In [515]:

```
import numpy as np
import scipy as sp
from scipy.optimize import minimize
import matplotlib.pyplot as plt
from math import pi
```

In [516]:

```
def f(x):
    return (x*np.sin(10*x*np.pi)+1)  # function to be MAXIMIZED
```

In [517]:

```
x = np.arange(-0.5, 1, 0.0001)
y = f(x)
plt.plot(x,y)
plt.xlabel('Value of x')
plt.ylabel('Value of Function')
plt.title('Objective Function')
plt.legend()
plt.show()
```

```
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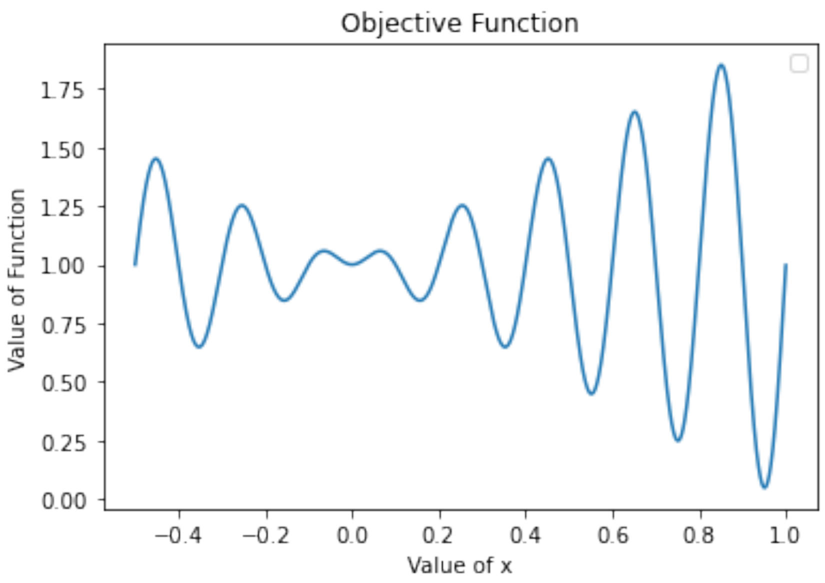
```



In [518]:

```
def initialize_population(population_size):
    population = []
    for j in range(population_size):
        x1 = np.random.randint(-1,1)   #Value that will determine the sign of the candidate solution
        x2 = np.random.randint(low=0, high=9, size = 4)
        x = np.append(x1,x2)
        population = np.append(population,x)
    population = np.split(population, population_size)
    return population

#initialize_population(100)
```

In [519]:

```
def double_point_crossover(parents, num_offspring):
    children = []
    for i in range(int(num_offspring/2)):
        index1 = np.random.randint(low=0, high=99)
        index2 = np.random.randint(low=0, high=99)
        parent1 = parents[index1]
        parent2 = parents[index2]
        #print(i)
        offspring1 = np.append(parent1[0:2],parent2[2:4])
        offspring1 = np.append(offspring1 ,parent1[4:])
        offspring2 = np.append(parent2[0:2],parent1[2:4])
        offspring2 = np.append(offspring2, parent2[4:])
        children = np.append(children, offspring1)
        children = np.append(children, offspring2)
    children = np.split(children, num_offspring)
    return children
```

In [520]:

```
def mutation(children, prop):
    num_offspring = len(children)
    for i in range(num_offspring):
        for j in range(1,5):
            probability = np.random.uniform(low=0, high=1)
            if probability < prop:
                random_value = np.random.randint(low=0, high=9)
                children[i][j] = random_value
    return children
```

In [521]:

```
def selection(population,children,num_parents):
    parents, fitness = np.zeros((100,5)), np.zeros(100)
    for i in children:
        population.append(i)
    f = evaluate_fitness(population)
    pop_f = [[population[i],f[i]] for i in range(len(f))]
    pop_f = sorted(pop_f, reverse=True, key=lambda pop: pop[1])
    pop_f = pop_f[:100]
    #print(np.shape(pop_f))
    parents, fitness = [], []
    for i in range(len(pop_f)):
        parents.append(pop_f[i][0])
        fitness.append(pop_f[i][1])
    return parents, fitness
```

