Stresses and deflections in Helical Springs

There are three main types of springs:
(1) wire springs (e.g. springs made with round or square wire),
(2) flat springs (e.g. cantillever, power springs, Belleville washers), &
(3) special-shaped springs.

Helical springs are wire springs made of helically coiled wire. This is the most common type of wire spring. Extensive analysis has been performed on this type of spring. The basic stress analysis is presented in overview first and refined for wire curvature afterwards. See the figure below by Budynas.

Figure 10–1

(*a*) Axially loaded helical spring; (*b*) free-body diagram showing that the wire is subjected to a direct shear and a torsional shear.

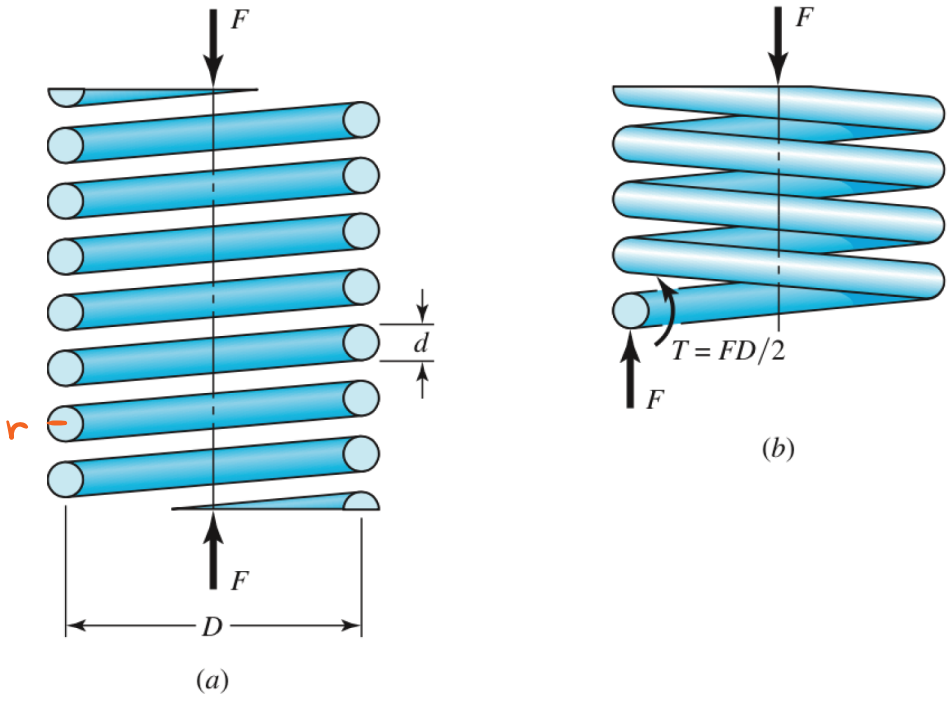
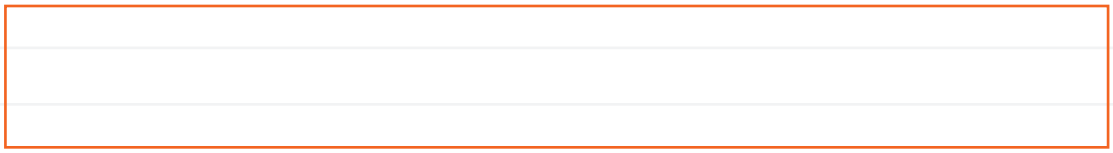


Figure 10-1b shows that the direct shear force on a given cross-sectioin of the spring is V = F and the torsional moment T = FD/2 where D is the mean diameter. Then the torsional shear stress is maximum at the inner diameter of the spring and its value is

If we insert known quantities into this equation and define the spring index C = D/d (which should range from 4--12), we can rewrite the shear formula as



is the shear stress-correction factor.

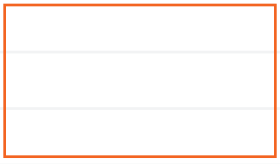
The use of wire that has a cross-section other than a circle is discouraged and rare. These springs are more expensive and have been studied less, so their properties are not well-understood. Occasionally an application with limited space will require one, but other means should be attempted, first.

The Curvature Effect

The curvature of the spring's coil has not been taken into account in the preceding. We will use the Bergstrasser factor K_B to replace the shear stress-correction factor.

Deflection of Helical Springs

It can be shown that the displacement y across a helical spring is linear to the applied force F with proportionality constant called the spring constant/rate k. I.e. F = ky where



Example (Budynas 10-3a)

A helical compression spring is wound using 2.5-mm-diameter music wire. The spring has an outside diameter of 31 mm with plain ground ends, and 14 total coils. Estimate the spring rate.

Solution