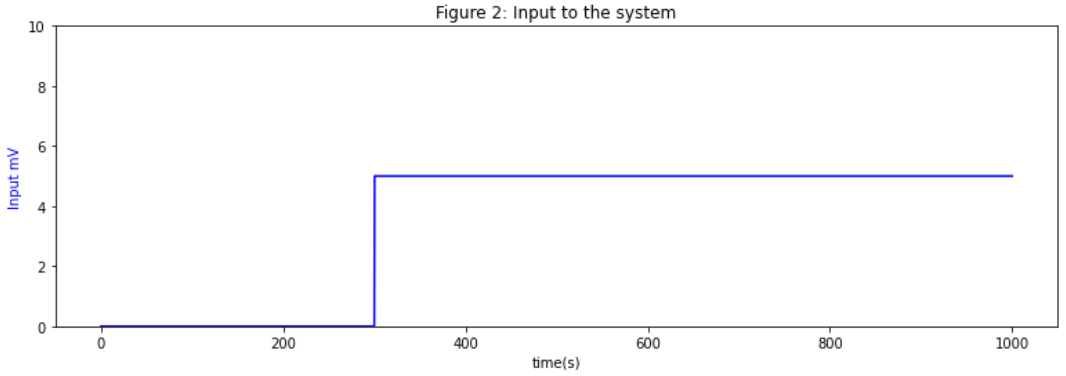
```
import numpy as np
import sys
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings("ignore")
```

```
h =0.3
input_onset=300
input_amp=5

time = np.arange(0,1000.1,h)

def Input(input_onset,input_amp):
  I=np.zeros((len(time)))
  for k in range(0,len(time)):
    if time[k]>input_onset:
      I[k]=input_amp
  return I

fig,ax1=plt.subplots(figsize=(13,4))
ax1.plot(time,Input(input_onset,input_amp),'b-')
ax1.set_xlabel('time(s)')
ax1.set_ylabel('Input mV', color='b')
ax1.set_ylim(0,input_amp*2)
plt.title('Figure 2: Input to the system')
plt.show()
```



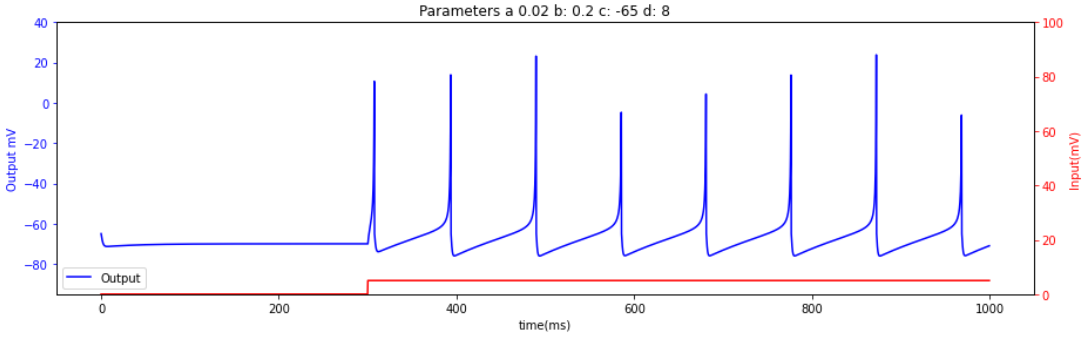

```
def Discrete_Model(a,b,u,v,I):
  v=v+h*(0.04*v*v+5*v+140-u+I)
  u=u+h*(a*(b*v-u))
  return u,v
```

```
def Izhikevich(a,b,c,d):
  v=-65*np.ones((len(time)))
  u=0*np.ones((len(time)))
  u[0]=b*v[0]

  spiketime=[]
  fired=[]
  I=Input(input_onset,input_amp)
  for k in range(0,len(time)-1):
    u[k+1],v[k+1]=Discrete_Model(a,b,u[k],v[k],I[k])
    if v[k+1]>30:
      v[k+1]=c
      u[k+1]=u[k+1]+d
  plot_input_output(time,v,I,a,b,c,d)
```

