Tutorial Sheet No. -1

Course: B.Tech. I[st] Year (All)

Subject: Basic Mechanical Engineering **Subject Code:** BME G0001

Semester: Odd/Even **Session:** 2020-2021

Q1. The temperature T on a thermometric scale is defined as T = (alnK)+b where a and b are constants. The values of K are found to be 1.83 and 6.78 at 0°C and 100°C respectively. Calculate the temperature for a value of K=2.42. **[Ans.: 21.33°C[**

Q2. The readings T_A and T_B of two thermometer of A and B agree at ice point and steam point and related by equation $T_A = mT_B + n\ T_B^2 + L$ between these temperature where L, m and n are constant both are immersed in oil A reads 51°C and B reads 50°C. Determine the reading on A, When B reads 25°C. Discuss which thermometer is correct. **[Ans.: m=1.04, n= -4 x 10^4 and T_A =25.75°C]**

Q3. To a closed system 150 kJ of work is supplied. If the initial volume is 0.6 m^3 and pressure of the system changes as p = 8 – 4V, where p is in bar and V is in m^3. Determine the final volume and pressure of the system. **[Ans.: V2=0.354 m^3, P2=6.584 x 10^5 Pa.]**

Q4. A fluid at a pressure of 3 bar, and with specific volume of 0.18 m^3/kg, contained in a cylinder behind a piston expands reversibly to a pressure of 0.6 bar according to a law, $p = C/v^2$ where C is a constant. Calculate the work done by the fluid on the piston. **[Ans.: W = 29840 Nm/kg]**

Q5. A person starts a 60 W table fan in an insulated room of volume 86.4m^3. The person expects to cool the room from 32°C (pressure = 100 kPa) and allows the fan to rotate for 4 hours. What will be the temperature of the room after 4 hours? **[Ans.: increased by 12°C]**

Q6. A certain balloon maintains an internal gas pressure of P_o = 100 kPa until the volume reaches V_o = 20 m^3. Beyond a volume of 20 m^3, the internal pressure varies as $P = P_o + 2(V - V_o)2$, where P is in kPa and V is in m^3. Initially the balloon contains helium gas at 20°C, 100 kPa with a 15 m^3 volume. The balloon is then heated until the volume becomes 25 m^3 and the pressure is 150 kPa. Assume ideal gas behaviour for helium. Calculate: (a) Final temperature of the balloon in K. (b) The work done by the balloon for the entire process in kJ. **[Ans.: 733 K, 1083 kJ]**

Q7. A fluid system, contained in a piston and cylinder machine, passes through a complete cycle of four processes. The sum of all heat transferred during a cycle is – 340 kJ. The system completes 200 cycles per minute. Complete the following table showing the method for each item, and compute the net rate of work output in kW.

Process	**Process**	**W (kJ/min)**	**ΔE (kJ/min)**
1-2	0	4340	…………
2-3	42000	0	…………
3-4	-4200	…………	-73200
4-1	…………	…………	…………

Ans.

Process	**Process**	**W (kJ/min)**	**ΔE (kJ/min)**
1-2	0	4340	**-4340**
2-3	42000	0	**42000**
3-4	-4200	**69000**	-73200
4-1	**-105800**	**-141340**	**35540**

Q8. An imaginary engine receive heat and perform work on slowly moving piston at such a rate that the cycle of operation of 1Kg of working fluid can representing as cycle of 10 cm dia on PV diagram. The scale is 1 cm is equal to 300 KPa on Y axis and 1cm is equal to 0.1 m^3 on X axis. Find the net work done. **[Ans. 2356.19 kJ]**

Q9. An engine cylinder has a piston of area 0.12 m^3 and contained gas at a pressure of 1.5MPa.The gas expands according to a process which represented by inclined straight line on P-V diagram. The final pressure is 0.15MPa. Calculate the work done by the gas on the piston if the stroke length is 0.30m. **[Ans. -29.4 MJ]**

Q10. A fluid system undergoes a non-flow frictionless process following the Pressure-volume relation as $p = (5/V) + 1.5$ where p is in bar and V is in m^3. During the process the volume changes from 0.15 m^3 to 0.05 m^3 and the system rejects 45 kJ of heat. Determine (i) Change in internal energy (ii) Change in enthalpy. **[Ans. Change in internal energy = 519 kJ, Change in enthalpy=504 kJ]**

Q11. The properties of a system, during a reversible constant pressure non-flow process at p = 1.6 bar, changed from V_1 = 0.3 m^3/kg, T_1 = 20°C to V_2 = 0.55 m^3/kg, T_2 = 260°C. The specific heat of the fluid is given by Cp=1.5+(75/(T+45)) kJ/kg°C, where T is in °C. Determine: (i) Heat added/kg; (ii) Work done/kg; (iii) Change in internal energy/kg; (iv) Change in enthalpy/kg.
[Ans.: Heat added = 475.94 kJ/kg, Work done = 40 kJ/kg, Change in internal energy =435.94 kJ/kg, Change in enthalpy=475.94 kJ/kg]

