Doppler Effect

For sound waves

Approaching Source

$f_+ = \frac{f_0}{1-v_s/v}$ or $f_o = f_s(\frac{v_w}{v_w-v_s})$

Receding Source

$f_- = \frac{f_0}{1+v_s/v}$ or $f_o = f_s(\frac{v_w}{v_w+v_s})$

Approaching Observer

$f_+ = (\frac{1+v_o}{v})f_0$ or $f_o = f_s(\frac{v_w+v_o}{v_w})$

Receding Observer

$f_- = (\frac{1-v_o}{v})f_0$ or $f_o = f_s(\frac{v_w-v_o}{v_w})$

For observers the wavelength doesn't change when they move.

Bouncing sound (object approaching):

$f_o = f_i(\frac{v_s+v_{obj}}{v_s})(\frac{v_s}{v_s-v_{obj}})$

Open-open or closed-closed tubes:

$m = 1, 2, 3, 4...$

$\lambda_m = \frac{2L}{m}$

$f_m = m\frac{v}{2L} = mf_1$

Open-closed tubes:

$m = 1, 3, 5, 7$

$\lambda_m = \frac{4L}{m}$

$f_m = m\frac{v}{4L} = mf_1$

Maximum interference

Maximum constructive:

$\Delta\phi = 2\pi\frac{\Delta x}{\lambda} + \Delta\phi_0 = m \cdot 2\pi \text{ rad},\ m = 0, 1, 2, 3...$

Maximum destructive:

$\Delta\phi = 2\pi\frac{\Delta x}{\lambda} + \Delta\phi_0 = (m + \frac{1}{2}) \cdot 2\pi \text{ rad},\ m = 0, 1, 2, 3...$

For light waves

Receding Source

$\lambda_- = \sqrt{\frac{1+v_s/c}{1-v_s/c}}\lambda_0$

Approaching Source

$\lambda_+ = \sqrt{\frac{1-v_s/c}{1+v_s/c}}\lambda_0$

Superposition

$D(x,t) = a\sin(kt-wt) + a\sin(kt+wt) = sin(\alpha)\cos(\beta) \pm \cos(\alpha)\sin(\beta)$

$f_m = \frac{v}{\lambda_m} = \frac{v}{2L/m} = m\frac{v}{2L} \quad m = 1, 2, 3, 4...$

Fundamental frequency: $f_1 = \frac{v}{2L}$

Allowed frequencies: $f_m = mf_1 \quad m = 1, 2, 3, 4$

$M = 1$	$\lambda_1 = \frac{2L}{1}$	$F_1 = \frac{V}{2L}$
$m = 2$	$\lambda_2 = \frac{2L}{2}$	$f_2 = 2\frac{v}{2L}$
$m = 3$	$\lambda_3 = \frac{2L}{3}$	$f_3 = 3\frac{v}{2L}$

Sound

Velocity

$v_{sound} = \sqrt{\frac{B}{\rho}}$

$B = \text{Bulk moduli}Pa$

$\rho = \text{density } kg/m^3$

Dry air at 20degC $\approx 343\ \ m/s$

Beat Frequency = $|f_1 - f_2|$

Phase

$\phi_1 = kx_1 - wt + \phi_0$

$\phi_2 = kx_1 - wt + \phi_0$

Phase difference $\Delta\phi = 2\pi\frac{\Delta X}{\lambda}$

Power

$I = \frac{P_{source}}{4\pi r^2}$

I Is in W/m^2 and P_{source} is in W

Decible

$\beta = 10db\log_{10}(\frac{I}{I_0})$

$I_0 = 1 \times 10^{-12}\ W/m^2$

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