Birzeit University
Mechanical & Mechatronics Engineering Department
Heat Transfer ME 431
Homework # 3 Steady State Conduction (7^{th}.ed)

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3.12 A thermopane window consists of two pieces of glass 7 mm thick that enclose an air space 7 mm thick. The window separates room air at 20°C from outside ambient air at -10°C. The convection coefficient associated with the inner (room-side) surface is 10 $W/m^2 . K$.
(a) If the convection coefficient associated with the outer (ambient) air is *ho* =80 $W/m^2 . K$, what is the heat loss through a window that is 0.8 m long by 0.5 m wide? Neglect radiation, and assume the air enclosed between the panes to be stagnant.

3.62 A bakelite coating is to be used with a 10-mm-diameter conducting rod, whose surface is maintained at 200°C by passage of an electrical current. The rod is in a fluid at 25 C, and the convection coefficient is 140 $W/m^2 . K$.
What is the critical radius associated with the coating?
What is the heat transfer rate per unit length for the bare rod and for the rod with a coating of bakelite that corresponds to the critical radius? How much bakelite should be added to reduce the heat transfer associated with the bare rod by 25%?

3.63 A storage tank consists of a cylindrical section that has a length and inner diameter of *L* = 2 m and *Di* = 1m, respectively, and two hemispherical end sections. The tank is constructed from 20-mm-thick glass (Pyrex) and is exposed to ambient air for which the temperature is 300 K and the convection coefficient is 10 $W/m^2 . K$. The tank is used to store heated oil, which maintains the inner surface at a temperature of 400 K. Determine the electrical power that must be supplied to a heater submerged in the oil if the prescribed conditions are to be maintained. Radiation effects may be neglected, and the Pyrex may be assumed to have a thermal conductivity of 1.4 W/m. K.

3.81 A plane wall of thickness 0.1 m and thermal conductivity 25 W/m.K having uniform volumetric heat generation of 0.3 MW/m^3 is insulated on one side, while the other side is exposed to a fluid at 92 C. The convection heat transfer coefficient between the wall and the fluid is 500 $W/m^2 .K$. Determine the maximum temperature in the wall.

3.96 A cylindrical shell of inner and outer radii, *ri* and *ro*, respectively, is filled with a heat-generating material that provides a uniform volumetric generation rate (W/m^3) of *q* . The inner surface is insulated, while the outer surface of the shell is exposed to a fluid at $T\infty$ and a convection coefficient *h*.
(a) Obtain an expression for the steady-state temperature distribution *T*(*r*) in the shell, expressing your result in terms of *ri, ro, q* . , *h, T*∞, and the thermal conductivity *k* of the shell material.
(b) Determine an expression for the heat rate, *q*'(*ro*), at the outer radius of the shell in terms of *q*· and shell dimensions.

3.129 A long, circular aluminum rod is attached at one end to a heated wall and transfers heat by convection to a cold fluid.
(a) If the diameter of the rod is tripled, by how much would the rate of heat removal change?

(b) If a copper rod of the same diameter is used in place of the aluminum, by how much would the rate of heat removal change?

3.136 Two long copper rods of diameter D = 10 mm are soldered together end to end, with solder having a melting point of 650 °C. The rods are in air at 25C with a convection coefficient of 10 W/m^2 .K. What is the minimum power input needed to effect the soldering?