In [33]:
```
from __future__ import division
import numpy as np
import passive
from util import *

#plots
import matplotlib.pyplot as plt
import matplotlib.pylab as pylab
pylab.rcParams['figure.figsize'] = 16, 12  # that's default image size for thi
s interactive session
from matplotlib.legend_handler import HandlerLine2D

%matplotlib inline

# 3D plots
from mpl_toolkits.mplot3d import Axes3D
from matplotlib import cm
from matplotlib.ticker import LinearLocator, FormatStrFormatter
```

Part 1. Simulation of multi compartment model of passive neurite

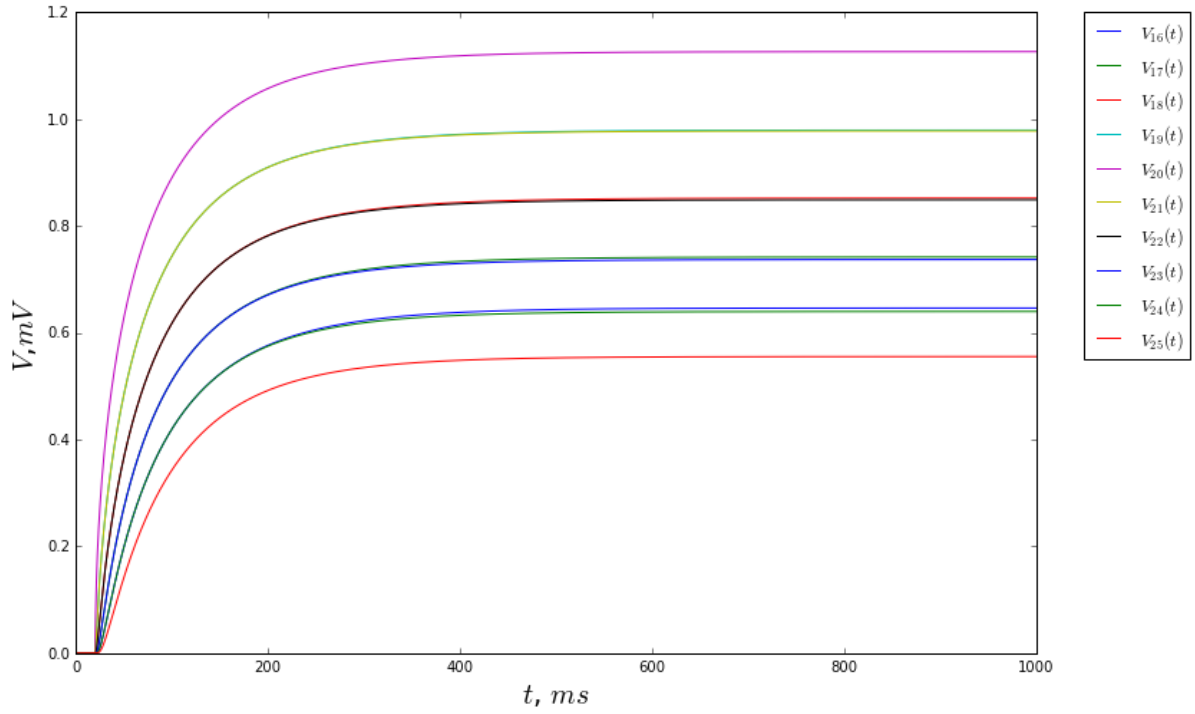
In [36]:
```
N=50
j=20
Neurite=[passive.Compartment() for k in range(N)]

Neurite[0].type="sealed"
Neurite[-1].type="killed"  #actually, I don't use it in code

Neurite[j-1].current=lambda t: I_e_step(10**(-11),20*10**(-3),t) # j-1 because
 in python ind are from 0
```

