Approach

The approach below gives a guideline in how to solve the problems presented during this course. Correctly applying this approach will lead to a good understanding of the concepts presented in this course.

Analysis

1. Explain the problem: which physical phenomena are important in this problem?
2. Make a sketch of the problem
3. Give the known variables (with the appropriate units!)

Approach

1. Explain the assumptions you make to solve the problem
2. Show the solution method for solving the problem

Elaboration

1. Show the calculation steps and explain the equations you use
2. Give references if values are found online or in tables

Evaluation

1. Check the units of your solution
2. Is the answer realistic/expected?
3. Did you answer all the questions asked?
4. Iterate if this is required

Lecture 3

3.1 Cooling a potato

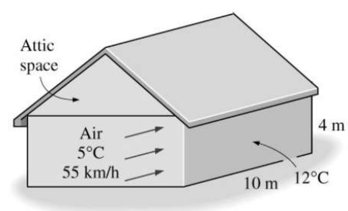
During air cooling of potatoes, the heat transfer coefficient h is determined experimentally to be : Consider an

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.



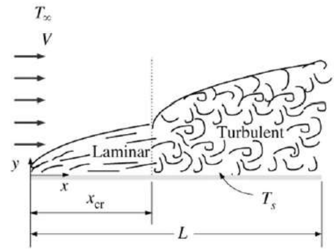
3.3 Flow over an airplane wing

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 $\mathrm{km\,h^{-1}}$. 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 $\mathrm{km\,h^{-1}}$.

3.6 Roof of a train - <u>Hand in</u>

The top surface of a railway carriage moving at a velocity of 70 km/h is 2.8 m wide and 8.0 m long. The top surface is absorbing solar radiation at a rate of 200 $\mathrm{W/m^2}$ and the temperature of the ambient air is 30 °C. Assuming the roof of the car to be perfectly insulated at its bottom side and the radiation heat exchange with the surroundings to be small relative to convection, determine the equilibrium temperature of the top surface of the railway carriage.