```
#From Class Discussion 8/26/2014
from __future__ import division
import sys,re,random,math
import numpy as np
sys.dont_write_bytecode = True

kmax = 5000
cooling = 1

#Structure from SA Lecture
def say(x):
  sys.stdout.write(str(x)); sys.stdout.flush()

rand = random.random

class Fonesca:
  smin = −4
  smax = 4
  XVar = [random.uniform(smin, smax) for i in range (0, 3)]
  XVarMax = XVar
  eMax = 0
  eMin = 0

  def Energy(self):
    f1 = (1−math.e**(−np.sum([self.XVar[i]−(1/np.sqrt(i+1))**2 for i in range (0, 3)])))
    f2 = (1−math.e**(−np.sum([self.XVar[i]+(1/np.sqrt(i+1))**2 for i in range (0, 3)])))
    return (math.fabs(f1+f2) − self.eMin) / (self.eMax − self.eMin)

  def RawEnergy(self):
    f1 = (1−math.exp(−np.sum([self.XVar[i]−(1/np.sqrt(i+1))**2 for i in range (0, 3)])))
    f2 = (1−math.exp(−np.sum([self.XVar[i]+(1/np.sqrt(i+1))**2 for i in range (0, 3)])))
    return math.fabs(f1+f2)

  def Neighbor(self):
    self.XVar[random.randint(0, 2)] = random.uniform(self.smin, self.smax)

  def Chaos(self):
    self.XVar[0] = random.uniform(self.smin, self.smax)
    self.XVar[1] = random.uniform(self.smin, self.smax)
    self.XVar[2] = random.uniform(self.smin, self.smax)

  def Baseline(self, numRuns):
    self.Chaos()
    self.eMax = self.eMin = self.RawEnergy()
    runs = 1
    while runs < numRuns:
      self.Neighbor()
      eNew = self.RawEnergy()
      if eNew > self.eMax: #find largest difference
        self.eMax = eNew
        self.XVarMax = self.XVar
        #print self.XVarMax, eNew
      if eNew < self.eMin: #find smallest difference
        self.eMin = eNew
        #print ’Min: ’, self.XVar, eNew
      runs += 1
    print ’Baseline: ’, self.eMin, ’,’, self.eMax

  def __init__(self):
    print ’Initializing Fonesca...’
    self.Baseline(10000)
    self.XVar = self.XVarMax
    print ’Initialized.’

#Structure from SA Lecture
def main():
  fon = Fonesca()
  XVarBest = fon.XVar
  eBest = e = 1
  print ’start energy: ’, eBest
  k = 1
  say(int(math.fabs(eBest−1)*100))
  say(’ ’)
  while k < kmax:
    fon.Neighbor()
    eNew = fon.Energy()
    if eNew < eBest:
```

```
      eBest = eNew
      XVarBest = list(fon.XVar)
      say(’!’)

    #print ’Check: ’, math.exp(−1*(eNew−e)/(k/kmax**cooling))

    if eNew < e:
      e = eNew
      say(’+’)
    #Probability Check from SA Lecture
    elif math.exp(−1*(eNew−e)/(k/kmax**cooling)) < random.uniform(0,1):
    #P function should be between 0 and 1
    #more random hops early, then decreasing as time goes on
      fon.Chaos()
      say(’?’)
    say(’.’)
    k = k + 1
    if k % 50 ≡ 0 ∧ k ≠ kmax:
      print ’’
      say(int(math.fabs(eBest−1)*100))
      say(’ ’)

  print ’\nFound best − e: ’, eBest
  print ’Variables: ’, XVarBest[0], ’,’, XVarBest[1], ’,’, XVarBest[2]

main()
```

```
Initializing Fonesca...
Baseline:  4.5882286632e-05 ,  558799.359426
Initialized.
start energy:  1
0 !+.........?........?.!+.........!+.............!+.....!+....
99 ..................................................
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Found best − e:  1.78963630605e−10
Variables:  3.64764598844 ,  3.73831469169 ,  3.25415662207
```

```
#From Class Discussion 8/26/2014
from __future__ import division
import sys,re,random,math
import numpy as np
sys.dont_write_bytecode = True

maxTries = 500
maxChanges = 500
#threshold; well, how close do we want to get?
