

“Twice as Hot” Has Three Answers, and Only One Gives a Ratio of 2

— Doubling **20** degrees Celsius gives **40.0000** in Celsius, **57.7778** in Fahrenheit, and **313.1500** in Kelvin —
Outside Kelvin the absolute-temperature ratio is only **1.068224** and **1.128868** — On a scale with an arbitrary
origin, multiplication carries no meaning — [Paper 379]

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— *From thinking to syncing.* —

Abstract

Temperature is written as a number. This paper asks whether that number may be multiplied—the answer is that it depends on the scale, and only Kelvin permits it. No new mathematical theorem and no new law is claimed. First, doubling **20** degrees Celsius gives three answers, one per scale (Section 2). Second, this is the core of the paper. **40.0000** in Celsius, **57.7778** in Fahrenheit, **313.1500** in Kelvin (Section 2). Third, in absolute temperature those are ratios of **1.068224**, **1.128868** and **2.000000** (Section 2). Fourth, only Kelvin gives exactly **2** (Section 3). Fifth, **0** degrees Celsius doubled in Celsius stays **0**; doubled in Kelvin it becomes **273.15** (Section 3). Sixth, the separator is whether the origin is fixed by physics, not how fine the scale is (Section 5).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed——Celsius, Fahrenheit, Kelvin, and the distinction between interval and ratio scales are all standard. We do not build thermodynamics——why absolute zero exists, and the third law, are not entered. They are named and no more. Measurement is not treated——the fixed points and realisation of ITS-90 are not the subject. We do not discuss units——the redefinition of the kelvin via the Boltzmann constant is named and no more. We build no theory of measurement scales——Stevens’s classification itself is not entered. Other quantities are not treated——years and elevations, which share the structure, are mentioned only as examples. Relation to earlier papers: Paper 345 showed one logarithm counting a ratio in one place and items in another——there too the question was what is being counted. Paper 375 showed the units choosing the first principal component——there the scale fixed a direction; here the origin fixes a ratio. Paper 300 showed whether two things share a root is decidable——by that test, a temperature difference and a temperature ratio have distinct roots. Paper 358 showed a convention fixing a number——here the convention is the origin. What is added is giving “doubling” on three scales as numbers, showing that only Kelvin gives a ratio of 2, solving for the -40 crossing point and confirming the formula closes, using the degenerate case at 0 Celsius as a control, and putting the separator on whether the origin is fixed by physics.

1. Notation and the Question

Setting: Write the three scales relative to Celsius.

$$K = C + 273.15, \quad F = \frac{9}{5}C + 32$$

Both are affine, with a slope and an intercept.

Observation 1.1

With an intercept, multiplication depends on the scale. $2 \times (C + a) \neq 2C + a$ ——addition (differences) is scale-independent; multiplication (ratios) is not.

Observation 1.2

Only Kelvin has no intercept. Because absolute zero is fixed by physics——that there is no temperature below 0 K is not a convenience of the scale.

Observation 1.3

This paper gives that difference as numbers. Not “ratio and interval scales differ” but “by how many degrees”——the size shows the weight of the error.

Question: What temperature is “twice as hot”?

2. Three Answers Appear

Calculation 2.1: Doubling 20 degrees Celsius on each scale (computed in this paper).

Scale	Original	Doubled	Back in Celsius	Absolute ratio
Celsius	20.0000	40.0000	40.0000	1.068224
Fahrenheit	68.0000	136.0000	57.7778	1.128868
Kelvin	293.1500	586.3000	313.1500	2.000000

Observation 2.2

This is the core of the paper. One “doubling” becomes 40.0000, 57.7778, or 313.1500 degrees——lowest and highest differ by 273.15.

Observation 2.3

The rightmost column is the real ratio. Doubling in Celsius raises the absolute temperature only 1.068224 times——a “doubling” that raises it by 7 per cent.

Observation 2.4

Fahrenheit gives 1.128868. Larger than Celsius, and far from 2——because its intercept of 32 puts its origin lower.

Observation 2.5

Only Kelvin gives 2.000000. Not approximately——with an origin at 0, multiplication is the ratio.

3. What Zero Reveals

Observation 3.1

0 degrees Celsius doubled in Celsius stays $0.0 \times 2 = 0$ ——“twice as hot” changing nothing at all.

Observation 3.2

The same 0 doubled in Kelvin becomes 273.15 degrees. $273.15 \times 2 = 546.30$ K——one operation, one starting point, and answers 273.15 degrees apart.

Observation 3.3

Celsius zero carries no physical meaning. It is where water freezes, and no more——choose another substance and zero lands elsewhere.

Observation 3.4

Fahrenheit’s zero is more arbitrary still. It derives from the freezing point of brine——the form “measured from zero” lends an air of absoluteness it does not have.

Calculation 3.5: Solving for the point where Celsius equals Fahrenheit (computed in this paper).

Quantity	Value
Solution of $C = F$, that is $32/(1 - 9/5)$	−40.0000000000
Converting it to Fahrenheit	−40.0000000000

Observation 3.6

The -40 closes. Convert and return and the value is unchanged—two affine functions crossing at one point, and nothing more. It is not a mystery.

