Nomenclatur

Subscript:

η	Wavenumber-specific
λ	Wavelength-specific
0	Incident radiation
s	Black Body
$\mathrm{i} \rightarrow \mathrm{j}$	From object *i* to object *j*

Superscript:

$''$	Area-derivative
$'''$	Volume-derivative
$\dot{}$	Time derivative (Heat flux, mass flow, enthalpy flow etc.)

Black Body:

λ	Wavelength of the radiation	$[\mathrm{m}]$
ν	Frequency of radiation	$[\mathrm{s}^{-1}]$
σ	Stefan-Boltzmann-Constant	$[\mathrm{W/(m^2K^4)}]$
c	Speed of Light	$[\mathrm{m/s}]$
E	Photon energy	$[\mathrm{J}]$
$\mathrm{F}(\lambda)$	Radiation fraction	[-]
h	Planck constant	$[\mathrm{Js}]$
$\dot{q}''_{\mathrm{s},\lambda}$	Spectral radiant flux density of a black body	$[\mathrm{W/(m^2m)}]$

Real Objects:

α	Absorptivity	[-]
ε	Emissivity	[-]
ρ	Reflectivity	[-]
τ	Transmissivity	[-]
φ	Viewing angle	$[\mathrm{rad}]$

View factors:

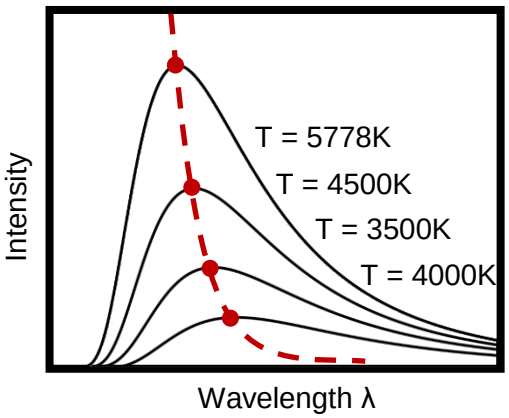
ϕ_{ij}	View factor from object *i* to object *j*	[-]
Ω	Solid angle	$[\mathrm{rad}]$
L	Diffuse radiation	$[\mathrm{W/m^2}]$
$\dot{Q}_{\mathrm{i}\rightarrow\mathrm{j}}$	Radiation from surface *i* to *j*	$[\mathrm{W}]$

Heat- and Mass Transfer 1: Learning Path Radiation

V 01: Black Body Radiation

Learning Goals:

- Understanding of the Wave-Quantum Duality
- Black Body: Description of the spectral radiation intensity according to Planck
- Solution approach for integration of the Planck's Distribution Law
- Use of Stefan-Boltzmann Law
- Relationship from temperature and position of maximum spectral radiation intensity



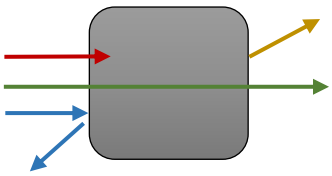
Comprehension questions:

- ☐ What is a "Black Body "?
- ☐ Which assumptions are valid for the calculation of "Black bodies "?
- ☐ Which law can be used to determine the wavelength at the intensity maximum of a "Black body "?
- ☐ Which approach was used to determine the Stefan-Boltzmann constant?
- ☐ How can the radiation intensity in a certain wavelength range $\boldsymbol{\lambda_1 - \lambda_2}$ be calculated?

V 02: Radiation of real objects

Learning Goals:

- Definition and interpretation of Emissivity, Absorptivity, Transmissivity and Reflectivity
- Behaviour of real bodies compared to ideal bodies
- Angular dependence of the radiation properties of real bodies

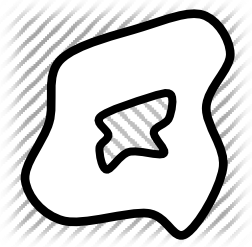


Comprehension questions:

- ☐ In which proportions is divided the radiation that hits a body (real bodies)?
- ☐ What is the difference between black, grey and real bodies (related to wavelength)?

