Module 6: Learning objectives

- In this chapter attempts have been made to develop, in a logical fashion, the mathematical and physical bases of convection transport. To test your comprehension of the material, you should challenge yourself with appropriate question. What are the velocity, thermal, and concentration boundary layers? Under what conditions do they develop, and why are they of interest to the engineer? How do laminar and turbulent boundary layer is laminar or turbulent? There are numerous processes that affect momentum, energy, and species transfer in a boundary layer. What are they? How are they represented mathematically? What are the boundary layer approximations, and in what way do they alter the conservation equations? What are the relevant dimensionless groups for the various boundary layers? How may they be physically interpreted? How will the use of these groups facilitate convection calculations? How are velocity, thermal, and concentration boundary layer behaviors analogous? How the effects of turbulence may be treated in a boundary layer analysis? Finally, what is the central problem of convection?
- In this chapter convection correlations that may be used to estimate convection transfer rates for a variety of external flow conditions have been developed. For simple surfaces geometries these results may be derived from a boundary layer analysis, but in most cases they are obtained from generalization based on experiment. The student should know when and how to use various expressions, and he/she should be familiar with the general methodology of a convection calculation.
- Internal flow is encountered in numerous applications, and it is important to appreciate its unique features. What is the nature of fully developed flow, and how does it differ from flow in the entry region? How does the Prandtl number influence boundary layer development in the entry region? How do thermal conditions in the fluid depend on the surface condition? For example, how do the surface and mean temperatures vary with x for the case of uniform surface heat flux? Or how do mean temperatures and the surface heat flux vary for the case of uniform surface temperature?
- The student must be able to perform engineering calculations that involve an energy balance and appropriate convection correlations. The methodology involves determining whether the flow is laminar or turbulent and establishing the length of the entry region. After deciding whether one is interested in local conditions (at a particular axial location) or in average conditions (for the entire tube), the convection correlation may be selected and used with the appropriate form of the energy balance to solve the problem.
- Several features that complicate internal flows have not been considered in this chapter. For example situation may exists for which there is a prescribed axial variation in T_s or q_s^n, rather than uniform surface conditions. Among other things, such a variation would preclude the existence of a fully developed region. There may also exist surface roughness effects, circumferential heat flux or temperature variations, widely varying fluid properties, or transition flow conditions.

- We have considered convective flows that originate in part or exclusively form buoyancy forces, and we have introduced the dimensionless parameters needed to characterize such flows. The student should be able to discern when free convection effects are important and to quantify the associated heat transfer rates. An assortment of empirical correlations has been provided for this purpose.
- In short, by the end of the module, the student should have a fundamental understanding of the convection process and its mathematical description.