```
     from __future__ import division
     import sys, random, math, datetime, time,re
     sys.dont_write_bytecode = True

 5   class Model:

       def name(i):
         return i.__class__.__name__

10     def generate_x(i):
         x= [i.lo + (i.hi-i.lo)*random.random() for _ in range(i.n)]
         return x

       def sa_neighbor(i, old):
15       new = old
         for j in range(len(old)):
           if random.random() ≤0.33:
             new_gen = i.generate_x()
             old[j] = new_gen[0]
20       # print old
         return old

       def mws_neighbor(i,solution):
         optimized_index = random.randint(0, len(solution)-1)
25       increment = (i.hi - i.lo)/10
         temp_min = 10*(5)
#        print "old solution : %s" % solution
         for _ in range(10):
           solution[optimized_index] = i.lo + increment
30         temp = i.norm(i.f1_plus_f2(solution))
           if temp < temp_min:
             temp_min = temp
#        print "new solution : %s" % solution
         return solution

35

       def baseline(i):
       # model = eval(model+"()")
         i.min = 10**(5)
40       i.max = -10**(5)
         for _ in xrange(100000):
           temp = i.f1_plus_f2(i.generate_x())
           if temp > i.max:
             i.max = temp
45         if temp < i.min:
                 i.min = temp
         return i.min, i.max

       def norm(i, x):
50         e = (x - i.min)/(i.max - i.min)
             return e

     class Schaffer(Model):
       def __init__(i):
55       i.lo = -2
         i.hi = 2
         i.n = 1
       def f1_plus_f2(i, x_list):
         # x = i.generate_x()
60       for item in x_list:
           f1 = item**2
           f2 = (item-2)**2
         return f1 + f2


65
     class Fonseca(Model):
       def __init__(i):
         i.lo = -4
         i.hi = 4
70       i.n = 3

       def f1_plus_f2(i, x_list):
         n = i.n
```

```
       def f1_sum(x_list, n):
75       value = []
         for item in x_list:
           value.append((item - 1/math.sqrt(n))**2)
         return sum(value)

80     def f2_sum(x_list, n):
         value = []
         for item in x_list:
           value.append((item + 1/math.sqrt(n))**2)
         return sum(value)

85
       f1 = 1 - math.e ** (-1* f1_sum(x_list, n))
       f2 = 1 - math.e ** (-1* f2_sum(x_list, n))
       return f1+f2

90   '''kusarys'''
     class Kursawe(Model):
       def __init__(i):
         i.lo = -5
         i.hi = 5
95       i.n = 3

       def f1_plus_f2(i, x_list):
         n = i.n
         def f1_inner(x_list, n):
100         value = []
           for i in range(n-1):
             value.append(-10 * math.e **(-0.2 * math.sqrt(x_list[i]**2 + x_list[i+1]
     **2)))
           return value

105       def f2_inner(x_list, n):
           value = []
           a = 0.8
           b = 3
           for item in x_list:
110           value.append(abs(item)**a + 5 * math.sin(item)**b )
           return value
         f1 = sum(f1_inner(x_list, n))
         f2 = sum(f2_inner(x_list, n))
         return f1+f2
115
     class ZDT1(Model):
       def __init__(i):
         i.lo = 0
         i.hi = 1
120       i.n = 30

       def f1_plus_f2(i, x_list):
         def f1(x_list):
           return x_list[0]
125       def g(x_list):
           val = 0
           for item in x_list[1:]:
             val += item
           return 1+ 9*(val)/(i.n-1)
130       def f2(x_list):
           g1 = g(x_list)
           return  g1* (1 - math.sqrt(x_list[0]/g1))
         return f1(x_list)+f2(x_list)


135
```

```
     from __future__ import division
     import sys, random, math
     from models import *
     from base import *
5    import numpy as np
     from xtile import *
     sys.dont_write_bytecode = True


10   @printlook
     def sa(model):
       def P(old, new, t):
         prob = math.e**((old - new)/t)
         return prob
15     min_energy, max_energy = model.baseline()
       s = model.generate_x()
       e = model.norm(model.f1_plus_f2(s))
       sb = s
       eb = e
20     k = 1
       while k < Settings.sa.kmax:
         sn = model.sa_neighbor(s)
         en = model.norm(model.f1_plus_f2(s))
         if en < eb:
25           sb = sn
             eb = en
             say('!')
