Buddha Institute Of Technology			
Department: Mechanical Engineering			
Academic Semester: July- Dec 2022			
Semester: V	Section: B	Course Code: KME501	Course: Heat & Mass Transfer

Course Instructor: Nitin Tripathi	Contact Hours /week: 5 (4+1)	# of credits: 04
CIE Marks: 50	SEE Marks:100	Exam Hours: 03

Prerequisites if any:			
Code No	Course Name	Description	Semester
NOT APPLICABLE			

Content delivery:	Chalk & Board, DLP, System/Laptop with social media videos

COURSE SYLLABUS:			
Module No	**Contents of Module**	**Hrs**	**COs**
1	Thermodynamics and Heat Transfer. Modes of Heat Transfer: Conduction, convection and radiation. Effect of temperature on thermal conductivity of materials, Introduction to combined heat transfer mechanism, General differential heat conduction equation in the rectangular, cylindrical and spherical coordinate systems. Initial and boundary conditions, Simple and Composite Systems in rectangular, cylindrical and spherical coordinates with and without energy generation, Concept of thermal resistance, Analogy between heat and electricity flow, Thermal contact resistance and over all heat transfer coefficient; Critical radius of insulation.	**18**	**CO1**
2	Heat transfer from extended surfaces, Fins of uniform cross-sectional area, Errors of measurement of temperature in thermometer wells, Transient heat conduction, Lumped capacitance method, Time constant, Unsteady state heat conduction in one dimension only, Heisler charts.	**16**	**CO2**
3	Basic concepts, Hydrodynamic boundary layer, Thermal boundary layer, Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Mixed boundary layer, Flow over a flat plate, Flow across a single cylinder and a sphere, Flow inside ducts, Thermal entrance region, Empirical heat transfer relations, Relation between fluid friction and heat transfer, Liquid metal heat transfer. Physical mechanism of natural convection; Buoyant force, Empirical heat transfer relations for natural convection over vertical planes and cylinders, horizontal plates and cylinders, and sphere, Combined free and forced convection.	**14**	**CO3**
4	Basic radiation concepts, Radiation properties of surfaces, Black body radiation Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchoff's law, Gray body, Shape factor, Black-body radiation, Radiation exchange between diffuse non black bodies in an enclosure, Radiation shields, Radiation combined with conduction and convection; Absorption and emission in gaseous medium; Solar	**9**	**CO4**

	radiation, Green house effect.		
5	Types of heat exchangers, Fouling factors; Overall heat transfer coefficient, Logarithmic mean temperature difference (LMTD) method, Effectiveness-NTU method, Compact heat exchangers, Introduction to condensation phenomena, Heat transfer relations for laminar film condensation on vertical surfaces and on outside & inside of a horizontal tube, Effect of non-condensable gases, Drop wise Condensation, Heat pipes, Boiling modes, pool boiling, Hysteresis in boiling curve, Forced convection boiling.	**9**	**CO5**

COURSE OUTCOMES: At the end of the Course, the Student will be able to:

KME501.1	understand the mode of heat transfer and governing equations concerned to conduction and one dimensional steady state heat flow
KME501.2	express the knowledge of design skills of heat exchangers
KME501.3	describe the real time applications of fluid medium heat transfer
KME501.4	illustrate the real time applications of radiation mode of heat transfer
KME501.5	analyse the heat exchanger and process of boiling, condensation and mass transfer

Mapping of CO v/s PO:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
KME501.1	3	-	-	-	-		-	-	-	-	-	-
KME501.2	3	-	-	-	-		-	-	-	-	-	-
KME501.3	2	-	-	-	-		-	-	-	-	-	-
KME501.4		-	2	-	-	2	-	-	-	-	-	-
KME501.5		-	-	3	-	1	-	-	-	-	-	-

Correlation levels: 1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

Mapping of CO v/s PSO:

	PSO1	PSO2
KME501.1	1	-
KME501.2	1	-
KME501.3	1	-
KME501.4	1	-
KME501.5	1	-

Gap in the syllabus	NIL

Topics to be covered beyond syllabus	Demographic survey – A case study

Assessment Methodologies:

Sl. No.	Description	Type
1	Student Assignment	Direct
2	Internal assessment	Direct
3	University exam	Direct
4	Student feedback	Indirect
5	Alumni feedback	Indirect
6	Employers feedback	Indirect

LESSON PLAN

Lecture #	**Module#**	**Topics**	**RBT Levels**	**Course Outcome Mapping**	**Planned Date**	**Actual Date**	**Faculty Sign**	**Remarks**
1.	**1**	Thermodynamics and Heat Transfer,	**L3**	**CO1**	22/08/2022			
2.		Modes of Heat Transfer Conduction			23/08/2022			
3.		Convection, Radiation,			24/08/2022			
4.		Effect of temperature on thermal conductivity of materials.			26/08/2022			
5.		**Tutorial**			27/08/2022			
6.		Introduction to combined heat transfer mechanism.			29/08/2022			
7.		General differential heat conduction equation in the rectangular coordinate systems			30/08/2022			
8.		General differential heat conduction equation in the rectangular coordinate systems			31/08/2022			
9.		General differential heat conduction equation in the cylindrical coordinate systems			02/09/2022			
10.		**Tutorial**			03/09/2022			

