

Chapter 4

Radiation and Heat Transfer

CHAPTER HIGHLIGHTS

- ✦ Black Body
- ✦ Emissive Power
- ✦ Transmissibility, Absorptivity, Reflectivity
- ✦ Gray Body
- ✦ Emissivity of a Gray Surface
- ✦ Coloured Body
- ✦ Kirchhoff's Law
- ✦ Shape Factor
- ✦ Radiation Shields
- ✦ Quantum Theory or Planck's Theory
- ✦ Surface Emission Properties
- ✦ The Stefan-Boltzmann Law
- ✦ Heat Exchange Between Two Black Bodies
- ✦ Electrical Network Analogy for Thermal Radiation Systems

INTRODUCTION

As the molecules and free electron transport the energy in conduction and convection, a medium is required for heat transfer. But heat transfer by radiation does not require any medium and it is more effective in vacuum rather than in a medium. When a surface radiates, then energy released by the surface is not continuous but it is in the form of packet (quanta) of energy called photons. They propagate through the space as rays. These are known as electromagnetic waves. They move with light velocity in space. When these rays strikes to any surface then, they impart their energy in the form of thermal energy which is partly absorbed, received and transmitted by the surface. According to wave theory or Maxwell theory, all type of waves carry energy and travel at different wave length λ and frequency ν . In a medium at velocity equal to velocity of light $C = \nu\lambda$.

Velocity of light in vacuum $C = 3 \times 10^8 \text{ m/s}$.

Thermal radiation is considered in the wave length range of $0.1 \mu\text{m}$ to $100 \mu\text{m}$.

Thermal radiation is continuously emitted by all bodies whose temperature is above absolute zero. Thermal radiations are those spectrum of rays whose wavelength vary from $0.1 \mu\text{m}$ to $100 \mu\text{m}$.

A body that emits some radiation in the visible range is known as a light source.

The radiations emitted by bodies at room temperature fall in the infra red region of the spectrum which extends from 0.76 to $100 \mu\text{m}$.

The amount of radiation emitted from a surfaces depends on

1. Material of the body
2. Surface condition
3. Surface Temperature

∴ Different bodies emit different radiation/unit area even though they are the same temperature.

Radiative Heat Transfer

Let us take a body with very high temperature kept in ambient condition.



Let A be the surface area of the body, ϵ is the emissivity of the surface and σ be the Stephan Boltzman constant then the radiative heat transfer will be given as

$$Q = \epsilon \sigma A [T_s^4 - T_a^4]$$

Where,

T_s = Surface temperature of body

T_a = Ambient temperature

$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{-K}^4$

Solution Radiative Heat Transfer

E. M. Sparrow



Solution Radiative Heat Transfer:

Radiative Heat Transfer Michael F. Modest, 2003-03-07 The basic physics of radiative heat how surfaces emit reflect and absorb waves and how that heat is distributed *Thermal Radiation Heat Transfer, Fourth Edition* Robert Siegel, 2001-12-07 This extensively revised 4th edition provides an up to date comprehensive single source of information on the important subjects in engineering radiative heat transfer It presents the subject in a progressive manner that is excellent for classroom use or self study and also provides an annotated reference to literature and research in the field The foundations and methods for treating radiative heat transfer are developed in detail and the methods are demonstrated and clarified by solving example problems The examples are especially helpful for self study The treatment of spectral band properties of gases has been made current and the methods are described in detail and illustrated with examples The combination of radiation with conduction and or convection has been given more emphasis nad has been merged with results for radiation alone that serve as a limiting case this increases practicality for energy transfer in translucent solids and fluids A comprehensive catalog of configuration factors on the CD that is included with each book provides over 290 factors in algebraic or graphical form Homework problems with answers are given in each chapter and a detailed and carefully worked solution manual is available for instructors ***Thermal Radiation Heat Transfer, 5th Edition*** John R. Howell, M. Pinar Menguc, Robert Siegel, 2010-09-28 Providing a comprehensive overview of the radiative behavior and properties of materials the fifth edition of this classic textbook describes the physics of radiative heat transfer development of relevant analysis methods and associated mathematical and numerical techniques Retaining the salient features and fundamental coverage that have made it popular *Thermal Radiation Heat Transfer Fifth Edition* has been carefully streamlined to omit superfluous material yet enhanced to update information with extensive references Includes four new chapters on Inverse Methods Electromagnetic Theory Scattering and Absorption by Particles and Near Field Radiative Transfer Keeping pace with significant developments this book begins by addressing the radiative properties of blackbody and opaque materials and how they are predicted using electromagnetic theory and obtained through measurements It discusses radiative exchange in enclosures without any radiating medium between the surfaces and where heat conduction is included within the boundaries The book also covers the radiative properties of gases and addresses energy exchange when gases and other materials interact with radiative energy as occurs in furnaces To make this challenging subject matter easily understandable for students the authors have revised and reorganized this textbook to produce a streamlined practical learning tool that Applies the common nomenclature adopted by the major heat transfer journals Consolidates past material reincorporating much of the previous text into appendices Provides an updated expanded and alphabetized collection of references assembling them in one appendix Offers a helpful list of symbols With worked out examples chapter end homework problems and other useful learning features such as concluding remarks and historical notes this new edition continues its tradition of serving both as a

