Fluid Mechanics and Rate Processes: Tutorial 11

P1. Consider a 150-W incandescent lamp. The filament of the lamp is 5 cm long and has a diameter of 0.5 mm. The diameter of the glass bulb of the lamp is 8 cm. Determine the heat flux, in W/m^2, (a) on the surface of the filament and (b) on the surface of the glass bulb, and (c) calculate how much it will cost per year to keep that lamp on for eight hours a day every day if the unit cost of electricity is 5.34Rs./kWh.

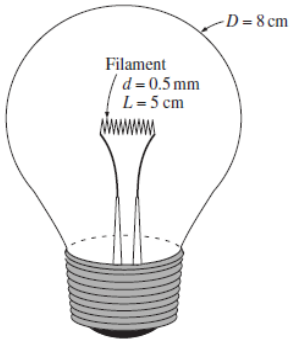

Fig.1 P1

P2. Starting with an energy balance on a cylindrical shell volume element, derive the steady one-dimensional heat conduction equation for a long cylinder with constant thermal conductivity in which heat is generated at a rate of $\dot{g}$

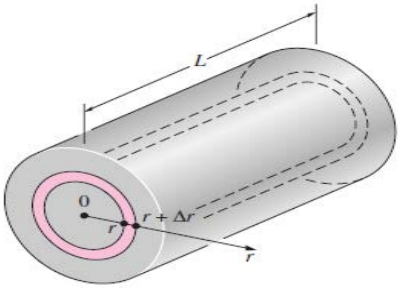

Fig.2 P2

P3. Water flows through a pipe at an average temperature of T_∞ = 50°C. The inner and outer radii of the pipe are r_1=6 cm and r_2 = 6.5 cm, respectively. The outer surface of the pipe is wrapped with a thin electric heater that consumes 300 W per m length of the pipe. The exposed surface of the heater is heavily insulated so that the entire heat generated in the heater is transferred to the pipe. Heat is transferred from the inner surface of the pipe to the water by convection with a heat transfer coefficient of h =55 W/m^2 °C. Assuming constant thermal conductivity and one-dimensional heat transfer, express the mathematical formulation (the differential equation and the boundary conditions) of the heat conduction in the pipe during steady operation. Do not solve.

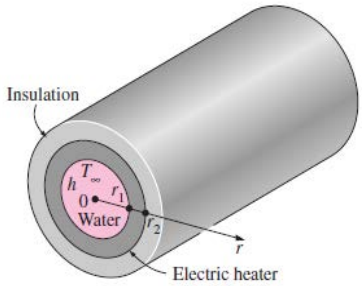

Fig.3 P3

P4. Consider the base plate of a 800-W household iron with a thickness of L =0.6 cm, base area of A =160 cm^2, and thermal conductivity of k =20 W/m°C. The inner surface of the base plate is subjected to uniform heat flux generated by the resistance heaters inside. When steady operating conditions are reached, the outer surface temperature of the plate is measured to be 85°C. Disregarding any heat loss through the upper part of the iron, (*a*) express the differential equation and the boundary conditions for steady one-dimensional heat conduction through the plate, (*b*) obtain a relation for the variation of temperature in the base plate by solving the differential equation, and (*c*) evaluate the inner surface temperature.

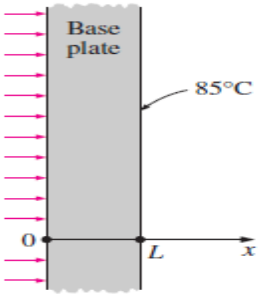

Fig.4 P4