

Of the Seven Hundredfold Geometry Promises, One Tenth Arrives

— A screw of pitch **1.75** mm turned on a **20** cm lever promises **718.0783**, yet **50** N m yields a clamp force only **0.1161** of the ideal — **88.39** per cent goes to friction — and halving the diameter doubles the force at the same torque — [Paper 463]

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September 2026

— *From thinking to syncing.* —

Abstract

A screw is thought to be a device that multiplies force by geometry. This paper shows that of the **718.0783** geometry promises, **11.61** per cent arrives—the rest goes to friction. No new theorem or law is claimed. First, a **20** cm lever on a **1.75** mm pitch gives an ideal advantage of **718.0783** (Section 2). Second, **50** N m would ideally give a clamp force of **179519.5802** N (Section 2). Third, this is the core of the paper. The real clamp force is **20833.3333** N, only **0.1161** of the ideal (Section 3). Fourth, taking the torque coefficient from **0.30** to **0.10** multiplies the force by exactly **3.000000000** (Section 3). Fifth, at the same torque a smaller diameter gives more force: **31250.0000** N for **M8** (Section 3). Sixth, the separator is whether geometry decides, or geometry paired with friction (Section 4). **Keywords:** bolted joint, torque coefficient, bolt preload, mechanical advantage, friction loss.

Scope of this paper (scope note): No new theorem or law is claimed—the mechanical advantage of a screw, the torque coefficient method and frictional loss are all standard. No joint is designed—property class, bearing face, locking and fatigue are not the subject, and real design always includes them. The numbers are representative—torque coefficients of 0.10 to 0.30 are a typical range, not measurements; they move greatly with finish and lubrication. The plastic range is excluded—yield-point tightening and the turn-of-nut method beyond yield are not the subject. Measurement is not discussed—wrench accuracy and direct measurement of clamp force are not the subject. Relation to earlier papers: Paper 462 showed that two states carry the same flow—there too, the observable quantity was not the one wanted. Paper 300 showed that common root and distinct root can be decided—“the ideal advantage” and “the real clamp force” are distinct roots by that criterion. Paper 459 showed that a round trip multiplies the loss by 1.9—there too, the quoted number did not stand for the whole path. What is added is giving the ideal advantage as 718.0783, giving the ideal clamp force as 179519.5802 N, giving the ratio to the real force as 0.1161, giving the effect of lubrication as exactly 3.000000000, confirming the inverse dependence on diameter at M8, and placing the separator at geometry versus geometry with friction.

1. Notation and the Question

Setting: Turn a screw of pitch p on a lever of length L . Without friction, conservation of work gives a mechanical advantage

$$MA_0 = \frac{2\pi L}{p}$$

and a torque T would ideally give a clamp force

$$F_0 = \frac{2\pi T}{p}$$

In practice the relation between tightening torque and clamp force is written with a torque coefficient K and the nominal diameter d as

$$T = K F d$$

Below, $L = 0.20$ m, $p = 1.75$ mm, $d = 12$ mm and $T = 50$ N m.

Observation 1.1

A screw is thought to multiply force by geometry. It is an inclined plane wrapped round—so a finer pitch should be stronger.

Observation 1.2

But the inclined plane has friction. In two places, the thread and the bearing face—and the multiplied force is itself what the friction acts on.

Question: How much of the promise arrives.

2. Geometry Promises 718.0783

Computation 2.1: Take the frictionless mechanical advantage.

$$2\pi \times 0.20 / 0.00175 = \mathbf{718.0783}.$$

Observation 2.2

Over seven hundredfold. Ten kilograms of hand force would give seven tonnes—this is the ground of the intuition that a screw is strong.

Computation 2.3: Take the frictionless clamp force from 50 N m.

$$2\pi \times 50 / 0.00175 = \mathbf{179519.5802 \text{ N}}.$$

Observation 2.4

Eighteen tonnes. From one M12 bolt—were it true, the bolt would break first.

3. Eleven Point Six One Per Cent Arrives

Computation 3.1: Take the real clamp force at four torque coefficients.

Torque coefficient K	Clamp force [N]
0.10 (lubricated)	41666.6667
0.15	27777.7778
0.20 (standard)	20833.3333
0.30 (dry, rough)	13888.8889

Observation 3.2

The **20833.3333 N** at $K = 0.20$ is only **0.1161** of the ideal.**88.39** per cent goes to friction—of the 718 promised, **83.3** arrives.

Observation 3.3

This agrees with the standard rule of thumb.Tightening a screw is said to convert a little over a tenth of the input into clamp force—**11.61** per cent falls in that range.

Observation 3.4

Taking K from 0.30 to 0.10 multiplies the force by exactly **3.000000000**.From **13888.8889** to **41666.6667**—the force goes inversely with K , so the ratio is exactly three.

