2022-23

MECHANICAL ENGINEERING

HEAT TRANSFER

PREPARED BY
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Techno India NJR Institute of Technology

Course File

Heat transfer (5ME4-02)

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Syllabus

3rd Year - V Semester: B.Tech. : Mechanical Engineering

5ME4-02: HEAT TRANSFER

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**
3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	HOURS
1	Introduction: Objective, scope and outcome of the course.	1
2	Introduction: Heat transfer processes, conduction and radiation. Fourier's law of heat conduction, thermal conductivity, thermal conductivity of solids, liquids and gases, effect of temperature on thermal conductivity. Newton's law of cooling, definition of overall heat transfer coefficient. General parameters influence the value of heat transfer coefficient.	4
	Conduction: General 3-Dimensoinal conduction equation in Cartesian, cylindrical and spherical coordinates; different kinds of boundary conditions; nature of differential equations; one dimensional heat conduction with and without heat generation; electrical analogy; heat conduction through composite walls; critical thickness of insulation	3
3	Heat transfer from extended surfaces: Governing differential equation of fin, fin efficiency and effectiveness for different boundary conditions.	3
	Unsteady state heat conduction for slab, cylinder and sphere, Heisler chart.	2
	Convection: Review of Navier - Stokes and energy equation, hydrodynamic and thermal boundary layers; laminar boundary layer equations; forced convection appropriate non dimensional members; effect of Prandtl number; empirical relations for flow over a flat plate and flow through pipes.	4
4	Natural convection: Dimensional analysis, Grashoff number, boundary layers in external flows (flow over a flat plate only), boundary layer equations and their solutions, heat transfer correlations.	4
	Heat transfer with change of phase: Nature of vaporization phenomena; different regimes of boiling heat transfer; correlations for saturated liquid vaporization; condensation on flat plates; correlation of experimental results, drop wise condensation.	4
5	Heat exchanger: Types of heat exchangers, arithmetic and logarithmic mean temperature differences, heat transfer coefficient for parallel, counter and cross flow type heat exchanger; effectiveness of heat exchanger, N.T.U. method, fouling factor. Constructional and manufacturing aspects of Heat Exchangers.	8
6	Thermal Radiation: Plank distribution law, Krichoff's law; radiation properties, diffuse radiations; Lambert's law. Radiation intensity, heat exchange between two black bodies heat exchanger between gray bodies. Shape factor; electrical analogy; reradiating surfaces heat transfer in presence of reradiating surfaces.	8
	TOTAL	**41**

Course Overview:

This course is an introduction to the principal concepts and methods of heat transfer. The objectives of this integrated subject are to develop the fundamental principles and laws of heat transfer and to explore the implications of these principles for system behavior; to formulate the models necessary to study, analyze and design heat transfer systems through the application of these principles; to develop the problem-solving skills essential to good engineering practice of heat transfer in real-world applications.

Course Outcomes:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis&Design	Understand the basic modes of heat transfer & Determine Thermal Conductivity.
2	Synthesis & Design	Compute temperature distribution in steady-state and unsteady-state heat conduction & Determine Stefan Boltzmann Constant.
3	Synthesis & Design	Understand and analyse heat transfer through extended surfaces. &Estimate heat transfer coefficient & Measure heat transfer coefficient in free convection
4	Synthesis & Design	Interpret and analyze forced and free convection heat transfer &To Study and Compare LMTD and Effectiveness
5	Synthesis & Design	Understand the principles of radiation heat transfer and basics of mass transfer

.Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)	
CO. NO.	Domain Specific (PSO)	Domain Independent (PO)

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	1	0	0	0	1	1	0	1
CO2	3	3	2	3	1	0	0	0	1	0	0	1
CO3	3	2	2	3	1	0	0	0	1	1	0	1
C04	3	2	2	3	1	0	0	0	1	1	0	1
C05	2	1	2	2	1	0	0	0	1	0	0	1
C06	2	2	2	3	1	0	0	0	1	1	0	1
Average	2.67	2.00	2.00	2.83	1.00	0.00	0.00	0.00	1.00	0.67	0.00	1.00

Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	**1**	Introduction: Objective, scope and outcome of the course.
2	**2**	Introduction: Heat transfer processes, conduction and radiation
3	2	Fourier's law of heat conduction, thermal conductivity, thermal conductivity of solids, liquids and gases
4	2	effect of temperature on thermal conductivity. Newton's law of cooling
5	2	definition of overall heat transfer coefficient. General parameters influence the value of heat transfer coefficient..
6	2	Conduction: General 3-Dimensoinal conduction equation in Cartesian, cylindrical and spherical coordinates;
7	2	different kinds of boundary conditions; nature of differential equations; one dimensional heat conduction with and without heat generation;
8	2	electrical analogy; heat conduction through composite walls; critical thickness of insulation
9	2	Numerical
10	**2**	Numerical
11	2	Numerical
12	3	Heat transfer from extended surfaces: Governing differential equation of fin
13	**3**	fin efficiency and effectiveness for different boundary conditions
14	**3**	Unsteady state heat conduction for slab, cylinder and sphere, Heisler chart
15	3	Convection: Review of Navier – Stokes and energy equation, hydrodynamic and thermal boundary layers;
16	3	laminar boundary layer equations; forced convection appropriate non dimensional num.
17	3	effect of Prandtl number; empirical relations for flow over a flat plate and flow through pipes.
18	**3**	Numericals
19	3	Numericals
20	3	Numericals
21	4	Natural convection: Dimensional analysis, Grashoff number, boundary layers in external flows (flow over a flat plate only)
22	4	layer equations and their solutions, heat transfer correlations
23	4	Heat transfer with change of phase: Nature of vaporization phenomena;
24	4	different regimes of boiling heat transfer; correlations for saturated liquid vaporization
25	4	Condensation on flat plates; correlation of experimental results, drop wise condensation.
26	4	Numericals
27	4	Numericals
28	4	Numericals
29	5	Heat exchanger: Types of heat exchangers, arithmetic and logarithmic mean temperature differences,
30	5	heat transfer coefficient for parallel, counter and cross flow type heat exchanger;
31	5	effectiveness of heat exchanger, N.T.U. method,
32	5	, fouling factor. Constructional and manufacturing aspects of Heat Exchangers
33	5	Numericals
34	5	Numericals

35	5	Numericals
36	5	Numericals
37	6	Thermal Radiation: Plank distribution law, Krichoff's law; radiation
38	6	properties, diffuse radiations; Lambert's law. Radiation intensity,
39	6	, heat exchange between two black bodies heat exchanger between gray bodies
40	6	Shape factor; electrical analogy
41	6	reradiating surfaces heat transfer in presence of reradiating surfaces.
42	6	Numericals
43	6	Numericals
44	6	Numericals
45	6	Numericals

TEXT/REFERENCE BOOKS

1. Heat transfer, Cengel Yunus A.
2. Heat transfer, domkundwar
3. Heat transfer, D.s.Kumar
4. Heat Transfer, R.K.Rajput

Course Level Problems (Test Items):

CO.NO.	Problem description
1	A. Study the basics modes of heat transfer B. Differentiate thermodynamics & heat transfer with practical application C. Attempt numerical on conduction
2	A. Application of fourier equation in cartesian , cylindrical & speherical coordinate system. B. Explain & derive critical thickness of insulation C. Attempt numerical on conduction through plane wall.
3	A. Explain fins & its applications B. Derive heat transfer through infineetly long fin , fin insulated at the tip and efficency & effectiveness of the fin. C. Impoertance of fins and how we improve the efficency oof fine by practical approach
4	A. Study unsteadty heat transfer and its practical approach B. Explain dimensionless number and their importance C. Attempt numerical approach to unsteady state problems.
5	D. Explain heat exchanger & their applications E. Explain N.T.U and L.M.T.D approach with practical examples F. Attempt numericals on LM.T.D approach
6	A. Expalin radiation concept and relate with practical life B. Exlain different radiation laws and relate with practical life.

Assessment Methodology

1. Practical exam in lab where they have to prepare practical model related to thermodynamic laws .(Once in a week)
2. Assignments one from each unit.
3. Midterm subjective paper where they have to attempt numericals.
4. Final paper at the end of the semester subjective.

