```
function [xopt, fopt, exitflag, output] = optimize_spring()


    % ------------Starting point and bounds------------
    %var= d D n hf   %design variables
    x0 = [0.01, 0.01, 1, 1]; %starting point
    ub = [0.2, 1, 50, 10]; %upper bound
    lb = [0.01,0.01,1,1.0]; %lower bound

    % ------------Linear constraints------------
    A = [];
    b = [];
    Aeq = [];
    beq = [];

    % ------------Objective and Non-linear Constraints------------
    function [f, c, ceq] = objcon(x)

        %design variables
        d = x(1);  % height (in)
        D = x(2);  % diameter (in)
        n = x(3); % number of coils (treating as continuous for this example)
        hf = x(4); % free height (in)

        % Constants
        G = 12e6;  % psi
        Se = 45000; % psi
        w = 0.18;
        Sf = 1.5;
        Q= 150000; % psi

        % Analysis variables
        h0 = 1.0; % preload height
        delta0 = 0.4;

        % Output variables
        hdef = h0-delta0;
        k = (G*d^4)/(8*D^3*n);
        K = (4*D-d)/(4*(D-d))+0.62*d/D;
        F_h0 = k*(hf-h0); %Fmin
        F_hdef = k*(hf-hdef); %Fmax
        tauh0 = (8*F_h0*D)/(pi*d^3)*K; %taumin
        tauhdef = (8*F_hdef*D)/(pi*d^3)*K; %taumax

        taumean = (tauhdef+tauh0)/2;
        tauavg = (tauhdef-tauh0)/2;

        hs = n*d;
        Fhs = k*(hf-hs);
        tauhs = (8*Fhs*D)/(pi*d^3)*K;

        Sy = 0.44*Q/(d^w);
```

```
        %objective function
        f = -F_h0; %maximize F_h0

        %inequality constraints (c<=0)
        c = zeros(7,1);         % create column vector
        c(1) = (tauhs - Sy)/1e4;   %scaled
        c(2) = (tauavg - (Se/Sf))/1e4; %scaled
        c(3) = (tauavg+taumean)-(Sy/Sf);
        c(4) = (D/d)-16;
        c(5) = 4-(D/d);
        c(6) = (D+d) - 0.75;
        c(7) = hs - (hdef-0.05);
        %equality constraints (ceq=0)
        ceq = [];

    end


    % ------------Call fmincon------------
    options = optimoptions(@fmincon,'display','iter-detailed','Diagnostics','on');
    [xopt, fopt, exitflag, output] = fmincon(@obj, x0, A, b, Aeq, beq, lb, ub, @co
    xopt %design variables at the minimum
    fopt %objective function value at the minumum  fopt = f(xopt)
    [f,c,ceq] = objcon(xopt);
    c
    %contour_plot(xopt(3),xopt(4));




    % ------------Separate obj/con (do not change)------------
    function [f] = obj(x)
        [f, ~, ~] = objcon(x);
    end
    function [c, ceq] = con(x)
        [~, c, ceq] = objcon(x);
    end
end
```

Your initial point x0 is not between bounds lb and ub; FMINCON shifted x0 to strictly satisfy the bounds.

Diagnostic Information

Number of variables: 4

Functions

Objective:	*optimize_spring/obj*
Gradient:	*finite-differencing*
Hessian:	*finite-differencing (or Quasi-Newton*
Nonlinear constraints:	*optimize_spring/con*

```
Nonlinear constraints gradient:       finite-differencing

Constraints
Number of nonlinear inequality constraints: 7
Number of nonlinear equality constraints:   0

Number of linear inequality constraints:    0
Number of linear equality constraints:      0
Number of lower bound constraints:          4
Number of upper bound constraints:          4

Algorithm selected
   interior-point


   End diagnostic information
                                                    First-order      Norm of
 Iter F-count            f(x)  Feasibility   optimality         step
    0       5   -6.567827e+02   1.565e+06    1.137e+05
    1      10   -6.867149e+02   1.092e+06    5.648e+04    3.049e-01
    2      15   -6.540337e+02   8.646e+05    4.126e+04    6.016e-01
    3      20   -6.320025e+02   8.486e+05    4.112e+04    9.827e-03
    4      25   -2.251413e+02   5.436e+05    4.034e+04    7.968e-02
    5      30   -2.230312e+02   5.420e+05    4.038e+04    1.070e-03
    6      35   -2.230193e+02   5.420e+05    4.038e+04    4.212e-06
    7      40   -3.623346e+00   1.304e+05    5.711e+04    1.756e+00
    8      45   -1.438662e-01   5.094e+00    6.205e+04    3.743e-01
    9      50   -1.426911e-01   5.100e+00    6.604e+02    1.643e-03
   10      55   -9.617007e-02   4.607e+00    1.132e+03    9.210e-02
   11      60   -9.595835e-02   4.580e+00    1.139e+03    7.258e-03
   12      65   -9.856008e-04   2.522e+00    1.122e+03    3.697e-01
   13      70   -4.961714e-06   2.498e+00    1.127e+03    9.421e-04
   14      75   -2.483553e-08   2.492e+00    1.128e+03    1.008e-03
   15      80   -4.194285e-06   4.402e-01    1.150e+03    4.307e-01
   16      85   -9.380372e-06   1.427e-02    1.266e+03    8.500e-02
   17      90   -2.052171e-04   0.000e+00    3.108e+02    3.189e-03
   18      95   -3.953216e-02   0.000e+00    1.706e+02    3.686e-02
   19     100   -3.265267e-02   0.000e+00    1.689e+02    9.883e-03
   20     106   -5.194312e-02   0.000e+00    1.588e+02    7.885e-02
   21     112   -9.213069e-02   0.000e+00    1.499e+02    1.040e-01
   22     118   -3.540567e-01   0.000e+00    1.101e+02    4.663e-01
   23     134   -4.882138e-01   0.000e+00    1.092e+01    1.365e-01
   24     139   -1.866662e+00   0.000e+00    7.207e+01    9.719e-01
   25     144   -2.483754e+00   0.000e+00    5.984e+01    3.296e-01
   26     149   -2.645003e+00   0.000e+00    7.161e+01    9.487e-02
   27     154   -3.450745e+00   0.000e+00    1.256e+02    4.791e-01
   28     159   -5.797646e+00   0.000e+00    2.481e+02    1.100e+00
   29     168   -5.626449e+00   0.000e+00    6.095e+00    8.902e-02
   30     173   -5.682070e+00   0.000e+00    8.647e+00    2.334e-02

                                                    First-order      Norm of
 Iter F-count            f(x)  Feasibility   optimality         step
   31     178   -6.082542e+00   0.000e+00    2.616e+01    1.651e-01
```

```
   32     183   -6.238794e+00    0.000e+00    3.281e+01    7.749e-02
   33     188   -6.296937e+00    1.395e-04    3.525e+01    2.907e-02
   34     193   -6.286596e+00    0.000e+00    3.207e+01    3.230e-03
   35     198   -6.285148e+00    0.000e+00    3.199e+01    5.182e-04
   36     203   -6.285085e+00    0.000e+00    3.198e+01    5.185e-05
   37     208   -6.285205e+00    0.000e+00    3.199e+01    2.188e-04
   38     213   -6.285815e+00    0.000e+00    3.202e+01    1.093e-03
   39     218   -6.288832e+00    0.000e+00    3.218e+01    5.454e-03
   40     223   -6.303067e+00    0.000e+00    3.294e+01    2.701e-02
   41     228   -6.353881e+00    0.000e+00    2.971e+01    1.290e-01
   42     234   -6.390078e+00    0.000e+00    2.715e+01    2.158e-01
   43     239   -6.431686e+00    0.000e+00    2.531e+01    1.168e-01
   44     244   -6.442943e+00    0.000e+00    3.170e+00    2.135e-03
   45     249   -6.442101e+00    0.000e+00    1.102e-01    1.071e-03
   46     254   -6.454019e+00    0.000e+00    3.061e-01    4.145e-03
   47     259   -6.454101e+00    0.000e+00    7.386e-02    7.731e-05
   48     264   -6.454101e+00    0.000e+00    9.172e-03    3.033e-04
   49     269   -6.454101e+00    0.000e+00    8.009e-06    1.134e-04

Optimization completed: The relative first-order optimality measure, 2.247
is less than options.TolFun = 1.000000e-06, and the relative maximum const
violation, 0.000000e+00, is less than options.TolCon = 1.000000e-06.

Optimization Metric                                        Options
relative first-order optimality =   2.25e-08       TolFun =   1e-06 (defau
relative max(constraint violation) =   0.00e+00    TolCon =   1e-06 (defau


xopt =

    0.0724    0.6776    7.5928    1.3691


fopt =

   -6.4541


c =

   -3.0700
   -1.1647
   -0.0420
   -6.6461
   -5.3539
   -0.0000
   -0.0000


ans =

    0.0724    0.6776    7.5928    1.3691
```

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