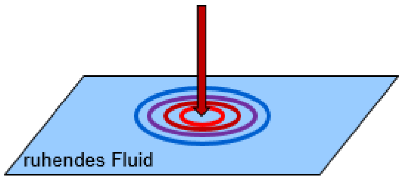
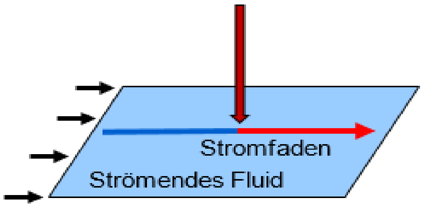
V 01: Introduction to convection and the conservation equations

Learning Goals:

- Understanding Convection and the distinction from Advection
- Convection as the interaction of heat Conduction and Advection
- Classification of convection problems
- Derive the conservation equations for mass, momentum and energy
- Understand the similarity between momentum and energy transport





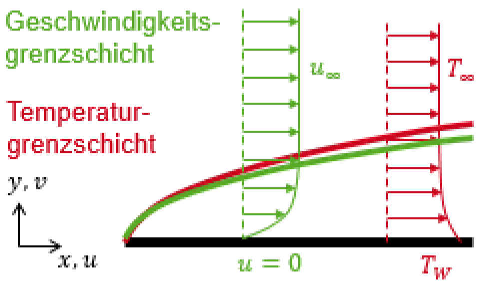
Comprehension Questions:

- ☐ What is meant by a heat transfer coefficient and what does it describe?
- ☐ Why does the Fourier's law of heat conduction also apply on the fluid side in the immediate vicinity of the wall?
- ☐ What does the dimensionless Nusselt number mean?
- ☐ What is the difference between natural and forced convection?

V 02: Boundary Layer Equation– Forced Convection

Learning Goals:

- Understanding the boundary layer concept on a flat plate in a constant laminar flow.
- Similarity of velocity and temperature profiles in the boundary layer, and the resulting relation between the heat transfer coefficient and the shear stress for this case



Comprehension Questions:

- ☐ What is the difference between the Nusselt and Biot numbers?
- ☐ What is the relevance of the Prandtl number for Boundary Layer theory?
- ☐ If there is an identity between the thickness of the Flow Boundary Layer and the Temperature Boundary Layer ($\delta_u = \delta_T$), what is the relationship for the Nusselt number? (not relevant to the exam)

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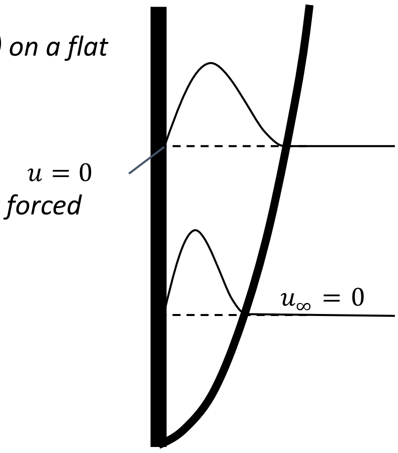
V 03: Boundary Layer equations– Natural convection

Learning Goals:



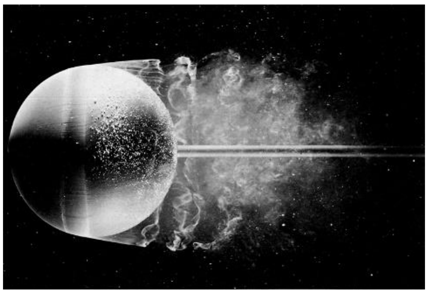
- *Understanding the Boundary Layer profile (Temperature and Velocity) on a flat plate with natural (free) convection*
- *Derivation and meaning of the Grashof number*
- *Knowledge of the differences between the Boundary Layer profiles for forced and free convection*

Comprehension Questions:

- ☐ What is the driving potential of Natural Convection?
- ☐ Why are buoyancy forces negligible in Forced Convection?

V 04: Turbulent Flow

Learning Goals:



- Konzept turbulenter Strömungen
- Makroskopische Auswirkung turbulenter Fluktuationen auf den Masse- und Wärmetransport verstehen

Comprehension Questions:

- ☐ Wie wirkt sich die Turbulenz auf den Wärmeübergang aus?

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V 05: Application of Dimensional Analysis

Learning Goals:

$$Nu = Nu(Re, Gr, Pr)$$

- Basic understanding of Dimensional Analysis.
- Understand the physical meanings of relevant dimensionless numbers that can describe a convection problem.
- Ability to distinguish different convective heat transfer problems in terms of flow and boundary conditions.

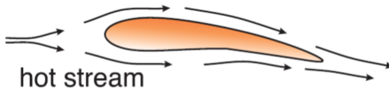
Comprehension Questions:

- ☐ *What does the Dimensional Analysis say and what must be taken into account so that the solutions of two different problems are identical?*
- ☐ Which Dimensionless numbers are essential for the empirically found heat transfer laws?

V 06: Heat transfer laws for the forced convection in external flow

Learning Goals:

- Knowledge and understanding of the Dimensionless numbers
- Overview of different application cases and associated correlations



cooled turbine blade

Comprehension Questions:

- ☐ *Which dimensionless numbers have to be considered in forced convection? How is the applicability of a correlation checked?*
- ☐ At what temperature are the material properties occurring in the dimensionless numbers to be determined?
- ☐ What is the difference between local and average heat transfer in a flat plate with heating or cooling?

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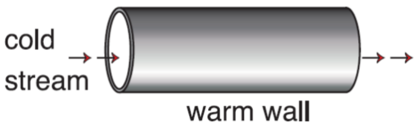
V 07: Forced Convection in Internal Flow – Developing versus Fully Developed Flows and the Caloric Mean Temperature

Learning Goals:

- Knowledge of the essential differences between external and internal flows
- Understanding of the hydrodynamic and thermal **inlet behavior**
- Ability to calculate the **caloric mean temperature**
- Ability to calculate the local temperatures and heat fluxes as well as the average heat transfer coefficient

Comprehension Questions:

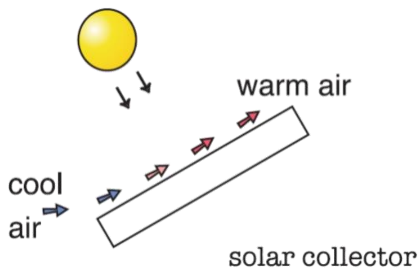


- ☐ What are the differences between external and internal flows?
- ☐ What is the meaning of the hydrodynamic and thermal entrance length?
- ☐ What is the meaning of the caloric mean temperature and how can it be calculated?
- ☐ How does the local heat transfer coefficient change inside a laminar pipe flow?

V 08: Forced Convection in Internal Flow and the LMTD

Learning Goals:

- Knowledge of meaning of the **logarithmic mean temperature difference (LMTD)**
- Ability to apply and calculate the LMTD



Comprehension Questions:

- ☐ What is the meaning of the logarithmic mean temperature difference, and when do we need to apply this?

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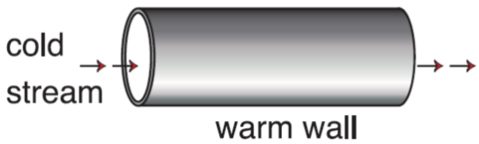
V 09: Forced Convection in Internal Flows – HTC in laminar fully developed flows

Learning Goals:

- ► Ability to calculate the heat transfer coefficient in laminar flows under fully developed conditions
- ► Ability to distinguish between different flow configurations and to choose the proper correlation for the HTC



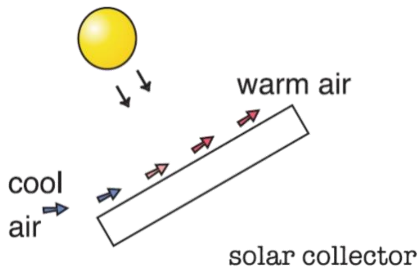
Comprehension Questions:

- ☐ Why is the HTC constant in the fully developed region of an internal flow?
- ☐ What are the major steps to calculate the HTC in the fully developed region?
- ☐ What can result in a loss of self-similarity of the heat transfer behavior?

V 10: Natural Convection in External Flow

Learning Goals:

- ➢ Knowledge of the correlations given in the reader and on the formula sheet for cases of natural convection



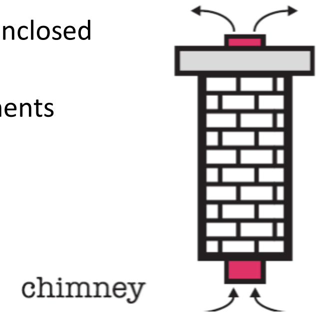
Comprehension Questions:

- ☐ Which dimensionless numbers must be taken into account when applying the heat transfer laws?
- ☐ What is the driving potential in natural convection?
- ☐ Which are the two different cases for horizontal plates and how do they differ from vertical plates?

V 11: Natural Convection in enclosed spaces

Learning Goals:

- Understanding of the influence of heated and cooled surfaces in enclosed spaces.
- Decision-making competence for vertical and horizontal arrangements
- Gain an overview of different applications



Comprehension Questions:

- ☐ Why is heat generally transferred between two horizontal surfaces in a fluid layer only by conduction when the upper plate is heated?
- ☐ Which exception exists to the rule stated in the question above?

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