhausts at 10 kPa. Changes in kinetic and potential energies between the inlet and the exit of the turbine are small. The power output of the turbine is 800 kW. What is the mass flow rate of steam through the turbine? **(5 M)**

4. A reversible adiabatic compressor receives 0.05 kg/s saturated vapor R-134 at 200 kPa and has an exit presure of 800 kPa. Neglect kinetic energies and find the exit temperature and the minimum power needed to drive the unit. **(5 M)**

5. A piston/cylinder contains 2 kg of water at 5 MPa and 100 °C. Heat is added from a reservoir at 700 °C to the water until it reaches 700 °C through a constant pressure process. Find the total irreversibility in the process if the ambient temperature is 25 °C. **(5 M)**

x----------x

BITS-PILANI, DUBAI CAMPUS

DUBAI INTERNATIONAL ACADEMIC CITY

SECOND SEMESTER 2013-'14

COURSE: BITS F111 Thermodynamics-Test 2 (Open Book)

Max. Marks: 40 Date: 10.04.2014

Weightage : 20% Time: 50 min

Note: Answer all the Questions and Assume suitable value if required. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1. In an exchanger, air is brought from 35 °C to 5 °C at a rate of 0.5 kg/s. The output then mix with a flow of 0.25 kg/s air at 20 °C, sending the combined flow into a room. Find the heat transfer in the exchanger and the temperature of the air flowing in to the room. Assume the pressure of all the air streams is 101.3 kPa. **(7 M)**
2. In a laboratory an exhaust fan (D=0.4 m) should remove 2.5 kg/s air at 98 kPa, 20 °C. How high a velocity must it generate and how much power is required to do that? **(7 M)**
3. An insulated rigid tank is initially filled with 5 kg of saturated liquid-vapor mixture of water at 100 kPa. Initially three quarters of the mass is in the liquid phase. An electric heater in the tank which is connected to a 110 V source and a current of 8 A flows through when the switch is turned on. Determine how long it will take for the entire liquid in the tank to vaporize? Also show the process in a P-v diagram. **(6 M)**
4. A cooling system is being designed to cool eggs with an average mass of 0.065 kg (ρ=1080kg/m^3 and Cp =3.35kJ /kg °C). Eggs are cooled from 30 °C to its final average temperature of 10 °C by chilled air maintained at 1 °C at a rate of 10,000 eggs per hour. Determine (a) the rate of heat removal from the eggs and (b) the required volume flow rate of air in m^3/s if the temperature rise of the air does not exceed 6 °C. **(6 M)**
5. In a turbine, steam enters at the rate of 5 kgs^{-1} with a velocity of 50 ms^{-1} at 1.6 MPa, 400 °C and leaves the turbine with a velocity of 150 ms^{-1} at 100 kPa. The loss of heat to the surroundings is 25 kJkg^{-1}. Determine the power output of the turbine and the diameter of the inlet pipe. **(7 M)**
6. A gas undergoes a thermodynamic cycle consisting of the following processes: I process from state *1-2* at constant pressure 140 kPa, a initial volume of 0.028 m^3 and ${}_1W_2$ = 10.5 kJ. II process from state *2-3* is isothermal compression. III process from state *3-1* at constant volume, where the heat evolved is 26.4 kJ. There are no significant changes in KE and PE. Calculate the net work for the cycle and the heat transfer for the process *1–2*. **(7 M)**

BITS-PILANI, DUBAI CAMPUS

DUBAI INTERNATIONAL ACADEMIC CITY

SECOND SEMESTER 2013-'14

COURSE: BITS F111 Thermodynamics

Test I (Closed Book)

Max. Marks: 50 **Date: 20.02.2014**

Weightage : 25% **Time: 50 min**

Note: Answer all the Questions and Assume suitable value if required. Mention appropriate units in your answers. Without units, the answer will not be deemed as correct, even if the numerical value is correct.

1. a) Separate the list, temperature, volume, density, specific volume, mass and pressure as intensive and extensive properties. **(3 M)**

   b) The absolute pressure in a tank is 200 kPa. What is this pressure in $kgm^{-1}s^{-2}$? **(1 M)**

   c) During a heating process, the temperature of an object rises by 20 °C. What is the equivalent rise in temperature in Kelvin? **(1 M)**

   d) A rigid tank contains water vapor at 250 °C and unknown pressure. When it is cooled to 150° C the vapor starts condensing. Estimate the initial pressure in the tank. **(4 M)**

2. Determine the state and the specific volume of ammonia at 30 °C and 50 kPa. Indicate the relative position of this state in P-T, T-v and P-v diagram. **(8 M)**
3. A $1m^3$ rigid tank has carbon dioxide at 200 kPa, 400 K and connected by a valve to another tank of $0.5m^3$ with carbon dioxide at 500 kPa, 600 K. The valve is opened and the two tanks come to a uniform state at 450 K. What is the final pressure? **(7M)**
4. (a) Water at 140 ^{0}C with a quality of 40% has its temperature raised to 160 ^{0}C in a constant volume process. What is the new quality and pressure? **(5M)**

   (b) Determine the phase and missing properties of P, T, v and x for CH_4. (T = 180K, $v = 0.02m^3/kg$). **(5M)**

5. Superheated steam at 500 kPa and 300 °C is converted in to saturated vapor at the same pressure. Then it is cooled to 100 °C and becomes a mixture of liquid and vapor water at constant volume. Determine (i) Temperature of the saturated vapor (ii) Final quality (iii) The change in specific volume (iv) Plot the process in Pv and Tv diagrams. **(16 M)**

BITS, PILANI – DUBAI CAMPUS **A**

SECOND SEMESTER 2013 – 2014

First Year Sections 1, 2 & 3

Quiz 2

Course Code: BITS F111 Date: 08.05.2014 **Name:**----------

Course Title: THERMODYNAMICS Max Marks: 14 **ID.No:**----------

Duration: 20minutes Weightage : 7% **Sec.:** ----------

Instructions: 1. Attempt all questions 2. Assume suitable value if required

1. A window air-conditioner unit is placed on a laboratory bench and tested in cooling mode using 750 W of electric power with a COP of 1.75. What is the cooling power capacity? **(2 M)**

2. Calculate the thermal efficiency of a Carnot cycle heat engine operating between reservoirs at 300 °C and 45 °C. **(2 M)**

3. Determine how much heat will be rejected and what will be the temperature at rejection, if a Carnot engine of efficiency 42 % receives 6 kW at 250 °C. **(2 M)**

4. Name any two ideal machines. **(1 M)**

5. How much would be the electricity generated in a thermal power station, having overall efficiency of 38% and consumes one ton of coal per minute. The energy value of coal is 35 MJ/kg. **(2 M)**

6. A refrigerator is removing heat from a cold medium at 3 °C at a rate of 7200 kJ/h and rejecting the waste heat to a medium at 30 °C. What is the power consumed by the refrigerator? **(2 M)**

7. An inventor claims to have made a heat engine operating between 550K and 300K. It is claimed that this engine produces 5 kW while rejecting heat at a rate of 15,000 kJ/h. Is this claim valid? Justify. **(3 M)**

BITS, PILANI – DUBAI CAMPUS

SECOND SEMESTER 2013 – 2014

First Year Sections 1, 2 & 3

Quiz 1 **A**

Course Code: BITS F111	Date: 13.03.2014	**Name:**----------
Course Title: THERMODYNAMICS	Max Marks: 16	**ID.No:**----------
Duration: 20minutes	Weightage : 8%	**Sec.:** ----------

Instructions: 1. Attempt all questions 2. Assume suitable value if required

(R_{air} = 0.287 kJ/kg/K: σ = 5.67 x 10^{-8} W/m^2K^4)

1. The rolling resistance of a car depends on its weight as: F = 0.006 mg. How long will a car of 1400 kg drive for a work input of 25 kJ? **(2 M)**

2. A piston cylinder contains air at 600 kPa, 290 K and a volume of 0.01 m^3. A constant pressure process gives 54 kJ of work. Find the final V and T of the air. **(2 M)**

3. A gas initially at 1 MPa, 500°C is contained in a piston and cylinder arrangement with an initial volume of 0.1 m^3. The gas is then slowly expanded in an isothermal process until a final pressure of 100 kPa is reached. Determine the work for this process. **(2 M)**

4. A hydraulic cylinder of area $0.01 m^2$ must push a 1000 kg arm and shovel 0.5 m straight up. What pressure is needed and how much work is done? **(3 M)**

5. Find the rate of heat transfer per unit area through a 1.5cm thick hard wood board, k = 0.16 W/mK, with a temperature difference between the two sides of 20^0 C. **(2 M)**

6. A 55 cm^2 surface area of a metal having $\varepsilon = 0.8$ radiates 250 W heat. What will be the temperature of the surface? **(3 M)**

7. An 1 m^2 window has a surface temperature of 20 °C and the outside wind is blowing air at 7 °C across it with a convection heat transfer coefficient of $h = 0.125 kW/m^2K$. What is the total heat transfer loss? **(2 M)**