

A River Bends with Nothing to Bend Around

— Producing a sinuosity of **1.5** takes an amplitude of **0.262020** wavelengths, close to the $\pi/2 = \mathbf{1.5707963268}$ of linked semicircles — observed meandering rivers sit **0.0708** short of it — the cause of the bending is not the terrain — [Paper 431]

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— *From thinking to syncing.* —

Abstract

Seeing a river bend, one supposes it went around something. This paper shows that it bends with nothing to go around—and that the bending has a numerical ceiling. No new theorem or law is claimed. First, sinuosity is the length of the course over the straight-line distance, and is exactly **1** when straight (Section 2). Second, amplitudes of **0.1**, **0.2** and **0.4** wavelengths give sinuosities of **1.092384**, **1.320658** and **1.951899**, increasing monotonically (Section 2). Third, this is the core of the paper. Producing a sinuosity of **1.5** takes an amplitude of **0.262020** wavelengths, and putting it back returns **1.500000** (Section 2). Fourth, linked semicircles give a sinuosity of $\pi/2 = \mathbf{1.5707963268}$ (Section 3). Fifth, the **1.5** commonly used for meandering rivers sits **0.0708** short of that (Section 3). Sixth, the separator is whether it went around something or bent of its own accord (Section 4).

Scope of this paper (scope note): No new theorem or law is claimed—the definition of sinuosity, sine-generated curves, and the mechanism of meander formation are all standard. The mechanism is not derived—secondary flow, erosion of the outer bank and deposition on the inner are used as known; only the geometry is put into numbers. $\pi/2$ is not asserted as a law—that linked semicircles give $\pi/2$ is a consequence of geometry, and it is not claimed that real rivers take that value. No survey is collected—which river has which value is not the subject; 1.5 is used as the conventional dividing line for meandering. Discharge and slope are not treated—how the wavelength relates to the channel width is not the subject. The influence of terrain is not denied—some rivers do follow hard rock or faults. This paper says only that a river bends without anything to go around, not that no river goes around anything. Relation to earlier papers: Paper 430 showed that widening the contact does not change the friction—there a quantity imposed from outside did not act; here no quantity from outside is needed. Paper 300 showed that common root and distinct root can be decided—“a bend around terrain” and “a bend of its own making” are distinct roots by that criterion. Paper 409 showed that no undistorted map exists—there too, attributing the cause to the maker was the error. Paper 412 showed that “nearest” is not defined until the distance is—here “how much it bends” is not defined until the measure is. What is added is giving the sinuosity at four amplitude ratios, inverting for the amplitude that gives 1.5 by bisection and testing that inversion, placing the $\pi/2$ of linked semicircles as an independent known value, giving the gap to 1.5 as 0.0708, placing the straight case at exactly 1 as the other side of the boundary, and placing the separator at “went around, or bent of itself”.

1. Notation and the Question

Setting: With L the length of the course and D the straight-line distance between its ends, the sinuosity is

$$S = \frac{L}{D}$$

Take a course in the shape of a sine curve, of amplitude a and wavelength λ . Below, the ratio a/λ is varied and S measured.

Observation 1.1

Seeing a river bend, one supposes it went around something. Hard rock, a hill, a fault—a reading in which the bend has a reason.

Observation 1.2

But rivers bend on flat sand as well. Where there is nothing at all to go around—it happens in a laboratory flume.

Question: With nothing to go around, how far does it bend.

2. A Sinuosity of 1.5 Takes 0.262020 Wavelengths

Computation 2.1: For a sine-shaped course, vary the ratio of amplitude to wavelength and take the sinuosity.

Amplitude / wavelength	Sinuosity
0.00	1.000000
0.10	1.092384
0.20	1.320658
0.40	1.951899

Observation 2.2

At zero amplitude the sinuosity is exactly 1.1.000000000002, within the error of the numerical integration—the other side of the boundary, and evidence that the computation is implemented correctly.

Observation 2.3

It increases monotonically with amplitude. 1.09 → 1.32 → 1.95—with no turning back.

Computation 2.4: Ask the inverse question: what amplitude ratio gives a sinuosity of 1.5? Solve by bisection.

$a/\lambda = 0.262020$. Putting that value back returns a sinuosity of 1.500000.

Observation 2.5

A ratio of 0.26 looks, to the eye, like a well-bent river. At a wavelength of 1 km the amplitude is 262 m—a swing of 524 m between the extremes.

Observation 2.6

No terrain enters this computation. A sine shape and two numbers—with nothing to go around, fixing the shape fixes the sinuosity.

3. Linked Semicircles Give $\pi/2$

Computation 3.1: Consider bends made of linked semicircles. A semicircle is $\pi/2$ times its diameter.

The sinuosity is $\pi/2 = 1.5707963268$.

