PhysiologyProject_MinaAhmadian

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

[2]:
```
T = 1.0
dt = 0.0001
t = np.arange(0,4*T,dt)
```

[3]:
```
Emax = 2
Emin = 0.06
HR = 60
tc = 60 / HR
Tmax = 0.2 + 0.15*tc
```

[4]:
```
def En(tn):
    tn = (tn % T)/Tmax
    v1 = ((tn / 0.7)**1.9)
    v2 = ((tn / 1.17)**21.9)
    return 1.55 * (v1 / (1 + v1)) * (1 / (1 + v2))
```

[5]:
```
def Et(t):
    return (Emax - Emin) * En(t) + Emin
```

[6]:
```
E = []
for i in (t):
    E.append(Et(i))
```

[7]:
```
Rs = 1.0000
Rm = 0.0050
Ra = 0.0010
Rc = 0.0398

Cr = 4.4000
Cs = 1.3300
Ca = 0.0800

Ls = 0.0005
```

```
V0 = 10
```

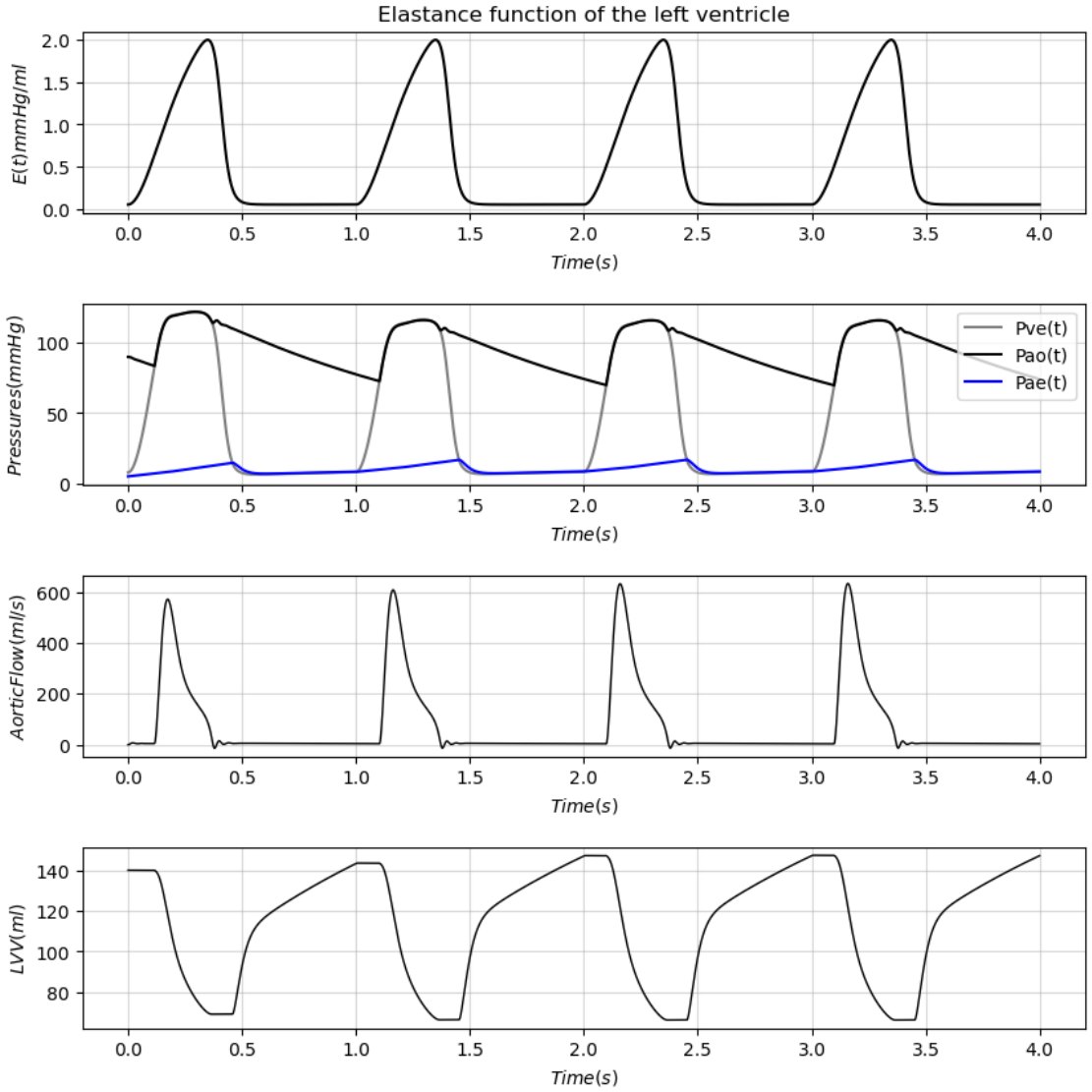
[8]:
```
Pae = np.zeros(len(t))
Vve = np.zeros(len(t))
Pao = np.zeros(len(t))
Q   = np.zeros(len(t))
Pas = np.zeros(len(t))
Pve = np.zeros(len(t))
```

