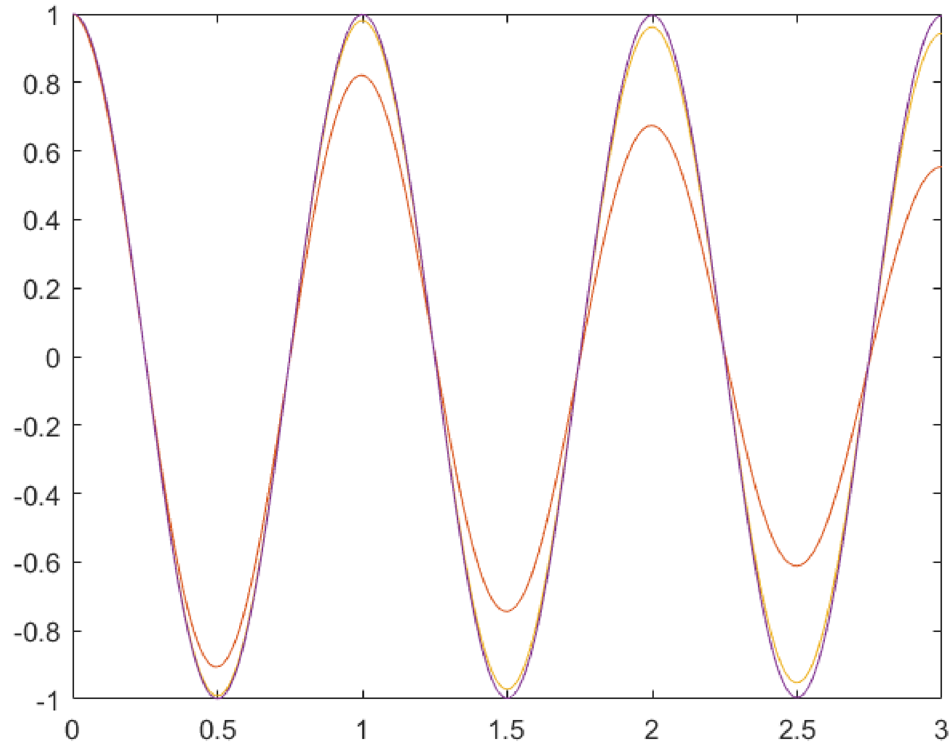
```
%Aurélia Song Wanling SY1924125
%3.5
delta_t=0.01;
[q_implicite_compare1,A_compare1]=q_avecA_implicite(delta_t);
delta_t=0.001;
[q_implicite_compare2,A_compare2]=q_avecA_implicite(delta_t);
delta_t=0.0001;
[q_implicite_compare3,A_compare3]=q_avecA_implicite(delta_t);
figure(1)
t_start=0;
t_end=3;
delta_t=0.01;
t=t_start:delta_t:t_end;
plot(t,q_implicite_compare1);
hold on;
delta_t=0.001;
t=t_start:delta_t:t_end;
plot(t,q_implicite_compare2);
hold on;
delta_t=0.0001;
t=t_start:delta_t:t_end;
plot(t,q_implicite_compare3);
hold on;
[x1,y1]=eig(A_compare1)
[x2,y2]=eig(A_compare2)
[x3,y3]=eig(A_compare3)
%donc, on a le schema plus stable quand on a delta_t plus petit.
%4.1 4.2
dt6=0.01;
T0=3;
t6=(0:dt6:T0)';
np6=size(t6,1);
q0=1;
dq0=0;
q6=zeros(np6,1);
dq6=zeros(np6,1);
q6(1)=q0;
dq6(1)=dq0;
qj=[q0;dq0];
omega_0=2*pi;
for index=2:np6
    t_c=t6(index-1);
    x_c=qj;
    k1=cal_f(x_c,t_c,omega_0);
    x_c=qj+k1*dt6/2;
    k2=cal_f(x_c,t_c+dt6/2,omega_0);
    x_c=qj+k2*dt6/2;
    k3=cal_f(x_c,t_c+dt6/2,omega_0);
    x_c=qj+k3*dt6;
    k4=cal_f(x_c,t_c+dt6,omega_0);
    dq=(k1+2*k2+2*k3+k4)/6;
    qj=qj+dq*dt6;
```