comprehensive textbook for those studying and applying radiative transfer and as a repository of vital literary references for the serious researcher *Thermal Radiation Heat Transfer: Radiation transfer with absorbing, emitting, and scattering media* Robert Siegel, John R. Howell, 1971 **Analysis of Radiative Heat Transfer for Large Objects at Meteoric Speeds** Kenneth K. Yoshikawa, 1967 *Blunt-body Stagnation-region Flow with Nongray Radiation Heat Transfer* Walter B. Olstad, United States. National Aeronautics and Space Administration, 1968 A singular perturbation solution to the blunt body stagnation region flow of an inviscid radiating gas has been obtained by means of the Poincaré-Lighthill-Kuo or perturbation of coordinates method A number of results for a gray gas have been presented in order to provide some physical insight into the effects of various parameters on the shock layer enthalpy profiles and the radiant heat transfer rates A nongray absorption coefficient model was developed which includes in an approximate way the important vacuum ultraviolet contributions of bound free and line transitions This model was used to obtain solutions pertinent to the case of reentry into the earth's atmosphere While the results are restricted to small values of the radiation cooling parameter which characterizes the relative importance of radiation and convection as energy transport mechanisms they cover broad ranges of vehicle velocity altitude and nose radius which are of practical interest The characteristic enthalpy variation of the model absorption coefficient was found to be nearly independent of altitude and nose radius for fixed vehicle velocity except for velocities lower than 10 67 km/sec Thus it was possible to correlate certain quantities by plotting these quantities as functions of the nondimensional adiabatic radiant heat transfer rate for various altitudes and nose radii at fixed vehicle velocity Among the quantities correlated was the cooling factor the ratio of the stagnation point radiant heat transfer rate to the adiabatic radiant heat transfer rate The cooling factor correlation is particularly useful because it eliminates the need to perform nonadiabatic calculations whenever radiant heat transfer rates are desired Also correlated was the factor by which the convective heat transfer rate is reduced because of radiation losses in the shock layer Finally upper bound estimates were made of the effects of absorption of precursor radiation by the free stream air on the radiant and convective heat transfer rates **Scientific and Technical Aerospace Reports**, 1968 *Thermal Radiation Heat Transfer* John R. Howell, M. Pinar Menguc, Robert Siegel, 2015-09-18 Explore the Radiative Exchange between Surfaces Further expanding on the changes made to the fifth edition *Thermal Radiation Heat Transfer* 6th Edition continues to highlight the relevance of thermal radiative transfer and focus on concepts that develop the radiative transfer equation RTE The book explains the fundamentals of radiative transfer introduces the energy and radiative transfer equations covers a variety of approaches used to gauge radiative heat exchange between different surfaces and structures and provides solution techniques for solving the RTE What's New in the Sixth Edition This revised version updates information on properties of surfaces and of absorbing/emitting/scattering materials radiative transfer among surfaces and radiative transfer in participating media It also enhances the chapter on near field effects addresses new applications that include enhanced solar cell performance and self-regulating

