A flat, very long panel is composed of two layers: a thin film (k_{film} = 0.025 W/mK, thickness = 0.25 mm) and a substrate ($k_{substrate}$ = 0.05 W/mK, thickness = 1 mm). A heat flux q (W/m^2) is applied to the back of the substrate, while the film is subject to cooling by a forced convection air flow. The back of the substrate is maintained at T_1 = 90 °C while the free surface of the film is exposed to air at T_{air} = 20 °C and an average, unknown convection heat transfer coefficient h (W/m^2K). Also, it is required that the temperature T_2 between the film and the substrate must be equal to 60 °C. Determine the heat flux q to be applied to the substrate and the convection heat transfer coefficient of the air flow.

A shell-and-tube exchanger (two shells, four tube passes) is used to cool down 100 kg/h of pressurized water from 87 to 47 °C with 200 kg/h of methyl alcohol (methanol, $cp_{methanol}$=2672 J/kgK) entering the exchanger at 27 °C. If the overall heat transfer coefficient is 300 W/m^2K, determine the outlet temperature of the methanol and the required heat exchanger area.

Atmospheric air enters a 10-m-long, 150-mm-diameter uninsulated heating duct at 60 °C and 0.04 kg/s. The duct surface temperature is approximately constant at T_{wall} = 15 °C.
What are the outlet air temperature, the heat rate q, and pressure drop p for these conditions?
Also, assuming that the tube wall is thin, an air flow at T_{out} = 0 °C flows over the whole tube with a velocity of 4 m/s. Determine the outer heat transfer coefficient and the overall heat transfer coefficient.

A long, thin-walled horizontal tube 100 mm in diameter is maintained at uniform temperature T_{tube} = 120 °C by the passage of steam through its interior. The tube is diffuse and it can be considered a gray surface with an emissivity ε = 0.8. The tube is located into a big chamber, which can be considered a blackbody at a temperature T_{wall} = 35 °C for the purpose of the radiative heat exchange. In the chamber, stagnant air is also present at T_{air} = 35 °C. Determine the total heat loss of the tube for unit tube length.