Solution to Problem 303A:

An air blower takes air ($\mathcal{R} = 280 m^2/s^2\ {}^\circ K$, $\gamma = 1.4$) from the atmosphere (pressure, $p_A = 100,000 kg/ms2$, temperature, $T_A = 293^\circ K$) and ingests it through a smooth entry duct so that the losses are negligible. The cross-sectional area of the entry duct just upstream of the blower and that of the exit duct are both $0.01 m^2$. The pressure ratio, p_2/p_1, across the blower itself is 1.05 and the exit pressure is equal to the atmospheric pressure, p_A. The air is assumed to behave isentropically upstream of the blower.

1. Since $p_2 = p_A$ and $p_2/p_1 = 1.05$ then $p_1/p_A = 1/1.05$ and since the upstream flow is isentropic:

$$\frac{T_1}{T_A} = \left(\frac{1}{1.05}\right)^{(\gamma-1)/\gamma} = \left(\frac{1}{1.05}\right)^{2/7} \tag{1}$$

and

$$c_p T_1 + u_1^2/2 = c_p T_A \tag{2}$$

therefore, the velocity of the air entering the blower is

$$u_1 = \left[2 c_p T_A (1 - (1.05)^{-2/7})\right]^{1/2} = 89\ m/s \tag{3}$$

2. Since the density upstream $\rho_1 = \rho_A (p_1/p_A)^{1/\gamma} = 1.18 kg/m^3$ the mass flow rate of air through the system is

$$\rho_1 u_1 A_1 = 1.18 \times 89 \times 0.01 = 1.05\ kg/s \tag{4}$$