surfaces for thermal control and updates references Comprised of 17 chapters this text Discusses the fundamental RTE and its simplified forms for different medium properties Presents an intuitive relationship between the RTE formulations and the configuration factor analyses Explores the historical development and the radiative behavior of a blackbody Defines the radiative properties of solid opaque surfaces Provides a detailed analysis and solution procedure for radiation exchange analysis Contains methods for determining the radiative flux divergence the radiative source term in the energy equation

Thermal Radiation Heat Transfer 6th Edition explores methods for solving the RTE to determine the local spectral intensity radiative flux and flux gradient This book enables you to assess and calculate the exchange of energy between objects that determine radiative transfer at different energy levels Applied Mechanics Reviews ,1989 Symmetry and Exact Solutions of Nonlinear Mathematical Physics Equations Gangwei Wang,Xiangpeng Xin ,Samir A. El-Tantawy,2024-08-13

Nonlinear problems originating from applied science that is closely related to practices contain rich and extensive content It makes the corresponding nonlinear models also complex and diverse Due to the intricacy and contingency of nonlinear problems unified mathematical methods still remain far and few between In this regard the comprehensive use of symmetric methods along with other mathematical methods becomes an effective option to solve nonlinear problems **NASA Technical Report** United States. National Aeronautics and Space Administration,1963 Radiative Heat Transfer in Two-Phase Media K. S. Adzerikho,E. F. Nogotov,V. P. Trofimov,1992-11-10

Radiative Heat Transfer in Two Phase Media is devoted to discussing and further developing the radiative heat transfer theory It provides thorough coverage of studies of physical processes in emitting two phase media as applied to combustion chambers of heat power plants Numerical methods are developed and a number of reliable approximate solutions to radiative heat transfer problems are proposed Widely accepted thermophysical concepts such as effective temperature effective emissivity of heat carriers and thermal efficiency of screens are covered in detail The book also provides programs for computing spectroscopic characteristics of emitting two phase media which are useful for solving complex radiative heat transfer problems

Radiative Heat Transfer in Two Phase Media is an important book for the library of any heat transfer specialist Technical Papers ,1964 **Thermal Radiation Heat Transfer. Volume 3 - Radiation Transfer with Absorbing, Emitting, and Scattering Media** ,1971 **Radiation Heat Transfer** Bassem F. Armaly,Ashley Francis Emery,1985 Radiation Heat Transfer, Augmented Edition E. M. Sparrow,2018-04-27

Revised to include more information on analytical models for wavelength independence **Radiation Heat Transfer Augmented Edition** has been rearranged providing problems within each chapter rather than at the end of the book Written by Ephraim M Sparrow a generalist who works on a very broad range of problems that encompasses almost all mechanical engineering topics the book presents key ideas without being exhaustive Sparrow oversees the Laboratory for Heat Transfer and Fluid Flow Practice whose function in to undertake both industrially bases and fundamental problems that fall within the bounds of heat transfer and fluid flow **General Papers in Radiative Heat Transfer** American Society of

Mechanical Engineers. Winter Annual Meeting,1993 **Radiative Transfer and Interactions with Conduction and Convection** M. Necati Özışık,1973 A Wiley Interscience publication *Computation of Radiative Heat Transfer in Non-gray Participating Media* Girija Parthasarathy,1996 Solutions of the Ionized Radiating Shock Layer, Including Reabsorption and Foreign Species Effects, and Stagnation Region Heat Transfer John T. Howe,John R. Viegas,1963

Solution Radiative Heat Transfer Book Review: Unveiling the Magic of Language

In an electronic digital era where connections and knowledge reign supreme, the enchanting power of language has been much more apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is actually remarkable. This extraordinary book, aptly titled "**Solution Radiative Heat Transfer**," written by a highly acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we shall delve to the book's central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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