ASSIGNMENT #9

Natural Convection Problems

9–1 The following equation has been proposed for the heat transfer coefficient in natural convection from long vertical cylinders to air at atmospheric pressure:

$$\bar{h}_c = \frac{536.5(T_s - T_\infty)^{0.33}}{T}$$

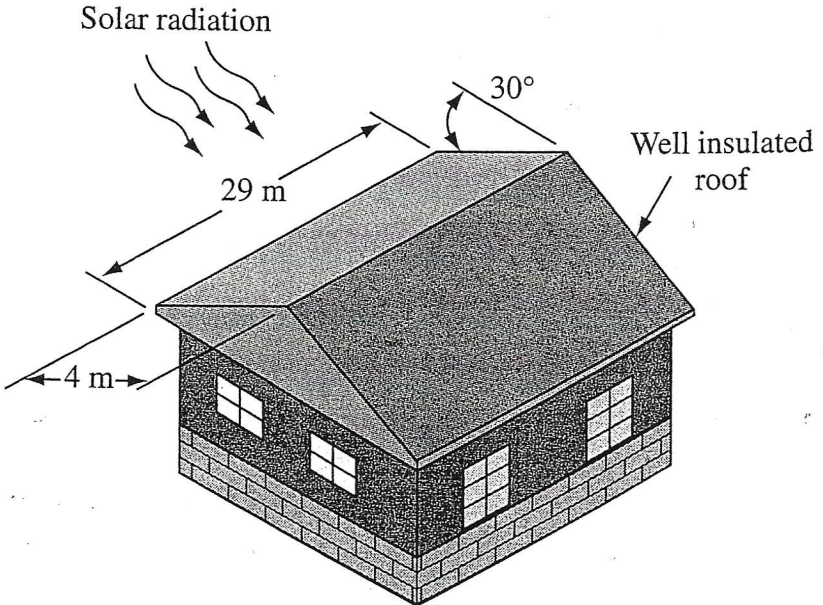
where T = the film temperature $= (T_s + T_\infty)/2$ and T is in the range 0 to 200 °C. The corresponding equation in dimensionless form is

$$\bar{h}_c L/k = C(\mathrm{GrPr})^m$$

Compare the two equations to determine the values of C and m such that the second equation will give the same results as the first equation.

9–2 Cooled air is flowing through a long, sheet metal air conditioning duct 0.2 m high and 0.3 m wide. If the duct temperature is 10°C and passes through a crawl space under a house at 30°C, estimate (a) the heat transfer rate to the cooled air per meter length of duct and (b) the additional air conditioning load if the duct is 20 m long. (c) Discuss qualitatively the energy conservation that would result if the duct were insulated with glass wool.

9–3 Solar radiation at 600 W/m^2 is absorbed by a black roof inclined at 30° as shown. If the underside of the roof is well insulated, estimate the maximum roof temperature in 20°C air.



9–4 A 2.5-m × 2.5-m steel sheet 1.5 mm thick is removed from an annealing oven at a uniform temperature of 425°C and placed in a large room at 20°C in a horizontal position. (a) Calculate the rate of heat transfer from the steel sheet immediately after its removal from the furnace, considering both radiation and convection. (b) Determine the time required for the steel sheet to cool to a temperature of 60°C. (*Hint:* This will require numerical integration.)

9–5 In petroleum processing plants, it is often necessary to pump highly viscous liquids such as asphalt through pipes. To keep pumping costs within reason, the pipelines are electrically heated to reduce the viscosity of the asphalt. Consider a 15-cm-OD uninsulated pipe and an ambient temperatures of 20°C. How much power per meter of pipe length is necessary to maintain the pipe at 50°C? If the pipe is insulated with 5 cm of fiberglass insulation, what is the power requirement?