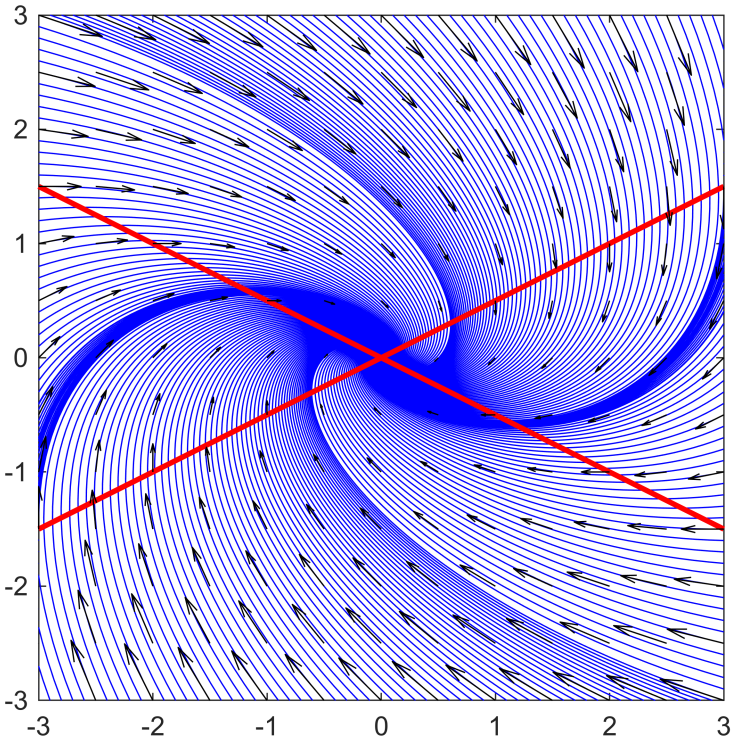
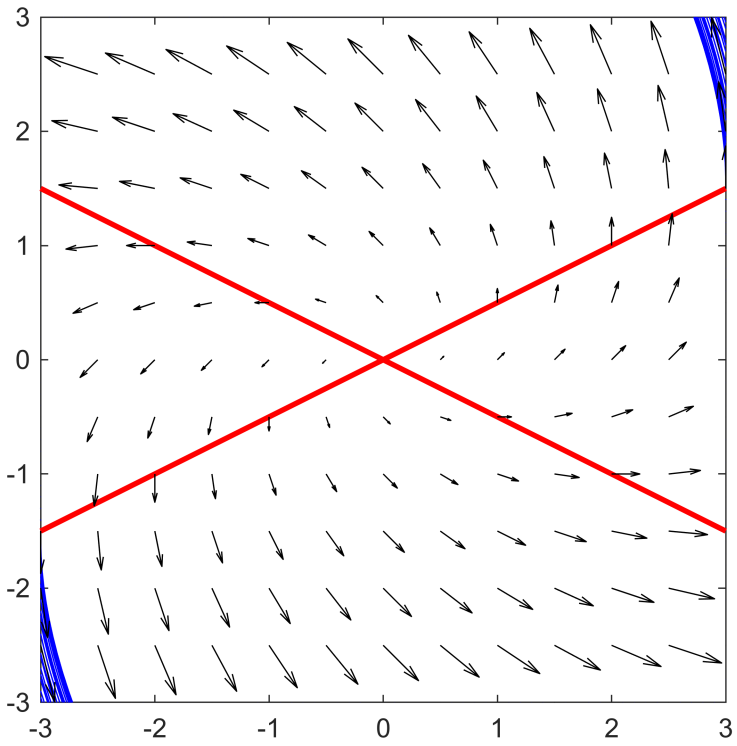
```
%% Q1 Simulate the linear dynamical system using dynamo4x.m (slides 33 and 34) given by the mat
M=[[-1 2];[-1 -2]];
figure
dynamo4x(-3:.1:3,.02,1000,M,[0 0]')
```




```
ans =
ans(:,:,1) =

   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.4000    0.5000    0.6000    0.7000    0
    0.9000    0.8000    0.7000    0.6000    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0


ans(:,:,2) =

   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.3500    0.4500    0.5500    0.6500    0
    0.8500    0.7500    0.6500    0.5500    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0


ans(:,:,3) =

   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.4000    0.5000    0.6000    0
    0.8000    0.7000    0.6000    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0


ans(:,:,4) =

   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.3500    0.4500    0.5500    0
    0.7500    0.6500    0.5500    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0


ans(:,:,5) =

   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.4000    0.5000    0
```

```
    0.7000    0.6000    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.

ans(:,:,6) =

   -0.5500   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.3500    0.4500    0.
    0.6500    0.5500    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.3500   -0.

ans(:,:,7) =

   -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.4000    0.
    0.6000    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.4000   -0.

ans(:,:,8) =

   -0.6500   -0.5500   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.3500    0.
    0.5500    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.3500   -0.4500   -0.

ans(:,:,9) =

   -0.7000   -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.
    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.4000   -0.5000   -0.

