Answer Key

Springs

1

$$\delta = \frac{8FC^3n}{Gd} \; ; \quad c = \frac{D_m}{d} = \frac{160mm}{20mm} = 8$$

from;

$$S_s = \frac{8K_w F D_m}{\pi d^3}$$

and; $$k_w = \frac{4c-1}{4c-4} + \frac{0.615}{c}$$

$$= \frac{4(8)-1}{4(8)-4} + \frac{0.615}{8}$$

$$k_w = 1.1840$$

Subst;

$$150000 \frac{kN}{m^2} = \frac{8(1.1840)F(0.160m)}{\pi(0.020m)^3}$$

$$F = 2.4875 \text{ kN}$$

Hence;

$$\delta = \frac{8(2.4875kN)(8)^3(20)}{(80\times10^6 kPa)(0.020m)}$$

$$\delta = 0.1274 \text{ m}$$

$$\boxed{\delta = 127.4 \text{ mm}}$$

2

$$\delta = \frac{8 F c^3 n}{G d}$$

$$F = m\left(\frac{g_o}{g_c}\right) = 120\,kg\left(\frac{9.81\,m/s^2}{1000\,\frac{kg-m}{kN-s^2}}\right) = 1.1772\,kN$$

$$D_m = D_o - d = (0.095 - 0.0095)\,m = 0.0855\,m$$

$$c = \frac{D_m}{d} = \frac{0.0855\,m}{0.0095\,m} = 9$$

$$n = 20 + 2 = 22$$

Substi

$$\delta = \frac{8(1.1772\,kN)(9)^3(22)}{(95 \times 10^6\,kPa)(0.0095\,m)}$$

$$\delta = 0.1674\,m$$

$$\boxed{\delta = 167.4\,mm}$$

3

$$k_w = \frac{4c-1}{4c-4} + \frac{0.615}{c}$$

$$C = \frac{D_m}{d} = \frac{D_o + D_i}{2d}$$

for d;

$$d = \frac{D_o - D_i}{2} = \frac{(0.120 - 0.110)m}{2} = 5 \times 10^{-3}\ m$$

then;

$$C = \frac{(0.120 + 0.110)m}{2(5 \times 10^{-3}\ m)} = 23$$

Hence;

$$k_w = \frac{4(23)-1}{4(23)-4} + \frac{0.615}{23}$$

$$\boxed{k_w = 1.0608}$$

4

$$S_s = \frac{8 K_w F D_m}{\pi d^3}; \quad D_m = Cd$$

$$S_s = \frac{8 K_w F c}{\pi d^2}$$

from; $K_w = \frac{4c-1}{4c-4} + \frac{0.615}{c}$

$$= \frac{4(8)-1}{4(8)-4} + \frac{0.615}{8}$$

$$K_w = 1.1840$$

Substi;

$$95000 \frac{lb}{in^2} = \frac{8(1.1840)(60\ lbs)(8)}{\pi d^2}$$

$$\boxed{d = 0.1234\ in}$$

EXPONENTIAL LEAP ONLINE REVIEW

$$\frac{1}{k_s} = \frac{1}{k_{s1}} + \frac{1}{k_{s2}} + \frac{1}{k_{s3}}$$

$$\frac{1}{k_s} = \frac{1}{0.3\ kg/mm} + \frac{1}{0.65\ kg/mm} + \frac{1}{0.65\ kg/mm}$$

$$k_s = 0.156\ kg/mm$$

Hence;

$$k_s = \frac{F}{\delta_T}$$

$$0.156\ kg/mm = \frac{80\ kg}{\delta_T}$$

$$\boxed{\delta_T = 512.8205\ mm}$$

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Exponential LEAP ONLINE REVIEW

$$S_s = \frac{8 K_w F D_m}{\pi d^3}$$

$$K_w = \frac{4c-1}{4c-4} + \frac{0.615}{c}\ ; \quad c = \frac{D_m}{d} = \frac{120\ mm}{13\ mm} = 9.2308$$

