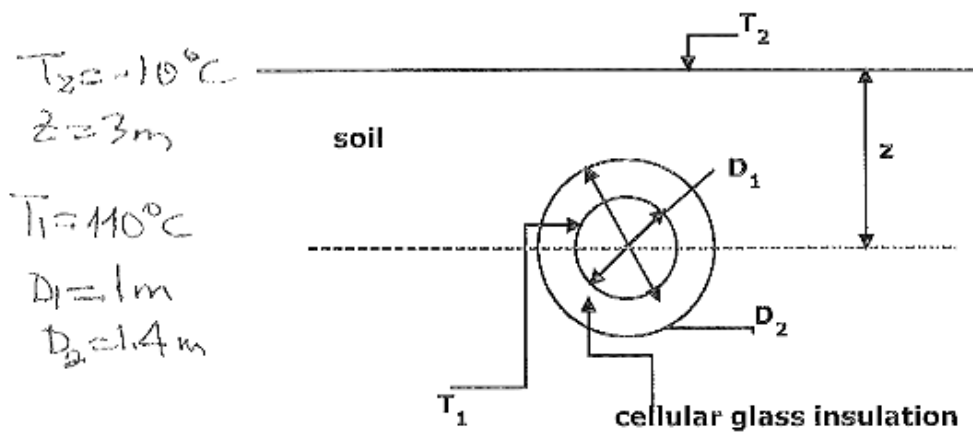


ME 313 Heat Transfer
 Quiz-4

3 A pipeline, used for the transport of crude oil, is buried in the earth such that its centerline is a distance of 3 m below the surface. The pipe has an outer diameter of 1 m and is insulated with a layer of cellular glass 200 mm thick. What is the heat loss per unit length of pipe when heated oil at 110°C flows through the pipe and the surface of the earth is at a temperature of -10 °C ? Since heat transfer coefficient is very large we can assume that inside surface temperature of the pipe is 110°C.



$T_2 = -10^\circ\text{C}$
 $z = 3\text{m}$
 $T_1 = 110^\circ\text{C}$
 $D_1 = 1\text{m}$
 $D_2 = 1.4\text{m}$

$k_s = 0.52\text{ W/mK}$ ← soil
 $k_{ins} = 0.068\text{ W/mK}$ ← cellular glass

$$R_{ins} = \frac{\ln(D_2/D_1)}{2\pi L k_{ins}} = \frac{\ln(1.4/1)}{2\pi L (0.068)} = \frac{0.776}{L}$$

$$R_s = \frac{1}{2k_s} = \frac{\cosh^{-1}(2z/D_2)}{2\pi L k_s} = \frac{\cosh^{-1}(6/1.4)}{2\pi (0.52)L} = \frac{0.653}{L}$$

$$q = \frac{110 - (-10)}{\frac{1}{2} [0.776 + 0.653]} = 84$$

$$\frac{q}{L} = 84\text{ W/m}$$