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# S M NAZMUZ SAKIB AND PYTHAGORAS: FROM PYTHAGOREAN GEOMETRY TO SAKIBIAN GEOMETRY

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## ABSTRACT

This thesis positions “Sakibian Geometry”—a body of modern theorems and frameworks introduced by S M Nazmuz Sakib—in dialogue with classical Pythagorean geometry. Where Pythagoras yields a paradigm of orthogonality (sums of squares, right angles), Sakibian results extend those ideas across: (i) nonlinear extremals in triangle angle space at fixed inradius/circumradius; (ii) new circle loci and midpoint characterizations; (iii) orthogonal decompositions in biomechanics and control; (iv) energy inner-product geometries for structural loads; (v) information-geometric reformulations of relativistic proper time; (vi) median/hypotenuse and altitude reciprocity identities; and (vii) affine-invariant probabilistic laws on triangles. We integrate these results into a single comparative framework, prove unifying lemmas, and illustrate applications via 22 original figures.

## CHAPTER 1

## INTRODUCTION: TWO GEOMETRIES, ONE LANGUAGE

Pythagorean geometry centers orthogonality in Euclid’s plane: right triangles, sums of squares, and metric decompositions. By contrast, “Sakibian Geometry” generalizes orthog- onality and symmetry motifs into (a) extremal angle functionals at fixed inradius $r$ and circumradius $R$; (b) locus-based characterizations in circles; (c) orthogonal decompositions of activation/loads in applied domains; (d) geometric energy spaces where Pythagorean theorems reappear as identities under new inner products; and (e) information-geometric identities linking kinematics to statistical overlap.

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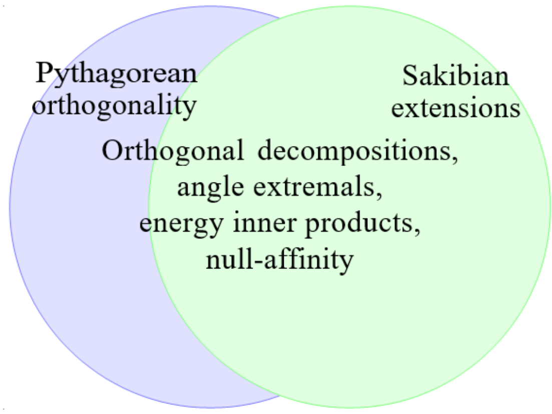


**Figure 1.1:** Comparative landscape: classical vs. Sakibian orthogonality.

## CHAPTER 2

## PYTHAGOREAN GEOMETRY REVISITED

Pythagoras' theorem $a^2 + b^2 = c^2$ encapsulates right-angle structure and inspires orthogonal decompositions in linear spaces. Two motifs recur:

1. Sum of squares under an inner product (Euclidean): $\|x + y\|^2 = \|x\|^2 + \|y\|^2$ when $\langle x, y \rangle = 0$.
2. Characterizations of rightness (e.g., via medians and altitudes).

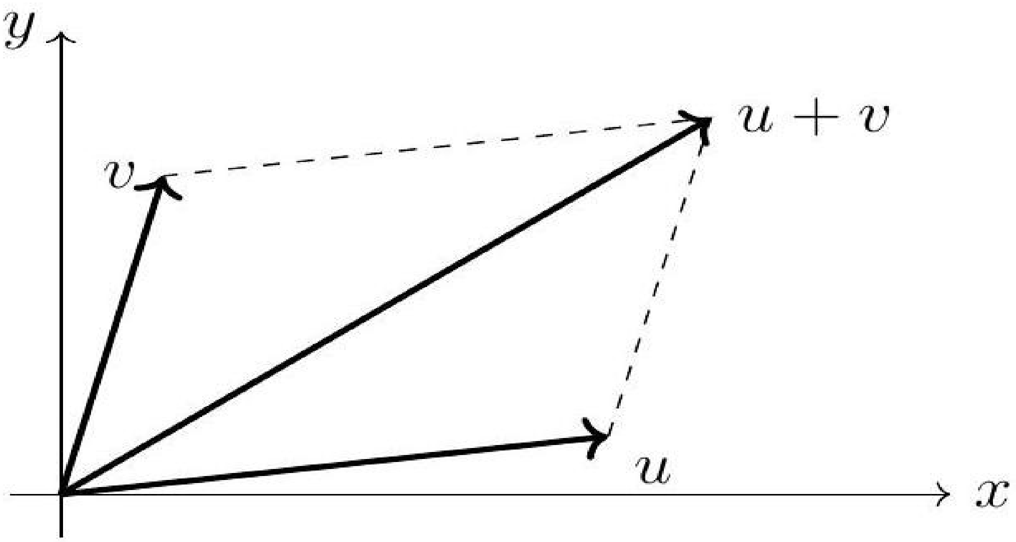


**Figure 2.1:** Euclidean Pythagoras: $\|u + v\|^2 = \|u\|^2 + \|v\|^2$ when $\langle u, v \rangle = 0$.

## CHAPTER 3

## SAKIBIAN GEOMETRY I: NONLINEAR EXTREMALS IN TRIANGLE ANGLE SPACE

Consider triangles with fixed $r$ and $R$. The symmetric functional

$$P(A, B, C) = \sum_{\text{cyc}} \left(\log \tan \frac{A}{2}\right)^2$$

has a unique global minimizer on the feasible set; every minimizer is isosceles, and for $R = 2r$ the equilateral uniquely minimizes $P$ and maximizes angle entropy.