In [37]:
```
Exp=passive.Experiment()
V=Exp.voltage(Neurite)
V.shape
```

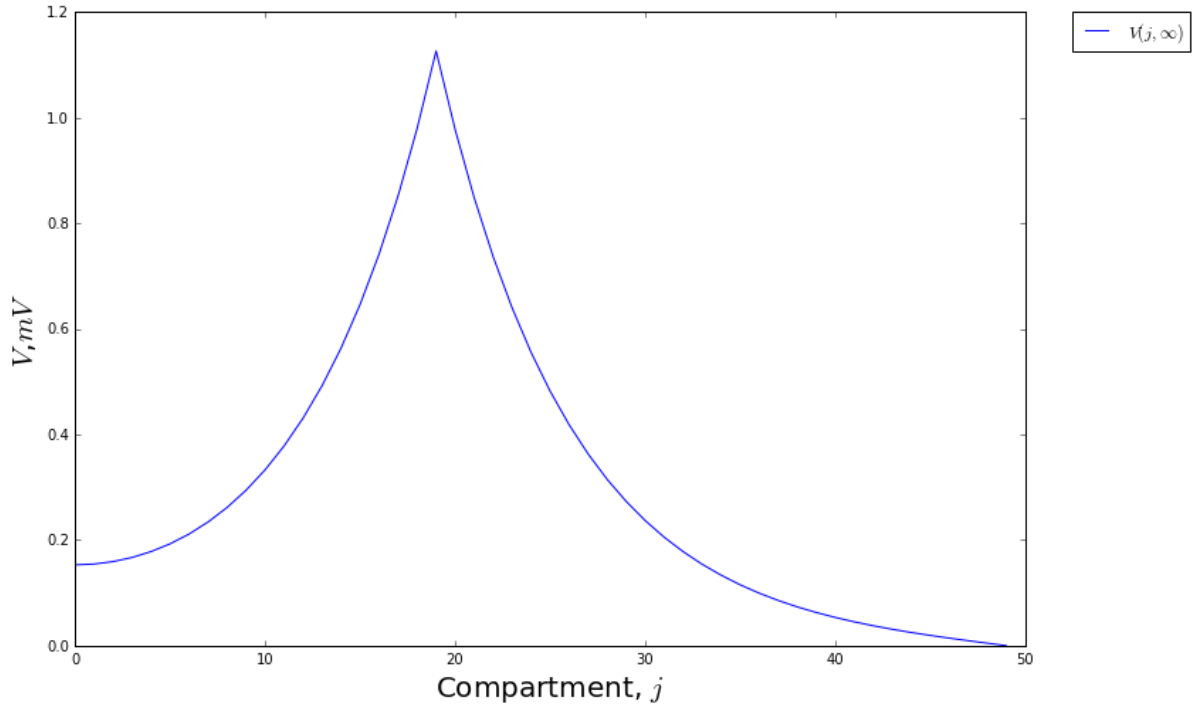
Out[37]: (50L, 10000L)