[9]:
```
Pae[0] = 5
Vve[0] = 140
Pao[0] = 90
Q  [0] = 0
Pas[0] = 90
Pve[0] = (Vve[0] - V0)*E[0]
```

[10]:
```
for i in range(len(t)-1):

    Dm = (1 if Pae[i] >= Pve[i] else 0)
    Da = (1 if Pve[i] >= Pao[i] else 0)

    Vve[i+1] = Vve[i]  + dt*( (Da/Ra)*Pao[i] - (Dm/Rm + Da/Ra)*E[i]*Vve[i] +␣
↪(Dm/Rm)*Pae[i] + (Dm/Rm + Da/Ra)*E[i]* V0)
    Pve[i+1] = E[i+1]*(Vve[i+1] - V0)

    Pae[i+1] = Pae[i]  + dt*(-(Dm/(Cr*Rm))*(Pae[i] - Pve[i]) + (Pas[i]-Pae[i])/
↪(Cr*Rs))
    Pao[i+1] = Pao[i]  + dt*((Da/(Ca*Ra))*(Pve[i] - Pao[i]) - Q[i]/Ca)
    Q  [i+1] =   Q[i]  + dt*((-(Rc*Q[i])/Ls) - (Pas[i]/Ls) + (Pao[i]/Ls))
    Pas[i+1] = Pas[i]  + dt*((Q[i]/Cs) - (Pas[i]-Pae[i])/(Cs*Rs))
```

[11]:
```
plt.figure(figsize=(10,10))
plt.subplots_adjust(hspace=0.5)
plt.subplot(4, 1, 1)
plt.plot(t, E, c = 'k', lw = 1.5)
plt.grid(alpha = 0.5)
plt.title('Elastance function of the left ventricle')
plt.ylabel('$E(t) mmHg/ml$')
plt.xlabel('$Time(s)$')

plt.subplot(4, 1, 2)
plt.plot(t, Pve, c = 'gray', lw = 1.5, label = 'Pve(t)')
plt.plot(t, Pao, c = 'k', lw = 1.5, label = 'Pao(t)')
plt.plot(t, Pae, c = 'b', lw = 1.5, label = 'Pae(t)')
plt.legend(loc="upper right")
plt.grid(alpha = 0.5)
plt.ylabel('$Pressures (mmHg)$')
```

```
plt.xlabel('$Time(s)$')

plt.subplot(4, 1, 3)
plt.plot(t, Q, c = 'k', lw = 1)
plt.grid(alpha = 0.5)
plt.ylabel('$Aortic Flow (ml/s)$')
plt.xlabel('$Time(s)$')

plt.subplot(4, 1, 4)
plt.plot(t, Vve, c = 'k', lw = 1)
plt.grid(alpha = 0.5)
plt.ylabel('$LVV (ml)$')
plt.xlabel('$Time(s)$')

plt.show()
```



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