Problem 1b-c script

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```
clear all
close all
% Universal constants
g0=9.8066; %[g0]=m/s^2
Ru=8314.3; %[Ru]=J/k-mol-K
k_b=8.617333262145e-5; %[k_b]=eV/K
e=1.602176634e-19; %[e]=J/eV
eps0=8.8541878128e-12; %[eps0]=SI units
mu_0=4*pi*1e-7; %[mu_0]=SI units
c=299792458; %[c]=m/s
h=6.62607015e-34; %[h]=J*s
m_a=1.6605e-27; %[m_a]=kg/u
m_e=9.10938356e-31; %[m_e]=kg
% Problem input parameters
l_0=100e-9;
R=5e-3;
C=400e-6;
input.l_1=l_0;
input.l_2=l_0;
input.R1=R;
input.R2=R;
input.C=C;
% Gas params
T=1e3/k_b; %[T_i]=eV
g=1.3;
MW=4; % need this
% Transformer params
mu_r=1;
r_T=0.1; %[r]=m
N_T1=25;
l_T1=1; %[l_T1]=m
input.L1=mu_0*mu_r*(pi*r_T^2)*N_T1.^2/l_T1;

N_T2_vec=4;
l_T2=3; %[l_T1]=m
input.L2=mu_0*mu_r*(pi*r_T^2)*N_T2_vec.^2/l_T2;
input.k=0.9;

N_Fcc=10;
r_Fcc=3.4; %[r_Fcc]=m
L_Fcc=mu_0*(pi*r_Fcc^2)*N_Fcc^2/r_Fcc;
R_gas=Ru/MW;
input.tau=(r_Fcc/(4*sqrt(g*R_gas*T)));
input.v_exp_hand= @(t) sqrt(g*R_gas*2*T)*(cos(pi*t/(2*input.tau)).*...
    ((t/input.tau)<2)-(1.*(t/input.tau)>=2));
input.dL_nozz_hand=@(t) -0.5*mu_0*N_Fcc*input.v_exp_hand(t);
input.L_nozz_hand=@(d) 0.5*mu_0*N_Fcc*d;
input.I0=5e6;
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```
input.Rp0=0;
input.R_Fcc=r_Fcc;

[t,I_1,I_2,V_Cap,d_vec] = circuitModelFunction_V_Cassibry2(input);
L_t_vec=input.L_nozz_hand(d_vec);
[V_Cap_maxVal,V_Cap_maxInd]=max(V_Cap);
E_cap=0.5*input.C*(V_Cap(V_Cap_maxInd)^2-V_Cap(1)^2);
V_sqig_vec=I_1.*input.dL_nozz_hand(t);
% Calulcate current changes
L0_vec=input.L1+input.l_1+L_t_vec;
M_circ=input.k*sqrt(input.L1*input.L2);
dI2_vec=(V_Cap-I_2*input.R2-(M_circ*(V_sqig_vec-I_1*input.R1)./
L0_vec))...
    ./(input.l_2+input.L2-(M_circ^2./L0_vec));
dI1_vec=(V_sqig_vec-I_1*input.R1-M_circ*dI2_vec)./(L0_vec);
% Calculate energy of each component
E_Cap=0.5*input.C*V_Cap(1:V_Cap_maxInd).^2;

E_in=ones(V_Cap_maxInd,1);
for i=1:length(E_in)
    if i == 1
        E_in(i)=0;
    else
        E_in(i)=trapz(t(1:i),I_1(1:i).*V_sqig_vec(1:i));
    end
end
E_gen=ones(V_Cap_maxInd,1);
for i=1:length(E_gen)
    if i == 1
        E_gen(i)=0;
    else
        E_gen(i)=trapz(t(1:i),I_1(1:i).*L_t_vec(1:i).*dI1_vec(1:i));
    end
end

E_L1=0.5*input.L1*I_1(1:V_Cap_maxInd).^2;
E_L2=0.5*input.L2*I_2(1:V_Cap_maxInd).^2;
E_M=0.5*M_circ*(I_1(1:V_Cap_maxInd)-I_2(1:V_Cap_maxInd)).^2;

E_l1=0.5*input.l_1*I_1(1:V_Cap_maxInd).^2;
E_l2=0.5*input.l_2*I_2(1:V_Cap_maxInd).^2;

E_R1=ones(V_Cap_maxInd,1);
for i=1:length(E_R1)
    if i == 1
        E_R1(i)=0;
    else
        E_R1(i)=-trapz(t(1:i),input.R1*(I_1(1:i)).^2);
    end
end
E_R2=ones(V_Cap_maxInd,1);
for i=1:length(E_R2)
    if i == 1
        E_R2(i)=0;
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    else
        E_R2(i)=-trapz(t(1:i),input.R2*(I_2(1:i)).^2);
    end
end

