In [1]:
```
import random
import math
import matplotlib.pyplot as plt
import numpy as np
```

In [3]:
```
pi = 3.14
def objective_function(x):
    #Format to input the objective function
    #x = x[0]
    #y = x[1]
    #z = x[2]
    y = x[0]**4 + 4*(x[0]**3) + 4*(x[0]**2) + (x[2]**2) - 2*(x[2]) - 20*math.e
xp(-0.2*x[1]) - math.exp(math.cos(pi*x[1])) + 21
    return y
```

In [4]:
```
bounds=[(-10,10),(-10,10),(-10,10)]   # upper and lower bounds of variables
#First Index Location for x bounds
#Second Index Location for Y Bounds
#Third Index Location for Z Bounds
nv = 3                      # number of variables
# if minimization problem, mm = -1; if maximization problem, mm = 1
mm = -1

# THE FOLLOWING PARAMETERS ARE OPTINAL.
particle_size=100          # number of particles
iterations=200             # max number of iterations
w=0.85                     # inertia constant
c1=1                       # cognitive constant
c2=2                       # social constant
```

In [5]:
```
class Particle:
    def __init__(self,bounds):
        self.particle_position=[]                     # particle position
        self.particle_velocity=[]                     # particle velocity
        self.local_best_particle_position=[]          # best position of the p
article
        self.fitness_local_best_particle_position= initial_fitness  # initial
 objective function value of the best particle position
        self.fitness_particle_position=initial_fitness             # objective
function value of the particle position

        for i in range(nv):
            self.particle_position.append(random.uniform(bounds[i][0],bounds[i
][1])) # generate random initial position
            self.particle_velocity.append(random.uniform(-1,1)) # generate ran
dom initial velocity

    def evaluate(self,objective_function):
        self.fitness_particle_position=objective_function(self.particle_positi
on)
        if mm == -1:
            if self.fitness_particle_position < self.fitness_local_best_partic
le_position:
                self.local_best_particle_position=self.particle_position
# update the local best
                self.fitness_local_best_particle_position=self.fitness_particl
e_position  # update the fitness of the local best
        if mm == 1:
            if self.fitness_particle_position > self.fitness_local_best_partic
le_position:
                self.local_best_particle_position=self.particle_position
# update the local best
                self.fitness_local_best_particle_position=self.fitness_particl
e_position  # update the fitness of the local best

    def update_velocity(self,global_best_particle_position):
        for i in range(nv):
            r1=random.random()
            r2=random.random()

            cognitive_velocity = c1*r1*(self.local_best_particle_position[i] -
self.particle_position[i])
            social_velocity = c2*r2*(global_best_particle_position[i] - self.p
article_position[i])
            self.particle_velocity[i] = w*self.particle_velocity[i]+ cognitive
_velocity + social_velocity

    def update_position(self,bounds):
        for i in range(nv):
            self.particle_position[i]=self.particle_position[i]+self.particle_
velocity[i]

            # check and repair to satisfy the upper bounds
            if self.particle_position[i]>bounds[i][1]:
                self.particle_position[i]=bounds[i][1]
            # check and repair to satisfy the lower bounds
```

```
            if self.particle_position[i] < bounds[i][0]:
                self.particle_position[i]=bounds[i][0]
```

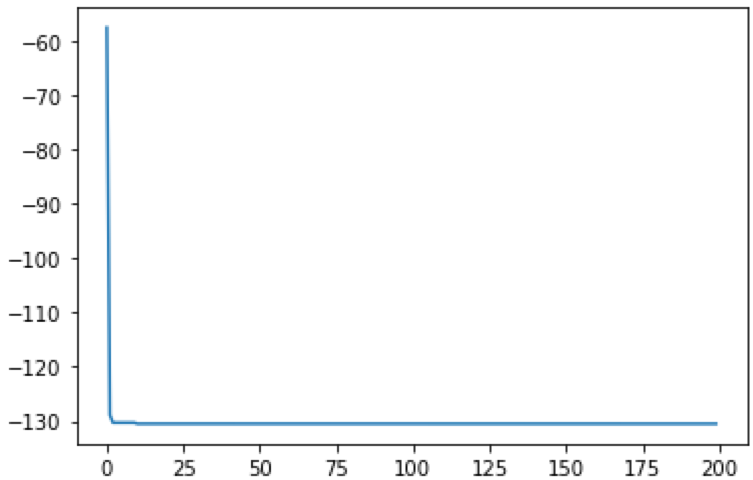
In [6]:
```
class PSO():
    def __init__(self,objective_function,bounds,particle_size,iterations):

        fitness_global_best_particle_position=initial_fitness
        global_best_particle_position=[]

        swarm_particle=[]
        for i in range(particle_size):
            swarm_particle.append(Particle(bounds))
        A=[]

        for i in range(iterations):
            for j in range(particle_size):
                swarm_particle[j].evaluate(objective_function)

                if mm ==-1:
                    if swarm_particle[j].fitness_particle_position < fitness_g
lobal_best_particle_position:
                        global_best_particle_position = list(swarm_particle[j]
.particle_position)
                        fitness_global_best_particle_position = float(swarm_pa
rticle[j].fitness_particle_position)
                if mm ==1:
                    if swarm_particle[j].fitness_particle_position > fitness_g
lobal_best_particle_position:
                        global_best_particle_position = list(swarm_particle[j]
.particle_position)
                        fitness_global_best_particle_position = float(swarm_pa
rticle[j].fitness_particle_position)
            for j in range(particle_size):
                swarm_particle[j].update_velocity(global_best_particle_positio
n)
                swarm_particle[j].update_position(bounds)

            A.append(fitness_global_best_particle_position) # record the best
 fitness


        print('Optimal solution:', global_best_particle_position)
        print('Objective function value:', fitness_global_best_particle_positi
on)
        print('Evolutionary process of the objective function value:')
        plt.plot(A)
```

In [7]:
```
if mm == -1:
    initial_fitness = float("inf") # for minimization problem
#if mm == 1:
    #initial_fitness = -float("inf") # for maximization problem
```

In [8]:
```
# Main PSO
PSO(objective_function,bounds,particle_size,iterations)
```

```
Optimal solution: [-2.0001142030897783, -10, 0.9994200975232187]
Objective function value: -130.49905869548613
Evolutionary process of the objective function value:
```

Out[8]:
```
<__main__.PSO at 0x1c2f2b2deb0>
```



In [ ]: