```
clear
clc

a = 1:10;
b = 'stybn';
c = [1 1 2; 2 3 4];
who
```

您的变量为:

```
a  b  c
```

```
whos
```

```
  Name      Size            Bytes  Class     Attributes

  a         1x10               80  double
  b         1x5                10  char
  c         2x3                48  double
```

```

save a

clear
load a
who
```

您的变量为:

```
a  b  c
```

```
whos
```

```
  Name      Size            Bytes  Class     Attributes

  a         1x10               80  double
  b         1x5                10  char
  c         2x3                48  double
```

实验一．MATLAB 语言基础

一．MATLAB 的基本计算功能

例1.1.1：用**Matlab** 显示**430/12**的不同显示结果

```

clear
clc
430/12
```

```
ans = 35.8333
```

```
format short
430/12
```

```
ans = 35.8333
```

```
format long
430/12
```

```
ans =
  35.833333333333336
```

```
format short e
430/12
```

```
ans =
   3.5833e+01
```

```
format long e
430/12
```

```
ans =
     3.583333333333334e+01
```

```
format hex
430/12
```

```
ans =
   4041eaaaaaaaaaab
```

```
format bank
430/12
```

```
ans =
         35.83
```

```
format +
430/12
```

```
ans =
+
```

```
format rat
430/12
```

```
ans =
     215/6
```

二．MATLAB 矩阵和数组的创建和保存

例1.2.1： 用指令产生数值矩阵

```
clear
```

```
clc
format short

A = [];
x = 9;
y = pi/6;
A = [3 5 sin(y);cos(y) x^2 7;x/2 5 1]
```

```
A = 3×3
    3.0000    5.0000    0.5000
    0.8660   81.0000    7.0000
    4.5000    5.0000    1.0000
```

例1.2.2：矩阵元素的修改

```
A(3,3) = 0
```

```
A = 3×3
    3.0000    5.0000    0.5000
    0.8660   81.0000    7.0000
    4.5000    5.0000         0
```

```
A(2,6) = 1
```

```
A = 3×6
    3.0000    5.0000    0.5000         0         0         0
    0.8660   81.0000    7.0000         0         0    1.0000
    4.5000    5.0000         0         0         0         0
```

例1.2.3：复数矩阵的建立和输入

```
a = 2.7;
b = 13/25;
C = [1 2*a+i*b b*sqrt(a);sin(pi/4) a+5*b 3.5+1]
```

```
C = 2×3 complex
   1.0000 + 0.0000i   5.4000 + 0.5200i   0.8544 + 0.0000i
   0.7071 + 0.0000i   5.3000 + 0.0000i   4.5000 + 0.0000i
```

```
R = [1 2 3 ;4 5 6];
M = [11 12 13 ;14 15 16];
CN = R+i*M
```

```
CN = 2×3 complex
   1.0000 +11.0000i   2.0000 +12.0000i   3.0000 +13.0000i
   4.0000 +14.0000i   5.0000 +15.0000i   6.0000 +16.0000i
```

例1.2.4：符号矩阵的生成

```
a11 = 'a';
a12 = 'b';
a13 = 'c';
a21 = 'Jack';
a22 = 'Help Me!';
a23 = 'No Way!';
sym_matrix = str2sym('[a, b, c;Jack,HelpMe,NoWay ]')
```

sym_matrix =

$$\begin{pmatrix} a & b & c \\ \mathrm{Jack} & \mathrm{HelpMe} & \mathrm{NoWay} \end{pmatrix}$$

```
help sym
```

```
sym - Create symbolic variables, expressions, functions, matrices

    This MATLAB function creates symbolic variable x.

    x = sym('x')
    A = sym('a',[n1 ... nM])
    A = sym('a',n)
    sym(___,set)
    sym(___,'clear')
    sym(num)
    sym(num,flag)
    sym(strnum)
    symexpr = sym(h)

    另请参阅 assume, double, reset, str2sym, symfun, syms, symvar

    sym 的文档
    名为 sym 的其他函数
```

```
% sym1 = str2sym('[a,b,c;a21,a22,a23]')
% sym2 = sym([a11,a12,a13;a21,a22,a23])

sym_digits = str2sym('[1 2 3;a b c;sin(x) cos(y) tan(z)]')
```

sym_digits =

$$\begin{pmatrix} 1 & 2 & 3 \\ a & b & c \\ \sin(x) & \cos(y) & \tan(z) \end{pmatrix}$$

```
syms a b c;
M1 = sym('Classical');
M2 = sym('Jazz');
M3 = sym('Blues');
syms_matrix = [a b c;M1 M2 M3;2 3 5]
```

syms_matrix =

$$\begin{pmatrix} a & b & c \\ \mathrm{Classical} & \mathrm{Jazz} & \mathrm{Blues} \\ 2 & 3 & 5 \end{pmatrix}$$

```
Dight_Matrix = [1/3 sqrt(2) 3.4234;exp(0.23) log(29) 23^(-11.23)]
```

```
Dight_Matrix = 2×3
    0.3333    1.4142    3.4234
    1.2586    3.3673    0.0000
```

```
Syms_Matrix = sym(Dight_Matrix)
```