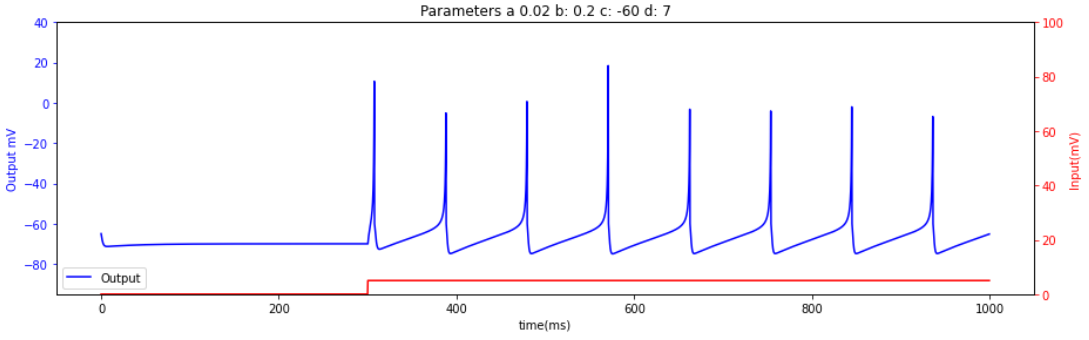
```
def plot_input_output(time,v,I,a,b,c,d):
  fig,ax1=plt.subplots(figsize=(13,4))
  ax1.plot(time,v,'b-',label='Output')
  ax1.set_xlabel('time(ms)')
  ax1.set_ylabel('Output mV',color='b')
  ax1.tick_params('y',colors='b')
  ax1.set_ylim(-95,40)
```

```
  ax2=ax1.twinx()
  ax2.plot(time,I,'r',label='Input')
  ax2.set_ylim(0,input_amp*20)
  ax2.set_ylabel('Input(mV)',color='r')
  ax2.tick_params('y',colors='r')

  fig.tight_layout()
  ax1.legend(loc=1)
  ax1.legend(loc=3)
  ax1.set_title('Parameters a %s b: %s c: %s d: %s' %(a,b,c,d))
  plt.show()
```

