Name:

Enrolment No:

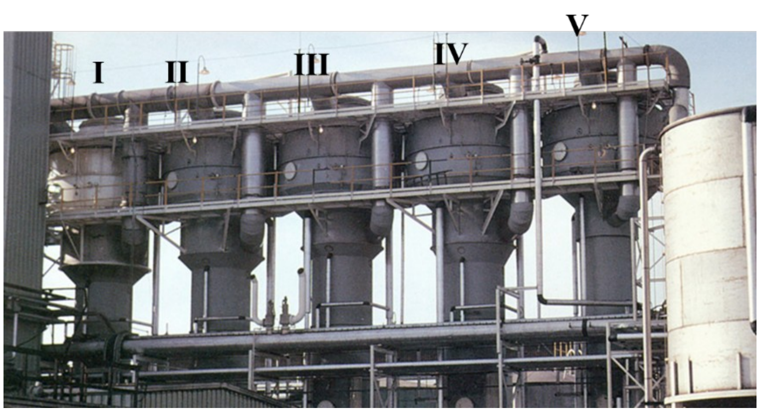
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

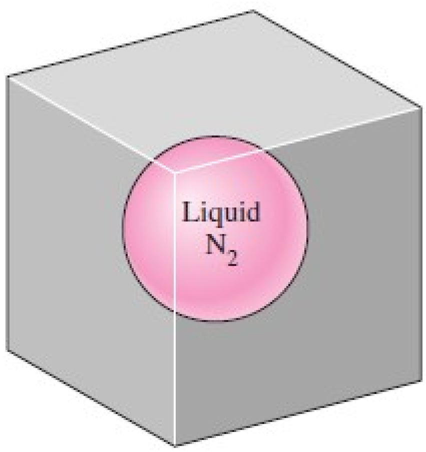
End Semester Examination, May 2019

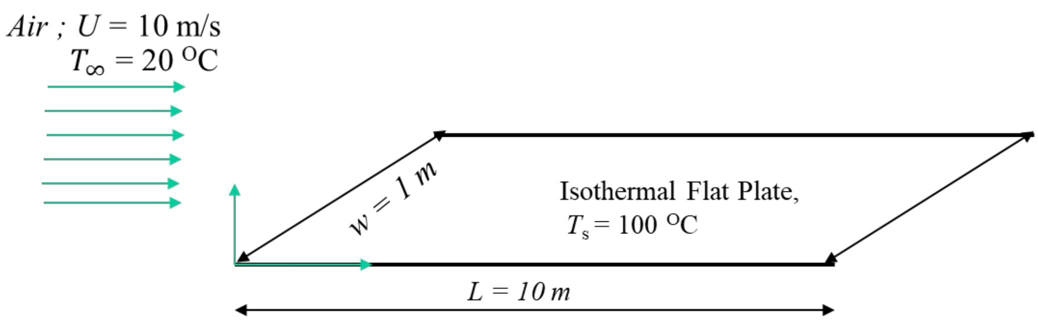
Programme Name: B Tech Mechanical Engineering **Semester : VI**
Course Name : Heat Transfer **Time : 03 hrs**
Course Code : GNEG356 **Max. Marks : 100**
Nos. of page(s) : 5

- Section A constitutes of 20 Marks (5 questions x 4 marks); Attempt All.
- Section B constitutes of 40 Marks (5 questions of 8 marks each). Attempt All (One choice question).
- Section C constitutes of 40 Marks (2 question worth 20 marks). Attempt All (One choice question).
- Question #7 and Question#11 have options. Please answer only one of the options.
- ***Please answer the sub-parts of a question together.*** **Highlight the numerical answers.**

