


CONDUCTION AND CONVECTION: FUNDAMENTALS AND APPLICATIONS

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PRE-REQUISITES : First and Second year Mathematics Courses. The basic core course in Fluid Mechanics

INTENDED AUDIENCE : BTech (UG) in Mechanical. Chemical and Aerospace; MSc in Mathematics; MTech (PG) in Mechanical (Fluids and Thermal),

INDUSTRY SUPPORT : DRDO Labs, ISRO, Some CSIR Labs, BHEL, BARC, Thermax, Reliance Energy, Solar energy companies, GE etc.

COURSE OUTLINE :

This is the first introductory course on heat transfer and will be useful for undergraduates as well as graduate level students. In the first part of the course, the focus is on analytical treatment of the subject wherein the thermal transport phenomena by conduction and convection modes are delineated under different conditions which are encountered in engineering practice. Analytical solutions of the governing equations are presented with sufficient rigour and depth. The course also introduces phase-change heat transfer, i.e., boiling and condensation. The later part of the course deals with engineering applications, with a focus on understanding conventional industrial heat exchangers and passive heat pipes and thermosyphons.

ABOUT INSTRUCTOR :

Prof. Gautam Biswas is presently a Professor of Mechanical Engineering at the Indian Institute of Technology Kanpur. Earlier, he has been the Director of Indian Institute of Technology Guwahati, and Director of the CSIR-Central Mechanical Engineering Research Institute at Durgapur. He was the G.D. and V.M. Mehta Endowed Chair Professor, and Dean of academic affairs at IIT Kanpur. The research group of Professor Biswas at IIT Kanpur identified the phenomenon of Rayleigh-Taylor Instability during the bubble formation in film boiling. This was a significant addition to the classical theory, based on Taylor Helmholtz instability. Another seminal contribution of his group is identification of zone of large bubble entrapment and underlying physics during the complete coalescence of a falling drop on a liquid surface. Professor Biswas is the author of more than 150 publications in the International Journals. He has completed guidance of 23 PhD theses. He was a Humboldt Fellow in Germany in 1987-88 and JSPS invited fellow in Japan 1994. He is a Fellow of the American Society of Mechanical Engineers (ASME). He has served a full term as the Associate Editor of the Journal of Heat Transfer (Trans ASME). He was a Guest Professor at the University of Erlangen-Nuremberg in 2002. Currently he is Associate Editor of a well-known CFD-Journal, - Computer and Fluids. Prof Gautam Biswas is a Fellow of the all three major Science Academies of India, such as, the Indian National Science Academy (INSA), New Delhi, the Indian Academy of Sciences (IAS, Bangalore) and the National Academy of Sciences India (NASI, Allahabad). He is a Fellow of the Indian National Academy of Engineering (INAE) and Institution of Engineers India (IEI). He has been awarded the esteemed J.C. Bose National Fellowship by the Department of Science and Technology, New Delhi in 2011. Prof. Biswas was bestowed with Distinguished Alumnus Award by BESU (now IIEST, Shibpur) in the year 2013. He has been awarded the Distinguished Alumnus Award by the Indian Institute of Technology Kharagpur in 2016. Prof. Biswas was conferred Honorary Doctorate (Honoris Causa) by National Institute of Technology Agartala, India, in 2017. He has been conferred Honorary Doctorate by the Aristotle University of Thessaloniki, Greece, in 2018.

Prof. Sameer Khandekar is affiliated to the Department of Mechanical Engineering, Indian Institute of Technology Kanpur, India, since September 2004. He completed M. Tech. program from IIT Kanpur, India (1998-2000) with specialization in Fluid-Thermal Engineering, and subsequently earned doctoral degree from University of Stuttgart, Germany (2000-2004). Earlier, after his undergraduate studies in Mechanical Engineering from Government Engineering College, Jabalpur (MP), he worked as a marine power plant engineer on board sea-going merchant ships for four years (1994-1998). At present, Prof. Khandekar is an occupant of Sir M. Visvesvaraya Chair at IIT Kanpur. He is also a Fellow of the Indian National Academy of Engineering (elected in 2019) and Fellow of Institution of Engineers (India) since 2016. He is a recipient of P. K. Kelkar Research Fellowship from IIT Kanpur in 2008, DAAD Fellowship (2011), Prof. K. N. Seetharamu Award from the Indian Society of Heat and Mass Transfer in 2010, George Grover Medal from the International Heat Pipe Committee in 2007, and Young Scientist Award (Department of Atomic Energy, India, 2005). Prof. Khandekar is Associate Editor of International Journal of Thermal Sciences and Interfacial Phenomena and Heat Transfer. He is also an executive member of the International Heat Pipe Committee and Indian Heat and Mass Transfer Society. He has served as an invited faculty member at five international universities in Germany, France, Brazil, Russia and Thailand. He has over one hundred research publications in international journals, over one hundred publications/ presentations in international conferences, including 16 Keynote lectures/Invited Talks, eight patents, and four books to his credit. He has served as the Associate Dean (Innovation and Incubation) and coordinator of the SIDBI Innovational and Incubation Center, IIT Kanpur during 2015 - 2017. He is also the President of Shiksha Sopan, a voluntary organization (registered NGO), serving the underprivileged sections of the society in and around IIT Kanpur. His current research interests are in experimental microscale phase-change thermo-fluidic systems, evaporation, boiling, condensation, heat pipes and energy systems.

COURSE PLAN :

Week 1: Introduction about the Course, Conduction Fundamentals, The diffusion equation and the boundary conditions, 1-D Steady State Conduction in Various Geometry, Heat Transfer from Extended Surfaces
Week 2: Heat Transfer from a Tapered Fin, Heat Transfer from an Annular Fin, 2-D Conduction: Analytical Solution, 2-D Heat Conduction in a Finite Cylinder
Week 3: Transient Conduction, Unsteady State Conduction in an Infinite Slab, Conduction in a Semi- Infinite Solid
Week 4: Computational Methods for Conduction, ADI Scheme and TDMA, Methods for solving Steady State Conduction
Week 5: Introduction to Convection-1, Velocity and the Thermal Boundary Layers, Flow and heat transfer over a heated flat plate-1, Flow and heat transfer over a heated flat plate-2
Week 6: Approximate Method for calculating heat transfer on a heated flat plate, Heat Transfer from non-zero pressure-gradient surfaces, Internal flows and heat transfer (preliminaries)
Week 7: Flow and heat transfer in a circular pipe; Thermally fully developed flow in a pipe, Turbulent Flow and Heat Transfer (preliminaries), Prandtl's mixing length and universal velocity profile,
Week 8: Turbulent flow and heat transfer in a pipe, Natural (Free) Convection (preliminaries), Free Convection on Vertical Flat Plate and Other Geometries
Week 9: Introduction to Boiling heat transfer, Wetting and heterogeneous nucleation, bubble growth, Pool Boiling, Regimes of pool boiling, Nukiyama curve
Week 10: Condensation heat transfer, Filmwise condensation, Nusselt analysis, Dropwise condensation, modeling
Week 11: Introduction to Heat Exchangers, Overall Heat Transfer Coefficient, Fouling, Evaporators, and Condensers, Performance analysis, Logarithmic Mean Temperature Difference, Effectiveness, Number of Transfer Units
Week 12: Passive thermal management, Theory and operation of heat pipes, Limitations, Modeling capillary limit, Two-phase Thermosyphons, Non-conventional heat pipes