# Helical Torsion Spring Rate and Stress

Angular rate, deflection and bending stress of a helical torsion spring from wire and coil diameters, active turns and moment, with the curvature factor.

**Method:** Shigley's Mechanical Engineering Design (Budynas and Nisbett); ch. 10 (helical torsion springs, k = d⁴E/(64 D N_a), K_i)

## Input parameters

Unit system: SI

| Parameter | Value | Unit |
|---|---|---|
| Wire diameter | 3.0000 | mm |
| Mean coil diameter | 25.000 | mm |
| Active turns (body turns + end-leg equivalent) | 6.0000 | |
| Modulus of the wire | 196.50 | GPa |
| Applied moment | 2.0000 | N·m |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Rate (moment per radian) | 1.6580 | N·m |
| Rate (moment per turn) | 10.417 | N·m |
| Angular deflection under the moment | 69.116 | ° |
| Curvature factor (inner fibre) | 1.0982 | |
| Bending stress K_i 32 M/(π d³) | 828.59 | MPa |

**Notes for this case**

- Theoretical rate; friction between coils and over the arbor lowers it slightly (Shigley's empirical 10.8 instead of 64/(2π) = 10.2).

## Formula and method

$$k = \frac{d^4 E}{64 D N_a}, \quad K_i = \frac{4C^2 - C - 1}{4C(C-1)}, \quad \sigma = K_i \frac{32M}{\pi d^3}, \quad C = \frac{D}{d}$$

### Variables

| | | |
|---|---|---|
| $d$ | Wire diameter | m |
| $D$ | Mean coil diameter | m |
| $N_a$ | Active turns (body turns + end-leg equivalent) | - |
| $E$ | Modulus of the wire | Pa |
| $M$ | Applied moment | N·m |
| $k$ | Rate (moment per radian) | N·m |
| $k'$ | Rate (moment per turn) | N·m |
| $\theta$ | Angular deflection under the moment | rad |
| $K_i$ | Curvature factor (inner fibre) | - |
| $\sigma$ | Bending stress K_i 32 M/(π d³) | Pa |

### Method and standards

Bending of the coiled wire.

### Assumptions and limits

- The rate is the theoretical d⁴E/(64 D N_a). Shigley notes that coil friction makes measured rates a little lower and gives an empirical form with 10.8 in place of 64/(2π) = 10.19 per turn, about 6 % softer; use it when matching test data.

- Round wire, close-wound.

### References

- Shigley's Mechanical Engineering Design (Budynas and Nisbett)
- ch. 10 (helical torsion springs, k = $d^4E/(64\ D\ N_a)$, K_i)

## Report details

| | |
|---|---|
| Report reference | FCC-Q6Z2-AA76 (the same inputs always give the same reference) |
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| Calculator | Helical Torsion Spring Rate and Stress |
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| Release checks | 3 reference cases of this calculator, computed independently, are checked on every release |

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

### This calculator online

https://calc.firecad.com/mechanical/machine-design/torsion-spring-rate

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.