$V_j(t)$ for 50 different compartments

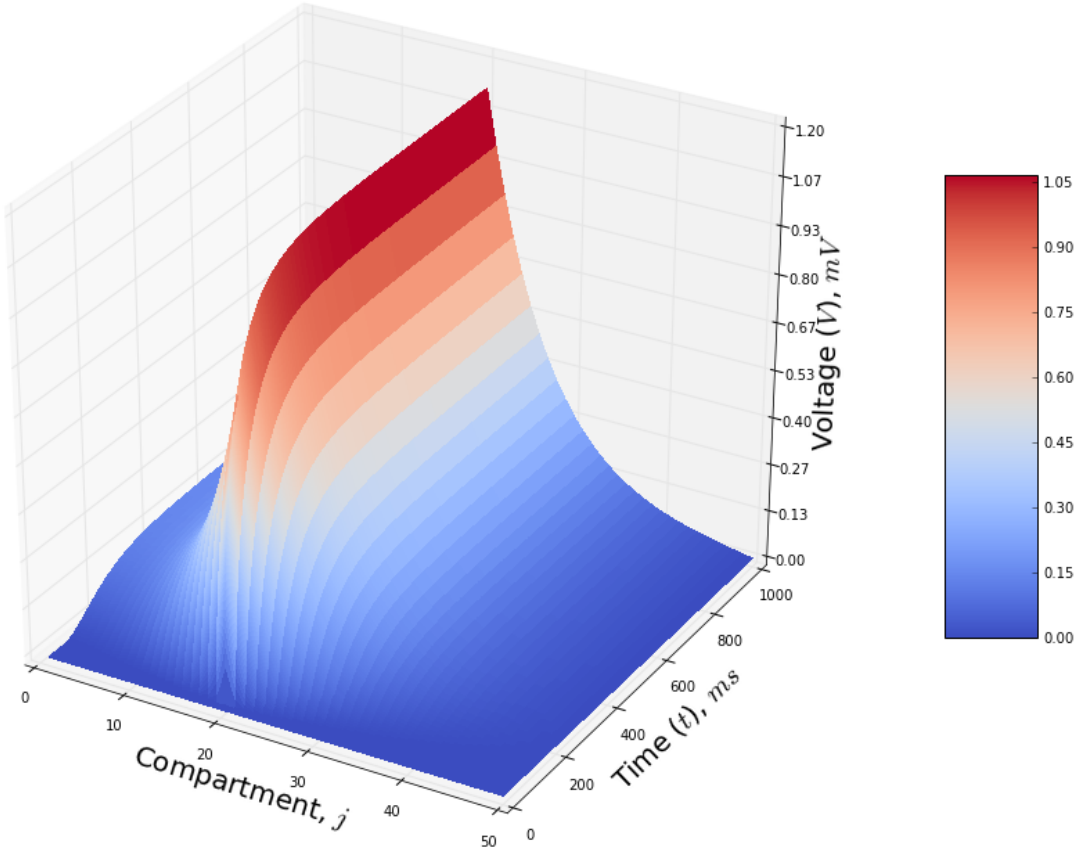
In [40]:
```
plt.figure(figsize=(12,8))
for k in range(j-5,j+5):
    plt.plot(Exp.t*1000,V[k,:]*1000, label="$V_{"+str(k+1)+"}(t)$")
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
plt.xlabel('$t$, $ms$',fontsize=20)
plt.ylabel('$V$,$mV$',fontsize=20)
plt.savefig('exp_1_first_ten_coms.pdf',bbox_inches='tight')
```



