Walking speed

An average person has a body surface area of 1.8 m^2 and a skin temperature of 33 °C. The convection heat transfer coefficient for a clothed person walking in still air is expressed as $\alpha = 8.2V^{0.49}$ for $1 < V < 2.5$ m/s, where V is the walking velocity in m/s. Assuming the average surface temperature of the clothed person to be 30°C, determine the rate of heat loss (total heat flux) from an average person walking in still air at 15°C by convection at a walking velocity of :

a) V = 1 m/s

b) V = 1.5 m/s

c) V = 2 m/s

d) V = 2.5 m/s

Thick solid plate

The top surface of a 25-cm-thick solid plate ($\lambda = 219\ \frac{\mathrm{W}}{\mathrm{m \cdot K}}$) is being cooled by water with a temperature of 15 °C. The upper and lower surfaces of the solid plate are maintained at constant temperatures of 60 °C and 120 °C, respectively. Determine the convection heat transfer coefficient from the upper surface to the water as well as the temperature gradient inside the water at the interface.

Properties of water:

T $^{\circ}C$	ρ kg/m^3	c kJ/kgK	λ W/mK	ν $10^{-6}\ m^2/s$	a $10^{-6}\ m^2/s$	**Pr** -
0	0.9998	4.218	0.561	1.793	0.133	13.48
20	0.9982	4.181	0.598	1.004	0.1434	7.001
40	0.9922	4.177	0.631	0.658	0.1521	4.3280
60	0.9832	4.184	0.654	0.475	0.1591	2.983
80	0.9586	4.197	0.67	0.365	0.1643	2.221

Free flow over a hot plate

Consider airflow over a plate surface maintained at a temperature of 180 °C. The temperature profile of the airflow is given as

$$T(y) = T_\infty - (T_\infty - T_s)\exp\left(-\frac{V}{a_{\text{fluid}}}y\right)$$

The airflow at 1 bar has a free stream velocity and temperature of 1 m/s and 20 °C, respectively. Determine the heat flux on the plate surface and the convection heat transfer coefficient of the airflow.

Properties of air:

T °C	ρ kg/m^3	c kJ/kgK	λ 10^{-3} W/mK	ν 10^{-6} m^2/s	a 10^{-6} m^2/s	**Pr** -
0	1.275	1.006	24.18	13.52	18.83	0.7179
20	1.188	1.007	25.69	15.35	21.47	0.7148
40	1.112	1.007	27.16	17.26	24.24	0.7122
80	0.9859	1.01	30.01	21.35	30.14	0.7083
100	0.9329	1.012	31.39	23.51	33.26	0.707

Chilled fruit

During air cooling of oranges, grapefruits and grapes, the heat transfer coefficient for combined convection, radiation and evaporation for air velocities of $0.11 < V < 0.45$ m/s is determined experimentally and is expressed as

$$\alpha = 5.05 \cdot \lambda_{\text{air}} \cdot \text{Re}^{1/3}/D,$$

where the diameter D is the characteristic length. Oranges are cooled by refrigerated air at 7 °C and 1 bar at a velocity of 0.4 m/s.

Properties of air:

T °C	ρ kg/m^3	c kJ/kgK	λ 10^{-3} W/mK	ν 10^{-6} m^2/s	a 10^{-6} m^2/s	**Pr** -
0	1.275	1.006	24.18	13.52	18.83	0.7179
20	1.188	1.007	25.69	15.35	21.47	0.7148
40	1.112	1.007	27.16	17.26	24.24	0.7122
80	0.9859	1.01	30.01	21.35	30.14	0.7083
100	0.9329	1.012	31.39	23.51	33.26	0.707

Determine:

a) the initial rate of heat transfer from a 6-cm-diameter orange initially at 25 °C with a thermal conductivity of $\lambda = 0.62$ W/mK

b) the value of the initial temperature gradient inside the orange at the surface

c) the value of the Nusselt number

c) Draw the temperature profile inside and outside the orange at $t = 0$, $t > 0$, and $t = \infty$