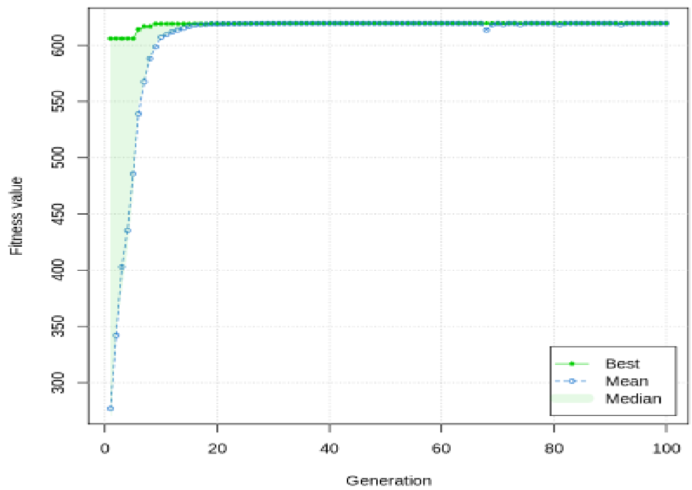
Assignment 5
Trevor Lacoste

Cross Section Area (f1) = (2*x2*x4) + x3*(x1-2*x4)




```
GA settings:
Type                  =  real-valued
Population size       =  50
Number of generations =  100
Elitism               =  2
Crossover probability =  0.75
Mutation probability  =  0.001
Search domain =
      x1 x2  x3  x4
lower 10 10 0.9 0.9
upper 80 50 5.0 5.0

GA results:
Iterations             = 100
Fitness function value = 619.643
Solution =
           x1       x2      x3       x4
[1,] 76.71968 46.80869 4.33688 3.377758
[1] "Best Solution:"
       x1        x2         x3         x4
76.719678 46.808686  4.336880  3.377758
```

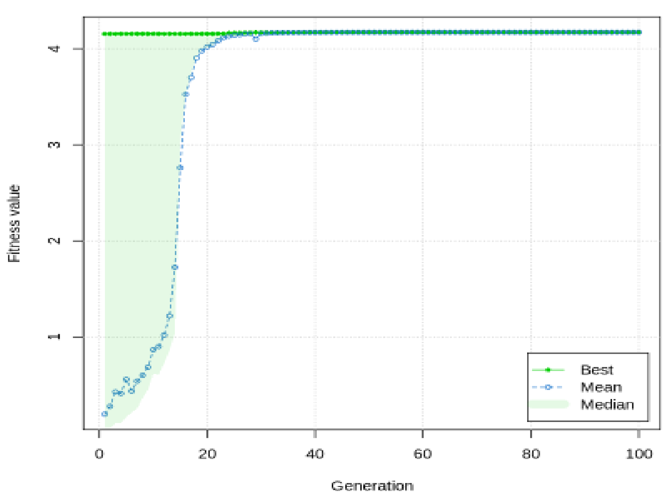
Best solution values:

- X1 = 76.72
- X2 = 46.81
- X3 = 4.37
- X4 = 3.38

Average population fitness = 619.643

With the graph of the cross-section area, as the generation increases, the fitness value rises rapidly at first, then starts to level out around generation 20.

Static deflection (f2) = (60000) / (x3*((x1 - 2*x4)^3) + 2*x2*x4*(4*(x4^2) + 3*x1*(x1 - 2*x4)))




```
GA settings:
Type                  =  real-valued
Population size       =  50
Number of generations =  100
Elitism               =  2
Crossover probability =  0.75
Mutation probability  =  0.001
Search domain =
      x1 x2  x3  x4
lower 10 10 0.9 0.9
upper 80 50 5.0 5.0

GA results:
Iterations             = 100
Fitness function value = 4.172078
Solution =
           x1       x2       x3       x4
[1,] 11.74513 10.57188 1.528805 2.511262
[1] "Best Solution:"
       x1        x2         x3         x4
11.745135 10.571883  1.528805  2.511262
```

Best solution values:

- X1 = 11.75
- X2 = 10.57
- X3 = 1.53
- X4 = 2.51

Average population fitness = 4.172

With the static deflection graph, the fitness value increase is more gradual, and it starts to level out around generation 25.