Observation 3.2

This value is fixed by geometry alone. No property of a river, no terrain—a consequence of linking semicircles.

Observation 3.3

The 1.5 used as a mark for meandering sits **0.0708** short of it. A gap of 4.5 per cent—close, but not agreement.

Observation 3.4

Closeness is no ground for saying rivers aim at $\pi/2$. By the criterion of Paper 300, numerical agreement alone does not establish a common root—and 1.5 is a conventional dividing line, not a constant obtained from measurement.

Observation 3.5

What can be said is that a ceiling is writable in geometry. Bend more sharply than a semicircle and the neck is eventually cut, leaving an oxbow—so the shape side has a limit.

4. The Separator

The separator: did it go around something, or bend of its own accord.

Observation 4.1

A bend around something is tied to that thing's location. Move the rock and the bend moves—a shape imposed from outside.

Observation 4.2

A bend of its own making is not tied to a place. The bend itself migrates downstream—its position changes from year to year.

Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called meandering—one set by terrain, one by the flow itself.

Observation 4.4

And it can be measured. Does it stay in place or migrate—overlay old maps and it shows; the value of the sinuosity alone does not say.

Observation 4.5

A bend arises of itself because the flow cannot hold its symmetry. Deviate slightly and the outside runs faster, the inside slower—the outside is cut, the inside fills, and the deviation grows.

Observation 4.6

To be honest—only the geometry has been put into numbers here. How long it takes to reach that shape is not treated—the mechanism of secondary flow is used as known.

Observation 4.7

One last thing—it is not claimed that no river follows terrain. Some do follow hard rock or faults—what is said is that since a river bends with nothing to go around, a bend cannot be taken as evidence that the terrain caused it.

5. Roll Call and Closing

1. Straight gives a sinuosity of 1 (Observation 2.2): **the other side of the boundary.**
2. 1.092384 at a ratio of 0.10 (Computation 2.1): **the start of the rise.**
3. 1.951899 at a ratio of 0.40 (Computation 2.1): **strongly bent.**
4. A sinuosity of 1.5 takes 0.262020 (Computation 2.4): **by bisection.**
5. Putting it back returns 1.500000 (Computation 2.4): **a self-test.**
6. No terrain enters the expression (Observation 2.6): **shape alone fixes it.**
7. Linked semicircles give $\pi/2 = 1.5707963268$ (Computation 3.1): **an independent value.**
8. The gap to 1.5 is 0.0708 (Observation 3.3): **4.5 %.**
9. Agreement alone is not a common root (Observation 3.4): **the criterion of Paper 300.**
10. The separator is staying or migrating (Observation 4.4): **it can be measured.**

Closing: Seeing a river bend, one supposes it went around something—hard rock, a hill, a fault—a reading in which the bend has a reason. But rivers bend on flat sand as well, where there is nothing at all to go around. How far it bends is writable in numbers—for a sine-shaped course, amplitudes of 0.1, 0.2 and 0.4 wavelengths give sinuosities of 1.092384, 1.320658 and 1.951899, increasing monotonically, and zero amplitude gives exactly 1. Inverted, a

sinuosity of 1.5 takes an amplitude of **0.262020** wavelengths, and putting that value back returns 1.500000. At a wavelength of 1 km that is an amplitude of 262 m, a swing of 524 m between the extremes. No terrain enters the computation—a sine shape and two numbers suffice, so with nothing to go around, fixing the shape fixes the sinuosity. And the shape side has a ceiling—bends made of linked semicircles give $\pi/2 = 1.5707963268$, fixed by geometry alone. The 1.5 used as a mark for meandering sits **0.0708** short of it, a gap of 4.5 per cent: close, but not agreement. Closeness is no ground for saying rivers aim at $\pi/2$ —by the criterion of Paper 300, numerical agreement alone does not establish a common root, and 1.5 is a conventional dividing line rather than a measured constant. What can be said is that bending more sharply than a semicircle eventually cuts the neck and leaves an oxbow, so a limit is writable in geometry. One thing separates them—did it go around something, or bend of its own accord. A bend around something is tied to that thing’s location, so moving the rock moves the bend; a bend of its own making is not tied to a place, and migrates downstream year by year. They are distinct roots by the criterion of Paper 300, one set by terrain and one by the flow itself. And it can be measured: overlay old maps and staying or migrating shows, whereas the value of the sinuosity alone does not say. A bend arises of itself because the flow cannot hold its symmetry—deviate slightly and the outside runs faster while the inside runs slower, so the outside is cut, the inside fills, and the deviation grows. To be honest—only the geometry has been put into numbers here. How long it takes to reach that shape is not treated, and the mechanism of secondary flow is used as known. One last thing—it is not claimed that no river follows terrain; some do follow hard rock or faults. What is said is that since a river bends with nothing to go around, a bend cannot be taken as evidence that the terrain caused it.

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