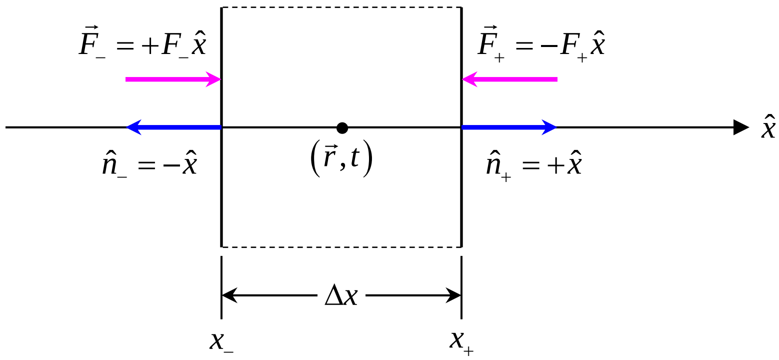

Note that here we must be mindful of the nature of the compressive force(s) due to the {small} over-pressure $p(\vec{r},t)$ acting on the infinitesimal volume element V_o – namely, that thermal equilibrium of the air contained within the volume V_o, as well as <u>*all*</u> <u>*other*</u> adjacent / neighboring infinitesimal volume elements of air must be maintained at all times during this process. The restriction that $|p(\vec{r},t)| \ll 100\ RMS\ Pascals$ { $SPL \ll 134\ dB$ } for harmonic/periodic over-pressure amplitudes with frequencies in the audio range of human hearing (20 Hz < f < 20 KHz) guarantees that thermal equilibrium holds during this process. From a thermodynamic perspective, this is clearly a <u>reversible</u>, <u>adiabatic</u>, and hence <u>isentropic</u> process.

The infinitesimal <u>vector</u> area elements associated with the x_- (LHS) and x_+ (RHS) of the infinitesimal volume element V_o are: $\vec{A}_- = A\hat{n}_- = -A_o\hat{x}\ (m^2)$ and $\vec{A}_+ = A\hat{n}_+ = +A_o\hat{x}\ (m^2)$. Note that the unit normal vectors $\hat{n}_- = -\hat{x}$ and $\hat{n}_+ = +\hat{x}$ associated with these two surfaces, <u>by convention</u>, point <u>outward</u> from/perpendicular to the surface S_o.

The x-force acting on the LHS surface located at x_- is: $\vec{F}_- = +F_-\hat{x} = -p_-\vec{A}_- = +p_-A_o\hat{x}$.

The x-force acting on the RHS surface located at x_+ is: $\vec{F}_+ = -F_+\hat{x} = -p_+\vec{A}_+ = -p_+A_o\hat{x}$.

The <u>*net*</u> x-force acting on the infinitesimal volume element V is: $\vec{F}_{net_x} = \vec{F}_+ + \vec{F}_- = -(p_+ - p_-)A_o\hat{x}$.

The <u>*net*</u> x-force <u>*per*</u> <u>*unit*</u> <u>*volume*</u> acting on the infinitesimal volume element $V_o = A_o \cdot \Delta x$ is:

$$\vec{f}_{net_x} = \frac{\vec{F}_{net_x}}{V_o} = \frac{-\overbrace{(p_+ - p_-)}^{\equiv \Delta p}\cancel{A_o}\hat{x}}{\cancel{A_o}\cdot\Delta x} = -\frac{\Delta p}{\Delta x}\hat{x}$$

In the limit that the volume V_o of the infinitesimal volume element $\rightarrow 0$:

$$\vec{f}_{net_x}(\vec{r},t) = -\frac{\partial p(\vec{r},t)}{\partial x}\hat{x}$$

We can repeat this analysis for the y- and z-components of the ***net*** force per unit volume due to the overpressure amplitude acting on the infinitesimal volume element V_o of air, the results are similar:

$$\vec{f}_{net_y}(\vec{r},t) = -\frac{\partial p(\vec{r},t)}{\partial y}\hat{y} \quad \text{and:} \quad \vec{f}_{net_z}(\vec{r},t) = -\frac{\partial p(\vec{r},t)}{\partial z}\hat{z}$$