$$= \frac{4(9.2308)-1}{4(9.2308)-4} + \frac{0.615}{9.2308}$$

$$K_w = 1.1577$$

Solving force F that caused solid deflection on spring

$$k_s = \frac{F}{\delta_s}\ ; \quad \delta_s = FL - SL$$

$$SL = (n+2)d$$

$$= (12+2)(13\ mm)$$

$$SL = 182\ mm$$

$$\delta_s = (300-182)\ mm = 118\ mm$$

Subst;

$$130\ \frac{kN}{m} = \frac{F}{0.118\ m}$$

$$F = 15.34\ kN$$

Hence;

$$S_s = \frac{8(1.1577)(15340\ N)(120\ mm)}{\pi (13\ mm)^3}$$

$$\boxed{S_s = 2470.0895\ MPa}$$

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$$L = \pi D n = \pi(1.2\,in)(10)$$

$$\boxed{L = 37.6991\ in}$$

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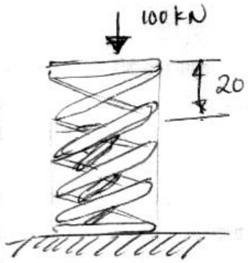
Concentric Springs



$k_{si} = 490\ kN/m$

$k_{so} = 125\ kN/m$

$F = F_i + F_o$; $k = \frac{F}{\delta}$; $\delta_o = \delta_i + 20mm$

$100kN = k_i \delta_i + k_o \delta_o$

$100\ kN = k_i \delta_i + k_o(\delta_i + 0.020m)$

$100\ kN = \left(490\frac{kN}{m}\right)\delta_i + \left(125\frac{kN}{m}\right)(\delta_i + 0.020m)$

$\delta_i = 0.1585\ m$

Then;

$k_{si} = \frac{F_i}{\delta_{si}}$

$490\ \frac{kN}{m} = \frac{F_i}{0.1585\,m}$

$F_i = 77.6829\ kN$

for F_o;

$100kN = 77.6829kN + F_o$

$F_o = 22.3170\ kN$

Hence;

The percent load carried by inner spring

$\% = \frac{77.6829\ kN}{100\ kN} * 100\%$

$\boxed{\% = 77.68\%}$

$$\delta = \frac{8Fc^3n}{Gd} \quad ; \quad c = \frac{D_m}{d}$$

$$\delta = \frac{8FD_m^3n}{Gd^4}$$

$$80\,mm = \frac{8(12000\,N)D_m^3(15)}{\left(85000\,\frac{N}{mm^2}\right)(30\,mm)^4}$$

$$\boxed{d = 156.3905\,mm}$$

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$$k_T = \frac{F}{\delta_T}$$; for sprigs in parallel

$$\delta_T = \delta_1 = \delta_2 = \delta_3 = \delta_4$$

$$k_T = k_{s_1} + k_{s_2} + k_{s_3}$$

$$4\left(0.725\ \frac{kg}{mm}\right) = \frac{380\ kg}{\delta_T}$$

$$\boxed{\delta_T = 131.0345\ mm}$$

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$$\delta_T = \delta_1 + \delta_2 + \delta_3 \quad ; \quad k_s = \frac{F}{\delta} \quad ; \quad F_T = F_1 = F_2 = F_3$$

$$= \frac{80\ \text{kg}}{0.20\ \text{kg/mm}} + \frac{80\ \text{kg}}{0.650\ \text{kg/mm}} + \frac{80\ \text{kg}}{0.650\ \text{kg/mm}}$$

$$\boxed{\delta_T = 646.1538\ \text{mm}}$$

$$k_s = \frac{F}{\delta} = \frac{30\ kg}{180\ mm} = 0.16667\ kg/mm$$

Hence, the load required for the spring to deflect by 50mm

$$k_s = \frac{F}{\delta}$$

$$0.16667\ kg/mm = \frac{F}{50\ mm}$$

$$\boxed{F = 8.3335\ kg}$$

$$w(h+\delta) = \frac{F}{2}\delta$$

$$120\text{ lbs}\,(20\text{ in} + 5\text{ in}) = \frac{F}{2}\,(5\text{ in})$$

$$\boxed{F = 1200\text{ lbs}}$$

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$$S_s = \frac{8 K_w F D_m}{\pi d^3} \quad ; \quad C = \frac{D_m}{d} = \frac{8d}{d} = 8$$

