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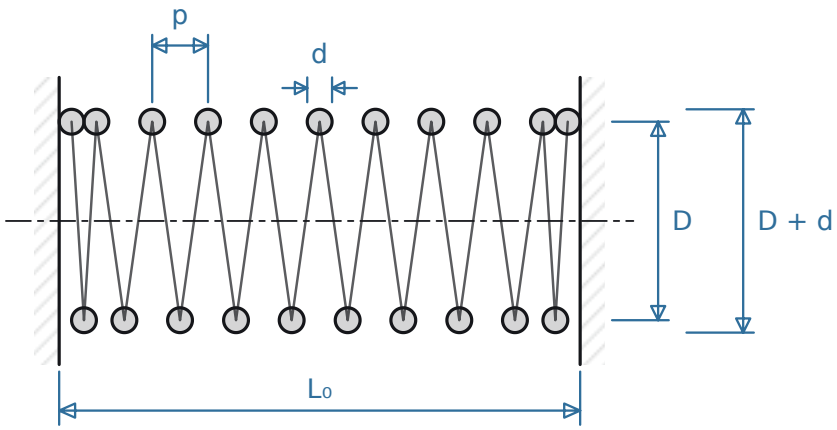
Compression spring formulas: rate, stress, end types and shear moduli

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2. Formulas: rate, stress, index

Cylindrical helical spring in round wire, constant pitch, linear characteristic. All formulas use the **mean diameter D** = outside diameter − d = inside diameter + d.

Quantity	Formula	Note
Spring rate k	$G \cdot d^4 / (8 \cdot D^3 \cdot n)$	N/mm with N, mm, MPa; lbf/in with lbf, in, psi
Force F	$k \cdot s$	s: compression from the free length
Spring index C	D / d	4 to 12 preferably: below, hard to coil; above, a floppy spring that tangles
Wahl factor K	$(4C - 1) / (4C - 4) + 0.615 / C$	corrects for wire curvature and direct shear
Shear stress τ	$K \cdot 8 \cdot F \cdot D / (\pi \cdot d^3)$	highest on the inside of the coil
Pitch p (squared and ground)	$(L_0 - 2 \cdot d) / n$	see the end type table



inactive coil

3. End types, coils and solid height

The end type sets the number of inactive coils, the solid height L_s and the relation between free length and pitch. n: active coils; n_t: total coils.

End type	Total coils	Solid height	Free length
Squared and ground	$n + 2$	$d \cdot n_t$	$p \cdot n + 2 \cdot d$
Squared (closed), not ground	$n + 2$	$d \cdot (n_t + 1)$	$p \cdot n + 3 \cdot d$
Plain and ground	$n + 1$	$d \cdot n_t$	$p \cdot (n + 1)$
Plain	n	$d \cdot (n_t + 1)$	$p \cdot n + d$

Squared and ground ends are the usual choice in machine design: the spring stands square on its seats and the load is better centred. In practice, the actual solid height is slightly above these theoretical values (wire tolerance, coils not touching perfectly): I recommend keeping a margin of 10 to 15% of the available travel before going solid.

4. Shear modulus of spring wires

It is the shear modulus G (modulus of rigidity), not Young's modulus E, that sets the rate. Typical published values for spring design; they vary by a few percent with the wire condition and temperature: the supplier's data sheet prevails.

Wire	G (10^6 psi)	G (MPa)
Music wire, hard-drawn steel, carbon steel	11.5	79 300
Chrome alloy steel (Cr-V, Cr-Si)	11.2	77 200
Stainless 302, 304, 316	10.0	68 900
Stainless 17-7 PH	10.5	72 400
Phosphor bronze	6.0	41 400
Beryllium copper	7.0	48 300

Source of the psi values: PTC's modulus of rigidity table for compression springs (Windchill Risk and Reliability, accessed 10/11/2026); exact conversion, 1 psi = 6.894757 kPa.

Reference values taken from the article https://www.baouch.fr/en/blog/ressort-compression-calcul-raideur/, which explains the assumptions, formulas and edge cases. For critical use, check the current standard or the manufacturer's documentation. Free to print and share with credit to the source.