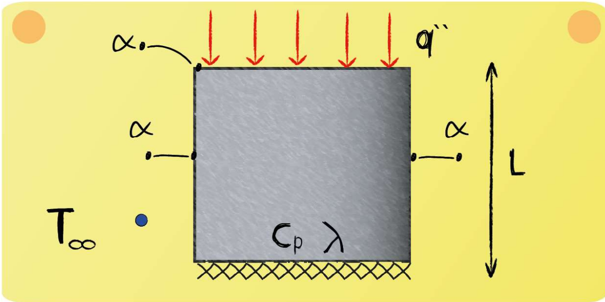
Lecture 14 - Question 8



A steel cube is exposed to a heat flux from the upper side. The bottom is adiabatic. Furthermore all free surfaces are subjected to convection. Derive the differential equation that expresses the change in temperature of the cube over the course of time. Assume the temperature to be homogeneous and neglect radiation.

Energy balance:

$$\frac{\partial U}{\partial t} = \sum \dot{Q}_{in} - \sum \dot{Q}_{out}$$

The heat transfer can be classified as transient, for that reason the change of internal energy over time equals the sum of the in and outgoing fluxes.

Change of internal energy over time:

$$\frac{\partial U}{\partial t} = \rho \cdot c_p \cdot L^3 \cdot \frac{dT_w}{dt}$$

The internal energy of the control volume can be described as: $U = m \cdot c_p \cdot T$.

Heat fluxes:

$$\sum \dot{Q}_{in} = q'' L^2$$

$$\sum \dot{Q}_{out} = 5\alpha \left(T_w - T_\infty\right) L^2$$