threshold = .000001
cooling = 1


#Structure from SA Lecture
def say(x):
  sys.stdout.write(str(x)); sys.stdout.flush()

rand = random.random

class FonescaMWS:
  smin = −4
  smax = 4
  XVar = [random.uniform(smin, smax) for i in range (0, 3)]
  XVarMax = XVar
  eMax = 0
  eMin = 0
  slices = 10

  def Energy(self):
    f1 = (1−math.e**(−np.sum([self.XVar[i]−(1/np.sqrt(i+1))**2 for i in range (0, 3)])))
    f2 = (1−math.e**(−np.sum([self.XVar[i]+(1/np.sqrt(i+1))**2 for i in range (0, 3)])))
    return (math.fabs(f1+f2) − self.eMin) / (self.eMax − self.eMin)

  def RawEnergy(self):
    f1 = (1−math.exp(−np.sum([self.XVar[i]−(1/np.sqrt(i+1))**2 for i in range (0, 3)])))
    f2 = (1−math.exp(−np.sum([self.XVar[i]+(1/np.sqrt(i+1))**2 for i in range (0, 3)])))
    return math.fabs(f1+f2)

  def Neighbor(self, toChange):
    self.XVar[toChange] = self.smin + (self.smax − self.smin) * random.uniform(0,1)

  def BestNeighbor(self, toChange):
    toIncrement = (self.smax − self.smin) / self.slices
    curMax = 1
    maxVal = self.XVar[toChange]
    for i in xrange(10):
      self.XVar[toChange] = self.smin + toIncrement
      x = self.Energy()
      if x < curMax:
        curMax = x
        maxVal = self.XVar[toChange]

  def Chaos(self):
    self.XVar[0] = random.uniform(self.smin, self.smax)
    self.XVar[1] = random.uniform(self.smin, self.smax)
    self.XVar[2] = random.uniform(self.smin, self.smax)

  def Baseline(self, numRuns):
    self.Chaos()
    self.eMax = self.eMin = self.RawEnergy()
    runs = 1
    while runs < numRuns:
      self.Neighbor(random.randint(0,2))
      eNew = self.RawEnergy()
      if eNew > self.eMax: #find largest difference
        self.eMax = eNew
        self.XVarMax = self.XVar
        #print self.XVarMax, eNew
      if eNew < self.eMin: #find smallest difference
        self.eMin = eNew
        #print ’Min: ’, self.XVar, eNew
      runs += 1
    print ’Baseline: ’, self.eMin, ’,’, self.eMax

  def EnergyChecker(self, x, y, z):
    self.XVar[0] = x
    self.XVar[1] = y
```

```
    self.XVar[2] = z
    print ’Energy @ ’, x, ’ ’, y, ’ ’, z, ’:’, self.Energy()

  def __init__(self):
    print ’\nInitializing Fonesca (MaxWalkSat)...’
    self.Baseline(10000)
    self.XVar = self.XVarMax
    print ’Initialized.’

#Structure from MaxWalkSat Lecture
def MWS(probability):
  fon = FonescaMWS()
  XVarBest = fon.XVar
  eBest = e = 1
  k = 1
  say(int(math.fabs(eBest−1)*100))
  say(’ ’)
  for i in xrange(maxTries):
    fon.Chaos()
    for j in xrange(maxChanges):
      eNew = fon.Energy()
      if(eNew < threshold):
        #% means found a solution and quit
        say(’%’)
        eBest = eNew
        XVarBest = list(fon.XVar)
        print ’\nQuitting...’
        return eBest, XVarBest
      else:
        #modify random part of solution
        if probability > random.uniform(0,1):
          fon.Neighbor(random.randint(0, 2))
          say(’+’)
        #maximize for some random
        else:
          fon.BestNeighbor(random.randint(0,2))
        say(’.’)
        if (i+1)*(j+1) % 40 ≡ 0:
          print ’’
          say(int(math.fabs(eNew−1)*100))
          say(’ ’)
    print ’’
    return −1, XVarBest

for i in [0.25, 0.5, 0.75]:
  eBest, XVarBest = MWS(i)
  if eBest ≡ −1:
    print ’No Best Found for prob = ’, i
  else:
    print ’Found best − e: ’, eBest, ’ for prob = ’, i
    print ’Variables: ’, XVarBest[0], ’,’, XVarBest[1], ’,’, XVarBest[2]
```

```
Initializing Fonesca (MaxWalkSat)...
Baseline:  0.00217219138581 ,  489100.818994
Initialized.
0 ...+.+...........+..+........+........+......
80 .+..................+...+.....+.....+.+..+..+.+..
0 +..+....+....+..+...+..+...+.+.+..+...+.......+.+..+.+..
98 +.+..+.+.+....+.+...+...+.+.......+..........+..+.+.+..
99 +.......+......+..+.+.+....+.+.....+.+...+......+...
80 .+...+..+.....+........+...+.....+...........+..
87 ...+.+.....+.+......+.+...+.+......+.+..+..+.+..+...+..
98 ...+....+...+....+........+..................
80 +....+.+.+........+......+......+...+.+.....+.+....
80 +...........+..+.+............+.........+.....
99 +...+.+...+.....+............+.+..+.....+.....+...
99 ....+..+...+........+..+.+....+.+.+.....+...+......
80 +.+...+.......+.........
No Best Found for prob = 0.25

Initializing Fonesca (MaxWalkSat)...
Baseline:  0.000932916523078 ,  469528.012899
Initialized.
0 .+..+.........+..+..+.+....+..+.+...+.+.+.+...+..+.+..+.+.
99 +.+.+.+.+..+..+.+.%
Quitting...
Found best − e:  1.04329763784e−07  for prob =  0.5
Variables:  3.64250077891 ,  1.23269440387 ,  −3.68449263252

Initializing Fonesca (MaxWalkSat)...
Baseline:  0.00125834048295 ,  781901.399856
Initialized.
