School of Engineering & Built Environment

MEng/BEng(Hons) in:

Mechanical-Electronic Systems Engineering
Mechanical & Power Plant Systems
Electrical Power Engineering
Computer-Aided Mechanical Engineering

Module: Engineering Design & Analysis 2
(Module No. M2H721926)

Design of Springs – A Summary

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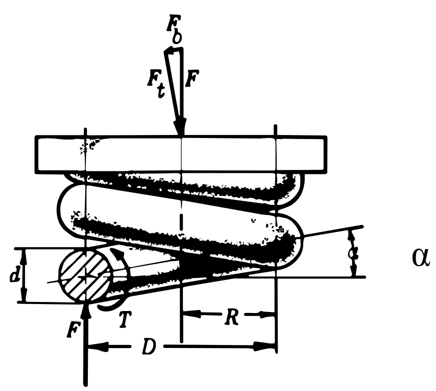
ENGINEERING DESIGN & ANALYSIS 2 (M2H721926): Design of Springs

Introduction

The principal purpose of any spring is to absorb energy and then to release it under controlled conditions, e.g. may be used to absorb the shock of collision as in the suspension of a car, or the buffers of railway rolling stock. Generally, they are used in mechanical machine design to cushion impact and shock loading, to store energy, to maintain contact between members, for force measuring devices, to control vibration, and other related functions.

Helical Springs

Helical Springs are usually made of circular cross section wire or rod as shown in the figure. These springs are subjected to a torsional shear stress and to a transverse shear stress. There is also an additional stress effect due to the curvature of the helix. In order to take into account the effects of transverse shear and curvature, it is customary to multiply the torsional shear stress by a correction factor *K*, called the Wahl factor.



A typical helical compression spring arrangement

Shear Stress

The shear stress induced in a helical spring due to an axial load *F* is: $\tau = K\dfrac{8FD}{\pi d^3} = K\dfrac{8FC}{\pi d^2}$

where τ = total shear stress (N/m^2), F = axial load (N), D = mean diameter of coil (m),

d = diameter of wire (m), $K = \dfrac{4C-1}{4C-4} + \dfrac{0.615}{C}$ = Wahl Factor, where $C = \dfrac{D}{d}$ =

spring

index.

Spring Deflection

The deflection of a helical spring due to an axial load F is: $\delta = \dfrac{8FD^3n}{d^4G} = \dfrac{8FC^3n}{dG}$

where, n = number of active coils, δ = axial deflection (m), and G = modulus of rigidity (N/m^2).

Spring Rate

Spring rate, spring or stiffness defined as the force per metre of deflection, $s = \dfrac{F}{\delta}$ (N/m)

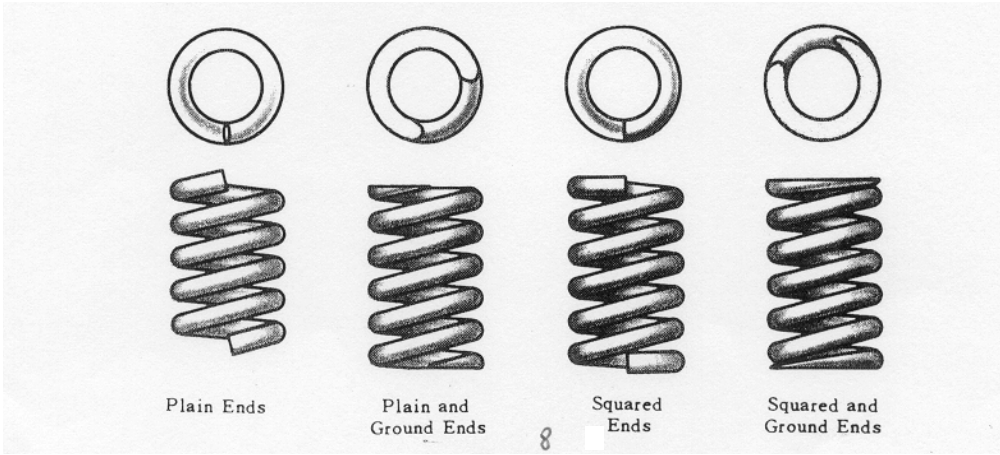
Note: $s = \dfrac{Gd}{8C^3n}$ for a helical spring under axial load.

