Heat Transfer and Industrial Furnaces (Code: MEP293)

1. **The inner and outer surfaces of a 5 m x 6 m brick wall of thickness 30 cm and thermal conductivity $0.69\ W/m.°C$ are maintained at temperatures of 20°C and 5°C, respectively. Determine the temperature at location 10 cm from the inner surface.**

2. **Consider a large 3 cm thick stainless steel plate ($k = 15.1\ W/m.°C$) in which heat is generated uniformly at a rate of $5 * 10^5\ W/m^3$. Both sides of the plate are exposed to an environment at 30°C with a heat transfer coefficient of $60\ W/m^2.°C$. Obtain a relation for the variation of temperature in the wall by solving the differential equation, and determine the location and value of maximum temperature.**

3. **Consider a large 5 cm thick brass plate ($k = 111\ W/m.°C$) in which heat is generated uniformly at a rate of $2 * 10^5\ W/m^3$. One side of the plate is insulated while the other side is exposed to an environment at 25°C with a heat transfer coefficient of $44\ W/m^2.°C$. Obtain a relation for the variation of temperature in the wall by solving the differential equation, and determine the location and value of maximum temperature.**

4. **A semiconductor material of thermal conductivity $k = 2\ W/m.°C$ and electrical resistivity $\rho_e = 2 * 10^{-5}\ \Omega.m$ is used to fabricate a cylindrical rod 10 mm in diameter and 40 mm long. The longitudinal surface of the rod is well insulated, while the ends are maintained at temperatures of 0 and 100°C. If the rod carries a current of 10 A, what is its midpoint temperature?**

5. **Consider a large plane wall of thickness $L = 0.05$ m. The wall surface at $x = 0$ is insulated, while the surface at $x = L$ is maintained at a temperature of 30°C. The thermal conductivity of the wall is $k = 30\ W/m.°C$, and heat is generated in the wall at a rate of $\dot{q} = Bx^2\ W/m^3$ where $B = 9.6 * 10^7\ W/m^5$. Assuming steady one-dimensional heat transfer. Obtain a relation for the variation of temperature in the wall by solving the differential equation and determine the temperature of the insulated surface of the wall.**

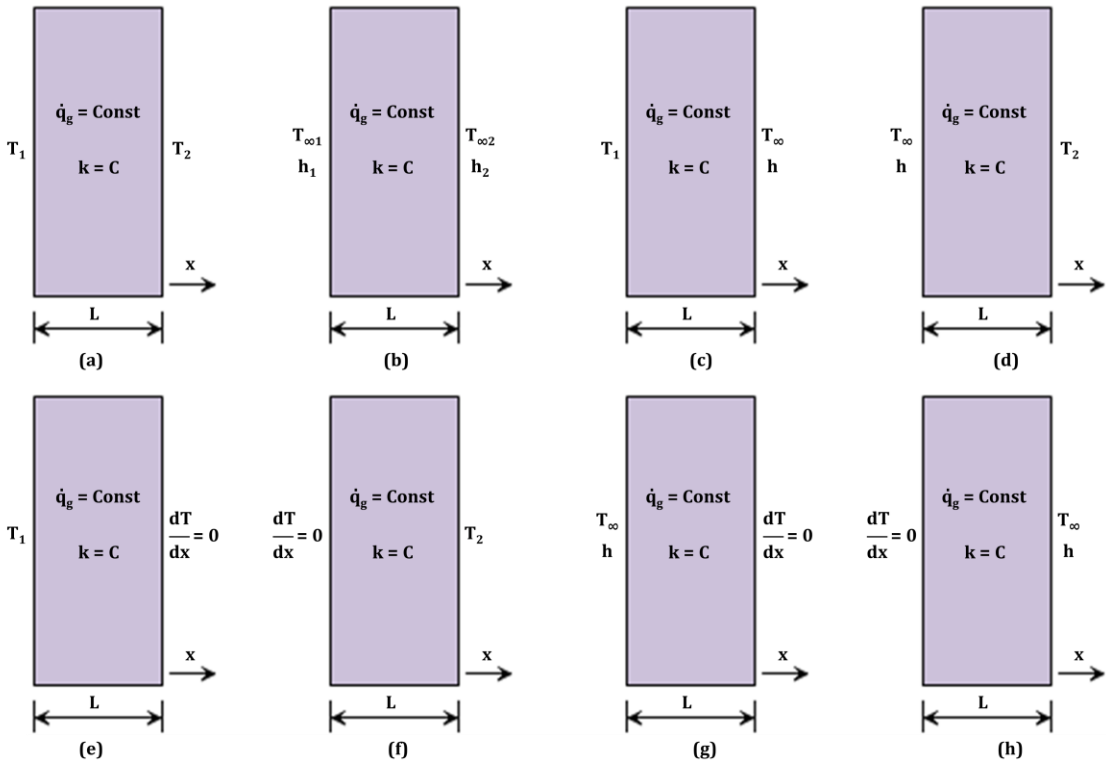
6. **In a nuclear reactor, 1 cm diameter cylindrical uranium rods cooled by water from outside serve as the fuel. Heat is generated uniformly in the rods ($k = 29.5\ W/m.°C$) at a rate of $7 * 10^7\ W/m^3$. If the outer surface temperature of rods is 175°C, determine the temperature at their center.**