ans(:,:,10) =

   -0.7500   -0.6500   -0.5500   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.
    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.3500   -0.4500   -0.5500   -0.

ans(:,:,11) =

   -0.8000   -0.7000   -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.
    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.4000   -0.5000   -0.6000   -0.

ans(:,:,12) =

   -0.8500   -0.7500   -0.6500   -0.5500   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.
    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.3500   -0.4500   -0.5500   -0.6500   -0.

ans(:,:,13) =

   -0.9000   -0.8000   -0.7000   -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.
    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.4000   -0.5000   -0.6000   -0.7000   -0.
ans = 2×1001
    3.0000    3.0600    3.1116    3.1552    3.1912    3.2200    3.2420    3.2575 ···
    3.0000    2.8200    2.6460    2.4779    2.3157    2.1593    2.0085    1.8633
```

```
%% Q2 Repeat by using a new matrix that is -M.  How is it different?
figure
dynamo4x(-3:.1:3,.02,1000,-M,[0 0]')
```




```
ans =
ans(:,:,1) =

    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.4000   -0.5000   -0.6000   -0.7000   -0.
   -0.9000   -0.8000   -0.7000   -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.


ans(:,:,2) =

    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.3500   -0.4500   -0.5500   -0.6500   -0.
   -0.8500   -0.7500   -0.6500   -0.5500   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.


ans(:,:,3) =

    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.4000   -0.5000   -0.6000   -0.
   -0.8000   -0.7000   -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.


ans(:,:,4) =

    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.3500   -0.4500   -0.5500   -0.
   -0.7500   -0.6500   -0.5500   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.


ans(:,:,5) =

    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.4000   -0.5000   -0.
   -0.7000   -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.


ans(:,:,6) =

    0.5500    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.3500   -0.4500   -0.
```

```
   -0.6500   -0.5500   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.3500    0.

ans(:,:,7) =

    0.6000    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.4000   -0.
   -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.4000    0.

ans(:,:,8) =

    0.6500    0.5500    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.3500   -0.
   -0.5500   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.3500    0.4500    0.

ans(:,:,9) =

    0.7000    0.6000    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.3000   -0.
   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.4000    0.5000    0.

ans(:,:,10) =

    0.7500    0.6500    0.5500    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.2500   -0.
   -0.4500   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.3500    0.4500    0.5500    0.

ans(:,:,11) =

    0.8000    0.7000    0.6000    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.2000   -0.
   -0.4000   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.4000    0.5000    0.6000    0.

ans(:,:,12) =

    0.8500    0.7500    0.6500    0.5500    0.4500    0.3500    0.2500    0.1500    0.0500   -0.0500   -0.1500   -0.
   -0.3500   -0.2500   -0.1500   -0.0500    0.0500    0.1500    0.2500    0.3500    0.4500    0.5500    0.6500    0.

