The coffee cup problem 2

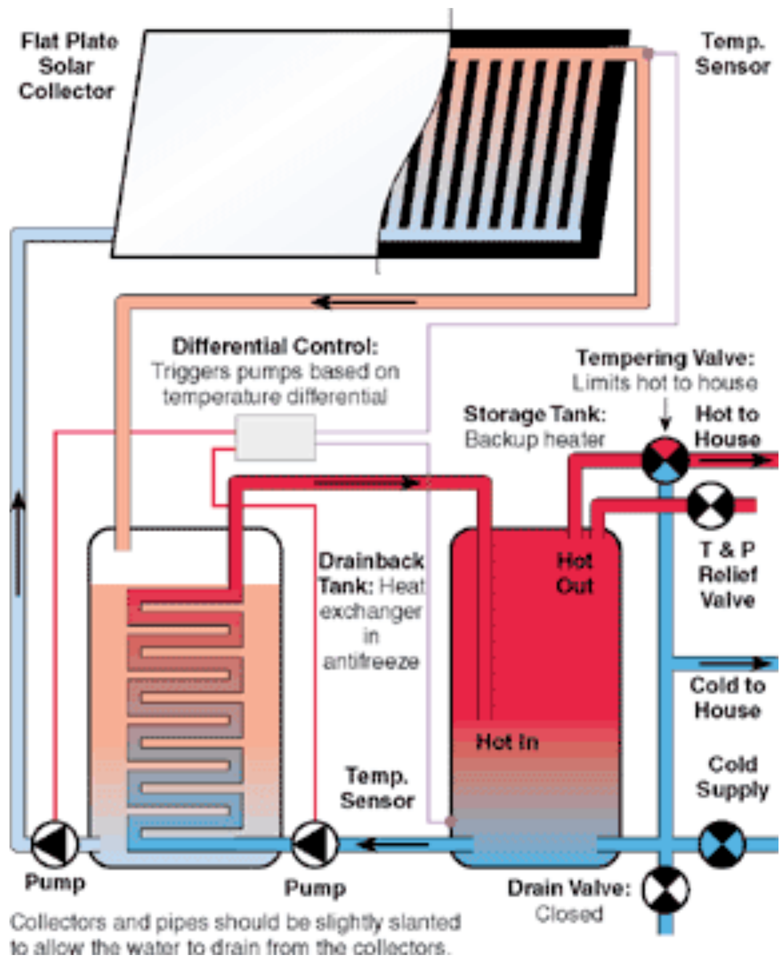
How long does it take for the sucrose to diffuse to the top ?
At least weeks, months for a big cup.

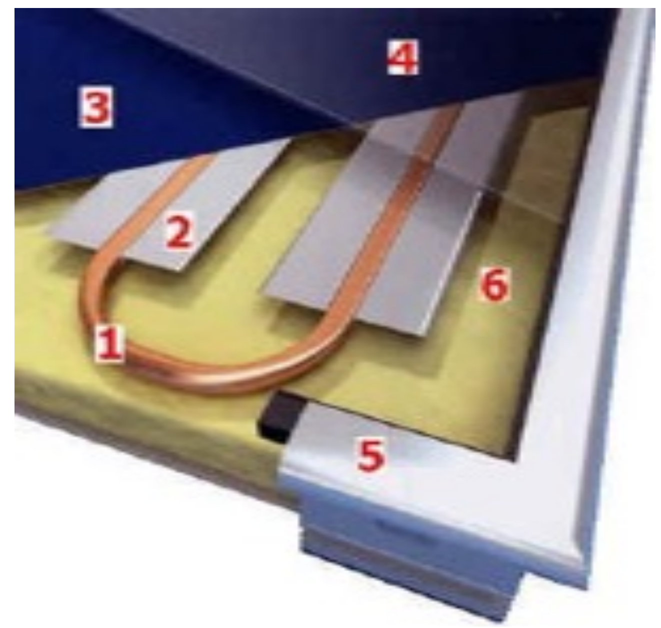
How long does it take to cool down to room temperature ?

