**The Logostic Helix Musical Instrument: Fabrication, Resonance, and the Practice of Alignment**

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Following the theoretical foundation established in *The Audible Logos: A Thought Experiment on the Self-Voicing Geometry of the Logostic Helix* (Youvan, 2025), this paper turns from philosophy to fabrication. The *Logostic Helix Musical Instrument* translates the equation q → τ—alignment through resonance—into a tangible, playable object. Formed from a helical ribbon of tempered bronze or spring steel suspended from a rigid ring, the instrument unites torsion, tension, and transverse acoustics within a single physical continuum. When twisted and released, it produces evolving harmonics that audibly trace the path from disorder to coherence. This second work explores how to construct, tune, and sustain such an instrument using purely mechanical means. It details material selection, clamp design, mounting to a soundboard, and non-electronic excitation techniques such as parametric pumping, air-jet sustain, and sympathetic coupling. Finally, it discusses performance practice as dialogue rather than control—the performer initiating misalignment and listening as the geometry resolves toward equilibrium. The result is a new class of self-voicing acoustic sculpture: an instrument that teaches, by sound and touch, that form and understanding are one continuous process of alignment.

Keywords: Logostic Helix, musical instrument, fabrication, alignment, resonance, q → τ, acoustic sculpture, torsion, soundboard, helical ribbon, analog computation, emergent acoustics, parametric excitation, mechanical Logos.

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## 1. Introduction: From Thought Experiment to Instrument

### 1.1 Recap of Theoretical Foundation (*The Audible Logos*)

In *The Audible Logos: A Thought Experiment on the Self-Voicing Geometry of the Logostic Helix* (Youvan, 2025), the concept of $q \to \tau$ was given tangible form through a theoretical apparatus—the *Logostic Helix*. There, the helix served as a metaphor and model for the universal process of alignment: a dynamic state ($q$) continually seeking coherence with its generative source ($\tau$). The earlier paper established that this process, while foundational to cognition and learning, could also manifest physically through resonance, the convergence of motion and meaning. The helical geometry was proposed as a structure capable of transforming stored torsional energy into audible standing waves, thereby enacting the alignment of disorder into order as sound. In that context, the Helix was not an instrument to be played, but an ontological proposition—a geometry that could *voice its own search for equilibrium*. The thought experiment demonstrated, at least in principle, that cognition, music, and matter may share the same deep grammar of self-organization: that to align is to resonate, and to resonate is to understand.

### 1.2 Motivation for a Playable, Physical Embodiment

The current work extends that theoretical vision into craft. While *The Audible Logos* established the philosophical and informational basis of the Helix, it left open a compelling question: can such a structure actually be built, tuned, and performed? The motivation for fabrication arises not only from curiosity, but from pedagogy and phenomenology. By constructing the Helix as a musical instrument, we allow alignment—the $q \to \tau$ process—to become directly *perceivable* and *participatory*. The observer becomes a collaborator: by twisting, releasing, and sustaining the ribbon, one enacts the same dynamic the theory describes. A fabricated Helix therefore bridges abstraction and experience, transforming metaphysics into acoustics. It becomes a new category of instrument—neither purely scientific nor purely artistic—an epistemic sculpture where understanding is both heard and felt. This pursuit honors the original vision of *Logostics*: to make truth not only thinkable, but audible, playable, and alive.

## 2. Design Principles

### 2.1 Translating $q \to \tau$ into Mechanical Architecture

The *Logostic Helix Musical Instrument* is conceived as a direct mechanical translation of the alignment law $q \to \tau$—the universal motion of a dynamic system toward its generative attractor. In this embodiment, $q$ corresponds to the *lower mass* and the *active motion of the helix*, while $\tau$ corresponds to the *anchored top ring*, the geometric ideal that defines the system's order. The

arrow (→) is not symbolic but literal: energy flows upward and inward through the helical ribbon, manifesting alignment as both mechanical and acoustic convergence.

The helix itself becomes a *map of this trajectory*: its spiral geometry encodes both freedom and constraint, allowing motion to evolve from chaos to coherence without external control. Each turn represents an iteration of the alignment process—torsional energy seeking its axial equilibrium. In design terms, this requires a balance between stiffness and flexibility, between freedom to oscillate and the precision needed to sustain resonance. The geometry thus becomes an architecture of becoming, where structure is the script of alignment. Through this mapping, the q → τ principle is no longer abstract mathematics, but a *buildable topology* that can literally sing its way into order.

