MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293
Website: www.must.ac.ke Email: info@mucst.ac.ke

UNIVERSITY EXAMINATIONS 2023/2024

DIPLOMA IN AUTOMOTIVE/ELECTRICAL/MECHATRONICS/ MECHANICAL PLANT/MECHANICAL TECH.

ENG/05/MPE/CC/04/6/B: APPLY THERMODYNAMICS PRINCIPLES

DATE: APRIL 2024 **TIME: 3 HOURS**

INSTRUCTIONS: Answer All questions.

SECTION A (40 MARKS)

1. Define the following terms as used in thermodynamics;
   a. Thermodynamics (2 Marks)
   b. Heat engine (2 Marks)
   c. Thermal equilibrium (2 Marks)
2. Unit mass of a fluid at a pressure of 3 bar, and with a specific volume of 0.18m^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 during the process.(4 Marks)
3. Unit mass of a certain fluid is contained in a cylinder at an initial pressure of 20 bar. The fluid is allowed to expand reversibly behind a piston according to a law pV2 =constant until the volume is doubled. The fluid is then cooled reversibly at constant pressure until the piston regains its original position; heat is then supplied reversibly with the piston firmly locked in position until the pressure rises to the original value of 20 bar. Calculate the net work done by the fluid, for an initial volume of 0.05 m3 (6 Marks)

4. Define the principle of conservation of energy. (2 Marks)
5. Define the following terms as used for steam (4 Marks)
   a. wet steam
   b. degree of superheat
6. A vessel of 0.3 rn^3 capacity contains a mixture of air and steam which is 0.75 dry. If the Pressure is 7 bar and the temperature is 116.9^0 C. Calculate the mass of water present, the mass of dry saturated vapour, and the mass of air. (4 Marks)
7. Air at 1.02 bar, 22 0C, initially occupying a cylinder volume of 0.015m3 , is compressed reversibly and adiabatically by a piston to a pressure of 6.8 bar. Calculate the final temperature, the final volume, tand the work done on the mass or air in the cylinder. (4 Marks)
8. Define non-flow equations and explain their significance in analysing closed systems.
9. Explain the difference between an open system, a closed system, and an isolated system in thermodynamics. Provide examples of each. (3 Marks)
10. Using a p-v diagram. Illustrate the concept of reversible and irreversible processes in thermodynamics (4 Marks)

SECTION B – Long Answer Questions – Answer Any Questions. (60 MARKS)

11. a. Air at 20 bar is initially contained in a vessel the volume of which can be assumed to be $1m^3$. The valve is opened and the air expands to fill another adjacent vessel. Assuming that the vessels are of equal volume, calculate the final pressure of the air. (8 Marks)
    b. Air at 1.02 bar, 22^0C, initially occupying a cylinder volume of $0.015m^3$, is compressed reversibly and adiabatically by a piston to a pressure of 6.8 bar. Calculate the final temperature, the final volume, and the work done on the mass or air in the cylinder. (12 Marks)
12. a. Steam at 150 bar has a specific enthalpy of 3309 kJ/kg. Calculate the temperature, the specific volume, and the specific internal energy. (6 Marks)
    b. A perfect gas has a molar mass of 26 kg/kmol and a value of γ=l .26. Calculate the heat rejected:
       i. when unit mass of the gas is contained in a rigid vessel at 3 bar and 315^0 C, and is then cooled until the pressure falls to 1.5 bar; (7 Marks)

ii. when unit mass flow rate of the gas enters a pipe tine at 280^0 C, and flows steadily to the end of the pipe where the temperature is 20^0C. Neglect changes in velocity of the gas in the pipeline. (7 Marks)

13. a. Derive the steady flow equation (10 Marks)

b. A certain perfect gas of mass 0.01 kg occupies a volume of 0.003 m^3 at a pressure of 7 bar and a temperature of 131^0 C. The gas is allowed to expand until the pressure is 1 bar and the final volume is 0.02 m^3 . Calculate:

i. the molar mass of the gas; (5 Marks)

ii. the final temperature. (5 Marks)

14. a. In a gas turbine unit, the gases flow through the turbine is 15 kg/s and the power developed by the turbine is 12000 kW. The enthalpies of the gases at the inlet and outlet are t 1260 Kj/Kg and 400 kj/kg respectively and the velocities of gases at the inlet and outlet are 50m/s and 110 m/s respectively. Calculate;

i. The rate at which heat is rejected to the turbine (7 Marks)

ii. The area of the inlet pipe given that the specific volume of the gases at the inlet is 0.45 m3/kg. (7 Marks)

2. b. Ikg of air enclosed in a rigid container initially at 4.8 bar and 15^0C.The container is heated until the temperature is 200^0c. Calculate the pressure of the air finally and the heat supplied during the process. (6 Marks)