         if en < e:
           s = sn
30         e = en
           say('+')
         elif P(e, en, (k/Settings.sa.kmax)) < random.random():
           s = sn
           e = en
35         say('?')
         say('.')
         k = k+1
         if k % 40 ≡ 0:
           print "\n"
40         say(str(round(eb,3)))

       # say(str(sb))
       print "\n------\n:e",str(round(eb,3)),"\n:solution",sn
       return eb
45   #
     @printlook
     def mws(model):
       max_tries = 50
       max_changes = 2000
50     min_energy, max_energy = model.baseline()
       threshold = 0.01
       total_changes = 0
       total_tries = 0
       norm_energy = 0
55     p = 0.25
       for _ in range(Settings.mws.max_tries):
         total_tries += 1
         solution = model.generate_x()
         for _ in range(Settings.mws.max_changes):
60         norm_energy = model.norm(model.f1_plus_f2(solution))
           if norm_energy ≤ Settings.mws.threshold:
             print "total tries: %s" % total_tries
             print "total changes: %s" % total_changes
             print "min_energy:{0}, max_energy:{1}".format(min_energy, max_energy)
65           print "min_energy_obtained:%s" % model.f1_plus_f2(solution)
             print "\n------\n:e",str(round(norm_energy,3)),"\n:solution",solution
             return norm_energy
           if Settings.mws.prob < random.random():
             solution[random.randint(0,model.n-1)] = model.generate_x()[random.randin
     t(0,model.n-1)]
70         else:
             # solution = optimal_neighbor(solution, model, min, max)
             solution = model.mws_neighbor(solution)
```

```
             total_changes +=1

75   def Demo():
       r = 20
       for klass in [Schaffer, Fonseca, Kursawe, ZDT1]:
         print "\n!!!!", klass.__name__
         for searcher in [sa, mws]:
80         name = searcher.__name__
           n = 0.0
           reseed()
           scorelist = []
           for _ in range(r):
85           name, x =searcher(klass())
             n += float(x)
             scorelist +=[float(x)]
           print xtile(scorelist,lo=0, hi=1.0,width = 25)
           print "#{0}:{1}".format(name, n/r)

90   if __name__ ≡ "__main__": Demo()
```

```
     from __future__ import division
     import sys, random, math, datetime, time,re
     sys.dont_write_bytecode = True

5    class Options: #"Thanks for Peter Norvig's trick"
       def __init__(i, **d): i.__dict__.update(d)

     Settings = Options(sa = Options(kmax = 1000,
                                     baseline = 1000),
10                      mws= Options(threshold = 0.1,
                                     max_tries = 50,
                                     max_changes = 1000,
                                     prob = 0.25,
                                     ) )

15   def reseed():
             seed = 1
             return random.seed(seed)

20   def say(mark):
       sys.stdout.write(mark)
       sys.stdout.flush()

     def printlook(f):
25     def wrapper(*lst): #tricks from Dr.Menzies
         ShowDate = datetime.datetime.now().strftime
         print "\n###", f.__name__, "#" * 50
         print "#", ShowDate("%Y-%m-%d %H:%M:%S")
         beginTime = time.time()
30       x = f(*lst)
         endTime = time.time()
         print "\n" +("-"*60)
         dump(Settings, f.__name__)
         print "\n# Runtime: %.3f secs" % (endTime-beginTime)
35       return f.__name__, x # return the searcher name and the results
       return wrapper

     def dump(d, searchname, lvl = 0): # tricks from Dr. Menzies
       d = d if isinstance(d, dict) else d.__dict__
40     callableKey, line , gap = [], "", " "*lvl
       for k in sorted(d.keys()):
         val= d[k]
         if isinstance(val, (dict, Options)):
           callableKey += [k]
45       else:
           #if callable(val):
           # val = val.__name__
           line +=(" {0}:{1}".format(k, val))
       print gap + line
50     for k in callableKey:
         if k ≡ searchname:
           print gap + (":{0}{1}".format(k, "options"))
           dump(d[k], lvl+1)
```

```
     from __future__ import division
     import sys, random, math, datetime, time,re
     sys.dont_write_bytecode = True


5
     def pairs(lst):
       last=lst[0]
       for i in lst[1:]:
         yield last,i
10       last = i

     def xtile(lst,lo=0,hi=0.001, width = 50,
                  chops=[0.1 ,0.3,0.5,0.7,0.9],
                  marks=["-" ," "," ","-"," "],
15                 bar="|",star="*",show=" %3.0f"):
       """The function _xtile_ takes a list of (possibly)
     unsorted numbers and presents them as a horizontal
     xtile chart (in ascii format). The default is a
     contracted _quintile_ that shows the
20   10,30,50,70,90 breaks in the data (but this can be
     changed-- see the optional flags of the function).