E_tot=E_Cap+E_in+E_gen+E_L1+E_L2+E_M+E_l1+E_l2+E_R1+E_R2;
G=E_cap/(E_tot(end)-E_tot(1)-E_R1(end)-E_R2(end))
```

```
G =

    0.1965
```

Plotting

```
h=figure(1);
plot(t*10^6,I_1*1e-6,t*10^6,I_2*1e-6)
grid on
xlabel('\textbf{Time since ignition, }\boldmath$\mu$
\textbf{s}','interpreter','latex','fontsize',22)
ylabel('\textbf{Current, MA}','interpreter','latex','fontsize',22)
title('\textbf{Current vs. Time since ignition with load
 connected}','interpreter','latex','fontsize',22)
legend({'\boldmath $I_1$','\boldmath
 $I_2$'},'interpreter','latex','fontsize',18)
h.Children(2).LineWidth=2;
h.Children(2).FontSize=18;
set(findall(gca, 'Type', 'Line'),'LineWidth',2);
xlim([0 10])

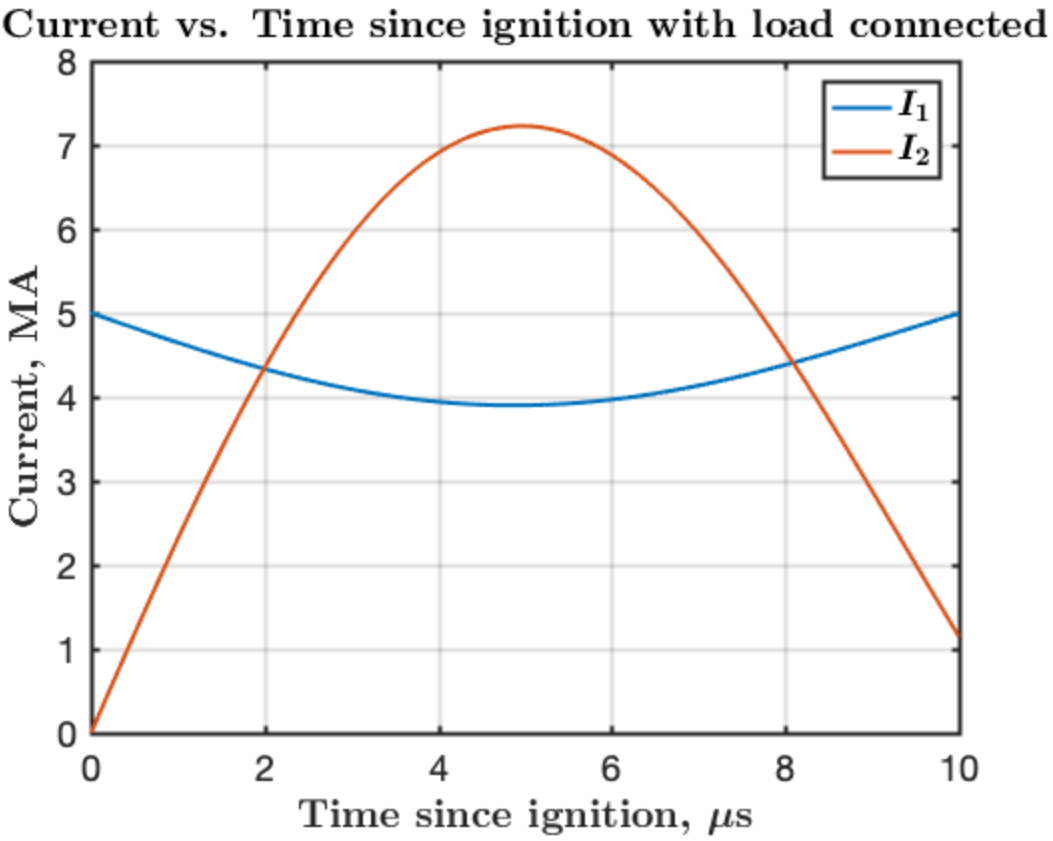
figure(2)
plot(t*10^6,V_Cap*1e-3)
grid on
title('\textbf{U(kV) vs. Time since ignition}','interpreter','latex')
xlabel('\textbf{Time since ignition (}{\boldmath$\mu
$}\textbf{sec)}','interpreter','latex')
ylabel('\textbf{Voltage across capacitor \textup{U}
(kV)}','interpreter','latex')
set(gca,'fontsize',28)
set(findall(gca, 'Type', 'Line'),'LineWidth',2);
xlim([0 10])