0 +.+.+..+..+.+.+.+.+.+.+..+.+.+..+.+.+.+.+.+.%
Quitting...
Found best − e:  3.19187866439e−07  for prob =  0.75
Variables:  −2.94522839581 ,  3.64262171318 ,  0.349880488063

###################################
```

Based on the runs above, I would assume that there isn’t much difference between running at higher probabilities of randomizing, depending on the threshold set. The higher probabilities terminated faster and still had reasonable results. This may change as you modify your threshold, however.

Note that I also don’t trust my energy functions right now for Fonesca despite spending hours upon hours trying to fiddle with them. It seems like the scale is all out of whack when normalizing, but I can’t find anything wrong with my math (yet).

```
#From Class Discussion 8/26/2014
from __future__ import division
import sys,re,random,math
import numpy as np
sys.dont_write_bytecode = True

kmax = 5000
cooling = .6

#Structure from SA Lecture
def say(x):
  sys.stdout.write(str(x)); sys.stdout.flush()

rand = random.random

class Kursawe:
  smin = −5
  smax = 5
  XVar = [random.uniform(smin, smax) for i in range (0, 3)]
  XVarMax = XVar
  eMax = 0
  eMin = 0
  a = 0.8
  b = 3

  def Energy(self):
    X = self.XVar
    f1 = np.sum([−10*math.exp(−0.2*(np.sqrt(X[i]**2+X[i]**2))) for i in range (0, 3−1)])
    f2 = np.sum([math.fabs(X[i])**self.a + 5*np.sin(X[i])**self.b for i in range (0, 3)])
    return (math.fabs(f1−f2) − self.eMin) / (self.eMax − self.eMin)

  def RawEnergy(self):
    X = self.XVar
    f1 = np.sum([−10*math.exp(−0.2*(np.sqrt(X[i]**2+X[i]**2))) for i in range (0, 3−1)])
    f2 = np.sum([math.fabs(X[i])**self.a + 5*np.sin(X[i])**self.b for i in range (0, 3)])
    return math.fabs(f1−f2)

  def Neighbor(self):
    self.XVar[random.randint(0, 2)] = random.uniform(self.smin, self.smax)

  def Chaos(self):
    self.XVar[0] = random.uniform(self.smin, self.smax)
    self.XVar[1] = random.uniform(self.smin, self.smax)
    self.XVar[2] = random.uniform(self.smin, self.smax)

  def Baseline(self, numRuns):
    self.Chaos()
    self.eMax = self.eMin = self.RawEnergy()
    runs = 1
    while runs < numRuns:
      self.Neighbor()
      eNew = self.RawEnergy()
      if eNew > self.eMax: #find largest difference
        self.eMax = eNew
        self.XVarMax = self.XVar
        #print self.XVarMax, eNew
      if eNew < self.eMin: #find smallest difference
        self.eMin = eNew
        #print ’Min: ’, self.XVar, eNew
      runs += 1
    print ’Baseline: ’, self.eMin, ’,’, self.eMax

  def __init__(self):
    print ’Initializing Kursawe...’
    self.Baseline(10000)
    self.XVar = self.XVarMax
    print ’Initialized.’

#Structure from SA Lecture
def main():
  sa = Kursawe()
  XVarBest = sa.XVar
  eBest = e = 1
  print ’start energy: ’, eBest
  k = 1
  say(int(math.fabs(eBest−1)*100))
  say(’ ’)
```

```
  while k < kmax:
    sa.Neighbor()
    eNew = sa.Energy()
    if eNew < eBest:
      eBest = eNew
      XVarBest = list(sa.XVar)
      say(’!’)

    if eNew < e:
      e = eNew
      say(’+’)
    #Probability Check from SA Lecture
    elif math.exp(−1*(eNew−e)/(k/kmax**cooling)) < random.uniform(0,1):
    #P function should be between 0 and 1
    #more random hops early, then decreasing as time goes on
      sa.Chaos()
      say(’?’)
    say(’.’)
    k = k + 1
    if k % 50 ≡ 0 ∧ k ≠ kmax:
      print ’’
      say(int(math.fabs(eBest−1)*100))
      say(’ ’)

  print ’\nFound best − e: ’, eBest
  print ’Variables: ’, XVarBest[0], ’,’, XVarBest[1], ’,’, XVarBest[2]

main()
```

```
Initializing Kursawe...
Baseline:  0.177029099874 ,  31.6067662396
Initialized.
start energy:  1
0 !+.!+.?.!+.!+.?.!+.?.!+.!+.?.?.?.?.?.?.?.!+.?.?.?.?..?.?.?.?.?..?.?.?.?.?.?.
  ?..?..?.?.?.?.?...?.?.?.
85 ?.?.?.?.?..?.?...?.?.?.?...?.....?..?...?..?.?..?.?.?.......?.?.?..?.?.....
85 ..?.?..?...?......?.!+...?...............?.?.?....?..?..?.?.?...?..
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Found best − e:  0.00357909119159
Variables:  −1.74434673516 ,  4.42207333232 ,  −1.77862694257
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