SECTION A

S. N.		Marks	CO
Q1	Figure below shows a multiple effect evaporator with five effects (flow is from I → V) at *Gopal Juice Company*  How do these compare (increasing, decreasing or equal) in the different effects a) The temperature of the inlet vapors. b) The pressure maintained in these different effects. **NO EXPLANATIONS REQUIRED.**	**[4]**	**CO5**
Q2	An analysis of the comparison between diurnal and nocturnal temperatures at India's biggest metros – Delhi and Mumbai reveals an interesting trend. The temperature swings are much larger in Delhi as compared to Mumbai. What is ONE SINGLE most important reason behind this? Explain.	**[4]**	**CO5**
Q3	*Ramnath Luhaar*, a roadside blacksmith takes an iron piece and immerses in a hot flame at $t_1 = 0$ and keeps it inside the flame till $t_2 = 10$ minutes. He reports that he did observe	**[4]**	**CO2**

	that the color of the metallic piece changes. What color changes is expected to be observed? Explain by drawing the wavelength spectra at time intervals t_1 and t_2. Will the metal ever appear blue? Justify.		
Q4	In a country-side road event, *Jaadugar Shakuni Sarkar* shows a wonderful show amidst the loud uproar of cheering people. The magician claims – 'I can defy the laws of Science. Just wait and watch!'. The magician climbs over a platform on which a colored liquid was being boiled in a glass beaker on a flame. He takes it off the flame, closes the lid and shouts after an half an hour (when the liquid has cooled down) – Today, I will make "hot ice" by my powers. He shouts – '*Aabra ca daabra, hocus pocus'* takes the "hot ice" and touches it to the glass beaker. Surprisingly, the liquid actually starts boiling. The people cheer and hand out loads of 10-rupee notes. How did *Shakuni Sarkar* manage to do this? What is your assessment? Explain.	**[4]**	**CO3**
Q5	Boiling is effected at the base of a bubble column by heating a hot plate and bubbles are being generated at the base. Assuming vertically upward direction as the +ve x-axis, draw approximate curves for the bubble size as a function of x for the case of subcooled boiling. Explain.	**[4]**	**CO5**
	SECTION B		
Q6	 A spherical tank of diameter, D = 2 m that is filled with liquid nitrogen at 100 K is kept in an evacuated cubic enclosure whose sides are 3 m long. The emissivities of the spherical tank and the enclosure are 0.1 and 0.8, respectively. If the temperature of the cubic enclosure is measured to be 240 K, determine the net radiation of heat transfer to the liquid nitrogen.	**[8]**	**CO3**
Q7	A composite hollow cylinder with steady internal heating is made of two layers of materials of equal thickness with thermal conductivities in the ratio of 1:2 for inner to outer layers. Ratio of inside to outside diameter is 0.8. What is the ratio of temperature drop across the inner and outer layers?	**[8]**	**CO1**

	OR The temperature distribution in a cylindrical stainless fin (thermal conductivity 0.17 W/cm-°C) of constant cross-sectional area of 2 cm^2 and length of 1 cm, exposed to an ambient of 40°C (with a surface heat transfer coefficient of 0.0025 W/cm°C) is given by $$T - T_{\infty} = 3x^2 - 5x + 60$$ where T is in °C and ***x*** (distance from the fin base) in in cm. If the base temperature is 100°C, then find the heat dissipated by the fin surface.		
Q8	Two cylinders of radius r_1 and r_2 and length *L* are placed concentrically. The outer surface of inner cylinder is marked as 1 whereas the inner surface of the outer cylinder is marked as 2. Determine all four view factors F_{ij} for i,j = 1,2.	**[8]**	**CO3**
Q9	A solid iron sphere with surface temperature T_s is suspended in a room with ambient temperature T_o a. For $T_s > T_o$ *and* $T_s < T_o$, show the boundary layer development for both cases. b. Plot the variation of *Nu* with respect to the angle from the horizontal (angle increasing counterclockwise) for both the cases on the same axis.	**[8]**	**CO2**
Q10	A household oven door of 0.5-m height and 0.7-m width reaches an average surface temperature of 32°C during operation. Estimate the heat loss to the room with ambient air at 22°C. If the door has an emissivity of 1.0 and the surroundings are also at 22°C, comment on the heat loss by free convection relative to that by radiation.	**[8]**	**CO1**
	SECTION-C		
Q11	 Air at a temperature of 20 deg C is incident on an isothermal hot flat plate with a velocity of 10 m/s. (a) Determine shear stress at the trailing edge. (b) Determine average shear stress on the plate. (c) Determine the heat flux at the trailing edge. (d) Determine the total heat transfer from the plate to the air.	**[20]**	**CO2**

