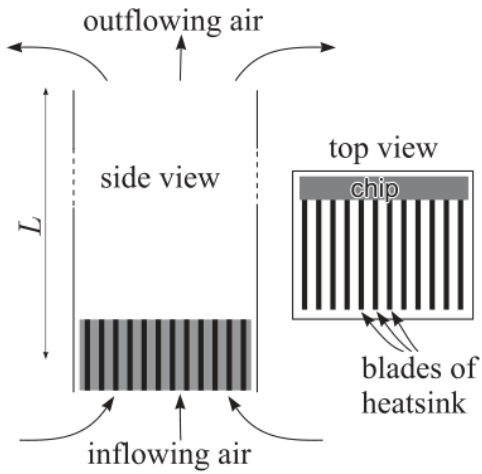
7. Passive air-cooling (9 pts)

Consider a passive cooling system depicted in figure. Cold air (at normal conditions: $p_0 = 10^5\,\mathrm{Pa}$, $T_0 = 293\,\mathrm{K}$) flows over the heat sink of a chip of power dissipation $P = 100\,\mathrm{W}$, into a vertical pipe of length $L = 1\,\mathrm{m}$ and cross-sectional area $S = 25\,\mathrm{cm}^2$. After passing the pipe, air enters the ambient room. Assume that the air inside the pipe becomes well mixed; neglect the viscous and turbulent friction of air inside the pipe and heat sink. Air can be considered as an ideal gas with adiabatic exponent $\gamma = 1.4$ and molar mass $\mu = 29\,\mathrm{g/mol}$.



1) Express heat capacitance at constant pressure c_p via quantites γ and R (1 pt).

2) Find a relationship between the outflowing air density ρ and temperature T (the relationship may contain also the parameters defined above) (2 pts).

3) Find a relationship between the air flow velocity in the pipe v and outflowing air density ρ (the relationship may contain also the parameters defined above) (2 pts).

4) Express the power disspation P in terms of the air flow velocity v, the outflowing air temperature T, and density ρ (the relationship may contain also the parameters defined above) (2 pts).

5) What is the temperature T of the outflowing air? In your calculations, you may use approximation $T - T_0 \ll T_0$ (2 pts)?