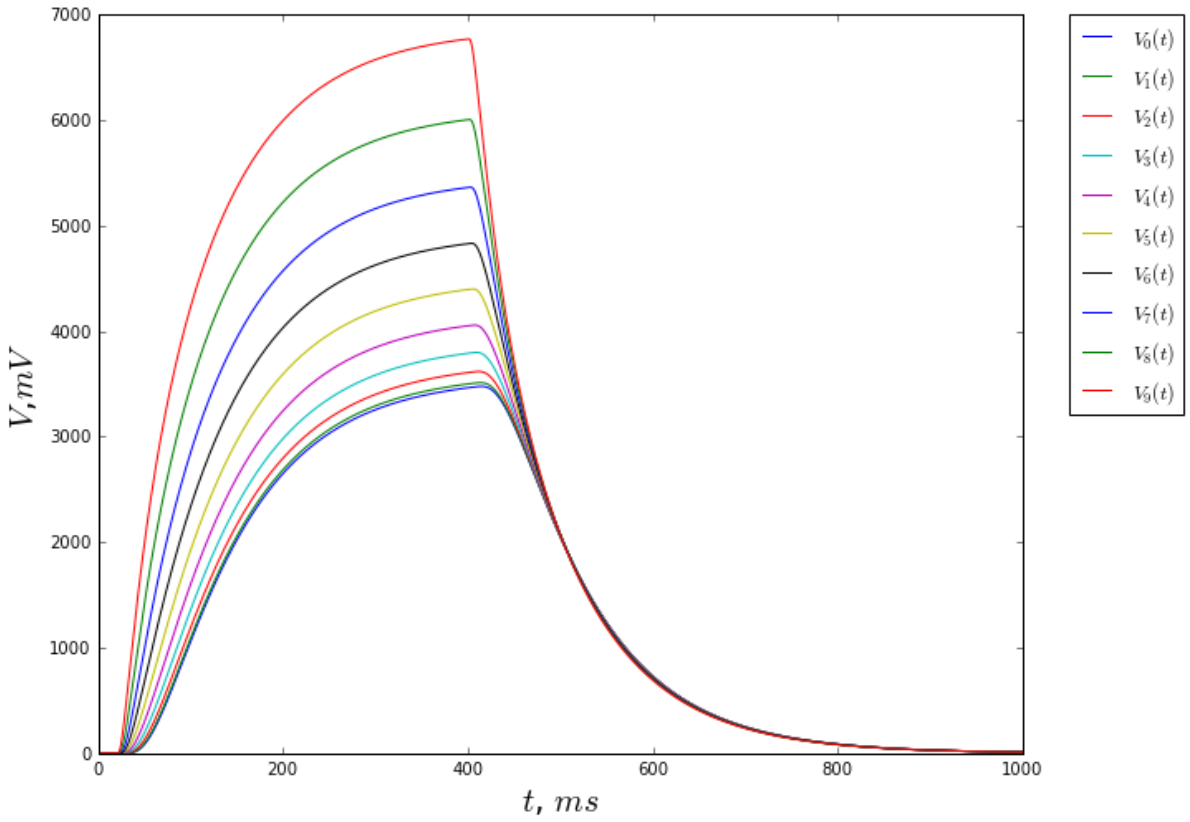
In [42]:
```
plt.figure(figsize=(12,8))
plt.plot(range(V.shape[0]),V[:,-1]*1000, label="$V(j,\infty)$")
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
plt.xlabel('Compartment, $j$',fontsize=20)
plt.ylabel('$V$,$mV$',fontsize=20)
plt.savefig('exp_1_inf.pdf',bbox_inches='tight')
```



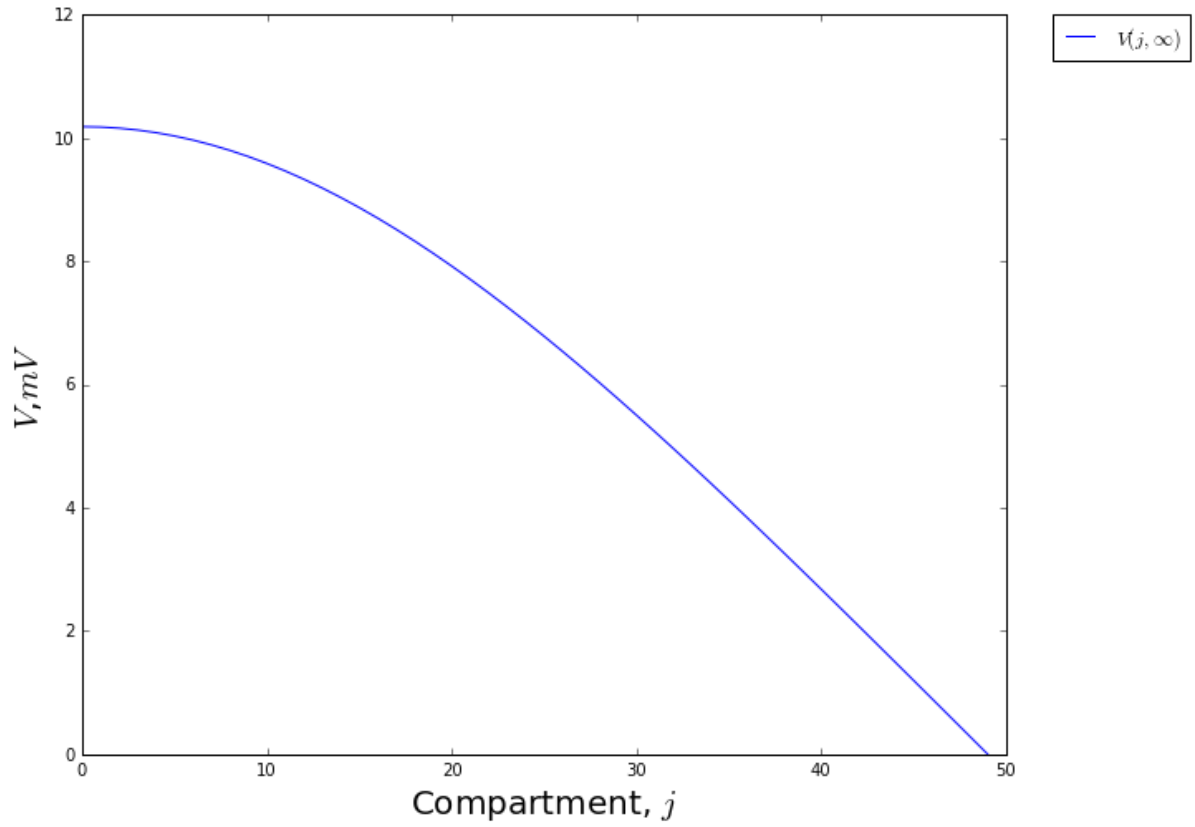
In [47]:
```
fig = plt.figure(figsize=(16, 12))
ax = fig.gca(projection='3d')
Y=Exp.t[::10]*1000
X, Y = np.meshgrid(range(1,N+1),Y)
V_plot=V[:,::10]*1000
surf = ax.plot_surface(X, Y, V_plot.T, rstride=1, cstride=1, cmap=cm.coolwarm,
                       linewidth=0, antialiased=False)


ax.zaxis.set_major_locator(LinearLocator(10))
ax.zaxis.set_major_formatter(FormatStrFormatter('%.02f'))

ax.set_xlabel('Compartment, $j$',fontsize=20)
ax.set_ylabel('Time ($t$), $ms$',fontsize=20)
ax.set_zlabel('Voltage ($V$), $mV$' ,fontsize=20)

fig.colorbar(surf, shrink=0.5, aspect=5)
plt.savefig('fig1.pdf', bbox_inches='tight')
plt.show()
```



