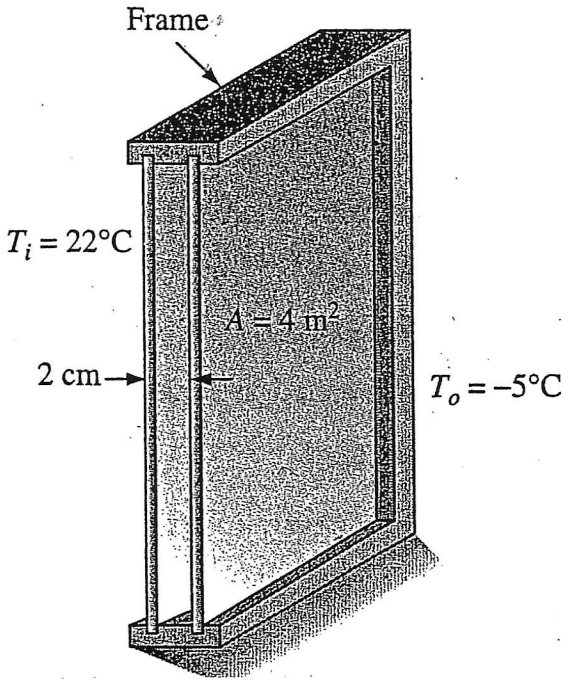
ASSIGNMENT #2

Cartesian Problems / Cylindrical Problems

2–1 A high-speed computer is located in a temperature-controlled room at 26°C. When the machine is operating, its internal heat generation rate is estimated to be 800 W. The external surface temperature of the computer is to be maintained below 85°C. The heat transfer coefficient for the surface of the computer is estimated to be 10 W/m^2 K. What surface area would be necessary to assure safe operation of this machine? Comment on ways to reduce this area.

2–2 To reduce home heating requirements, modern building codes in many parts of the country require the use of double-glazed or double-pane windows, i.e., windows with two panes of glass. Some of these so-called thermopane windows have an evacuated space between the two glass panes while others trap stagnant air in the space. (a) Consider a double-pane window with the dimensions shown in the following sketch. If this window has stagnant air trapped between the two panes and the convection heat transfer coefficients on the inside and outside surfaces are 4 W/m^2 K and 15 W/m^2 K, respectively, calculate the overall heat transfer coefficient for the system. (b) If the inside air temperature is 22°C and the outside air temperature is −5°C, compare the heat loss through a 4-m^2 double-pane window with the heat loss through a single-pane window. Comment on the effect of the window frame on this result. (c) If the total window area of a home heated by electric resistance heaters at a cost of \$0.10/k Wh is 80 m^2. How much more cost can you justify for the double-pane windows if the average temperature difference during the six winter months when heating is required is about 15°C?



2–3 Estimate the rate of heat loss per unit length from a 2-in.ID, $2\frac{3}{8}$ in. OD steel pipe covered with high temperature insulation having a thermal conductivity of 0.065 Btu/h ft and a thickness of 0.5 in. Steam flows in the pipe. It has a quality of 99% and is at 300°F. The unit thermal resistance at the inner wall is 0.015 h ft^2 °F/Btu, the heat transfer coefficient at the outer surface is 3.0 Btu/h ft^2 °F, and the ambient temperature is 60°F.

2–4 The rate of heat flow per unit length q/L through a hollow cylinder of inside radius r_i and outside radius r_o is

$$q/L = (\bar{A}\ k\ \Delta T)/(r_o - r_i)$$

where $\bar{A} = 2\pi(r_o - r_i)/\ln(r_o/r_i)$. Determine the percent error in the rate of heat flow if the arithmetic mean area $\pi(r_o + r_i)$ is used instead of the logarithmic mean area $\bar{A}$ for ratios of outside-to-inside diameters (D_o/D_i) of 1.5, 2.0, and 3.0.

2–5 A cylindrical liquid oxygen (LOX) tank has a diameter of 4 ft, a length of 20 ft, and hemispherical ends. The boiling point of LOX is −297°F. An insulation is sought that will reduce the boil-off rate in the steady state to no more than 25 lb/h. The heat of vaporization of LOX is 92 Btu/lb. If the thickness of this insulation is to be no more than 3 in., what would the value of its thermal conductivity have to be?