II. Mathematical integration

M00 • Universe, evidence and identity

$\mathbb{U} = \mathbb{U}_{ac} \times \mathbb{U}_{inst} \times \mathbb{U}_{perf} \times \mathbb{U}_{tune} \times \mathbb{U}_{harm} \times \mathbb{U}_{time} \times \mathbb{U}_{form} \times \mathbb{U}_{text} \times \mathbb{U}_{aff} \times \mathbb{U}_{orch} \times \mathbb{U}_{mix} \times \mathbb{U}_{master}$.

S = Commit(id,v,parent,C,z,E,X,P,stems,F,motifs,B,Meter,Tune,A,D,Assets,Rights,Hashes); $S^{v} \neq S^{v+1}$ whenever a committed field changes.

e = (claim,value,unit,source,hash,method,version,time,confidence,status); status∈{E,M,R,U}; missing ≠ 0; requested ≠ executed.

Archive = (S,PCM,assets,permitted model copies,library versions,DSP versions,seeds,environment,settings,licenses); same(S) ⇏ same(PCM).

The product notation groups domains and does not assert their independence. An immutable specification fixes intended score and configuration, not compliance by a stochastic or insufficiently controlled renderer. Exact playback is secured by storing the PCM; repeatable rerender requires complete dependencies and deterministic execution.

M01 • Acoustics and timbral state

$p(x,s) \approx \Sigma_m a_m(s)\varphi_m(x) \cos(2\pi \int_0^s f_m(u)du + \phi_m) + \eta(x,s)$.

$\ddot{q}_m + 2\zeta_m\omega_m\dot{q}_m + \omega_m^2 q_m = F_m/M_m$; $f_n = n/(2L)\sqrt{(Tension/\mu)}$.

$f_{n,stiff} \approx n f_{ideal}\sqrt{(1+\beta n^2)}$; $f_{n,open} \approx nc/(2L_{eff})$; $f_{n,closed} \approx (2n-1)c/(4L_{eff})$.

$X[m,k] = \Sigma_n x[n]w[n-kH] \exp(-2\pi imn/N)$; $C_k = \Sigma_m f_m|X[m,k]|/(\Sigma_m|X[m,k]|+\varepsilon)$; RMS = $\sqrt{mean(x^2)}$.

$\Phi_i = (f_0,partials,inharmonicity,centroid,rolloff,flux,roughness,noise,envelope,formants,transient,modulation,stereo,room,velocity)$.

E: ideal linear relations with stated boundary assumptions. M: hybrid rendering chooses modal, FDTD, waveguide, wave-digital, mass-spring, source-filter, sample-based, additive, subtractive, FM, wavetable, granular or neural components. Nonlinear bow/reed/lip behavior and inharmonic plates are not proved by a harmonic series. Stable/passive discretization is a separate requirement.

M02 • Instrument and embodied-event ontology

I_i = (source,exciter,resonator,range,tuning,polyphony,envelope,controls,limits,articulations,culture,history,provenance).

e_j = (UID,i,p_j,s_j,d_j,v_j,g_j,o_j,a_j,b_j,f_j,x_j,room_j); π(e_j | score,skill,body,phrase,affect,neighbors).

Feasible_i(E) = $\bigwedge_j$ [p_j∈range_i ∧ reach_j≤reach_i ∧ breath_j≤capacity_i ∧ transition_j∈technique_i].

δ_phrase ~ P(δ_time,δ_velocity,δ_articulation,δ_breath | phrase,C); Cov(δ_phrase) is contextual, not assumed diagonal.

M: source taxonomies are retained as separate records for idiophones, membranophones, chordophones, aerophones, electrophones, voices and hybrids. Bow, pluck, key/hammer, air jet, reed, lip, membrane, mallet, pickup, tine, tonewheel, oscillator and sampler gestures require distinct controls. Every named instrument and technique remains explicitly present in Appendix A. Unsupported synthetic exceptions must be labeled.