ME 331 Homework Assignment #2
Due Tuesday April 11, by 5 pm in MEB main office

1. A composite wall consists of a 1.0 mm thick AISI 304 stainless steel plate, 2.0 cm of industrial calcium silicate insulation, and 2.0 cm of industrial mineral fiber blanket insulation. The stainless steel surface is maintained at 380 K while the other side loses heat to the ambient air at 300 K, with a convection heat transfer coefficient of 5.0 W/m^2-K. Estimate the heat flow per unit area.

2. A 2.0 m long cylindrical chemical reactor has an inside diameter of 5.0 cm, has a 1.0 cm thick stainless steel shell, and is insulated on the outside by a layer of medium-density (ρ = 28 kg/m^3) fiberglass blanket insulation (0.038 W/m-K), 5.0 cm thick. The ambient air is at 25°C, and the surroundings can be assumed to be large and also at 25°C. The convective heat transfer coefficient between the insulation and air is 6.0 W/m^2-K, and the gray surface emissivity (and absorptivity) of the insulation is 0.80. At steady state the outer surface of the insulation is measured at 32°C. Draw the thermal circuit and determine the temperature of the inner surface of the stainless steel shell. Take k = 16 W/m-K for the stainless steel.

3. A 1.0 mm thick copper plate (k = 386 W/m-K) is sandwiched between two 5.0 mm thick epoxy boards (k = 0.26 W/m-K) that are 15 cm x 20 cm in size. If the thermal contact resistance on each side of the copper plate is estimated to be 8.3x10^{-3} K/W, determine the error involved in the total thermal resistance of the plate if thermal contact resistances are ignored.

4. A 0.30 cm thick, 12 cm high, and 18 cm long circuit board houses 80 closely spaced logic chips on one side, each dissipating 0.040 W. The board is impregnated with copper filling and has an effective thermal conductivity of 20 W/m-K. All the heat generated in the chips is conducted across the circuit board and is dissipated from the backside of the board to a medium at 40°C with a heat transfer coefficient of 50 W/m^2-K. (*a*) Determine the temperatures on the two sides of the circuit board. (*b*) Now a 0.20 cm thick, 12 cm high, 18 cm long aluminum plate (k = 237 W/m-K) with a total of 864 aluminum pin fins each of diameter 0.25 cm and length 2.0 cm, is attached to the back side of the circuit board with a 0.020 cm thick epoxy adhesive (k = 1.8 W/m-K). Determine the new temperatures on the two sides of the circuit board.

5. A long, 12.0 cm O.D., 11.0 cm I.D., plain carbon steel pipeline for oil is centrally enclosed in 20 cm square concrete (k = 0.80 W/m-K) along the pipe's entire length. The concrete enclosed pipe assembly is submerged in seawater with the outer surface of the concrete maintained at 12°C. The oil has a bulk mean temperature of 100°C with an inner surface heat transfer coefficient of 350 W/ m^2-K. Find the heat transfer rate per meter of pipe length.