       """
       ordered_list = sorted(lst)  # Dr.Menzies tricks
       lo = min(lo, ordered_list[0])
25     hi = max(hi, ordered_list[-1])
       showNumbers = [ ordered_list[int(percent * len(lst))] for percent in chops]
       # print showNumbers
       showMarks = [" "] * width
       def find_index (x):
30       return int(width*float((x-lo))/(hi-lo))
       markIndex = [find_index(i) for i in showNumbers]
       for i in range(width):
         if i in range(markIndex[0],markIndex[1]+1) ∨ i in range(markIndex[-2],markI
     ndex[-1]+1):
           showMarks[i] = "-"
35     #print showMarks
       showMarks[int(width * 0.5)] = "|"
       showMarks[find_index(ordered_list[int(len(lst)*0.5)])] = "*"
       return " ".join(showMarks) + " ".join([str(round(i,3)) for i in showNumbers])

40   def Demo() :
       import random
       random.seed(1)
       # nums = [random.random()**2 for _ in range(100)]
       #nums = [0.011,0.01,0.01,0.01,0.01,0.01,0.01,0.01,0.01]
45     nums = [0,0.1,0.1,0.1,0.1,0.1,0.1,0.1, 0.1]
       print xtile(nums,lo=0,hi=1.0,width=25,)


     if __name__ ≡ "__main__": Demo()
```

```
       !!!! Schaffer

     ### sa #################################################
     # 2014-09-16 11:20:06
 5   ....?..........+.....!+..!+..?..+....!+..?....+..?..

     0.005..+.+.....?....?..?....+.....+.......+.......?...

     0.005..+....?..........?......+..?..+.!+...?.?.+........
10   0.001.......?..+.?..+...?.+..?..+...?......+.......?....

     0.001.?.....+....+...!+....?.....+..........?.+.+.+...
15   0.0+...?.+..+.....?.+..?..+...+.......+...........?..+..

     0.0....?.+....+..........+...+..?.+...?.+..+........?.

     0.0....+.......?...?....+.?.....+.................
20   0.0+.....?..+...+.+.....?.!+...?...+..+.?.?...+...!+......

     0.0......?..+...............+.........+.....?.+..+...
25   0.0+....?..+..+...+.+.?..+........+..?....+.....+.+.....

     0.0.+....+......?..........+.....?......?...

     0.0..?.+...+.......?.+....?...+..+..?.+.....+.?..?..+.+.?..
30   0.0.+...?....+..?..+.....+..........?...+..?...+....?.+..

     0.0........?.....+.......+...+......?..+....?.
35   0.0?........?.....+...+..?........?.+........?.....

     0.0+.......+.............?..?..+.+.?...?...+......+..?.+..

     0.0..+..?..+.+.?.+.+..?........+..?...+.......+.?..+..?.+...
40   0.0?..+..........+.....+.+..+.............?.......

     0.0...+....+....+....?.+..?.......?..+.........?....+.

45   0.0.......+..?...+.......?......+..?.+.....?..+....

     0.0...?...+..+..+...?..+.............?.+.+..?.+.....+.+.+..

     0.0....?...+.+..+.....+...?.....+..?..+..........
50   0.0+..........?....+....?....+.......?.....+..+.+.+.

     0.0...................?..+...+......?..+.+....+..