Teaching and Learning resources unit-wise:

Unit-1

Basics of heat transfer

A. Conduction. Convection & Radiation

Video Tutorials:https://www.youtube.com/watch?v=sieo7oZGsWQ

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:
https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

Unit-2

B. Fourier equation and its application

Video Tutorials: https://www.youtube.com/watch?v=hZ5cCrGNS1U

Theory concepts:https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:
https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

C. Critical thickness of insulation

Video Tutorials: https://www.youtube.com/watch?v=5P5S_MzdcS4

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz: https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

Unit-3

A. Heat transfer from extended surfaces

Video Tutorials:https://www.youtube.com/watch?v=SNnd0f3xXlg

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz: https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

B. Unsteady state heat transfer

Video Tutorials: https://www.youtube.com/watch?v=ztZlwcHUL7k

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

Unit-4

A. Heat flow, laminar & turbulent

Video Tutorials: https://www.youtube.com/watch?v=uvREDOh0X2s

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz: https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

B. Heat transfer with change of phase: Nature of vaporization phenomena;

Video Tutorials: https://www.youtube.com/watch?v=FEr6mFQj37U

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:
https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

C. different regimes of boiling heat transfer; correlations for saturated liquid vaporization

Video Tutorials: https://www.youtube.com/watch?v=NaSMTsscEao

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:
https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

Unit-5

A. Heat exchanger: Types of heat exchangers, arithmetic and logarithmic mean temperature differences,

Video Tutorials:https://www.youtube.com/watch?v=gDaLG16op_Y

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:
https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

B. LMTD & NTU approach

Video Tutorials:https://www.youtube.com/watch?v=MSZwREBCXTs

Theory concepts:https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:
https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

Unit-6

A. Radiation and its basic concepts

Video Tutorials: https://www.youtube.com/watch?v=3bAEipA5ZpI

Theory concepts: https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:
https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

B Variation radiation laws and their practical approach

Video Tutorials:https://www.youtube.com/watch?v=JzcFdwEscPU

Theory concepts:https://nptel.ac.in/courses/112/108/112108149/

Sample Quiz:
https://engineeringinterviewquestions.com/heat-transfer-mechanical-engineering-multiple-choice-questions-and-answers/

Previous Year Question Papers:

Roll No. 15EEBME009

[Total No. of Pages : 3

5E 6201

5E 6201

B.Tech. V Semester (Main/Back) Examination, Nov./Dec. - 2017

Mechanical Engineering

5ME1A Heat Transfer

Time : 3 Hours

Maximum Marks : 80

Min. Passing Marks : 26

Instructions to Candidates :

*Attempt any **five questions**, selecting **one question** from **each unit**. All Questions carry **equal** marks. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitable be assumed and stated clearly). Units of quantities used/calculated must be stated clearly.*

Unit - I

1. a) What is critical thickness of insulation? Explain its importance in heat transfer. **(6)**

   b) A furnace wall is composed of 220mm of brick, 150mm of common brick, 50mm of 85% magnesia and 3mm of steel plate on the outside. If the inside surface temperature is 1500°C and outside surface temperature is 90°C, estimate the temperatures between layers and calculate the heat loss in kJ/hm². Assume, k (for fire brick) = 4kJ/mh °C, k (for common brick) = 2.8kJ/mh °C, k(for 85% magnesia) = 0.24 kJ/mh °C and k(steel) = 240 kJ/mh °C. **(10)**

OR

1. a) A 160 mm diameter pipe carrying saturated steam is covered by a layer of lagging of thickness of 40 mm (k=0.8W/m °C).Later an extra layer of lagging 10 mm thick (k=1.2W/m^2 °C) is added. if the surroundings temperature remains constant and heat transfer coefficient for both the lagging material is 10W/m^2 °C, determine the percentage change in the rate of heat loss due to extra lagging layer. **(8)**

   b) Derive General 3-dimensional conduction equation in Rectangular Cartesian coordinate system. **(8)**

Unit - II

2. a) Explain the non-dimensional parameters used in the analysis of Forced Convection? **(6)**

b) Cylindrical pieces of size 60 mm dia and 60 mm height with density = 7800 kg/m^3, specific heat = 486 J/kgK and conductivity 43 W / mK are to be heat treated. The pieces initially at 35°C are placed in a furnace at 800 °C with convection coefficient at the surface of 85 W / m^{2}K. Determine the time required to heat the pieces to 650°C. If by mistake the pieces were taken out of the furnace after 300 seconds, determine the shortfall in the requirements. **(10)**

