Ref: Shigley 10.3

$d \sim$ wire diameter $= 0.105$ inch $D_o \sim$ outside diameter $D_o = 1.225$ in

$N_t \sim$ total number of coils

$N_t = 12$

Ends ~ plain ground

Determine

(a) $L_s \sim$ solid height s.t $\tau \le \tau_{yp}$

(b) F to compress to solid height

(c) Spring constant, k

(d) Will spring buckle in service?

Material ~ spring wire (A228) ~ pg 817 (Norton)

$\sigma_{ult} \approx 260$ Ksi (pg 819 | Norton)

$\tau_{yp} = \tau_{all} = 0.45\sigma_{ult}$ Table 13-6 pg 830

$\sigma_{ult} = 260$ Ksi

$\tau_{yp} \approx 120$ Ksi

$D = D_o - d$

$= 1.225 - 0.105$

$D = 1.120$ in ~ mean spring diameter

C = spring index $= D/d$

$$C = \frac{1.120}{.105}$$

$C = 10.67 \approx 10.7$

L_s = solid length

$$\tau_s = K_s \frac{8F_sD}{\pi d^3} = \frac{8F_sC}{\pi d^2} K_s$$

Assume let spring deflect from whatever its unloaded length is to the solid height Plus, let the force required to deflect it be one which will cause the spring to "just reach" the yield strength (stress).

$$\tau = \tau_{yp} = 120\,ksi = \tau_{solid}$$

$$120\times10^3 \left(\frac{lb}{in^2}\right) = \frac{8F}{\pi d^2} C K_s$$

$$K_s = 1 + \frac{0.5}{C} = 1 + \frac{0.5}{10.7}$$ round-off ~ no appreciable error

$K_s = 1.05$ ~ check chart - what value do you read? (Pg 16 of notes)

$$F = (120\times10^3)(\pi)(.105)^2/(10.7\times1.05\times8)$$

$F = F_{solid} = 46.2\ lb$

L_o = no load length

$= \delta_F + L_s$

L_s — solid height

δ_F — deflection under force F_s

$$\delta_F = \frac{F_s}{k}$$

$$k = \frac{d^4 G}{8D^3 N_a} = \frac{dG}{8c^3 N_a}$$

$G = 11.5 \times 10^6$ ~ steel

$$k = \frac{(.105)(11.5 \times 10^6)}{(8)(10.7)^3(11)} \quad (in)(lb/in^2)$$

$\llcorner N_a = N_t - 1$

text pg 823 | notes pg 20

$k = 11.3$ lb/in

Substituting:

$$\boxed{L_o = \left(\frac{F}{k}\right) + \underbrace{d N_t}}$$

notes pg 12, note N_t

$$L_o = \frac{46.2}{11.3} + (.105)(12)$$

$L_o = 5.35$ inch ~ no clash considered.

Stability

$$L_f/D = \frac{5.35}{1.12} = 4.8$$

$$\delta/L_f = \frac{46.2/11.3}{5.35} = 0.8$$

Fig 13-14/pg 828, assuming non-parallel ends ~ unstable