Syms_Matrix =

$$\begin{pmatrix} \frac{1}{3} & \sqrt{2} & \frac{17117}{5000} \\ \frac{5668230535726899}{4503599627370496} & \frac{7582476122586655}{2251799813685248} & \frac{5174709270083729}{10141204801825835211973625643000} \end{pmatrix}$$

例1.2.5：大矩阵的生成

```
example;
```

```
exm = 5×6
         456          468          873            2          579           55
          21          687           54          488            8           13
          65         4567           88           98           21            5
         456           68         4589          654            5          987
        5488           10            9            6           33           77
```

```
size(exm)
```

```
ans = 1×2
     5     6
```

例1.2.6：多维数组的创建

```
A1 = [1 2 3 ;4 5 6 ;7 8 9];
A2 = A1';
A3=A1-A2;
A4(:,:,1) = A1;
A4(:,:,2) = A2;
A4(:,:,3) = A3;
A4
```

```
A4 = 
A4(:,:,1) =

     1     2     3
     4     5     6
     7     8     9


A4(:,:,2) =

     1     4     7
     2     5     8
     3     6     9
```

```
A4(:,:,3) =

     0    -2    -4
     2     0    -2
     4     2     0
```

```
A5 = cat(3,A1,A2,A3)
```

```
A5 =
A5(:,:,1) =

     1     2     3
     4     5     6
     7     8     9


A5(:,:,2) =

     1     4     7
     2     5     8
     3     6     9


A5(:,:,3) =

     0    -2    -4
     2     0    -2
     4     2     0
```

```
A6 = cat(2,A1,A2,A3)
```

```
A6 = 3×9
     1     2     3     1     4     7     0    -2    -4
     4     5     6     2     5     8     2     0    -2
     7     8     9     3     6     9     4     2     0
```

```
A7 = cat(1,A1,A2,A3)
```

```
A7 = 9×3
     1     2     3
     4     5     6
     7     8     9
     1     4     7
     2     5     8
     3     6     9
     0    -2    -4
     2     0    -2
     4     2     0
```

```
size(A)
```

```
ans = 1×2
     3     6
```

```
size(A4)
```

```
ans = 1×3
     3     3     3
```

例1.2.7：产生一个3×4随机矩阵

```
R = rand(3,4)
```

```
R = 3×4
    0.2511    0.3517    0.5497    0.7572
    0.6160    0.8308    0.9172    0.7537
    0.4733    0.5853    0.2858    0.3804
```

例1.2.8：产生一个在区间[10, 20]内均匀分布的4阶随机矩阵

```
a = 10;
b = 20;
x = a+(b-a)*rand(4)
```

```
x = 4×4
   15.6782   17.7917   14.6939   17.9428
   10.7585   19.3401   10.1190   13.1122
   10.5395   11.2991   13.3712   15.2853
   15.3080   15.6882   11.6218   11.6565
```

例1.2.9：产生均值为0.6，方差为0.1的4阶矩阵

```
mu = 0.6;
sigma = 0.1;
x = mu + sqrt(sigma)*randn(4)
```

```
x = 4×4
    0.6960    1.1413    1.0284    1.0543
    0.4102    0.5386    0.2610   -0.0201
    0.7549   -0.0762    0.9039    0.5375
    0.8338    0.3345    0.6392    0.2180
```

例1.2.10：用rand 函数可以产生任意行列的0～1 分布的随机矩阵

```
ra = rand(2,4)
```

```
ra = 2×4
    0.9619    0.7749    0.8687    0.3998
    0.0046    0.8173    0.0844    0.2599
```

例1.2.11：利用diag 函数产生对角阵

```
a = randn(5,5)
```

```
a = 5×5
    1.0984   -0.8236   -1.3337   -0.2620   -1.1564
   -0.2779   -1.5771    1.1275   -1.7502   -0.5336
    0.7015    0.5080    0.3502   -0.2857   -2.0026
   -2.0518    0.2820   -0.2991   -0.8314    0.9642
```

```
   -0.3538    0.0335    0.0229   -0.9792    0.5201
```

```
d = diag(a)
```

```
d = 5×1
    1.0984
   -1.5771
    0.3502
   -0.8314
    0.5201
```

```
D = diag(d)
```

```
D = 5×5
    1.0984         0         0         0         0
         0   -1.5771         0         0         0
         0         0    0.3502         0         0
         0         0         0   -0.8314         0
         0         0         0         0    0.5201
```