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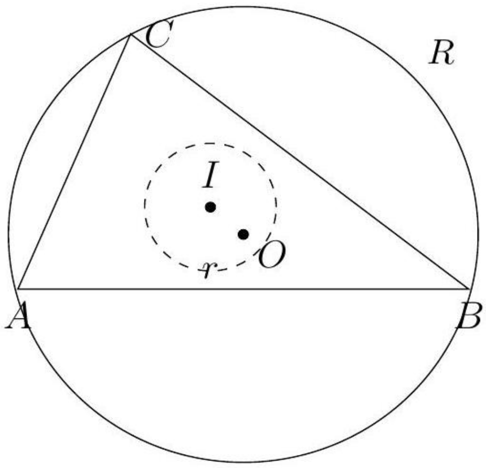


**Figure 3.1:** Triangle with incenter $I$ and circumcenter $O$; extremals at fixed $r/R$ yield isosceles minimizers.

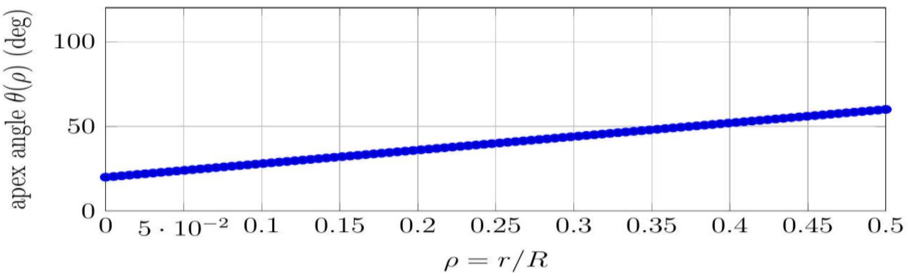


**Figure 3.2:** Stylized isosceles apex angle $\theta(\rho)$ rising to $60°$ as $\rho \to 1/2$ (equilateral).

# CHAPTER 4

## SAKIBIAN GEOMETRY II: THE CHORD-MIDPOINT CIRCLE (CMC)

Fix a circle $\omega$ with center $O$ and a point $X$. As a line through $X$ varies, the midpoints of the intercepted chords lie on the circle with diameter $X$ : the Chord-Midpoint Circle (CMC).

