University Institute of Engineering & Technology

(Recognised Under Section 2(f) and 12B of UGC)

Kurukshetra University, Kurukshetra

THEORY EXAMINATION – JAN 2021	
B.TECH – Mechanical Engineering	SEMESTER – V

TIME – 3 Hrs 15 Min

M.M. - 56

PAPER - MEC-301

SUBJECT- Heat Transfer

INSTRUCTIONS TO BE FOLLOWED

- **Allotted time for examination is 3 hours 15 minutes that includes time for downloading the question paper, writing answers, scanning of answer sheets and E-mailing the PDF files to the designated Email ID.**
- **For all B Tech. Mechanical Engineering Students, the Email ID is:- btechmechuiet@kuk.ac.in**
- **The candidates will be required to attempt 75% of the question paper (maximum) by choosing to their any best questions accumulating 56 marks.**
- **The PDF files should be saved as Roll No. and Subject Code. Proper attention should be given while sending the email and in the subject line, the Roll Number and Subject Code should be mentioned.**
- **Maximum Page Limit should be 20 (Twenty) for attempting the question paper on A4 sheets which could be downloaded and printed from the sample sheets given in the Kurukshetra University Examination guidelines.**
- **Over-attemptation should be avoided.**
- **Handwriting should be neat and clean and diagrams should be clear and contrasted.**
- **The candidate should not write their Mobile No. otherwise Unfair Means Case will be made.**
- **While attempting the paper, the candidate will use blue/black pen only.**
- **Before attempting the paper, the candidate will ensure that he/she has downloaded the correct question paper. No complaint for attempting wrong question paper by the candidate will be entertained.**
- **Candidate must ensure that he/she has put his/her signature on each page of the answer sheet used by him/her. Answer sheet without the signature of the candidate will not be evaluated.**

PART-A

Q. No. – 1 Answer the following questions. **15x1=15**

(i)	**Explain why is it that the science of thermodynamics cannot predict the rate of heat transfer?**
(ii)	**Identify the different modes of heat transfer in the following systems/operations.** **(a) Air/water cooling of an IC engine cylinder** **(b) Condensation of steam in a condenser** **(c) Heat loss from a vacuum flask** **(d) Heating of water in a bucket with an immersion heater.**
(iii)	**A fibre glass insulating board of thermal conductivity 0.038 W/(m °C) is used to limit the heat losses to 80 W/m^2 for a temperature difference of 160°C across the board. Determine the thickness of the insulating board.**
(iv)	**Describe the influence of fin length on the efficiency of a fin.**
(v)	**What is the importance of critical thickness of insulation in a plane wall?**
(vi)	**A 2 mm diameter electrical wire at 50°C is covered by 0.5 mm thick plastic insulation (k = 0.15 W/m K). The wire is exposed to a medium at 10°C, with a combined convection and radiation heat transfer coefficient of 15 W/m^2 K. Determine if the plastic insulation on the wire will increase or decrease heat transfer from the wire.**
(vii)	**Identify which of the following does not behave as a black body:** **Sun, sand, snow, furnace, aluminium foil, piece of charcoal, green grass**
(viii)	**Select which of the following has the least value of Prandtl number:** **Oils, water, air, liquid metals**
(ix)	**Consider two identical blackbodies, one at 1000 K and the other at 2000 K. Which body emits more radiation at a wavelength of 20 μm?**
(x)	**Estimate the net radiation interchange per square metre for two very large planes at temperatures 560˚C and 300˚C respectively. Assume that the emissivity of the hot and cold planes are 0.8 and 0.6 respectively.**
(xi)	**Define fouling factor.**

Match the following

(xii)	**1**	**Stanton Number**	**A**	**Free Convection**
(xiii)	**2**	**Rayleigh Number**	**B**	**Forced Convection**
(xiv)	**3**	**Fourier Number**	**C**	**Transient Conduction**
(xv)	**4**	**Peclet Number**		

PART-B

2	**The temperature of a surface is maintained at 300°C by separating it from an air flow by a layer of insulation 20 mm thick for which the thermal conductivity is 0.01 W/(m K). If the air temperature is 30°C and the convective heat transfer coefficient between the air and the outer surface of the insulation is 400 W/(m^2 K), determine the temperature of this outer surface.**	**5**
3	**Show that the local convection coefficient in a thermally fully developed internal flow does not change in the direction of flow with constant properties both for constant surface temperature as well for constant heat flux.**	**5**
4	**The temperature of the flame in a furnace is 1900K, find (a) monochromatic energy emission at 1 μm per m^2 per second (b) wavelength at which emissions are maximum (c) maximum energy emissions (d) ratio of monochromatic emissions to maximum emissions (e) total energy flux emitted.**	**5**
5	**Consider an oil-to-oil double-pipe heat exchanger whose flow arrangement is not known. The temperature measurements indicate that the cold oil enters at 20°C and leaves at 55°C, while the hot oil enters at 80°C and leaves at 45°C. Is it a parallel-flow or counter-flow heat**	**5**

	exchanger? Assuming the mass flow rate of both fluids to be the same, determine the effectiveness of the heat exchanger [*cp*,oil = 2.2 kJ/(kg K)].	