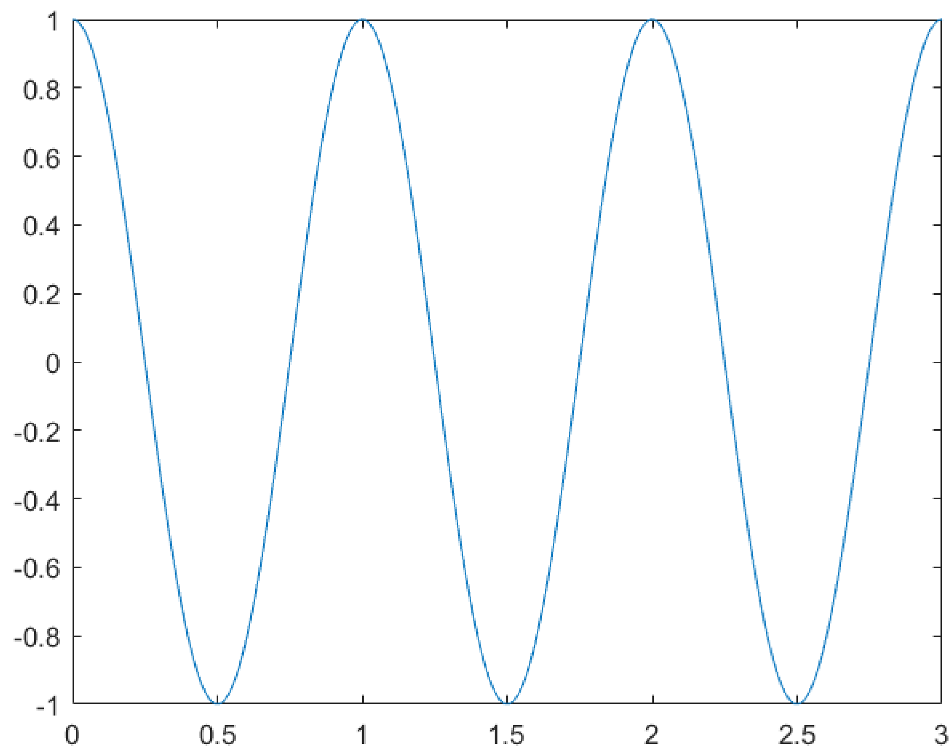
```
    q6(index)=qj(1);
    dq6(index)=qj(2);
    Energie_RungeKutta(index)=1/2 * (dq6(index)^2+omega_0^2 *
 q6(index)^2);
end
t6_plot=(0:dt6:T0);
figure(2)
plot(t6_plot,q6);
%4.3
figure(3)
t_start=0;
t_end=3;
delta_t=0.01;
t=t_start:delta_t:t_end;
plot(t,q_implicite_compare1);
hold on;
plot(t6_plot,q6);
hold on;
q_exacte = dsolve('D2q+omega_0^2*q=0','q(0)=1','Dq(0)=0');
syms t;
Dq_exacte = diff(q_exacte,t);
E_etoile_exacte = 1/2 * ( Dq_exacte^2 + omega_0^2  * q_exacte^2);
plot(t6_plot,exp(-omega_0*t6_plot*1i)/2 + exp(omega_0*t6_plot*1i)/2);
hold on;
j=1;
q_explicite(1) = 1;
dq_explicite(1) =0;
ddq_explicite(1)=0;
Energie_explicite(1)=1/2 * (dq_explicite(1)^2+omega_0^2 *
 q_explicite(1)^2);
pas=0.01;
for t =0:pas:T0
    q_explicite(j+1) = q_explicite(j)+pas*dq_explicite(j);
    dq_explicite(j+1) = dq_explicite(j) +pas*ddq_explicite(j);
    ddq_explicite(j+1) = -omega_0^2*q_explicite(j+1);
    Energie_explicite(j+1) = 1/2 * (dq_explicite(j+1)^2+omega_0^2 *
 q_explicite(j+1)^2);
    j=j+1;
end
q_explicite(:,1)=[];
Energie_explicite(:,1)=[];
t=0:pas:T0;
plot(t,q_explicite);
%On peut voir avec le même pas de temps, le schema RUNGE-KUTTA
 présente
%mieux que l'Euler implicite
%4.4
figure(4)
[demo,Energie_implicite]=Euler_implicite(0.01);
Energie_implicite(:,1)=[];
plot(t,Energie_implicite);
hold on;
plot(t,Energie_explicite);
hold on;
```