例1.2.12：提取矩阵的子阵

```
B = magic(5)
```

```
B = 5×5
    17    24     1     8    15
    23     5     7    14    16
     4     6    13    20    22
    10    12    19    21     3
    11    18    25     2     9
```

```
B1 = B(1:2,[1 3 5])
```

```
B1 = 2×3
    17     1    15
    23     7    16
```

```
B2 = B([3,1],:)
```

```
B2 = 2×5
     4     6    13    20    22
    17    24     1     8    15
```

```
B([1,3],[2,4])=zeros(2)
```

```
B = 5×5
    17     0     1     0    15
    23     5     7    14    16
     4     0    13     0    22
    10    12    19    21     3
    11    18    25     2     9
```

```
L = B(1,:)<5
```

```
L = 1×5 logical 数组
   0   1   1   1   0
```

```
B = B(1,L)
```

```
B = 1×3
     0     1     0
```

例1.2.13：矩阵的旋转和转置的区别

```
A = [1 2 3 4;5 6 7 8;9 10 11 12];
B1 = rot90(A)
```

```
B1 = 4×3
     4     8    12
     3     7    11
     2     6    10
     1     5     9
```

```
BT = A'
```

```
BT = 4×3
     1     5     9
     2     6    10
     3     7    11
     4     8    12
```

```
B2 = rot90(A,2)
```

```
B2 = 3×4
    12    11    10     9
     8     7     6     5
     4     3     2     1
```

例1.2.14：矩阵的变维

```
B = reshape(A,2,6)
```

```
B = 2×6
     1     9     6     3    11     8
     5     2    10     7     4    12
```

例1.2.15：部分元素的截取

```
LA = tril(A,-1)
```

```
LA = 3×4
     0     0     0     0
     5     0     0     0
     9    10     0     0
```

```
UA = triu(A,1)
```

```
UA = 3×4
     0     2     3     4
     0     0     7     8
     0     0     0    12
```

```
save mytrix A B
```

```
clear
load mytrix
```

例1.2.16：创建等差数列

```
clear
clc
a = [0:0.5:10];
x = linspace(0,1,75);
a = 1:4;
b = 1:2:7;
c = [b,a]
```

```
c = 1×8
     1     3     5     7     1     2     3     4
```

```
d = [a(1:2:4),4 0.2 8]
```

```
d = 1×5
    1.0000    3.0000    4.0000    0.2000    8.0000
```

例1.2.17：利用函数 **logspace** 创建等比数列

```
logspace(0,2,11)
```

```
ans = 1×11
    1.0000    1.5849    2.5119    3.9811    6.3096   10.0000   15.8489   25.1189 ⋯
```

例1.2.18：矩阵相加运算

```
A = [1 1 1 ;1 2 3 ;1 3 6];
B = [8 1 6 ;3 5 7 ;4 9 2];
C = A+B
```

```
C = 3×3
     9     2     7
     4     7    10
     5    12     8
```

```
D = A-B
```

```
D = 3×3
    -7     0    -5
    -2    -3    -4
    -3    -6     4
```

例1.2.19：矩阵乘法运算

```
X = [2 3 4 5;1 2 2 1];
Y = [0 1 1;1 1 0;0 0 1;1 0 0];
```

```
Z = X*Y
```

```
Z = 2×3
     8     5     6
     3     3     3
```

```
a = 2*X
```

```
a = 2×4
     4     6     8    10
     2     4     4     2
```

例1.2.20：矩阵的点积运算

```
X = [-1 0 2];
Y = [-2 -1 1];
Z = dot(X,Y)
```

```
Z = 4
```

```
sum(X.*Y)
```

```
ans = 4
```

例1.2.21：向量的叉乘

```
a = [1 2 3];
b = [4 5 6];
c = cross(a,b)
```

```
c = 1×3
    -3     6    -3
```

例1.2.22：计算混合积

```
a = [1 2 3];
b = [4 5 6];
c = [-3 6 -3];
x = dot(a,cross(b,c))
```

```
x = 54
```

例1.2.23：展开多项式

```
w = conv([1 2 2],conv([1 4],[1 1]))
```

```
w = 1×5
     1     7    16    18     8
```

```
P = poly2str(w,'s')
```

```
P =
```

```
'   s^4 + 7 s^3 + 16 s^2 + 18 s + 8'
```

