Module title: Particles transportation and diffusion

Module code: 24-14-734-01

Module credit: 3

Module objectives: This course is presented for PhD students in mechanical engineering. This course is designed to introduce a basic study of the phenomena of particles diffusion and transportation, to develop methodologies for solving a wide variety of material diffusion. While momentum, heat, and mass transfer developed independently as branches of classical physics long ago, their unified study has found its place as one of the fundamental engineering sciences. This development, in turn, less than half a century old, continues to grow and to find applications in new fields such as biotechnology, microelectronics, nanotechnology, and polymer science. Evolution of transport phenomena has been so rapid and extensive that complete coverage is not possible. While we have included many representative examples, our main emphasis has, of necessity, been on the fundamental aspects of this field. Enough material has been included for two courses, one introductory and one advanced. Long regarded as a rather mathematical subject, transport phenomena is most important for its physical significance. The essence of this subject is the careful and compact statement of the conservation principles, along with the flux expressions, with emphasis on the similarities and differences among the three transport processes considered. Often, specialization to the boundary conditions and the physical properties in a specific problem can provide useful insight with minimal effort. Nevertheless, the language of transport phenomena is mathematics, and in this course we have assumed familiarity with ordinary differential equations and elementary vector analysis. We introduce the use of partial differential equations with sufficient explanation that the interested student can master the material presented. Numerical techniques are deferred, in spite of their obvious importance, in order to concentrate on fundamental understanding.

Term: Fall-January

Text:
M. F. Modest, *Radiative Heat Transfer*, Third Edition, Academic Press, 2013.
R. B. Bird, W. E. Stewart, E. N. Lightfoot,Transport Phenomena, Second Edition, 2001.
C. B. Alcock, Thermochemical Processes: Principles and Models, First Edition, 2001.

Instructor information:

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Assessments: The students learning will be evaluated according to the below table:

Homework (paper report and oral presentation):	20%
Project:	20%
Final-term exam:	60%

References

[1] R. Siegel, J. R., Howell, *Thermal radiation Heat*, Fourth edition, 2001.
[2] M. F. Modest, *Radiative Heat Transfer*, Third Edition, Academic Press, 2013.
[3] C. B. Alcock, Thermochemical Processes: Principles and Models, First Edition, 2001.
[4] R. B. Bird, W. E. Stewart, E. N. Lightfoot,Transport Phenomena, Second Edition, 2001

Module subjects:

1st week: The Equation of Radiative Transfer in Participating Media
2st week: Approximate Solution Methods for One-Dimensional Media
3st , 4th weeks: The Optically Thin & Thick Approximation
5st weeks: Temperature and Pressure Dependence of Thermal Conductivity
6th weeks :Theory of Thermal Conductivity of Gases at Low Density
7st , 8th weeks :Molecular Theory of the Viscosity of Gases at Low Density
9st weeks: Estimation of Diffusivity at Low Density
10st week: Estimation of Self-Diffusivity at High Density
11st week: Estimation of Binary Diffusivity at High Density
12st , 13th weeks :Mass and Molar Transport by Convection
14st week: Theory of Diffusion in Gases at Low Density
15st week: The Maxwell-Stefan Equations for Multicomponent Diffusion in Gases at Low Density
16st week: Mixed diffusion and radiation problems (Fortran code)
Final-term exam