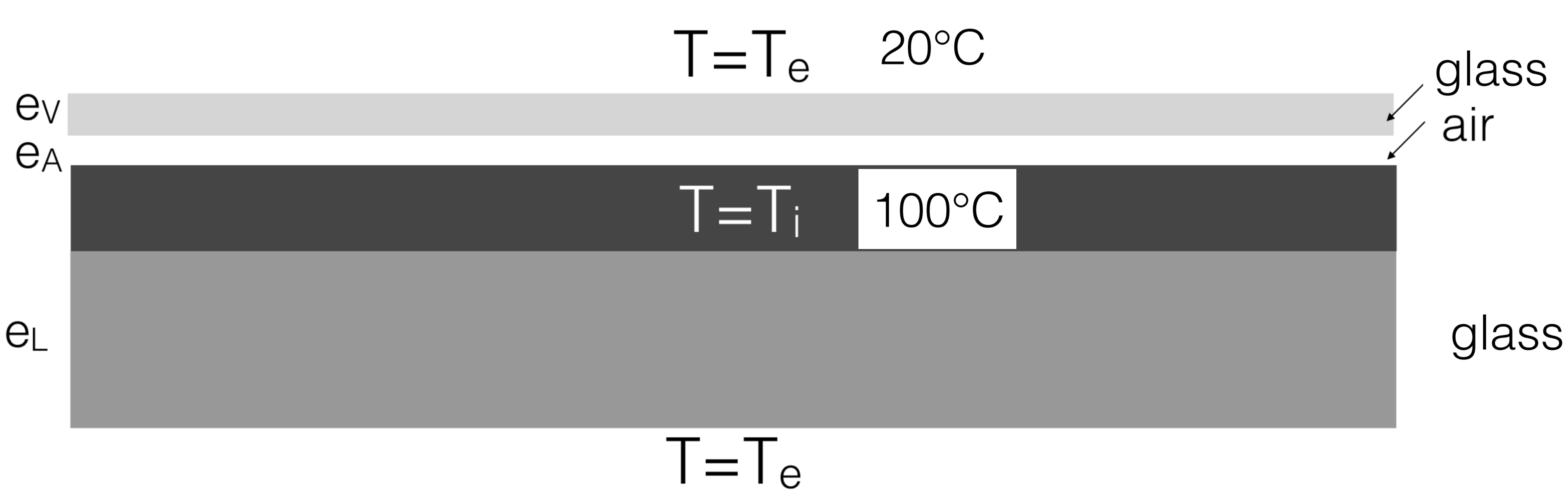
What if diffusion in air is the only mechanism ?

Physical properties of air :
density $\rho = 1$ kg/m^3
specific heat $C_p = 1000$ J/kg.K
thermal conductivity $\lambda = 0.025$ W/m.K

The solar heater problem 1 : how much heat do we lose from the collector ?







glass: 4 mm, thermal cond. 0,8 W/m.K

air: 4 mm, thermal cond. 0,025 W/m.K

glass fiber 40 mm thermal cond. 0,025 W/m.K

use the 1D steady state diffusion and the concept of thermal resistance to compute heat fluxes on both sides of the collector

The microprocessor problem 1 and 2

Power to dissipate : 50 W
Typical dimension : L= 3cm
Physical properties of air :
  density 1 kg/m^3
  specific heat 1000 J/kg.K
  thermal conductivity 0.025 W/m.K

If we rely only on diffusion in air, how much power can we dissipate from the flat chip without fins?

how much power can we dissipate by adding a radiator with fins ?

is there an optimum length for fins given their thickness e and the heat transfer coefficient h between the fins and the surrounding air ?

Physical properties of aluminum (material of the fins) :
  thermal conductivity 240 W/m.K

