Mechanical Engineering Department, IIT Delhi

(MEL-140) **Engineering Thermodynamics** **(RRG)**
(OC category)

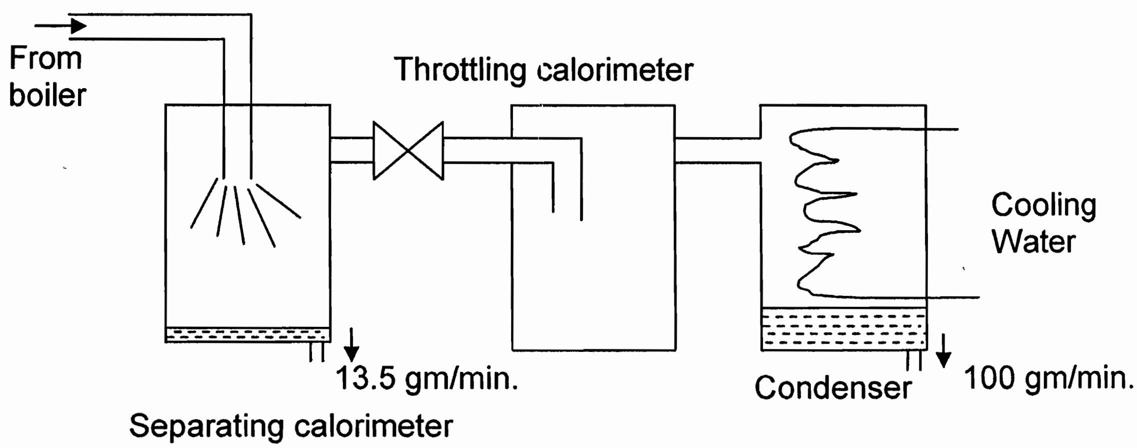
Major Test

Max. Marks: 80 **Date: 22-Nov., 2008**
Time: 3:30-5:30 PM

(Note: Use of Steam Tables is permitted)

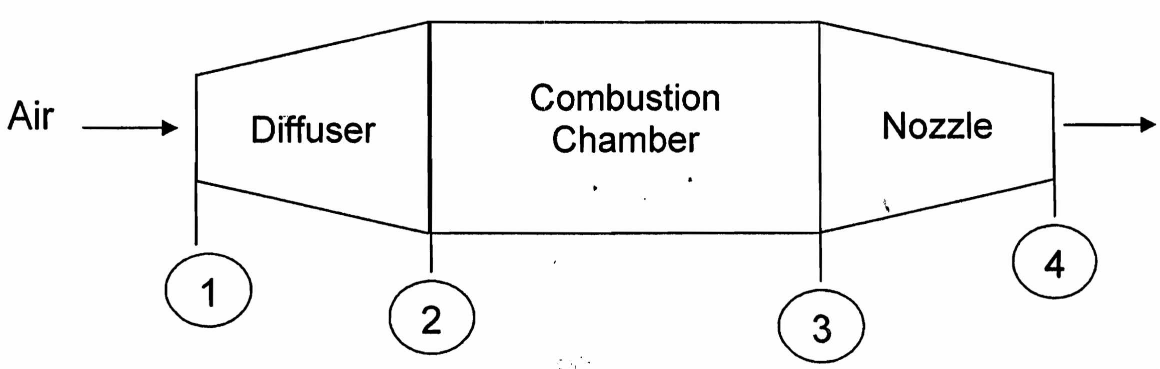
Q1 (a) With the help of p-v, T-v and p-T diagrams, show the behaviour of water in different phases and two-phase regions. Also, explain the significance of critical point. **(10)**

(b) In an experimental set up to measure dryness fraction, wet steam from a boiler operating at 11 bar pressure, is passed steadily through a separating calorimeter where, out of the liquid present in wet vapour, 13.5 gm/min liquid is separated out. The remaining vapour (which is still wet) is throttled in a throttling calorimeter to 1.0 bar and 110^{0}C. Subsequently, it is taken to a condenser, where it is fully condensed at the rate of 100 gm/min. Calculate the dryness fraction of steam coming out of the boiler and the dryness fraction just before throttling. What is the state of the fluid in throttling calorimeter? Sketch the above process on p-h diagram. **(10)**



Q2 (a) Explain the 'Air Standard Cycle' concept and its utility. **(4)**

(b) A booster-jet engine for aircraft consists of a diffuser, combustion chamber and a nozzle as shown below.



P.T.O.

At a given operating condition, 1.5 kg/sec of air flows steadily into the engine at inlet velocity of 210 m/s.

$p_1 = p_4 = 0.6$ bar, and $T_1 = 3^0C$
the pressure in the combustion chamber is constant, flow velocity negligible and the energy released due to combustion is equivalent to heat addition of 1200 kJ per kg of air. Calculate velocity at nozzle exit, outlet temperature T_4 and nozzle exit area. Sketch the whole process on p-v and T-s diagrams. **(16)**

Q 3 (a) What is the significance of 'Entropy'. Derive the principle of increase of entropy. **(8)**

(b) Show that, if two bodies of thermal capacity C_1 and C_2 at temperature T_1 and T_2 are brought to the same temperature T by means of a reversible heat engine, then

$$\ln T = \frac{C_1 \ln T_1 + C_2 \ln T_2}{C_1 + C_2}$$ **(4)**

(c) A vapour compression heat pump cycle is used to heat a room in winter. It uses water as a working fluid and operates between ambient temperature of 10^0C and room temperature of 30^0C. The fluid at the end of evaporator is saturated vapour and at the end of condenser before throttling, saturated liquid. Sketch the cycle on T-s and p-h diagrams and graphically show the work input to the compressor on both the diagrams. Also compute the Coefficient of Performance of the cycle. **(8)**

Q 4 (a) Clearly state the advantages of using **superheat** and **regeneration** with feedwater heaters over simple Rankine cycle. Sketch the system diagram as well as T-s diagram of typical vapour power cycle with superheat and regeneration with TWO feed water heaters. **(8)**

(b) In a Rankine cycle with superheat, steam at 5MPa and 500^0C is fed to turbine where it is expanded to a condenser pressure of 10 kPa. Find the thermal efficiency and specific steam consumption for this cycle. Compare efficiency of this cycle with Carnot cycle between the same temperature limits. **(12)**