MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SPECIAL/SUPPLIMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 203: ENGINEERING THERMODYNAMICS 1

DATE: 23/3/2021 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

This paper contains FIVE questions.

Question ONE is compulsory and carries 30 marks.

Four remaining questions carry 20 marks each.

Attempt Question ONE and any other TWO.

QUESTION ONE (30 MARKS)

a) Distinguish between an open and a closed system (2 marks)

b) Define the first law of thermodynamics (2 marks)

c) A fluid of volume $0.05\ m^3$ is contained behind a piston at a pressure of $1.0 \times 10^6\ N/m^2$. After a reversible expansion at constant pressure, the final volume is $0.2\ m^3$. Calculate the work done by the fluid. (4 marks)

d) A mass of gas flows through a gas turbine unit at a constant rate of $18\ kg/s$ and develops $15000\ kW$. The enthalpies of the gasses at inlet and outlet are $1250\ kJ/kg$ and $400\ kJ/kg$ respectively, and the velocities of the gases at inlet and outlet are $60\ m/s$ and $150\ m/s$ respectively

i. Calculate the rate at which heat is rejected from the turbine (8 marks)

ii. Find the area of the inlet pipe (2 marks)

e) Show that for a polytropic process,

$W = \frac{p_1 v_1 - p_2 v_2}{n-1}$ (6 marks)

f) Why is the perpetual motion machine of the first kind an impossibility? (1 mark)

g) Define a heat engine and give 4 examples of practical heat engines (3 marks)

h) What is availability? (2 marks)

QUESTION TWO (20 MARKS)

a) At the beginning of a reversible expansion according to a linear law, the fluid behind a piston exerts a force of $8\ kN$ on the piston. The expansion causes the volume to increase from $0.05\ m^3$ to $0.2\ m^3$. If the effective cross-sectional area and the final pressure are $0.008\ m^3$ and $200\ kN/m^3$ respectively, calculate the work done on the fluid. (11 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 $0.1\ m^3$. (9 marks)

QUESTION THREE (20 MARKS)

A mass of air flows steadily through an air compressor at the rate of $0.35\ kg/s$. It enters at a velocity of $6.2\ m/s$, a pressure of $1 \times 10^5\ N/m^2$ and a specific volume of $0.80\ m^3/kg$ and leaves at a velocity of $4.2\ m/s$, a pressure of $7.0 \times 10^5\ N/m^2$ and a specific volume of $0.15\ m^3/Kg$. The internal energy of air leaving is $90\ kJ/kg$ greater than that of the air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of $60\ kJ/s$. Calculate:

a) The power required to drive the compressor (15 marks)

b) The area of cross-section of the inlet pipe (3 marks)

c) The area of cross-section of the outlet pipe (2 marks)

QUESTION FOUR (20 MARKS)

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 and the work done when the fluid is:

a) Air initially at $130°C$ (9 marks)

b) Steam initially dry saturated (11 marks)

QUESTION FIVE (20 MARKS)

Steam at a pressure of $7.0 \times 10^6\ N/m^2$ and temperature $300°C$ contained in a rigid cylinder of volume $0.02m^3$. The cylinder is cooled until the final pressure is $4.0 \times 10^6\ N/m^2$. Determine the state of the steam after cooling and the amount of heat rejected by the steam. Sketch the process on a T-s diagram, indicating the area which represents the heat flow.