```
%Aurélia Song Wanling SY1924125
omega_0 = 2*pi;
q0 =1;
dq0 = 0;
T0 =3;
% 1.1
dsolve('D2q+omega_0^2*q=0','q(0)=1','Dq(0)=0');
% 1.2
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 = 1/2 * ( Dq_exacte^2 + omega_0^2  * q_exacte^2);
t=0:0.01:T0;
plot(t,eval(E_etoile));
%donc,il est conservatif
%2.1 pour la première ligne de l'équation (6), selon  la prmière ligne de l'équation (5),
il est évident.
%pour la deuxième ligne de l'équation (6), selon l'équation 1, on sait que
%ddqj = -omega_0*qj,avec la deuxième ligne de l'équation 5, on a bien dqj+1
%=-omega_0^2*dt*qj+dqj
%2.2 2.3 2.4
j=1;
q(1) = 1;
dq(1) =0;
ddq(1)=0;
Energie(1)=1/2 * (dq(1)^2+omega_0^2 * q(1)^2);
pas=0.01;
%pas=0.001;
for t =0:pas:T0
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    q(j+1) = q(j)+pas*dq(j);
    dq(j+1) = dq(j) +pas*ddq(j);
    ddq(j+1) = -omega_0^2*q(j+1);
    Energie(j+1) = 1/2 * (dq(j+1)^2+omega_0^2 * q(j+1)^2);
    j=j+1;
end
t=0:pas:T0+pas;
figure(1);
subplot(3,2,1),plot(t,q);title('explicite q');
subplot(3,2,2),plot(t,Energie);title('explicite energy');
%2.5
A = [1 pas; -omega_0^2*pas 1];
[x,y] = eig(A)
%En variant le pas, on trouve que le plus de pas de temps donne le plus
%grand de la partie imaginaire de valeur propre.Avec l'itération de fois la matrix
d'amplification, cela va donne plus
%instable.
%3.1
j=1;
q(1) = 1;
dq(1) =0;
ddq(1)=0;
Energie(1)=1/2 * (dq(1)^2+omega_0^2 * q(1)^2);
pas=0.01;
%pas=0.001;
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);
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```
    Energie(j+1) = 1/2 * (dq(j+1)^2+omega_0^2 * q(j+1)^2);

    j=j+1;

end

t=0:pas:T0+pas;

subplot(3,2,3),plot(t,q);title('implicite q');

subplot(3,2,4),plot(t,Energie);title('implicite energy');

%3.2

q(1) = 1;

dq(1) =0;

Energie=[];

Energie(1)=1/2 * (dq(1)^2+omega_0^2 * q(1)^2);

j=1;

for t=0:pas:T0

    q(j)=exp(-omega_0*t*1i)/2 + exp(omega_0*t*1i)/2;

    Energie(j)=1/2 * (dq(j)^2+omega_0^2 * q(j)^2);

    j=j+1;

end

t=0:pas:T0+pas;

subplot(3,2,5),plot(t,q);title('exacte q');

t=0:pas:T0;

subplot(3,2,6),plot(t,Energie);title('exacte energy');

%3.3

j=1;

q(1) = 1;

dq(1) =0;

ddq(1)=0;

Energie(1)=1/2 * (dq(1)^2+omega_0^2 * q(1)^2);

pas=0.01;

%pas=0.001;
```

```
[q_exactecompare1,Energie_exactecompare1]=Euler_implicite(0.01);
[q_exactecompare2,Energie_exactecompare2]=Euler_implicite(0.001);
[q_exactecompare3,Energie_exactecompare3]=Euler_implicite(0.0001);
t=0:0.01:T0+0.01;
figure(2);
subplot(3,2,1),plot(t,q_exactecompare1),title('q`exactecompare1');
subplot(3,2,2),plot(t,Energie_exactecompare1),title('Energie`exactecompare1');
t=0:0.001:T0+0.001;
subplot(3,2,3),plot(t,q_exactecompare2),title('q`exactecompare2');
subplot(3,2,4),plot(t,Energie_exactecompare2),title('Energie`exactecompare2');
t=0:0.0001:T0+0.0001;
subplot(3,2,5),plot(t,q_exactecompare3),title('q`exactecompare3');
subplot(3,2,6),plot(t,Energie_exactecompare3),title('Energie`exactecompare3');
%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(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;
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.
