

A Bat Has Three Sweet Spots, and They Lie **23** cm Apart

— The centre of percussion is at **0.5600** m, the first bending node at **0.6517** m, the point of greatest effective mass at **0.4200** m — A spread of **27.58** per cent of the bat — Three points avoiding three different unwanted things, not one point — [Paper 363]

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— *From thinking to syncing.* —

Abstract

A bat is said to have a sweet spot. This paper asks whether it is one point—the answer is that there are three, lying **23** cm apart on the same bat. No new mathematical theorem and no new law is claimed. First, for a uniform rod of length **0.84** m the centre of percussion is **0.5600** m from the knob (Section 2). Second, the first bending node is at **0.6517** m, further out than the centre of percussion (Section 2). Third, the point of greatest effective mass is the centre of mass, at **0.4200** m (Section 2). Fourth, this is the core of the paper. The three span **0.2317** m, or **27.58** per cent of the bat (Section 2). Fifth, the effective mass is **0.9000** kg at the centre of mass and falls to **0.2250** kg at the tip (Section 3). Sixth, the separator is which unwanted thing is being avoided; nothing about the bat changes (Section 5).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed—the centre of percussion, free-beam vibration modes, effective mass, and collision efficiency are all standard. We do not build elasticity theory—solving the eigenvalue equation of the Euler–Bernoulli beam is not entered. The first-mode node at $0.2241698L$ is used as a known value. We perform no experiment—no measurement on a real bat is made. The computation is on a uniform-rod model. We evaluate no equipment—the design of particular bats is not the subject. We do not discuss hitting—a batter’s technique and swing path are not the subject. Vibration is not pursued—second and higher modes, and damping, are not the subject. Relation to earlier papers: Paper 357 showed maximum power and maximum efficiency to be different points—there there were two; here there are three, and all three are called “the sweet spot”. Paper 313 showed the corpus using “synchrony” in four senses—the shape of one word naming several things is the same. Paper 300 showed whether two things share a root is decidable—by that test, no two of the three sweet spots share a root. Paper 351 showed one word “pumping” naming two mechanisms—here one word names three points. What is added is giving the three positions measured from the knob, showing the spread to be 27.58 per cent of the bat, giving effective mass and collision efficiency at six points, confirming that the effective-mass formula returns the bat’s mass exactly at the centre of mass, and putting the separator on which unwanted thing is avoided.

1. Notation and the Question

Setting: Model the bat as a uniform rod of length $L = 0.84$ m and mass $M = 0.9$ kg.

$$I_{\text{cm}} = \frac{ML^2}{12}, \quad m_{\text{eff}}(x) = \frac{M}{1 + Mz^2/I_{\text{cm}}}, \quad z = x - \frac{L}{2}$$

Here x is measured from the knob.

Observation 1.1

The phrase “sweet spot” is used for at least three phenomena. The point where the hands are not jarred, where no vibration is transmitted, and where the ball goes furthest—all are called “hitting the sweet spot”.

Observation 1.2

The three come from different physics. Rigid-body rotation, beam vibration, and collision momentum—there is no reason at all for them to be in the same place.

Observation 1.3

A uniform rod is a coarse model. A real bat is thicker at the barrel——so the absolute positions move. What does not move is the structure: the three are different points.

Question: Is “the sweet spot” one point?

2. The Three Points Lie 23 cm Apart

Calculation 2.1: Positions of the three sweet spots (computed in this paper, measured from the knob).

Name	Position [m]	What it avoids
Greatest effective mass (centre of mass)	0.4200	loss of ball speed
Centre of percussion	0.5600	recoil into the hands
First bending node	0.6517	vibration into the hands
Spread	0.2317 (27.58 per cent)	—

Observation 2.2

This is the core of the paper. The three lie 23 cm apart——more than a quarter of an 84 cm bat. That is not close enough to be called “a point”.

Observation 2.3

The centre of percussion is $2L/3$. The known value for a uniform rod pivoted at the knob——
 $0.84 \times 2/3 = 0.5600$ m, exactly and not approximately.

Observation 2.4

The node lies beyond the centre of percussion. 0.6517 m against 0.5600 m——a difference of 9.17 cm. Confuse the two and the thing you meant to avoid is not avoided.

Observation 2.5

The point of greatest effective mass is the innermost.0.4200 m——so the point where the ball travels best and the point where the hands are not jarred are 14 cm apart.

Observation 2.6

By the criterion of Paper 300, no two share a root.One comes from rigid-body rotation, one from beam vibration, one from collision momentum——that three numbers are close is not evidence that they are the same thing.

3. At the Tip, Effective Mass Falls to a Quarter

Calculation 3.1: Effective mass and collision efficiency against position (computed in this paper; ball 0.145 kg, restitution 0.5, bat at rest).

Position [m]	Effective mass [kg]	Collision efficiency e_A
0.42 (centre of mass)	0.9000	0.2919
0.56 (centre of percussion)	0.6750	0.2348
0.65 (node)	0.4738	0.1485
0.70	0.3857	0.0902
0.78	0.2809	−0.0107
0.84 (tip)	0.2250	−0.0878

Observation 3.2

At the tip the effective mass is a quarter of the bat's.0.2250 kg against 0.9000 kg——two-thirds of the bat's mass takes no part in the collision.

Observation 3.3

Beyond 0.78 m the collision efficiency goes negative.—0.0107——struck against a stationary bat, the ball does not come back toward the hitter. The bat is pushed instead.

