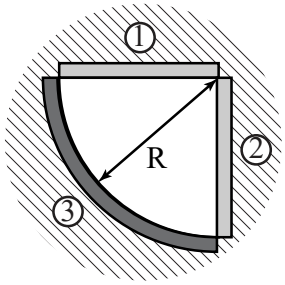
Section IV

Radiation exercises

Exercise IV.1: (Infinite pipe segment ⋆⋆)

Consider an infinite long pipe segment as in the figure.



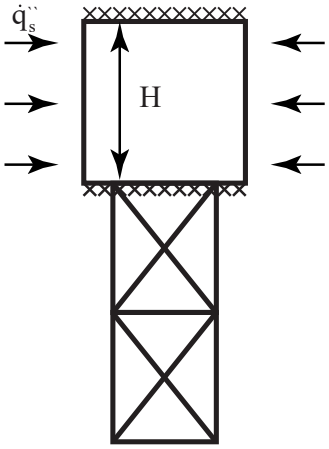
Tasks:

a) Specify the view factors Φ_{12}, Φ_{31} and Φ_{33} as a function of Φ_{13}.

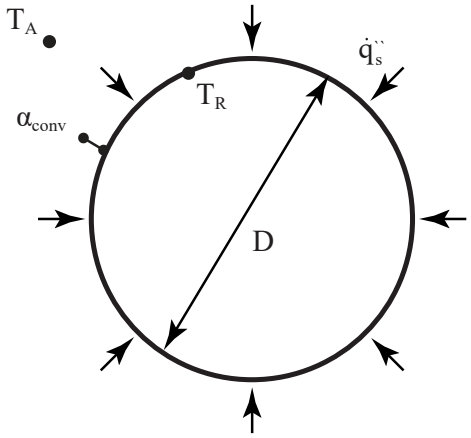
b) Determine Φ_{13}.

Exercise IV.2: (Solar power tower ⋆)

Solar radiation is uniformly and radially redirected toward a central cylindrical receiver in a solar tower plant by a surrounding mirror field (radiation density $\dot{q}''_S$). Consequently, the surface of the receiver is heated to a temperature of T_R, and the thermal power output of the plant is $\dot{Q}_{th}$.



(a) Side view



(b) Top view

Given parameters:

- Receiver height: H
- Receiver outer diameter: D
- Receiver surface temperature: T_R
- Receiver emissivity of the surface: ϵ
- Heat transfer coefficient: α_{conv}
- Ambient temperature: T_A

Hints:

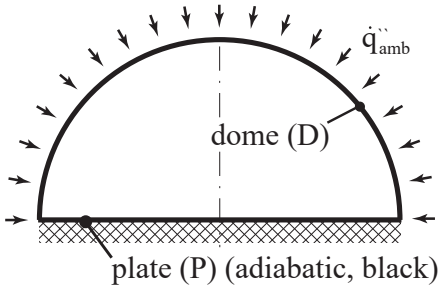
- Heat losses in the interior of the receiver as well as at its ends can be neglected.
- Radiation from the ambient can be neglected.
- The receiver can be considered as a grey body.

Tasks:

a) From a balance around the receiver, determine the mean radiation density $\dot{q}''_S$ as a function of the thermal load $\dot{Q}_{th}$.

Exercise IV.3: (Hemispherical dome ⋆⋆)

A thin circular plate (P) is covered by a hemispherical, transparent, grey dome (D). A radiative heat flux from the ambient $\dot{q}''_{\text{amb}}$ is uniformly falling on the dome.



Given parameters:

- Temperature of the dome: T_{D}
- Surfaces of the plate and dome: $A_{\text{P}},\ A_{\text{D}}$
- Radiative heat flux: $\dot{q}''_{\text{amb}}$
- View factor: Φ_{DP}
- Absorptivity of the plate: $\alpha_{\text{P}} = 1$
- Reflectivity of the dome: $\rho_{\text{D}} = 0$
- Transmissivity of the dome: τ_{D}
- Emissivity of the dome: ϵ_{D}

Hints:

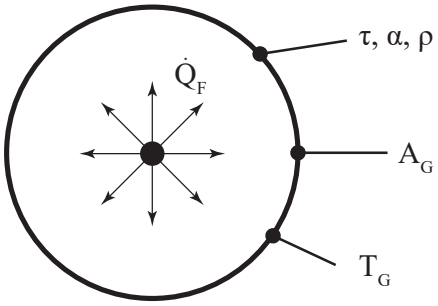
- Conduction and convection are to be neglected.
- All surfaces are radiating diffusely.

Tasks:

a) Derive an expression for the temperature of the plate T_{P}.

Exercise IV.4: (Light bulb ⋆⋆)

The filament of a light bulb emits diffuse radiation $\dot{Q}_\mathrm{F}$. The glass of the bulb is thin, spherical, and acts as a gray body. The surface of the filament is small in comparison to the glass body and the problem is steady in time.



Given parameters:

- Power consumption of the filament: $\dot{Q}_\mathrm{F}$
- Glass properties: τ, α, ρ
- Surface of the glass sphere: A_G

Hints:

- The surface of the filament in comparison to the glass body is small.

Tasks:

a) Provide the energy balance in terms of given variables for determining the glass temperature T_G, while neglecting radiation from the environment.