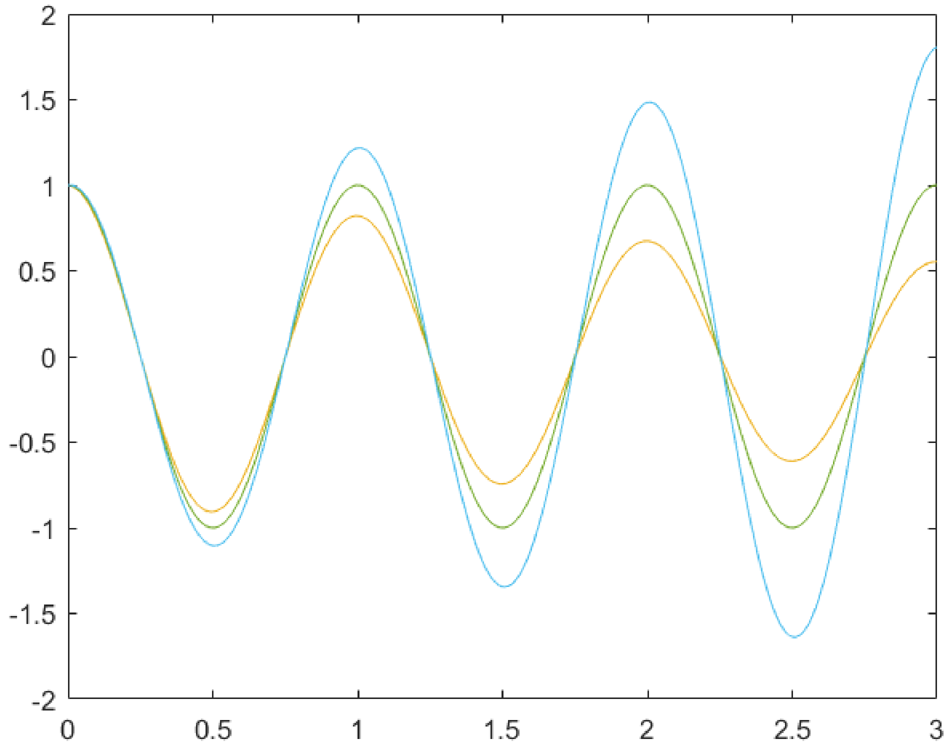
```
plot(t,eval(E_etoile_exacte));
hold on;
plot(t,Energie_RungeKutta);
%Pour conclure, on peut voir que pour q, explicite diverge, implicite
%converge, avec delta_t plus petit, on a la vitesse plus lentement.
 Pour
%l'énergie, c'est prèsque la même chose, on a Runge-kutta le mieux
%explicite le plus mauvais.
function [dU_c] = cal_f(U_c,t_c,omega_0_c)
dU_c=zeros(2,1);
dU_c(1)=U_c(2);
dU_c(2)=-omega_0_c^2*U_c(1);
end
function [q_avecA,A_implicite] = q_avecA_implicite(delta_t)
omega_0=2*pi;
A_implicite=[1/(1+delta_t^2*omega_0^2) delta_t/
(1+delta_t^2*omega_0^2);-delta_t*omega_0^2/(1+delta_t^2*omega_0^2) 1/
(1+delta_t^2*omega_0^2)];
i=0;
U=[];
t_start=0;
t_end=3;
t=t_start:delta_t:t_end;
for t_i=t
    if i==0
        U(:,1)=[1;0]
    else
        U(:,i+1)=A_implicite*U(:,i);
    end
    i=i+1;
end
q_avecA=U(1,:);
end

function [q,Energy] =Euler_implicite(pas)
j=1;
q(1) = 1;
dq(1) =0;
ddq(1)=0;
T0=3;
omega_0=2*pi;
for t =0:pas:T0
    q(j+1) = (q(j)+pas*dq(j))/(1+pas^2*omega_0^2);
    ddq(j+1) = -omega_0^2*q(j+1);
    dq(j+1) = dq(j) +pas*ddq(j);
    Energie(j+1) = 1/2 * (dq(j+1)^2+omega_0^2 * q(j+1)^2);
    j=j+1;
end
Energy=Energie;
end
```