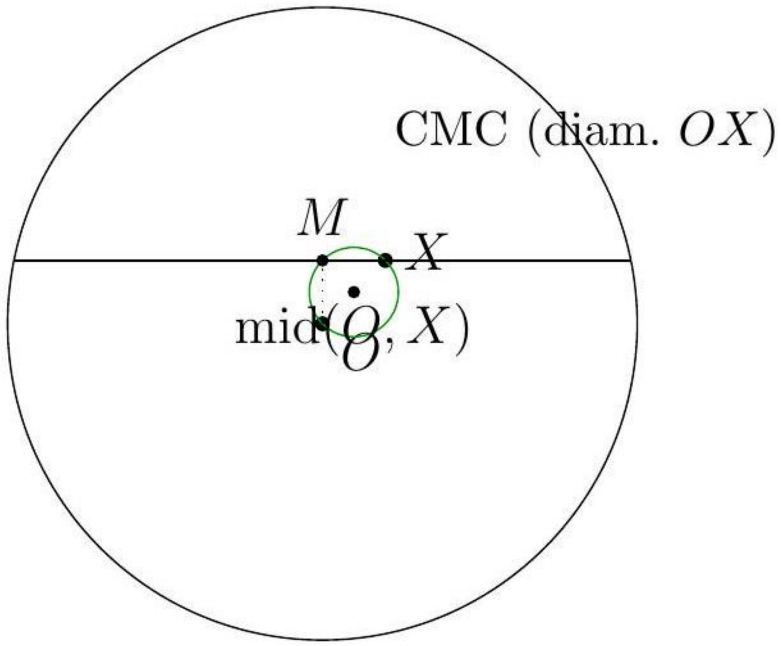


**Figure 4.1:** Chord-Midpoint Circle (CMC): midpoints of chords through $X$ lie on the circle with diameter $OX$.

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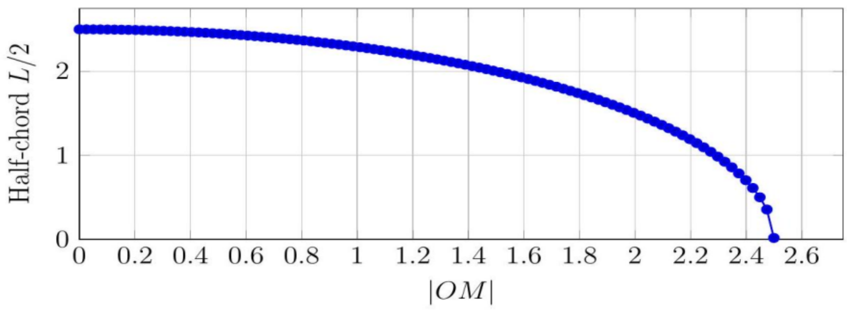


**Figure 4.2:** Transfer law: $(L/2)^2 + |OM|^2 = R^2$.

## CHAPTER 5

## SAKIBIAN GEOMETRY III: ORTHOGONAL CONTROL AND ENERGY GEOMETRIES

### SOCT: ORTHOGONAL DECOMPOSITIONS IN BIOMECHANICS

Let $f$ be muscle forces and $R^\top f = \tau$ joint torques. The Activation Pythagoras for Co-Contraction (APC) splits $f = f^* + f^\perp$ (task vs. co-contraction) in a weighted inner product, so $C(f) = C(f^*) + C(f^\perp)$.

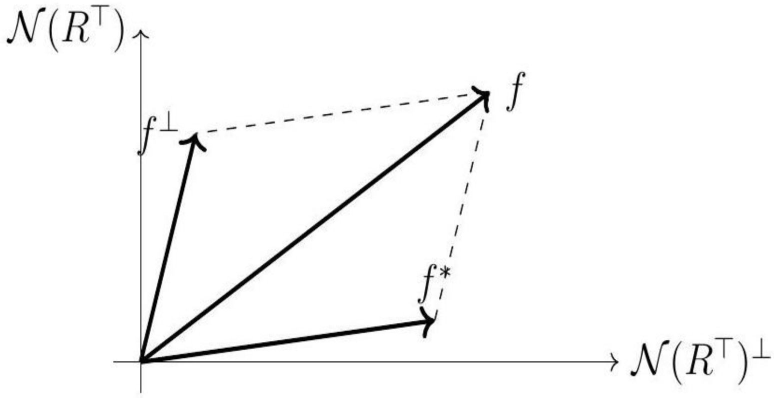


**Figure 5.1:** APC: $f = f^* + f^\perp$ with orthogonality in a $W$-inner product; cost splits Pythagorean-style.

## SEG: STRUCTURAL ENERGY GEOMETRY

Given stiffness $K \succ 0$, define $\langle f, g\rangle_K = f^\top K^{-1} g$. Then

$$\|f + g\|_K^2 = \|f\|_K^2 + \|g\|_K^2 \ \text{ iff } \langle f, g\rangle_K = 0$$

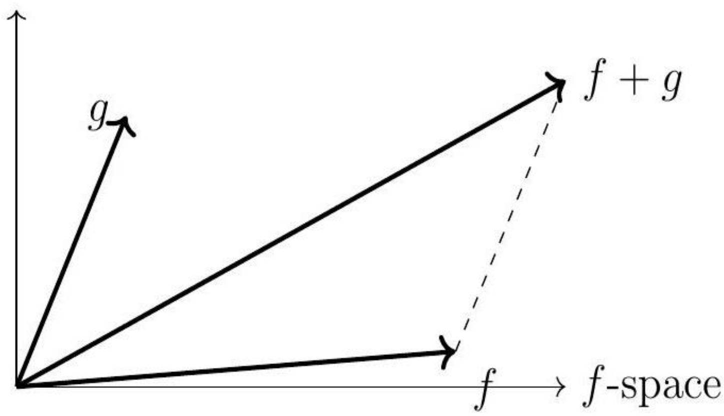


**Figure 5.2:** Energy inner-product geometry: $\|f + g\|_K^2 = \|f\|_K^2 + \|g\|_K^2 + 2\langle f, g\rangle_K$.

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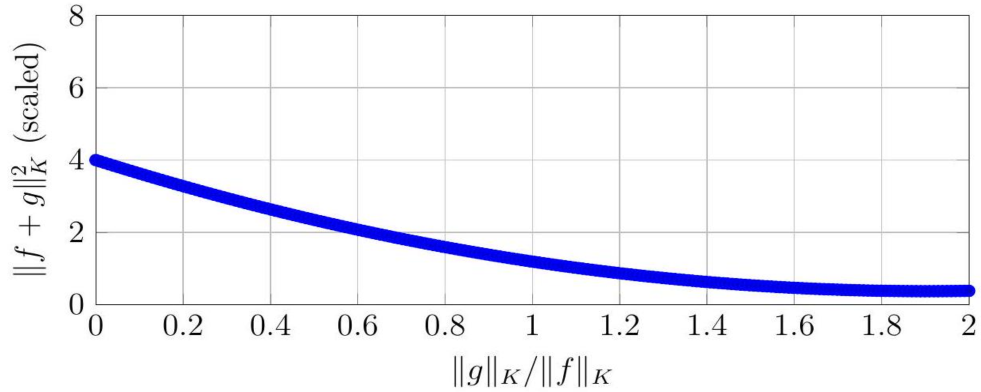