例1.2.24：矩阵的非整数乘方

```
A = [3 6 7;9 2 5;1 6 3];
Ap1 = A.^0.3
```

```
Ap1 = 3×3
    1.3904    1.7118    1.7928
    1.9332    1.2311    1.6207
    1.0000    1.7118    1.3904
```

```
pA1 = (0.5)^A
```

```
pA1 = 3×3 complex
   1.4867 + 0.0000i   0.2124 + 0.0000i  -2.5695 + 0.0000i
 -13.2981 + 0.0000i   8.4944 + 0.0000i   6.7506 - 0.0000i
  11.3044 - 0.0000i  -8.2394 + 0.0000i  -4.1478 + 0.0000i
```

```
Ap2 = A.^0.4
```

```
Ap2 = 3×3
    1.5518    2.0477    2.1779
    2.4082    1.3195    1.9037
    1.0000    2.0477    1.5518
```

```
pA2 = (0.4)^A
```

```
pA2 = 3×3 complex
  -0.7682 - 0.0000i   2.6657 + 0.0000i  -3.0069 + 0.0000i
 -25.5662 + 0.0000i  14.0796 + 0.0000i  16.4940 - 0.0000i
  24.9116 - 0.0000i -15.6848 - 0.0000i -13.0019 + 0.0000i
```

例1.2.25：求方程组的解

```
clear
clc
A = [5 6 0 0 0;1 5 6 0 0;0 1 5 6 0;0 0 1 5 6;0 0 0 1 5];
B = [1 0 0 0 1]';
R_A = rank(A)
```

```
R_A = 5
```

```
X = A\B
```

```
X = 5×1
    2.2662
   -1.7218
    1.0571
   -0.5940
    0.3188
```

```
C = [A,B]
```

```
C = 5×6
     5     6     0     0     0     1
     1     5     6     0     0     0
     0     1     5     6     0     0
     0     0     1     5     6     0
     0     0     0     1     5     1
```

```
R = rref(C)
```

```
R = 5×6
    1.0000         0         0         0         0    2.2662
         0    1.0000         0         0         0   -1.7218
         0         0    1.0000         0         0    1.0571
         0         0         0    1.0000         0   -0.5940
         0         0         0         0    1.0000    0.3188
```

例1.2.26：求方程组的一个特解

```
A = [1 1 -3 -1;3 -1 -3 4;1 5 -9 -8];
B = [1 4 0]';
X = A\B
```

```
警告: 秩亏，秩 = 2，tol =  8.837264e-15。
X = 4×1
         0
         0
   -0.5333
    0.6000
```

```
C = [A,B]
```

```
C = 3×5
     1     1    -3    -1     1
     3    -1    -3     4     4
     1     5    -9    -8     0
```

```
R = rref(C)
```

```
R = 3×5
    1.0000         0   -1.5000    0.7500    1.2500
         0    1.0000   -1.5000   -1.7500   -0.2500
         0         0         0         0         0
```

```

```

三．MATLAB 程序设计

例1.3.1：字符变量的输入和检查

```
clear
clc
a = 'this is a string';
isstr(a)
```

```
ans = logical
```

1

例1.3.2：建立学生档案结构体

```
student_rec.number=1;
student_rec.name='张三'
```

```
student_rec = 包含以下字段的 struct:
    number: 1
      name: '张三'
```

```
student_rec.height=180;
student_rec.test=[100 80 75;77,60,92;67 28 90;100 89 78];
student_rec
```

```
student_rec = 包含以下字段的 struct:
    number: 1
      name: '张三'
    height: 180
      test: [4×3 double]
```

```
student_rec.test
```

```
ans = 4×3
   100    80    75
    77    60    92
    67    28    90
   100    89    78
```

```
b(50,2) = struct(student_rec)
```

```
b = 包含以下字段的 50×2 struct 数组:
    number
    name
    height
    test
     ⋮
```

```
b(43,2).Number=50+43;
b(43,2).Name='李四'
```

```
b = 包含以下字段的 50×2 struct 数组:
    number
    name
    height
    test
    Number
    Name
     ⋮
```

```
b(43,2).Height=186;
b(43,2).Test=[83 80 78;97 80 72;69 88 80;87 99 100];
b(1,1).weight = 90
```

```
b = 包含以下字段的 50×2 struct 数组:
    number
```

```
    name
    height
    test
    Number
    Name
    Height
    Test
    weight
     ⋮
```

```
b = rmfield(b,'weight')
```

```
b = 包含以下字段的 50×2 struct 数组:
    number
    name
    height
    test
    Number
    Name
    Height
    Test
     ⋮
```

