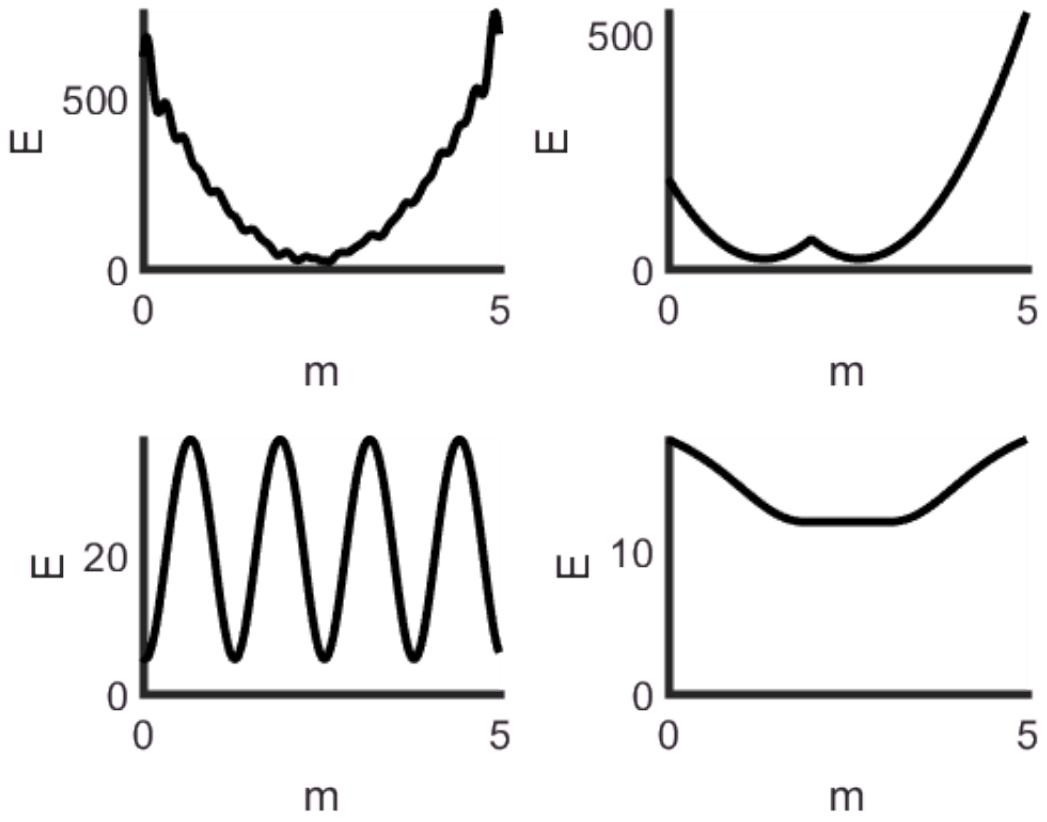
```
% gda09_05
%
% E(m) for several hypothetial 1D non-linear problems
% supports Figure 9.4

clear all;

% auxiliary parameter z
N = 11;
zmin = 0;
zmax = 5.0;
Dz = (zmax-zmin)/(N-1);
z = zmin + Dz*[0:N-1]';

% set up 1D grid search
Mg = 501;
mmin = 0;
mmax = 5;
Dm = (mmax-mmin)/(Mg-1);
m = mmin + Dm*[0:Mg-1];

% only one model parameter, m1
M=1;

% model 1
m1true=2.5;
d1true = sin(5*(m1true-2.5)*z)-((m1true-2.5))*z;
sd=2;
d1obs=d1true+random('Normal',0,sd,N,1);

% tabulate error on the grid
E1=zeros(Mg,1);
for i=[1:Mg]
    d1pre = sin(5*(m(i)-2.5)*z)-((m(i)-2.5))*z;
    e = d1obs - d1pre;
    E1(i) = (e'*e);
end

% find point of minimum error
[E1min, iE1min] = min(E1);
m1est=m(iE1min);

figure(1);
clf;

% plot E(m)
subplot(2,2,1);
set(gca,'LineWidth',3);
set(gca,'FontSize',14);
hold on;
axis( [mmin, mmax, 0, max(E1)] );
axis xy;
plot( m, E1, 'k-', 'Linewidth', 3 );
xlabel('m');
ylabel('E');

% model 2
m1true=2.5;
d1true = ((abs((m1true-2))-0.5)*z);
```

```
sd=2;
d1obs=d1true+random('Normal',0,sd,N,1);

% tabulate error on the grid
E1=zeros(Mg,1);
for i=[1:Mg]
    d1pre = ((abs((m(i)-2))-0.5)*z);
    e = d1obs - d1pre;
    E1(i) = (e'*e);
end

% find point of minimum error
[E1min, iE1min] = min(E1);
m1est=m(iE1min);

% plot E(m)
subplot(2,2,2);
set(gca,'LineWidth',3);
set(gca,'FontSize',14);
hold on;
axis( [mmin, mmax, 0, max(E1)] );
axis xy;
plot( m, E1, 'k-', 'Linewidth', 3 );
xlabel('m');
ylabel('E');

% model 3
m1true=2.5;
d1true = sin(5*(m1true+z));
sd=1;
d1obs=d1true+random('Normal',0,sd,N,1);

% tabulate error on the grid
E1=zeros(Mg,1);
for i=[1:Mg]
    d1pre = sin(5*(m(i)+z));
    e = d1obs - d1pre;
    E1(i) = (e'*e);
end

% find point of minumum error
[E1min, iE1min] = min(E1);
m1est=m(iE1min);

% plor E(m)
subplot(2,2,3);
set(gca,'LineWidth',3);
set(gca,'FontSize',14);
hold on;
axis( [mmin, mmax, 0, max(E1)] );
axis xy;
plot( m, E1, 'k-', 'Linewidth', 3 );
xlabel('m');
ylabel('E');

% model 4
m1true=2.5;
t = abs(m1true-2.0) + abs(m1true-3.0);
d1true = exp( -(t*z/10).^2 );
sd=1;
d1obs=d1true+random('Normal',0,sd,N,1);
```

```
% tabulate error on the grid
E1=zeros(Mg,1);
for i=[1:Mg]
    t = abs(m(i)-2.0) + abs(m(i)-3.0);
    d1pre = exp( -(t*z/10).^2 );
    e = d1obs - d1pre;
    E1(i) = (e'*e);
end

% find point of minimum error
[E1min, iE1min] = min(E1);
m1est=m(iE1min);

% plot E(m)
subplot(2,2,4);
set(gca,'LineWidth',3);
set(gca,'FontSize',14);
hold on;
axis( [mmin, mmax, 0, max(E1)] );
axis xy;
plot( m, E1, 'k-', 'Linewidth', 3 );
xlabel('m');
ylabel('E');
```




```
% Figure 9.4 (A–D) Prediction error, E, as a function of a single model parameter, m.
% (A) A single minimum (red dot) corresponds to an inverse problem with a unique
% solution. (B) Two solutions. (C) Many well-separated solutions. (D) Finite range
% of solutions (red arrow).
```