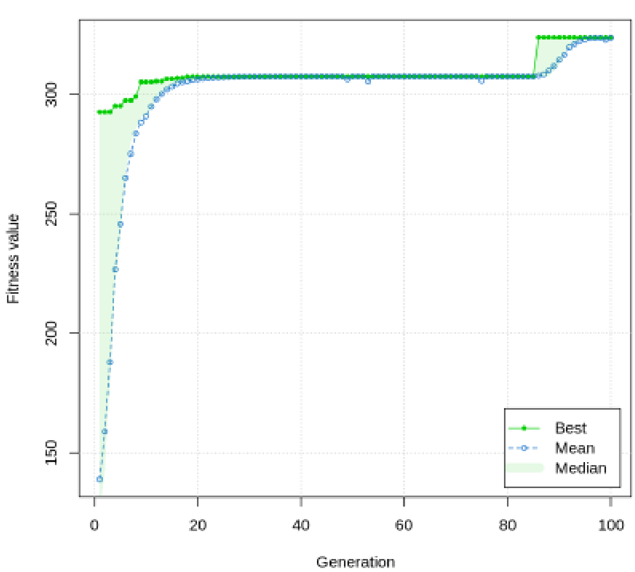
The solution values of the cross-section area graph show that all the x values are higher than those of the static deflection graph. This is because as the width of the beams increases, the area of the cross-section would also increases. The highest values would be optimal for this metric. In the case of static deflection, the x values are lower. Having a smaller area in the cross-section of a beam means that there is less static deflection. Since both traits are desirable but are only possible with conflicting dimensions, balancing both may lead to the strongest beam.

By combining both equations into one function, we can test how altering the prioritization of each attribute affects the solution.

```
a <- .5
b <- .5

crossSection <- (2*x2*x4) + x3*(x1-2*x4)
staticDeflection <- (60000) / (x3*((x1 - 2*x4)^3) + 2*x2*x4*(4*(x4^2) + 3*x1*(x1 - 2*x4)))

return (a*crossSection + b*staticDeflection)
```




```
GA settings:
Type                  =  real-valued
Population size       =  50
Number of generations =  100
Elitism               =  2
Crossover probability =  0.75
Mutation probability  =  0.001
Search domain =
      x1 x2  x3  x4
lower 10 10 0.9 0.9
upper 80 50 5.0 5.0

GA results:
Iterations             = 100
Fitness function value = 323.7836
Solution =
           x1       x2       x3      x4
[1,] 71.92134 48.81362 4.051641 3.97836
[1] "Best Solution:"
       x1         x2         x3         x4
71.921340 48.813615  4.051641  3.978360
```

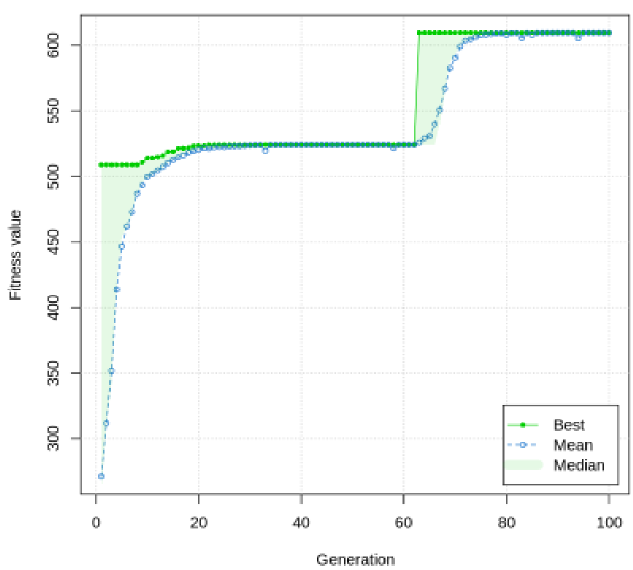
When a has a value of .5 and b has a value of .5, the graph differs from the previous two. After 20 generations, the best line has flattened out and is nearly equal to the mean. After generation 80, there is another jump in fitness value for the best, and after generation 90, the best and mean are equal again. The solution values are all near the higher end of the constraints, closer to the solution when only looking at the cross-section area.