4. Differences, by Contrast, Are Scale-Free

Observation 4.1

A temperature difference is the same number in Celsius and Kelvin. Because the slope is 1—“it rose 10 degrees” is 10 in both.

Observation 4.2

In Fahrenheit even the difference changes. The slope is $9/5$ —10 Celsius degrees are 18 Fahrenheit degrees.

Observation 4.3

So which operations are available differs by scale. Celsius allows differences and forbids ratios—Kelvin allows both; Fahrenheit needs a conversion even for differences.

Observation 4.4

Distinct roots by the criterion of Paper 300. A difference is fixed by the slope, a ratio by the origin—under one word “temperature”, two operations demand different conditions.

Observation 4.5

The structure appears elsewhere. Years, elevations, longitudes—“the year 2000 is twice the year 1000” is meaningless in the same way. This paper has not computed those.

5. The Separator: Is the Origin Fixed by Physics?

Observation 5.1

The separator——whether the origin is fixed by physics; not how fine the scale is.

Scale	Origin	Differences	Ratios
Kelvin	absolute zero (physical)	allowed	allowed
Celsius	freezing water (arbitrary)	allowed	not allowed
Fahrenheit	freezing brine (arbitrary)	needs conversion	not allowed

Observation 5.2

All three rows measure the same quantity. The same body in the same state——only the scale differs, and yet the permitted operations differ.

Observation 5.3

Fineness is irrelevant. Fahrenheit has finer divisions than Celsius and still forbids ratios——resolution and the availability of ratios are different things.

Observation 5.4

The separator cannot be moved. Celsius cannot be given an origin——all one can do is convert to Kelvin and take the ratio there.

Observation 5.5

To be stated honestly——1.068224 and 57.7778 are values from the starting point of 20 degrees Celsius. Another temperature gives other numbers——what does not move is the structure: outside Kelvin the ratio is never exactly 2.

Observation 5.6

One last thing—that something can be written as a number does not mean the number may be operated on. A Celsius temperature is a number and must not be multiplied—which operations are permitted is fixed not by the number but by how the number was made.

6. The Census and the Close

1. Doubling in Celsius gives **40.0000** (Calculation 2.1): **absolute ratio 1.068224**.
2. In Fahrenheit, **57.7778** (Calculation 2.1): **ratio 1.128868**.
3. In Kelvin, **313.1500** (Calculation 2.1): **ratio 2.000000**.
4. The three span **273.15 degrees** (Observation 2.2): **one “doubling”**.
5. Celsius doubling is a **7 per cent rise** (Observation 2.3): **seen as a ratio**.
6. **0 Celsius doubled stays 0** (Observation 3.1): **nothing changes**.
7. The same **0 in Kelvin gives 273.15** (Observation 3.2): **one starting point**.
8. $C = F$ at **−40.0000000000** (Calculation 3.5): **unchanged on return**.
9. Differences agree in Celsius and Kelvin (Observation 4.1): **the slope is 1**.
10. Fineness is irrelevant (Observation 5.3): **resolution is not ratio**.

Closing: Temperature is written as a number—but whether that number may be multiplied depends on the scale. With an intercept, multiplication depends on the scale— $K = C + 273.15$ and $F = (9/5)C + 32$ are both affine, so addition (differences) is scale-independent while multiplication (ratios) is not. Only Kelvin has no intercept, because absolute zero is fixed by physics. So “doubling” has three answers—doubling 20 degrees Celsius gives **40.0000** in Celsius, **57.7778** in Fahrenheit, and **313.1500** in Kelvin. Lowest and highest differ by 273.15. As absolute ratios those are 1.068224, 1.128868 and **2.000000**, so the Celsius “doubling” is really a 7 per cent rise. Only Kelvin gives exactly 2, and not approximately: with an origin at 0, multiplication is the ratio. Zero makes this plainest—0 degrees Celsius doubled in Celsius stays 0, while the same 0 doubled in Kelvin becomes 273.15 degrees. One operation, one starting point, answers 273.15 degrees apart. Celsius zero is where water freezes and Fahrenheit zero derives from brine—neither is a point fixed by physics. Solving $C = F$ gives **−40.0000000000**, unchanged on conversion and return: two affine functions crossing at one point, and nothing more. Differences, by contrast, are scale-free—Celsius and Kelvin share a slope of 1, so “it rose 10 degrees” is 10 in both, while Fahrenheit’s slope of 9/5 makes it 18. Which operations are available differs by scale, and by the criterion of Paper 300 differences and ratios have distinct roots: one is fixed by the slope, the other by the origin. One thing separates them—whether the origin is fixed by physics; not how fine the scale is. All three rows measure the same body in

the same state, and only the scale differs, yet the permitted operations differ. Fahrenheit is finer than Celsius and still forbids ratios, so resolution and the availability of ratios are different things. And Celsius cannot be given an origin — all one can do is convert to Kelvin and take the ratio there. To be said honestly——1.068224 and 57.7778 follow from a starting point of 20 degrees Celsius, and another temperature gives other numbers. What does not move is the structure: outside Kelvin the ratio is never exactly 2. One last thing——that something can be written as a number does not mean the number may be operated on. A Celsius temperature is a number and must not be multiplied. Which operations are permitted is fixed not by the number but by how the number was made.

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