例1.3.3：用单元数据结构来构造某个学生的档案。

```
B={1,'张三',180,[100 80 75;77,60,92;67,28,90;100,89,78]}
```

```
B = 1×4 cell 数组
    {[1]}    {'张三'}    {[180]}    {4×3 double}
```

```
size(B)
```

```
ans = 1×2
     1     4
```

```
B{4}
```

```
ans = 4×3
   100    80    75
    77    60    92
    67    28    90
   100    89    78
```

```
celldisp(B)
```

```
B{1} =

     1



B{2} =

张三


B{3} =

   180
```

```
B{4} =

   100    80    75
    77    60    92
    67    28    90
   100    89    78
```

```
B(3) = []
```

```
B = 1×3 cell 数组
    {[1]}    {'张三'}    {4×3 double}
```

例1.3.4：计算向量元素的平均值

```
average(1:100)
```

```
m = 1
n = 100
ans = 50.5000
```

```
help average
```

```
'average' 用于 声明函数。
```

例1.3.5：计算 **Matlab** 中特殊值**EPS**

```
clear
clc
EPS = 1;
num = 0;
while(1+EPS>1)
    EPS = EPS/2;
    num = num + 1;
end
num
```

```
num = 53
```

```
EPS
```

```
EPS = 1.1102e-16
```

```
EPS = EPS*2
```

```
EPS = 2.2204e-16
```

```
eps
```

```
ans = 2.2204e-16
```

例1.3.6：求 **EPS** 的另一种方法

```
EPS = 1;
for num=1:100
    EPS = EPS/2;
    if (1+EPS)<=1
        EPS = 2*EPS;
        break;
    end
end
EPS
```

```
EPS = 2.2204e-16
```

```
num
```

```
num = 53
```

例1.3.7：折扣问题，购买**2.5**元/斤的苹果，若购买量超过**50**斤，给**20%**的折扣；超过**100**斤，给**30%**的折扣

```
apples = 100;
cost = apples*2.5;
if (apples>50)&&(apples<100)
    cost = 0.8*cost;
elseif apples>100
    cost = 0.7*cost
end
```

例1.3.8：用 **eval** 产生**5** 阶的**Hilbert** 矩阵

```
n = 5;
t = '1/(i+j-1)';
a = zeros(n);
for i=1:n
    for j=1:n
        a(i,j)=eval(t);
    end
end
a
```

```
a = 5×5
    1.0000    0.5000    0.3333    0.2500    0.2000
    0.5000    0.3333    0.2500    0.2000    0.1667
    0.3333    0.2500    0.2000    0.1667    0.1429
    0.2500    0.2000    0.1667    0.1429    0.1250
    0.2000    0.1667    0.1429    0.1250    0.1111
```

例1.3.9：**feval** 函数的使用

```
disp('函数对应索引值为sin->1,cos->2,log->3')
```

```
函数对应索引值为sin->1,cos->2,log->3
```

```
fun = ['sin';'cos';'log'];
k = input('选择函数号:')
```

```
k = 1
```

```
x = input('输入要计算的值:')
```

```
x = 67
```

```
feval(fun(k,:),x)
```

```
ans = -0.8555
```

例1.3.10：用递归调用形式计算**n**的阶乘

```
clear
clc
factor(6)
```

```
ans = 720
```

例1.3.11：编写函数 **M** 文件并对其进行调试

```
test(magic(4))
```

```
q = 4.7133e+17
a = 4×4
   -3.1863    1.0883   -3.5366    3.0117
   -1.9563    2.5800   -0.1965   -0.8170
   -2.6270    1.7545    0.8161    0.2333
   -1.1552    3.3609   -3.0005    3.5246
a = 4×4
   -3.1863    1.0883   -3.5366    3.0117
   -1.9563    2.5800   -0.1965   -0.8170
   -2.6270    1.7545    0.8161    0.2333
   -1.1552    3.3609   -3.0005    3.5246
ans = 4×4
   -3.1863    1.0883   -3.5366    3.0117
   -1.9563    2.5800   -0.1965   -0.8170
   -2.6270    1.7545    0.8161    0.2333
   -1.1552    3.3609   -3.0005    3.5246
```

