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| 1 ) Two stainless steel plates 10 mm thick are subjected to a contact pressure of 1 atm under vacuum conditions for which there is an overall temperature **drop of 100◦C** across the plates. What is the **heat flux through the plates**? What is the **temperature drop** across the contact plane? Hint: Use the contact conductance value in Table 2.1. | . x R1 Rconect R2 |

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| 2) A stainless steel (AISI 304) tube used to transport a chilled pharmaceutical has an inner **diameter of 36 mm** and a wall thickness **of 2 mm**. The pharmaceutical and ambient air are at **temperatures of 6◦C and 23◦C,** respectively, while the corresponding inner and outer convection coefficients are **400 W/m2-K** and **6 W/m2-K**, respectively.  (a) What is the heat gain per unit length [W/m]?  Outside 23◦C  6◦C  (b) What is the heat gain per unit length if a 10 mm thick layer of calcium silicate insulation (kins = 0.05 W/m-K) is applied to the outside of the tube? | 16mm  18mm |

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| 3) Steam at a temperature of 250◦C flows through a steel pipe (AISI 1010) of 60 mm inner diameter and 75 mm outer diameter. The convection coefficient between the steam and the inner surface of the pipe is 500 W/m2-K, while that between the outer surface of the pipe and the surroundings is 25 W/m2-K. The pipe emissivity is 0.8, and the temperature of the air and surroundings is 20◦C. What is the heat loss per unit length of pipe? |  |

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| 4) A spherical shell of inner and outer radii of ri and ro, respectively, is filled with a heat-generating material that provides for a uniform volumetric generation rate (W/m3) of q ̇. The outer surface of the shell is exposed to a fluid having a temperature T∞ and a convection coefficient h. Obtain an expression for the steady-state temperature distribution T(r) in the shell, expressing you results in terms of ri, ro, q ̇, h, T∞, and the thermal conductivity k of the shell material. |  |

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| 5. The exposed surface (x = 0) of a plane wall of thermal conductivity k is subjected to microwave radiation that causes volumetric heating to vary as    where q ̇o (W/m3) is a constant. The boundary at x = L is perfectly insulated, while the exposed surface is maintained at a constant temperature To. Determine the temperature distribution T(x) in terms of x, L, k, q ̇o, and To. |  |

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| 6) A long cylindrical rod of diameter 200 mm with thermal conductivity of 0.5 W/m-K experiences uniform volumetric heat generation of 24,000 W/m3. The rod is encapsulated by a circular sleeve having an outer diameter of 400 mm and a thermal conductivity of 4 W/m-K. The outer surface of the sleeve is exposed to a cross flow of air at 27◦C with a convection coefficient of 25 W/m2-K.  (a) Find the temperature at the interface between the rod and sleeve and on the outer surface. (b) What is the temperature at the center of the rod? |  |

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| 6) Radioactive waste (krw = 20 W/m-K) is stored in a spherical, stainless steel (kss = 15 W/m-K) container of inner and outer radii of ri = 0.5 m and ro = 0.6 m, respectively. Heat is generated volumetrically within the waste at a uniform rate of q ̇ = 105 W/m3, and the outer surface of the container is exposed to a water flow for which h = 1000 W/m2-K and T∞ = 25◦C.  (a) Evaluate the steady-state outer surface temperature of the container, Ts,o. (b) Evaluate the steady-state inner surface temperature of the container, Ts,i.  (c) Obtain an expression for the temperature distribution, T(r) in the radioactive waste. Evaluate the temperature at r = 0. |  |