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Acoustic Wave Equation and its Boundary Conditions in 1-D Ducts with Inhomogeneous Media and Mean Flow[1] SATTIK BASU, SARMA RANI, University of Alabama in Huntsville — We derive the generalized Helmholtz equation governing the acoustic pressure field in a quasi 1-D duct with axially varying cross-section and inhomogeneous mean flow properties such as the velocity, temperature, density and pressure. A linearly-exact derivative boundary condition to the Helmholtz equation of the form $\hat{p}x(x;\omega) = f(\hat{p}, \hat{u}, \hat{\rho}; \omega)$ is also developed, where $\hat{p}$, $\hat{u}$ and $\hat{\rho}$ are the pressure, velocity and density fluctuation fields, respectively, and ω is the angular frequency. It is seen that the pressure fluctuation field obtained by solving the Helmholtz equation in conjunction with the derivative boundary condition is identical to that obtained through the solution of the Euler equations. Furthermore, the linearly exact relationship between the density and pressure fluctuations is obtained, which is then compared with the "classical" relation, $\hat{\rho} = \hat{p}/\bar{c}^2$, where $\bar{c}$ is the mean sound speed. In ducts with inhomogeneous mean properties, the classical $\hat{\rho} - \hat{p}$ relation differs substantially from the exact relation both in amplitude and phase.

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