Problems of the Week 1

Always show your all work to receive credit (NO WORK=NO CREDIT)-1point

1. The expression, $H = \frac{dQ}{dt} = kA\frac{T_H - T_C}{L}$, describes the heat current in a conducting rod. It describes the rate in which heat is transferred from a location x on the rod to x+Δx. This equation assumes that the temperature varies in a uniform manner along the length of the rod. If the temperature varies in a non-uniform manner along the length of the rod, then we must consider how heat is transferred over an infinitesimal distance from x to x+dx. In such cases, the expression for the heat current must be rewritten as $H = \frac{dQ}{dt} = -kA\frac{dT}{dx}$ where the negative sign indicates that heat flows in the direction of decreasing temperature. To determine the temperature as a function of x, we must integrate. This latter equation still ignores heat transferred radially along the lateral surface of the rod. We can ignore this heat loss as long as the rod is sufficiently thin.

What if the rod is not sufficiently thin? For example, what if we need to consider the heat loss through the lateral surface of a steam pipe or the insulation around the steam pipe? Then we must consider the heat loss through a cylinder of thickness dr, meaning that dx in the latter equation is replaced with dr. Suppose there is a steam pipe of outer diameter 10.0cm and surface temperature 150^{o}C. The pipe is covered with a layer of asbestos 2.50cm thick, whose outer surface is at 25^{o}C. If the thermal conductivity of asbestos is 0.166W/m-K, how much energy is lost per minute from a 1.00m section of pipe?

A. 3.53kJ B. 7.21kJ C. 11.4kJ D. 15.2kJ E. 19.3kJ