MACHAKOS UNIVERSITY

University Examinations 2023/2024

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 211: ENGINEERING THERMODYNAMICS 1

DATE: **TIME:**

INSTRUCTIONS

1. ***This paper contains FIVE questions.***
2. ***Question ONE is compulsory and carries 30 marks.***
3. ***Four remaining questions carry 20 marks each.***
4. ***Attempt Question ONE and any other TWO.***

QUESTION ONE (30 MARKS)

a) Define the following terms as used in thermodynamics

(i) Thermodynamic system **(1 Marks)**

(ii) Thermodynamic property **(1 Marks)**

(iii)Working fluid **(1 Marks)**

(iv) Dryness fraction **(1 Marks)**

(v) Internal energy **(1 Marks)**

b) A certain fluid at 10 bar is contained in a cylinder behind a piston, the initial volume being $0.005\ m^3$. Calculate the work done by the fluid when it expands reversibly according to a law, $p = \frac{A}{V^2} - \frac{B}{V}$, to a final volume of $0.1\ m^3$ and a final pressure of 1 bar. Where **A** and **B** are constants

(8 Marks)

c) In the steam plant represented by Figure 1(c) the turbine develop $1500\ kW$. The heat supplied to the steam in the boiler is $3200\ kJ/kg$ and the heat rejected by the steam to

the cooling water in the condenser is $2500\ kJ/kg$ and the feed pump work required to pump back the condensate into the boiler is $10\ kW$. Calculate the mass flow rate of the steam. **(4 Marks)**

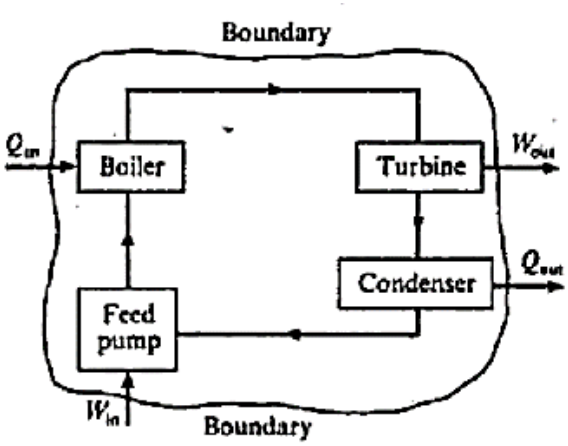

Figure 1(c)

d) Find the temperature, specific volume, internal energy and enthalpy of dry saturated steam at 9.8 bar. **(8 Marks)**

e) Show that the work done by a perfect gas undergoing a reversible adiabatic process is given by:

$$= \frac{p_1 v_1 - p_2 v_2}{\gamma - 1}$$

(5 Marks)

QUESTION TWO (20 MARKS)

a) Show that the specific heats of at constant volume c_v and constant pressure c_p can be related using the following equation:

$c_v + R = c_p$ **(9 Marks)**

b) A turbine operating under steady flow conditions receives steam at the following state: pressure 13.8 bar; specific volume, 0.143 m^3/kg; specific internal energy, 2590 kJ/kg; velocity, 30 m/s. The state of the steam leaving the turbine is as follows: pressure, 0.35 bar; specific volume, 4.37 m^3/kg; specific internal energy, 2360 kJ/kg; velocity, 90 m/s. Heat is rejected to the surroundings at the rate of 0.25 kW and the rate of steam flow through the turbine is 0.38 kg/s. Calculate the power developed by the turbine

(11 Marks)

QUESTION THREE (20 MARKS)

a) Steam at $7\ bar$, dryness fraction 0.9, expands reversibly at constant pressure until the temperature is 200^oC. Calculate:

(i) Work done by the system **(7 Marks)**

(ii) Heat supplied into the system **(6 Marks)**

b) $0.9\ kg$ of nitrogen gas (molar mass $28\ kg/kmol$) is compressed reversibly and isothermally from a pressure of $1.01\ bar$ and temperature 20^oC to a pressure of $4.2\ bar$. Calculate:

i. The work done by nitrogen **(5 Marks)**

ii. The heat flow during the process **(2 Marks)**

QUESTION FOUR (20 MARKS)

a) 1 kg of steam at $100\ bar$ and $375°C$ expands reversibly in a perfectly thermally insulated cylinder behind a piston until the pressure is $38\ bar$ and the steam is then dry saturated. Calculate the work done. **(7 Marks)**

b) A perfect gas has a molar mass of $26\ kg/mol$ and a value of $\gamma = 1.26$. Calculate the heat rejected:

(i) When a unit mass of the gas is contained in a rigid vessel at $3\ bar$ and $315°C$, and is then cooled until the pressure falls to $1.5\ bar$ **(7 Marks)**

(ii) When a unit mass flow rate of the gas enters a pipeline at $280°C$, and flows steadily to the end of the pipeline where the temperature is $20°C$. Neglect the changes in velocities of the gas in the pipeline. Take $R_o = 8314.15\ Nm/mole.K$ **(6 Marks)**

QUESTION FIVE (20 MARKS)

a) A certain fluid is heated at constant pressure of $2.0 \times 10^5\ N/m^2$ to final volume of $0.070\ m^3$. If the mass of the fluid is $0.06\ kg$, calculate the heat supplied:

(i) If the fluid is air initially at $130°C$ **(6 Marks)**

(ii) If the fluid is steam initially dry saturated **(8 marks)**

b) Air is expanded reversibly behind a piston according to a law $PV = constant$. If the final volume is twice the initial volume and the work done on the fluid during expansion

is $34{,}7 \times 10^3\ Nm$, determine the initial volume and pressure. Take the final volume as $0.1\ m^3$ **(6 Marks)**