7. **A copper cable ($k = 400\ W/m.°C$) of 30 mm diameter has an electrical resistance of $5 * 10^{-3}\ \Omega/m$ and is used to carry an electrical current of 250 A. The cable is exposed to ambient air at 20°C, and the associated convection coefficient is $25\ W/m^2.°C$. What is the centerline and surface temperature of the wire?**

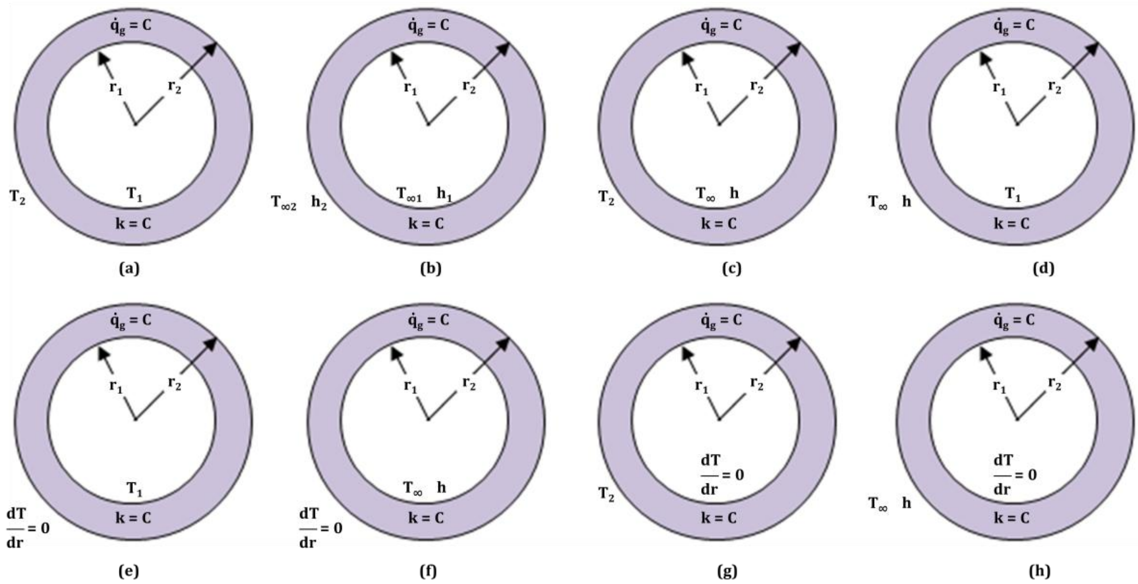
8. **In a long cylindrical fuel element in a nuclear reactor; energy generation occurs uniformly in the thorium fuel rod, which is of diameter $D = 25$ mm and is wrapped in a thin aluminum cladding. It is proposed that, under steady state conditions, the system operates with a generation rate of $\dot{q} = 7 * 10^8\ W/m^3$ and cooling system characteristics of $T_\infty = 95°C$ and $h = 7000\ W/m^2 °C$. The thermal conductivity and melting point temperature of the thorium fuel are $60\ W/m.K$ and 2023 K respectively, while the melting point temperature of aluminum is 933 K. Is this proposal satisfactory?**

9. **A chemical reaction takes place in a packed bed between two coaxial cylinders with radii 1 cm and 3 cm. The inner is at 500℃ and it is insulated. Assuming the reaction rate of $6 * 10^5\ \mathrm{W/m^3}$ in the reactor volume, find out the temperature at the outer surface of the reactor. Take k (packed material) $= 0.5\ \mathrm{W/m.K}$.**

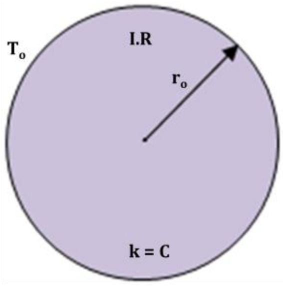
10. **Drive the temperature distribution, T(x), and heat flow rate, q(x), for one-dimensional, plane wall with the following boundary conditions where the thermal conductivity, k, and internal volumetric heat generation $\dot{q}_g$ are constants.**



11. **Drive the temperature distribution, T(r), and heat flow rate, q(r), for one-dimensional, hollow cylinder with the following boundary conditions where the thermal conductivity, k, and internal volumetric heat generation $\dot{q}_g$ are constants.**



12. Drive the formulas of radial distributions of temperature, and heat rate for a solid wire carrying an electric current I and the electrical resistance of the wire is R. The external surface with the following boundary condition



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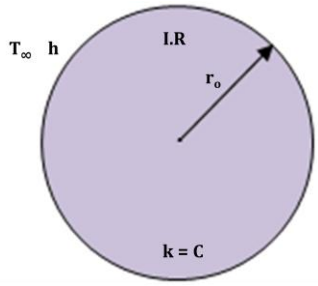

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