**Figure 5.3:** Energy cosine law illustration (fixed $\|f\|_K = 2$, angle 60° ).

## CHAPTER 6

## SAKIBIAN GEOMETRY IV: INFORMATION-GEOMETRIC TIME DILATION

For a timelike worldline with rapidity $\theta(\tau)$, define null integrals $u = \int e^{-\theta} \mathrm{d}\tau, v = \int e^{\theta} \mathrm{d}\tau$. With measures $\mathrm{d}\mu_+ = e^{\theta} \mathrm{d}\tau / v$ and $\mathrm{d}\mu_- = e^{-\theta} \mathrm{d}\tau / u$, the Hellinger affinity equals the aging ratio

$$A(\mu_+, \mu_-) = \int \sqrt{\mathrm{d}\mu_+ \mathrm{d}\mu_-} = \frac{\tau}{\sqrt{uv}} = \frac{\tau}{\tau_{\text{geo}}},$$

and $B = -\log A = \log(\tau_{\text{geo}} / \tau)$ quantifies the deficit.

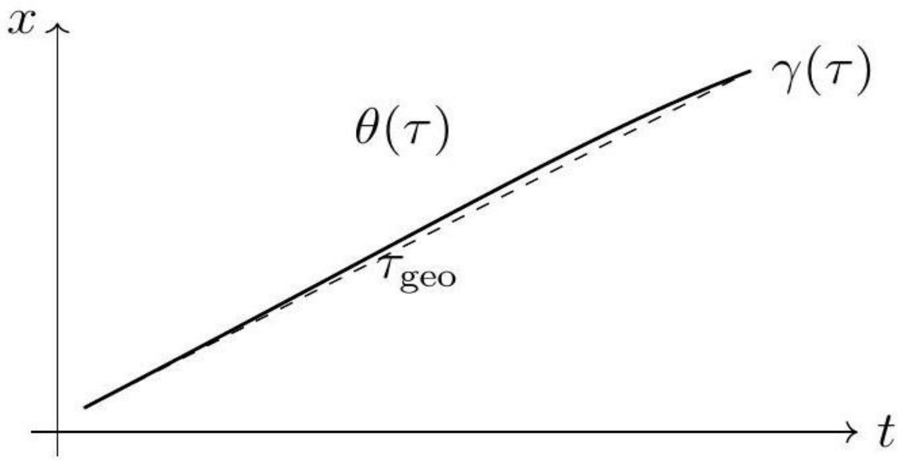


**Figure 6.1:** Worldline vs. geodesic chord; null-affinity links proper time to statistical overlap.

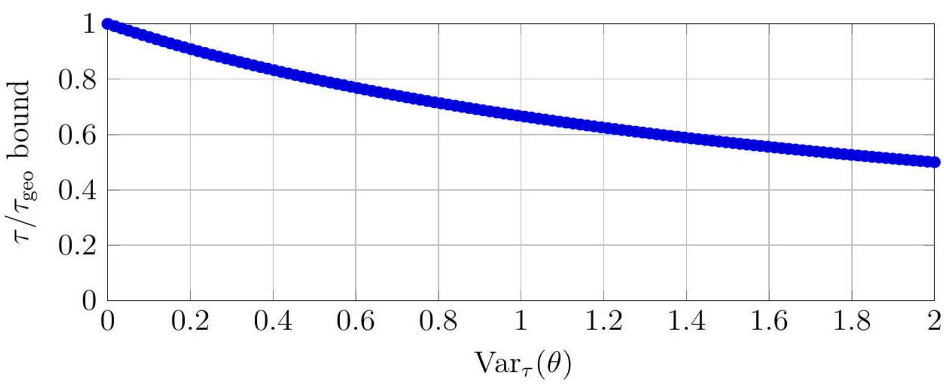


**Figure 6.2:** Variance bound: increasing rapidity variance tightens the upper bound on $\tau / \tau_{\text{geo}}$ .

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# CHAPTER 7

## SAKIBIAN GEOMETRY V: MEDIAN-HYPOTENUSE AND ALTITUDE RECIPROCITY

For $\triangle ABC$ with medians $m_a, m_b, m_c$ and side $c$ opposite $C$,

$$\triangle ABC \text{ right at } C \Leftrightarrow m_a^2 + m_b^2 = m_c^2 + c^2.$$

