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```
function output = ODEfile3(t,y,p,runType)

    ydot = zeros(size(y));

Not enough input arguments.

Error in ODEfile3 (line 2)
    ydot = zeros(size(y));
```

# state variables

```
dt = y(1);
ft = y(2);
ikr_act = y(3);
ikr_inact = y(4);
y_1_2 = y(5);
nai = y(6);
ki = y(7);
cai = y(9);
v = y(8);
```

# model parameters

```
R = 8.314472; % [J/mol*K]
T = 310.5; % [K]
F = 96.4845; % [C/kmol]
FRT = F/(R*T);

capacitance = 0.025; % [nF]
r_cell = 15/2; %[um]
v_cell = ((4/3)*pi*(r_cell)^3)/1000; %[pL]
```

```
nao = 140; % [mM]
ko = 5.4; % [mM]
cao = 1.8; % [mM]

ecat=45.0;
gcat = 0.4*0.186;
gkr = 1*(0.8*0.08);
gh = 0.0001;
gbna=0.0001215;
gbca=0.000015;
gbk =0.00025;
slope_gh = 16.3;
vhalf_gh = 106.8;
kmkp=1.4;
kmnap=14;
inakmax=1.85*0.077;
K1ni=395.3;
K1no=1628;
K2ni=2.289;
K2no=561.4;
K3ni=26.44;
K3no=4.663;
Kci=0.0207;
Kco=3.663;
Kcni=26.44;
Qci=0.1369;
Qco=0.0;
Qn=0.4315;
kNaCa = 5.5;
```

# model equations

```
ek  = (R*T/F)*log(ko/ki);
ena = (R*T/F)*log(nao/nai);
eca = (R*T/(2*F))*log(cao/cai);
```

# CaT

```
   tau_dt = 1.0/(1.068*exp((v + 26.3)/30.0) + 1.068*exp(-(v +
 26.3)/30.0));
   dt_inf = 1.0/(1.0+exp(-(v + 26.0)/6.0));
   dt_dot = (dt_inf - dt)/tau_dt;
   tau_ft = 1.0/(0.0153*exp(-(v+61.7)/83.3)+0.015*exp((v
+61.7)/15.38));
   ft_inf = 1.0/(1.0+exp((v + 61.7)/5.6));
   ft_dot = (ft_inf - ft)/tau_ft;
   icat = gcat*ft*dt*(v - ecat);
```

# If

```
ih_pK = 0.6167; % ih_PNa = 0.3833;
```

```
    y_inf = 1.0/(1.0 + exp((v+vhalf_gh)/slope_gh));
    tau_y_1_2 = 1*(1.5049/(exp(-(v+590.3)*0.01094)+
 exp((v-85.1)/17.2)));
    y_1_2_dot = (y_inf - y_1_2)/tau_y_1_2;
    ihk  = ih_pK*gh*y_1_2*(v - ek);
    ihna = (1-ih_pK)*gh*y_1_2*(v - ena);
    ih = (ihk + ihna);
```

# Ikr

```
    ikr_act_inf = 1.0/(1.0 + exp(-(v+21.173694)/9.757086));
    tau_ikr_act = 0.699821/(0.003596*exp((v)/15.339290) +
 0.000177*exp(-(v)/25.868423));
    ikr_act_dot = (ikr_act_inf-ikr_act)/tau_ikr_act;
    ikr_inact_inf = 1.0/(1.0 + exp((v+20.758474-4.0)/(19.0)));
    tau_ikr_inact = 0.2+0.9*1.0/
(0.1*exp(v/54.645)+0.656*exp(v/106.157));
    ikr_inact_dot = (ikr_inact_inf - ikr_inact)/tau_ikr_inact;
    ikr = gkr*ikr_act*ikr_inact*(v - ek);
```

# NaK

```
    inak = inakmax*((ko^1.2)/((kmkp^1.2)+(ko^1.2)))*((nai^1.3)/
((kmnap^1.3)+(nai^1.3)))/(1.0+exp(-(v-ena+120.0)/30.0));
```

# INaCa

```
    di=1+(cai/Kci)*(1+exp(-Qci*v*FRT)+nai/Kcni)+(nai/K1ni)*(1+(nai/
K2ni)*(1+nai/K3ni));
    doo=1+(cao/Kco)*(1+exp(Qco*v*FRT))+(nao/K1no)*(1+(nao/
K2no)*(1+nao/K3no));
    k43=nai/(K3ni+nai);
    k12=(cai/Kci)*exp(-Qci*v*FRT)/di;
    k14=(nai/K1ni)*(nai/K2ni)*(1+nai/K3ni)*exp(Qn*v*FRT/2.0)/di;
    k41=exp(-Qn*v*FRT/2.0);
    k34=nao/(K3no+nao);
    k21=(cao/Kco)*exp(Qco*v*FRT)/doo;
    k23=(nao/K1no)*(nao/K2no)*(1+nao/K3no)*exp(-Qn*v*FRT/2.0)/doo;
    k32=exp(Qn*v*FRT/2);
    x1=k34*k41*(k23+k21)+k21*k32*(k43+k41);
    x2=k43*k32*(k14+k12)+k41*k12*(k34+k32);
    x3=k43*k14*(k23+k21)+k12*k23*(k43+k41);
    x4=k34*k23*(k14+k12)+k21*k14*(k34+k32);
    inaca = kNaCa*(k21*x2-k12*x1)/(x1+x2+x3+x4);
```

# Background

```
    ibna = gbna*(v - ena);
    ibca = gbca*(v - eca);
    ibk = gbk*(v - ek);
    ib = (ibna + ibca + ibk);
```

# Concentrations

```
nai_tot = ihna+3.0*inak + 3.0*inaca+ibna;
nai_dot = (-nai_tot)/(F*v_cell);

ki_tot = ihk+ikr-2.0*inak+ibk;
ki_dot = (-ki_tot)/(F*v_cell);

cai_tot = icat-2.0*inaca+ibca;
cai_dot = (-cai_tot)/(F*v_cell);
```

# membrane pot

```
total_current = ih+ikr+icat+inak+ib+inaca;
v_dot = -(total_current)/capacitance;
```

# output

```
ydot(1) = dt_dot;
ydot(2) = ft_dot;
ydot(3) = ikr_act_dot;
ydot(4) = ikr_inact_dot;
ydot(5) = y_1_2_dot;
ydot(6) = nai_dot;
ydot(7) = ki_dot;
ydot(9) = cai_dot;
ydot(8) = v_dot;
```

# adjust output

```
if (nargin == 3)
    output = ydot;
elseif (nargin == 4) && strcmp(runType,'ydot')
    output = ydot;
elseif (nargin == 4) && strcmp(runType,'currents')
    currents = [v_dot icat ih ikr inak inaca ib];
    output = currents;
end

end
```

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