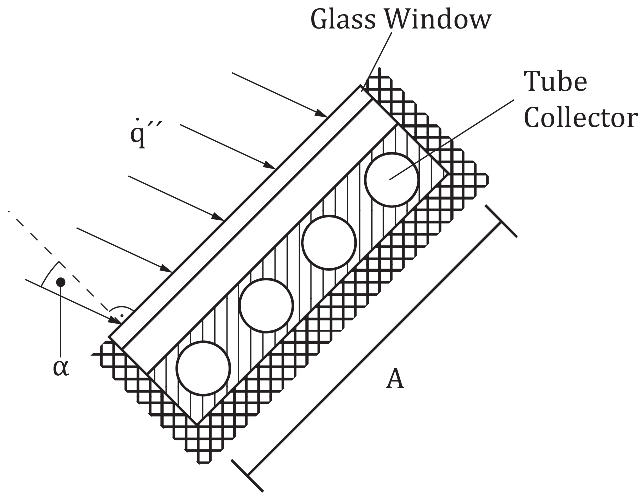
1.1 Solar cell ★

A solar thermal collector with a lateral surface A, receives a radiation flux $\dot{q}''$ at an angle α. Water flows through the collector tubes with a mass flow rate $\dot{m}$ and it is heated from the inlet temperature T' to the outlet temperature T''. Determine the efficiency η of the thermal collector, and use the given numerical values to calculate the results.

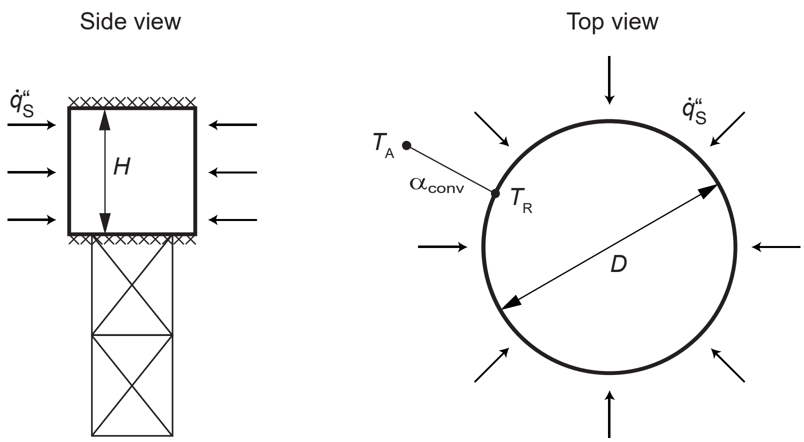


Given values:

- A: 2m^2
- $\dot{q}''$: $1367\,\text{W}/\text{m}^2$
- α: $20\,°$
- $\dot{m}$: $0.0145\,\text{kg}/\text{s}$
- c_p: $4.18\,\text{kJ}/\text{kgK}$
- T': $15\,°\text{C}$
- T'': $55\,°\text{C}$

1.2 Solar power tower ★

Solar radiation is homogenously and radially redirected towards a central, cylindrical receiver (diameter D, height H) of a solar tower plant by a surrounding mirror field (radiation density $\dot{q}''_\mathrm{S}$. Thus, the surface of the receiver is heated to a temperature of T_R = 480°C. The thermal power output of the plant is $\dot{Q}_\mathrm{th}$.



Tasks:

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

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.

Given variables:

<u>Receiver:</u>

- Height: H
- Outer diameter: D

- Surface temperature: T_{R}
- Emissivity of receiver surface: ϵ

Ambient conditions:

- Heat transfer coefficient: α_{conv}
- Ambient temperature: T_{A}

1.3 Infinite pipe segment ★★

Consider an infinite long pipe segment as in the figure.

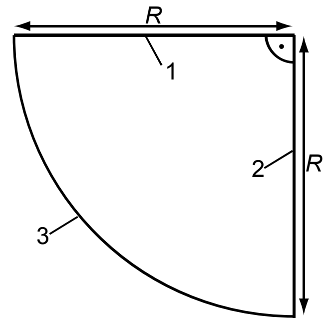


Figure 1.1: Top view of the pipe segment

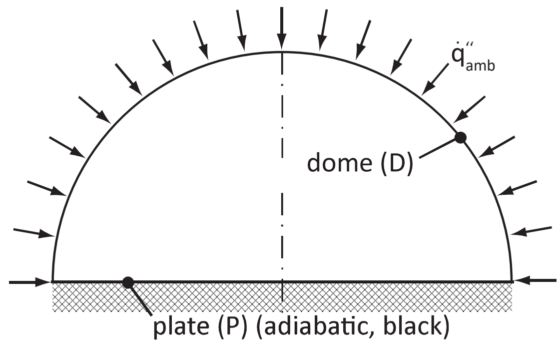
Tasks:

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

b) Determine Φ_{13}.

1.4 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. Derive an expression for the temperature of the plate T_{P}. Conduction and convection are to be neglected. All surfaces are radiating diffusely.

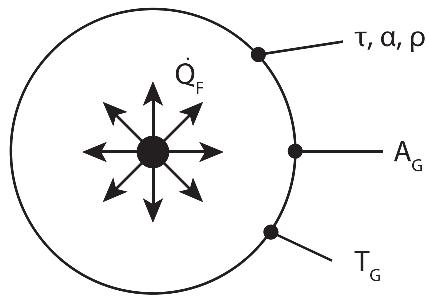


Given parameters:

- 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}

1.5 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.
Provide the energy balance in terms of given variables for determining the glass temperature T_{G}, while neglecting radiation from the environment.



Given properties:

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