Name of Student: SOLUTION
(LAST FIRST)

Class Time (circle one): 7:30 11:30 2:30

ME 452: Machine Design II
Fall Semester 2014
Class Test 4c - December 5, 2014

OPEN BOOK CLOSED NOTES

The following specifications are given for a spring design:

Material	music wire
Wire diameter	0.08 inches
Spring rate	8 lb/in
Ends	squared and ground
Setting	NO setting operation is performed
Peening	the spring is to be shot peened after winding
Load at solid height	22 lb
Yield factor of safety at solid height	1.5
Min load during fatigue cycles	~~25~~ lb 10
Max load during fatigue cycles	~~10~~ lb 22

(a) Calculate the shear ultimate strength and shear yield strength for the wire.

(b) Calculate the spring index, C, and the mean coil diameter, D, for the spring.

(c) Calculate the number of active coils, N_a, required for the spring.

(d) Calculate the solid length and the free length of the spring.

(e) Calculate the critical buckling load for the spring.

(f) Calculate the Goodman fatigue factor of safety for the spring when the load fluctuates between the min and max loads given above.

Revised

Solution
Test 4c Fall 2014

(a) $S_{ut} = A/d^m = 201/(.08)^{.145}$

$= 290$ Kpsi

$S_{sy} = .45\, S_{ut} = 130.4$ Kpsi (No set)

(b) $\alpha = S_{sy}/n_s = \frac{130.45}{1.5} = 86.97 \times 10^3$

$\beta = 8F/\pi d^2 = 8(22)/\pi(.08)^2 = 8753$

$\frac{2\alpha - \beta}{4\beta} = \frac{2(86,970) - 8753}{4(8753)} = 4.718 = *$

$C = * + \sqrt{*^2 - 3\alpha/4\beta}$

$= 4.718 + \sqrt{4.718^2 - 3(86970)/4(8753)}$

$= 4.718 + 3.848$

$C = 8.566$

$D = Cd = 8.566(.08)$

$D = .685$ inches

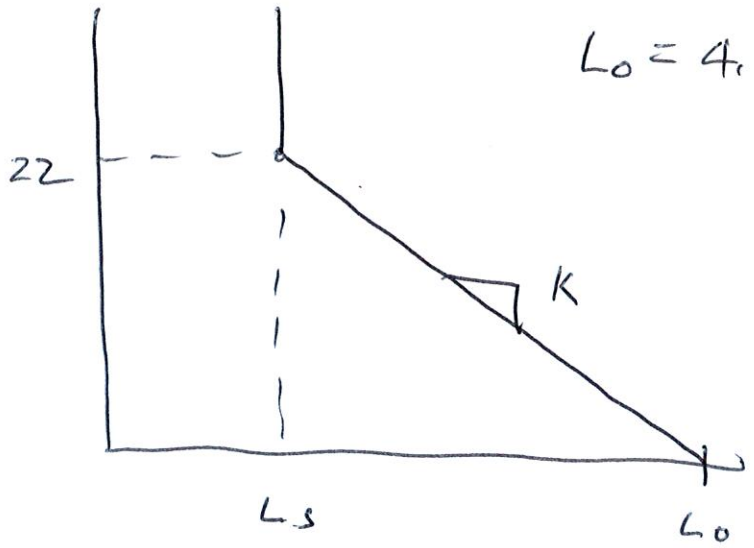
(c) $K = \frac{d^4 G}{8D^3 N_a} = \frac{1}{N_a} = \frac{K 8D^3}{d^4 G} = \frac{8(8)(.685)^3}{.08^4\ 11.8\times10^6}$

$N_a = 23.49$ coils

(d) $L_s = d N_t = .08(23.49 + 2)$

$= 2.04$ inches

$L_o = L_s + 22/K = 2.04 + 22/8$



$L_o = 4.79$ inches

(e) Buckling load

$\alpha = .5$

$L_o < 5.26D$ for obs stability

$4.79 \overset{?}{<} 5.26(.685) = 3.603$

NO $\Rightarrow$ buckles.

$$C_1' = \frac{E}{2(E-G)} = \frac{2.85E^7}{2(\cancel{4.18}\,2.85 - 1.18)E^7} = .853$$

$$C_2' = \frac{2\pi^2(E-G)}{2G+E} = \frac{2\pi^2(2.85-1.18)}{2(1.18)+2.85} = 6.33$$

$$\lambda_{eff} = \frac{\alpha L_o}{D} = \frac{.5(4.79)}{.685} = 3.496$$

$$\frac{y_{cr}}{L_0} = C_1'\left(1 - \sqrt{1 - C_2'/\lambda^2}\right)$$

$$= .853\left(1 - \sqrt{1 - 6.33/3.496^2}\right)$$

$$= .261$$

$$F_{cr\,t} = k\,y_{cr\,t} = k\left(\frac{y_{cr}}{L_0}\right)L_0$$

$$= 8\,(.261)(4.79)$$

$$F_{cr} = 9.992\ 16$$

(f) $$K_B = \frac{4C+2}{4C-3} = \frac{4(8.566)+2}{4(8.566)-3} = 1.16$$

$$\tau = K_B\frac{8FD}{\pi d^3} \Rightarrow \tau/F = 1.16\,\frac{8(.685)}{\pi(.08)^3}$$

$$= 3952$$

$10 \le F \le$ ~~25~~ 22

$F_m =$ ~~17.5~~ 16 $\Rightarrow$ $T_m =$ ~~69156~~ 63232 psi

$F_a =$ ~~7.5~~ 6 $T_a =$ ~~29638~~ 23712 psi

$$S_{su} = .67\,S_{ut} = .67\,(290{,}000)$$

$$= 194\,300$$

Peened $S_{sa} = 57500$

$S_{sm} = 77500$

$$S_{se}|_{goodman} = \frac{S_{sa}}{1 - S_{sm}/S_{su}} = \frac{57500}{1 - \frac{77500}{194300}}$$

$$= 95,653$$

$$\frac{1}{n} = \frac{T_a}{S_{se}|_g} + \frac{T_m}{S_{su}}$$

$$= \frac{\cancel{29638}\ 23712}{95653} + \frac{\cancel{69156}\ 63232}{194300} = \cancel{.3098}\ .2479 + \cancel{.3559}\ .3254$$

$n_f = \cancel{1.502}\ 1.744$