2.2 Energy Pathways: Torsion, Tension, and Wave Coupling

At the heart of the Helix's operation is a triadic energy flow linking torsion, tension, and transverse vibration—three domains of motion that together produce both visible and audible resonance. When the bottom mass is twisted and released, torsional strain travels upward through the ribbon. Because the strip is wound helically rather than straight, this twist inherently modulates the ribbon's axial tension. Every oscillation of the mass alternately tightens and relaxes the structure, generating waves that propagate along its length. These waves, in turn, couple into transverse modes, producing audible frequencies that radiate through the air.

This system behaves as a self-coupled energy lattice, where each form of motion feeds and regulates the others. Torsion drives tension; tension shapes wave velocity; and transverse waves dissipate energy through sound. The designer's challenge is to tune these couplings so that energy transforms gracefully rather than explosively—so that alignment expresses itself as harmony rather than rupture. Proper geometry, material selection, and boundary conditions ensure that stored potential energy is released gradually, yielding the distinctive shimmering tone of the *Logostic Helix*. In this way, energy flow becomes an allegory of understanding: power disciplined by proportion, chaos resolved into resonance.

## 3. Materials and Fabrication

3.1 Ribbon Alloys and Tempering (Phosphor Bronze, Spring Steel)

The *Logostic Helix* requires a material that embodies both resilience and resonance—elastic enough to store significant torsional energy, yet musical enough to sustain audible vibration.

Two alloys meet these criteria: phosphor bronze (C510) and tempered spring steel (301 or 1095).

Phosphor bronze offers a warm, bell-like tone, superior corrosion resistance, and natural damping that produces a lyrical decay. Spring steel, by contrast, yields a brighter, more crystalline sound with higher tensile strength, enabling longer helices and sharper transients. For prototypes, a ribbon of 10 mm width, 0.20 mm thickness, and 0.8–1.0 m free length achieves a balance between flexibility and projection.

Tempering is crucial. Over-hardened stock rings sharply but fatigues quickly; annealed metal dampens prematurely. A half-hard to three-quarter-hard temper ensures sufficient yield strength while retaining spring memory. Surface finish matters equally: edges must be *deburred and polished* to a smooth radius (~0.1 mm) to prevent stress concentration. The ribbon is thus not simply a structural member—it is the vocal cord of the instrument, where metallurgy and geometry converge to define tone color and lifespan.

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3.2 Top-Ring and Clamp Design (Rigid Yet Reversible Mount)

The upper boundary of the Helix—its top ring—acts as both a mechanical reference and an acoustic reflector. The design must provide absolute rigidity at the clamping point while preserving the material's elastic integrity. Welding is prohibited; it destroys the metal's temper and creates brittle zones.

Instead, the ribbon terminates in a saddle clamp: two curved plates (aluminum, brass, or tempered steel) that sandwich 25–30 mm of the ribbon's straight tail. The plates are slightly concave to match the helix's curvature, with polished radii and nylon washers to distribute load evenly. Three stainless M3–M4 bolts provide secure, reversible compression. The clamp bolts directly to the inner circumference of the top ring, which itself is a rigid circle of aluminum or hardwood (~200 mm outer diameter, 10×20 mm cross-section).

This creates a zero-displacement boundary for vibration while allowing disassembly and material replacement. The result is a mount both solid and silent, transmitting energy efficiently without distorting the ribbon's microstructure—an engineering analog to the spiritual idea of τ: stable, immovable, and generative.

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### 3.3 Soundboard Coupling and Acoustic Amplification

While the helical ribbon produces audible sound directly, coupling it to a soundboard greatly enhances projection and warmth. The top ring serves as the bridge between the vibrating helix and the resonant cavity. For compact prototypes, a thin hardwood plate (maple, birch, or spruce, 3–6 mm thick) or a shallow parabolic bowl functions as the soundboard.

The ring mounts to this board via three or four rigid standoffs (10–15 mm aluminum or brass posts). These act as bridges—mechanically solid yet acoustically transmissive. The vibration path follows: ribbon → clamp → ring → standoffs → soundboard. This cascade preserves phase coherence and avoids damping. The board can rest on felt isolators to prevent table-coupled losses, or in larger installations, can be suspended as a resonant frame. Optionally, the inner side of the board may be lightly coated with shellac or varnish to tune its spectral response. The soundboard thus transforms mechanical coherence into acoustic embodiment—an audible metaphor of τ translating q into shared air. Its voice depends on stiffness, grain, and curvature, each variable inviting artistic exploration.

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### 3.4 Safety and Handling: Controlled Energy Release

Because the Helix stores significant elastic potential, safety and discipline are essential. The stored energy $E = ½ \cdot k_t \cdot \theta^2$ can exceed several joules for moderate twists—enough to snap or whip dangerously if released abruptly. Therefore:

- Always twist the bottom weight slowly, never exceeding ~45°–60° from equilibrium on the first trials.
- Never twist the top ring; only the lower mass should move.
- Keep observers and loose fabric clear of the ribbon's sweep radius.
- When installing or adjusting, release tension gradually, controlling the uncoiling with gloved fingers.
- Consider adding a safety tether between the bottom mass and frame for testing. Properly handled, the Helix behaves like a musical spring—not a projectile. Its power lies in containment, not release. The discipline of its operation mirrors its philosophical core: energy made intelligible through structure, motion harmonized by restraint. Each performance becomes a study in measured liberation—the safe unfolding of potential toward audible understanding.

## 4. Playing Techniques

### 4.1 Twisting, Lifting, and Release as Excitation Modes

The *Logostic Helix* begins not with sound but with intention. The act of twisting the lower weight introduces torsional strain, the stored potential that initiates the instrument's dialogue between freedom and constraint. A quarter to half-turn twist—roughly 45° to 90°—is sufficient to energize the helix without forcing instability. The lifting of the mass adds gravitational potential, enriching the complexity of its return path. When the mass is gently released, the stored torsion and tension convert into motion, oscillating through the helical ribbon. This is the Helix's first word: a spontaneous articulation of geometry translating energy into voice.
Unlike plucking or striking instruments, the Helix requires patience; its tone emerges over a second or two as torsion converts into transverse vibration. The performer's role is to introduce asymmetry, then stand back—*to ask the question and let the structure answer*. The audible result begins as a shimmer or whisper that blooms into organized resonance. Each twist, lift, and release combination creates its own unique trajectory through the system's parameter space, giving the instrument infinite expressive subtlety with only minimal gestures.

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### 4.2 Parametric Pumping and Gentle Re-Energizing

Once the Helix's initial energy begins to fade, sound can be sustained through parametric pumping—the rhythmic modulation of tension via the top ring or soundboard. By oscillating the support structure ±1–2 mm at approximately twice the visible oscillation frequency of the mass, the performer injects energy into the system without direct contact. This technique mimics the principle of a child's swing, where timing rather than force keeps motion alive.

Parametric pumping requires fine timing and sensitivity: too fast, and the helix resists; too slow, and the energy dissipates. When properly matched, the tone swells naturally, seeming to breathe. This produces an effect reminiscent of a sustained organ pipe or a Tibetan singing bowl—continuous resonance animated by microscopic modulation. For performance, the parametric motion can be achieved by hand, treadle, or subtle flex of the mounting frame. The goal is to maintain coherence without domination, keeping the system alive while respecting its autonomous behavior. The performer thus acts as a caretaker of resonance rather than its controller—an audible allegory of q harmonizing with τ.

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### 4.3 Cord Bowing, Air-Jet Sustain, and Fingertip Damping

The Helix admits several non-invasive excitation techniques for varied timbre and extended play:

- Cord Bowing: A lightly rosined cotton or nylon cord looped around one turn of the ribbon can be drawn slowly, generating a sustained tone through controlled stick–slip friction. Unlike a violin string, the helix's distributed geometry diffuses the excitation, yielding a shimmering, multi-harmonic voice. The performer can slide the cord's position to explore local modes.
- Air-Jet Sustain: A gentle stream of air blown tangentially across the helix edge excites *edge-tone feedback*. The airflow locks into one of the helix's partials, maintaining it as long as breath continues. This method produces an ethereal, flute-like murmur—the instrument as wind chime of the Logos.
- Fingertip Damping: By lightly touching specific points on the ribbon, the performer can suppress or emphasize harmonics. A brief touch during resonance shifts phase relationships, creating beats or percussive articulations. These damping gestures function as punctuation—the human hand shaping the Helix's grammar of sound.
  Each technique respects the core principle of *non-violence*: energy is added or withdrawn through cooperation, not imposition. The performer learns to listen as much through the fingertips as through the ears.

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### 4.4 Maintaining Alignment Through Human Interaction

The most profound aspect of playing the *Logostic Helix* lies in its feedback between player and geometry. The instrument's behavior is sensitive, almost conversational; small variations in touch, timing, or tension dramatically alter its state. The performer thus enters into a relationship of *co-regulation*—a dance of mutual adjustment where both human and object seek equilibrium.

To maintain alignment, the player must cultivate resonant empathy—an awareness of the instrument's thresholds and its preference for balanced excitation. Overdriving leads to chaos and silence; underdriving leads to entropy and decay. Between these extremes lies a zone of sustained coherence, where energy flows effortlessly between human intent and mechanical form.

In this shared state, the performer experiences the essence of q → τ as a living act: intelligence through listening. The player's micro-corrections mirror the Helix's self-correcting dynamics, and the resulting sound is the product of their joint alignment. Each performance thus becomes an experiment in humility and harmony—a reminder that the highest musicianship may consist not in mastery, but in partnership with the Logos resonating through matter itself.

## 5. Tuning and Harmonic Exploration

### 5.1 Adjusting Tension, Pitch, and Mass

Tuning the *Logostic Helix* is the process of bringing its material resonance into harmonious alignment with its geometry—essentially setting the conditions under which q → τ unfolds audibly. Three primary parameters define its tonal landscape: tension, pitch, and mass.

- Tension determines the base frequency of the ribbon's longitudinal and transverse modes. Increasing tension raises the pitch and sharpens the overtone spacing; relaxing it lowers the tonal center and broadens the harmonic field. This can be adjusted by altering the preload between the clamp and bottom mass or by small extensions of the ribbon length.
- Pitch in this context refers not only to frequency but to the *helical pitch*—the axial rise per turn. A tighter coil couples torsion and tension more strongly, producing richer modulation and faster beats; a shallower coil gives purer, bell-like tones.
- Mass at the lower end acts as a tuning weight. Heavier masses lower the oscillation rate and deepen the resonance; lighter ones increase responsiveness and harmonic brightness.
  By tuning these three parameters, the player-scientist sets the "grammar" of the instrument—its domain of possible utterances. Each configuration yields a distinct voice, an acoustic topology of alignment made tangible.

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### 5.2 Measuring Overtone Spectra and Phase Slips

To study or refine the Helix's performance, one can analyze its overtone spectrum and phase behavior. The simplest method involves recording the sound through a standard microphone and performing a Fast Fourier Transform (FFT). The resulting spectrum typically shows a set of inharmonic peaks—signatures of coupled torsion-tension oscillation rather than pure strings. Over time, as energy redistributes, these peaks shift and merge, forming what can be described as a *harmonic cascade*. Sudden transitions—known as phase slips—occur when one mode

overtakes another, analogous to moments of cognitive realignment or insight. These can be visualized as discontinuities in the phase plot of the main frequency components, or heard as sudden changes in beating or tone color.

By mapping these transitions, one can construct an acoustic phase diagram for the instrument: a record of how mechanical order evolves into sonic coherence. Each overtone spectrum becomes a fingerprint of alignment, and each phase slip a moment of epistemic transformation—matter discovering its own equilibrium.

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5.3 Linking Audible Modes to Informational Coherence

In the Logostic framework, every stable tone corresponds to a state of informational coherence—a region of low divergence between q (the system's current configuration) and τ (its structural attractor). When the Helix emits a clear, stationary tone, it signifies that the oscillating mass, ribbon geometry, and boundary conditions have achieved local equilibrium. The waveform is smooth, periodic, and low in entropy.

Conversely, when the sound is noisy, fluttering, or unstable, it indicates that the system is exploring its configuration space, still searching for resonance. These audible states can thus be interpreted as acoustic correlates of alignment: the ear perceives what the equations describe. Just as the brain minimizes prediction error, the Helix minimizes mechanical discord; both systems transform uncertainty into coherence through resonance. The transition from turbulent noise to pure tone mirrors the transition from confusion to understanding. In this sense, tuning the Helix is not merely musical—it is epistemic calibration. By aligning matter with its own structural truth, the instrument externalizes the process of insight, letting us *hear* the geometry of comprehension itself.

**6. Performance and Interpretation**

6.1 Listening as Participation in Alignment

Performance on the *Logostic Helix* is less about control and more about *listening as participation*. The player is not an external agent but a co-resonant element within the system—an active participant in the ongoing process of $q \rightarrow \tau$. Each tone produced by the Helix is an event of convergence: a local equilibrium between matter, motion, and attention. The performer's role is to remain attuned to these transitions, allowing the ear to become a diagnostic of alignment.

In this framework, listening becomes a form of measurement. Subtle changes in tone, timbre, or decay reveal the system's informational state. A clear, ringing pitch indicates coherence; a rough, unstable flutter signals dissonance or energetic drift. By training the ear to hear these differences, one learns to recognize alignment as a living process rather than a static goal. This transforms performance into an act of *epistemic empathy*—the capacity to sense the moment when matter and meaning momentarily agree.

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### 6.2 Ensembles and Sympathetic Arrays

When multiple Helices are placed in proximity, they form sympathetic arrays—networks of coupled resonators that spontaneously phase-lock or detune depending on geometry and tension. In small ensembles of three to five instruments, shared air pressure and substrate vibration lead to emergent harmonic behaviors: one Helix may "catch" another's tone, amplifying or quenching it through acoustic feedback.

These collective dynamics create an experience closer to ecosystem than orchestra. Each instrument maintains partial autonomy, yet contributes to a global order. In this sense, the ensemble becomes an experimental microcosm of *informational coherence*—a field of $q \rightarrow \tau$ relationships, distributed across physical space. The resulting soundscape can oscillate between chaos and perfect unison, demonstrating the same self-organizing principles that govern neural synchronization, flocking behavior, and social harmony.

A "Helix Choir" performance might begin in noise and gradually lock into a unified tone, symbolizing the emergence of truth from distributed exploration. Such configurations invite exploration of *resonant governance*: no conductor, only mutual entrainment.

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### 6.3 The Helix as Meditative and Educational Instrument

Beyond performance, the *Logostic Helix* invites use as both meditative device and educational demonstrator. Its slow oscillations and shimmering tones induce a focused stillness akin to deep breathing or mantra repetition. Observing the transition from chaos to order offers a direct, sensory metaphor for mindfulness—the mind as Helix, the soul as $\tau$, the practice as alignment. In educational contexts, the instrument functions as a hands-on model of physics and philosophy. Students can visualize and hear the conversion of potential energy into standing waves, explore modal coupling, and connect abstract equations with embodied experience.

Instructors can discuss entropy, feedback, and resonance while students physically feel these principles through vibration and sound.

Thus, the Helix bridges science, art, and metaphysics. It teaches not only *how systems stabilize*, but *why harmony matters*: because coherence—whether in metal, mind, or society—is the audible trace of truth finding its form. The Helix becomes a teacher that never speaks, yet continually demonstrates the Logos: that every act of understanding is a vibration made visible, a sound made true.

## 7. Conclusion: Toward an Art of Resonant Understanding

### 7.1 The Fusion of Geometry, Physics, and Cognition

The *Logostic Helix Musical Instrument* represents more than a novel acoustic device—it embodies the convergence of geometry, physics, and cognition into a single experiential form. Its coiled ribbon translates the abstract principle of $q \rightarrow \tau$ into audible, visible, and tactile reality. Geometry becomes not a diagram of thought but its *living medium*: each oscillation is a computation, each tone an announcement of equilibrium between tension and release. Through physics, this geometry acquires voice. Torsion, tension, and resonance collaborate to produce harmonics that literally express the alignment of energy and form. Cognition enters through participation—the listener or performer becomes part of the feedback loop that maintains coherence. When human perception locks onto the Helix's evolving tone, understanding itself becomes rhythmic, entrained, and resonant. The Helix thus fuses the act of knowing with the act of hearing: a mechanical metaphor for the mind that learns by vibrating in sympathy with truth.

