```
% C. Petersen, H. Werkle, Dynamik der Baukonstruktionen
% 2. Auflage, Springer Vieweg, Wiesbaden, 2018
%
% ML_22_1_Seilschwingungen_parametererregt: Parametererregte
% Seilschwingungen
%
% 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: Zeitverläufe der Bewegungsgrößen


%--------------------------- EINGABEBLOCK --------------------------------
% Eingaben im Quellcode

m=14.30;              % Ersatzmasse des Seils [kg]
d=0.5845;             % Durchhang des Seiles (Ersatzmodell) [m]
xi=0.00;              % Dämpfungsmaß [-]
l=100;                % Seillänge [m]
EA=7.705*10^6;        % Dehnsteifigkeit des Seiles [N]
S0=6000;              % Vorspannkraft des Seiles [N]
delta=0.1;            % Auf den Seildurchhang bezogene Amplitude der
                      % harmonischen Zwangserregung [-]
om=9.5;               % Erregerkreisfrequenz [1/s]

nt=2000;              % Anzahl der Berechnungszeitschritte [-]
dt=0.01;              % Berechnungszeitschritt [s]
ita_0=0;              % Bezogene Anfangsauslenkung [-]
ita_p_0=0;            % Bezogene Anfangsgeschwindigkeit [1/s]
%-------------------------------------------------------------------------

%------------------------- BERECHNUNGSBOLCK ------------------------------
% Berechnung der Systemparameter
K1=2*(EA/S0)*(d/l)^2;
K2=3*K1/(1+2*K1);
K3=K1/(1+2*K1);
K4=(K1/(2*(1+2*K1)))*(l/d);
omega=sqrt((1+2*K1)*4*S0/(m*l));

% Funktionsdefinition
g=@(t,u,v) -omega^2*(u+K2*u^2+K3*u^3+K4*(1+u)*delta*sin(om*t))-...
           2*omega*xi*v;

% Berechnung der Schwingungsantwort mittels Runge-Kutta-Verfahren

% Definition der Ergebnisvektoren
ita=zeros(nt,1);
ita_p=zeros(nt,1);
ita_pp=zeros(nt,1);

% Erstellung eines Zeitvektors für die Darstellung
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t_b=0:dt:dt*(nt-1);

% Erfassung der Anfangswerte
t=0; u=ita_0; v=ita_p_0; vp=g(t,u,v);
ita(1)=u; ita_p(1)=v; ita_pp(1)=vp;

% Berechnungsvorschrift
for i=1:1:nt-1
    t0=t; u0=u; v0=v; vp0=vp;
    z1=1/2; z2=t0+dt/2; z3=t0+dt; z4=z1*dt;

    l1=dt*vp0;
    l2=dt*g(z2,u0+z4*v0,v0+z1*l1);
    l3=dt*g(z2,u0+z4*v0+z4*l1/2,v0+z1*l2);
    l4=dt*g(z3,u0+dt*v0+z4*l2,v0+l3);

    u=u0+dt*v0+dt*(l1+l2+l3)/6;
    v=v0+(l1+2*l2+2*l3+l4)/6;

    t=i*dt;
    vp=g(t,u,v);

    ita(i+1)=u;
    ita_p(i+1)=v;
    ita_pp(i+1)=vp;
end

% Extremwerte
ita_max=max(ita);          ita_min=min(ita);
ita_p_max=max(ita_p);      ita_p_min=min(ita_p);
ita_pp_max=max(ita_pp);    ita_pp_min=min(ita_pp);
%-------------------------------------------------------------------------

%------------------------ DARSTELLUNGSBLOCK -----------------------------
% Grafische Darstellung der Ergebnisse
name_fig1 = 'Bewegungszeitverläufe';
fig1=figure('Name',name_fig1,'NumberTitle','off');
set(fig1,'Position',[200 300 800 500]);

subplot(3,1,1)
plot(t_b,ita,'MarkerSize',3);
title('Verschiebungszeitverlauf');
xlabel('Zeit [s]');
ylabel('Verschiebung [-]');
grid on; zoom on;

subplot(3,1,2)
plot(t_b,ita_p,'MarkerSize',3);
title('Geschwindigkeitszeitverlauf');
xlabel('Zeit [s]');
ylabel('Geschwindigkeit [1/s]');
grid on; zoom on;

subplot(3,1,3)
plot(t_b,ita_pp,'MarkerSize',3);
title('Beschleunigungszeitverlauf');
```

```
xlabel('Zeit [s]');
ylabel('Beschleunigung [1/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_22_1: 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','Ersatzmasse des Seils [kg]:');
fprintf(fid,'%d\n',m);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Durchhang des Seils (Ersatzmodell) [m]:');
fprintf(fid,'%d\n',d);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Daempfungsmass [-]:');
fprintf(fid,'%d\n',xi);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Seillaenge [m]:');
fprintf(fid,'%d\n',l);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Dehnsteifigkeit des Seils [N]:');
fprintf(fid,'%d\n',EA);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Vorspannkraft des Seils [N]:');
fprintf(fid,'%d\n',S0);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s %s\n%s\n','Auf den Seildurchhang bezogene Amplitude der',...
