Acoustic & Vibrational Structure Inspirations

Chladni Plate Patterns

CHLADNI_PLATE_VIBRATION

Based on Ernst Chladni's 18th-century experiments where sand on vibrating metal plates collects along nodal lines. When a flat plate vibrates at a resonant frequency, stationary nodal lines form intricate geometric patterns. For cylindrical lampshade surfaces, we map the 2D Chladni equation (nabla-squared-w + k-squared-w = 0) onto the unwrapped cylinder, creating displaced ridges along the nodal contours. The mode numbers (m, n) control the complexity: low modes produce simple star patterns while high modes create dense, lace-like grids. Perfect for lampshades because the raised nodal ridges provide structural reinforcement while the anti-nodal regions can be thinned or perforated for light transmission.

Cymatics Ring Interference

CYMATICS_RING_PATTERN

Inspired by Hans Jenny's cymatics experiments where sound frequencies create standing wave patterns in water and fine powders. When multiple frequencies interact on a circular membrane, concentric rings and radial node lines create complex interference patterns. Applied to lampshade geometry, this produces nested ring-like ridges with radial spokes. The frequency ratio between radial and circumferential modes determines whether the pattern appears as concentric ripples, star-bursts, or complex mandalas. The natural thickness variation (peaks at antinodes, thin at nodes) makes these inherently printable while creating beautiful light-filtering gradients.

Resonance Harmonics Surface

RESONANCE_HARMONIC_MODE

Based on the vibrational modes of cylindrical shells studied in structural acoustics. A hollow cylinder vibrates in characteristic patterns described by circumferential wave number (n) and axial half-wave number (m). The displacement follows w(theta, z) = cos(n*theta) * sin(m*pi*z/L), producing diamond-shaped or rectangular grid patterns when multiple modes superimpose. For lampshades, combining 2-3 harmonic modes at different amplitudes creates organic interference patterns that are structurally robust. The nodal grid naturally subdivides the surface into printable cells.

Helmholtz Resonator Array

HELMHOLTZ_RESONATOR_GRID

Inspired by arrays of Helmholtz resonators used in acoustic metamaterials. Each resonator is a small cavity with a narrow neck opening, and when arrayed across a surface they create a structured grid of bulbous chambers connected by narrow channels. Applied to lampshade surfaces, this creates a honeycomb-like array of small dome-shaped bulges with pinched necks between them. The varying cavity sizes can be tuned to create gradient patterns from dense small cells to sparse large ones. Structurally excellent for 3D printing due to the self-supporting dome geometry.

Standing Wave Tube

STANDING_WAVE_TUBE_MODE

Based on acoustic standing waves inside cylindrical tubes. When sound reflects at both ends, pressure nodes and antinodes form at precise intervals determined by the tube length and wavelength. Mapping pressure amplitude to wall displacement creates lampshades with regular bulging and pinching along the vertical axis. Multiple harmonics can be superimposed, each adding finer detail. The fundamental mode creates a simple belly shape, while overtones add increasingly fine corrugations. Naturally blends with other styles since it primarily modifies the vertical profile.

Acoustic Diffuser Surface

QRD_DIFFUSER_PATTERN

Inspired by Quadratic Residue Diffuser (QRD) panels used in recording studios and concert halls. These surfaces use wells of varying depths arranged according to a number-theoretic sequence (quadratic residues modulo a prime number). Applied to a cylindrical lampshade, radial columns of varying depth create a mathematically precise irregular surface that scatters light in interesting patterns. The prime-number-based sequence ensures non-repeating variation while maintaining structural regularity. The well depths are constrained to printable ranges.

Vibrating String Envelope

STRING_HARMONIC_ENVELOPE

Based on the displacement envelope of vibrating strings as studied since Pythagoras. The fundamental mode is a simple sine arch, while harmonics create multiple lobes. Vertical cross-sections of the lampshade follow different harmonic envelopes, and rotating these profiles around the axis with angular phase shifts creates helical or braided patterns. Combining odd and even harmonics produces asymmetric profiles reminiscent of plucked versus bowed strings. The smooth sine-based profiles ensure good printability with no overhangs.

Doppler Wavefront Surface

DOPPLER_WAVEFRONT_SHIFT

Based on the asymmetric wavefront compression and expansion of the Doppler effect. When a point source moves relative to an observer, the wavefronts ahead are compressed while those behind are stretched. Applied to lampshade geometry, this creates an asymmetric radial pattern where one side has tightly spaced ridges and the opposite side has broadly spaced ones. This controlled asymmetry produces dramatic directional lighting effects and striking visual tension. The gradual spacing change ensures smooth printability throughout.

Tuning Fork Resonance

TUNING_FORK_PRONG

Inspired by the vibrational modes of tuning fork prongs, which exhibit bending, torsional, and longitudinal vibration patterns. The characteristic shape of a vibrating prong (clamped at one end, free at the other) produces a displacement curve with a single or double antinode. Arranging multiple virtual tuning fork profiles around the lampshade circumference creates elegant fin-like protrusions. Higher modes add secondary wiggles to the fins. The tapered profile from base to tip is naturally self-supporting for 3D printing.

Acoustic Metamaterial Lattice

PHONONIC_CRYSTAL_LATTICE

Inspired by phononic crystals, which are periodic structures designed to control wave propagation. Their geometry features repeating unit cells with specific fill factors that create band gaps for certain frequency ranges. Applied to lampshade surfaces, this creates a lattice of geometrically precise inclusions (circles, squares, or cross-shapes) arranged in square or hexagonal grids. The fill factor (ratio of inclusion to unit cell) controls the density of the pattern, from sparse isolated bumps to dense, nearly-connected networks. Excellent for blending because the lattice pattern naturally overlays with any underlying profile shape.

Each of these acoustic and vibrational inspirations provides a unique mathematical foundation for creating parametric 3D surfaces. These patterns combine wave physics with structural engineering principles, producing forms that are inherently suited to 3D printing due to their smooth, self-supporting geometries and natural thickness variations. When used as lampshades, the nodal/antinodal patterns create striking light-and-shadow interplay.