MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR FIRST SEMESTER EXAMINATION FOR BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

SUPPLIMENTARY EXAMINATION

EMM 203: ENGINEERNG THERMODYNAMICS I

DATE: **TIME:**

INSTRUCTIONS

i. This Paper Contains **<u>Five</u>** Questions
ii. Question one is Compulsory and carries **30 marks**
iii. All the other Questions Carry **20 marks** each
iv. Attempt **Question One** and **Any other Two** Questions
v. Steam tables are provided for use

QUESTION ONE (30 MARKS)

a) Differentiate between a closed system and an open system. (2 marks)

b) Using a neat diagram of a piston moving from point 1 to 2, show that the work done is given by; $W = \int_1^2 pdv$. (5 marks)

c) With the aid of neat diagrams of thermodynamic-property relations, define the following non-flow processes for a perfect gas; isobaric and isometric processes. (4 marks)

d) 0.05 kg of steam at 15 bar is contained in a rigid vessel of volume 0.0076 m^3. Determine the temperature of the steam. If the vessel is cooled until the pressure in the vessel is 11 bar, calculate the dryness fraction of the steam and the total heat rejected. (6 marks)

e) Determine the temperature and enthalpy of dry saturated steam at 9.8 bars. (4 marks)

f) The turbine of a steam power plant operating in a closed cycle develops 1000kW. The heat supplied to the steam in the boiler is 2800 kJ/kg, heat rejected by the system to the cooling water in the condenser is 2100 kJ/kg and feed pump work required to pump the condensate back into the boiler is 5kW. Calculate the mass flow rate of steam round the kg/s. (7 marks)

g) State the Boyles' law as used for a perfect gas. (2 marks)

QUESTION TWO (20 MARKS)

a) State the Clausius and kelvin-Planck's statements of the second law of thermodynamics. (2 marks)

b) State the Charles' law as used for perfect gas. (2 marks)

c) Starting from Boyle's and Charles' laws and with the aid of a sketch show that the characteristic equation of a perfect gas is given as: $PV = mRT$ where P is the pressure, V is the volume, m is mass of gas, R the characteristic gas constant and T the temperature. (11 marks)

d) A quantity of gas has a pressure of 350 kN/m^2 when its volume is 0.03 m^3 and its temperature is 35ºC. If the value of gas constant (R) = 0.289 kJ/kgK, determine the mass of gas present. If the pressure of this gas is now increased to 1.05 MN/m^2 while the volume remains constant, determine the new temperature of the gas. (5 marks)

QUESTION THREE (20 MARKS)

a) Define entropy as used in thermodynamics. (2 marks)

b) With regard to steam;

i. Define *dryness fraction*, and explain how it is related to the *quality* of the steam. (2 marks)

ii. State two reasons why high moisture content in steam is detrimental to steam turbines. (2 marks)

c) Determine the dryness fraction and specific internal energy of steam at 7 bar and enthalpy 2600 kJ/kg. (4 marks)

d) In food processing industry that uses steam, wet steam supplied with a pressure of 0.3 MPa has a quality of 72%. (5 marks)

i. Using steam tables determine the steam's entropy and specific volume.

ii. From the results above, calculate the internal energy of steam.

e) In a steam power plant, superheated steam is supplied to the turbine at a pressure of 7 bar and a specific enthalpy of 3300 kJ/kg. Determine its degree of superheat and specific entropy. (5 marks)

QUESTION FOUR (20 MARKS)

a) Show that in a constant pressure non-flow process for a perfect gas the entropy change is given by: $s_2 - s_1 = \Delta s = c_v \ln\left(\frac{T_2}{T_1}\right)$ (4 marks)

b) Air at 15^0C and 1.05 bar occupies 0.02 m^3. The air is heated at constant volume until the pressure is 4.2 bar. Calculate the heat flow and the entropy change for this process.

(5 marks)

c) Prove that for a polytropic non-flow process for a perfect gas the work done and entropy change are given by;

$w = \frac{R(T_1 - T_2)}{n-1}$, $\Delta s = c_n \ln \frac{T_2}{T_1}$ where n is the index of expansion and c_n is the the polytropic specific heat capacity. (7 marks)

d) Calculate the change of entropy of 1 kg of air expanding polytropically in a cylinder behind a piston from 6.3 bar and 550^0C to 1.05 bar. The index of expansion is 1.3.

(4 marks)

QUESTION FIVE (20 MARKS)

a) With the aid of a *P–T (phase diagram) for a pure water*, illustrate the following phases; solid, Liquid, and vapor phases. (3 marks)

b) With reference to the first law of thermodynamics, show that for a constant pressure process from state 1 to state 2 the specific work done, $w = p(v_2 - v_1)$ and the specific heat supplied, $q = h_2 - h_1$. (5 marks)

c) In the compression stroke of an internal combustion engine, the heat rejected to the cooling water is 45 kJ/kg and the work input is 90 kJ/kg. Calculate the change in specific internal energy of the working fluid. (3 marks)

d) In a steady flow open system, a fluid substance flows at a rate of 1.7 kg/s and the power developed by the system is 1400 kW. The specific enthalpies of the fluid at inlet and outlet are 1200 kJ/kg and 360 kJ/kg respectively, and the velocities of the fluid at inlet and outlet are 60 m/s and 150 m/s respectively.

i. State the steady flow energy equation for the system (2 marks)

ii. Calculate the rate at which heat is rejected from the system (5 marks)

iii. Find the area of the inlet section to the system given that the specific volume of the fluid at inlet is 0.5 m^3/kg. (2 marks)