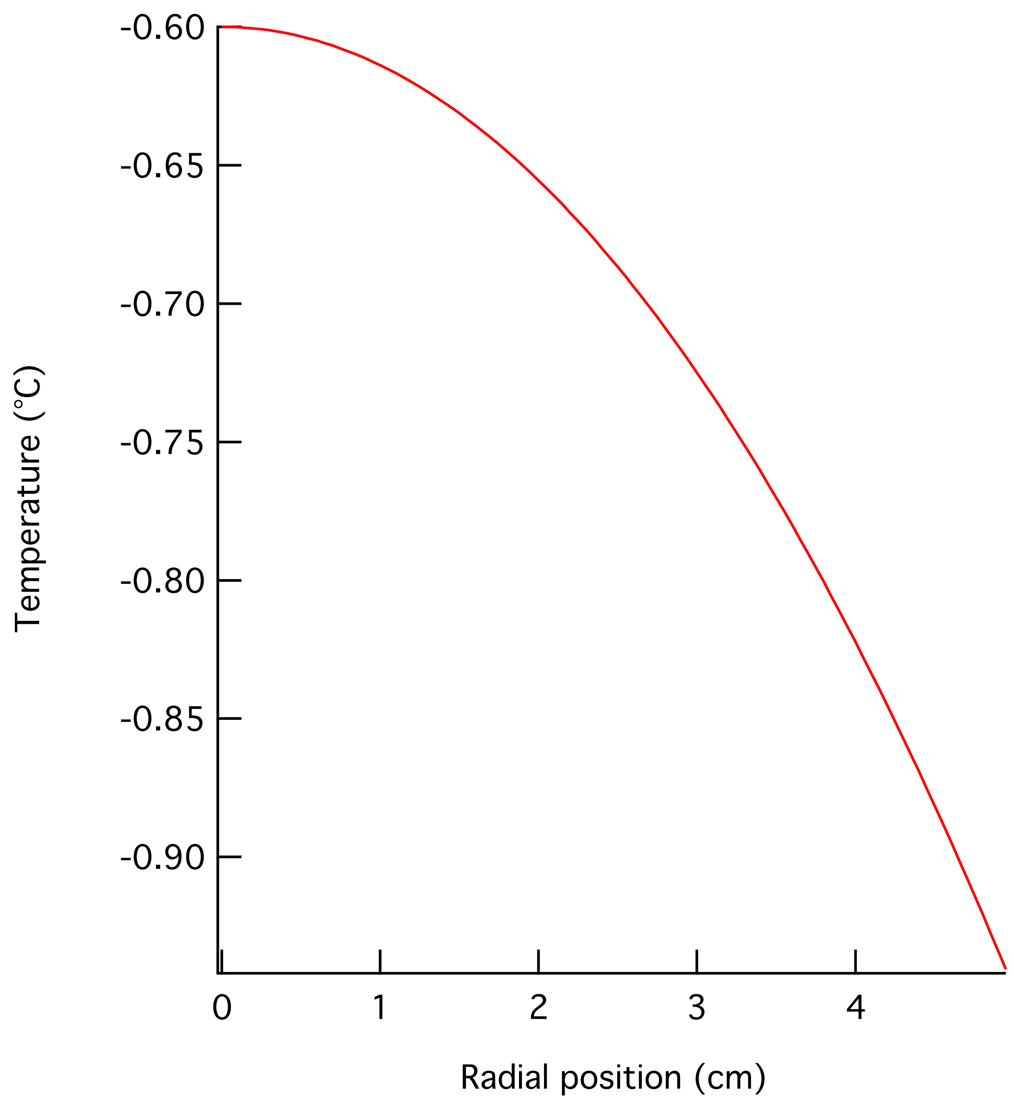
The Maurice Herzog problem 1

How long can you stand on top of Annapurna without gloves ? (no wind)

use the 1D bioheat equation to determine the temperature in Maurice's fingers (3mm of tissue between bone and skin) at steady state

