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Mechanical Engineering Department

MEE 4572 Heat and Mass Transfer

Quiz 4

Full Name: Fall 2023

1- A 30 m long, 10 cm-diameter hot-water pipe of a district heating system is buried in the soil 50 cm below the ground surface. The outer surface temperature of the pipe is 80 °C. Taking the surface temperature of the earth to be 10 °C, and the thermal conductivity of the soil at that location to be 0.9 W/m.K, determine the rate of heat loss from the pipe.
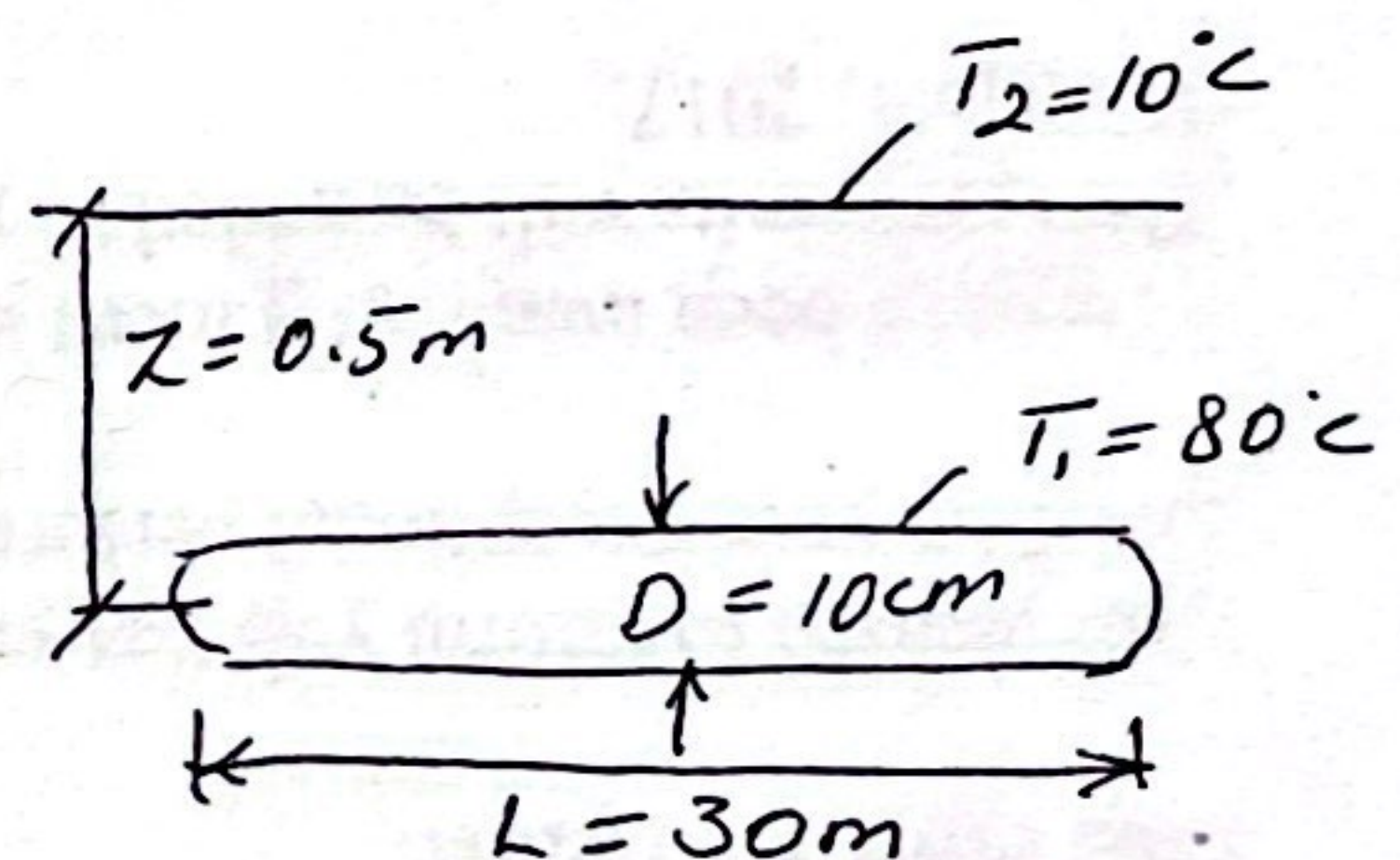
① ✓ $S = \dfrac{2\pi L}{\ln(4z/D)}$ $\qquad$ $L \gg D$

$\qquad\qquad\qquad\qquad z > 3D/2$

or

② ✓ $S = \dfrac{2\pi L}{\cosh^{-1}(2z/D)}$ $\qquad L \gg D$

$T_2 = 10°C$

$z = 0.5m$

$T_1 = 80°C$

$D = 10cm$

$L = 30m$

① $\Rightarrow S = \dfrac{2\pi \times 30}{\ln \dfrac{4 \times 0.5}{0.1}} = 62.9\,m$

$L = 30\,m \gg D = 0.1m$

$z = 0.5 > \left(\dfrac{3 \times D = 0.1}{2}\right) = 0.15$

$q = kS(T_1 - T_2) = 0.9 \times 62.9(80 - 10) = 3963\,W$

② $S = \dfrac{2 \times \pi \times 30}{\cosh^{-1}\left(\dfrac{2 \times 0.5}{0.1}\right)} = \dfrac{2\pi \times 30}{2.993}$

$= 62.97$

$\cosh^{-1}(x) = \ln\left(x + \sqrt{x^2 - 1}\right)$

$\qquad = \ln\left(10 + \sqrt{100 - 1}\right)$

$\qquad = 2.993$