The next step was giving the cross-section area a way higher priority than static deflection and seeing how that affected the results.

```
a <- .9
b <- .1

crossSection <- (2*x2*x4) + x3*(x1-2*x4)
staticDeflection <- (60000) / (x3*((x1 - 2*x4)^3) + 2*x2*x4*(4*(x4^2) + 3*x1*(x1 - 2*x4)))

return (a*crossSection + b*staticDeflection)
```

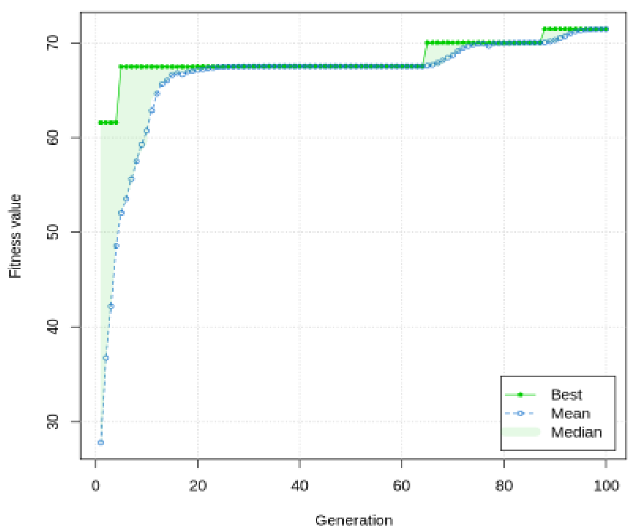



```
GA settings:
Type                  =  real-valued
Population size       =  50
Number of generations =  100
Elitism               =  2
Crossover probability =  0.75
Mutation probability  =  0.001
Search domain =
      x1 x2  x3  x4
lower 10 10 0.9 0.9
upper 80 50 5.0 5.0

GA results:
Iterations             = 100
Fitness function value = 609.629
Solution =
           x1       x2       x3       x4
[1,] 72.87427 46.28623 4.668795 4.050341
[1] "Best Solution:"
         x1        x2        x3        x4
72.874270 46.286229  4.668795  4.050341
```

Giving the value .9 to a and .1 to b results in a graph with two giant leaps in fitness value. In the first 20 generations, the mean fitness value quickly increases to the best fitness value and remains stagnant until generation 60. Then, there is a significant spike in the best fitness value, and at around generation 75, the mean fitness value is about equal to the best at around 600. Since the cross-section area is heavily prioritized in this function, it is unsurprising that the solution values are similar to those of the model that only uses the cross-section area.

The last test was to see how heavily prioritizing static deflection in the combined model affects the solution and fitness value.




```
GA settings:
Type                  =  real-valued
Population size       =  50
Number of generations =  100
Elitism               =  2
Crossover probability =  0.75
Mutation probability  =  0.001
Search domain =
      x1 x2  x3  x4
lower 10 10 0.9 0.9
upper 80 50 5.0 5.0

GA results:
Iterations             = 100
Fitness function value = 71.49106
Solution =
           x1       x2       x3       x4
[1,] 77.1352 48.74584 3.943895 4.582752
[1] "Best Solution:"
        x1         x2         x3         x4
77.135201 48.745843  3.943895  4.582752
```

Giving the value of .1 to a and .9 to b yields a graph with consistent increases in the best fitness value over the 100 generations. Eventually, at around generation 90, the best and mean fitness values stagnate at about 70. The solution results are surprising. Given that static deflection has a weight of .9, you would expect the solution values to be lower and similar to the values where only static deflection was used. However, the solution values are all relatively high and closer to the model that only uses cross-section area.

Based on these results, minimizing the cross-section area tends to lead to a lighter beam, but it comes at the expense of increased static deflection. Also, minimizing the static deflection may require an increase in the cross-section area to enhance the stiffness of the beam. Based on the lowest fitness value of the last model, where static deflection is prioritized over the cross-section area, that model yields the best solution dimensions for the beam.