55   0.0
     ------
     :e 0.0
     :solution [1.5671454312713342]

60   ------------------------------------------------------------

       :sa options
       baseline :1000  kmax :1000

65   # Runtime: 0.214 secs
     *                       |                    0.0 0.0 0.0 0.0 0.0
     # sa:1.05761319584e-05

70   ### mws #################################################
     # 2014-09-16 11:20:10
     total tries: 1
     total changes: 4
```

```
     min_energy:2.0000000001, max_energy:19.9995723424
75   min_energy_obtained: 2.56908160955

     ------
     :e 0.032
     :solution [0.4665763365073734]
80
     ------------------------------------------------------------

       :mws options
       max_changes :1000  max_tries :50  prob :0.25  threshold :0.1
85
     # Runtime: 0.244 secs
     - * -                   |                    0.001 0.024 0.044 0.07 0.086
     # mws:0.0408786903341

90   !!!! Fonseca

     ### sa #################################################
     # 2014-09-16 11:20:31
     ...........!+.!+..!+.!+..........?.......!+.!+......?.
95
     0.996+........+........+.!+.?.+....................

     0.827...............+..?...+..?..+.?.....?....+..+.....
100  0.827.?....!+.?.+.+..+.....?..+......+...?..........+....

     0.662...............?.+..+..+..?....?.....+..+.....+..

     0.662.+...+....+..+.+.?.........................+.!+.?.
105  0.073+.?...+............+....+.?...+..+....?...+..?....

     0.073......+.....+.+.....?..+............+...........
110  0.073?......+..+..........+........?....+.+.........

     0.073.+......................+...?...+.........+.+.

     0.073..+..?.....+......+......+.....?.+.....+.+.+......
115  0.073?.+..........+....?......+..........+.....

     0.073+...?...+..+.......+......+.?.+...+.........+...?...
120  0.073...+....?.+...+.+.+......+...............+..?..

     0.073.+.?.+......+.?.....+.+..+....+...?.+..?...?..+..+...+.+...

     0.073.....+.?.+.........?.+....+.............+....
125  0.073..............+.+..?....+..+...+.....?.+..+.+....

     0.073................+....................
130  0.073....................+.+.?....+..........

     0.073...................................

     0.073...........+.+.....?.+..+.................
135  0.073...+...+.....?............+..............

     0.073...................................

     0.073...........+.+.....?.+..+.................
140  0.073.+...................................

     0.073........?.+..+...+..?..+.+...?...+..?..+.....?......
     0.073
145  ------
     :e 0.073
```

```
        :solution [3.4127805946152137, -0.8408355720745444, -1.5435740246839105]

       ------------------------------------------------------------

        :sa options
150      baseline :1000  kmax :1000

       # Runtime: 0.910 secs
155    -  *   - - -            |                    0.043 0.073 0.102 0.181 0.248
       # sa:0.115887816564

       ### mws ##############################################
       # 2014-09-16 11:20:48
160    total tries: 5
       total changes: 4858
       min_energy:0.986700811861, max_energy:2.0
       min_energy_obtained: 1.07551905128

165    ------
       :e 0.088
       :solution [-0.42051556091774067, -0.3937083660305962, -0.26033259709415013]

       ------------------------------------------------------------
170
        :mws options
        max_changes :1000  max_tries :50  prob :0.25  threshold :0.1

       # Runtime: 0.879 secs
175    -  *  -                 |                    0.027 0.045 0.07 0.078 0.096
       # mws:0.0603071977659

        !!!! Kursawe
       ### sa ##############################################
180    # 2014-09-16 11:21:04
       ?.?..+...!+.?.?.+.?.+..?.?.!+.?.+..?.+.?.?.+.?.+...?.?.+.+...?.+..+..?.

       0.26+.+.?.+..?.!+.!+.!+.?.?.?.?...+..+.+..+......?.?.?.+..+.+.?.+.+.?.+.?.+..

185    0.177?.?..+..?.....+......+..+...!+.?.+.?..+..+..?.+..+..?..+...

       0.105?.+.+.+.+...+...?.+.?.+..+..+.?....?...+.+...?.+.+...?.+...?.+.?.

       0.105+..+..+..?...+......+..+...?.+.+......+...+..?.....+.?.
