



B.E DEGREE EXAMINATIONS: MAY 2017

(Regulation 2014)

Sixth Semester

MECHANICAL ENGINEERING

U14MET602: Heat and Mass Transfer

COURSE OUTCOMES

- CO1:** Appraise the conduction, convection and radiation mode of heat transfer through various applications.
CO2: Evaluate the heat transfer for forced and free convection applications.
CO3: Calculate the parameters of heat exchangers, condensers and evaporator using LMTD and NTU Methods for various applications.
CO4: Explain the radiation heat transfer problems.
CO5: Apply principles of heat and mass transfer to basic thermal engineering systems.

Time: Three Hours

Maximum Marks: 100

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Matching type item with multiple choice code

CO1 [K₂]

List I	List II
A. Conduction	i. Fick's law
B. Convection	ii. Fourier's Law
C. Radiation	iii. Newton's law of cooling
D. Mass transfer	iv. Stefan-Boltzmann law

- | | A | B | C | D |
|----|-----|-----|-----|----|
| a) | ii | i | iii | iv |
| b) | iii | iv | ii | i |
| c) | ii | iii | iv | i |
| d) | iii | i | ii | iv |

2. The property which represents how fast the heat transfer takes place in transient conduction is CO1 [K₁]

- | | |
|------------------------|-------------------------|
| a) Density | b) Specific heat |
| c) Thermal diffusivity | d) Thermal conductivity |

3. Which of the two dimensionless numbers are used in heat transfer by natural convection CO2 [K₂]

1. Reynold's number 2. Rayleigh number 3. Grashof number 4. Biot number

- | | |
|--------|--------|
| a) 1,3 | b) 1,4 |
| c) 1,2 | d) 2,3 |

4. In natural convection fluid motion occurs by CO2 [K₂]
 a) Fan b) Blower
 c) Pump d) Buoyancy
5. Assertion (A): It is convenient to work with overall heat transfer co-efficient in a heat exchanger CO3 [K₂]
 Reason (R): Heat transfer in a heat exchanger involves both convection and conduction
 a) Both A and R are Individually true and R is the correct explanation of A b) Both A and R are Individually true but R is not the correct explanation of A
 c) A is true but R is false d) A is false but R is true
6. Boiling and condensation occurs at CO3 [K₂]
 a) Constant pressure and temperature b) Constant temperature
 c) Constant pressure d) Both pressure and temperature are not constant
7. Determine the sequence of the sentences given below CO4 [K₂]
 1) The effect of orientation on radiation between two surfaces is accounted by view factor
 2) View factor is a purely geometric quantity.
 3) Reciprocity theorem allows the calculation of view factor of a surface from a knowledge of other surface
 4) Super position rule is applied for finding view factor when geometry of a surface is not a standard one
 a) 2-3-4-1 b) 1-2-3-4
 c) 3-4-2-1 d) 4-1-3-2
8. rule says that the sum of the view factors from surface *i* of an enclosure to all surfaces of the enclosure, including to itself, must equal to unity. CO4 [K₁]
 a) Superposition b) Summation
 c) Reciprocity d) Kirchoff
9. Assertion (A): The solutions of mass diffusion equations can be obtained from the solutions of corresponding heat conduction equations for the same type of boundary conditions CO5 [K₂]
 Reason (R): The differential equations for both heat conduction and mass diffusion are of the same form
 a) Both A and R are Individually true and R is the correct explanation of A b) Both A and R are Individually true but R is not the correct explanation of A
 c) A is true but R is false d) A is false but R is true
10. Flow of a commodity or species is always in the direction of concentration COL [K₁]
 a) Increasing b) Decreasing
 c) Equal d) Both a) and b)

PART B (10 x 2 = 20 Marks)
(Answer not more than 40 words)