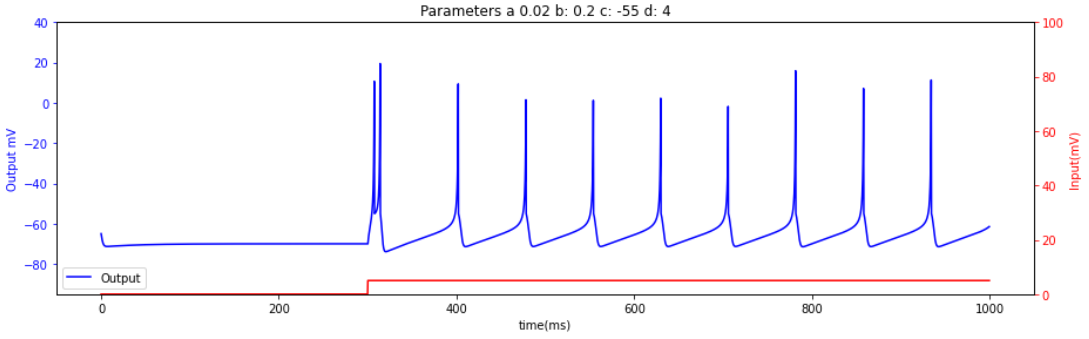
```
Izhikevich(0.02,0.2,-65,8)
```



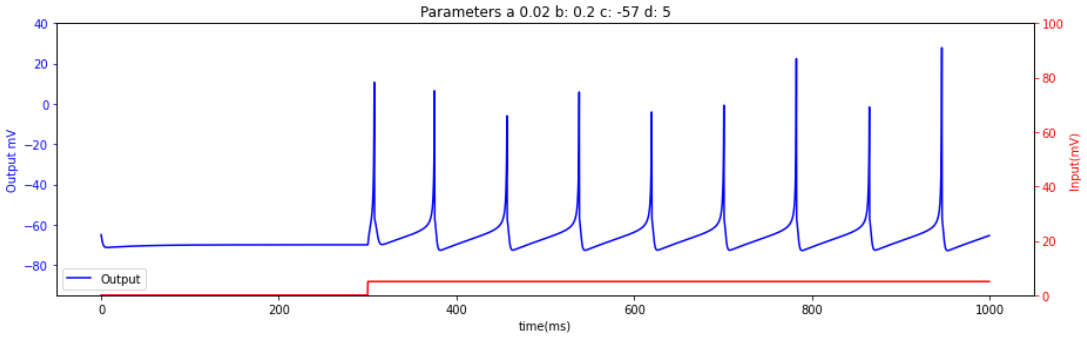

```
Izhikevich(0.02,0.2,-60,7)
```



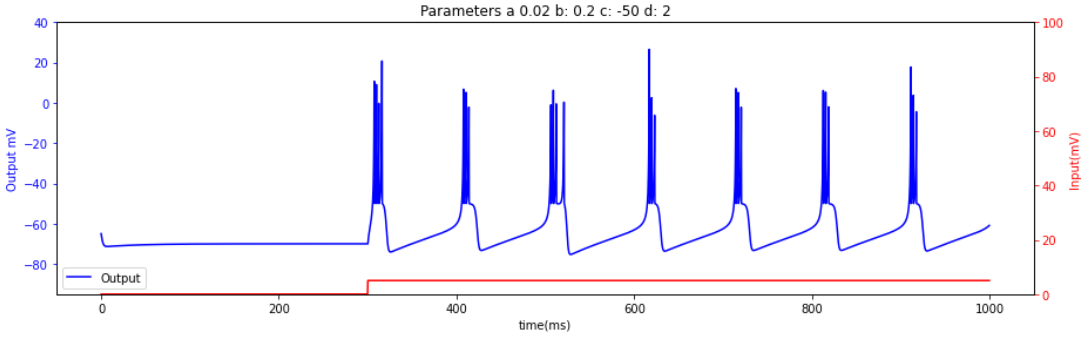

```
Izhikevich(0.02,0.2,-55,4)
```



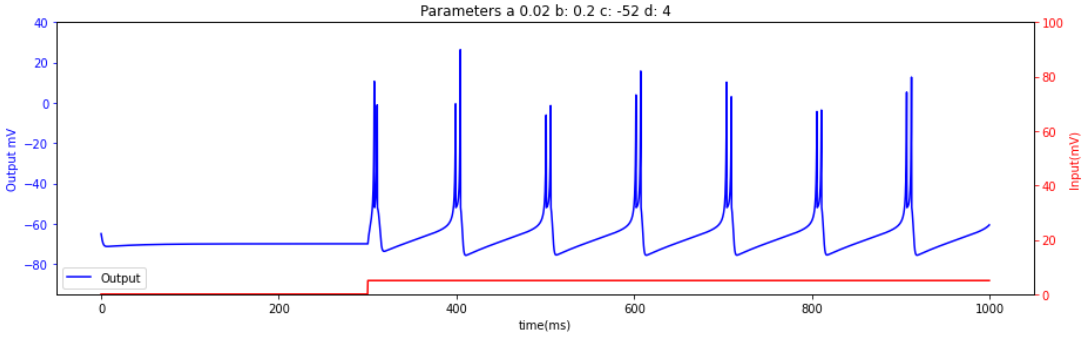

```
Izhikevich(0.02,0.2,-57,5)
```