	(e) Determine the thermal boundary layer thickness at the trailing edge. **(a-e above) OR (the question below)** Air at a free stream temperature of $T_{\infty}=$¿ $20℃$ is in parallel flow velocity 5m/s with over a flat plate of length L = 5 m and temperature $T_{s}=$¿ $90℃$. However, obstacles placed in the flow intensify mixing with increasing distance x from the leading edge, and the spatial variation of temperatures measured in the boundary layer is correlated by an expression of the form T(℃) = 20 + 70 exp (-600xy), where x and y are in meters. (a) Determine and plot the manner in which the local convection coefficient h varies with x. (b) Evaluate the average convection coefficient $\acute{h}$ for the plate. (c) Estimate the average drag coefficient on the plate using Chilton-Colburn Analogy. (d) What is the total shear drag force on the plate?		
Q12	Water (Cp = 4180 J/kg · °C) enters the 2.5-cm internal-diameter tube of a double-pipe counter-flow heat exchanger at 17°C at a rate of 3 kg/s. Water is heated by steam condensing at 120°C (h_{fg} = 2203 kJ/kg) in the shell. If the overall heat transfer coefficient of the heat exchanger is 900 W/m^2 °C, determine the length of the tube required in order to heat the water to 80°C using (a) the LMTD method and **[5]** (b) the ε–NTU method. **[5]** (c) Draw the velocity profiles, beginning from the pipe entrance to the point flow has become fully developed. Also, draw the temperature profiles, beginning from the pipe entrance to the point flow has become fully developed. **[5]** (d) Estimate the thermal and hydrodynamic entry lengths for flow of water inside the pipe. **[5]**	**[20]**	**CO4**

Data-sheet

- Correlations for flat vertical plate
  In forced convection, $Nu = C\,Re^m\,Pr^n$ and $C_{Df} = B\,Re^H$ *(C, m, n, B, H are given below respectively)*

Type of Convection (Flat Plate)	Remark	Given Parameters
Free Convection (Vertical plate)	$Ra = 10^4 - 10^9$	$Nu = 0.59\,Ra^{1/4}$
Free Convection (Vertical plate)	$Ra = 10^9 - 10^{13}$	$Nu = 0.1\,Ra^{1/3}$
Laminar Local Isothermal		0.332; 0.5; 0.33; 0.664; -0.5
Laminar Local Isoflux		0.453; 0.5; 0.33; 0.664 ; -0.5
Turbulent Local Isothermal	5e5 < Re < 1e7; 0.6 <= Pr <= 60	0.0296; 0.8; 0.33; 0.0592; -0.2
Turbulent Local Isoflux	5e5 < Re < 1e7	0.0308; 0.8; 0.33; 0.0592; -0.2
Laminar Averaged Isothermal	Pr>= 0.6	0.664; 0.5; 0.33; 1.328; -0.5
Laminar Averaged Isoflux		0.906; 0.5; 0.33; 1.328; -0.5
Turbulent Averaged Isothermal	5e5 < Re < 1e7; 0.6 <= Pr <= 60	0.037; 0.8; 0.33; 0.074; -0.2
Turbulent Averaged Isoflux		0.0385; 0.8; 0.33; 0.074; -0.2
Combined BL (Isothermal) 5e5< Re < 1e7; 0.6<Pr<60	$C_f = \frac{0.074}{Re_L^{1/5}} - \frac{1742}{Re_L}$	$Nu = \left(0.037\,\Re_L^{4/5} - 871\right) Pr^{1/3}$

- Fluid properties

	Air (300 K)	Air (328 K)	Air(333 K)	Water(321.5K)
Kinematic viscosity (m^2/s), **ν** =	1.594E-05	1.872E-05	1.923E-05	5.533E-07
Thermal Conductivity (W/mK), **k** =	0.03	0.03	0.03	0.64
Specific heat J/(kg K), $\mathbf{C_p}$ =	1007.02	1007.87	1008.09	4066.15
Dynamic Viscosity (Pa s), **μ** =	1.850E-05	1.983E-05	2.006E-05	5.469E-04
Density (kg/m^3), **ρ** =	1.16	1.06	1.04	988.41
Prandtl Number, **Pr** =	0.71	0.70	0.70	3.46

If you find that some required Air/ Water Properties are missing, use the most accurate fluid property from the above table. **You must state this explicitly in your solution in such a case!**