W03

A refrigeration truck is in motion at a speed of 80 km/h. The truck's depiction is presented in the image below.

Figure 1: Refrigeration truck

The dimensions of the truck's upper section measure 3 meters in length and 2.1 meters in width. The truck interior houses stored ice cream, requiring temperature regulation. The internal air maintains a temperature of -7 °C, featuring a heat transfer coefficient of $h_\mathrm{i} = 10\ \mathrm{W/m^2K}$. To insulate the roof, a sandwiched arrangement employs insulation ($t_2 = 40$ mm, $k_2 = 0.0320$ W/mK) nestled between two aluminum sheets ($t_1 = t_3 = 3$ mm, $k_1 = k_3 = 180$ W/mK). The ambient external temperature stands at 28°C.

a) Determine the Reynolds number for the roof of the passenger truck. Assume the average fluid properties to be $T_f = 25^\mathrm{o}$C. Please clearly indicate what properties or air are used and which assumptions have been made.

b) Determine at which length the laminar flow becomes turbulent.

c) Find an expression for the heat transfer coefficient h_o outside the truck. Also, explain what the heat transfer coefficient tells us.

d) Provide a sketch of the thermal network. Include all known temperatures, resistances, and the direction of the flow of heat. Explain each component

e) Determine the rate of heat transfer from the ambient through the top of the truck.

f) Determine the temperature T_s of the top surface of the truck roof. What would have been a good estimate for T_f in task a)?

g) Give a sketch of the temperature profile. The domain drawn should cover the inside temperature of -7 $^\mathrm{o}$C as well as the outside temperature of 28 $^\mathrm{o}$C.