OR

2. a) Explain the concept of hydrodynamic boundary layer and thermal boundary layer. What is their significance in the analysis of convection heat transfer? **(8)**

b) In a process water at 30°C flows over a plate maintained at 10°C with a free stream velocity of 0.3 m/s. Determine the hydrodynamic boundary layer thickness, thermal boundary layer thickness, local and average values of friction coefficient, heat transfer coefficient and refrigeration necessary to maintain the plate temperature. Also find the values of displacement and momentum thicknesses. Consider a plate of 1 m × 1 m size. **(8)**

Unit - III

3. a) Water in a tank is heated by a horizontal steam pipe of 0.25 m dia, maintained at 60°C. The water is at 20°C. Calculate the value of convective heat transfer coefficient by different correlations and compare the results. **(12)**

b) What is Grashoff Number and how it is useful in natural convective heat transfer? **(4)**

OR

3. a) Water at atmospheric pressure (saturation temperature = 100°C) is boiling on a brass surface heated from below. If the surface is at 108°C, determine the heat flux and compare the same with critical heat flux. **(10)**

b) Explain different regimes of boiling heat transfer. **(6)**

Unit - IV

4. a) What is 'fouling factor'? How it affects the design of heat exchanger? **(6)**

b) A cross flow heat exchanger with both fluids unmixed is used to heat water flowing at a rate of 20 kg/s from 25°C to 75°C using gases available at 300°C to be cooled to 180°C. The overall heat transfer coefficient has a value of 95 W / m^{2}K. Determine the area required. For gas c_p = 1005 J/kgK. **(10)**

OR

4. a) Define effectiveness and N.T.U. of heat exchanger. In which cases, N.T.U. method is used in designing of heat exchangers? **(8)**

b) An economiser in a boiler has flow of water inside the pipes and hot gases on the outside flowing across the pipes. The flow rate of gases is 2,000 tons/hr and the gases are cooled from 390°C to 200°C. The specific heat of the gas is 1005 J/kg K. Water is heated (under pressure) from 100°C to 220°C. Assuming an overall heat transfer coefficient of 35 W / m² K, determine the area required. Assume that the air flow is mixed. **(8)**

Unit - V

5. a) Explain Lambert's law for radiation. **(6)**

b) Two large parallel planes are at 1000 K and 600 K. Determine the heat exchange per unit area. (i) if surfaces are black (ii) if the hot one has an emissivity of 0.8 and the cooler one 0.5 (iii) if a large plate is inserted between these two, the plate having and emissivity of 0.2. **(10)**

OR

5. a) Explain Plank distribution law of radiation. **(6)**

b) Determine the shape factor from the base of a cylinder to the curved surface. Also find the shape factor from curved surface to base and the curved surface to itself. **(10)**

5E6201

Roll No. ___________ Total No of Pages: 4

5E6201

B. Tech V Sem. (Main/Back) Exam. Nov-Dec. 2015
Mechanical Engineering
5ME1A Heat Transfer
Common with AE

Time: 3 Hours **Maximum Marks: 80**

Min. Passing Marks Main: 26

Min. Passing Marks Back: 24

Instructions to Candidates:

Attempt any ***five questions,*** *selecting* ***one question*** *from* ***each unit.*** *All questions carry* ***equal*** *marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*

Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination.

1. NIL. 2. NIL.

UNIT-I

Q.1 (a) Explain the physical mechanism of heat transfer by - [8]

(i) Conduction.

(ii) Convection, and

(iii) Radiation.

(b) What is thermal conductivity? How thermal conductivity varies for solids, liquids and gases? [8]

OR

Q.1 (a) Define the role of general 3-dimensional conduction equation in spherical coordinates, also generate heat conduction equation across a spherical shell. [8]

(b) A copper pipe carrying refrigerant at -20°C is 10mm in OD and is exposed to convection at 50 W/m²K to air at 25°C. It is proposed to apply insulation of conductivity 0.5 W/mK. Determine the thickness beyond which the heat gain will be reduced. Calculate the heat gains for 2.5mm, 5.0 mm and 7.5mm thickness for 1m length. The convection coefficient remains constant. [8]

UNIT-II

Q.2 (a) Derive an expression for general differential equation of fin. [8]

(b) Explain about Heisler chart for a long cylinder. Discuss variable parameters for Heisler chart. [8]

OR

Q.2 (a) Write the Navier- Stokes equations for convection. How these are useful for energy problems? [8]

(b) Water at 20°C flows through a small-bore tube, 1mm in diameter at a uniform speed of 0.2 m/s. The flow is fully developed at a point beyond which a constant heat flux of 6000 W/m_2 is imposed. How much further down the tube will the water reach 74°C at its hottest point? [8]