Observation 3.5

So at one wrench setting, lubrication alone moves the clamp force threefold.And the person tightening cannot tell—the torque is measured; the clamp force is not.

Computation 3.6: Take the clamp force from the same 50 N m on an M8 (nominal 8 mm).

31250.0000 N, which is 1.5 times the **20833.3333 N** of the M12.

Observation 3.7

The force goes inversely with diameter. $31250 \times 0.008 = 20833.3333 \times 0.012$, exactly—a thinner bolt is pulled harder at the same torque, so it is the thinner one that breaks.

4. The Separator

The separator: does geometry decide, or geometry paired with friction.

Observation 4.1

If geometry decides, pitch and lever suffice. The number 718.0783 comes out—available from the drawing alone.

Observation 4.2

If geometry and friction decide, nothing follows without the state of the surfaces. The same screw on the same drawing reads 0.1161 or 0.2321—moving with lubrication, plating, dirt and the number of times it has been tightened.

Observation 4.3

These are distinct roots by the criterion of Paper 300. Both are called “the clamping force of a screw”—one a property of geometry, one of geometry paired with a surface condition.

Observation 4.4

The same shape as Paper 462. There, a flow counted at a section matched two states—here a measured torque matches a range of clamp forces. In both, the measurable quantity does not fix the wanted one.

Observation 4.5

It overlaps Paper 459 as well. There, the quoted 0.90 did not stand for the whole path—here the quoted torque does not stand for the clamp force.

Observation 4.6

So critical joints are controlled by something other than torque. Turn of the nut, elongation, ultrasonics—each of them a route that does not pass through K .

Observation 4.7

To be honest—the values of K are representative. The spread from 0.10 to 0.30 is itself the content of the claim—the problem is that there is a spread, not which value is right.

5. Roll Call and Closing

1. The ideal advantage is **718.0783** (Computation 2.1): **what geometry promises.**
2. The ideal force is **179519.5802 N** (Computation 2.3): **eighteen tonnes.**
3. The real force is **20833.3333 N** (Computation 3.1): **the core.**
4. A ratio of **0.1161** (Observation 3.2): **88.39 % to friction.**
5. It matches the rule of thumb (Observation 3.3): **a little over a tenth.**
6. Lubrication gives **3.000000000** (Observation 3.4): **inverse in K .**
7. The tightener cannot tell (Observation 3.5): **torque measured, force not.**
8. M8 gives **31250.0000 N** (Computation 3.6): **inverse in diameter.**
9. The separator is geometry or geometry with friction (Observation 4.3): **distinct roots by Paper 300.**
10. Critical joints avoid torque control (Observation 4.6): **routes around K .**

Closing: A screw is thought to multiply force by geometry—it is an inclined plane wrapped round, so a finer pitch should be stronger. But the inclined plane has friction, in two places, and the multiplied force is itself what the friction acts on. The promise is large—a 20 cm lever on a 1.75 mm pitch gives an ideal advantage of **718.0783**, so ten kilograms of hand force would give seven tonnes. This is the ground of the intuition that a screw is strong. From 50 N m the ideal clamp force is **179519.5802 N**, eighteen tonnes from one M12 bolt—were it true, the bolt would

break first. But only a tenth arrives—at $K = 0.20$ the real clamp force is **20833.3333** N, only **0.1161** of the ideal. **88.39** per cent goes to friction, and of the 718 promised, 83.3 arrives. This agrees with the standard rule of thumb that a little over a tenth of the input becomes clamp force. Taking K from 0.30 to 0.10 multiplies the force by exactly **3.000000000**, from 13888.8889 to 41666.6667, because the force goes inversely with K . So at one wrench setting, lubrication alone moves the clamp force threefold, and the person tightening cannot tell: the torque is measured, the clamp force is not. The same 50 N m on an M8 gives **31250.0000** N, and $31250 \times 0.008 = 20833.3333 \times 0.012$ exactly—a thinner bolt is pulled harder at the same torque, so it is the thinner one that breaks. One thing separates them—does geometry decide, or geometry paired with friction. If geometry decides, pitch and lever suffice and 718.0783 is available from the drawing alone. If friction enters, nothing follows without the state of the surfaces: the same screw reads 0.1161 or 0.2321 with lubrication, plating, dirt and reuse. They are distinct roots by the criterion of Paper 300, one a property of geometry and one of geometry paired with a surface condition. It is the same shape as Paper 462, where a flow counted at a section matched two states: in both, the measurable quantity does not fix the wanted one. It overlaps Paper 459 too, where the quoted 0.90 did not stand for the whole path: here the quoted torque does not stand for the clamp force. So critical joints are controlled by turn of the nut, elongation or ultrasonics—each a route that does not pass through K . To be honest—the values of K are representative, and the spread from 0.10 to 0.30 is itself the content of the claim. The problem is that there is a spread, not which value is right.

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