实验二．控制系统时域分析法

例2.1：试绘制出典型二阶系统中，当**ωn** =6，ξ分别为0.1，0.2，……，1.0，2.0 时的单位阶跃响应

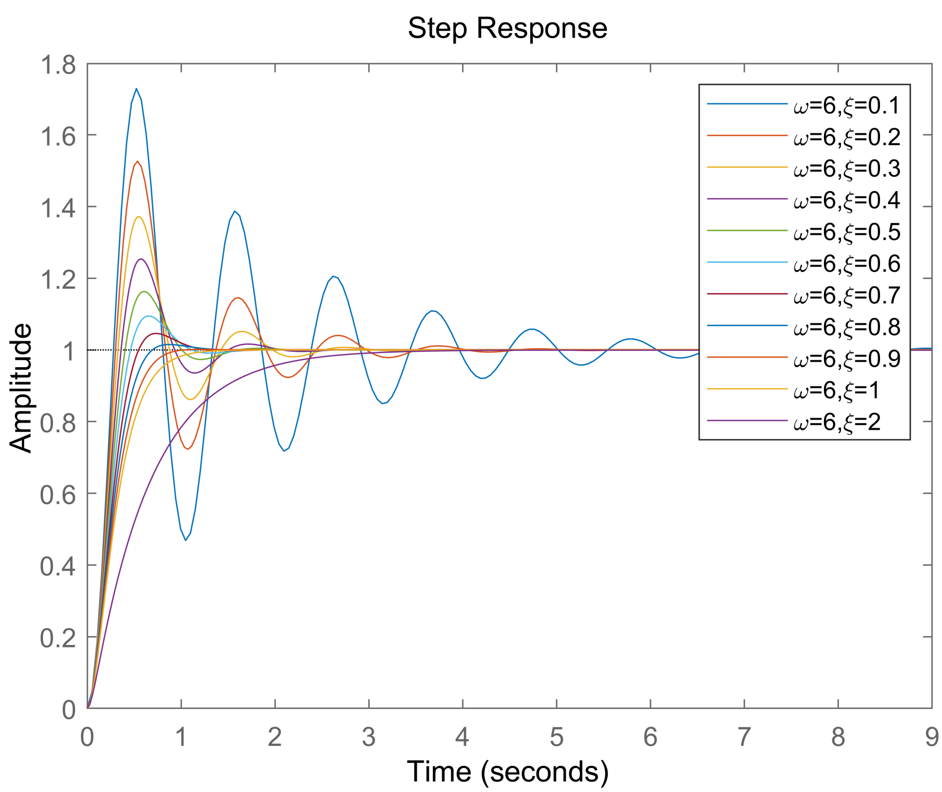
```
clear
clc
clf

Wn = 6
```

```
Wn = 6
```

```
kesai = [0.1:0.1:1,2]
```

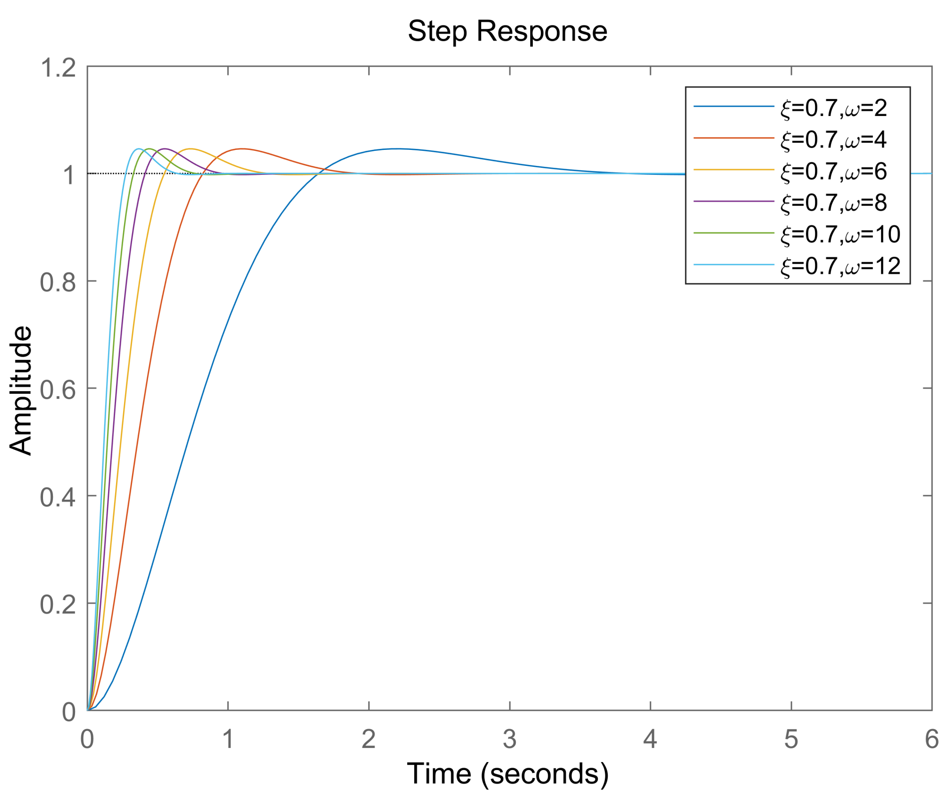
```
kesai = 1×11
    0.1000    0.2000    0.3000    0.4000    0.5000    0.6000    0.7000    0.8000 ⋯
```

```
le = [];
x = '\omega=6,\xi=';
hold on
for kos=kesai
    num = Wn^2;
    den = [1,2*kos*Wn,Wn^2];
    step(num,den);

    num2str(kos);
    y = [x,num2str(kos)];
    le = [le,string(y)];

end
legend(le)
hold off
```