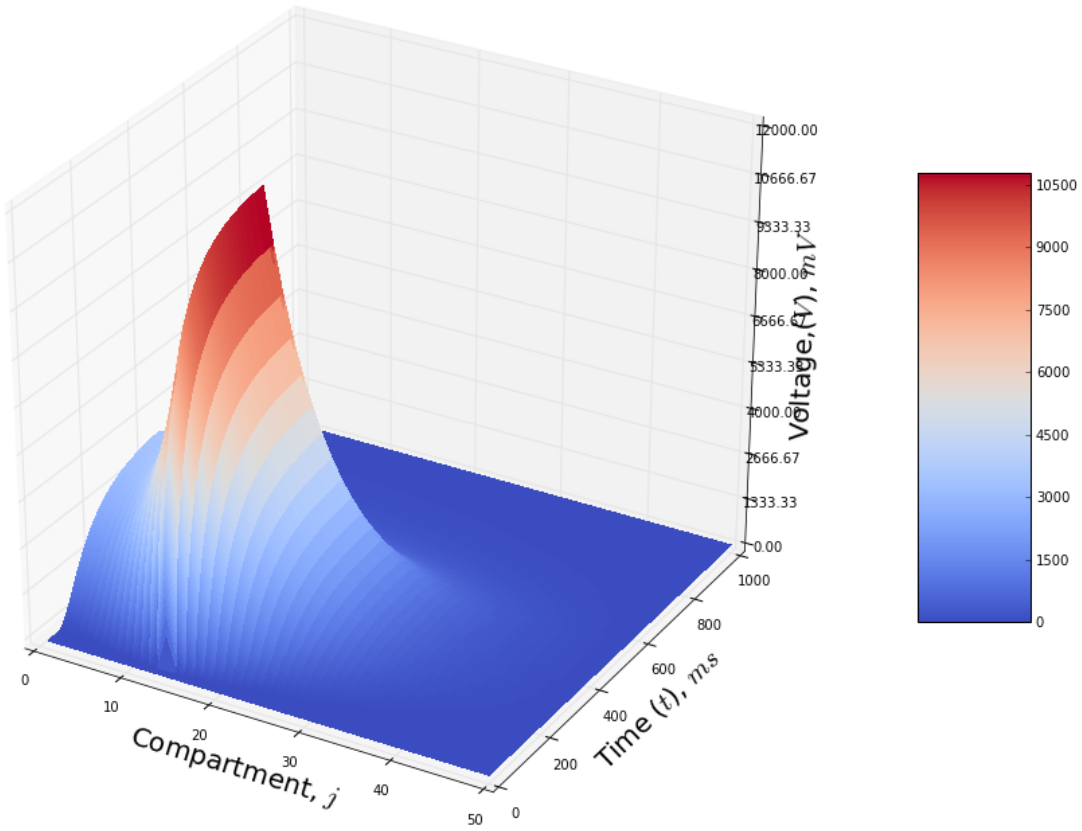
In [43]:
```
N=50
j=14
Neurite=[passive.Compartment() for k in range(N)]

Neurite[0].type="sealed"
Neurite[-1].type="killed"  #actually, I don't use it in code

Neurite[j-1].current=lambda t: I_e_step(10**(-10),20*10**(-3),t)-I_e_step(10**
10),400*10**(-3),t)
# j-1 because in python ind are from 0


Exp2=passive.Experiment()
V_2=Exp2.voltage(Neurite)*1000
plt.figure(figsize=(10,8))
for j in range(V.shape[0]-40):
    plt.plot(Exp2.t*1000,V_2[j,:]*1000, label="$V_{"+str(j)+"}(t)$")
plt.xlabel('$t$, $ms$',fontsize=20)
plt.ylabel('$V$,$mV$',fontsize=20)
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
plt.savefig('exp_2_first_ten_coms.pdf',bbox_inches='tight')
```