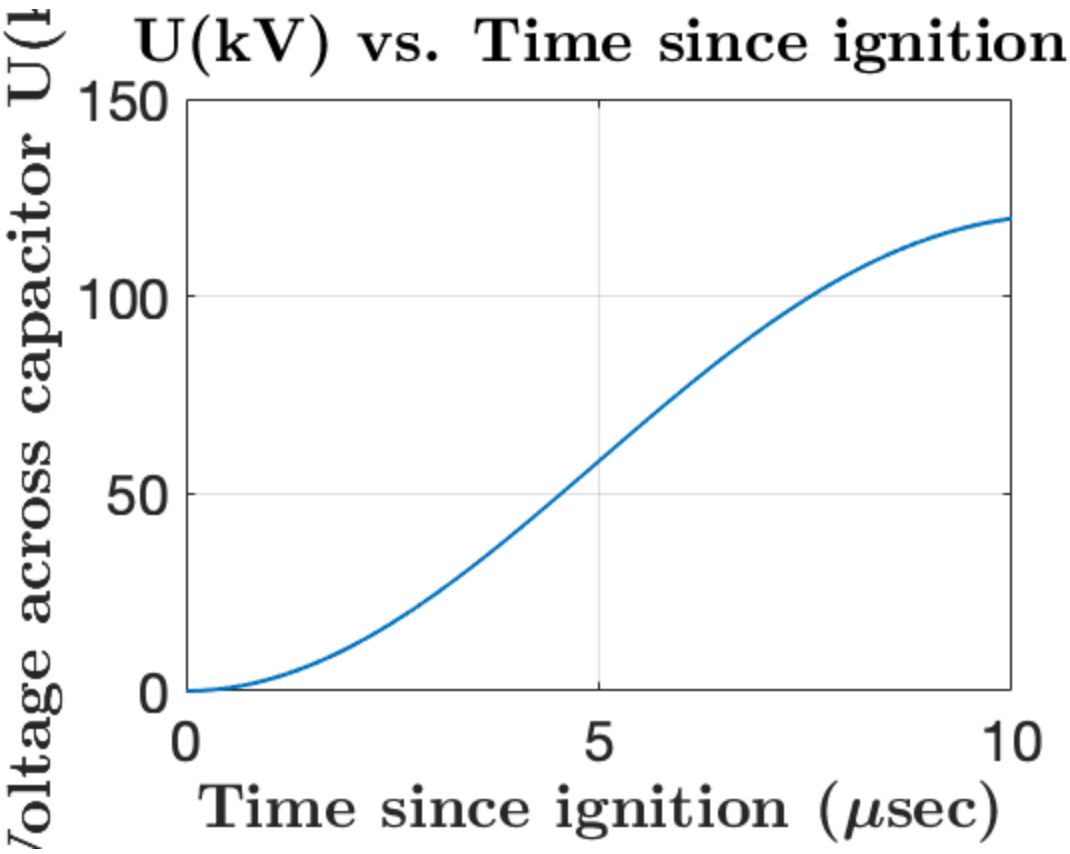
% Domain of time from t=0 to t=V_cap_max
t_max_domain=t(1:V_Cap_maxInd);