UNIT-III

Q.3 (a) What is natural convection? Explain its different mechanisms with suitable examples. [8]

(b) An dir duct carries chilled air at an inlet bulk temperature of T_{bin} = 17°C and a speed of 1m/s. The duct made of thin galvanized steel, has a square cross-section of 0.3m by 0.3m, and is not insulated. A length of the duct 15m long runs outdoors through warm air at T_{∞} = 37°C. The heat transfer coefficient on the outside surface, due to natural convection and thermal radiation, is 5 W/m²K. Find the bulk temperature change of the air over this length. [8]

OR

Q.3 (a) What is vaporization? Discuss effect of various parameters on vaporization. [8]

(b) What is q_{max} in mercury on a large flat plate at 1 atm? Also give your comment.

Hint:-

The normal boiling point of mercury is 355°C. At this temperature –

h_{fg}=2,92,500 J/kg, ρ_f = 13,400 kg/m^3, ρ_g=4.0 kg/m^3 and σ = 0.418 kg/s^2 [8]

UNIT-IV

Q.4 (a) Derive an expression of LMTD for counter flow heat exchanger. Also discuss about LMTD correction factor. [8]

(b) Consider the following parallel-flow heat exchanger specification-

Cold flow enters at 40°C: C_c = 20,000 W/K.

Hot flow enters at 150°C: C_h = 10,000 W/K.

A = 30 m^2, U = 500 W/m^{2}K.

Determine the heat transfer and the exit temperatures. [8]

OR

Q.4 (a) On which parameters, the effectiveness of heat exchanger depends and how? [8]

(b) Discuss various constructional and manufacturing aspects of heat exchangers. [8]

UNIT-V

Q.5 (a) Differentiate the Plank distribution law and Krichoff's law with respect to their applications and boundary conditions. [8]

(b) A black thermocouple measures the temperature in a chamber with black walls. If the air around the thermocouple is at 20°C, the walls are at 100°C and the heat transfer coefficient between the thermocouple and the air is 75 W/m^{2}K, what temperature will the thermocouple read? [8]

OR

Q.5 (a) What is shape factor? Discuss role of it, for thermal resistance, thermal conductivity and heat transfer. [8]

(b) Discuss the role of reradiating surfaces on heat transfer. Which parameters affect the reradiating surfaces and how? [8]

5E3176

Roll No. ________________ Total No. of Pages : 4

5E3176
B.Tech. V Sem.(Main/Back) Exam. Dec. 2012
Mechanical Engg.
5ME2 Heat Transfer

Time : 3 Hours **Maximum Marks : 80**
Min. Passing Marks : 24

Instructions to Candidates:

*Attempt any **five question** selecting **one question** from **each unit** . All Questions carry equal marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used / calculated must be stated clearly.*

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. ____________Nil______ 2. ___________Nil______ .

UNIT-I

Q.1 (a) What is thermal contact resistance ? How it is related to thermal contact conductance? 6

ii) What is the importance of thermal diffusivity?

iii) What is the physical mechanism of heat conduction in a solid, a liquid, and a gas?

(b) Consider a 0.8m high and 1.5 m wide double-pane window consisting of two 4-mm thick layers of glass (k=0.78 W/m.K) separated by a 10mm wide stagnant air space (k=0.026 W/m.K). Determine the steady rate of heat transfer through this double pane window and the temperature of its inner surface for a day during which the room is maintained at 20°C while the temperrature of the outdoors is -10°C. Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be h_1=10 W/m².°c and h_2=40 W/m².°c, which includes the effects of radiation. 10

OR

(a) (i) What is the critical radius of nsulation? How is it defined for a cylindri cal layer?

(ii) What does the thermal resistance of a medium represent ?