V 03: Kirchhoff's Law

Learning Goals:



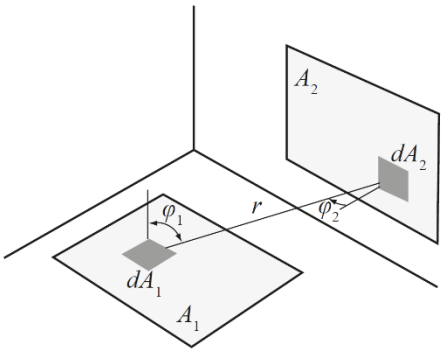
- Relationship between absorptivity and emissivity
- Conditions where "ε = α" (wavelength independent) is valid?

Comprehension questions:

- ☐ In which case can it be assumed that both $\alpha(\lambda) = \varepsilon(\lambda)$ and $\alpha = \varepsilon$ are valid?
- ☐ To which part of radiation does the emissivity refer and to which part the Absorptivity?
- ☐ When $\alpha(\lambda) = \varepsilon(\lambda)$ is valid, is then the absorbed and emitted heat flux identical?

V 04: View factors

Learning Goals:



- Understanding of radiated to incident radiation
- Understanding of the distribution of radiation irradiating from a surface using an enclosing hemisphere
- Ability to determine the view factors between two surfaces at determined angles

Comprehension questions:

- ☐ Which parameters of radiation emerging from a surface are included in/ described by the view factor concept?
- ☐ Calculation of radiation exchange by using visual factors ⇨ valid also, if the bodies radiate directionally?
- ☐ In general, what are view factors dependent on?

V 05: View factor calculation rules

Learning Goals:

$$\sum_{j} \phi_{ij} = 1$$

$$\phi_{ij} \rightarrow$$

$$\leftarrow \phi_{ji}$$

- Summation rule of view factors for one object
- Determine view factors from looking at the opposite surface or object
- Smart usage of symmetry conditions
- Identify meaningful auxiliary planes

Comprehension questions:

- ☐ Which rules are used for view factor determination?
- ☐ For which body shapes must $\phi_{i,i}$ be considered?

HQ 01: View factors

Learning Goals:

- ➢ Practicing the calculation of view factors on simple 2- and 3-dimensional geometries

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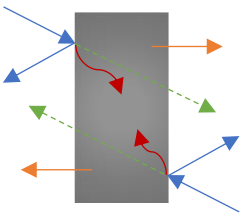
V 06: Surface Brightness

Learning Goals:



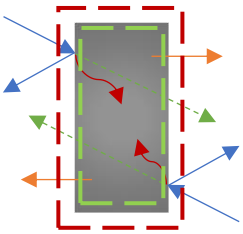
- ➢ Understanding of Surface Brightness and its meaning
- ➢ Learn and practice to formulate the Surface Brightness of Bodies and System of bodies

Comprehension questions:

- ☐ How can surface brightness be interpreted physically?
- ☐ Which principles should be observed when setting up surface brightness?
- ☐ Why is infrared measurement of surface temperatures difficult? Which part of Surface Brightness carries this information?

V 07: Energy Balance

Learning Goals:



- ➢ Understanding the concept of energy balances in radiative heat transfer
- ➢ Ability to set up energy balances around a body
- ➢ Understanding of internal and external energy balances

Comprehension questions:

- ☐ Which events lead to a temporal change of the thermal energy in the control volume?
- ☐ Which terms are considered additionally in the outer energy balance?How can inner and outer energy balance be transformed into each other?
- ☐ For which applications is an internal or external energy balance more useful?

HQ 02: Surface Brightness

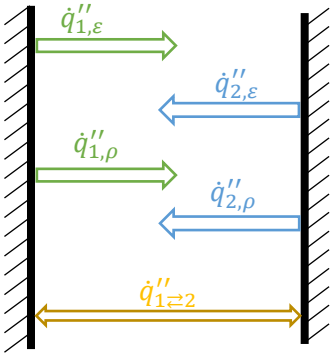
Learning Goals:

- Training the ability to set up surface brightnesses.

