BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION MO/2023)

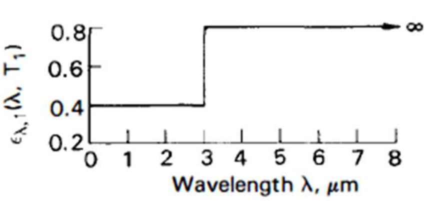
CLASS: B.TECH **SEMESTER : 7th**
BRANCH: MECHANICAL **SESSION : MO/2023**

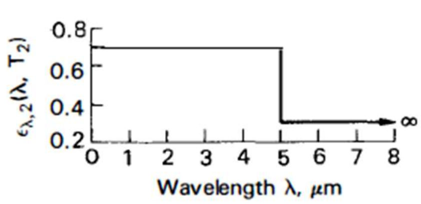
SUBJECT: ME479 ADVANCED HEAT TRANSFER

TIME: 03 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Heat Transfer Data Book, authored by C. P. Kothandaraman, is allowed in the exam hall. Invigilators can cross check the data book brought by students for any unfair means.**

			CO	BL
Q.1	A two-dimensional rectangular plate of length L in x-direction and width W in y-direction is subjected to prescribed temperature boundary conditions of temperature T_1 on three sides and a uniform heat flux (q_s”) into the plate at the top surface. Using the separation of variables method, derive an expression for the temperature distribution in the plate. Also, derive an expression for the shape factor, S_{max}, associated with the maximum top surface temperature, such that $q = S_{max}\, k\, (T_{2,max} - T_1)$ where $T_{2,max}$ is the maximum temperature along y = W.	[10]	1	1-3
Q.2	Using the separation of variables method, derive the generalized solution in non-dimensional form for transient one-dimensional conduction heat transfer in cartesian coordinates through a plane wall with no internal heat generation, having constant thermal properties and with convection heat transfer at the boundaries. Use symbols discussed in class and state any additional assumption if necessary. Also state the simplified form of the solution and the conditions for validity of the simplified form.	[10]	2	1-3
Q.3	Two infinite parallel plates are diffuse, opaque and isothermally in equilibrium at temperatures of T_1=1680 K and T_2=1120 K respectively. Their approximate spectral emissivities at their respective temperatures are shown in the figure below. What is the heat flux q transferred between the two plates? The blackbody radiation function for spectral blackbody emissive power is attached in the Appendix 1. (Hint: Use direct formula similar to the formulation for radiation between two gray surfaces.)	[10]	3	1-3





			CO	BL
Q.4	(a) For a thin slab of thickness L made of clear glass-like transparent material and at room temperature, determine the net transmittance, in terms of its total reflectivity ‘ρ’, given that the material has a constant value of total absorption coefficient ‘α’. Use symbols as discussed in the class. State any assumption, if necessary. (b) State the generalised mathematical form of the radiative transfer equation, clearly mentioning the physical significance of each term involved. Derive the form of the equation assuming no scattering, in terms of the absorptance and transmittance of the media, assuming constant radiative properties.	[6+4]	4	1-3

PTO

Q.5	Write down the continuity, momentum, and energy equations for two-dimensional uniform flow over a flat plate. Using scale or order of magnitude analysis, determine the dependence of the skin friction coefficient and the Nusselt No upon the Reynold's No and Prandtl No. for fluids having very high and low Prandtl no. Use the symbols discussed in class.	[10]	5	1-3

Appendix 1: Blackbody radiation function

λT (μm·K)	$F_{(0 \to \lambda)}$
3,000	0.273232
3,200	0.318102
3,400	0.361735
3,600	0.403607
3,800	0.443382
4,000	0.480877
4,200	0.516014
4,400	0.548796
4,600	0.579280
4,800	0.607559
5,000	0.633747
5,200	0.658970
5,400	0.680360
5,600	0.701046
5,800	0.720158
6,000	0.737818
6,200	0.754140
6,400	0.769234
6,600	0.783199
6,800	0.796129
7,000	0.808109
7,200	0.819217
7,400	0.829527
7,600	0.839102
7,800	0.848005
8,000	0.856288
8,500	0.874608
9,000	0.890029
9,500	0.903085
10,000	0.914199