MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 203: ENGINEERING THERMODYNAMICS 1

DATE: 27/9/2019 **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) With the aid of a sketch, differentiate between a thermodynamic system, a boundary and a surrounding **(4 Marks)**

(b) List 3 characteristics of a reversible process **(3 Marks)**

(c) State the law of conservation of energy **(1 Mark)**

(d) Derive the steady flow energy equation **(7 Marks)**

(e) A volume of air of internal energy 400 kJ/kg is expanded in the cylinder of an air motor to a final internal energy of 180 kJ/kg. Calculate the heat flow to or from the cylinder when the work done by air during the expansion is 80 kJ/kg **(3 Marks)**

(f) Show that for an isobaric process, $Q = h_2 - h_1$ **(5 Marks)**

(g) Differentiate between the Clausius and the Kelvin Planck statements of the second law of thermodynamics **(2 marks)**

(h) What is the perpetual motion machine of the second kind? **(1 Mark)**

(i) What is the highest possible theoretical efficiency of a heat engine operating with a hot reservoir of hot gasses at 2000°C when the cooling water available is at 10°C? **(4 Marks)**

QUESTION TWO (20 MARKS)

(a) A mass of gas flows through a gas turbine unit at a rate of $20\ kg/s$ and develops $16000\ kW$. The enthalpies of the gases at inlet and outlet are $1100\ kJ/kg$ and $300\ kJ/kg$ respectively, and the velocities of the gases at inlet and outlet are $70\ m/s$ and $130\ m/s$ respectively.

(i) Calculate the rate at which heat is rejected from the turbine **(8 Marks)**

(ii) Find the area of the unlet pipe (take the specific volume of the gases at inlet as $0.3\ m^3/kg$) **(2 Marks)**

(b) At the beginning of a reversible expansion according to a linear law, the fluid behind a piston exerts a force of $10\ kN$ on the piston. The expansion causes the volume to increase from $0.07\ m^3$ to $0.3\ m^3$. If the effective cross sectional area and the final pressure are $0.01\ m^3$ and $220\ kN/m^3$ respectively, calculate the work done on the fluid. **(10 Marks)**

QUESTION THREE (20 MARKS)

(a) A certain perfect gas has specific heat capacities as follows: $c_v = 0.657\ kJ/kg.K$ and $c_p = 0.846\ kJ/Kg.K$. Calculate the gas constant and the molar mass of the gas **(6 Marks)**

(b) A perfect gas has a molar mass of 26 kg/kmol and a value $\gamma = 1.26$. Calculate the heat rejected when the unit mass of the gas is contained in a rigid vessel at 3 bar and 315°C and is then cooled **(14 Marks)**

QUESTION FOUR (20 MARKS)

(a) Plot and label the P-V diagram of a vapour working fluid **(3 Marks)**

(b) Steam is expanded isothermally and reversibly behind a piston from a pressure of $6 \times 10^5 N/m^2$ and a dryness fraction 0.92 to a pressure of $1.5 \times 10^5\ N/m^2$. The heat supplied is $420\ kJ/kg$. Calculate the change in enthalpy and the work done per kg of steam. **(17 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. **(20 Marks)**