```
syms x1 x2 alpha k
```

```
f = x1^2 + 2*x2^2
```

f =

$$x_1^2 + 2\,x_2^2$$

```
g = gradient(f)
```

g =

$$\begin{pmatrix} 2\,x_1 \\ 4\,x_2 \end{pmatrix}$$

```
x = [x1;x2]
```

x =

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

```
x_val = [2;1]
```

```
x_val = 2×1
     2
     1
```

```
size = 100
```

```
size = 100
```

```
g_val = subs(g, x, x_val)
```

g_val =

$$\begin{pmatrix} 4 \\ 4 \end{pmatrix}$$

```
all_x = zeros(2, size + 1)
```

```
all_x = 2×101
     0     0     0     0     0     0     0     0     0     0     0     0 ···
     0     0     0     0     0     0     0     0     0     0     0     0
```

```
all_f = zeros(1, size + 1)
```

```
all_f = 1×101
     0     0     0     0     0     0     0     0     0     0     0     0 ···
```

```
all_x(:, 1) = x_val
```

```
all_x = 2×101
     2     0     0     0     0     0     0     0     0     0     0     0 ···
```

```
     1     0     0     0     0     0     0     0     0     0     0     0     0
```

```
all_f(1) = subs(f, x, x_val)
```

```
all_f = 1×101
     6     0     0     0     0     0     0     0     0     0     0     0     0 ···
```

```
threshhold = 0.001
```

```
threshhold = 1.0000e-03
```

```
echo off;
for i = 2:size+1
    d = - g_val;
    x_new = x_val + alpha * d;

    phi = subs(f, x, x_new);

    alpha_vals = solve([gradient(phi) == 0, alpha >= 0], alpha);
    phi_vals = double(subs(phi, alpha, alpha_vals));
    [phi_vals, alpha_idx] = sort(phi_vals);

    alpha_val = alpha_vals(alpha_idx(1));

    x_val = subs(x_new, alpha, alpha_val);
    g_val = subs(g, x, x_val);

    all_x(:, i) = x_val;
    all_f(i) = subs(f, x, x_val);
%     norm(g_val), threshhold *
end
echo on;
```

```
syms k

xk = 1/3^k * [2; (-1)^k]
```

```
xk =
```

$$\begin{pmatrix} \frac{2}{3^k} \\ \frac{(-1)^k}{3^k} \end{pmatrix}$$

```
xks = double(subs(xk, 0:size))
```

```
xks = 2×101
    2.0000    0.6667    0.2222    0.0741    0.0247    0.0082    0.0027    0.0009 ···
    1.0000   -0.3333    0.1111   -0.0370    0.0123   -0.0041    0.0014   -0.0005
```

```
sym(xks(:, 1:5))
```

```
ans =
```

$$\begin{pmatrix} 2 & 0.6667 & 0.2222 & 0.0741 & 0.0247 \\ 1 & -0.3333 & 0.1111 & -0.0370 & 0.0123 \end{pmatrix}$$

```
sym(all_x(:, 1:5))
```

```
ans =
```

$$\begin{pmatrix} 2 & 0.6667 & 0.2222 & 0.0741 & 0.0247 \\ 1 & -0.3333 & 0.1111 & -0.0370 & 0.0123 \end{pmatrix}$$

```
% compare the computed x's from sd and the equation
all(all(all_x - xks < 0.0001))
```

```
ans = logical
   1
```

```
sym(all_f(1:4) / 9)
```

```
ans = (0.6667   0.0741   0.0082   9.1111e-04)
```

```
sym(all_f(2:5))
```

```
ans = (0.6667   0.0741   0.0082   9.1449e-04)
```

```
% compare the recurrence relation of f
all(all_f(1:size-1)/9 - all_f(2:size) < 0.0001)
```

```
ans = logical
   1
```