Ref. No. **Ex/PG/ME/T/129C/2018**

**M.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER - 2018**

**Subject: CONDUCTION HEAT TRANSFER**

Time: **3** hours Full Marks: **100**

**Answer any four questions**

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| 1 | When is the heat transfer analysis for a slab done with adopting three directions? Derive a general heat conduction equation of a slab. Considering 2-D heat flow in a slab with the constant heat generation, write down the differential equation which governs the temperature field. Determine the temperature distribution $T(x, y, t)$ by solving this differential equation using separation of variables. The dimensions of this object in the x and y directions are $L_1$ and $L_2$, respectively. The initial and boundary conditions can be taken as follows:<br>i) at $t=0$, $T=T_0$; ii) at $x=0$ $(0 \le y \le L_2)$ and $x=L_1$ $(0 \le y \le L_2)$ for $t>0$, convection heat transfer takes place through the boundary surfaces; iii) at $y=0$ $(0 \le x \le L_1)$ and $y=L_2$ $(0 \le x \le L_1)$, $t>0$, boundary surfaces are insulated. Assume suitable notations if required. | 25 |
| 2 | A hot liquid of temperature $T_h$ flows through an elliptic tube. It can be needed to cool the hot fluid by the attachment of a fin to the outer surface of the tube. At the outer surface, cold gaseous fluid covers the tube. What type of fins can be needed to enhance the heat transfer rate optimally? Derive the heat conduction equation of that fin based on the two-dimensional heat flow. For this establishment, the following assumptions may be considered:<br>i) steady state heat transfer; ii) the thickness of the fin is very small to neglect the conductive resistance in that direction; iii) convective heat transfer coefficient, thermal conductivity, cold and hot fluid temperatures are constant. | 25 |
| 3 | Consider an object of volume 'V' and surface area 'A' immerged in a fluid maintaining a constant temperature $T_\infty$. The initial temperature of the body is $T_i$. If there is no conduction resistance of the body, determine the temperature response of the body as a function of time in immerged condition. Also estimate the instantaneous heat transfer rate. For this derivation, the following assumptions can be assumed:<br>a) Heat transfer takes place between the solid surface and fluid due to convection only with a constant convective heat transfer coefficient *h*.<br>b) The speed of propagation of heat is finite. This effect can be adopted by taking a relaxation time. | 25 |
| 4 | When is an annular disc used to enhance heat transfer from a primary surface? With considering 1-D heat conduction in an annular disc, derive the energy equation. Determine the temperature distribution in annular disc as a function of modified Bessel functions. Also calculate the heat transfer rate using this temperature field. For this determination, assume suitable boundary conditions. | 25 |
| 5 | Using Frobeneus power series method, solve the annular fin equation of triangular geometry with a constant base-temperature. When this method can be used as a solution methodology. Calculate the fin effectiveness. | 25 |
| 6. | For an anisotropic material, derive the heat conduction equation for a solid which is moving with a uniform velocity. This derivation will be made with considering Cartesian coordinates. | 25 |