In [326]:
```
import numpy as np
import math
import random
from scipy.interpolate import make_interp_spline
import matplotlib.pyplot as plt
```

In [327]:
```
def fn(x):
    y=-math.exp(x**2/100)*math.sin(13*x - x**4)**5*math.sin(1 - 3*x**2)**2
    return y
```

In [328]:
```
x=np.arange(-2,2,0.05)
y=[]
for i in x:
    y.append(fn(i))
```

In [329]:
```
def N():
    n=random.uniform(-2,2)
    return(n)
```

In [330]:
```
def Tp(c,n,T,fn):
    if fn(n)<fn(c):
        return(1.0)
    else:
        DE=fn(c)-fn(n)
        x=DE/T
        p=math.exp(x)
        return(p)
```

In [331]:
```
def simAnn(fn):
    c=0
    b=c
    bf=fn(b)
    T=0.00001
    cooling_rate=0.001
    while T>0.0000001:
        for n0 in range(0,1000000):
            n=N()
            nf=fn(n)
            p=Tp(c,n,T,fn)
            if p>random.random():
                c=n
                cf=nf
            if nf<bf:
                bf=nf
                b=n
        T*=cooling_rate
    return(b,bf)
```

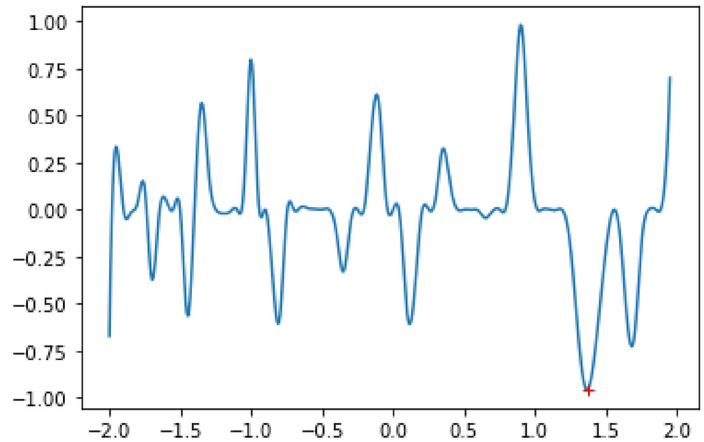
In [332]:
```
simAnn(fn)
```

Out[332]:
```
(1.3656886835017845, -0.9579456035176046)
```

Verification

In [333]:
```
X_Y_Spline = make_interp_spline(x, y)
X_ = np.linspace(x.min(), x.max(), 500)
Y_ = X_Y_Spline(X_)
plt.plot(X_, Y_)
c,fc=simAnn(fn)
plt.plot(c,fc,'r+')
```

Out[333]: [<matplotlib.lines.Line2D at 0x233d14b6c10>]



Coin Probability

In [334]:
```
def fnc(x):
    ax=x*cx
    g=math.e**ax
    p=g/sum(g)
    px=cx*p
    s=sum(px)
    f=abs(mean-s)
    return(f)
```

In [335]:
```
coin=[1, 5, 10, 25, 50, 100]
cx=np.array(coin)
mean=10.3828
```

In [336]:
```
alpha=[-1,0]
t=0
```

In [337]:
```
#Coin
a0=simAnn(fnc)
a0
```

Out[337]: (-0.03773222090348005, 0.00014853996820285443)

Estimated optimal probabilities

In [338]:
```
ax=a0[0]*cx
g=math.e**ax
p=g/sum(g)
p
```

Out[338]:
```
array([0.31670063, 0.27233367, 0.22551055, 0.12804524, 0.04985297,
       0.00755695])
```

In [339]:
```
px=cx*p
s=sum(px)
s
```

Out[339]:
```
10.382948539968202
```

In [340]:
```
print(f'actual Mean:{mean}')
print(f'observed Mean:{s}')
print(f'The difference between\nobserved mean & estimated mean\n(loss value):{abs(mean-s)
```

```
actual Mean:10.3828
observed Mean:10.382948539968202
The difference between
observed mean & estimated mean
(loss value):0.0001485399682028543
```

Verification

In [341]:
```
x=np.arange(-5,1,0.01)
y=[]
for i in x:
    y.append(fnc(i))
```

In [342]:
```
X_Y_Spline = make_interp_spline(x, y)
X_ = np.linspace(x.min(), x.max(), 500)
Y_ = X_Y_Spline(X_)
plt.plot(X_, Y_)
plt.plot(a0[0],fnc(a0[0]),'r+')
```

Out[342]:
```
[<matplotlib.lines.Line2D at 0x233d152ee80>]
```