SPRINGS

Spring: Device for storing energy (strain energy) and releases back whenever it's required.
Springs are design to have **high resilience**. Eg. Shock Absorbers, Spring Matters, Spring Balance.

Helical Springs	
Open Coil Helical Springs	**Closed Coil Helical Springs**
Compression Springs	Expansion Spring
Eg. Ball Point Pen, Shock Absorber	Eg. Bike Stands
Helix Angle (α) More	Helix Angle (α) Less
Effect is present due to bending and torsion effect	Effect is present due to torsion effect

Closed Coil Helical Springs:

Assumptions: 1) Stress developed in the spring is pure shear
2) Axial force in wire is ignored.
3) Bending Couple is ignored.

$\tau_{max} = [(8WD)/\pi d^3] * [1+1/(2C)]$

If D >>> d, $\tau_{max} = (8WD) / \pi d^3$

For Safety Condition, $\tau_{max} \leq \tau_{allowable}$

$\delta = \theta * D/2$

$\theta = TL/GJ = 16\ WnD^2 / (Gd^4)$

$K_{spring} = W/\delta = Gd^4 / (8nD^3)$

Where, d = Wire Diameter,
D = Coil Diameter,
N = number of active turns in coil,
C = D/d = Spring Index,
θ = Angle of twist in wire cross section,
K_{spring} = Spring Stiffness,
δ = Deflection in spring.

Springs In Series	Springs In Parallel
$\delta_{eq} = \delta_1 + \delta_2$	$\delta_{eq} = \delta_1 = \delta_2$
$P_{eq} = P_1 = P_2$	$P_{eq} = P_1 + P_2$
$K_{eq} = K_1K_2 / (K_1+K_2)$	$K_{eq} = K_1+K_2$

Laminated / Leaf Springs: (Rarely Asked Question)

Leaf/Laminated Spring: It Consist of no. of parallel strips of a metal having **different length** and **same width & thickness** place one above the other and act as beam. It works on concept of beam of uniform strength.
Applied Bending moment = Total Resisting bending moment be "n" Springs.

$(W/2)\ (L/2) = \sigma_{max} nbt^2/6 \Longrightarrow \sigma_{max} = (3/2)\ WL / (nbt^2) \leq \sigma_{allowable}$ (For Safety condition)

Where, L = Span of Spring,
b = Width of plate
t = thickness of plate
σ_{max} = Maximum Stress developed in each plate
n = number of plates

Central deflection, $\delta = L^2 / 8R = L^2\ \sigma_{max} / (Ey) = (3/8)\ WL^3 / (nbt^3 E)$ (From Flexure Formula)