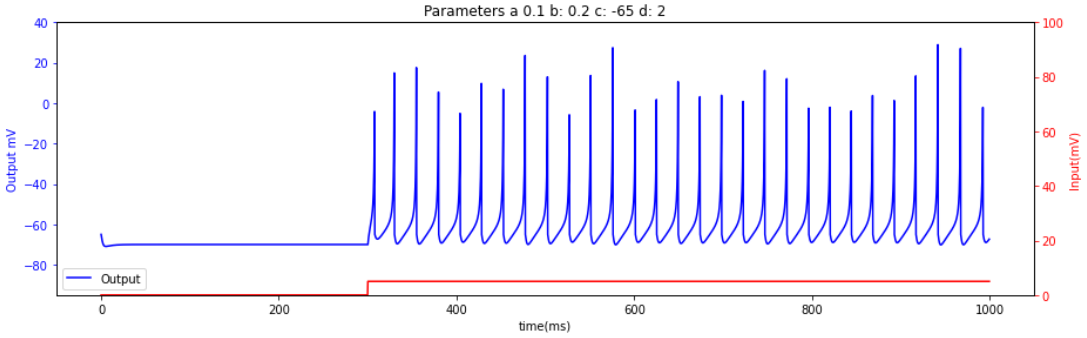

```
Izhikevich(0.02,0.2,-50,2)
```



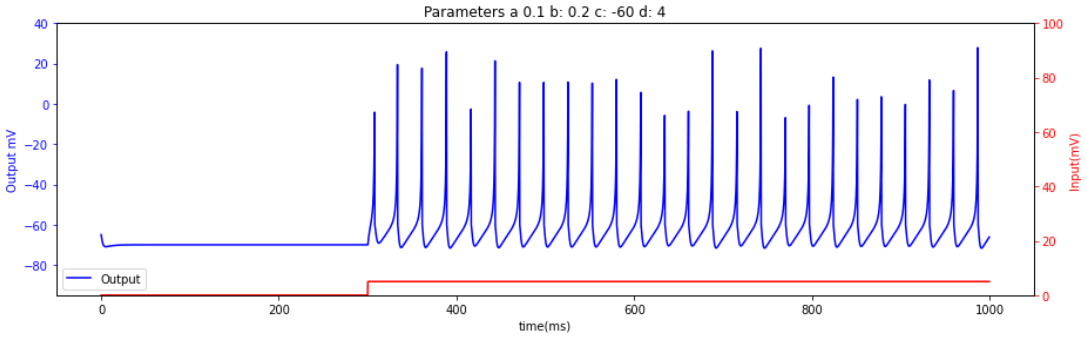

```
Izhikevich(0.02,0.2,-52,4)
```



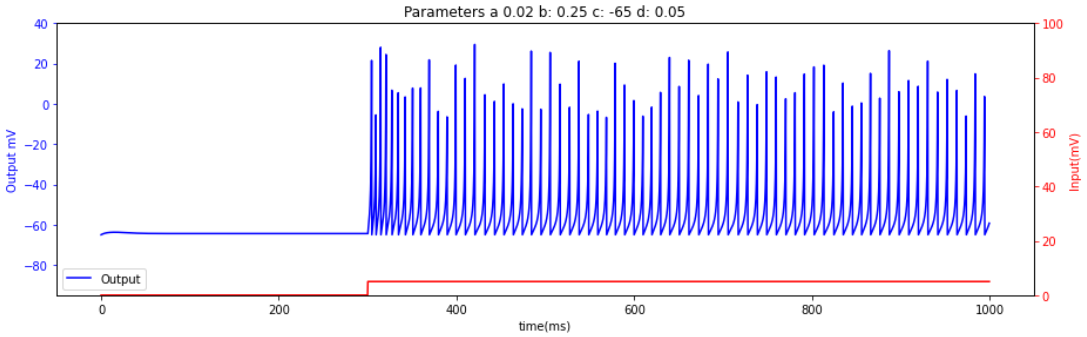

```
Izhikevich(0.1,0.2,-65,2)
```



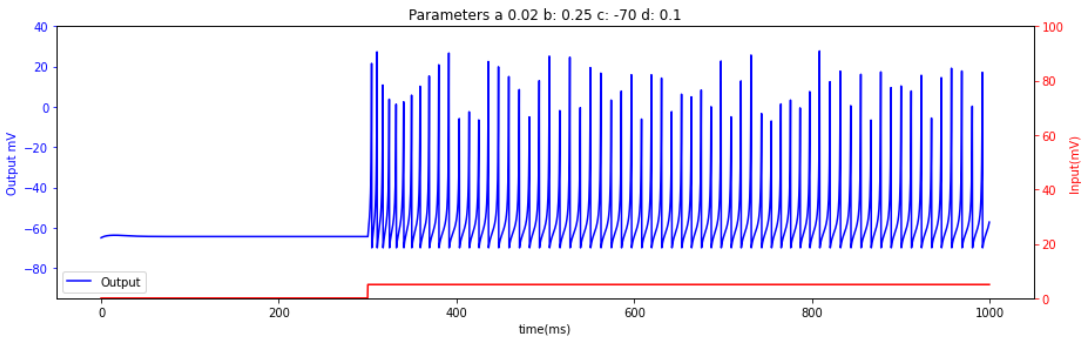

```
Izhikevich(0.1,0.2,-60,4)
```



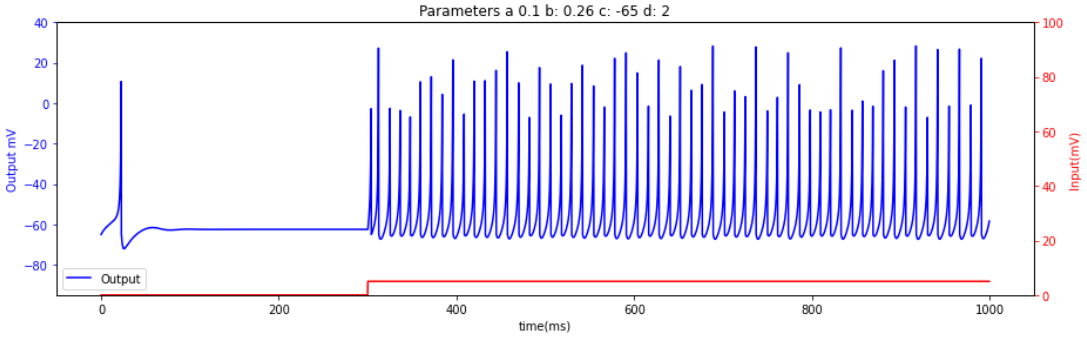

