MUEO

MOI UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR
(ACADEMICS, RESEARCH & EXTENSION)

UNIVERSITY EXAMINATIONS
2016/2017 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER EXAMINATION
FOR THE DEGREE OF
BACHELOR OF ENGINEERING
IN
MECHANICAL & PRODUCTION ENGINEERING

COURSE CODE: MPE 272

COURSE TITLE: THERMODYNAMICS I

DATE: 21ST JUNE, 2017 **TIME:** 2.00 P.M. – 5.00 P.M.

INSTRUCTION TO CANDIDATES

- THIS PAPER CONTAINS SEVEN (7) QUESTIONS
- ANSWER ANY FIVE (5) QUESTIONS
- ALL QUESTIONS CARRY EQUAL MARKS
- STEAM TABLES PROVIDED

QUESTION ONE

a) Starting with the Non-Flow-Energy-Equation (NFEE), show that, for a closed system, the heat transfer during a constant pressure process is given by the expression:

$$Q = (h_2 - h_1)$$ **[4 marks]**

b) Steam at a pressure of 30 bar and at a temperature of 375°C is isentropically expanded to a pressure of 4 bar. It is then reheated at constant pressure until it has a temperature of 300°C. It is then further isentropically expanded to a pressure of 0.14 bar. Determine:

i. The condition of the steam after both expansions.

ii. The heat transfer/kg steam for the constant pressure reheat. **[10 marks]**

QUESTION TWO

a) Briefly describe the terms "thermodynamic property", "system", "boundary" and "surroundings" as they are used in thermodynamics. **[4 marks]**

b) When a certain perfect gas is heated at constant pressure from 15°C to 105°C, the heat required is 468 kJ/kg. When the same gas is heated at constant volume between the same temperatures, the heat required is 380 kJ/kg. Calculate c_p, c_v, R and the relative molecular mass of the gas. **[10 marks]**

Take universal gas constant $\bar{R} = 8.3145 kJ/Kmol\ K$

QUESTION THREE

a) Describe two conditions that must be met for a process to be reversible and explain two phenomena which, when present, will make the process irreversible. **[4 marks]**

b) A mass of 0.12 kg of steam initially saturated at 10 bar expands reversibly in a cylinder until the pressure is 1 bar. The volume is then found to be 0.17 m^3. Assuming that the process is polytropic, determine:

i. The polytopic index.

ii. Work done

iii. The heat transferred. **[10 marks]**

QUESTION FOUR

a) For a perfect gas undergoing a polytropic process, show that the relationship between the initial and final temperatures and pressures can be given by the expression:

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}$$ **[5 marks]**

b) Steam enters a turbine at the rate of 12 kg/s with an initial pressure and temperature of 3 bar and 150°C, respectively. If the final pressure is 0.8 bar and the isentropic efficiency of the turbine is 0.85, determine:

i. The power developed

ii. The change in entropy between inlet and outlet. **[9 marks]**

QUESTION FIVE

a) Describe what you understand by the term "Perpetual motion machine of the second kind" and explain how it contradicts the second law of thermodynamics **[4 marks]**

b) A fluid expands from 3 bar to 1 bar in a nozzle. The initial velocity is 90 m/s, the initial temperature is 150°C, and the isentropic efficiency is 0.90, calculate the final velocity when the fluid is:

i. Steam

ii. Air. **[10 marks]**

QUESTION SIX

a) Two heat engines work in series between a hot temperature reservoir of 900°C and a cold temperature reservoir at 150°C. Deriving any expression used, determine the intermediate temperature when the engines have the same work output **[6 marks]**

b) Air passes through a gas turbine system at the rate of 5 kg/s. It enters the turbine system with a velocity of 95 m/s and a specific volume of 0.9 m^3/kg. It leaves the turbine system with a specific volume of 1.5 m^3/kg. The exit area of the turbine system is 0.04 m^2. In its passage through the turbine system, the specific enthalpy of the air is reduced by 210 kJ/kg and there is a heat transfer loss of 45 kJ/kg. Determine:

i. The inlet area of the turbine,

ii. The exit velocity of the air,

iii. The power developed by the turbine system in kW. **[8 marks]**

QUESTION SEVEN

a) State the assumptions made when deriving the steady flow energy equation. **[4 marks]**

b) Describe what you understand by the terms "adiabatic process" and "isothermal process". **[2 marks]**

b) Air, initially at 130°C and 1 bar, is compressed reversibly and isothermally to a state where the specific volume is 0.5 m^3/kg. Determine:

i. The change in internal energy.

ii. The change of entropy.

iii. The heat transfer.

iv. The work transfer **[8 marks]**