Wire Sag

Span (in): $a' := 1500$

Own weight (lb/in): $w := 7.78 \cdot 10^{-6}$

Approximating to a Parabola:

From Schaum's collection, Engineering Mechanics, 3rd ed., 1978, p.68:

Assuming (lb): $T := 2.866$

$$d := \frac{a'}{4} \cdot \sqrt{\frac{1}{\left(\frac{T^2}{\frac{1}{4} \cdot w^2 \cdot a'^2}\right) - 1}}$$

$d = 0.7635$

If: $H := T$

Sag (in) **<equation I>**: $d' := \frac{w \cdot a'^2}{8 \cdot H}$ $d' = 0.7635$

Difference: $D := d - d'$ $D = 1.582 \times 10^{-6}$

Length of wire: $L := a' \cdot \left[1 + \frac{8}{3} \cdot \left(\frac{d}{a'}\right)^2 - \frac{32}{5} \cdot \left(\frac{d}{a'}\right)^4 + \frac{256}{7} \cdot \left(\frac{d}{a'}\right)^6\right]$ $L = 1500.001$

Catenary

Estimating the sag assuming T and w as above and span 2x = a', from Mark's Handbook, 9th ed., 1987, p. 2-24:

$x := \frac{a'}{2}$ $x = 750$

$\frac{w \cdot x}{T} = 2.04 \times 10^{-3}$

Calculating z:

Guessing: $z_g := 0.001$, we have: $z := \mathrm{root}\left[\left[\frac{w \cdot x}{T} - \left(z_g \cdot \cosh\left(z_g\right)\right)\right], z_g\right]$

$z = 2.04 \times 10^{-3}$ and $\cosh(z) = 1.000$

Then: $a := \frac{x}{z}$ $a = 3.684 \times 10^5$

So: $y := x \cdot \frac{[(\cosh(z)) - 1]}{z}$ $\boxed{y = 0.7635}$

Length of wire: $s := a \cdot \sinh(z)$ $2 \cdot s = 1500.001$

Roark and Young's approach:

Elastic Modulus (psi): $E := 29000000$

Area (in^2): $A := 2.74 \cdot 10^{-5}$

With no additional load other than required to hold the wire in equilibrium:

$y_{max} := a' \cdot \left(\frac{3 \cdot w \cdot a'}{64 \cdot E \cdot A}\right)^{\frac{1}{3}}$ $y_{max} = 13.245$

Tension (lb): $P := \frac{w \cdot a'^2}{8 \cdot y_{max}}$ $P = 0.165$

Note that this formula is the same as **<equation I>**, only rearranged.

Wire Stretch

$\sigma := \frac{T}{A}$ $\sigma = 104599$

$\varepsilon := \frac{\sigma}{E}$ $\varepsilon = 3.607 \times 10^{-3}$

$\Delta l := a' \cdot \varepsilon$ $\boxed{\Delta l = 5.4103}$

Wire Thermal Contraction

Room Temperature (°F): $T_a := 72$

Operational Temperature (°F): $T_o := -308$

$\Delta T := T_a - T_o$ $\Delta T = 380$

$\alpha := 9.5 \cdot 10^{-6}$

$\Delta L := a' \cdot \alpha \cdot \Delta T$ $\boxed{\Delta L = 5.4150}$

Wire Sag Sensitivity

To Span:

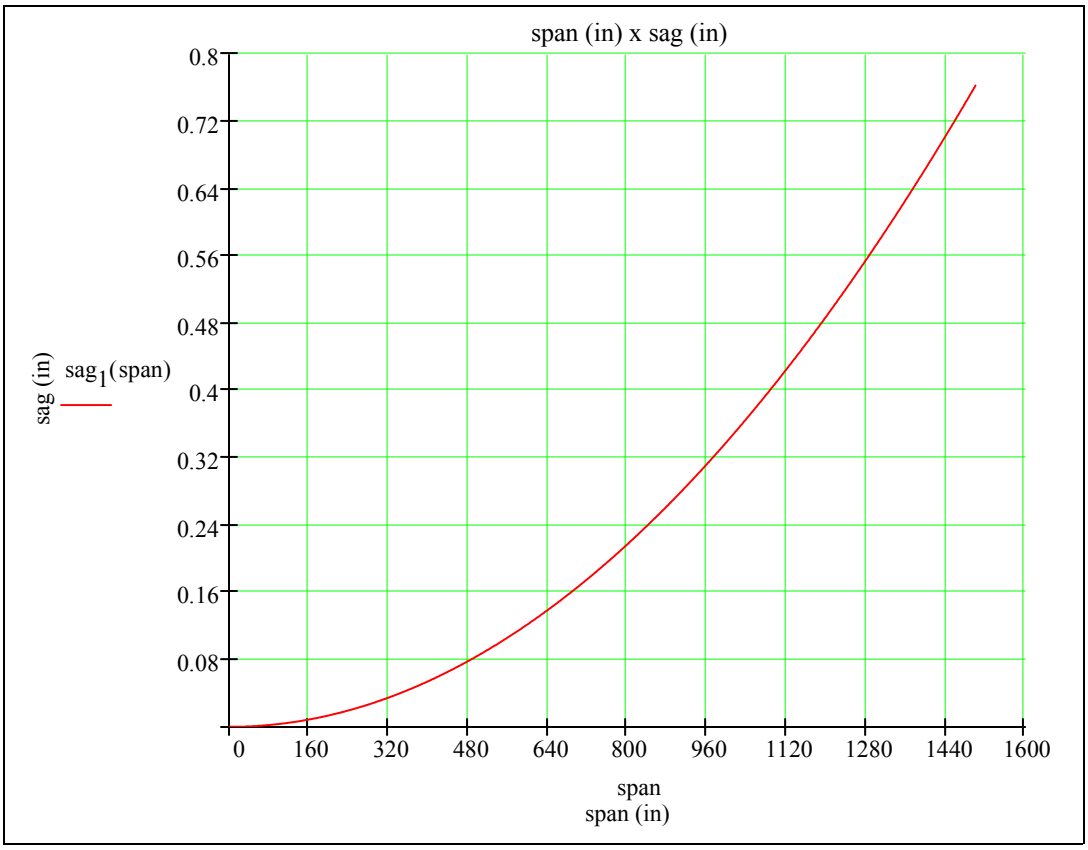
Own weight (lb/in): $weight := 7.78 \cdot 10^{-6}$

