Heat Exchanger

The shell and tube heat exchanger is employed for heating a steady stream of fluid from an inlet temperature T_1 to an exit temperature T_2. This is achieved by continuously condensing a saturated vapor in the shell, maintaining its temperature at T_s. The heat balance on a differential element yields the following equation

$$\frac{dT}{dx} = \frac{\pi D}{\dot{m}} \frac{h(T_s - T)}{c_p}$$

where D is the tube diameter, and $\dot{m}$ is the mass flow rate,. The heat transfer coefficient h is given by

$$h = \frac{0.023k}{D}\left(\frac{4\dot{m}}{\pi D \mu}\right)^{0.8}\left(\frac{\mu c_p}{k}\right)^{0.4}$$

where μ is the dynamic viscosity, and c_p is the specific heat, and k the thermal conductivity of the of the fluid, respectively. These quantities are functions of temperature.
Write a program to calculate the required heat exchanger length, L for heating the fluid to the required exit temperature T_2. Perform the calculations for carbon dioxide (CO_2) as the fluid medium. Assume, for simplicity, that the fluid properties (given below) are constant.

$$\dot{m} = 2.8345 \times 10^{-3} \text{ kg/s}$$
$$T_1 = 15.56\ ^{o}\text{C}$$
$$T_2 = 137.78\ ^{o}\text{C}$$
$$T_s = 287.8\ ^{o}\text{C}$$
$$D = 1.257 \text{ cm}$$
$$c_p = 841.8 \left(\frac{\text{Nm}}{\text{kg K}}\right)$$
$$\mu = 2 \times 10^{-5}\left(\frac{\text{Ns}}{\text{m}^2}\right)$$
$$k = 0.03 \left(\frac{\text{W}}{\text{mK}}\right)$$