In [45]:
```
plt.figure(figsize=(10,8))
plt.plot(range(V_2.shape[0]),V_2[:,-1]*1000, label="$V(j,\infty)$")
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
plt.xlabel('Compartment, $j$',fontsize=20)
plt.ylabel('$V$,$mV$',fontsize=20)
plt.savefig('exp_2_inf.pdf',bbox_inches='tight')
```



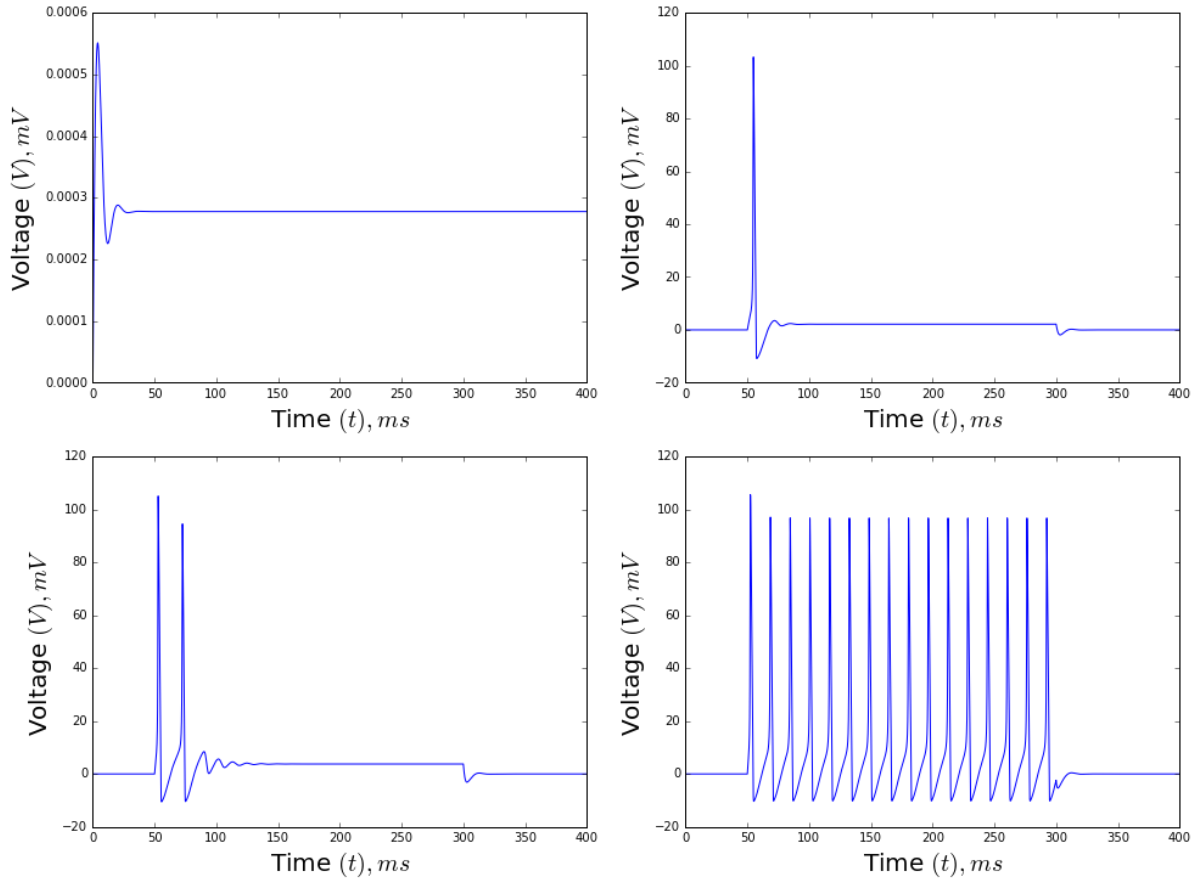
In [46]:
```
fig = plt.figure(figsize=(16, 12))
ax = fig.gca(projection='3d')
Y=Exp2.t[::10]*1000
X, Y = np.meshgrid(range(1,N+1),Y)
V_plot2=V_2[:,::10]

surf = ax.plot_surface(X, Y, V_plot2.T, rstride=1, cstride=1,
cmap=cm.coolwarm,
                       linewidth=0, antialiased=False)


ax.zaxis.set_major_locator(LinearLocator(10))
ax.zaxis.set_major_formatter(FormatStrFormatter('%.02f'))

ax.set_xlabel('Compartment, $j$',fontsize=20)
ax.set_ylabel('Time ($t$), $ms$',fontsize=20)
ax.set_zlabel('Voltage ($V$), $V$' ,fontsize=20)

fig.colorbar(surf, shrink=0.5, aspect=4)
plt.savefig('fig2.pdf', bbox_inches='tight')
plt.show()
```



Part 2. Simulation of single compartment Hodgkin-Huxley model of active neurite.