```
Izhikevich(0.02,0.25,-65,0.05)
```



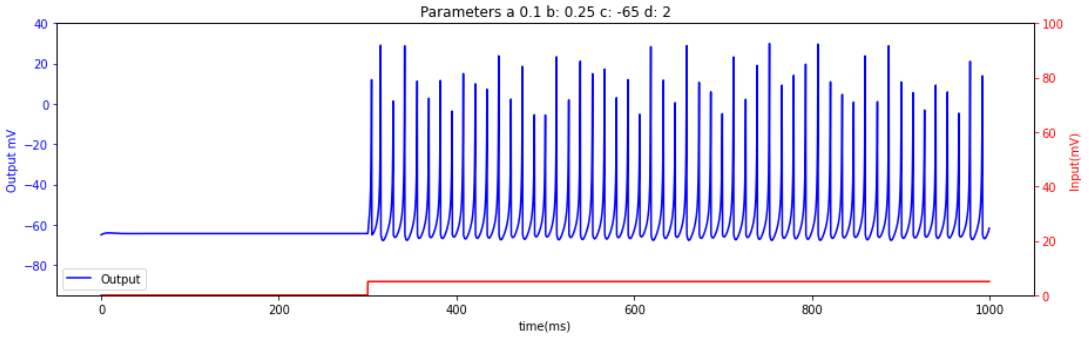

```
Izhikevich(0.02,0.25,-70,0.1)
```



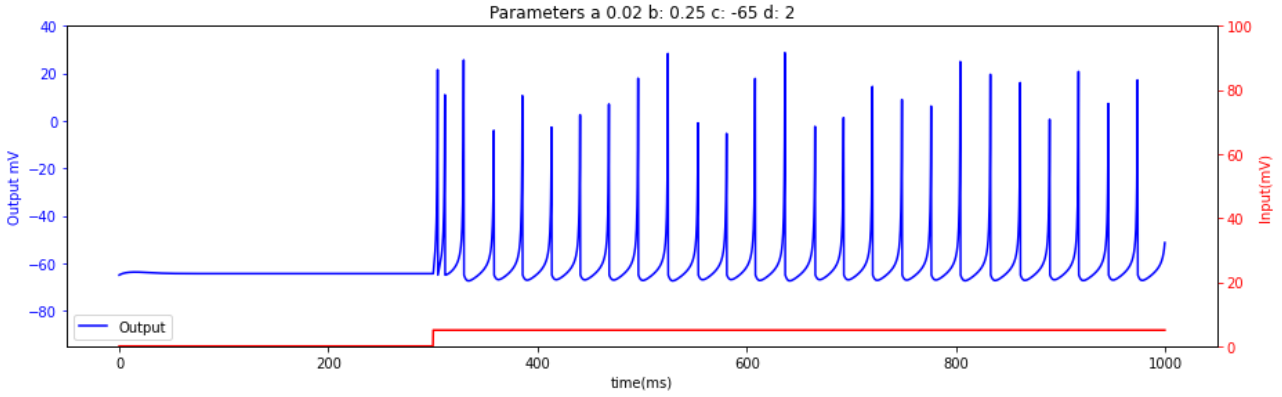

```
Izhikevich(0.1,0.26,-65,2)
```




```
Izhikevich(0.1,0.25,-65,2)
```




```
Izhikevich(0.02,0.25,-65,2)
```




```
Izhikevich(0.02,0.25,-60,3)
```