Exam 1 – 2019/2020: Problem 1

1. (4.0 points) Transient heat conduction experiments were performed with a plane wall with 0.2 m of thickness at the initial temperature of 20°C (T_i), immersed at different occasions in three different fluid media. The three media have the same temperature, equal to 180°C (T_∞), but different convection heat transfer coefficients (h). Heat conduction within the wall was observed only along the wall thickness (one-dimensional) and both sides of the wall were subjected to the same (symmetrical) convection boundary condition. The wall material thermal conductivity, k, is equal to $200\,\mathrm{W \cdot m^{-1} \cdot K^{-1}}$.

   Figure 1 presents the plane wall temperature profiles registered for the three media (Media 1 – 3) when the plane wall surface temperature value, $T\,(x = \pm 0.1\,\mathrm{m})$, reached 100°C. For the three profiles presented in Figure 1, the Fourier number is greater than 0.5. **Do not use the Heisler plots in the resolution.**

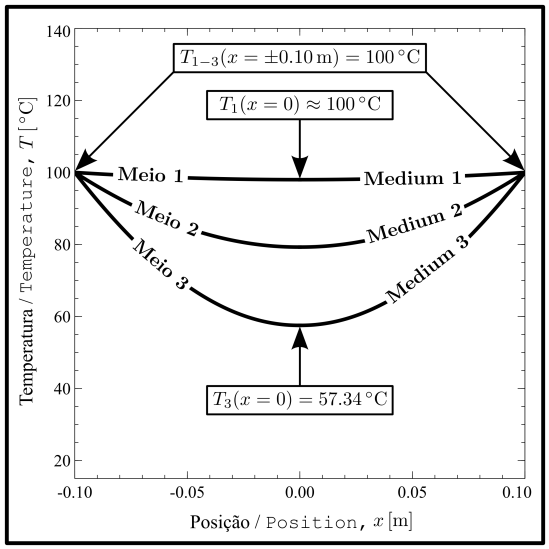

Figure 1

   (a) (2.0 points) Determine the wall volumetric heat capacity, ρc, knowing that the profile for Medium 1 is observed after 46 min of the beginning of the transient process ($t = 0$) and the convection heat transfer coefficient of Medium 1 is equal to $100\,\mathrm{W \cdot m^{-2} \cdot K^{-1}}$. (If you did not solve this question, assume $\rho c = 4\,\mathrm{MJ \cdot m^{-3} \cdot K^{-1}}$ for the following question.)

   (b) (2.0 points) Determine the required time from the beginning of the transient process to observe an average wall temperature, $\overline{T}$, equal to 100°C with Medium 3. Note that $Q/Q_o = (1/V) \int (1 - \theta^*)\, dV = 1 - \overline{\theta^*}$ and in Figure 1 for the profile of Medium 3, $T\,(x = 0) = 57.34$°C.