

## Sound and Doppler Effect

### Doppler Effect

$$f_m = f_s \frac{v - v_m}{v - v_s}$$

### Supersonic Speed

$$\sin \theta = \frac{v_{\text{sound}}}{v_{[\text{planar}/[\text{plan}]]}} = \frac{1}{M\alpha}$$

### Compressibility coefficient

$$\kappa = -\frac{1}{\Delta P} \cdot \frac{\Delta V}{V}$$

### Sound Pressure

$$p = -\frac{1}{\kappa} \cdot \frac{\partial s}{\partial x}$$

$$p = \mp p_0 \cos \left[ 2\pi \left( \frac{t}{T} \pm \frac{x}{\lambda} \right) \right]$$

### Pressure Amplitude

$$p_0 = \frac{2\pi s_0}{\kappa\lambda} = Z s_0 \omega$$

### Acoustic Impedance

$$Z = \rho v$$

### Speed of Sound (Fluid and Gas)

$$v = \frac{1}{\sqrt{\kappa\rho}}$$

$$v = \sqrt{\frac{c_p RT}{c_v M}}$$

### Speed of Sound (String and Rod)

$$v = \sqrt{\frac{F}{\mu}}$$

$$v = \sqrt{\frac{E}{\rho}}$$

## Sound Intensity

$$I = \frac{Z}{2} s_0^2 \omega^2$$

$$I = \frac{p_0^2}{2Z}$$

### Sound Intensity Level

$$L_I = 10 \lg \frac{I}{I_0}$$

$$\text{med } I_0 = 1,0 \cdot 10^{-12} \text{ W/m}^2$$

### Refraction and Transmittance of Sound

$$R \equiv \frac{I_r e f}{I_i n} = \left( \frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2$$

$$T \equiv \frac{I_t r}{I_i n} = 1 - R$$

### Harmonics (Strings and Open Cylinders)

$$f_m = m \cdot f_1 \quad m = 2, 3, 4, \dots$$

### Harmonics (Half Open Cylinders)

$$f_m = (2m - 1) \cdot f_1 \quad m = 2, 3, 4, \dots$$