(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER EXAMINATIONS

MAIN EXAMINATION

FOR THE DEGREE OF

MASTER OF SCIENCE IN

INDUSTRIAL ENGINEERING AND MANAGEMENT

COURSE CODE: IEM 841E

COURSE TITLE: APPLIED HEAT AND UTILITY SERVICES

DATE: 14TH DECEMBER 2023 TIME: 14:00 - 17:00 HRS

Instructions to Candidates:

1. Attempt any **four** questions.
2. Steam tables, psychrometric charts, and a list of formulae are provided.
3. Symbols have the usual meaning.

DURATION: 3 Hours

QUESTION ONE – 20 MARKS

a) For a lumped capacity system of transient conduction, show that during cooling:

$$\theta_2 = \theta_1 e^{-t/T}$$

(8 Marks)

b) An electric motor is designed to operate on a repetitive load duty between temperature limits of 30^0C and 55^0C with an ambient temperature of 15^0C. Heat dissipation on load is 0.38kW, and the off-load period is 294 seconds. The motor has an effective mass of 3.5kg, a specific heat capacity of 0.45kJ/kgK, and a surface heat transfer coefficient of 0.15kW/m^{2}K. Determine the:

i. Cooling area to be provided.

(6 Marks)

ii. Maximum temperature that would be achieved if the motor ran indefinitely.

(2 Marks)

iii. Duration of the allowable load period.

(4 Marks)

QUESTION TWO – 20 MARKS

a) Explain the significance of economic insulation thickness in engineering applications.

(5 Marks)

b) Show that for critical insulation thickness,

$$r_{o,crit} = \frac{k_c}{h_o}$$

(7 Marks)

c) A copper wire, 5.2mm in diameter, is insulated with a layer of PVC having a thermal conductivity of 0.43W/m°C. The wire carries a current, and its temperature is 60^0C. The film coefficient at the outer surface of insulation is 11.35W/m^{2o}C. Calculate the critical insulation thickness.

(8 Marks)

QUESTION THREE – 20 MARKS

A small-size cooling tower is designed to cool 5.5 litres per second, the inlet temperature of which is 44^0C. The motor-driven fan induces 9m^3/s of air through the tower and the power absorbed is 4.75 kW. The air entering the tower is at 18^0C, and has 60% RH. The air leaving the tower is saturated, and its temperature is 26^0C. The pressure remains constant throughout the plant.

a) Calculate the amount of make-up water required for cooling for optimal performance of the cooling tower.

(10 Marks)

b) Determine the final temperature of the cooled water.

(10 Marks)

QUESTION FOUR – 20 MARKS

A vapour compression plant uses R12 and has a suction pressure of 2.61 bar and a condenser pressure of 12.19 bar. The vapour is dry saturated on entering the compressor and there is no undercooling of the condensate. The compression is carried out isentropically in two stages and a flash chamber is employed at an interstage pressure of 4.914 bar.

Calculate the:

a) Amount of vapour bled off at the flash chamber.

(6 Marks)

b) State of the vapour at the inlet to the second stage of compression.

(4 Marks)

c) Refrigerating effect per kg of refrigerant in the condenser.

(2 Marks)

d) Work done per kg of refrigerant in the condenser.

(5 Marks)

e) Coefficient of performance.

(3 Marks)

QUESTION FIVE – 20 MARKS

Air is supplied at a rate of 250m^3/min from outdoor conditions of 40^{0}C DBT and 26^{0}C WBT to an air-conditioned room. The air is dehumidified first by a cooling coil having a by-pass factor of 0.32 and a dew point temperature of 15^{0}C; and then by a chemical dehumidifier where air leaves at 30^{0}C DBT. The air then passes over a cooling coil whose surface temperature is 15^{0}C and a by-pass factor of 0.26.

a) Outline the procedure of determining the states on the psychrometric chart

(3 Marks)

b) Show the processes on the psychrometric chart

(4 Marks)

c) Calculate the capacities of the:

(i) First cooling coil (in TR)

(7 Marks)

(ii) Second cooling coil (in TR)

(3 Marks)

(iii) Dehumidifier

(3 Marks)

QUESTION SIX – 20 MARKS

a) Define the following terms as used in Acoustics:

i. Absorption **(1 Mark)**

ii. Reverberation **(1 Mark)**

iii. Diffraction **(1 Mark)**

iv. Refraction **(1 Mark)**

b) Briefly explain the following in acoustic sub-disciplines:

i. Vibration and dynamics. **(3 Marks)**

ii. Architectural acoustics. **(3 Marks)**

iii. Noise control. **(4 Marks)**

iv. Ultrasonics. **(3 Marks)**

c) Suggest a solution to the following acoustic problems:

i. Echoes. **(1 Mark)**

ii. Acoustic shadows. **(2 Mark)**