Spring Ends

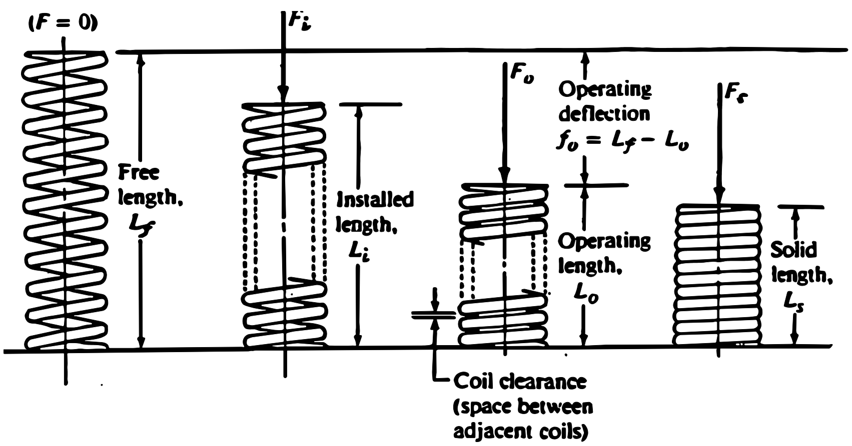
Spring ends for helical springs may be either plain, plain ground, squared, or squared and ground as shown in the figure below. This results in a decrease of the number of active coils and affects in the free length and solid length of the spring as shown the table below.

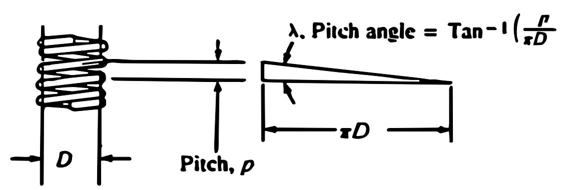
Type of Ends	Total Coils	Solid Length	Free Length
Plain	n	$(n + 1)d$	$np + d$
Plain ground	n	nd	np
Squared	$n + 2$	$(n + 3)d$	$np + 3d$
Squared and ground	$n + 2$	$(n + 2)d$	$np + 2d$

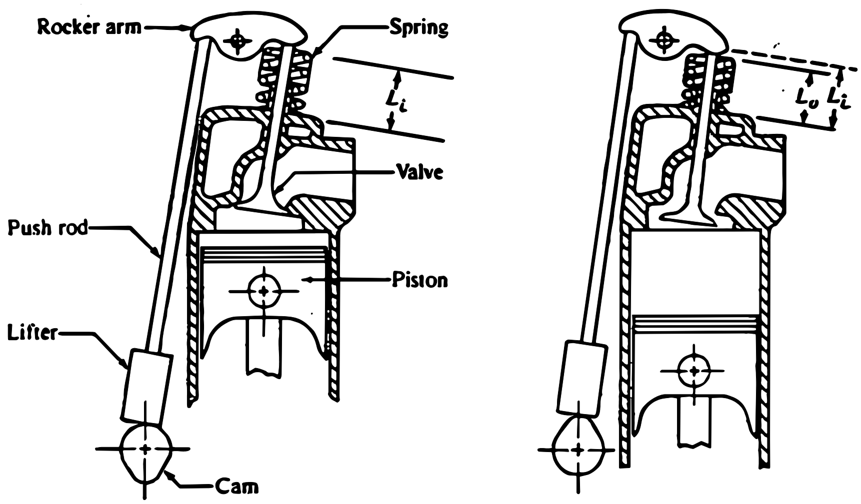
where, p = pitch, n = number of active coils, d = wire diameter



Common spring end conditions.







(a) Valve closed: spring length, L_i (b) Valve open: spring length, L_o

Examples of Spring Applications Showing Notations for Lengths and Forces