

## 1.1 Walking speed



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

$$\alpha = 8.2V^{0.49} \quad \text{for } 0.5 \text{ [m/s]} < V < 5 \text{ [m/s]}$$

$V$  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  $15 \text{ }^\circ\text{C}$  by convection in the case of:

- a) walking in still air with a velocity of  $1 \text{ m/s}$ .
- b) standing still, while the wind blowing at a velocity of  $1.5 \text{ m/s}$ .
- c) walking in the opposite direction of the flow of the wind with a velocity of  $2 \text{ m/s}$ , while the wind blowing at a velocity of  $1.5 \text{ m/s}$ .

### 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:

- What type of flow regime will the airflow experience in the boundary layer at 0.25 m from the leading edge?
- Determine the position of the plate where the flow starts its transition from laminar to turbulent flow.

### Given parameters:

#### Average fluid properties:

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

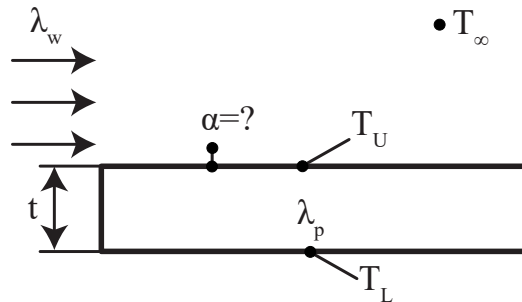
### Hints:

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

## 1.3 Thick solid plate

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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:

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

### Given parameters:

#### Plate properties:

- Thermal conductivity:  $\lambda_p$
- Thickness:  $t$
- Upper surface temperature:  $T_U$
- Lower surface temperature:  $T_L$

#### Water properties:

- Average thermal conductivity:  $\lambda_w$
- Ambient temperature :  $T_\infty$