Observation 3.4

This does not mean “do not hit near the tip”. In a real swing the bat is moving, and the tip moves fastest——the loss in effective mass competes with the gain in speed. This paper does not resolve that competition.

Observation 3.5

The formula closes at the centre of mass. $m_{\text{eff}}(L/2) = 0.9000000000$ kg, the bat’s own mass——because $z = 0$ makes the denominator 1.

4. Consequences of Calling Three Things One

Observation 4.1

“I missed the sweet spot” has three readings. The hands were jarred, vibration came through, or the ball did not travel——different causes call for different corrections.

Observation 4.2

To cure jarring, move toward the centre of percussion. 0.5600 m——which is not the node, so the vibration remains.

Observation 4.3

To kill the vibration, move to the node. 0.6517 m——where the effective mass is only 0.4738 kg, about half the 0.9000 kg at the centre of mass.

Observation 4.4

The three cannot be satisfied at once. They are at different places, so one must be chosen—the same shape as “optimal” being undetermined without an objective function in Paper 357.

Observation 4.5

To be stated honestly—on a real bat the three are closer. A thick barrel moves the point of greatest effective mass outward—that is to say, bringing them together is what the design does. This paper has not computed that design.

5. The Separator: Which Unwanted Thing Is Avoided

Observation 5.1

The separator—what is being avoided; nothing about the bat changes at all.

Avoided	Physics used	Point [m]	Effective mass there [kg]
Loss of ball speed	collision momentum	0.4200	0.9000
Recoil into the hands	rigid-body rotation	0.5600	0.6750
Vibration into the hands	beam vibration	0.6517	0.4738

Observation 5.2

The rightmost column gives the exchange rate. Go for the vibration and the effective mass falls from 0.9000 to 0.4738, roughly halving—choose what to avoid and you lose something else.

Observation 5.3

The separator can be moved. Change the mass distribution and the three points move—but bat design is the problem of how far they can be brought together.

Observation 5.4

But they cannot be made to coincide. The three come from different equations, so nothing guarantees agreement—this paper has not computed how far they can be brought together. What it says is that on a uniform rod they are 23 cm apart.

Observation 5.5

To be stated honestly—0.5600 m and 0.6517 m are values on a uniform-rod model. A real bat gives other numbers—what does not move is the structure: the three come from different physics.

Observation 5.6

One last thing—when one word names several points, advice using that word has silently chosen one of them. “Hit the sweet spot” does not say which of the three—when advice does not work, the cause is sometimes in the word rather than in the technique.

6. The Census and the Close

1. Centre of percussion 0.5600 m (Calculation 2.1): $2L/3$ for a uniform rod.
2. Bending node 0.6517 m (Calculation 2.1): 9.17 cm beyond it.
3. Greatest effective mass 0.4200 m (Calculation 2.1): the centre of mass.
4. Spread 0.2317 m (Calculation 2.1): 27.58 per cent of the bat.
5. Tip effective mass 0.2250 kg (Calculation 3.1): a quarter of the bat.
6. e_A negative beyond 0.78 m (Observation 3.3): no rebound off a stationary bat.
7. 0.4738 kg at the node (Observation 4.3): about half the centre-of-mass value.
8. The formula closes at the centre of mass (Observation 3.5): 0.9000000000 kg.

9. **The three cannot be satisfied at once** (Observation 4.4): **they are at different places.**

10. **No two share a root** (Observation 2.6): **closeness is not evidence of sameness.**

Closing: A bat is said to have a sweet spot—but the phrase is used for at least three phenomena: the point where the hands are not jarred, where no vibration is transmitted, and where the ball goes furthest. All are called “hitting the sweet spot”. And the three come from different physics—rigid-body rotation, beam vibration, and collision momentum, with no reason at all for them to be in the same place. On a uniform rod of 0.84 m they lie 23 cm apart—greatest effective mass (the centre of mass) at **0.4200 m**, the centre of percussion at **0.5600 m**, the first bending node at **0.6517 m**. A spread of **0.2317 m**, **27.58** per cent of the bat — not close enough to be called “a point”. The $2L/3$ of the centre of percussion is exact for a uniform rod, and the node lies 9.17 cm beyond it. The effective mass varies greatly with position—0.9000 kg at the centre of mass, 0.4738 kg at the node, and 0.2250 kg at the tip — a quarter of the bat’s mass. Beyond 0.78 m the collision efficiency goes negative, so a ball struck against a stationary bat does not come back toward the hitter. This does not mean “do not hit near the tip”: in a real swing the tip moves fastest, and the loss in effective mass competes with the gain in speed. This paper does not resolve that competition. Calling three things one has consequences—“I missed the sweet spot” has three readings, and different causes call for different corrections. Cure the jarring by moving to the centre of percussion and the vibration remains; kill the vibration at the node and the effective mass halves. They are at different places, so the three cannot be satisfied at once. One thing separates them—what is being avoided; nothing about the bat changes at all. Change the mass distribution and the three points move, so bat design is the problem of how far they can be brought together — but they come from different equations, and nothing guarantees agreement. To be said honestly—0.5600 m and 0.6517 m are values on a uniform-rod model; on a real bat a thick barrel moves the point of greatest effective mass outward and the three are closer. What does not move is the structure: the three come from different physics. One last thing—when one word names several points, advice using that word has silently chosen one of them. “Hit the sweet spot” does not say which of the three. When advice does not work, the cause is sometimes in the word rather than in the technique.

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