Reg. No.										

MANIPAL UNIVERSITY

THIRD SEMESTER B.S. (ENGG.) DEGREE EXAMINATION – DECEMBER 2015
SUBJECT: PRINCIPLES OF THERMODYNAMICS – I (ME 231)
(BRANCH: MECHANICAL/IP)

Friday, December 11, 2015

Time: 10:00 – 13:00 Hrs. Max. Marks: 100

- **Answer any FIVE full questions.**
- **Use of Thermodynamic data handbook is permitted.**
- **Missing data if any may be suitably assumed.**

1A. Distinguish between the following:
   i) Microscopic and Macroscopic approaches
   ii) Path and Point Functions
   iii) Intensive and Extensive Properties

1B. The readings t_A and t_B of two thermometers A and B on the Celsius scale agree at the ice point and the steam point, and are assumed to be related by the expression $t_A = l + m\ t_B + n t_B^2$ where l,m,n are constants. When both thermometers are immersed in a well stirred oil bath, thermometer A reads 51°C and B reads 50°C. Determine the reading on thermometer A when thermometer B reads 25°C.

(12+8 = 20 marks)

2A. State the Zeroth Law of Thermodynamics. How do this forms the basis for temperature measurement?

2B. Show that heat and work are path functions.

2C. Gas from a cylinder of compressed helium is used to inflate an inelastic flexible balloon, originally folded completely flat, to a volume of 0.6 m^3. If the barometer reads 760mm Hg, what is the amount of work done upon the atmosphere by the balloon? Sketch the system before and after the process.

(6+8+6 = 20 marks)

3A. Explain the Joule's experiment for the 1st law of thermodynamics.

3B. Prove that the heat absorbed or rejected during a polytropic process is $\frac{\gamma - n}{\gamma - 1} \times Work\ done$, where γ is the ratio of specific heat and n is the polytropic index.

3C. In a centrifugal compressor, the suction and delivery pressures are 100 kPa and 550 kPa respectively. The compressor draws 15m^3/min of air which has a specific volume of 0.77m^3/kg. At delivery point, the specific volume is 0.20 m^3/kg. The compressor is driven by a 40kW motor and during passage of air through the compressor, the heat lost to the surroundings is 30 kJ/kg of air. Neglecting changes in PE and KE, make calculations for change in internal energy per kg of air.

(5+7+8 = 20 marks)

4A. State the mechanics and thermodynamics definition of work.

4B. List out the characteristics of a steady flow process.

4C. A system receives 200kJ of heat at constant volume and rejects 220 kJ of heat at constant pressure during which 40kJ of work is done on the system. The system is brought back to its original state by an adiabatic process. Calculate the adiabatic work. If the initial internal energy is 240 kJ, then calculate the value of internal energy at all states.

(6+5+9 = 20 marks)

5A. With the help of a neat sketch, explain the working principle of combined separating and throttling calorimeter.

5B. Explain the concept of triple point of water with the help P-T diagram.

5C. Determine the state of steam in the following cases:

i) Steam has a pressure of 10 bar and specific volume 0.175 m^3/kg

ii) Steam has a pressure of 15 bar and a temperature of 220°C.

iii) Steam has a pressure of 20 bar and if 2700 kJ/kg of heat is required to generate the steam from water at 0°C.

(8+6+6 = 20 marks)

6A. State the Kelvin-Planck and Clausius statements of the second law of thermodynamics and establish the equivalence between them.

6B. Derive the relationship between COP of refrigerator and heat pump.

6C. A heat engine is used to drive a heat pump. The heat transfers from the heat engine and the heat pump are used to heat the water circulating through the radiators of the building. The engine has thermal efficiency of 27% and the COP of the heat pump is 4. Determine the ratio of heat transfer to the circulating water to the heat supplied to the heat engine.

(8+6+6 = 20 marks)

7A. Prove that entropy is a property of the system.

7B. State and prove 'Clausius inequality'.

7C. A fluid undergoes reversible adiabatic compression from 0.5 MPa, $0.2m^3$ to $0.05m^3$ according to the law $pV^{1.3}$= constant. Determine the change in enthalpy, internal energy and entropy, and the heat transfer and work transfer during the process.

(6+6+8 = 20 marks)

8A. Show that for an ideal gas $C_p-C_v=R$.

8B. Show that for a reversible adiabatic process pv^{γ}= Constant.

8C. A constant volume chamber of $0.3m^3$ capacity contains 1kg of air at 5°C. Heat is transferred to the air until the temperature of air is 100°C. Find the work done, the heat transfer and change in internal energy, enthalpy and entropy. Take c_p=1.005 kJ/kg K, c_v=0.718 kJ/kgK

(6+9+5 = 20 marks)