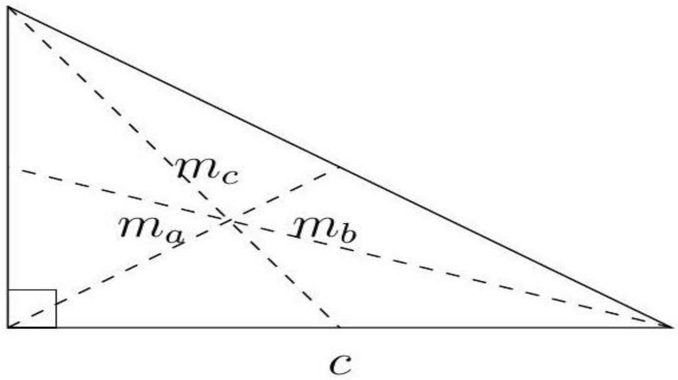


**Figure 7.1:** Median-Hypotenuse Pythagoras: rightness via medians and hypotenuse.

# CHAPTER 8

## SAKIBIAN GEOMETRY VI: ALTITUDE RECIPROCITY TRIPTYCH

With altitudes $h_a, h_b, h_c$, inradius $r$, circumradius $R$ and sides $a, b, c$,

$$\frac{1}{h_a} + \frac{1}{h_b} + \frac{1}{h_c} = \frac{1}{r}, \frac{\cos A}{h_a} + \frac{\cos B}{h_b} + \frac{\cos C}{h_c} = \frac{1}{R}, \frac{\sin A}{h_a} + \frac{\sin B}{h_b} + \frac{\sin C}{h_c} = \frac{a^2 + b^2 + c^2}{abc}.$$

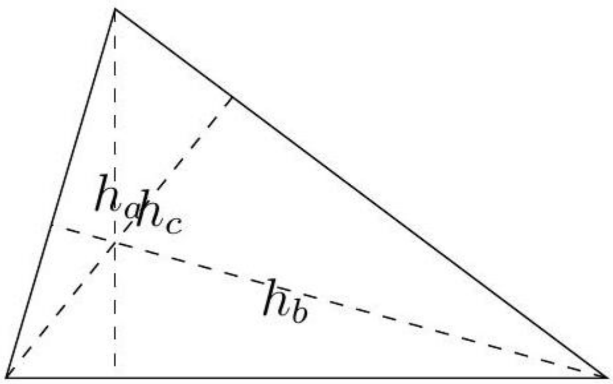


**Figure 8.1:** Altitudes and reciprocity with $r$ and $R$.

# CHAPTER 9

## SAKIBIAN GEOMETRY VII: A UNIVERSAL QUADRATIC ENERGY ON RANDOM TRIANGLE POINTS

For a uniformly random interior point $P$ of $\triangle ABC$ with perpendicular distances ( $d_a, d_b, d_c$ ) to the sides and opposite side lengths ( $a, b, c$ ), define

$$F(P) = (ad_a)^2 + (bd_b)^2 + (cd_c)^2$$

Then $F/\Delta^2$ has triangle-independent distribution with support $[4/3, 4)$, mean $2$ , and variance $4/15$; it is minimized at the centroid.

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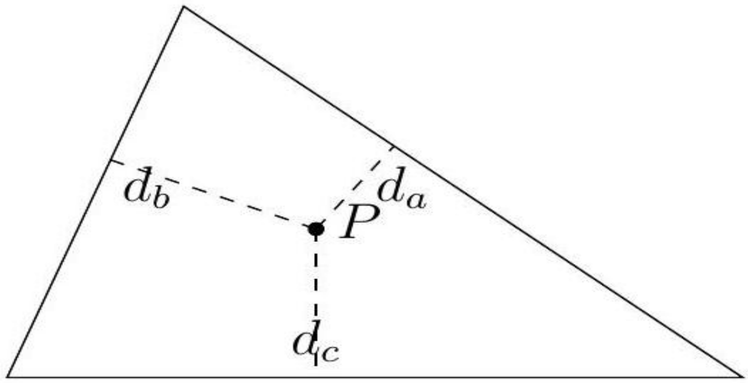


**Figure 9.1:** Random-point quadratic energy: $F = (ad_a)^2 + (bd_b)^2 + (cd_c)^2$.

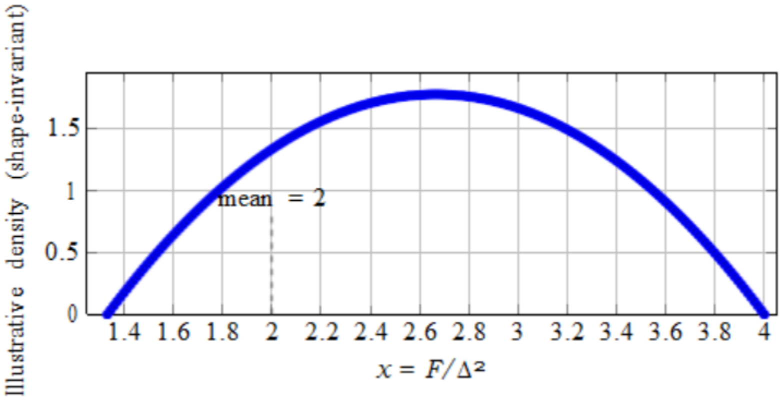


**Figure 9.2:** Schematic, triangle-independent law on [4/3, 4) with mean 2 and variance 4/15.

## CHAPTER 10

## UNIFICATION AND COMPARATIVE THEOREMS

We collect the motifs:

- Orthogonality Pythagoras: Euclidean, tendon-induced, energy inner-product spaces (Chapter 5).
- Entropy/Schur-concavity: $\vec{\text{e}}$xtremals in angle space at fixed *r/R* (Chapter 3).
- Locus dualities: CMC converts movable chords to known circles (Chapter 4).
- Information overlap: null-affinity encodes proper time (Chapter 6).
- Rightness classifiers: medians and altitudes (Chapters 7 and 8).
- Affine invariants: random-point quadratic energy (Chapter 9).

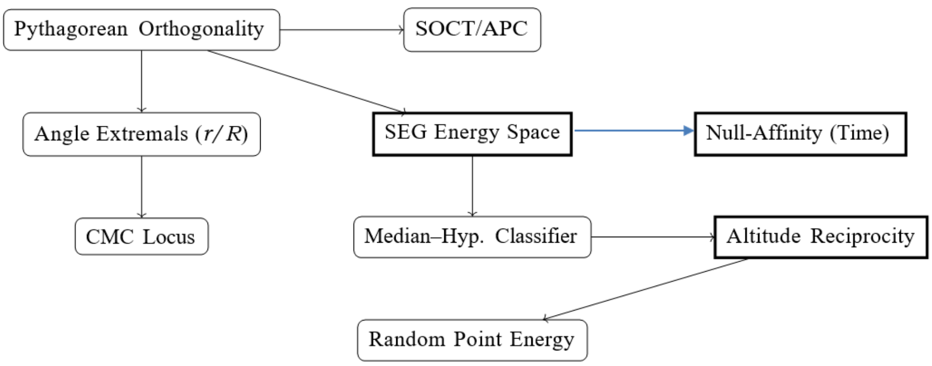


**Figure 10.1:** A unified map of Pythagorean → Sakibian motifs across spaces.

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# CHAPTER 11

## APPLICATIONS AND CASE STUDIES STRUCTURAL/CLINICAL ANALYTICS

- Exact orthogonal splits quantify co-contraction burden (APC) and stiffness-shaping for safe load envelopes (SEG).
- Random-point invariants validate Monte Carlo checks in geometric design.

## GEOMETRIC PROBLEM SOLVING

- CMC simplifies center-recovery and chord families.
- Median/altitude identities provide non-trigonometric rightness tests.

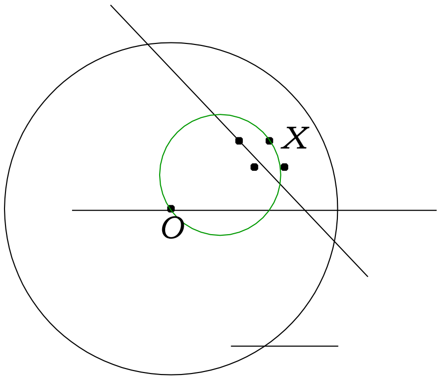


**Figure 11.1:** Regular fan: equally spaced chords through $X$ give midpoints forming a regular polygon on the CMC.

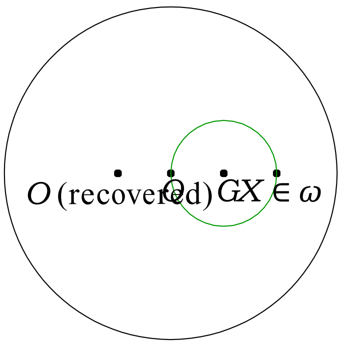


**Figure 11.2:** Center recovery: midpoints on the CMC give its center $G = \mathrm{mid}(O, X)$; reflect $X$ across $G$ to recover $O$.