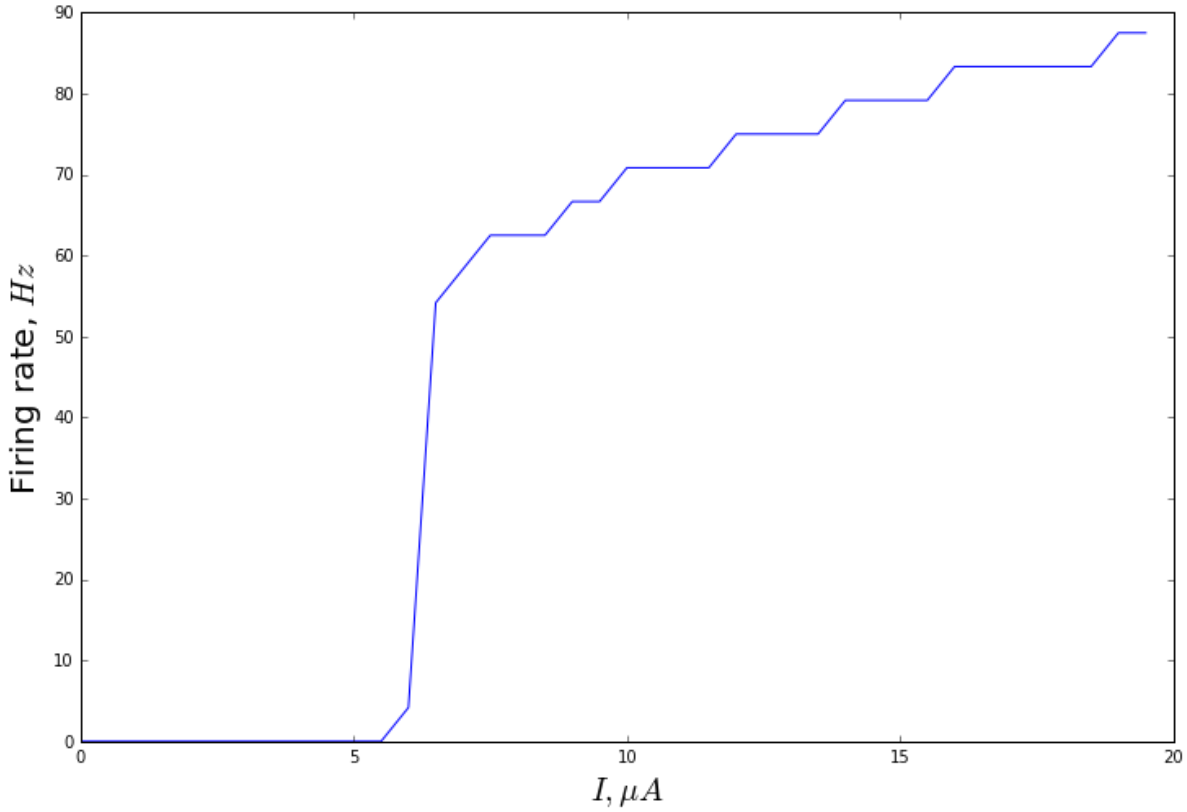
In [17]:
```
import active
```

In [18]:
```
Neurite=[active.Compartment()]
I_0_list=[0,3,6,8]
j=1
for I_0 in I_0_list:
    Neurite[0].current=lambda t: I_e_step(I_0,50,t)-I_e_step(I_0,300,t)
    Exp=active.Experiment(delta_t=2.5*10**(-2),t_start=0.0,t_end=400)
    (V,m,h,n)=Exp.voltage(Neurite)
    plt.figure(1,figsize=(16, 12))
    plt.subplot(2,2,j)
    plt.plot(Exp.t,V)
    plt.xlabel('Time $(t), ms$', fontsize=20)
    plt.ylabel('Voltage $(V),mV$', fontsize=20)
    j+=1
```



In [48]:
```
Neurite=[active.Compartment()]
I_0_list=list(np.arange(0,20,0.5))

threshold=80
start_stim=50
end_stim=300

rate=[]
for I_0 in I_0_list:
    Neurite[0].current=lambda t: I_e_step(I_0,start_stim,t)-I_e_step(I_0,end_s
tim,t)
    Exp=active.Experiment(delta_t=2.5*10**(-2),t_start=0.0,t_end=400)
    (V,m,h,n)=Exp.voltage(Neurite)
    # Number of spikes

    V_bin=[int(el) for el in list(V[Exp.t>start_stim+10]>threshold)] # we star
t cound after 10 ms of start current stimulation
    V_bin=squeeze(V_bin) #left only unique 0,1 for example squeeze([0,0,0,1,0,
1,1,1,0,0,1])=[0,1,0,1,0,1]
    N_spikes=sum(V_bin)
    t_spikes=(end_stim-(start_stim+10))/1000 # /1000 ms in seconds
    rate.append(N_spikes/t_spikes)

plt.figure(figsize=(12, 8))
plt.plot(I_0_list,rate) # 1/s or Hz
plt.xlabel('$I, \mu A$', fontsize=20)
plt.ylabel('Firing rate, $Hz$', fontsize=20)
```

Out[48]: <matplotlib.text.Text at 0x11ffde48>



In [ ]: