Clear the memory of all variables and values

In[∘]:=
```
ClearAll["Global`*"]
```

specify cost and constraint functions

In[∘]:=
```
P = 2 * 7833 * 5 * Pi * x2 * x1; (* Tube mass where x1 it t and x2 is R *)
fact = 1.00; (* up to 2.5 is good, down to 0.65 is good *)
g1 = 10 * 10^6 / (2 * Pi * x2 * x1) - 248 * 10^6 * fact; (* stress constraint *)
g2 = 10 * 10^6 - (Pi^3 * (207 * 10^9) * x2^3 * x1) / (4 * 5 * 5); (* buckling constraint *)
g3 = -x2; (* non-negativity constraint *)
g4 = -x1; (* non-negativity constraint *)
```

specify the plot ranges for the design variables

In[∘]:=
```
x1L = 0;
x1U = 0.1;
x2L = 0;
x2U = 0.3;
```

specify the title of the plot

In[∘]:=
```
titleplot = "Tube Column Problem"
```

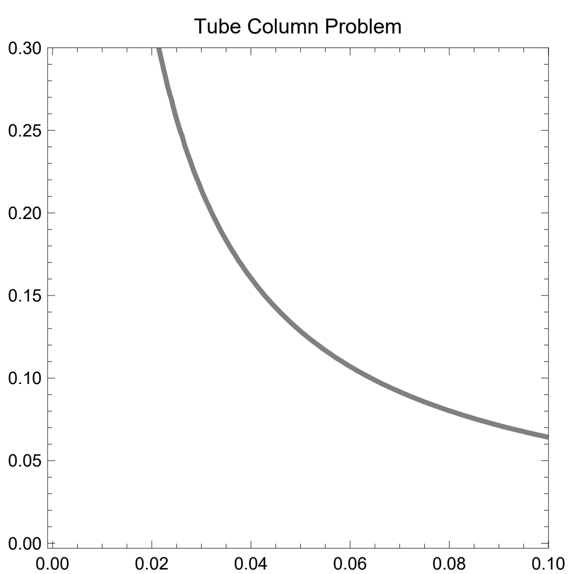
Out[∘]=
```
Tube Column Problem
```

Plot the constraint boundary for g1 constraint

In[∘]:=
```
Plotg1 = ContourPlot[g1, {x1, x1L, x1U}, {x2, x2L, x2U},
   ContourShading → False, Contours → {0}, ContourStyle → {{Thickness[0.01]}},
   AxesLabel → {"x1", "x2"}, Axes → True, PlotLabel → titleplot,
   ImageSize → 290, PlotRange → {{-0.01 * x1U, x1U}, {-0.01 * x2U, x2U}}];
```

In[∘]:=
```
Show[Plotg1]
```

Out[∘]=



Identify the infeasible and feasible side of constraint g1

In[ ]:=
```
x1g1infeas = 0.06;
x2g1infeas = 0.06;
testg1 = g1 /. {x1 → x1g1infeas, x2 → x2g1infeas}
g1test1pt = Graphics[{PointSize[Medium], Red, Point[{x1g1infeas, x2g1infeas}]}];
```

Out[ ]=

1.94097×10^8

In[ ]:=
```
x1g1feas = 0.06;
x2g1feas = 0.2;
testg1 = g1 /. {x1 → x1g1feas, x2 → x2g1feas}
g1test2pt = Graphics[{PointSize[Medium], Blue, Point[{x1g1feas, x2g1feas}]}];
```