11.		General differential heat conduction equation in the cylindrical coordinate systems			05/09/2022			
12.		General differential heat conduction equation in the spherical coordinate systems.			06/09/2022			
13.		General differential heat conduction equation in the spherical coordinate systems. Initial and boundary conditions.			07/09/2022			
14.		Simple and Composite Systems in rectangular, cylindrical and spherical coordinates with and without energy generation.			09/09/2022			
15.		**Tutorial**			10/09/2022			
16.		Concept of thermal resistance, Analogy between heat and electricity flow.			12/09/2022			
17.		Thermal contact resistance and over all heat transfer coefficient;			13/09/2022			
18.		Critical radius of insulation.			14/09/2022			
19.	**4**	Basic radiation concepts, Radiation properties of surfaces.	**L4**	**CO4**	16/09/2022			
20.		**Tutorial**			17/09/2022			
21.		Black body radiation, Planck's law,			23/09/2022			
22.		Wein's displacement law. Stefan Boltzmann law,			24/09/2022			
23.		Kirchoff's law, Gray body.			26/09/2022			
24.		Shape factor, Black-body radiation.			27/09/2022			
25.		**Tutorial**			28/09/2022			
26.		Radiation exchange between diffuse non black bodies in an enclosure.			30/09/2022			
27.		Radiation shields, Radiation combined with conduction and convection.			01/10/2022			
28.		Absorption and emission in gaseous medium, Solar Radiation, Green house effect.			03/10/2022			
29.	**5**	Types of heat exchangers,	**L4**	**CO5**	07/10/2022			
30.		**Tutorial**			08/10/2022			
31.		Fouling factors. Overall heat transfer coefficient.			10/10/2022			
32.		Logarithmic mean temperature difference (LMTD) method.			11/10/2022			

33.		Effectiveness-NTU method.			12/10/2022			
34.		Compact heat exchangers. Introduction to condensation phenomena,			14/10/2022			
35.		**Tutorial**			15/10/2022			
36.		Heat transfer relations for laminar film condensation on vertical surfaces and on outside & inside of a horizontal tube.	**L4**	**CO5**	17/10/2022			
37.		Effect of non-condensable gases, Dropwise Condensation.Heat pipes,			18/10/2022			
38.		Boiling modes, pool boiling.			19/10/2022			
39.		Hysteresis in boiling curve, Forced convection boiling.			21/10/2022			
40.		**Tutorial**			22/10/2022			
41.		Basic concepts, Hydrodynamic boundary layer.			31/10/2022			
42.		Thermal boundary layer, Approximate integral boundary layer analysis.			01/11/2022			
43.		Analogy between momentum and heat transfer in turbulent flow over a flat surface.	**L4**	**CO3**	02/11/2022			
44.		Mixed boundary layer, Flow over a flat plate.			04/11/2022			
45.		**Tutorial**			07/11/2022			
46.		Flow across a single cylinder, Flow across a single sphere.			08/11/2022			
47.	**3**	Empirical heat transfer relations, Relation between fluid friction and heat transfer.			09/11/2022			
48.		Liquid metal heat transfer, Physical mechanism of natural convection;			14/11/2022			
49.		Buoyant force. Empirical heat transfer relations for natural convection over vertical planes and cylinders.			15/11/2022			
50.		**Tutorial**			16/11/2022			
51.		Flow inside ducts, Thermal entrance region.			18/11/2022			
52.		Empirical heat transfer relations for natural convection over horizontal plates and cylinders.			19/11/2022			
53.		Empirical heat transfer relations for natural convection over sphere.			21/11/2022			
54.		Combined free and forced			22/11/2022			

		convection.						
55.	2	**Tutorial**	L6	CO2	23/11/2022			
56.		Heat transfer from extended surfaces.			25/11/2022			
57.		Fins of uniform cross-sectional area.			26/11/2022			
58.		Fins of uniform cross-sectional area.			28/11/2022			
59.		Errors of measurement of temperature in thermometer wells.			29/11/2022			
60.		**Tutorial**			31/11/2022			
61.		Transient heat conduction,			04/12/2022			
62.		Lumped capacitance method.			05/12/2022			
63.		Lumped capacitance method.			06/12/2022			
64.		Time constant			07/12/2022			
65.		**Tutorial**			12/12/2022			
66.		Time constant,			13/12/2022			
67.		Unsteady state heat conduction in one dimension only.			13/12/2022			
68.		Unsteady state heat conduction in one dimension only.			13/12/2022			
69.		Heisler charts.			13/12/2022			
70.		Heisler charts.			13/12/2022			