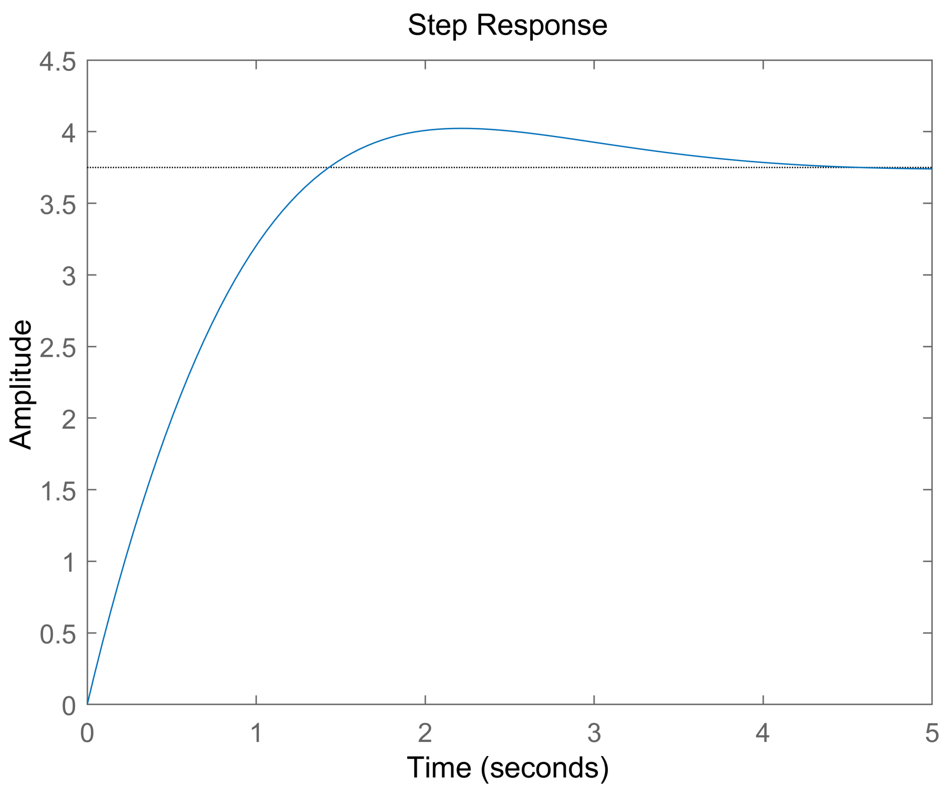
例2.2：绘制出当ξ=0.7， **ωn**取2，4，6，8，10，12 时的单位阶跃响应

```
clear
clc
clf

le = [];
x = '\xi=0.7,\omega=';
w = [2:2:12];
kesai = 0.7;
hold on
for Wn = w
    num = Wn^2;
    den = [1,2*kesai*Wn,Wn^2];
    step(num,den,6)

    num2str(Wn);
    y = [x,num2str(Wn)];
    le = [le,string(y)];

end
legend(le)
hold off
```



例2.3：求三阶系统的单位阶跃响应

```
clear
clc
clf

num = [5 25 30];
den = [1 6 10 8];
step(num,den)
```