PART-C

6	An electric cable 10 mm in diameter is to be insulated with rubber. The insulated cable is exposed to air at 20˚C. Find the most economical thickness of the rubber insulation from the heat transfer point of view assuming the cable surface temperature of 60˚C in bare as well as in insulation condition. Assume thermal conductivity of rubber as 0.14 W/mK and heat transfer coefficient on the surface of cable or on the insulation surface as 7 W/m^2 K. Also find the percentage increase in current carrying capacity when economical insulation thickness is provided.	10
7	(i) The aluminium square fins (0.5 mm x 0.5 mm) of 1 cm long are provided on the surface of an electronic semi-conductor device to carry 46 mW of energy generated by the electronic device and the temperature at the surface of the device should not exceed 80˚C. The temperature of the surrounding medium is 40˚C. Take k for aluminium 190 W/mK and convective coefficient as 12.5 W/m^2K. Find the number of fins required to carry out the above duty. Neglect the heat loss from the end of the fin. (ii) An aluminium alloy plate of 4 mm thick at 200˚C is suddenly quenched into liquid oxygen which is at -183˚C. Find the time required for the plate to reach the temperature of -70˚C. Take h = 5000 W/m^2K, c_p = 0.8 kJ/kgK, ρ = 3000 kg/m^3, plate dimensions = 40 cm x 40 cm.	5 5
8	Air at 20˚C and atmospheric pressure is flowing over a flat plate at a velocity of 3 m/s. If the plate is 30 cm wide and at 60˚C, calculate the following quantities at x = 30 cm. Given that the properties of air at the bulk mean temperature of 40˚C are: ρ = 1.128 kg/m^3, μ=19.1 x 10^{-6} kg/ms, k = 0.0273 W/m K and c_p = 1007 J/kg K. (i) Boundary layer thickness, (ii) Local skin friction coefficient, (iii) Average friction coefficient, (iv) Local shear stress and average shear stress, (v) Thickness of thermal boundary layer, (vi) Local heat transfer coefficient, (vii) Average heat transfer coefficient, (viii) Total heat loss per hour for the length of the plate 30 cm along the flow, (ix) Total drag force on the plate, (x) Total mass flow through the boundary. Assume cubic velocity profile and approximate method.	10
9	A light oil with 20˚C inlet temperature flows at a rate of 500 kg/min through 5 cm ID pipe which is enclosed by a jacket containing condensing steam at 150˚C. If the pipe is 10 m long, find the outlet temperature of the oil. Take the following properties of oil at 85˚C: ρ = 880 kg/m^3, ν=3.6 x 10^{-6} m^2/s, k = 0.12 W/m K and c_p = 2100 J/kg K. Use Dittus-Boelter correlation: $Nu_d = 0.023\mathrm{Re}^{0.8}\,\mathrm{Pr}^{0.33}$	10
10	A room 5 m x 5 m x 2.5 m is heated by electric heating provided in the ceiling. If the ceiling surface temperature is maintained at 45˚C and the temperature of wall is 25˚C in equilibrium condition, find the total heat loss from the ceiling by radiation. Emissivities of ceiling and walls are 0.75 and 0.65 respectively. Assume the floor is non-sensitive to radiation. Shape factor can be taken from the attached graph.	10
11	Two large parallel planes having emissivities of 0.25 and 0.5 are maintained at temperatures of 1000 K and 500 K, respectively. A radiation shield having an emissivity of 0.1 on both sides is placed between the two planes. Calculate (a) the heat-transfer rate per unit area if the shield were not present, (b) the heat-transfer rate per unit area with the presence of the shield, and (c) the temperature of the shield.	10

12	**The condensation temperature of a vapour in a condenser is 120˚C. The inlet and the outlet temperatures of cooling water flowing at the rate are 30˚C and 65˚C, respectively. The tube diameter is 40 mm, length is 8 m and the tubes are 10 in number. Determine the (i) overall heat transfer coefficient (ii) the number of transfer units (iii) the effectiveness of the condenser and (iv) the rate of condensation if the latent heat of condensation is 2200 kJ/kg.**	**10**
13	**(i)** **If the length of a counter-flow heat exchanger is increased, what will happen to the effectiveness of the exchanger—will it increase or decrease?**	**3**
	(ii) **In a double-pipe, counter-flow heat exchanger, water flows at the rate of 0.45 kg/s and is heated from 20°C to 35°C by an oil having a specific heat of 1.5 kJ/(kg °C). The oil enters the exchanger at 95°C and exits at 60°C. Determine the heat exchanger area for an overall heat transfer coefficient of *U* = 290 W/(m² °C). The specific heat of water is 4.18 kJ/(kg °C).**	**7**