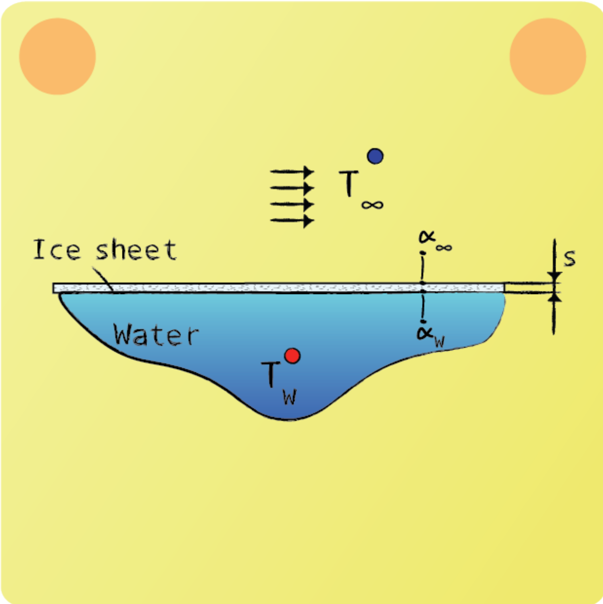
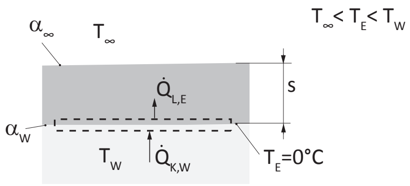
Exam Preparation Conduction 09



Air with the temperature T_∞ flows over a large lake with a constant water temperature T_W. Under the prevailing conditions, an ice sheet is formed on the surface of the water. What is the maximum sheet thickness s that this ice-cover can obtain under steady-state conditions?



By a heat balance (for example at the phase interface ice-water) under steady-state conditions

$$\dot{Q}_{\mathrm{L,I}} = \dot{Q}_{\mathrm{K,W}}$$

and by the knowledge of the temperate at the interface ice-water $T_{\mathrm{E}} = 0°\mathrm{C}$, the conduction within the ice sheet and the convection on the phase interface ice-water can be described as follows:

$$\frac{1}{W_{\mathrm{I}}}(T_{\mathrm{I}} - T_\infty) = A_{\mathrm{I}}\alpha_{\mathrm{W}}(T_{\mathrm{W}} - T_{\mathrm{I}})$$

The resistance W_{E} if formed by the heat conductivity λ_{E} and the thickness of the ice s as well as by the heat transfer coefficient α_∞ at the phase interface ice-environment:

$$W_{\mathrm{I}} = \frac{\frac{s}{\lambda_{\mathrm{I}}} + \frac{1}{\alpha_\infty}}{A_{\mathrm{I}}}$$

Converting the formula gives the maximum thickness s:

$$s = \frac{\lambda_{\mathrm{I}}}{\alpha_{\mathrm{W}}} \cdot (\frac{T_{\mathrm{I}} - T_\infty}{T_{\mathrm{W}} - T_{\mathrm{I}}} - \frac{\alpha_{\mathrm{W}}}{\alpha_\infty})$$