

**Shelly (Machine Design)**

Original (Design)

Material Name	ASTM A228 STEEL	Unit	For 4 Springs
Wire Diameter	2.425000000	Pa	-
Yield Stress (Lower)	80000000000	Pa	-
Shear Modulus (G)	0.0093	m	-
Mean diameter (d)	0.0005	m	-
Wire diameter (D)	0.0005	m	-
Spring index 'C'	18.6	-	-
No. total coils (Nt)	3	-	-
No. active coils (Na)	3	-	-
Solid Height (Ls) (Plain)	0.002	-	-
Solid Height (Ls) (Ground)	0.0015	m	0.008
Free Length (FL)	0.25	m	-
Types of Ends	Plain	-	-
Deflection based on Ls	0.242	m	-
Pitch (p)	0.083333333	m	-
OD @ (Solid Length)	0.078609433	m	-
Spring Rate (k)	295.00609249	N/m	1036.02422
Force required @ clearance SL	62.6794653	N	250.7178612
Wahl Correction factor (Kw)	1.079678152	-	-
Torsional Stress (S) (Wm Kw)	127.3816726	Pa	5109526696
Buckling (C/D)	26.88172043	-	-
Buckling (C/D) F	109.1250001	Pa	-
Max Allowable Tors. Stress	31.682566226	Pa	-

Preferred Range 5 to 9, but 3 to 15 possible. Low indices require special setup, high indices difficult to control could lead to tangling.

Spring Height if coils completely compressed 0.016  
With some clearance added, must be below 0.036 (height of funnel)

0.012

Accurate for deflection between 15 and 85% of available deflection)

(Before set out, accounts for bounding stress and curvature of spring)  
(If greater than 4 buckling may occur, see figure 24.6)

Table 24.6 shows its work of yield stress, therefore greater FOS included)  
(If there's a negative value, spring won't work)

**Design Limitations**

Will design for spring index range of 10.  
Solid height of spring will not exceed 28mm  
Minimum deployed height of 50mm  
Nt = Na

$$L_s = (N + 1)d$$

$$\tilde{L}_s = N \cdot d$$

$$OD_{at\ solid} = \sqrt{D^2 + \frac{p^2 - d^2}{\pi^2}} + d$$

$$k = \frac{P}{f} = \frac{Gd^4}{8D^3 N_a}$$

$$K_{w_1} = \frac{4C - 1}{4C - 4} + \frac{0.615}{C}$$

$$K_{w_2} = 1 + \frac{0.5}{C}$$

$$S = \frac{8K_w PD}{\pi d^3}$$

Figure 24.6 shows three types of helical compression springs: Plain Ends Coiled Right-hand, Squared and Ground Ends Coiled Left-hand, and Squared or Closed Ends Not Ground, Coiled Right-hand. Each type is illustrated with a 3D perspective view and a cross-sectional view showing the end configuration.

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Antenna Iteration 2: 1.91mm Wire; 42mm Helix Diameter; 88.7 mm Height				
Material Name:	ASTM A228 STEEL	Unit:	For 4 Springs:	
Yield Stress for 1.91mm diameter:	1970000000	Pa	-	-
Shear Modulus (G):	800000000000	Pa	-	-
Mean diameter (D):	0.042	m	-	-
Wire diameter (d):	0.00191	m	-	-
Spring Index 'C':	21.9895288	-	-	-
No. total coils (N):	2.5	-	-	-
No. active coils (Na):	2.5	-	-	-
Solid Height (Ls) (Plain)	0.006685	m	0.02674	0.05348
Solid Height (Ls) (Ground)	0.004775	m	0.0191	0.0382
Free Length (FL)	0.0887	m	-	-
Types of Ends	Plain	m	-	-
Deflection based on Ls	0.0596	m	-	-
Pitch (p)	0.03548	m	-	-
OD @ Solid Length	0.0459765	m	-	-
Spring Rate (k)	7363311311	N/m	3874.14624	-
Force required @ clearance SL	50.05978962	N	200.0359669	-
Wahl Correction Factor (Kw1)	1.039278292	-	-	-
Torsional Stress (S) (with Kw1)	84513321.3	Pa	376695285	-
Buckling (F) (D)	2.111904762	-	-	-
Buckling (Dof/FL)	0.794662418	-	-	-
Max Allowable Torsional Stress	885500000	Pa	-	-
MATS - Tors. Stress	6898678.74	Pa	-	-
Comments:				
Buckling will not occur.				
Spring index is fairly, but still below 25				