steady state 1D diffusion + source term

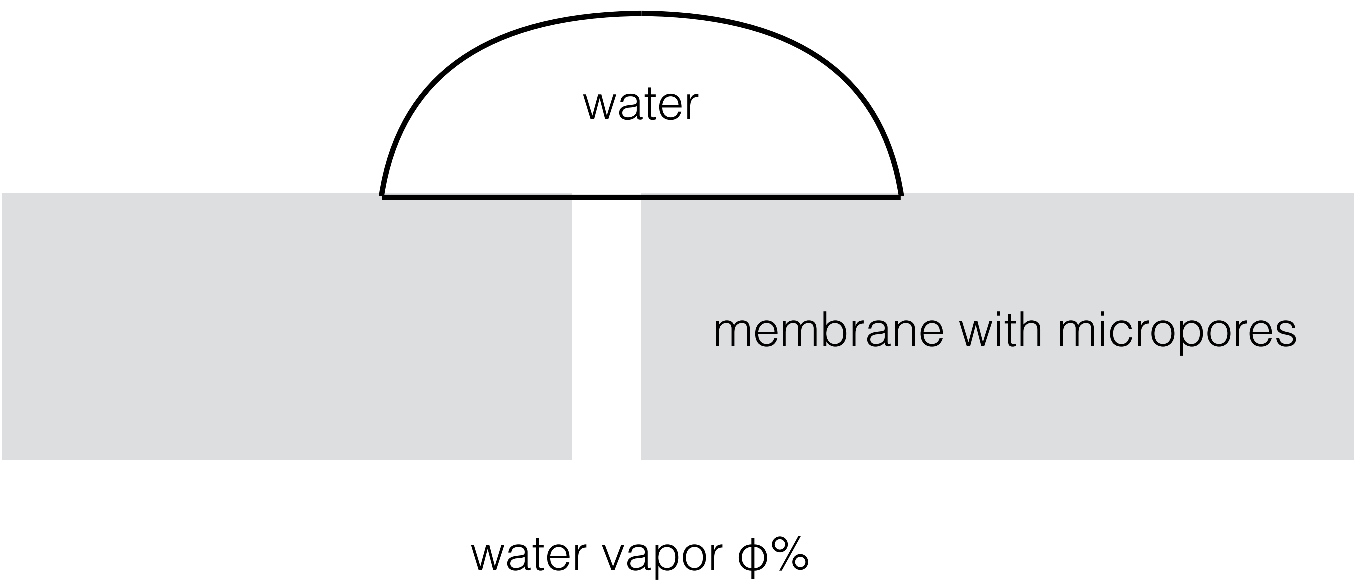
blood flow rate per unit volume of tissue: V_b 10^{-4} s^{-1}
blood density: ρ_b 1000 kg/m^3
blood specific heat: C_b 3600 J/kg.K
thermal conductivity of tissue: λ 0.5 W/m.K
metabolic heat generation rate: q_m 700 W/m^3
outside temperature: T_e -20°C
heat transfer coefficient with air: h 2 W/m^2.K

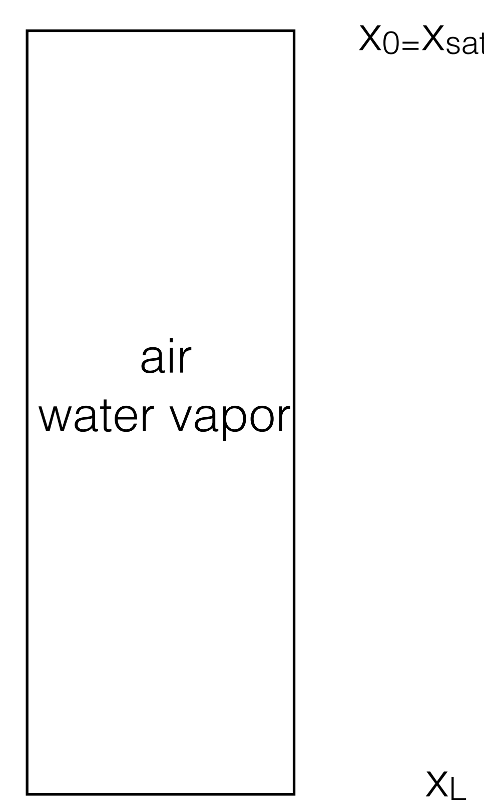


-0.60
-0.65
-0.70
-0.75
-0.80
-0.85
-0.90
Temperature (°C)
0
1
2
3
4
Radial position (cm)

The Alex Thomson problem

how much water vapor is permeating through his clothing ?