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
```

```
x =


   0.0000 - 0.1572i   0.0000 + 0.1572i

   0.9876 + 0.0000i   0.9876 + 0.0000i




y =


   1.0000 + 0.0628i   0.0000 + 0.0000i

   0.0000 + 0.0000i   1.0000 - 0.0628i
```

```
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 =

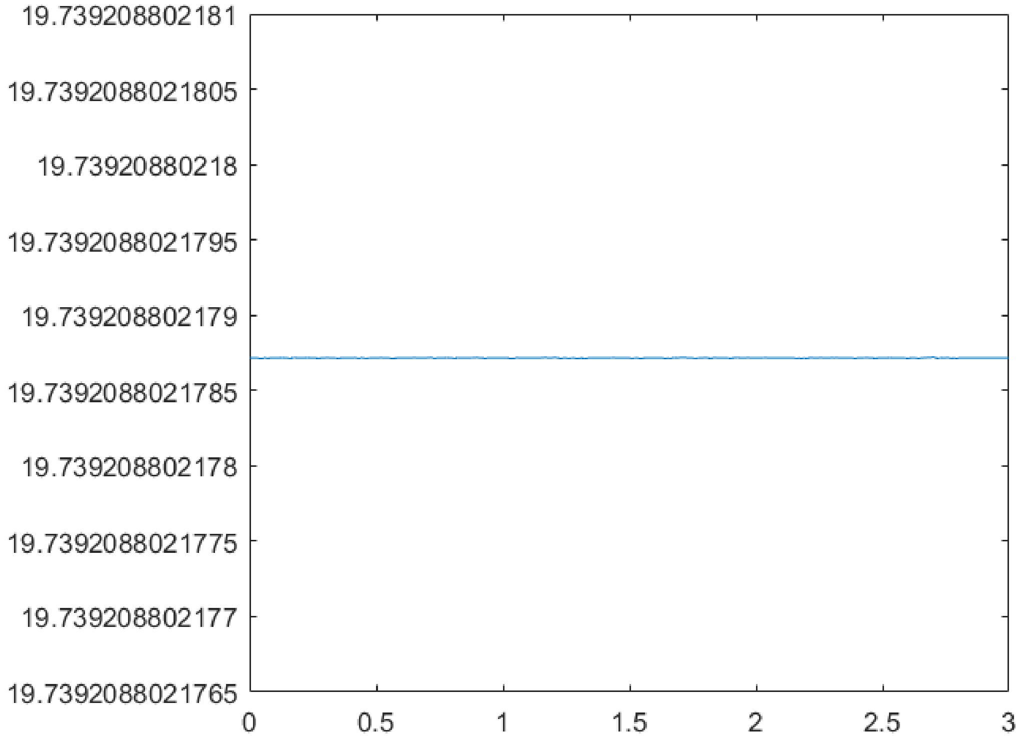
   1.0000 + 0.0063i   0.0000 + 0.0000i
   0.0000 + 0.0000i   1.0000 - 0.0063i