Antenna Iteration 2: 1.6mm Wire; 42mm Helix Diameter; 88.7 mm Height				
Material Name:	ASTM A228 STEEL	Unit:	For 4 Springs:	
Yield Stress for 1.6mm diameter:	2170000000	Pa	-	-
Shear Modulus (G):	800000000000	Pa	-	-
Mean diameter (D):	0.042	m	-	-
Wire diameter (d):	0.0011	m	-	-
Spring Index 'C':	38.18181818	-	-	-
No. total coils (N):	2.5	-	-	-
No. active coils (Na):	2.5	-	-	-
Solid Height (Ls) (Plain)	0.00385	m	0.0154	0.0308
Solid Height (Ls) (Ground)	0.00275	m	0.011	0.022
Free Length (FL)	0.0887	m	-	-
Types of Ends	Plain	m	-	-
Deflection based on Ls	0.0777	m	-	-
Pitch (p)	0.03548	m	-	-
OD @ Solid Length	0.0445905	m	-	-
Spring Rate (k)	7904883925	N/m	316.186157	-
Force required @ clearance SL	6.1419161	N	24.5676644	-
Wahl Correction Factor (Kw1)	1.039278292	-	-	-
Torsional Stress (S) (with Kw1)	551119047.3	Pa	2045745576	-
Buckling (F) (D)	2.111904762	-	-	-
Buckling (Dof/FL)	0.871696471	-	-	-
Max Allowable Torsional Stress	976500000	Pa	-	-
MATS - Tors. Stress	465063685.3	Pa	-	-
Comments:				
Buckling will not occur.				
Spring index is very high, achieving tolerances may be difficult/impossible to achieve.				

Antenna Iteration 2: 1.6mm Wire; 42mm Helix Diameter; 88.7 mm Height				
Material Name:	ASTM A228 STEEL	Unit:	For 4 Springs:	
Yield Stress for 1.6mm diameter:	2020000000	Pa	-	-
Shear Modulus (G):	800000000000	Pa	-	-
Mean diameter (D):	0.042	m	-	-
Wire diameter (d):	0.0016	m	-	-
Spring Index 'C':	26.25	-	-	-
No. total coils (N):	2.5	-	-	-
No. active coils (Na):	2.5	-	-	-
Solid Height (Ls) (Plain)	0.0056	m	0.0224	0.0448
Solid Height (Ls) (Ground)	0.004	m	0.016	0.032
Free Length (FL)	0.0887	m	-	-
Types of Ends	Plain	m	-	-
Deflection based on Ls	0.0727	m	-	-
Pitch (p)	0.03548	m	-	-
OD @ Solid Length	0.04508927	m	-	-
Spring Rate (k)	355.8273864	N/m	1415.311521	-
Force required @ clearance SL	25.953581	N	102.8931476	-
Wahl Correction Factor (Kw1)	1.03131502	-	-	-
Torsional Stress (S) (with Kw1)	70756809.5	Pa	2829427237	-
Buckling (F) (D)	2.111904762	-	-	-
Buckling (Dof/FL)	0.819616695	-	-	-
Max Allowable Torsional Stress	909000000	Pa	-	-
MATS - Tors. Stress	203643180.2	Pa	-	-
Comments:				
Buckling will not occur.				
Spring index is above 25, achieving tolerances may be difficult				

Antenna Iteration 2: 1.68mm Wire; 42mm Helix Diameter; 88.7 mm Height				
Material Name:	ASTM A228 STEEL	Unit:	For 4 Springs:	
Yield Stress for 1.6mm diameter:	2020000000	Pa	-	-
Shear Modulus (G):	800000000000	Pa	-	-
Mean diameter (D):	0.042	m	-	-
Wire diameter (d):	0.00168	m	-	-
Spring Index 'C':	25	-	-	-
No. total coils (N):	2.5	-	-	-
No. active coils (Na):	2.5	-	-	-
Solid Height (Ls) (Plain)	0.00588	m	0.02352	0.04704
Solid Height (Ls) (Ground)	0.0042	m	0.0168	0.0336
Free Length (FL)	0.0887	m	-	-
Types of Ends	Plain	m	-	-
Deflection based on Ls	0.0719	m	-	-
Pitch (p)	0.03548	m	-	-
OD @ Solid Length	0.045168622	m	-	-
Spring Rate (k)	43098	N/m	1720.32	-
Force required @ clearance SL	30.922752	N	123.691008	-
Wahl Correction Factor (Kw1)	1.05585	-	-	-
Torsional Stress (S) (with Kw1)	786477762	Pa	2945790875	-
Buckling (F) (D)	2.111904762	-	-	-
Buckling (Dof/FL)	0.81090753	-	-	-
Max Allowable Torsional Stress	909000000	Pa	-	-
MATS - Tors. Stress	172352780.3	Pa	-	-
Comments:				
Buckling will not occur.				
Spring index is exactly 25, tolerances may be difficult to achieve.				

