Out[ ]=

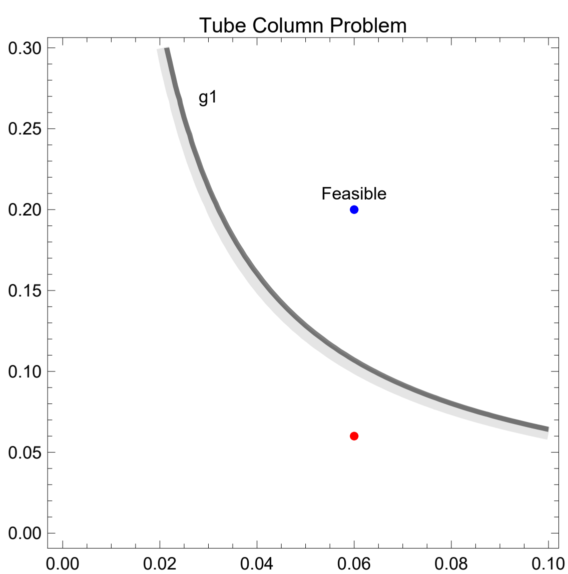
-1.15371×10^8

Plot constraint boundary, infeasible and feasible points for g1, and g1 constraint shading (which should be on infeasible side)

In[ ]:=
```
Plotg1 = ContourPlot[g1, {x1, x1L, x1U},
   {x2, x2L, x2U}, ContourShading → False, Contours → {0, 10000000.85},
   ContourStyle → {{Thickness[0.01]}, {GrayLevel[0.8], Thickness[0.025]}}];

Show[Plotg1, g1test1pt, g1test2pt,
 AxesLabel → {"x1", "x2"}, Axes → True, PlotLabel → titleplot,
 Epilog → {Text["g1", {0.03, 0.27}], Text["Feasible", {x1g1feas, x2g1feas + .01}]},
 ImageSize → 290, PlotRange → {{-0.01 * x1U, x1U}, {-0.01 * x2U, x2U}}]
```

Out[ ]=



You will need to plot the other constraints, identify their feasible and infeasible regions, and identify the overall feasible region.

In[∘]:=
```
x1feas = 0.06;
x2feas = 0.2;
feaspoint = Graphics[{PointSize[Medium], Magenta, Point[{x1feas, x2feas}]}];
```

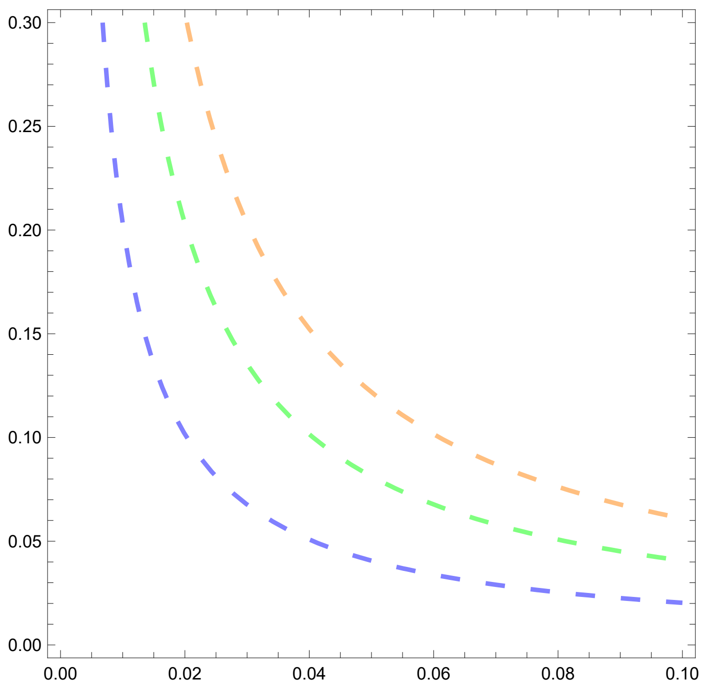
Pick contour values for cost function contour (you need at least 6)

In[∘]:=
```
cont1 = 500;
cont2 = 1000;
cont3 = 1500;
```

In[∘]:=
```
PlotP = ContourPlot[P, {x1, x1L, x1U}, {x2, x2L, x2U},
   ContourShading → False, Contours → {cont1, cont2, cont3},
   ContourStyle → {{Dashing[{0.03, 0.04}], Thickness[0.007], Blue}, {Dashing[{0.03, 0.04}],
      Thickness[0.007], Green}, {Dashing[{0.03, 0.04}], Thickness[0.007], Orange}}];
```

In[∘]:=
```
Show[PlotP]
```

Out[∘]=



Plotting contour legend values

In[∘]:=
```
contftext = ToString["f="];
cont1text = TextString[Row[{contftext , cont1}]]
```

Out[∘]=

```
f=500
```

In[∘]:=
```
cont2text = TextString[Row[{contftext , cont2}]];
cont3text = TextString[Row[{contftext , cont3}]];
```

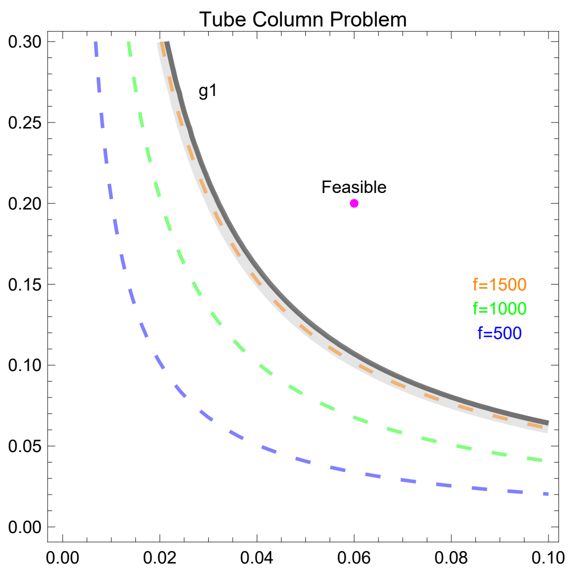
Plotting contour legend location in plot region, base is the bottom contour, shift is how much each subsequent contour is shifted from the previous contour legend

In[∘]:=
```
xfbase = 0.09;
xfshift = 0;
yfbase = 0.12;
yfshift = 0.015;
```

Combining constraints and contour plots

In[∘]:=
```
Show[Plotg1, PlotP, feaspoint, AxesLabel → {"x1", "x2"},
 Axes → True, PlotLabel → titleplot, Epilog → {Text["g1", {0.03, 0.27}],
   Text["Feasible", {x1feas, x2feas + .01}] , {Blue, Text[cont1text, {xfbase, yfbase}]},
   {Green, Text[cont2text, {xfbase + xfshift, yfbase + yfshift}]},
   {Orange, Text[cont3text, {xfbase + 2 * xfshift, yfbase + 2 * yfshift}]}},
 ImageSize → 290, PlotRange → {{-0.01 * x1U, x1U}, {-0.01 * x2U, x2U}}]
```

Out[∘]=



Plot the final plot with the solution point or with the end points and highlighted solution region as shown in the example

In[∘]:=
```
x1Apt = 0.029;
x2Apt = 0.22;

x1Bpt = 0.06;
x2Bpt = 0.108;

(* if cost function is parallel to portion of g1 constraint *)
HighPlot = ContourPlot[g1, {x1, x1Apt, x1Bpt}, {x2, x2Bpt, x2Apt},
   ContourShading → False, Contours → {0}, ContourStyle → {{Thickness[0.05], Magenta}}];
```

In[∘]:=
```
Show[Plotg1, PlotP, feaspoint, HighPlot, AxesLabel → {"x1", "x2"},
  Axes → True, PlotLabel → titleplot, Epilog → {Text["g1", {0.03, 0.27}],
    Text["Feasible", {x1feas, x2feas + .01}] , {Blue, Text[cont1text, {xfbase, yfbase}]},
    {Green, Text[cont2text, {xfbase + xfshift, yfbase + yfshift}]},
    {Orange, Text[cont3text, {xfbase + 2 * xfshift, yfbase + 2 * yfshift}]},
    {Red, Text["A", {x1Apt + 0.0015, x2Apt + 0.015}]},
    {Red, Disk[{x1Apt, x2Apt}, {0.0015, 0.005}]}, {Blue,
     Text["B", {x1Bpt + 0.0035, x2Bpt}]}, {Blue, Disk[{x1Bpt, x2Bpt}, {0.0015, 0.005}]}},
  ImageSize → 290, PlotRange → {{-0.01 * x1U, x1U}, {-0.01 * x2U, x2U}}]
```

Out[∘]=