MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 201 THERMODYNAMICS

DATE: 11/8/2021 **TIME: 2.00-4.00 PM**

INSTRUCTIONS

Answer question ONE and any other two questions

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the term phase as used in a thermodynamic system. Differentiate between homogenous and heterogeneous system and give one example of each. (5 marks)

b) Determine the work done by the air which enters into an evacuated vessel from atmosphere when the valve is opened. The atmospheric pressure is 1.013bar and 1.5 m^3 of air at atmospheric condition enters into the vessel. (5 marks)

c) A domestic food refrigerator maintains a temperature of -12°C. The ambient air temperature is 35°C. If heat leaks into the freezer at the continuous rate of 2kJ/s determine the least power necessary to pump this heat out continuously. (6 marks)

d) State **four** advantages of using superheated steam in thermodynamic systems? (4 marks)

e) State **four** limitations of a Carnot cycle (4 marks)

f) Enumerate the **three** modes by which heat can be transferred from one place to another. (6 marks)

QUESTION TWO (20 MARKS)

a) The properties of a closed system change following the relation between pressure and volume as pV = 3.0 where p is in bar V is in m^3. Calculate the work done when the pressure increases from 1.5bar to 7.5bar. (7 marks)

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

c) In a steam plant, 1kg of water per second is supplied to the boiler. The enthalpy and velocity of water entering the boiler are 800kJ/kg and 5m/s. The water receives 2200kJ/kg of heat in the boiler at constant pressure. The steam after passing through the turbine comes out with a velocity of 50m/s, and its enthalpy is 2520kJ/kg. The inlet is 4m above the turbine exit. Assuming the heat losses from the boiler and the turbine to the surroundings are 20kJ/s, calculate the power developed by the turbine. Consider the boiler and turbine as single system. Steady Flow Energy Equation can be expressed as:

$$h_1 + \frac{C_1^2}{2} + Z_1 g + Q = h_2 + \frac{C_2^2}{2} + Z_2 g + W$$

Where: h is enthalpy, Q is heat supplied per Kg of fluid, W is work done by 1kg of fluid, C is Velocity of fluid and Z is Height above datum, subscript 1 and 2 are respective conditions at inlet and outlet respectively. (11 marks)

QUESTION THREE (20 MARKS)

a) A house requires 2×10^5kJ/h for heating in winter. Heat pump is used to absorb heat from cold air outside in winter and send heat to the house. Work required to operate the heat pump is 3×10^4kJ/h. Determine:

i. Heat abstracted from outside

ii. Co-efficient of performance (7 marks)

b) Discuss with the aid of well labelled diagram and graph of temperature versus heat addition, the formation of steam considering 1kg of water at 0°C with volume v_f m^3 under the piston (13 marks)

QUESTION FOUR (20 MARKS)

a) Determine the amount of heat, which should be supplied to 2kg of water at 25°C to convert it into steam at 5bar and 0.9 dry.

Use an extracted Steam table as given in **Table Question 4** (10 marks)

b) In a steam power cycle, the steam supply is at 15 bars and dry and saturated. The condenser pressure is 0.4 bars. Calculate the Carnot and Rankine efficiencies of the cycle. Neglect pump work.

Use an extracted Steam table as given in **Table Question 4** (10 marks)

QUESTION FIVE (20 MARKS)

a) i. State the Fourier's law of heat conduction (2 marks)

ii. List any **four** Essential features of Fourier's law of heat conduction (4 marks)

b) The inner surface of a plane brick wall is at 60°C and the outer surface is at 35°C. Calculate the rate of heat transfer per m^2 of surface area of the wall, which is 220 mm thick. The thermal conductivity of the brick is 0.51W/m°C. (4 marks)

c) State any **four** examples of heat exchangers (2 marks)

d) Differentiate between the following: Black, Opaque, white and gray body radiation (4 marks)

e) State **four** factors which coefficient of convective heat transfer value depends. (4 marks)

Table Question 4: Saturated Water and Steam (Pressure)

Absolute pressure (bar) p	*Temp. (°C)* t_s	*Specific enthalpy (kJ/kg)* h_f	h_{fg}	h_g	*Specific entropy (kJ/kg K)* s_f	s_{fg}	s_g	*Specific volume (m^3/kg)* v_f	v_g
0.40	75.9	317.7	2 319.2	2 636.9	1.026 1	6.644 8	7.670 9	0.001026	3.993
0.42	77.1	322.6	2 316.3	2 638.9	1.040 2	6.614 0	7.654 2	0.001027	3.815
0.44	78.2	327.3	2 313.4	2 640.7	1.053 7	6.584 6	7.638 3	0.001028	3.652
0.46	79.3	331.9	2 310.7	2 642.6	1.066 7	6.556 4	7.623 1	0.001029	3.503
0.48	80.3	336.3	2 308.0	2 644.3	1.079 2	6.529 4	7.608 6	0.001029	3.367
5.0	151.8	640.1	2 107.4	2 747.5	1.860 4	4.958 8	6.819 2	0.001093	0.375
5.2	153.3	646.5	2 102.7	2 749.3	1.875 4	4.930 6	6.805 9	0.001094	0.361
5.4	154.7	652.8	2 098.1	2 750.9	1.889 9	4.903 3	6.793 2	0.001096	0.348
5.6	156.2	658.8	2 093.7	2 752.5	1.904 0	4.876 9	6.780 9	0.001098	0.337
5.8	157.5	664.7	2 089.3	2 754.0	1.917 6	4.851 4	6.769 0	0.001099	0.326
15.0	198.3	844.7	1 945.2	2 789.9	2.314 5	4.126 1	6.440 6	0.001154	0.132
15.5	199.8	851.7	1 939.2	2 790.8	2.329 2	4.099 6	6.428 9	0.001156	0.128
16.0	201.4	858.6	1 933.2	2 791.7	2.343 6	4.073 9	6.417 5	0.001159	0.124
16.5	202.8	865.3	1 927.3	2 792.6	2.357 6	4.048 9	6.406 5	0.001161	0.120
17.0	204.3	871.8	1 921.5	2 793.4	2.371 3	4.024 5	6.395 7	0.001163	0.117