ans(:,:,13) =

    0.9000    0.8000    0.7000    0.6000    0.5000    0.4000    0.3000    0.2000    0.1000         0   -0.1000   -0.
   -0.3000   -0.2000   -0.1000         0    0.1000    0.2000    0.3000    0.4000    0.5000    0.6000    0.7000    0.
ans = 2×1001
10^13 ×
    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000 ···
    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000    0.0000
```

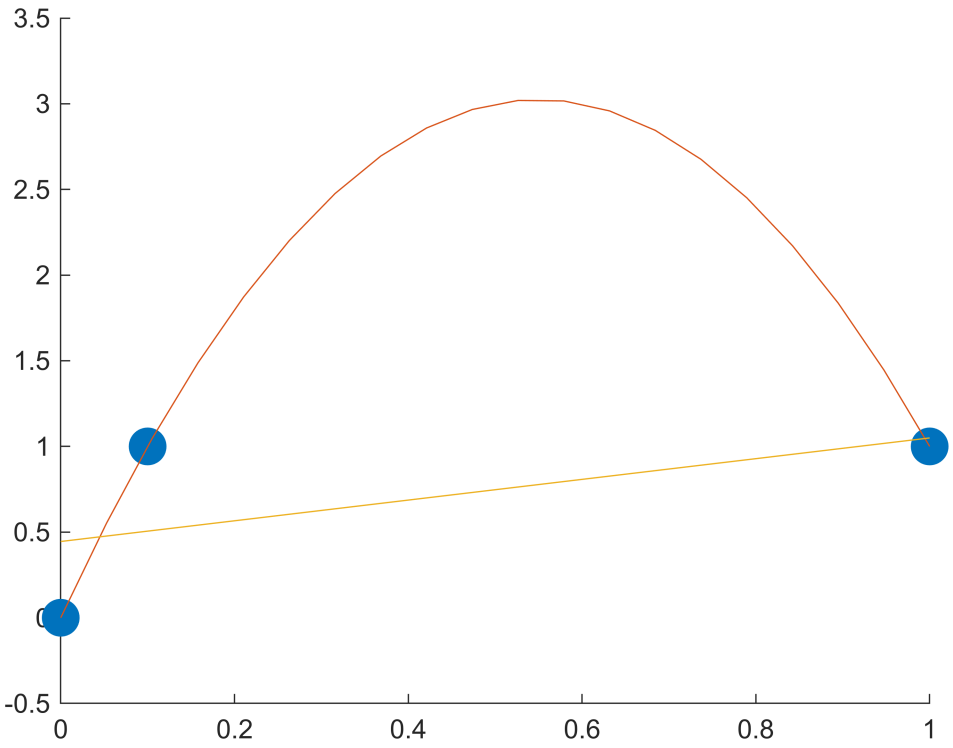
```
% It reverse the quiver thus make it a spiral out

%% Q3 Fit a second order polynomial to the data points (0,0, (0.1,1), and (1,1).  Plot the resu
clear;
xdata = [0 0.1 1];
ydata = [0 1 1];
figure
scatter(xdata,ydata,200,"filled")
hold on % this command is important to get the curves
% on the same graph as the points and each other
xvals=linspace(0,1,20);
p2=polyfit(xdata,ydata,2) % second order
```

```
p2 = 1×3
  -10.0000   11.0000   -0.0000
```

```
yvals=polyval(p2,xvals);
plot(xvals,yvals)
p1=polyfit(xdata,ydata,1) % linear
```

```
p1 = 1×2
    0.6044    0.4451
```

```
yvals=polyval(p1,xvals);
plot(xvals,yvals)
```




```
%% Attachments
% scraped from lecture slides
```

```
function ptseq = dynamo4x( rang,step,niter,cmtx,cvct )
figure
xinit=[rang rang rang(1)*ones(size(rang)) rang(end)*ones(size(rang))];
yinit=[rang(1)*ones(size(rang)) rang(end)*ones(size(rang)) rang rang];
[xcr,ycr] = meshgrid(linspace(rang(1),rang(end),100));
nullx=cmtx(1,1)*xcr+cmtx(1,2)*ycr+cvct(1,1);
nully=cmtx(2,1)*xcr+cmtx(2,2)*ycr+cvct(2,1);
% size(xinit)
for k=1:max(size(xinit))
```

```
    ptseq=[xinit(k);yinit(k)] ;
    curr=[xinit(k);yinit(k)] ;
    for i=1:niter
        curr=onestep(curr,cmtx,cvct,step) ;
        ptseq=[ptseq,curr] ;
    end
    plot(ptseq(1,:),ptseq(2,:),'blue')
    axis equal
    hold on ;
end
axis([rang(1) rang(end) rang(1) rang(end)])
contour(xcr,ycr,nullx,[0 0],'red','LineWidth',2) ;
contour(xcr,ycr,nully,[0 0],'red','LineWidth',2) ;
qplot(cmtx,cvct,rang(1):.5:rang(end))
end


function newx = onestep(oldx,cmat,cvec,dt)
newx=oldx+(cmat*oldx+cvec)*dt ;
end


function qv = qplot( cmat,cvec,rang )
%This function generates a quiver plot for the linear system
%specified by cmat. rang is the range (for both x and y)
[xx, yy] = meshgrid(rang) ;
qv=[] ;
for xp=rang
    tcol=[] ;
    for yp=rang
        temp=.1*(cmat*[xp yp]'+cvec) ;
        tcol=[tcol,temp] ;
    end
    qv=cat(3,qv,tcol) ;
end
qx=reshape(qv(1,:,:),size(xx,1),size(xx,2)) ;
qy=reshape(qv(2,:,:),size(yy,1),size(yy,2)) ;
quiver(xx,yy,qx,qy,'black') ;
axis equal
axis([[rang(1) rang(end)],[rang(1) rang(end)]]) ;
end


function [pfinal, xpow] = gdpoly( xx, yy, pinit, niter, eta )
% gradient descent in a polynomial function
%   dak/dt = 2(y*-y)x^k
nn=max(size(pinit)) ;
kk=max(size(xx)) ;

xmin=min(xx)-.1*(max(xx)-min(xx)) ;
```

```
xmax=max(xx)+.1*(max(xx)-min(xx)) ;
ymin=min(yy)-.1*(max(yy)-min(yy)) ;
ymax=max(yy)+.1*(max(yy)-min(yy)) ;
xstep=.02*(xmax-xmin) ;
xvals=xmin:xstep:xmax ;
xpow=ones(kk,1) ;
for ii=2:nn
    xpow=[xx'.*xpow(:,1),xpow] ;
end
pfinal=pinit ;
figure
h1=scatter(xx,yy,250,'red','filled') ;
hold on
yest=polyval(pfinal,xvals) ;
h2=plot(xvals,yest) ;
axis([xmin xmax ymin ymax]) ;
for ii=1:niter
    datapt=irand(kk,1) ;
    yest=polyval(pfinal,xx(datapt)) ;
    dp=(yest-yy(datapt))*xpow(datapt,:) ;
    pfinal=pfinal - dp*eta ;
    ycurve=polyval(pfinal,xvals) ;
    set(h2,'XData',xvals,'YData',ycurve) ;
    drawnow
end
end
```