1.1 Walking speed ★

An average person has a body surface area of 1.8 m^2 and a skin temperature of 33 °C, with an average surface temperature of the clothed person of 30 °C. The convection heat transfer coefficient for a clothed person walking in air is expressed as:

$$\alpha = 8.2V^{0.49} \qquad \text{for } 1 \text{ [m/s]} < V < 2.5 \text{ [m/s]}$$

V is the relative velocity of the person with respect to the air.

Determine the rate of heat loss from an average person walking in air at 15 °C by convection in the case of:

a) walking in still air with a velocity of 1 m/s.

b) standing still, while the wind blowing at a velocity of 1.5 m/s.

c) walking along in the flow direction of the wind with a velocity of 2 m/s, while the wind blowing at a velocity of 1.5 m/s.

Hint:

- Assume steady-state operating conditions.
- Assume the heat transfer coefficient to be constant over the entire surface.

1.2 Flat plate in a wind tunnel ★

Consider a flat plate positioned inside a wind tunnel, where air is flowing with a free stream velocity U.

Tasks:

a) What type of flow regime will the airflow experience in the boundary layer at 0.25 m from the leading edge?

b) Determine the position of the plate where the flow starts its transition from laminar to turbulent flow.

Given parameters:

Average fluid properties:

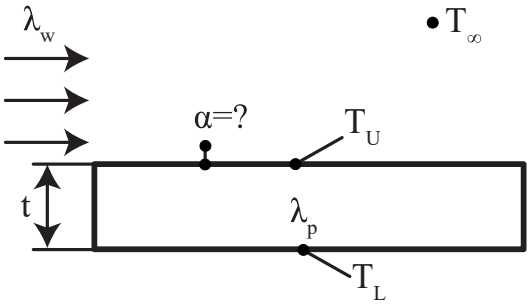
- Film temperature : $T_f = 20$ °C
- Pressure: $p = 1$ atm
- Density: $\rho = 1.88$ kg/m^3
- Thermal conductivity: $\lambda = 0.2716$ W/mK
- Kinematic viscosity: $\nu = 15.35 \cdot 10^6$ m^2/s
- Velocity: $U = 50$ m/s

Hints:

- Assume the critical Reynolds number R_{crit} to be $5 \cdot 10^5$

1.3 Thick solid plate ★

The top surface of a thick solid plate being cooled by water flowing. The upper and lower surfaces of the solid plate are maintained at constant temperatures T_{U} and T_{L} respectively by imposing a constant heat flux $\dot{q}''$.



Tasks:

a) Determine the convection heat transfer coefficient in terms of the given variables.
b) Determine the temperature gradient inside the water at the interface in terms of the given variables.

Given parameters:

Plate properties:

- Thermal conductivity: λ_{p}
- Thickness: t
- Upper surface temperature: T_{U}
- Lower surface temperature: T_{L}

Water properties:

- Average thermal conductivity: λ_{w}
- Ambient temperature : T_{∞}