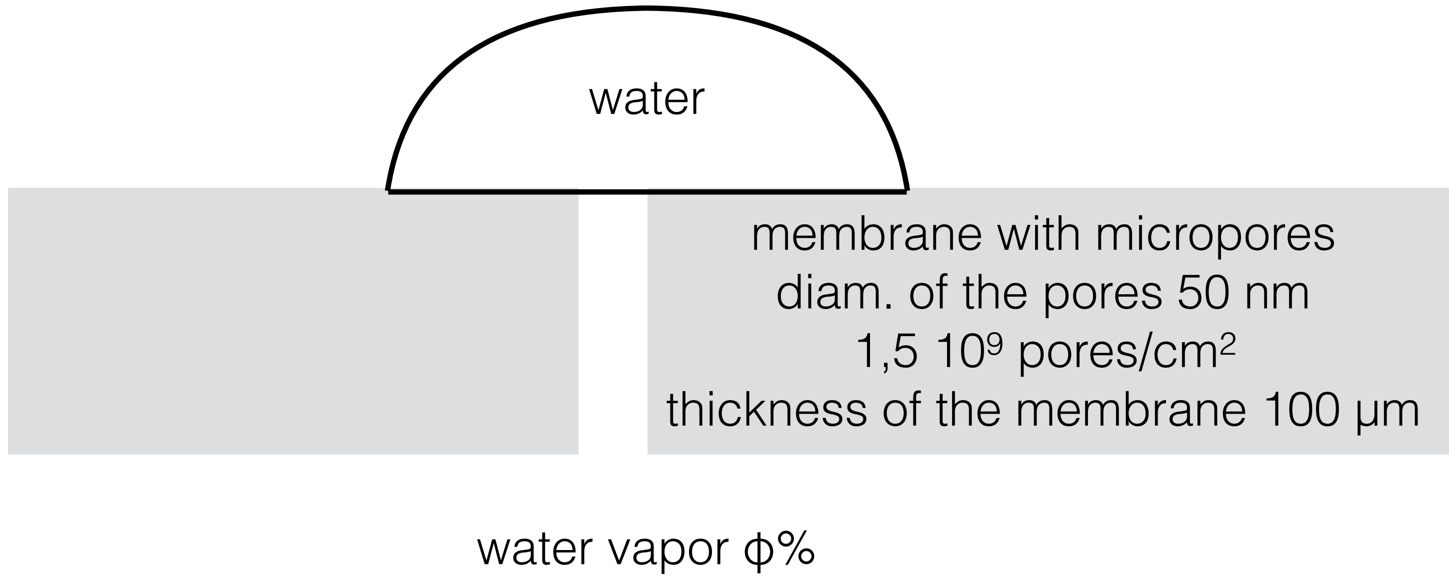


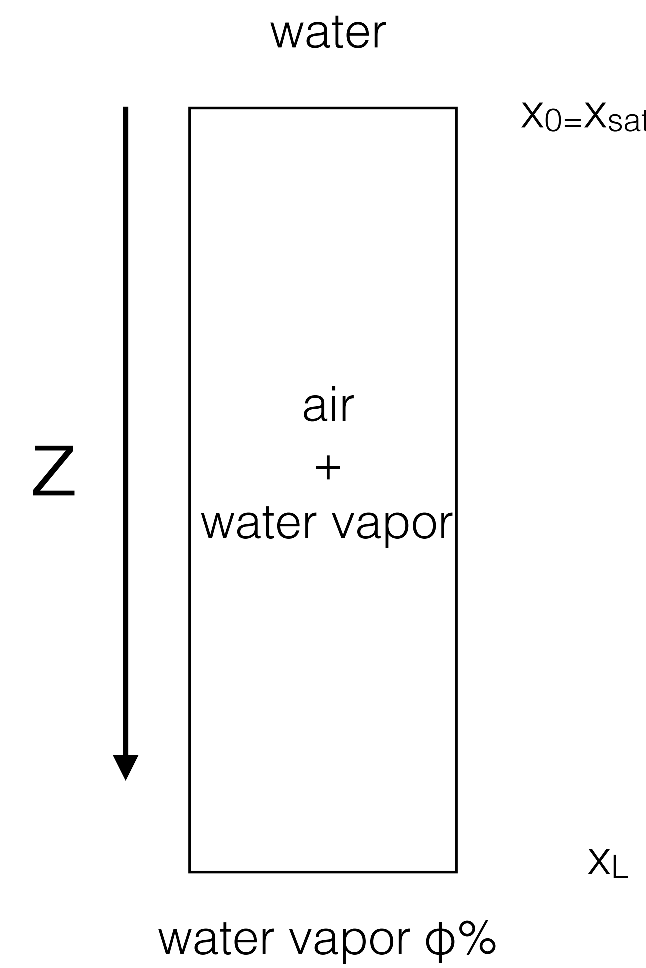
$x_0 = x_{sat} = p_{sat}/p$

$x_L = \phi\, x_{sat} = \phi\, p_{sat}/p$

$p_{sat} = 0.03$ bar at 298 K

$D = 0.25\ 10^{-4}\ m^2/s$





$x_{A0}=x_{sat} = p_{sat}/p$

$x_{AL}=\phi\ x_{sat} = \phi\ p_{sat}/p$

$p_{sat}= 0.03$ bar at 298 K

$D_A= 0.25\ 10^{-4}\ m^2/s$

the mixture A+B is treated as an ideal gaz mixture

Write the molar fluxes of vapor N_A and air N_B as a function of molar fractions x_A and x_B

$d\,N_A/dz$ = ? $d\,N_B/dz$ = ? value of N_B at the gaz/water interface ?