190
       0.105+..+.?.+...?...+..?....+...+.?....?.+..+.+..+.?.+.+.?..+..+..+.

       0.105.+.+..+.!+...?.?..?.+..+...?..+.....+..+...?.+..+.+..?.....

195    0.092.?.+...+.....+...?.......+...?.+.?.+.?...+...?.+.+.+..+.

       0.092?...+.?.+...?..?..+.+.+.....+......?.....+.......?.+.+.?.

       0.092+....+..+..?.+....+.+.+..+.?..?.+..+..+....?.+.......?...+.+.
200
       0.092....+.+.?...+..+....?...+..+....+..?.+..?.+.+.+.+.

       0.092..?...+...?............+...+.....?.+...?...?..?.+.

205    0.092........+.+...?..+.......+..?.+.?.+..?.+..+......+.

       0.092..?.+...+..+..+....?..?..+.+.+.!+.?...+.?...+...+.+..?..

       0.087.?......?.+....?.+...?.+.+.+.+...+.+....?..+....+.+.
210
       0.087.....+..?......+.+..?.....+.?.+.+..?.?.+..+.....+......

       0.087.......?.+.+....+.?.!+.?.+..?....+..+.+......+.....?..

215    0.048.....?..+.+.+.+.+.?.+....?..+..+.+.+.+.+.+.+....+.....?.+..

       0.048...+.+.+.?.....?.+..?....+.?...+....?..?........?..?.+.

       0.048.+........+......?.....+..?.+......+..+..+..?....
```

```
220
       0.048...+...+....?......+.+.+.........?.+..+..........

       0.048...+...+..?.+..?....?.+.+.....+.+..?.+.+..+..............?.

225    0.048..+...+.+.+..?..+..?.....+....?..+..?.+.+.+.....?.+...?.+.

       0.048....+..............?..+..+..+...?.?...+..+.+...?.+...

       0.048...?..+.+.....?..+.+.+.......?.+.+...?..+....+...?....+..
230
       0.048
       ------
       :e 0.048
       :solution [-0.8918921477563906, 0.3968432811879987, -4.815015048238008]
235
       ------------------------------------------------------------

        :sa options
        baseline :1000  kmax :1000
240
       # Runtime: 0.774 secs
       -  *                    |                    0.033 0.044 0.048 0.054 0.075
       # sa:0.0485061141047
       ### mws ##############################################
245    # 2014-09-16 11:21:20
       total tries: 1
       total changes: 931
       min_energy:-23.7069922568, max_energy:20.1835488796
       min_energy_obtained: -20.3945670322
250
       ------
       :e 0.075
       :solution [-0.021268023855830265, -1.2469559834035793, -1.0865411100224929]

255    ------------------------------------------------------------

        :mws options
        max_changes :1000  max_tries :50  prob :0.25  threshold :0.1

260    # Runtime: 0.769 secs
        *  -                   |                    0.063 0.075 0.078 0.09 0.097
       # mws:0.0790511335029

        !!!! ZDT1
265
       ### sa ##############################################
       # 2014-09-16 11:21:54
       !+.!+.?.!+.?.!+.?.+.+..!+.!+.!+.?.+.?.!+.!+..!+.?.?.?.?.+.+.?.?.+.?.+.+.?..+.+.+
       .?.+.
270
       0.157+..?.+.+.+.?.?.+..+..?...+.+.?..?.?.?.+.+.+.+.?...+.?.+.+.?.+..?.+.?.

       0.157+.?...?.?...+.?.+..?.?.+.+..+..?.?.?.+.?.?.+.!+..?.+...+.+..?.+..

275    0.148.+.?.?..+.+.?..+...?.+.+.?.+.+.+.?.+..+.?..+.?..?.?.+.+..+.?.+.+.+..

       0.148.?.+.+.+....+.?........?...?......+..?.?..+.+..?.+....+...

       0.148?.+.+..?.+.+.+..?..?.+.+.+...+.?.?..+.+..........?.+....?.+.+.+..
280
       0.148+..?.+......+..?....?.+.?..+..+..?.+......?.+.+.+.+..?.+.+...?.

       0.148+.+.+..+.+.?..+..?.?.+.+.+.+.?....?...?..?.+.?.+.+.+..+..?.+.+.+.

