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| 1. Water enters a tube at **27◦C** with a **flow rate of 450 kg/h**. The heat transfer from the tube wall to the fluid is given as **qs′ (W/m)= ax,** where the **coefficient a** is **20 W/m2** and x (m) is the axial distance from the tube entrance.   1. (a)  Beginning with a properly defined differential control volume in the tube, derive an expression for the temperature distribution Tm(x) of the water.     (d)  What value of a uniform wall heat flux, q′′ (instead of q′ = ax), would provide the same fluid ss  outlet temperature as that determined in part (b)? For this type of heating, repeat part (c).    **qs’’ = 95.4929/D KL/m^2** | q’=ax  q’=a x  T(x)  mDot\*Cp\*Tm🡪 🡪 mdot\*Cp\*(Tm-**d**Tm)  🡨 dx 🡪  (b)  What is the mean outlet temperature of the water for a heated section of 30 m long?    **44.22076058 Degrees C**  (c)  Sketch the mean fluid temperature, Tm(x), and the tube wall temperature, Ts(x), as a function of distance along the tube for fully developed and developing flow conditions. |

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| 2. **SAE 30 oil (k = 0.15 W/m-K)** is heated by flowing through a circular tube of diameter **D = 50 mm** and length **L = 25 m** and whose surface is **maintained at 150◦C**. If the flow rate and inlet temperature of the oil **are 0.5 kg/s** and **20◦C**, what is the outlet temperature **Tm,o**? What is the total heat transfer **rate q for the tube**?      h:= **33.02540672 𝑊 /𝑚2𝐾** | **15847.200 W** |

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| 3. To cool a summer home without using a vapor-compression refrigeration cycle, air is routed through a plastic pipe (**k = 0.15 W/m-K, Di = 0.15 m, Do = 0.17 m**) that is submerged in an adjoining body of water. The water temperature is nominally **at T∞ = 17◦C**, and a convection coefficient of **ho = 1500 W/m2-K** is maintained at the outer surface of the pipe. If air from the home enters the pipe at a temperature of **Tm,i = 29◦C** and a volumetric flow rate of **Vi = 0.025 m3/s**, what pipe length is needed to provide a discharge temperature of **Tm,o = 21◦C**? | Tmi Tmo  🡨 L 🡪    **14.73 m** |

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| 4. **Air at 4 × 10−4 kg/s and 27◦C** enters a triangular duct that is **20 mm** on a side and **2 m long**. The duct surface is maintained at **100◦C**. Assuming fully developed flow throughout the duct, determine the air **outlet temperature**.    **1175.11 degrees C** | 20mm  L:= 2m |