# Lecture 3

## 3.1 Cooling a potato

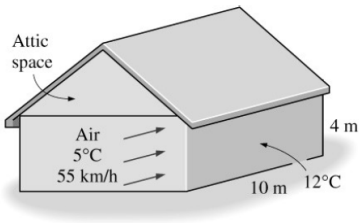
During air cooling of potatoes, the heat transfer coefficient $h$ is determined experimentally to be : Consider an

| Air velocity ($\mathrm{m\,s^{-1}}$) | Heat transfer coefficient ($\mathrm{W\,m^{-2}\,K^{-1}}$) |
|---|---|
| 0.66 | 14.0 |
| 1.00 | 19.1 |
| 1.36 | 20.2 |
| 1.73 | 24.4 |

potato with a diameter of 8 cm, initially at 20 °C. Potatoes are cooled by refrigerated air at 5 °C at a velocity of 1 m/s. Determine the initial rate of heat transfer from a potato.

## 3.2 Heat loss through a wall

During a cold winter day, wind at 55 $\mathrm{km\,h^{-1}}$ is blowing parallel to a 4 m high and 10 m long wall of a house. The air outside is at 5 °C and the surface temperature of the wall is 12 °C. Determine the rate of heat loss from that wall by convection.



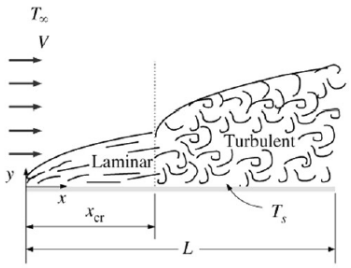

## 3.3 Flow over an airplane wing

An airplane is climbing rapidly to a height of 10 km. The air at this height is very cold. The airplane itself is still much warmer. Consider a wing of the airplane as a flat plate, over which wind is blown in a parallel direction. At a certain distance from the leading edge (front edge) of the wing, the laminar flow in the boundary layer turns into turbulent flow.

a) Explain what a boundary layer is.

b) Consider the laminar part of the boundary layer. Where in this region will the rate of heat loss be highest? Explain your answer using boundary layer theory.

c) Now consider the transition from laminar to turbulent flow. What change in the rate of heat transfer do you expect, comparing the flow just before and just after the transition?




## 3.4 Competition of soccer and tennis balls

Consider a soccer ball and a tennis ball, with diameters $D_s = 0.22$ m and $D_t = 0.066$ m, respectively. The soccer ball is moving with a velocity of 58 km h$^{-1}$. Assume that both balls have similar roughness patterns.

a) What should the velocity of the tennis ball be to obtain a flow pattern similar to the flow pattern around the soccer ball?

b) In this situation, which of both balls has a higher heat transfer coefficient? And which one has a higher rate of heat loss? Consider both balls to be at the same surface temperature and in the same environment. Prove your answer using heat transfer theory.

## 3.5 Cooling of an engine

Consider a hot automotive engine, which can be approximated as a 0.50-m-high, 0.40-m wide and 0.80-m-long rectangular block. The bottom surface of the block is at a temperature of 100 °C. The ambient air is at 20 °C. Determine the rate of heat transfer from the bottom surface of the engine block by convection as the car travels at a velocity of 80 km h$^{-1}$.