CLASS 11 PHYSICS — FORMULA SHEET

Chapter 14 : Waves (NCERT)

14.1 Wave Basics

Concept	Formula
Wave speed	$v = f\lambda = \lambda/T$
Angular frequency	$\omega = 2\pi f = 2\pi/T$
Wave number	$k = 2\pi/\lambda$
Wave speed (k, ω)	$v = \omega/k$
Transverse wave	Particle motion ⊥ to wave direction (e.g. string, light)
Longitudinal wave	Particle motion parallel to wave (e.g. sound)
Progressive wave equation	$y = A\sin(\omega t - kx)$ (moving in +x direction)

14.2 Speed of Waves

Medium / Wave	Formula
Wave on a string	$v = \sqrt{(T/\mu)}$; μ = mass per unit length
Sound in solid	$v = \sqrt{(Y/\rho)}$ (Y = Young's modulus)
Sound in liquid/gas	$v = \sqrt{(B/\rho)}$ (B = bulk modulus)
Newton's formula (sound in air)	$v = \sqrt{(P/\rho)}$ (isothermal — gives wrong value)
Laplace correction	$v = \sqrt{(\gamma P/\rho)}$ (adiabatic — correct value about 332 m/s)
Sound speed & temperature	$v \propto \sqrt{T}$; increases 0.61 m/s per °C

14.3 Principle of Superposition & Interference

Concept	Formula
Superposition	$y = y_1 + y_2$ (resultant displacement)
Constructive interference	Phase diff = $2n\pi$; path diff = $n\lambda$
Destructive interference	Phase diff = $(2n-1)\pi$; path diff = $(2n-1)\lambda/2$
Resultant amplitude	$A = \sqrt{(A_1^2 + A_2^2 + 2A_1A_2\cos\varphi)}$
Max amplitude	$A_1 + A_2$ (in phase)
Min amplitude	$\lvert A_1 - A_2\rvert$ (out of phase)

14.4 Standing (Stationary) Waves

System	Formula
Standing wave equation	$y = 2A\sin(kx)\cos(\omega t)$
Nodes	Points of zero amplitude (fixed)
Antinodes	Points of maximum amplitude

System	Formula
Distance node to node	$\lambda/2$; node to antinode = $\lambda/4$
String fixed both ends	$f_n = (n/2L)\sqrt{(T/\mu)}$; n = 1, 2, 3 …
Fundamental (string)	$f_1 = (1/2L)\sqrt{(T/\mu)}$
Harmonics (string)	All harmonics present (f_1, $2f_1$, $3f_1$ …)
Open pipe	$f_n = nv/(2L)$; all harmonics
Closed pipe	$f_n = (2n-1)v/(4L)$; only ODD harmonics

14.5 Beats & Doppler Effect

Concept	Formula
Beat frequency	$f_{beat} = \lvert f_1 - f_2 \rvert$
Beats condition	Two waves of slightly different frequencies
Doppler (general)	$f' = f\,(v \pm v_o) \div (v \mp v_s)$
Source approaching	$f' = f \times v \div (v - v_s)$ (frequency increases)
Source receding	$f' = f \times v \div (v + v_s)$ (frequency decreases)
Observer approaching	$f' = f \times (v + v_o) \div v$
Observer receding	$f' = f \times (v - v_o) \div v$
Sign rule	Top signs for approach (toward), bottom for recede (away)

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Wave relation	$v = f\lambda$. Speed is set by the MEDIUM, frequency by the SOURCE.
String speed	$v = \sqrt{(T/\mu)}$. Tighter string or lighter string → faster wave.
Laplace correction	Sound in air uses adiabatic: $v = \sqrt{(\gamma P/\rho)}$, not Newton's $\sqrt{(P/\rho)}$.
Sound & temperature	$v \propto \sqrt{T}$; rises about 0.61 m/s for every 1°C.
Node spacing	Node to node = $\lambda/2$; node to antinode = $\lambda/4$.
Open vs closed pipe	Open: all harmonics. Closed: only ODD harmonics (fundamental halved).
Beats	$f\_beat = \lvert f_1 - f_2 \rvert$. Used to tune instruments.
Doppler sign	'Toward' raises pitch, 'away' lowers it. Choose signs accordingly.