**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI**
**(MID SEMESTER EXAMINATION MO/2024)**

**CLASS:** BTECH **SEMESTER : III/ADD**
**BRANCH:** CHEMICAL ENGINEERING / FOOD ENGINEERING AND TECHNOLOGY **SESSION : MO/2024**

**SUBJECT: CL219 HEAT TRANSFER OPERATIONS**

**TIME:** 02 Hours **FULL MARKS: 25**

**INSTRUCTIONS:**
**1. The question paper contains 5 questions each of 5 marks and total 25 marks.**
**2. Attempt all questions.**
**3. The missing data, if any, may be assumed suitably.**
***4*. Tables/Data handbook/Graph paper etc., if applicable, will be supplied to the candidates**

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| Q.1(a) | Derive the differential equation of heat conduction in Cartesian coordinates Subsequently, derive the equation for One-dimensional, steady state, with no internal heat generation | [3] | 1 | 2 |
| Q.1(b) | Illustrate the term thermal diffusivity with its unit. | [2] | 1 | 2 |
| Q.2(a) | Derive the expression for critical thickness of insulation thickness and explain how it plays crucial role for wire insulation. | [2] | 5 | 5 |
| Q.2(b) | Derive the steady state conduction equation through a composite wall and explain the analogy between heat flow and electrical flow. | [3] | 5 | 2 |
| Q.3(a) | Differentiate between Hydrodynamic and thermal boundary layer? Explain the properties of fluid associated with the mentioned cases and why? | [3] | 2 | 1 |
| Q.3(b) | Describe the term mean film temperature. | [2] | 2 | 2 |
| Q.4(a) | A steel ball of diameter 60 mm is initially in thermal equilibrium at 1030 (oC) in a furnace. It is suddenly removed from the furnace and cooled in ambient air at 30(oC), with convective heat transfer coefficient h = 20 W / m2K. The thermo-physical properties of steel are density r = 7800 kg/ m2, conductivity k = 40 W / $m^2$.K and specific heat c = 600 J / kg K. Find the time required in seconds to cool the steel ball in air from 1030(oC), to 430(oC). | [2] | 3 | 3 |
| Q.4(b) | Describe the Biot number, Nusselt number and Prandtl Number with physical significance. Explain the physical significance when Biot number<0.01 and 10, Nusselt number- 1,10 and 1000 and Prandtl Number < 1 and 10. | [3] | 2 | 1 |
| Q.5(a) | Describe the term Fin effectiveness. | [2] | 2 | 2 |
| Q.5(b) | Which of the following arrangement of pin fin will give a higher heat transfer rate from a hot surface?<br>A. 6 fins of 10 cm length<br>B. 12 fins of 5 cm length<br>The base temperature of the fin is maintained at 200°C and the fin is exposed to the environment at 15°C with a convection coefficient of 25 W/$m^2$K. Each fin has a cross-sectional area of 2.5 $cm^2$, a perimeter 5 cm, and is made of a material having thermal conductivity of 250 W/mK. Consider the fin with an insulated tip (neglect the heat loss from the tip of the fin). | [3] | 3 | 4 |

**::::::24/09/2024::::::E**