(iii) Consider heat conduction through a wall of thickness L and area A. Under what conditions will the temperature distributions in the wall be a straight line? 6

(b) An 8 cm. thick plane wall generates heat at the rate of 1.2x10^5 W/m^3. One side of the wall is exposd to environment at 90^{0}c whilst the other side is insulated. The convective heat transfer coefficient between the wall and environment is 560 W/m^2-deg. Proceed from the basic principles to determine the maximum temperaure to which the wall will be subjected. The thermal conductivity of the wall material may be taken as 0.15 W/m-deg. 10

UNIT-II

2. (a) For a constant cross-section area fin, obtain the temperature distribution and total heat flow rate under steady state conditions when one end of the fin is attached to a body at high temperature and other end of the fin is insulated. 8

(b) An egg with mean diameter of 4cm and initially at 25^{0}c is placed in a boiling water pan for 4 minutes and found to be boiled to the consumer taste. For how long should a similar egg for same consumer be boiled when taken from a refrigerator at 5^{0}c? Use lumped parameter theory and presume the fol -lowing properties for egg :

k = 12 W/m-deg , h = 125 W/m^{2}deg , c = 2 kJ/kgk and ρ=1250 kg/m^3 8

OR

(a) Explain the essential features of Blasius method of solving laminar boundary layer equations for a flat plate. Derive expression for boundary layer thick-ness from this solution. 8

(b) Air at 2bar and 40^{0}c is heated as it flows through 30mm diameter tube at a velocity of 10 m/s. If the wall temperature is maintained at 100^{0}c all along the lenght of tube, make calculations for the heat transfer per unit lenght of the tube. Proceed to calculate the increase in bulk temperature over one meter lenght of the tube. Use the following correlation Nu = 0.023 $(Re)^{0.8}$ $(Pr)^{0.4}$ and take the following thermo-physical properties of air at the average film temperature of 70°C.

μ =20.6x10^{-6} Ns/m^2, Cp =1.009 kJ/kg-deg

k= 0.0297 W/m-deg, and Pr =0.694

UNIT-III

Q3. (a) Define and explain the physical significance of -

(1) Stanton Number (2) Grashof Number

(3) Prandtl Number (4) Nusselt Number. 8

(b) Calculate the rate of heat loss from a human body which may be cosidered as a vertical cylinder 30 cm in diameter and 175 cm. high in still air at 15°c. The skin temperature is 35°c and emissivity at the skin surface is 0.4.Nglect sweating and effect of clothing. Thermo-physical properties of air at 25°c are :

ν = 15.53x10^{-6} m^2/s , k= 0.0263 W/m-deg , Pr = 0.7
β = 0.00335 per degree kelvin. Use the relation Nu =0.13 $(Gr \times Pr)^{0.33}$
8

OR

(a) Discuss in detail the various regimes in boiling and explain the condition for the growth of bubbles. What is the effect of bubble size on boiling?
8

(b) How does filmwise condensation differ from dropwise condensation? Analyse film condensation on a flat vertical plate by considering shear, gravity and vapour forces acting on the condensate layer. Determine an expression for the condensate velocity and the mass flow rate. 8

UNIT-IV

Q4. (a) What is the heat capacity rate ? What can you say about the temperature changes of the hot and cold fluids in a heat exchanger if both fluids have the same capacity rate? What does a heat capacity of infinity for a fluid in a heat exchanger mean? 4

(b) Can the logarithmic mean temperature difference ΔT_{lm} of a heat ex changer be a negative quantity ? Explain. 4

(c) Derive the relationship between the effectiveness and the number of trans- -fer units for counter flow heat exchangers. 8

OR

(a) A counterflow heat exchanger is used to cool 2000 kg/hr of oil (Cp =2.5kJ/ kg K) from 105°c to 30°c by the use of water entering at 15°c. If the overall heat transfer coefficient is expected to be 1.5 kW/m²K, make calculations for the water flow rate, the surface area required and the effectiveness of heat exchanger. Presume that the exit temperature of the water is not to exceed 80°c. Use NTU-effectiveness approach. 12

(b) Under what conditions can a counterflow heat exchanger have an effective- ness of one? What would your answer be for a parallel flow heat exchanger ? 4

UNIT-V

Q5. (a) What is a graybody? How does it differ from a blackbody? What is a diffuse gray surface ? 4

(b) Derive a general relation for the radiation shape factor in case of radiation between two surfaces. 12

OR

(a) A thin shield of emissivity ϵ_s (on both sides) is placed between two infinite paralled plates of emissivities ϵ_1 and ϵ_2, and temperature T_1 and repectiv- ly. If $\epsilon_1=\epsilon_2=\epsilon_s$, show that temperature of the shield is given by

$$\left(\frac{T_1^4+T_2^4}{2}\right)^{3/4}$$ 8

(b) Consider a hemispherical furnace with a flat circular base of diameter D. Determine the view factor from the dome of this furnace to its base. 8