V 08: Example: Radiation transfer between two gray plates

Learning Goals:

- Understanding the calculation of the radiation transfer between two surfaces by means of radiation tracking (Attention: not useful)
- Ability to describe the radiation exchange by means of surface brightness (Method of choice)



Comprehension questions:

- ☐ In which case is Radiation Tracking a reasonable method for calculation?
- ☐ Why is the use of surface brightness the more elegant method for calculating radiation transfer?

VÜ 01: Task 1.1 from the exercise script "Solar collector"

Learning Goals:

- Explanation of the equivalence between the internal and external energy balance

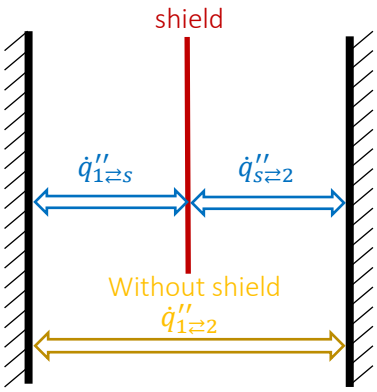
Comprehension questions:

- ☐ What contributes to the internal and what to the external energy balance?
- ☐ How to convert an internal energy balance into an external one?
- ☐ How is wavelength-dependent radiation taken into account in an energy balance?

V 09: Example: Radiation Protective Shield

Learning Goals:

- How well can radiation be shielded and which properties make a good radiation protective shield (in the case of two parallel plates)?



Comprehension questions:

- ☐ Why the radiation exchange is reduced despite the shield being a black body?
- ☐ What happens when the three plates have identical radiation properties ($\varepsilon_1 = \varepsilon_2 = \varepsilon_s$)?

VÜ 02: Task 1.4 from exercise script "wedge-shaped gap" & old exam task "free-range pig"

Learning Goals:

- Correct setting up of surface brightnesses
- Learning the relationship between internal energy balance, external energy balance and surface brightnesses.
- Correct setting up of view factors

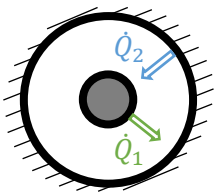
Comprehension questions:

- ☐ Why does a gray and adiabatic body have "black body properties" under steady state conditions?

V 10: Example: Radiation transfer between two self-enclosed grey bodies

Learning Goals:

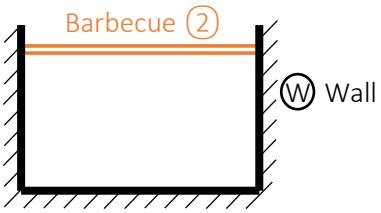
- Learn: Calculation of the radiation exchange for enclosed bodies
- to practice / to use: Approach for solving radiation tasks



Comprehension questions:

- ☐ For self-enclosed grey bodies, which properties may contribute to increase radiative exchange?
- ☐ Which marginal cases exist and what is their meaning?

V 11: Example: Three-body problem



Learning Goals:

- ► Expansion of the balances from two-body to multi-body problems
- ► Learning Approaches to solve Radiation tasks using the example of a three-body problem

Comprehension questions:

- ☐ Why is calculation of radiation transfer much more complicated when a third object is added?
- ☐ If several bodies are involved in the radiation transfer, can certain bodies be combined? In which case can bodies be combined?

VÜ 03: Variation of task 1.9 Exercise script "Ceiling heating" & old exam task "Solar radiation"

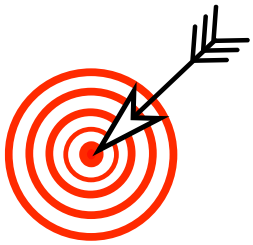
Learning Goals:

- ➢ Correct use of the radiation fraction $F(\lambda)$ in a given wavelength range.

Comprehension questions:

- ☐ How can surface brightnesses be used in an energy balance?

V 12: Summary: Procedure for radiation tasks



Learning Goals:

- ➢ Ability to solve radiation problems through a systematic approach

Comprehension questions:

- ☐ What are the most important points that need to be clarified before calculating radiation tasks?
