EngineeringRise

Standing waves, organ pipes and beats

Formulas and units, JEE Main. Status: Reviewed on 2026-11-20.

Result	Formula	Units or note
Standing wave (fixed end at x = 0)	y = 2 A sin(k x) cos(omega t) Valid when: string fixed at x = 0; two equal waves travelling oppositely	m
Node and antinode spacing	node to node = antinode to antinode = lambda/2; node to antinode = lambda/4 Valid when: standing wave of wavelength lambda	m
String fixed at both ends	f_n = n v/(2 L) = (n/(2 L)) sqrt(T/mu), n = 1, 2, 3, ... Valid when: string fixed at both ends, v from sqrt(T/mu)	Hz
Open pipe	f_n = n v/(2 L), n = 1, 2, 3, ... Valid when: pipe open at both ends; end correction ignored	Hz
Closed pipe	f = (2 n - 1) v/(4 L) = f1, 3 f1, 5 f1, ... Valid when: pipe closed at one end; end correction ignored	Hz
Overtone numbering	string or open: 1st overtone = 2nd harmonic; closed: 1st overtone = 3rd harmonic Valid when: string, open pipe or closed pipe as stated	dimensionless
Resonance column	L2 - L1 = lambda/2; v = 2 f (L2 - L1); e = lambda/4 - L1 Valid when: closed resonance column, two successive resonances	m (m/s)
Beat frequency	f_beat = |f1 - f2|; period 1/f_beat Valid when: two sources of close frequencies heard together	Hz (s)
Resultant of two close frequencies	y = 2 A cos(pi (f1 - f2) t) sin(pi (f1 + f2) t) Valid when: two waves of equal amplitude and close frequencies	m

Full lesson with worked examples:
https://www.engineeringrise.in/learn/learn/jee-main/physics/oscillations-and-waves/standing-waves-organ-pipes-and-beats

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