

Oscillations, Waves & Sound — Complete Formula Card

- Oscillation, waves and sound are one subject: everything reduces to $v = f\lambda$ plus SHM's ω
- Pendulum ignores mass; spring clock ignores gravity — examiners love both traps
- Doppler is a ratio game: source/listener speed relative to wave speed

What	Formula	Remember
SHM definition	$a = -\omega^2 x$	pull-back $\Rightarrow$ displacement
SHM motion	$x = A \sin(\omega t)$; $v_{\text{max}} = A\omega$; $a_{\text{max}} = \omega^2 A$	fastest at centre, strongest pull at ends
Clocks	pendulum: $2\pi\sqrt{L/g}$; spring: $2\pi\sqrt{m/k}$	mass-free pendulum; gravity-free spring
SHM energy	$\frac{1}{2}kA^2$ total; avg KE = avg PE	amplitude-squared
Springs combined	series $k/2$, parallel $2k$ (equal)	period $\Rightarrow 1/\sqrt{k}$
Resonance	driver = natural frequency	amplitude maximum; damping barely shifts f
Wave link	$v = f\lambda$	f by source, v by medium
String waves	$v = \sqrt{T/\mu}$	tighter/lighter = faster
Standing waves	$f_n = n \cdot v/2L$ (string, open pipe); closed: odd only ($v/4L$)	nodes $\lambda/2$ apart; ends are nodes
Beats	$f_{\text{beat}} = f_1 - f_2 $	zero beats = tuned
Doppler	approach $\rightarrow$ higher; recede $\rightarrow$ lower	shift $\propto$ speed $\div$ wave speed; light: red/blue

Mistakes to avoid

- Approach = higher pitch, ALWAYS — write the direction rule before any formula
- Shift scale = source speed $\div$ WAVE speed (343 m/s for sound, 3×10^8 for light) — never mix them
- The siren itself never changes: f_0 stays constant; only the arrival rate changes
- Redshift means stretched wavelengths, not literally a redder colour