- | | | |
|--|-----|-------------------|
| 11. What is Fourier's law of conduction? | CO1 | [K ₁] |
| 12. The heat flux through a wood slab 50 mm thick, whose inner and outer surface temperatures are 40 and 20°C respectively has been determined to be 40 W/m ² . What is the thermal conductivity of the wood? | CO1 | [K ₃] |
| 13. Differentiate between forced convection and natural convection. | CO2 | [K ₃] |
| 14. State the significance of Reynold's number. | CO2 | [K ₂] |
| 15. What is the major difference between pool boiling and flow boiling? | CO3 | [K ₂] |
| 16. Discuss the importance of saturation temperature with respect to condensation. | CO3 | [K ₂] |
| 17. What is irradiation? | CO4 | [K ₁] |
| 18. Discuss about absorption and emission in radiation heat transfer. | CO4 | [K ₂] |
| 19. State any two examples of mass diffusion. | CO5 | [K ₂] |
| 20. What are the driving forces for heat transfer and mass transfer? | CO5 | [K ₁] |

Answer any FIVE Questions:-
PART C (5 x 14 = 70 Marks)
(Answer not more than 300 words)

Q.No. 21 is Compulsory

- | | | |
|---|-----|-------------------|
| 21. A cold storage room has walls made of 0.23 m of brick on the outside, 0.08 m of plastic foam, and finally 1.5 cm of wood on the inside. The outside and inside air temperatures are 22°C and -2°C respectively. If the inside and outside heat transfer co-efficients are 29 and 12 W/m ² .K respectively. The thermal conductivities of brick, foam and wood are 0.98, 0.02 and 0.17 W/m.K respectively. Determine (a) the rate of heat removed by refrigeration if the total wall area is 90 m ² , and (b) the temperature of the inside surface of the brick. | CO1 | [K ₅] |
| 22. A long 10-cm-diameter steam pipe whose external surface temperature is 110°C passes through some open area that is not protected against the winds. Determine the rate of heat loss from the pipe per unit of its length. When the air is at 1 atm pressure and 10°C and the wind is blowing across the pipe at a velocity of 8 m/s. | CO2 | [K ₅] |
| 23. The engine cylinder of a motor cycle is constructed of 2024 -T6 aluminium alloy and is of height H=0.15 m and outside diameter D=50 mm. Under typical operating conditions, the outer surface of the cylinder is at a temperature of 500 K and is exposed to ambient air at 300 K, with a convective co-efficient of 500 W/m ² K. Annular fins are integrally cast with the cylinder to increase heat transfer to the surroundings. Consider five such fins, which are of thickness t=6 mm, length L=20 mm and equally spaced. What is the increase in heat transfer due to use of the fins? State your assumptions. | CO1 | [K ₆] |

24. A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin-walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 W/m².°C, determine the length of the heat exchanger required to achieve the desired heating. CO3 [K₅]

25. A furnace cavity shown in Figure 1 is in the form of a cylinder of 75 mm diameter and 150 mm length, is open at one end to large surroundings that are at 27° C. The sides and bottom may be approximated as blackbodies, are heated electrically, are well insulated, and are maintained at temperatures of 1350 and 1650° C, respectively. How much power is required to maintain the furnace conditions? CO4 [K₄]

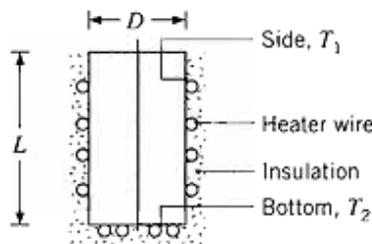


Figure 1. Furnace with top surface open to atmosphere

26. a) Discuss about the analogy between heat transfer and mass transfer. (5) CO5 [K₃]
 b) A nickel plate that is in contact with hydrogen gas at 358 K and 300 kPa. Determine (9) [K₅]
 the molar and mass density of hydrogen in the nickel at the interface. Take the molar mass of hydrogen as 2 kg/mol and the solubility of hydrogen in nickel at 358 K is 0.00901 kmol/m³.

27. Consider an IC engine cooling system with a radiator, water pump and thermostat system, discuss about the different modes of heat transfer occurs in the following cases along with the correlations used based on the knowledge gained in the subject “heat and mass transfer”. CO1 [K6]
 CO2
 CO3
 CO4

- Heat transfer from inside of combustion chamber to inside cylinder wall
- Heat transfer from inside cylinder wall to outside cylinder wall
- Heat transfer from outside cylinder wall to engine coolant circulated

Heat transfer from coolant which is inside the radiator to air flowing across the radiator