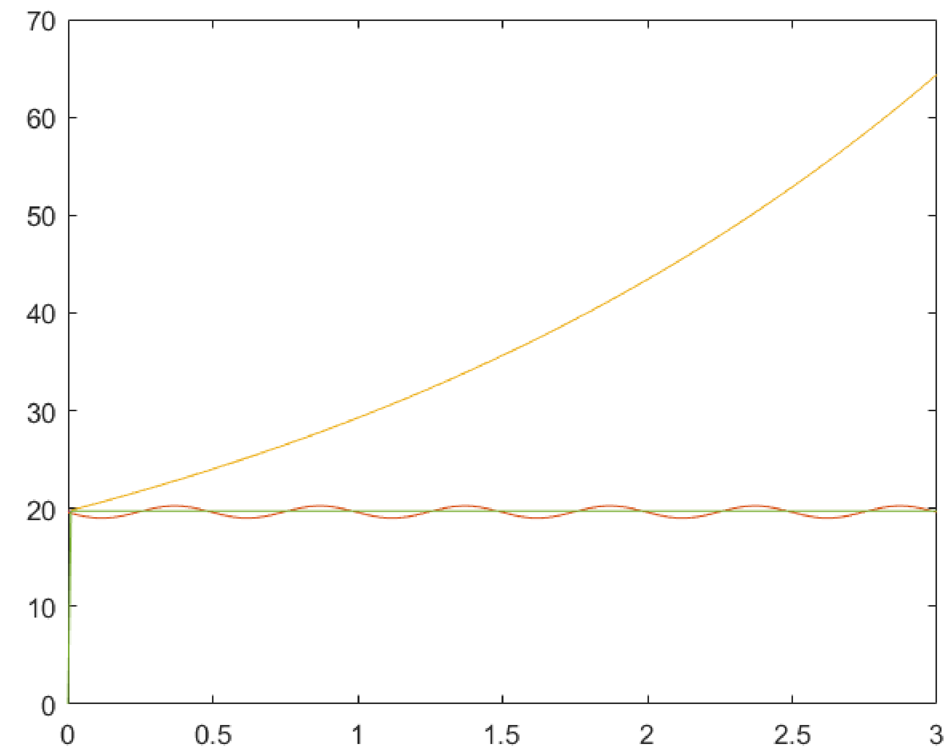
U =

```
     1
     0


U =

     1
     0


U =

     1
     0


x1 =

   0.0000 - 0.1572i   0.0000 + 0.1572i
   0.9876 + 0.0000i   0.9876 + 0.0000i


y1 =

   0.9961 + 0.0626i   0.0000 + 0.0000i
   0.0000 + 0.0000i   0.9961 - 0.0626i


x2 =

   0.0000 - 0.1572i   0.0000 + 0.1572i
   0.9876 + 0.0000i   0.9876 + 0.0000i


y2 =

   1.0000 + 0.0063i   0.0000 + 0.0000i
   0.0000 + 0.0000i   1.0000 - 0.0063i


x3 =

   0.0000 - 0.1572i   0.0000 + 0.1572i
   0.9876 + 0.0000i   0.9876 + 0.0000i


y3 =

   1.0000 + 0.0006i   0.0000 + 0.0000i
   0.0000 + 0.0000i   1.0000 - 0.0006i
```


1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.5
1
1.5
2
2.5
3


1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.5
1
1.5
2
2.5
3


2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
0.5
1
1.5
2
2.5
3


70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3

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