    'harmonischen','Zwangsanregung [-]:');
fprintf(fid,'%d\n',delta);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Erregerkreisfrequenz [1/s]:');
fprintf(fid,'%d\n',om);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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fprintf(fid,'%s\n','Anzahl der Berechnungszeitschritte [-]:');
fprintf(fid,'%d\n',nt);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Berechnungszeitschritt [s]:');
fprintf(fid,'%d\n',dt);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Bezogene Anfangsauslenkung [-]:');
fprintf(fid,'%d\n',ita_0);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Bezogene Anfangsgeschwindigkeit [1/s]:');
fprintf(fid,'%d\n',ita_p_0);
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 des Seils [1/s]:');
fprintf(fid,'%d\n',omega);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s %s\n','Zwischenwerte (Vorfaktoren in der',...
    'Differentialgleichung):');
fprintf(fid,'%s \t %d\n','K1=',K1);
fprintf(fid,'%s \t %d\n','K2=',K2);
fprintf(fid,'%s \t %d\n','K3=',K3);
fprintf(fid,'%s \t %d\n','K4=',K4);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Maximale bezogene Verschiebung [-]:');
fprintf(fid,'%d\n',ita_max);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Minimale bezogene Verschiebung [-]:');
fprintf(fid,'%d\n',ita_min);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Maximale bezogene Geschwindigkeit [1/s]:');
fprintf(fid,'%d\n',ita_p_max);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Minimale bezogene Geschwindigkeit [1/s]:');
fprintf(fid,'%d\n',ita_p_min);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Maximale bezogene Beschleunigung [1/s^2]:');
fprintf(fid,'%d\n',ita_pp_max);
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,'%s\n','Minimale bezogene Beschleunigung [1/s^2]:');
fprintf(fid,'%d\n',ita_pp_min);
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fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fprintf(fid,...
    '%s\n','-------------------------------------------------------------');
fprintf(fid, '%s\n', ' ');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
fclose(fid);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
Ergebnis_Bewegungsgroessen=[t_b' ita ita_p ita_pp];
fid = fopen('Outputdatei_2_Bewegungsgroessen.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 %s\n','Programm ML_22_1: Zeitverlaeufe der',...
    'bezogenen Bewegungsgroessen');
fprintf(fid, '%s\n', ' ');
fprintf(fid,...
    '%s\n','-------------------------------------------------------------');
fprintf(fid, '%s\n', ' ');
fprintf(fid,'%s\n','Zeitverlaufe der bezogenen Bewegungsgroessen');
fprintf(fid,'%s \t %s \t %s \t %s\n','Zeit [s]:', 'Verschiebung [-]',...
    'Geschwindigkeit [1/s]', 'Beschleunigung [1/s^2]');
for ii=1:1:length(ita)
    fprintf(fid,'%d \t %d \t %d \t %d\n',...
        Ergebnis_Bewegungsgroessen(ii,:));
end
fclose(fid);
%-------------------------------------------------------------------------
```