285    0.148+.+.?.?..+.+.....+.+..+!+.?.+........?.+.?........+.?.+..?..

       0.137?.?.+.+.+..+.+...+.?.?.+.+..+.+.+....?.+...+.?.?...?.+.+.+.+.+.+..?.

       0.137+.+..?.+.?.+..+.+..+..+....+......?.?..+..?..+.?.+.+..?..+.+.+..+.
290
       0.137..?.+..+.?.+.?....+.+.+.....+..?..+..?..+..?..+......?.+.
```

```
     0.137.+.+..+.?.+..+.+.+......?..+........+....?.+.?.....?.+.+.

295  0.137.?.+.+.+.+......?.+.+..?.?.+.+.+.+.+.+.+..?.+.+.+....+.....+.+.+...

     0.137...?.+.+.+.+.......?..+.+.?.+..?..+.+.+.+.+..+..?......+.?.?.

     0.137+...?.+.....+.+...?.+.+.+.+.+.....?.+.....?.+.+.+..?.+.+..+.

300  0.137+.......?.+.+.+.+.+..?..+....?.....?.+.....+.+..+.+.+..!+....

     0.133....?...+................?....+.+........+.?.+..

305  0.133+......?.?..+.+....?.+.+.+.+....?.?.+..............+....

     0.133.+.....?.+.+..+.+..+.+.?.+.+..+.+..?.+....?.+....?.+.+....+.+.

     0.133....+..+..........+...?.+.?.+........?..+..+.+.+....

310  0.133..?.+.+.......?.+.+.+.......?.+.......+..+..+.+..?....

     0.133+........+.+......+....?....+.+.+.+....?..+........

315  0.133.?.+.+.+..+..+.+..........?.+....+.+.+...?.+.+..+.......

     0.133+........?.+.+..+..+....+.+..........?.+.+.+........

     0.133
320  ------
     :e 0.133
     :solution [0.6226493416557429, 0.6456872454020296, 0.2687855026766621, 0.5956706
     219405223, 0.1141327473907695, 0.9026586810185874, 0.6224661786744874, 0.2429323
     5033409943, 0.4332931191306244, 0.35622003229698374, 0.6540829766757836, 0.69665
     65058304421, 0.43813124627197364, 0.2544068531181397, 0.03826837279431283, 0.110
     99842856556397, 0.1534933534196381, 0.31764002469979224, 0.577171168471057, 0.91
     44780717761192, 0.6800902595151318, 0.6711921278305072, 0.04696754246478341, 0.7
     016974598248148, 0.08817964398062184, 0.08484686616931092, 0.503507701870261, 0.
     5481624391094364, 0.13174000058736457, 0.7934796552278347]

     ----------------------------------------------------------------
325
      :sa options
      baseline :1000  kmax :1000

     # Runtime: 1.798 secs
330  - - * -          |                     0.029 0.063 0.1 0.126 0.172
     # sa:0.0954962600014

     ### mws ##################################################
     # 2014-09-16 11:22:29
335  total tries: 1
     total changes: 512
     min_energy:2.58239943243, max_energy:6.67260442937
     min_energy_obtained: 2.96141381544

340  ------
     :e 0.093
     :solution [0.9674549863279276, 0.1, 0.5726937918984928, 0.005452811788125067, 0.
     892125000653359, 0.42630376823985805, 0.1, 0.1, 0.009083274604547276, 0.1, 0.1,
     0.2271221575423248, 0.5599437829747516, 0.1, 0.4140735340241055, 0.9674876173027
     758, 0.1, 0.1, 0.6292884520678101, 0.7381131979995659, 0.20195481740338972, 0.1,
      0.3681510441151602, 0.8225228923278897, 0.6415627480716332, 0.3333915768353596,
      0.3697821265833152, 0.22131097626810248, 0.1, 0.10010103654839764]

     ----------------------------------------------------------------
345
      :mws options
      max_changes :1000  max_tries :50  prob :0.25  threshold :0.1

     # Runtime: 1.555 secs
350  - *              |                     0.075 0.089 0.094 0.096 0.099
     # mws:0.0905807202073
```