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

MED-PR 204: THERMODYNAMICS I

DATE: 26/9/2019 **TIME: 11.00-1.00 PM**

INSTRUCTIONS:

Answer question one (compulsory) and any other <u>TWO</u> questions

1. a) i) Define the following terminologies as used in applied thermodynamics;
   a) System.
   b) Phase.
   c) Boundary
   d) Enthalpy
   e) Thermalstatic property (5 marks)

   ii) A fluid at a pressure of 3 bar and with 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, $P = \frac{C}{V^2}$ where C is a constant. Calculate the work done by the fluid on the piston. (5 marks)

   iii) At a speed of 50km/h, the resistance to motion of a car is 900N. Neglecting losses, what is the power output of the engine of the car (3 marks)

   b) i) From first principles and with aid of a sketch derive the steady flow energy equation. (6 marks)

ii) During the working stroke of an engine the heat transferred out of the system was 150kj/kg of working substance. The intrinsic energy also decreased by 400kj/kg of working substance. Determine the work done and state whether it is work done on or by the engine. (4 marks)

iii) Lead is extruded slowly through a horizontal die. The pressure difference across the die is 154.45MN/m^2. Assuming that there is no cooling through the die, determine the temperature rise of the lead. Assume the lead is incompressible and to have a density of 11360kg/m^3 and a specific heat capacity of 130kJ/KgK. (5 marks)

c) It is impossible to have an engine having the perpetual motion of the first kind. Explain. (2 marks)

2 a) i) State the following Laws as used in Applied Thermodynamics

a) Boyles Law.

b) Charles Law. (2 marks)

ii) Show from the first principles that the specific heat capacity of a gas at a constant pressure is given by

$$C_P=\frac{R\gamma}{\gamma-1}$$

Where R is the specific gas constant

γ is the adiabatic index (8 marks)

iii) A certain perfect gas has a molecular weight of 26kg/Kmol and a value of γ= 1.26. Calculate the heat rejected per kg of gas;

(i) When the gas is contained in a rigid vessel at 3 bar and 315^{0}c and is then cooled until the pressure falls to 1.56 bar.

(ii) When the gas enters the pipe line at 280^{0}c and flows steadily to the end of the pipe where the temperature is 20^{0}c.Neglect velocity changes in the pipeline. (7 marks)

3 a) Define the following terms as used in thermodynamics

i) two phase fluid

ii) saturated steam

iii) dry steam

iv) dry fraction (4 marks)

b) Steam 0.95 dry at a pressure of 0.7MN/m^2 is supplied to a heater through a pipe of 25mm internal diameter, the velocity of the steam in the pipe being 12m/s. water enters the heater at 20^0c, the steam is blown into it and the mixture of water and condensate leaves the heater at 90^0c. Calculate

i) the mass of the steam entering the heater in kg/h (8 marks)

ii) the mass of water entering the heater in kg/h (8 marks)

4. A nozzle is a device for increasing the velocity of a steadily flowing stream of fluid. At the inlet to a certain nozzle the enthalpy of fluid is 3025kJ/kg and the velocity is 60m/s. At the exit from the nozzle, the enthalpy is 2790 kJ/kg. The nozzle is horizontal and there is negligible heat loss from it.

a) Find the velocity at the nozzle exit (6 marks)

b) If the area is 0.1m^2 and the specific volume at inlet is 0.19m^3/kg, find the rate of fluid flow (8 marks)

c) If the specific volume at the nozzle exit is 0.5m^3/kg, find the exit area of the nozzle. (6 marks)

5. 0.05 kg of CO_2 (molar mass 44kg/mol), occupying a volume of 0.03m^3 at 1.025 bar, is compressed reversibly until the pressure is 6.15 bar. Calculate the final temperature, the work done on the CO_2 and the heat flow to or from the cylinder walls,

a) When the process is according to the law $pv^{1.4}$=c,

b) When the process is isothermal,

c) When the process takes place in a perfectly thermally insulated cylinder.

(assume CO_2 to be a perfect gas and take γ=1.3) (20 marks)