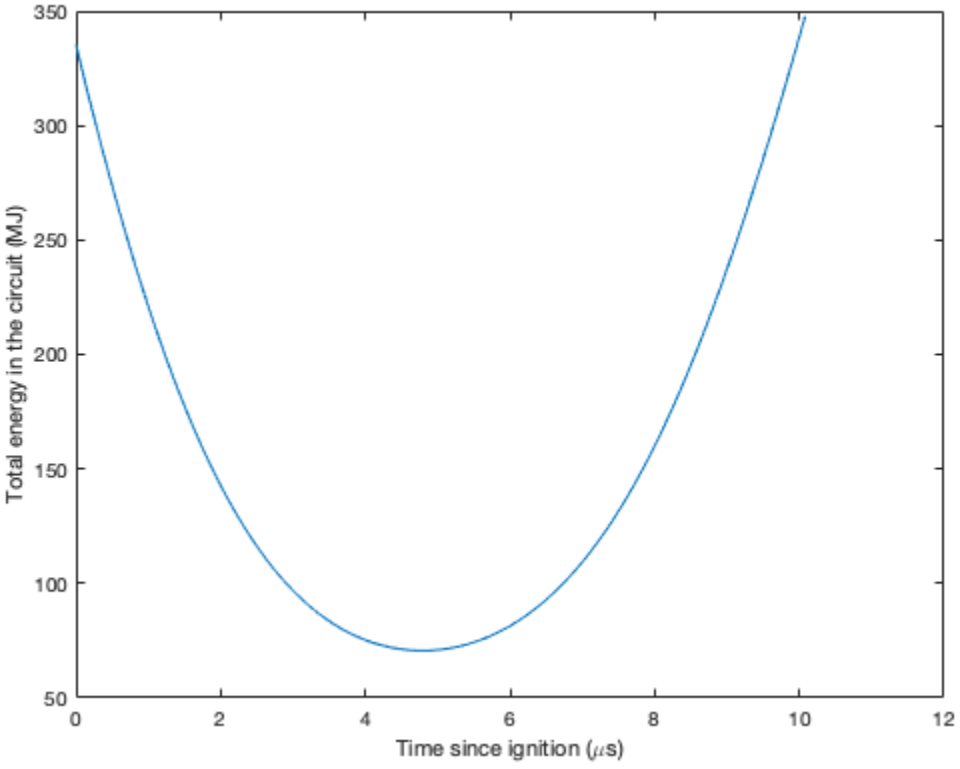
figure(3)
plot(t_max_domain*10^6,E_tot*10^-6)
xlabel('Time since ignition (\mus)')
ylabel('Total energy in the circuit (MJ)')

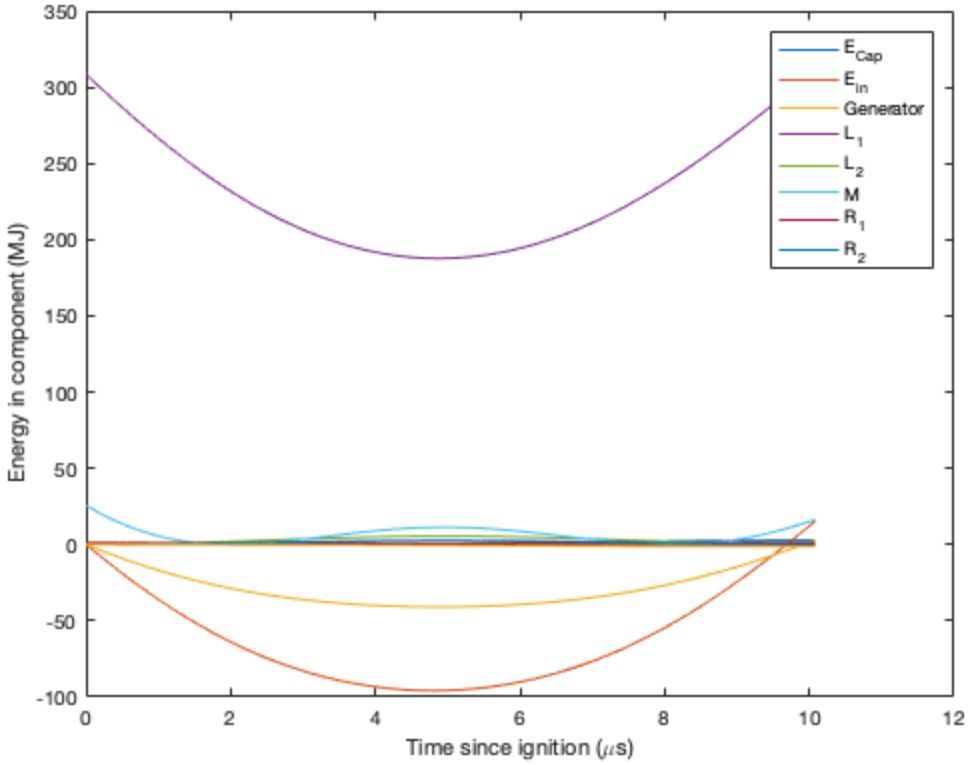
figure(4)
plot(t_max_domain*10^6,E_Cap*10^-6,t_max_domain*10^6,E_in*10^-6,t_max_domain*10^6,
```

```
xlabel('Time since ignition (\mus)')
ylabel('Energy in component (MJ)')
legend('E_{Cap}','E_{in}','Generator','L_1','L_2','M','R_1','R_2','Location','Nort
```




U(kV) vs. Time since ignition
Voltage across capacitor U(t
150
100
50
0
0
5
10
Time since ignition (μsec)


350
300
250
200
150
100
50
Total energy in the circuit (MJ)
0
2
4
6
8
10
12
Time since ignition (μs)



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