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
```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1
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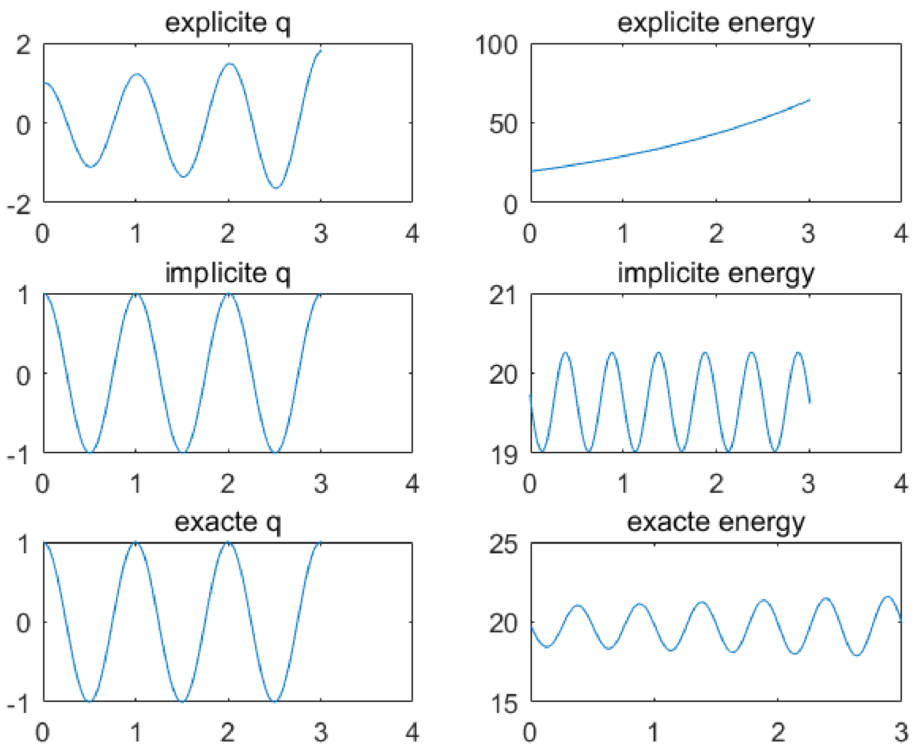
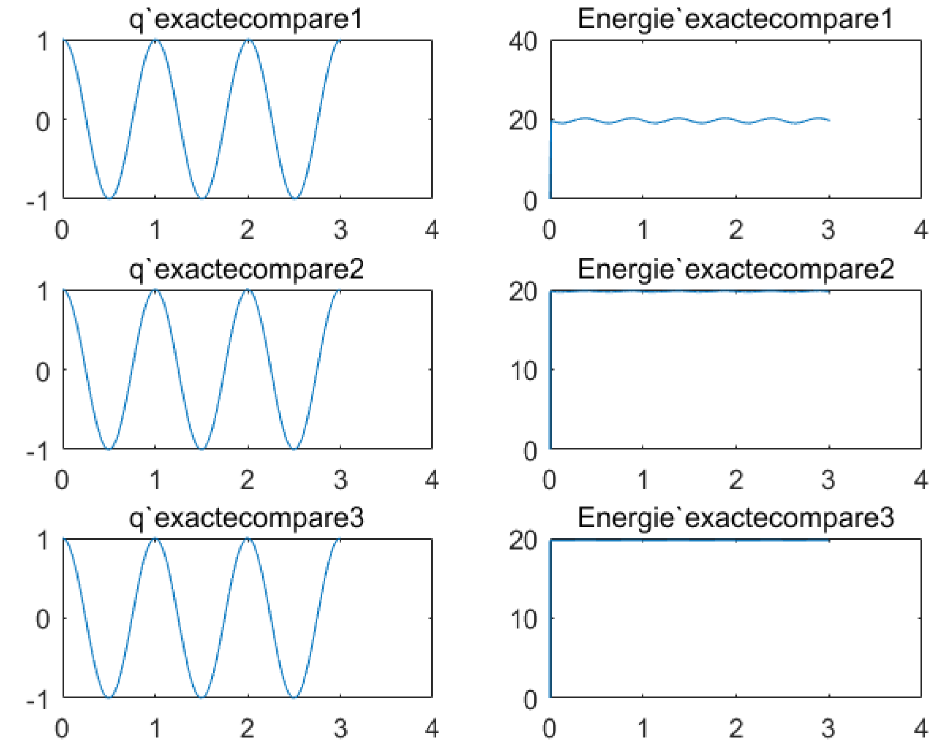
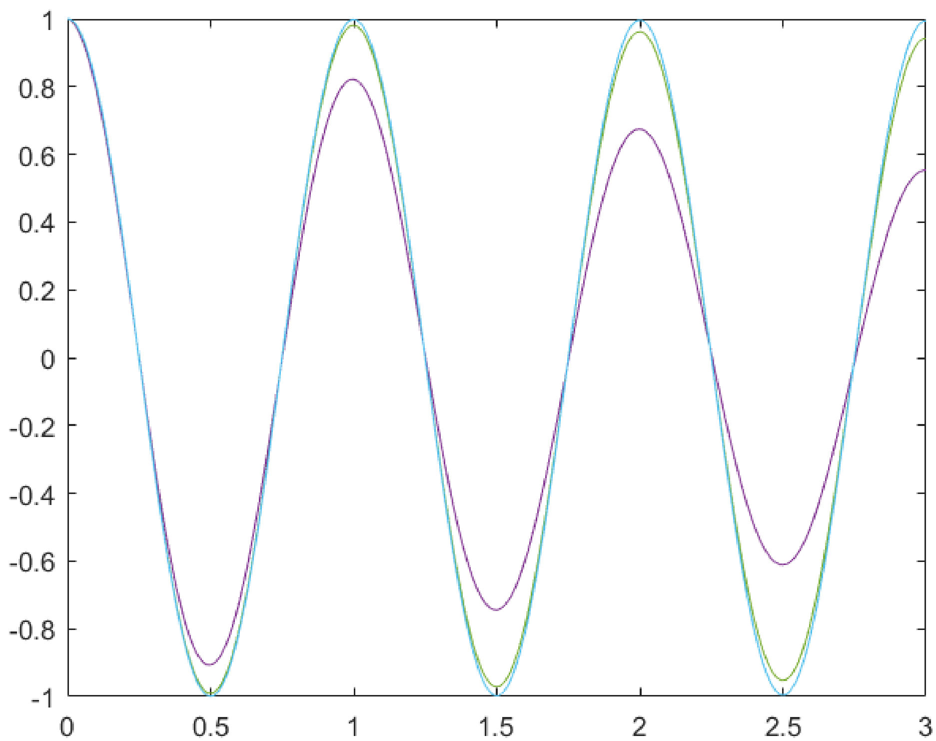
2
2.5
3


explicite q
explicite energy
implicite q
implicite energy
exacte q
exacte energy





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