```
clc; clear; close all;
E     = 30e6;
G     = 12e6;

cost = @(l,h,t,b) 2.21*l*h^2 + 0.048*(b*t*(14+l));
buckling_load = @(b,t) (4.013*sqrt((E*G*b^2*t^6)/36)/196)*...
                       (1-(t/28)*sqrt(E/(4*G)));
M  = @(l,b,t)   6000*(14 + 0.5*l);
R  = @(l,h,t)   0.5*sqrt(l^2 + (h + t)^2);
J  = @(l,h,t)   sqrt(2)*h*l*(((l^2)/12) + ((h + t)^2)/4);
shear_stress = @(l,h,t,b) sqrt((6000/(sqrt(2)*h*l))^2 + ...
                        (6000/sqrt(2)*h)*(M(l,b,t)/J(l,h,t)) + ...
                        ((M(l,b,t)*R(l,h,t))/J(l,h,t))^2);
bending_stress = @(l,h,t,b) 84*6000/(b*t^2);
end_deflection = @(l,h,t,b) (10976*6000)/(E*b*t^3);

% Inequality Constraints

h1  = @(l,h,t,b,s1 ) b-2     + s1^2;
h2  = @(l,h,t,b,s2 ) 0.125-h + s2^2;
h3  = @(l,h,t,b,s3 ) h-2     + s3^2;
h4  = @(l,h,t,b,s4 ) h-b     + s4^2;
h5  = @(l,h,t,b,s5 ) 0.1-t   + s5^2;
h6  = @(l,h,t,b,s6 ) t-10    + s6^2;
h7  = @(l,h,t,b,s7 ) 0.1-l   + s7^2;
h8  = @(l,h,t,b,s8 ) l-10    + s8^2;
h9  = @(l,h,t,b,s9 ) 6000-buckling_load(b,t)       + s9^2;
h10 = @(l,h,t,b,s10) shear_stress(l,h,t,b)-13600   + s10^2;
h11 = @(l,h,t,b,s11) bending_stress(l,h,t,b)-30000 + s11^2;
h12 = @(l,h,t,b,s12) end_deflection(l,h,t,b)-0.25  + s12^2;

L    = @(l,h,t,b,...
         p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,p11,p12,...
         s1,s2,s3,s4,s5,s6,s7,s8,s9,s10,s11,s12)...
      cost(l,h,t,b)...
    + p1  * h1 (l,h,t,b,s1 ) ...
    + p2  * h2 (l,h,t,b,s2 ) ...
    + p3  * h3 (l,h,t,b,s3 ) ...
    + p4  * h4 (l,h,t,b,s4 ) ...
    + p5  * h5 (l,h,t,b,s5 ) ...
    + p6  * h6 (l,h,t,b,s6 ) ...
    + p7  * h7 (l,h,t,b,s7 ) ...
    + p8  * h8 (l,h,t,b,s8 ) ...
    + p9  * h9 (l,h,t,b,s9 ) ...
    + p10 * h10(l,h,t,b,s10)...
    + p11 * h11(l,h,t,b,s11)...
    + p12 * h12(l,h,t,b,s12);


syms l h t b
syms p1 p2 p3 p4 p5 p6 p7 p8 p9 p10 p11 p12
syms s1 s2 s3 s4 s5 s6 s7 s8 s9 s10 s11 s12
```

```
state_array = [l h t b...
               p1 p2 p3 p4 p5 p6 p7 p8 p9 p10 p11 p12...
               s1 s2 s3 s4 s5 s6 s7 s8 s9 s10 s11 s12];

J = gradient(L,state_array);

for k = 1:length(J)
    fprintf("dL_d" + string(state_array(k)) +...
            " = " + string(J(k)) + ";\n");
end

int_guess = ones(1,28);
int_guess(1:4) = [5 1 5 1.2];


state_out = fsolve(@derivatives_question_5,int_guess);

fprintf("\nl = %0.2f inches\n",state_out(1));
fprintf("h = %0.2f inches\n"  ,state_out(2));
fprintf("t = %0.2f inches\n"  ,state_out(3));
fprintf("b = %0.2f inches\n"  ,state_out(4));
fprintf("cost = $%0.2f\n",cost(state_out(1),state_out(2),...
                               state_out(3),state_out(4)));


l = state_out(1);
h = state_out(2);
t = state_out(3);
b = state_out(4);

fprintf("\nbuckling load = %0.2f psi\n",buckling_load(b,t));
fprintf("shear stress = %0.2f psi\n",shear_stress(l,h,t,b));
fprintf("bending stress = %0.2f psi\n",bending_stress(l,h,t,b));
fprintf("end deflection = %0.2f inches\n",end_deflection(l,h,t,b));

dL_dl = p8 - p7 + (6*b*t)/125 + (221*h^2)/100 - (p10*(36000000/
(h^2*l^3) - (437328071996551125*2^(1/2))/(68719476736*l*((h +
 t)^2/4 + l^2/12)) + (1166208191990803*2^(1/2)*(3000*l + 84000))/
(3298534883328*((h + t)^2/4 + l^2/12)^2) - (3000*l + 84000)^2/
(4*h^2*l*((h + t)^2/4 + l^2/12)^2) + (1166208191990803*2^(1/2)*(3000*l
 + 84000))/(549755813888*l^2*((h + t)^2/4 + l^2/12)) + ((3000*l +
 84000)^2*((h + t)^2 + l^2))/(24*h^2*l*((h + t)^2/4 + l^2/12)^3)
 + ((3000*l + 84000)^2*((h + t)^2 + l^2))/(4*h^2*l^3*((h + t)^2/4
 + l^2/12)^2) - ((18000000*l + 504000000)*((h + t)^2 + l^2))/
(8*h^2*l^2*((h + t)^2/4 + l^2/12)^2)))/(2*(18000000/(h^2*l^2) +
 (1166208191990803*2^(1/2)*(3000*l + 84000))/(549755813888*l*((h
 + t)^2/4 + l^2/12)) + ((3000*l + 84000)^2*((h + t)^2 + l^2))/
(8*h^2*l^2*((h + t)^2/4 + l^2/12)^2))^(1/2));
dL_dh = p3 - p2 + p4 + (221*h*l)/50 - (p10*(36000000/(h^3*l^2) +
 ((3000*l + 84000)^2*((h + t)^2 + l^2))/(4*h^3*l^2*((h + t)^2/4
 + l^2/12)^2) - ((3000*l + 84000)^2*(2*h + 2*t))/(8*h^2*l^2*((h
 + t)^2/4 + l^2/12)^2) + (1166208191990803*2^(1/2)*(3000*l +
 84000)*(h/2 + t/2))/(549755813888*l*((h + t)^2/4 + l^2/12)^2)
```

```
 + ((3000*l + 84000)^2*((h + t)^2 + l^2)*(h/2 + t/2))/
(4*h^2*l^2*((h + t)^2/4 + l^2/12)^3)))/(2*(18000000/(h^2*l^2) +
 (1166208191990803*2^(1/2)*(3000*l + 84000))/(549755813888*l*((h
 + t)^2/4 + l^2/12)) + ((3000*l + 84000)^2*((h + t)^2 + l^2))/
(8*h^2*l^2*((h + t)^2/4 + l^2/12)^2))^(1/2));
dL_dt = p6 - p5 + (6*b*(l + 14))/125 +
 p9*((501625*2^(1/2)*5^(1/2)*10^(1/2)*(b^2*t^6)^(1/2))/2744
 + (3009750*10^(1/2)*b^2*t^5*((2^(1/2)*5^(1/2)*t)/112 - 1))/
(49*(b^2*t^6)^(1/2))) - (1008000*p11)/(b*t^3) - (4116*p12)/(625*b*t^4)
 - (p10*((1166208191990803*2^(1/2)*(3000*l + 84000)*(h/2 + t/2))/
(549755813888*l*((h + t)^2/4 + l^2/12)^2) - ((3000*l + 84000)^2*(2*h +
 2*t))/(8*h^2*l^2*((h + t)^2/4 + l^2/12)^2) + ((3000*l + 84000)^2*((h
 + t)^2 + l^2)*(h/2 + t/2))/(4*h^2*l^2*((h + t)^2/4 + l^2/12)^3)))/
(2*(18000000/(h^2*l^2) + (1166208191990803*2^(1/2)*(3000*l + 84000))/
(549755813888*l*((h + t)^2/4 + l^2/12)) + ((3000*l + 84000)^2*((h +
 t)^2 + l^2))/(8*h^2*l^2*((h + t)^2/4 + l^2/12)^2))^(1/2));
dL_db = p1 - p4 + (6*t*(l + 14))/125 -
 (504000*p11)/(b^2*t^2) - (1372*p12)/(625*b^2*t^3) +
 (1003250*10^(1/2)*b*p9*t^6*((2^(1/2)*5^(1/2)*t)/112 - 1))/
(49*(b^2*t^6)^(1/2));
dL_dp1 = b + s1^2 - 2;
dL_dp2 = s2^2 - h + 1/8;
dL_dp3 = h + s3^2 - 2;
dL_dp4 = h - b + s4^2;
dL_dp5 = s5^2 - t + 1/10;
dL_dp6 = t + s6^2 - 10;
dL_dp7 = s7^2 - l + 1/10;
dL_dp8 = l + s8^2 - 10;
dL_dp9 = s9^2 + (1003250*10^(1/2)*((2^(1/2)*5^(1/2)*t)/112 -
 1)*(b^2*t^6)^(1/2))/49 + 6000;
dL_dp10 = (18000000/(h^2*l^2) + (1166208191990803*2^(1/2)*(3000*l
 + 84000))/(549755813888*l*((h + t)^2/4 + l^2/12)) + ((3000*l
 + 84000)^2*((h + t)^2 + l^2))/(8*h^2*l^2*((h + t)^2/4 +
 l^2/12)^2))^(1/2) + s10^2 - 13600;
dL_dp11 = s11^2 + 504000/(b*t^2) - 30000;
dL_dp12 = s12^2 + 1372/(625*b*t^3) - 1/4;
dL_ds1 = 2*p1*s1;
dL_ds2 = 2*p2*s2;
dL_ds3 = 2*p3*s3;
dL_ds4 = 2*p4*s4;
dL_ds5 = 2*p5*s5;
dL_ds6 = 2*p6*s6;
dL_ds7 = 2*p7*s7;
dL_ds8 = 2*p8*s8;
dL_ds9 = 2*p9*s9;
dL_ds10 = 2*p10*s10;
dL_ds11 = 2*p11*s11;
dL_ds12 = 2*p12*s12;

Solver stopped prematurely.

fsolve stopped because it exceeded the function evaluation limit,
options.MaxFunctionEvaluations = 2800 (the default value).
```

```
l = 6.08 inches
h = 0.94 inches
t = 1.75 inches
b = 1.58 inches
cost = $14.60

buckling load = 523386.08 psi
shear stress = 9177.91 psi
bending stress = 103878.28 psi
end deflection = 0.26 inches
```

Published with MATLAB® R2018a