***L1 – Remembering; L2 – Understanding; L3 – Applying; L4 – Analysing; L5 – Evaluating; L6 - Creating**

Literature:

Reference 1	R1	Heat And Mass Transfer By Er. R.K. Rajput	11^{th}	S.Chand Company	2017(81-219-2617-3)
Reference 2	R2	A Textbook of Heat and Mass Transfer By R.C. Rchdeva	5^{th}	New age international limited publishers	2011(978-81-224-2785-1)

Sample Questions:

Question No.	Questions
1.	What do you understand by overall heat transfer coefficient?
2.	Explain black body, white body, gray body and opaque body.
3.	How heat exchangers are classified?
4.	For a steady flow process from state 1 to state 2 enthalpy changes from 400 KJ/kg to 100 KJ/kg and entropy changes from 1.1 KJ/kg-k to 0.7 KJ/kg-k and the ambient temperature is 300 K. Find the change in availability.(GATE 2009)
5.	What do you understand by Inversion curve? Define Joule Thomson Co-efficient with diagram.
6.	A reversible engine is supplied 900 KJ of heat from a heat source at 500 K. The engine develops 300 KJ of net work and rejects heat to two heat sinks at 400 K and 300 K. Determine the engine thermal efficiency and magnitude of heat interaction with each of the sink.
7.	Determine the enthalpy, Specific Volume, internal energy and entropy of superheated steam at 15 bar pressure and 220 ^{0}C. Take specific heat of superheat equal to 2.2 KJ/Kg-K
8.	Three Carnot engines 1 , 2 and 3 operate between temperature of 800 K and 500 K. Make calculations for the intermediate temperatures if the work produced by the engines are in the ratio of 5:3:1
9.	Discuss the coefficient of volume expansion, adiabatic and isothermal compressibility. Also find the loss in available energy due to given heat transfer. If 3 kg of gas (c_V = 0.81 kJ/kg K) initially at 2.5 bar and 400 K receives 600 kJ of heat from an infinite source at 1200 K and the surrounding temperature is 290 K
10.	Derive Steady Flow Energy Equation (S.F.E.E.). Also write the steady flow energy equation for turbine, boiler and centrifugal pump
11.	Discuss the Clapeyron equation and also explain the Joule-Kelvin effect with help of inversion curve and inversion temperature.
12.	Determine the enthalpy, Specific Volume, internal energy and entropy of superheated steam at 25 bar pressure and 250 ^{0}C. Take specific heat of superheat equal to 2.12 KJ/Kg-K.
13.	Expain the concept of principle of entropy increase..
14.	Steam at 1000 kPa and 300^0 C enters an engine and expands to 20 kPa. If the exhaust steam has a dryness fraction of 0.9. make calculation for the drop in enthalpy and change in entropy..
15.	A Single stage air turbine is to operate with an inlet pressure and temperature of 8 bar and 600K. The outlet pressure and temperature are 1 bar and 300K. the surroundings pressure and temperature is 1 bar and 200K. Mass flow rate is 5 kg/s , determine the decrease in availability, the maximum work and the Irreversibility. For air take C_P = 1.005 KJ/Kg-k and R = 0.287KJ/Kg-K
16.	A gas initially at 1.5 bar pressure, 0.15 m^3 volume and 300 K was compressed polytropically ($pv^{1.48}$= constant) to 13 bar pressure. Determine the change in entropy. Also work out the approximate entropy change obtained by dividing the heat transferred by the mean absolute temperature during compression. Take C_p=1.04 KJ/Kg-K and C_v=0.745 KJ/Kg-K
17.	Define the various methods of refrigeration and application of the refrigeration.
18.	Explain the Rankine cycle with the help of neat sketch, P-V and T-S diagram. If 5 kg water at 45°C is heated at a constant pressure of 10 bar until it becomes superheated vapour at 300°C. Find the change in volume, enthalpy, internal energy and entropy.

19.	Explain the vapour compression refrigeration cycle and its C.O.P. with the help of T-S, P-H and flow diagram. Can this cycle be reversible?
20.	An air- water vapour mixture at 25 ^{0}C. and 1 bar has a relative humidity of 75 percent . Determine a) The partial pressure of water vapour and dry air. b) the specific volume of each constituent c) the dew point temperature, the specific humidity and the saturation ratio. d) the density of the mixture.

Assessment rubrics that is going to be adopted for direct attainment is depicted in below table

Level of Achievement	**Elaboration on Course Grading Description**	**Bench Mark Set (Out of 100)**
Excellent (A)	The Student's performance is outstanding in almost all the intended course learning outcomes	21 to 25
Good (B)	The student's performance is good in most of the intended course learning outcomes.	15 to 20
Marginal (C)	The student's performance is barely satisfactory. It marginally meets the intended course learning outcomes	12 to 14
Fail (F)	The Students performance is inadequate. Student fails to meet many of the intended course learning outcomes	Less than 12