In [522]:

```
def form_elites(elites, elites_fx, population, fitness):
    if elites:
        for i in range(len(fitness)):
            if fitness[i] > elites_fx[i]:
                elites[i] = population[i]
                elites_fx[i] = fitness[i]
    else:
        elites = population
        elites_fx = fitness
    return elites, elites_fx
```

In [523]:

```
def evaluate_fitness(population):
    population_size = len(population)
    fitness = []
    bestx, fitx = -1, 0
    for j in range(population_size):
        ind = population[j]
        if ind[0]>=0:
            sign = 1
        else:
            sign = -1
        x = sign*float("0"+"."+str((int(ind[1])))+str((int(ind[2])))+str((int(
ind[3])))+str((int(ind[4]))))
        if float(x)<-0.5 or float(x)>1:
            fit = -1000
        else:
            fit = f(x)
        fitness = np.append(fitness,fit)
    return fitness
```

In [524]:

```
def genetic_algorithm(num_generations, population_size, prop=0.5):
    population = initialize_population(population_size)
    elites, elites_fx = [], []

    for gen in range(num_generations):

        children = double_point_crossover(population, num_offspring = int(popu
lation_size))
        children = mutation(children,prop=0.5)
        population, fitness = selection(population,children,num_parents = int(
population_size)*2)
        #print(np.shape(population))
        #elites, elites_fx = form_elites(elites, elites_fx, population, fitnes
s)
        #print(np.shape(elites), np.shape(elites_fx))

    return population, fitness #elites, elites_fx
```

In [525]:

```
elites, elites_fx = genetic_algorithm(num_generations = 10, population_size=10
0, prop = 0.01)
print(np.shape(elites_fx),np.shape(elites))
pop = []
for ind in elites:
    if ind[0]>=0:
        sign = 1
    else:
        sign = -1
    pop.append(sign*float("0."+str((int(ind[1])))+str((int(ind[2])))+str((int(
ind[3])))+str((int(ind[4])))))

x = np.arange(-0.5, 1, 0.01)
y = f(x)

print(np.shape(elites_fx),np.shape(pop))

for i in range(len(pop)):
    if elites_fx[i] < 0:
        elites_fx[i] = 1
        pop[i] = 0

ax = plt.subplot(111)
ax.plot(x,y)
ax.plot(pop,elites_fx,'x')
ax.set_xlabel('Value of x')
ax.set_ylabel('Value of Function')
ax.set_title('Objective Function')
ax.legend()
plt.show()
```

```
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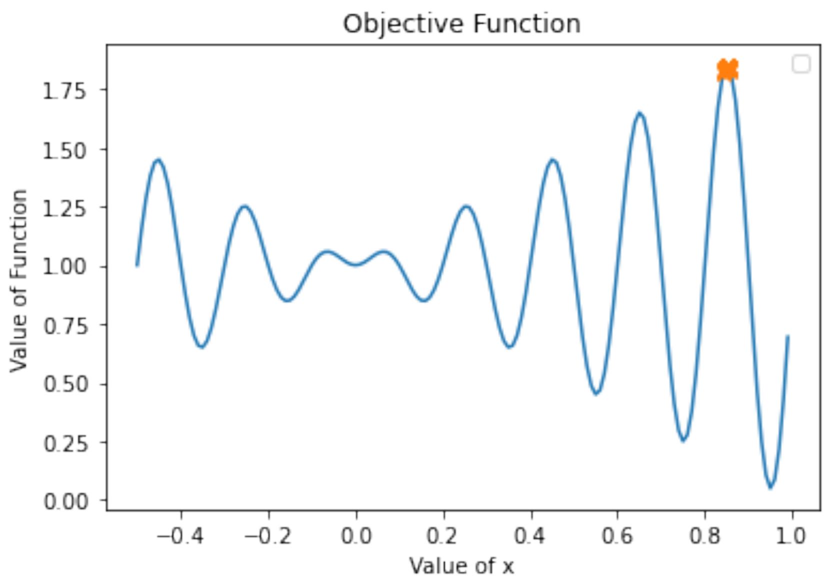
```

```
(100,) (100, 5)
(100,) (100,)
```



In [ ]:

```

```

In [ ]:

```

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