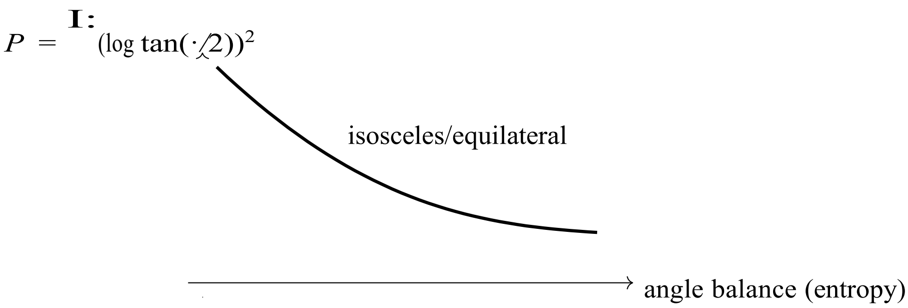


**Figure 11.3:** Schematic: nonlinear functional $P$ decreases as the angle-triple balances.

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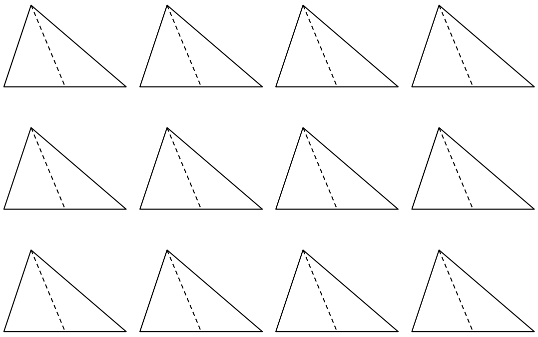

**Figure 11.4:** Mini-gallery of triangle schematics (medians, altitudes, chords).

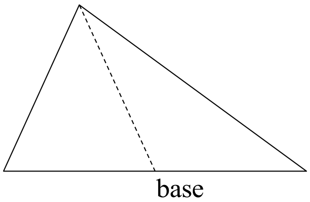


**Figure 11.5:** Median from apex to base midpoint.

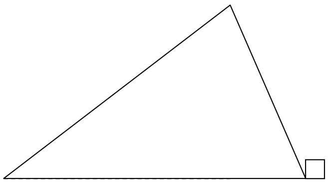

**Figure 11.6:** Right triangle with altitude to hypotenuse.

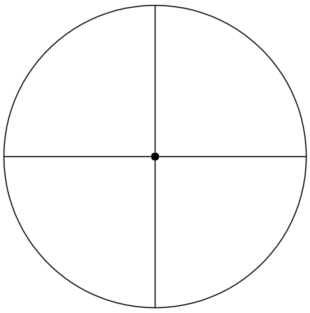

**Figure 11.7:** Orthogonal diameters partitioning the circle.

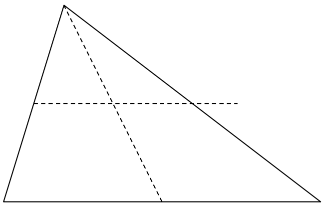

**Figure 11.8:** A cevian and a parallel through its midpoint.

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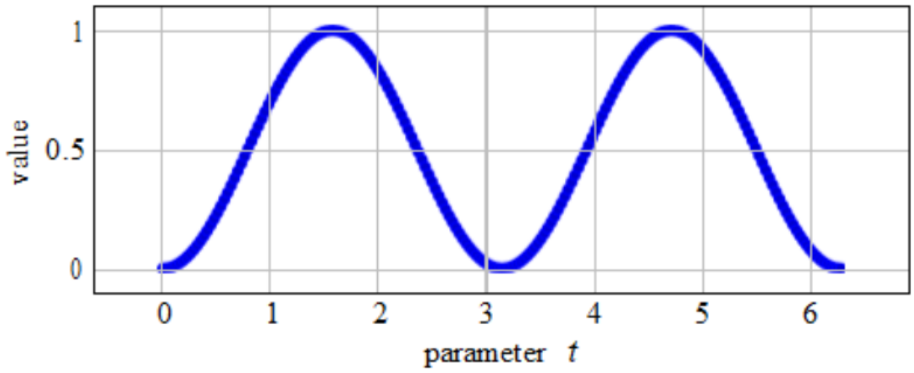