Assuming (lb): $Tension := 2.866$

$K := \dfrac{Tension^2}{\frac{1}{4} \cdot weight^2}$ $\quad K = 5.428 \times 10^{11}$

Span (in): $span := 0, 1 .. 1500$

$$sag_1(span) := \left(\frac{span^2}{4 \cdot \sqrt{K - span}} \right)$$



To tension:

Span (in): $a' := 1500$

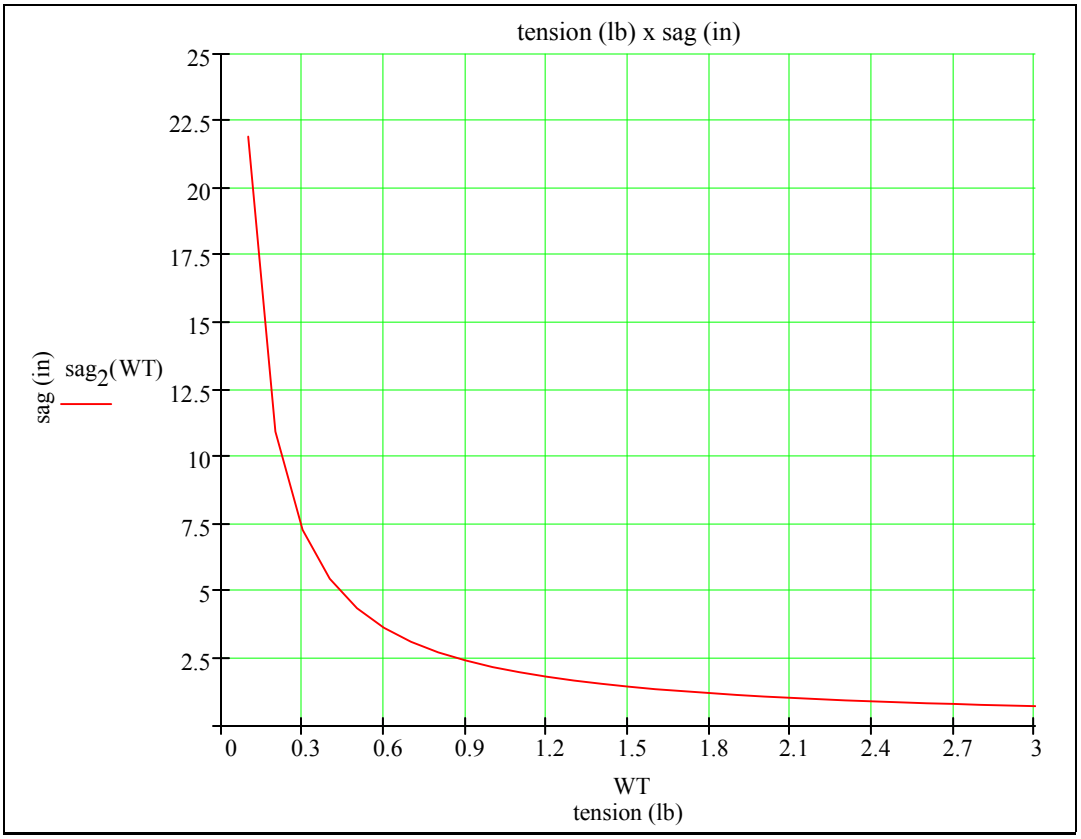
Own weight (lb/in): $weight := 7.78 \cdot 10^{-6}$

