```
% C. Petersen, H. Werkle, Dynamik der Baukonstruktionen
% 2. Auflage, Springer Vieweg, Wiesbaden, 2018
%
% ML_06_2_Freie_Schwingungen_eines_EFS_mit_Coulombscher_Reibung:
% Freie Schwingungen eines Einfreiheitsgradschwingers mit Coulombscher
% Reibung
%
% Version 1.0, April 2018
% Softwareentwicklung:
% Andrei Firus, M.Eng (andrei.firus@gmail.com)

% Aufbau Eingabedatei: Eingabedatei nicht notwendig

% Ausgabedateien:
% Outputdatei_1: Eingaben- und Ergebnisübersicht
% Outputdatei_2: Verschiebungszeitverlauf [m]
% Outputdatei_3: Geschwindigkeitszeitverlauf [m/s]
% Outputdatei_4: Beschleunigungszeitverlauf [m/s^2]
%----------------------------- EINGABEBLOCK ---------------------------------
m=100;                          % Masse des EFS [kg]
k=10000;                        % Federkonstante [N/m]

r=100;                          % Reibungskraft [N]

y0=0.125;                       % Anfangsauslenkung [m]
v0=0;                           % Anfangsgeschwindigkeit [m/s]


n_dt=40;                        % Anzahl der Unterteilungen von der
                                % Eigenschwingzeit für die Festlegung des
                                % Berechnungszeitschrittes [-]

t_ber=15;                       % Gesamtzeit der Berechnung [s]
%--------------------------------------------------------------------------

%--------------------------- BERECHNUNGSBLOCK -----------------------------
omega=sqrt(k/m);                % Eigenkreisfrequenz
f=omega/(2*pi);                 % Eigenfrequenz
T=1/f;                          % Eigenschwingzeit
dt=T/n_dt;                      % Zeitschritt
d_tau=dt/T;                     % Berechnungszeitschritt (bezogene Zeit)
nt=ceil(t_ber/dt);              % Anzahl Berechnungszeitschritte
tau_b=0:d_tau:t_ber/T;          % Bezogener Zeitvektor für die Berechnung
t_b=0:dt:t_ber;                 % Zeitvektor für die Berechnung
%--------------------------------------------------------------------------

% Berechnung der Schwingungsantwort mittels Differenzenverfahren
y=zeros(nt,1); % Definition des Verschiebungsvektors
v=zeros(nt,1); % Definition des Geschwindigkeitsvektors
a=zeros(nt,1); % Definition des Beschleunigungsvektors
y(1)=y0;
v(1)=v0;
y(2)=(1-2*pi^2*(d_tau)^2)*y(1)+v(1)*d_tau-((2*pi^2)/k)*sign(v(1))*r*...
    d_tau^2;
v(2)=(1/(2*dt))*(4*y(2)-4*y0-2*v0*dt);
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% Berechnung der Verschiebungen und Geschwindigkeiten
for i=3:1:nt
    y(i)=2*(1-2*pi^2*(d_tau)^2)*y(i-1)-y(i-2)-...
    sign(v(i-1))*r*((2*pi)^2/k)*d_tau^2;

    v(i)=(1/(2*dt))*(3*y(i)-4*(y(i-1))+y(i-2));

     if (sign(v(i))~=sign(v(i-1))) && (abs(y(i))<=r/k)
         nm=i; break    % nm: Zeitschritt bei Erreichung des Stillstandes
     end
end

% Vektoren bis zum Stillstand (Federkraft kleiner als die Reibungskraft)
tau_nm=tau_b(1:nm);
t_nm=t_b(1:nm);
y_nm=y(1:nm);
v_nm=v(1:nm);

% Berechnung der Beschleunigungen
a(1)=(-k*y(1)-sign(v(1))*r)/m;
for i=2:1:nm-1
    a(i)=(1/dt^2)*(y(i+1)-2*y(i)+y(i-1));
end
a_nm=a(1:nm);
%-------------------------------------------------------------------------

%------------------------- DARSTELLUNGSBLOCK -----------------------------
%Grafische Darstellung der Ergebnisse
name_fig1 = 'Zeitverläufe';
fig1=figure('Name',name_fig1,'NumberTitle','off');
set(fig1,'Position',[1000 50 700 900]);

subplot(3,1,1)
% Definition der Geraden (positiv und negativ)
if y0>=0
    [pks,locs]=findpeaks(y);
else
    [pks,locs]=findpeaks(-y);
end
g=zeros(length(pks)+1,1);
g(1)=abs(y0);
for i=2:1:length(g)
    g(i)=pks(i-1);
end
t_fig=[0 tau_nm(locs-1)];
plot(tau_nm,y_nm);
hold on;
plot(t_fig,g,'-.r',t_fig,-g,'-.r','MarkerSize',3);
title('Verschiebungszeitverlauf');
xlabel('bezogene Zeit [-]');
ylabel('Verschiebung [m]');
grid on; zoom on;

subplot(3,1,2)
plot(tau_nm,v_nm,'MarkerSize',3);
title('Geschwindigkeitszeitverlauf');
xlabel('bezogene Zeit [-]');
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ylabel('Geschwindigkeit [m/s]');
grid on; zoom on;

subplot(3,1,3)
plot(tau_nm,a_nm,'MarkerSize',3);
title('Beschleunigungszeitverlauf');
xlabel('bezogene Zeit [-]');
ylabel('Beschleunigung [m/s^2]');
grid on; zoom on;
%--------------------------------------------------------------------------

%---------------------------- AUSGABEBLOCK --------------------------------
% Ausgabe der Ergebnisse in eine Datei
fid = fopen('Outputdatei_1_Allgemein.txt', 'w');
fprintf(fid,...
    '%s\n','C. Petersen, H. Werkle, Dynamik der Baukonstruktionen');
fprintf(fid,...
    '%s\n','2. Auflage, Springer Vieweg, Wiesbaden, 2018');
fprintf(fid,...
    '%s\n','Softwareentwicklung: Andrei Firus (andrei.firus@gmail.com)');
fprintf(fid,'%s\n','Programm ML_06_2: Eingaben- und Ergebnisuebersicht');
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,...
    '%s\n','-------------------------------------------------------------');
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,...
    '%s\n','EINGABEDATEN:');
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Masse des Einfreiheitsgradschwingers [kg]:');
fprintf(fid,'%d\n',m);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Federkonstante [N/m]:');
fprintf(fid,'%d\n',k);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Reibungskraft [N]:');
fprintf(fid,'%d\n',r);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Anfangsauslenkung [m]:');
fprintf(fid,'%d\n',y0);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Anfangsgeschwindigkeit [m/s]:');
fprintf(fid,'%d\n',v0);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s %s\n%s\n','Anzahl der Unterteilungen der',...
    'Eigenschwingzeit für','den Berechnungszeitschritt [-]:');
fprintf(fid,'%d\n',n_dt);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Gesamtzeit der Berechnung [s]:');
fprintf(fid,'%d\n',t_ber);
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fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,...
    '%s\n','------------------------------------------------------------');
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,...
    '%s\n','ERGEBNISSE:');
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Eigenkreisfrequenz [1/s]:');
fprintf(fid,'%d\n',omega);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Eigenfrequenz [Hz]:');
fprintf(fid,'%d\n',f);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Eigenschwingzeit [s]:');
fprintf(fid,'%d\n',T);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Zeitschritt [s]:');
fprintf(fid,'%d\n',dt);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Auf die Eigenschwingzeit bezogener Zeitschritt [-]:');
fprintf(fid,'%d\n',d_tau);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Anzahl der Berechnungszeitschritte [-]:');
fprintf(fid,'%d\n',nt);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Berechnungszeitschritte bis zum Stillstand [-]:');
fprintf(fid,'%d\n',nm);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Endamplitude [m]:');
fprintf(fid,'%d\n',y(nm));
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,...
    '%s\n','------------------------------------------------------------');
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fclose(fid);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Ergebnis_Verschiebungen=[tau_nm' y_nm];
fid = fopen('Outputdatei_2_Verschiebungen.txt', 'w');
fprintf(fid,...
    '%s\n','C. Petersen, H. Werkle, Dynamik der Baukonstruktionen');
fprintf(fid,...
    '%s\n','2. Auflage, Springer Vieweg, Wiesbaden, 2018');
fprintf(fid,...
    '%s\n','Softwareentwicklung: Andrei Firus (andrei.firus@gmail.com)');
fprintf(fid,'%s\n','Programm ML_06_2: Verschiebungszeitverlauf');
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fprintf(fid, '%s\n', ' ');
fprintf(fid,...
    '%s\n','------------------------------------------------------------');
fprintf(fid, '%s\n', ' ');
fprintf(fid,'%s\n','Verschiebungszeitverlauf:');
fprintf(fid,'%s \t %s\n','Bezogene Zeit [-]', 'Verschiebung [m]');
for ii=1:1:length(y_nm)
    fprintf(fid,'%d \t %d\n',Ergebnis_Verschiebungen(ii,:));
end
fclose(fid);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Ergebnis_Geschwindigkeiten=[tau_nm' v_nm];
fid = fopen('Outputdatei_3_Geschwindigkeiten.txt', 'w');
fprintf(fid,...
    '%s\n','C. Petersen, H. Werkle, Dynamik der Baukonstruktionen');
fprintf(fid,...
    '%s\n','2. Auflage, Springer Vieweg, Wiesbaden, 2018');
fprintf(fid,...
    '%s\n','Softwareentwicklung: Andrei Firus (andrei.firus@gmail.com)');
fprintf(fid,'%s\n','Programm ML_06_2: Geschwindigkeitszeitverlauf');
fprintf(fid, '%s\n', ' ');
fprintf(fid,...
    '%s\n','------------------------------------------------------------');
fprintf(fid, '%s\n', ' ');
fprintf(fid,'%s\n','Geschwindigkeitszeitverlauf:');
fprintf(fid,'%s \t %s\n','Bezogene Zeit [-]', 'Geschwindigkeit [m/s]');
for ii=1:1:length(v_nm)
    fprintf(fid,'%d \t %d\n',Ergebnis_Geschwindigkeiten(ii,:));
end
fclose(fid);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

Ergebnis_Beschleunigung=[tau_nm' a_nm];
fid = fopen('Outputdatei_4_Beschleunigungen.txt', 'w');
fprintf(fid,...
    '%s\n','C. Petersen, H. Werkle, Dynamik der Baukonstruktionen');
fprintf(fid,...
    '%s\n','2. Auflage, Springer Vieweg, Wiesbaden, 2018');
fprintf(fid,...
    '%s\n','Softwareentwicklung: Andrei Firus (andrei.firus@gmail.com)');
fprintf(fid,'%s\n','Programm ML_06_2: Beschleunigungszeitverlauf');
fprintf(fid, '%s\n', ' ');
fprintf(fid,...
    '%s\n','------------------------------------------------------------');
fprintf(fid, '%s\n', ' ');
fprintf(fid,'%s\n','Beschleunigungszeitverlauf:');
fprintf(fid,'%s \t %s\n','Bezogene Zeit [-]', 'Beschleunigung [m/s^2]');
for ii=1:1:length(a_nm)
    fprintf(fid,'%d \t %d\n',Ergebnis_Beschleunigung(ii,:));
end
fclose(fid);
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%--------------------------------------------------------------------------
```