BITS, PILANI DUBAI CAMPUS
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
I Year First Semester 2013-2014

Course: BITS F111 Thermodynamics

Comprehensive Examination [Closed Book]

Max.Marks: 80
Weightage: 40 %

Date: 26-12-2013
Time: 3 hours

COMMON TO ALL BRANCHES

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

PART A

1. The hydraulic lift in an auto-repair shop has a cylinder diameter of 0.5 m. To what pressure should the hydraulic fluid be pumped to lift 50 kg of piston/arms and 1000 kg of a car? **(5 M)**

2. The difference in height between the columns of a manometer is 0.3m with a fluid of density 900kg/m3. What is the pressure difference? What is the height difference if the same pressure difference is measured using mercury (Density of mercury = 13600 kg/m^3) as manometer fluid? **(4 M)**

3. A spherical helium balloon of 10 m in diameter is at ambient T and P, 15^{0}C and 100 kPa. How much helium does it contain? It can lift a total mass that equals the mass of displaced atmospheric air. How much mass of the balloon fabric and cage can then be lifted? **(9 M)**

4. Air goes through a polytropic process from 125 kPa, 325 K to 300kPa and 500 K. Find the polytropic exponent n and the specific work in the process. **(9 M)**

PART B

1. Saturated vapor R-134a at 500 kPa is throttled to 200 kPa in a steady flow through a valve. The kinetic energy in the inlet and exit flow is the same. What is the exit temperature? **(6 M)**

2. A nozzle receives 0.1 kg/s steam at 1 MPa, 400°C with negligible kinetic energy. The exit is at 500 kPa, 350°C and the flow is adiabatic. Find the nozzle exit velocity and the exit area. **(6 M)**

3. A rigid container has 2 kg water at 300°C, 1200 kPa and is now cooled to a final pressure of 300 kPa. Find the final temperature, the work and the heat transfer in the process. **(6 M)**

4. A spherical balloon contains 4 kg of R-22 at 0°C, 21% quality. This system is heated until the pressure in the balloon reaches 800 kPa. For this process, it can be assumed that the pressure in the balloon is directly proportional to the balloon diameter. How does pressure vary with volume? Calculate the heat transfer and the work done for the process? **(8 M)**

PART C

1. An engine produces 15 MW with a thermal efficiency of 40%. The rejected heat is carried away by air which enters at 290 K and flows out at 800 K. How large a mass flow rate is required for this process? **(5 M)**
2. A steam turbine inlet is at 1200 kPa, 500 °C. The exit is at 200 kPa, 275 °C. What is the isentropic efficiency? **(5 M)**
3. A steam turbine inlet is at 1200 kPa, 500 °C. The actual exit is at 300 kPa with an actual work of 407 kJ/kg. Calculate the irreversibility and the second law efficiency? **(5 M)**
4. In a heat pump that uses R-134a as the working fluid, the R-134a enters the compressor at 150 kPa, −10 °C at a rate of 0.1 kg/s. In the compressor the R-134a is compressed in an adiabatic process to 1 MPa. Calculate the power input required to the compressor, assuming the process to be reversible. **(5 M)**
5. Ammonia is contained in a rigid sealed tank, unknown quality at 0 °C. When heated in boiling water to 100 °C its pressure reaches 1200 kPa. Find the initial quality, the heat transfer to the ammonia and the total entropy generation. **(7 M)**

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BITS-PILANI, DUBAI CAMPUS

DUBAI INTERNATIONAL ACADEMIC CITY

FIRST SEMESTER 2013-'14

COURSE: BITS F111 Thermodynamics

Test 2 (Open Book)

Max. Marks: 40 **Date: 10.11.2013**

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. Five kg water at 100kPa with a quality of 30% has its temperature raised 31°C in a constant volume process. Find (a) work done(b) heat transferred during this process? **(10 M)**

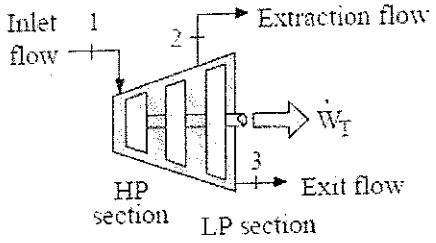
2. The average body temperature of a human rises by 2°C during strenuous exercise. Find the increase in the thermal energy content of a human body weighing 60 kg as a result of strenuous exercise, if the average specific heat of the human body is given to be 3.6 kJ/kg.°C. **(3 M)**

3. An insulated rigid tank initially contains 0.8 kg of helium at 25 °C and 300 kPa. A paddle wheel with a power rating of 0.02 kW is operated within the tank for 45 min. Determine

(a) The final temperature and (b) The final pressure of the helium gas **(7 M)**

4. A gas at an initial state of P_1 = 100kPa, V_1 = 1.5 m^3 and U_1 = 510kJ undergoes a compression process in a thermodynamic cycle with Pv = constant to P_2 =200 kPa,U_2= 690 kJ. Neglecting KE and PE changes, determine the heat interactions $Q_{1\text{-}2}$. **(6 M)**

5. Steam at 5 MPa, 350 °C enters a turbine with a volume flow rate of 10 m^3/s. An extraction of 20% of the inlet mass flow rate exits at 500 kPa, 250 °C. The rest exits the turbine at 25 kPa with a quality of 80%, and a velocity of 25 m/s. Determine the volume flow rate of the extraction flow and the diameter of the final exit pipe.



(7 M)

6. Steam at 1000 kPa, 200°C is used to heat cold water at 10 °C to 40 °C for domestic hot water supply. How much steam per kg liquid water is needed if the steam should not condense? **(7 M)**

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FIRST SEMESTER 2013-'14

COURSE: BITS F111 Thermodynamics

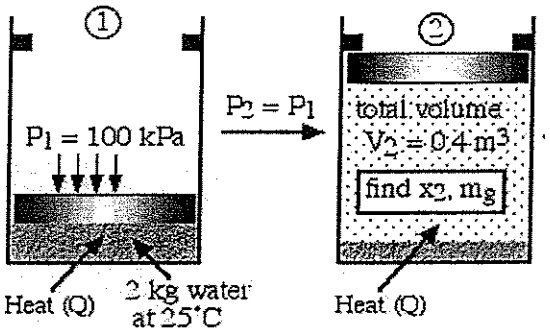
Test I (Closed Book)

Max. Marks: 50 **Date: 22.09.2013**

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. Two kilograms of water at 25°C placed in a piston cylinder device under 100 kPa pressure as shown in the diagram (State 1). Heat is added to the water at constant pressure until the piston reaches the stops at a total volume of 0.4 m^3 (State 2). Determine (a) the phase of water at state 1 & 2, (b) the quality & the mass of the vapor at state 2, (c) the temperature of water in state 2, (c) Plot the process in a P-v diagram. **(16 M)**



2. The main waterline into a tall building has a pressure of 500 kPa at 10 m elevation below ground level. How much extra pressure does a pump need to add to ensure a water line pressure of 300 kPa at the top floor 120 m above ground? **(6M)**

3. A vertical hydraulic cylinder has a 150 mm diameter piston with hydraulic fluid inside the cylinder and an ambient pressure of 100 kPa. Assuming standard gravity, find the piston mass that will create a pressure inside of 2000 kPa. **(6M)**

4. Water at 110 °C with a quality of 20% has its temperature raised to 140 °C in a constant volume process. What is the new quality and pressure? **(6M)**

5. A tank has two rooms separated by a membrane. Room A has 2 kg air and volume 1.5 m^3, room B has 1.75 m^3 air with density 0.8 kg/m^3. The membrane is broken and the air comes to a uniform state. Find the final specific volume of the air. **(6 M)**

6. What is the state and Pressure of water at 350 °C and 0.045 m^3/kg. Represent the state in a T-v, P-v and P-T diagram. **(10 M)**

BITS, PILANI – DUBAI CAMPUS
FIRST SEMESTER 2013 – 2014
First Year Sections 1, 2 & 3

Quiz 2 **A**

Course Code: BITS F111 Date: 07. 12 .2013 **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. An air conditioner discards 5 kW to the ambient with a power input of 2 kW. Find the rate of cooling and the coefficient of performance. **(3 M)**

2. Calculate the thermal efficiency of a Carnot cycle heat engine operating between reservoirs at 200 °C and 50 °C. **(2 M)**

3. Determine if the heat engine with $\dot{Q}_H = 6$ kW, $\dot{Q}_L = 0$ kW, $\dot{W} = 6$ kW, satisfies the first law and the second law. Justify.

(2 M)

4. A heat pump gives 4 kW to heat up a room with a power input of 1.5 kW. Find the coefficient of performance of the heat pump. **(2 M)**

5. An inventor has developed a refrigeration unit that maintains the cold space at −10°C, while operating in a 25°C room. A coefficient of performance of 8.5 is claimed. Evaluate the claim? **(3 M)**

6. An engine with efficiency 40 % utilizes 1.5 kg of fuel with calorific value 50 kJ/kg. How much work can be obtained? **(2 M)**

BITS, PILANI – DUBAI CAMPUS
FIRST SEMESTER 2013 – 2014
First Year Sections 1, 2 & 3

Quiz 1

A

Course Code: BITS F111 Date: 21. 10 .2013 **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

$[\sigma = 5.67 \times 10^{-8}\ W/m^2K^4]$

1. The air pressure in a 10 cm diameter piston/cylinder is limited to 500 kPa. If it has to deliver 3000 J of work to the piston rod how much distance should the piston move? **(2 M)**

2. A dynamo charges a battery of 6 volts and 2 amperes for 2 hours. Only 50 % of the work done by the dynamo is utilized, how much work the dynamo has to do? **(2 M)**

3. A piston/cylinder contains 1 kg water at 20°C with volume 0.1 m^3. By mistake someone locks the piston while the water is heated to saturated vapor. Find work done during this process.

(2 M)

4. A rigid tank contains an ideal gas at 350kPa and 40°C.A valve is opened and half of the mass is allowed to escape. If the final pressure in the tank is 250 kPa, find the final gas temperature in the tank. **(2 M)**

5. A balloon behaves so the pressure is $P = C\ V^{1/3}$, C = 100 kPa/m. The balloon is blown up with air from a starting volume of 1 m^3 to a volume of 3 m^3. Find the work done by the air. **(3 M)**

6. A radiant heating lamp has a surface temperature of 1500 K with $\varepsilon = 0.9$. How large a surface area is needed to provide 300 W of radiation heat transfer? **(3 M)**

7. A water-heater is covered up with insulation boards over a total surface area of 2 m^2. The inside board surface is at 80 ^{0}C and the outerside surface is at 25 ^{0}C and the board material has a conductivity of 0.09 W/m K. How thick a board should it be to limit the heat transfer loss to 300 W? **(2M)**