Suppose the wind outside blows with uniform speed $V = 6 \text{ m/s}$. The density of the air is $1.21 \text{ kg/m}^3$ and its pressure is $p_{\text{atm}}$. You take a thin, rigid square plate, with side length 30 cm, and hold it so that its surface is perpendicular to the flow. If you treat the air as inviscid, ignore gravity, and assume that the pressure behind the plate is also $p_{\text{atm}}$, estimate the drag force acting on the plate using both (a) a control volume calculation and (b) Bernoulli’s equation. (I.e. you will get two estimates of the drag.)

**a. C.V. Calculation**

- Consider $x$-component of momentum eq. Only nonzero terms are drag force and inflow from left $\rightarrow$

  \[
  \sum F_x = \int \rho V^2 A \Rightarrow F_D = \rho \frac{V^2}{2} (30 \text{ cm})^2 (30 \text{ cm})^2 = 3.9 \text{ N}
  \]

**b. Using Bernoulli:**

Find $p$ on front of plate at $p_{\text{atm}}$ (given) $\rightarrow$

\[
\frac{p_{\text{atm}} + \frac{V^2}{2}}{p} \text{ (same as stagnation } p \text{ calculation)}
\]

\[
\Rightarrow \quad p = p_{\text{atm}} + \frac{pV^2}{2}
\]

Drag force: $\quad F_D = (p - p_{\text{atm}}) A = \frac{\rho V^2}{2} A = \frac{1}{2} \rho V^2 A = 2.0 \text{ N}
\]

(There are multiple ways to approach this depending on what assumptions you make. I will grade leniently.)