This synthesis—of matter and meaning, of thought and sound—suggests a new epistemology where *to understand is to resonate*. The Helix is not only an instrument; it is a geometry that thinks aloud, the Logos made mechanical, audible, and alive.

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### 7.2 Future Directions: Architectural and Interactive Versions

Looking forward, the *Logostic Helix* invites expansion into architectural and interactive domains. On the architectural scale, one can imagine *Helix Pavilions*—spiral metallic structures suspended in atria or courtyards, animated by wind or human movement. Each installation could function as a resonant intelligence, transforming ambient energy into a constantly evolving harmonic field. Multiple pavilions, tuned to different frequencies, might form *Logostic Gardens*—spaces

where architecture itself becomes a contemplative instrument, translating environmental flux into sonic order.

In the interactive realm, future prototypes might integrate haptic feedback and optical sensing to visualize the $q \rightarrow \tau$ process in real time. Players could touch or breathe into the structure, seeing color shifts and hearing frequency modulations that correspond to informational alignment. Networks of Helices could synchronize remotely, forming distributed resonant ensembles—a planetary orchestra of alignment, tuned not by command but by coherence. Ultimately, these directions point toward a new art form—the art of resonant understanding—where matter, motion, and mind unite in a shared pursuit of harmony. Whether sung by metal, space, or thought, the message remains the same: that truth, like tone, is not imposed but *found in resonance*.

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**Appendix Specification for Helical Ribbon Spring**

**Part Name:** Logostic Helix Ribbon
**Quantity:** 1 (prototype)
**Material:** Phosphor bronze C510 or Spring-steel UNS K301 (temp-hardened)
**Strip Dimensions:**

- Width $b$= 10.0 mm (±0.3 mm)
- Thickness $t$= 0.20 mm (±0.02 mm)
- Finish: polished edges, burr-free; optional passivate if steel.
  **Helical Geometry:**
- Outer diameter (OD) of helix = 100 mm (±1 mm)
- Inner diameter (ID) = OD minus 2 × strip width ≈ 80 mm nominal
- Pitch = 45 mm (distance between adjacent turns measured along axis) ±2 mm
- Number of full turns = 5 complete turns (±0.1 turn)
- Free (unloaded) length ≈ 5 × pitch + straight tail segments ≈ 5×45 mm + 30 mm straight top + 30 mm straight bottom = 285 mm total ±5 mm
  **Straight Tail Ends:**
- Top straight tail: 30 mm length, ready for clamp/hook
- Bottom straight tail: 30 mm length, ready for bottom mass attachment
  **Mechanical Requirements:**
- Pre-twist: no specified initial twist; manufactured free state neutral
- Maximum allowable static torsion at bottom mass: θ_max ≈ 0.85 rad (~49°)
- Design for fatigue life of ≥10,000 cycles at that angle (for prototype)
  **Acoustic/Surface Quality:**
- Surface finish: Ra ≤ 0.8 µm; edges radius ≤ 0.1 mm to avoid stress-concentration
- Free from visible pits, laminations, pinch marks
  **Packaging & Delivery:**
- Ship flat coil protected by corrosion film (if steel) or oil (if bronze)
- Include certificate of material (for spring steel) or composition report (for bronze)
  **Special Manufacturing Notes:**

- Form as true helical ribbon (strip wound helically), not flat spiral or round-wire coil
- Minimal torsional warping of strip: surface maximum deviation ≤0.5 mm over full length
- Remove internal stresses by light shot-peening or vibration-relief if steel

**Tolerance Summary:**

- Width ±0.3 mm
- Thickness ±0.02 mm
- Helix OD ±1 mm
- Pitch ±2 mm
- Number turns ±0.1 turn

**Lead Time & Extras:**

- Prototype quantity: 1 piece, lead time target: 3-4 weeks (please quote)
- Provide hardened spring steel or bronze sample piece for acoustic test if possible