Tension (lb): $WT := 0, 0.1 .. 3$

$b := \frac{a'}{4}$ $\quad b = 375$

$c := a' \cdot b \cdot weight^2$ $\quad c = 3.405 \times 10^{-5}$

$$sag_2(WT) := \left(b \cdot \sqrt{\frac{c}{WT^2 - c}} \right)$$



To tension (in a smaller range):

Span (in): $a' := 1500$

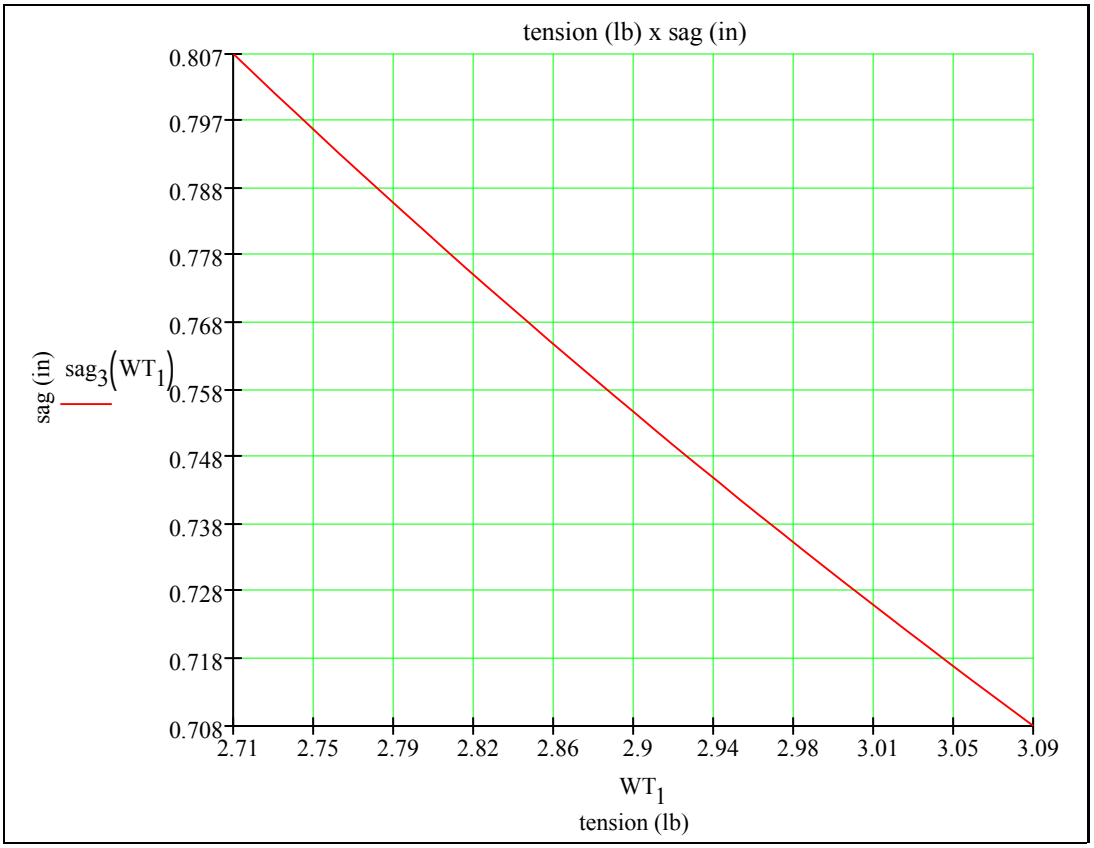
Own weight (lb/in): $weight := 7.78 \cdot 10^{-6}$

Tension (lb): $WT_1 := 2.71, 2.72 .. 3.09$

$b := \frac{a'}{4}$ $\quad b = 375$

$c := a' \cdot b \cdot weight^2$ $\quad c = 3.405 \times 10^{-5}$

$$sag_3(WT_1) := \left(b \cdot \sqrt{\frac{c}{WT_1^{\,2} - c}} \right)$$



$WT_1 =$	$sag_3(WT_1) =$
2.71	0.807
2.72	0.804
2.73	0.802
2.74	0.799
2.75	0.796
2.76	0.793
2.77	0.79
2.78	0.787
2.79	0.784
2.8	0.781
2.81	0.779
2.82	0.776
2.83	0.773
2.84	0.77
2.85	0.768
2.86	0.765
2.87	0.762
2.88	0.76
2.89	0.757
2.9	0.755
2.91	0.752
2.92	0.749
2.93	0.747
2.94	0.744
2.95	0.742
2.96	0.739
2.97	0.737
2.98	0.734
2.99	0.732
3	0.729
3.01	0.727
3.02	0.725
3.03	0.722
3.04	0.72
3.05	0.717
3.06	0.715
3.07	0.713
3.08	0.71