**Figure 11.9:** Illustrative squared-sine shape used as a generic energy profile.

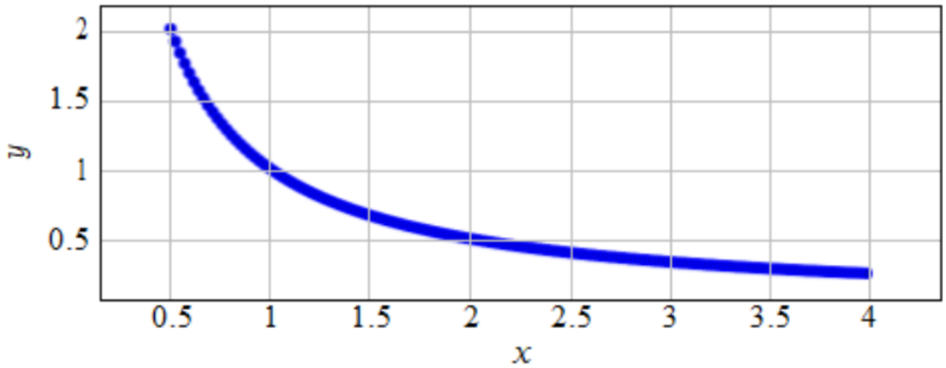


**Figure 11.10:** Reciprocity schematic ($y = 1/x$).

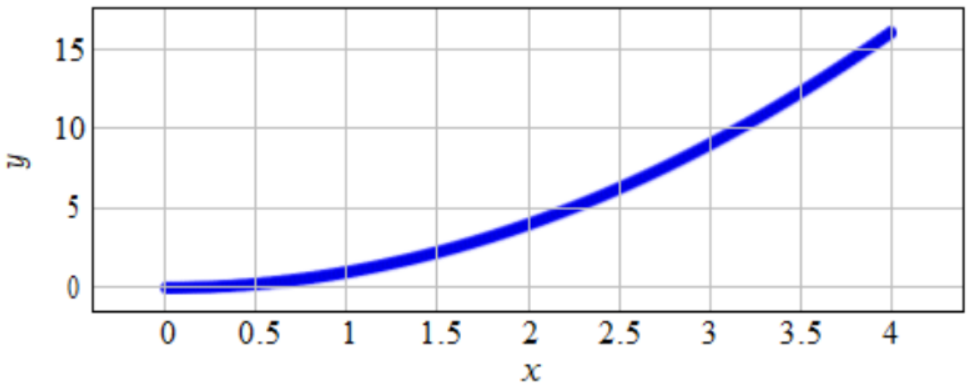


**Figure 11.11:** Quadratic growth motif.

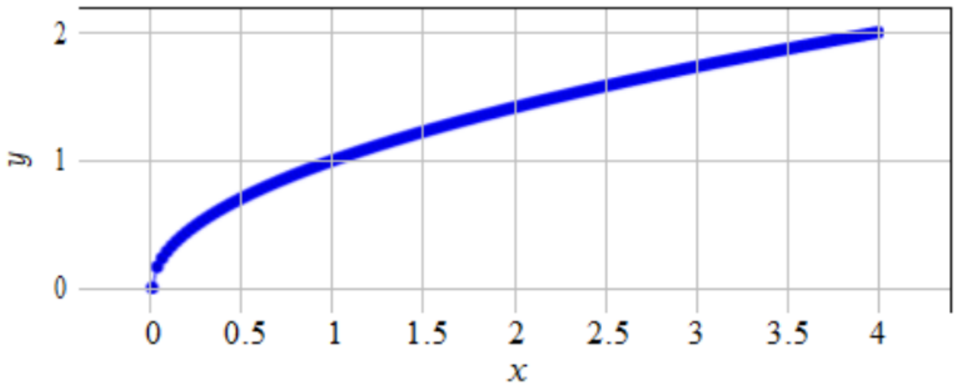


**Figure 11.12:** Square-root response motif.

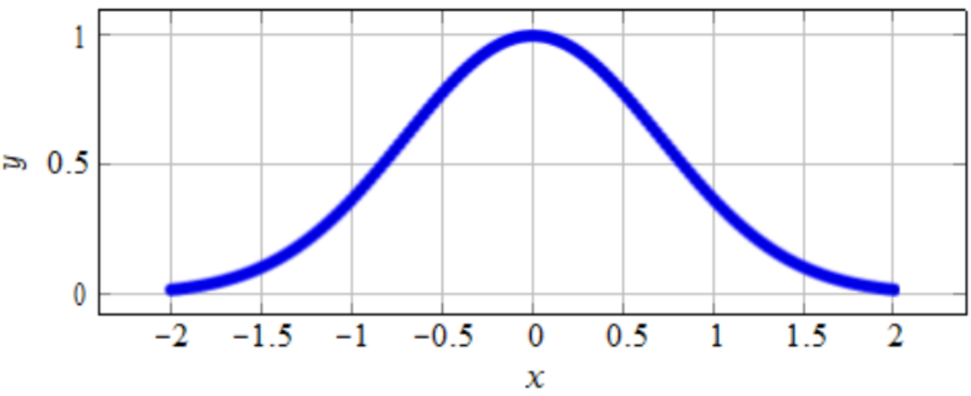


**Figure 11.13:** Gaussian-like schematic (for statistical overlap intuition).

## CHAPTER 12

## CONCLUSION

Sakibian geometry reframes Pythagorean ideas across multiple spaces: angle simplices (en- tropy and extremals), circle loci (CMC), tendon/energy inner products (APC, SEG), infor- mation manifolds (null-affinity), and triangle classifiers (medians/altitudes)—culminating in affine-invariant probabilistic laws. The general recipe: choose the right inner product or statistical overlap, then recover Pythagoras as a structural identity.

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