Q12. 0.2 m^3 of air at 4 bar and 130°C is contained in a system. A reversible adiabatic expansion takes place till the pressure falls to 1.02 bar. The gas is then heated at constant pressure till enthalpy increases by 72.5 kJ. Calculate: (i) The work done; (ii) The index of expansion, if the above processes are replaced by a single reversible poly-tropic process giving the same work between the same initial and final states take C_p = 1 kJ/kg K, C_v= 0.714 kJ/kg K.
[Ans. work done = 85454 Nm or J, value of index = 1.062]

Q13.1 kg of ethane (perfect) gas is compressed from 1.1 bar, 27°C according to a law $pV^{1.3}$ = constant, until the pressure is 6.6 bar. Calculate the heat flow to or from the cylinder wall. Given: Molecular weight of ethane = 30, C_p = 1.75 kJ/kg K. **[Ans. Heat supplied = 84.5 kJ/kg]**

Q14. 0.1 m^3 of an ideal gas at 300 K and 1 bar is compressed adiabatically to 8bar. It is then cooled at constant volume and further expanded isothermally so as to reach the condition from where it started. Calculate: (i) Pressure at the end of constant volume cooling. (ii) Change in internal energy during constant volume process. (iii) Net work done and heat transferred during the cycle. Assume C_p = 14.3 kJ/kg K and C_v = 10.2 kJ/kg K. **[Ans. (i) p_3: =4.4 bar (ii) – 20.27 kJ. (iii) – 5.45 kJ]**

Q15. The following is the equation which connects u, p and v for several gases u = a + bpv, where a and b are constants. Prove that for a reversible adiabatic process, pv^{γ} = constant, where γ= b+1/b.

Q16. An ideal gas is heated at constant volume until at its temperature is 3 times the original temperature then it is expanded isothermally till it reaches its original pressure the gas is then cold at constant pressure till it is rested to the original state determine (i) Net work done per kg of gas its initial temperature is 350 k expresses your answer in terms of gas constant R. **[Ans. W= 453 R]**

Q17. 3 kg of air is kept at an absolute pressure of 100kPa and temp. Of 300 K is compressed polytropically until pressure and temperature became 1500 kPa and 500K resp. Evaluate the polytropic exponent, the final volume, the work transfer of compression and heat interaction.
[Ans.: 1.232, .287 m^3, -742.241KJ, -311.741 KJ.]

Q18. A spherical balloon of 1 m diameter contains a gas at 150 kPa the gas inside the balloon is heated until pressure reaches 450 kPa during the process of heating the pressure of gas inside the balloon is proportional to cube of the diameter of balloon find the work done by gas inside the balloon.
[Ans.: W = 314 KJ]

Q19. In a gas turbine gas enters at the rate of 5 m/sec with a velocity of 50 m/sec and enthalpy of 900 kJ/kg and leaves the turbine with a velocity of 150 m/sec and enthalpy of 400 kJ/kg. The loss of heat from the gases to the surrounding is neglected. Assume for gas R=0.285 kJ/kg-K, C_p = 1.004 kJ/kg-K. Determine the power output of the turbine. **[Ans: 2450 kW]**

Q20. In the converging nozzle gas enter with negligible velocity and enthalpy of 800 kJ/kg and leaves with enthalpy of 350 kJ/kg. What is the velocity of gas at the outlet of the nozzle?
[Ans: 948.68 m/sec]

Q21. Air enters in a gas turbine system with a velocity of 105 m/sec and has a specific volume of 0.8m^3/kg. The inlet area of gas turbine system is 0.05 m^2. At exit the air has a velocity of 135 m/sec and a specific volume of 1.5 m^3/kg. In its passage through turbine system the specific enthalpy of air is reduced by 145 kJ/kg and the air also has heat transfer loss of 20 kJ/kg. Determine (a.) Mass flow rate of air through the turbine system in kg/sec (b.) The exit area of turbine system in m^2 (c.) The power developed by the turbine system in kW **[Ans: 6.56 kg/sec, 0.0729 m^2, 907.5 kW]**

Q22. Air flows steadily at the rate of 0.5 kg/s through an air compressor, entering at 7 m/s velocity, 100 kPa pressure and 0.95 m^3/kg volume, and leaving 5 m/s, 700 kPa, and 0.19 m^3/kg. The internal energy of the air leaving is 90kJ/kg greater than that of the air entering. Cooling water in the compressor jackets absorbs heat from the air at the rate of 58 kW. (a) Compute the rate of shaft work input to the air in kW. (b) Find the ratio of the inlet pipe diameter to outlet pipe diameter. **[Ans: 122 kW, ($\mathbf{d1/d2}$ = 1.89)]**

Q23. An axial flow compressor of a gas turbine plant receives air from atmosphere at a pressure 1 bar, temperature 300 K and velocity 300 m/sec. At the discharge of compressor, the pressure is 5 bar and the velocity is 100 m/sec. The mass flow rate through the compressor is 20 kg/sec. Assuming adiabatic compression, calculate the power required to drive the compressor. Also calculate the inlet and outlet pipe diameter. **[Ans: -3584.41 kW, 0.604 m, 0.263 m]**