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

$$= \frac{4(8)-1}{4(8)-4} + \frac{0.615}{8}$$

$$K_w = 1.1840$$

from: $E = F\delta$

$$F = \frac{E}{\delta}$$

subst: $$S_s = \frac{8 K_w E C}{\pi d^2 \delta}$$

$$100\,000 \frac{lb}{in^2} = \frac{8(1.1840)(300 \text{ ft-lb})\left(\frac{12 \text{ in}}{1 \text{ ft}}\right)(8)}{\pi d^2 (5 \text{ in})}$$

$$\boxed{d = 0.4167 \text{ in}}$$

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$$k_s = \frac{F}{\delta}$$

$$k_s = \frac{60\,lbs}{10\,in} = 6\ lbs/in$$

Hence; the load that will make the spring deflect by 3in

$$k_s = \frac{F}{\delta}$$

$$6\ lbs/in = \frac{F}{3\,in}$$

$$\boxed{F = 18\ lbs}$$

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exponential LEAP ONLINE REVIEW

$$S_s = \frac{8 k_w F D_m}{\pi d^3} \; ; \; c = \frac{D_m}{d}$$

$$S_s = \frac{8 k_w F c}{\pi d^2} \; ; \; k_w = \frac{4c-1}{4c-8} + \frac{0.615}{c}$$

$$= \frac{4(9)-1}{4(9)-4} + \frac{0.615}{9}$$

$$k_w = 1.1621$$

Subst;

$$95000 \frac{lb}{in^2} = \frac{8(1.1621)(60 lbs)(9)}{\pi d^2}$$

$$\boxed{d = 0.1297 \text{ in}}$$

$$k_s = \frac{F}{\delta} = \frac{60\,\text{lbs}}{6\,\text{in}}$$

$$\boxed{k_s = 10\,\text{lbs}/\text{in}}$$

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$$\delta = \frac{8FC^3n}{Gd}$$

$$\frac{\delta}{F} = \frac{8C^3n}{Gd} \;;\; C = \frac{D_m}{d} = \frac{80\,mm}{12\,mm} = 6.6667$$

$$\frac{1}{40\,\frac{kN}{m}} = \frac{8(6.6667)^3n}{\left(85000000\,\frac{kN}{m}\right)(0.012\,m)}$$

$$\boxed{n = 10.7577}$$

$$k_s = \frac{F}{\delta} \quad ; \quad \delta_s = FL - SL$$

$$FL = nP + d = (16)(12\,mm) + 7\,mm = 199\,mm$$

$$SL = (n+1)d = (16+1)(7\,mm) = 119\,mm$$

$$\delta_s = (199 - 119)\,mm = 80\,mm$$

Hence;

$$90\,\frac{kN}{m} = \frac{F}{0.080\,m}$$

$$\boxed{F = 7.2\,kN}$$

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$\delta_s = FL - SL$

$$FL = nP + 2d = (14)(18\,mm) + 2(12.4\,mm) = 276.8\,mm$$

$$SL = (n+2)d = (14+2)(12.4\,mm) = 198.4\,mm$$

Hence;

$$\delta_s = (276.8 - 198.4)\,mm$$

$$\boxed{\delta_s = 78.4\,mm}$$

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$$\delta = \frac{12FL^3}{bt^3E(2n_g + 3n_f)} = \frac{12\left(\frac{1200\,lbs}{2}\right)(15\,in)^3}{(4\,in)(0.20\,in)^3(30\times10^6\,psi)\left[2(6)+3(3)\right]}$$

$$\boxed{\delta = 1.2054\ in}$$

$$S_f = \frac{18FL}{bt^2(2n_g + 3n_f)}$$

$$= \frac{18\left(\frac{600\text{ lbs}}{2}\right)(18\text{ in})}{(3.5\text{ in})(0.3\text{ in})^2\left[2(5)+3(2)\right]}$$

$$\boxed{S_f = 19285.7143\text{ psi}}$$