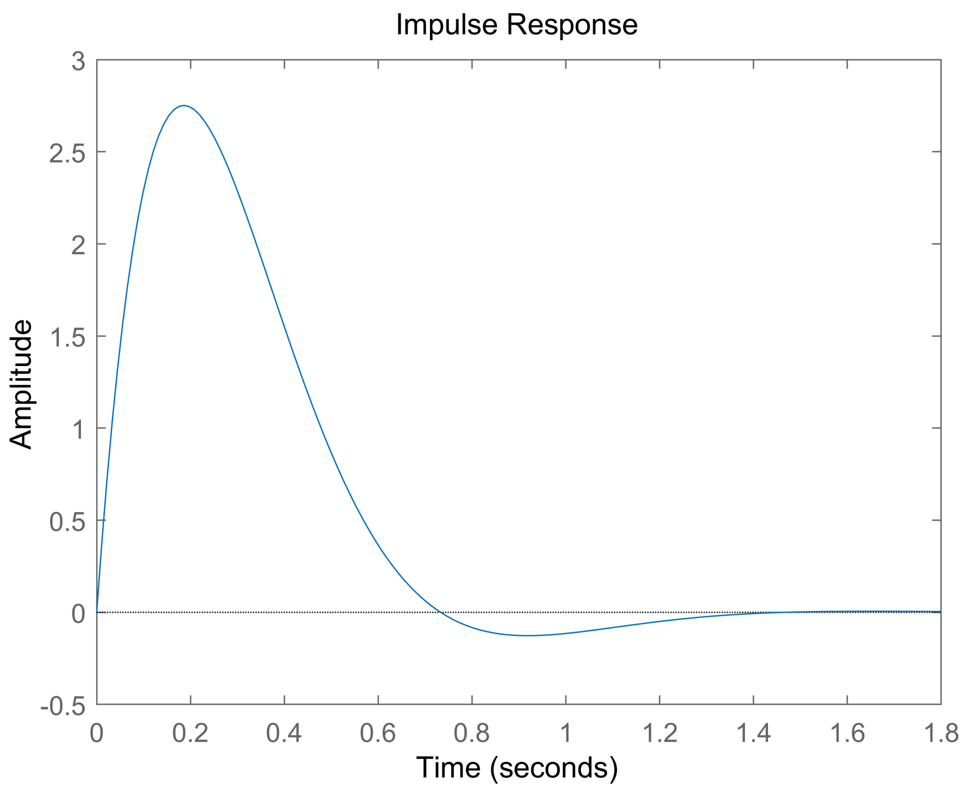


例2.4：当典型二阶系统中ξ=0.7，ωn **=6** 时的单位冲激响应

```
Wn =6;
kesai = 0.7
```

```
kesai = 0.7000
```

```
% hold on
num = Wn^2;
den = [1,2*kesai*Wn,Wn^2];
impulse(num,den)
```

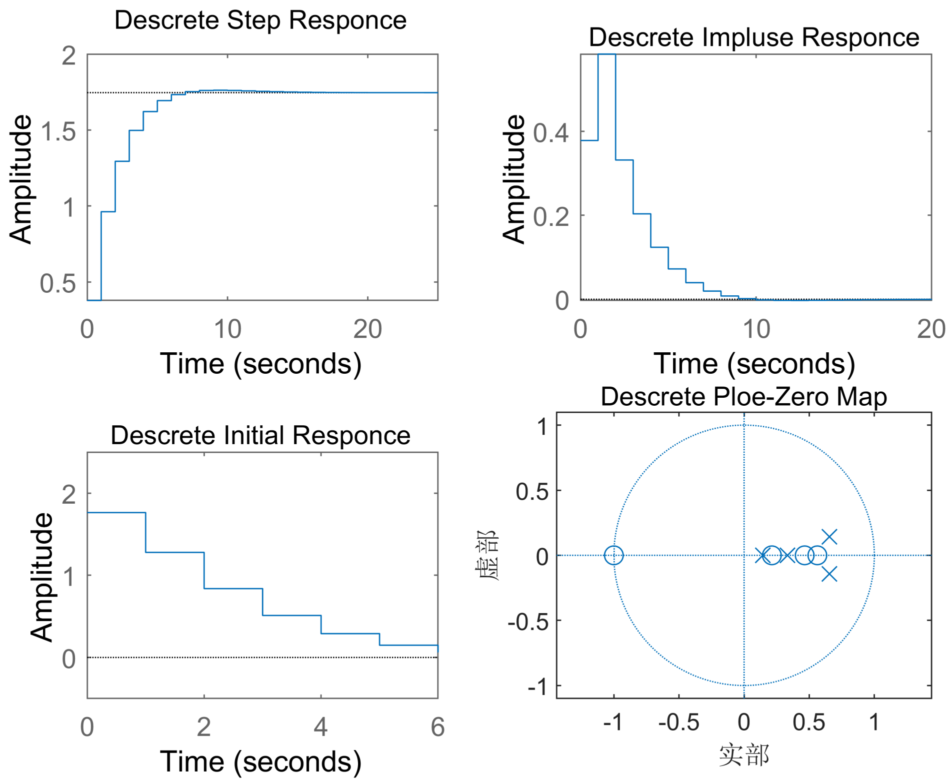



```
% hold off
```

例2.5：单位阶跃响应，单位冲激响应及零输入响应（设初始状态**x0=[1 1 1** -1]T）

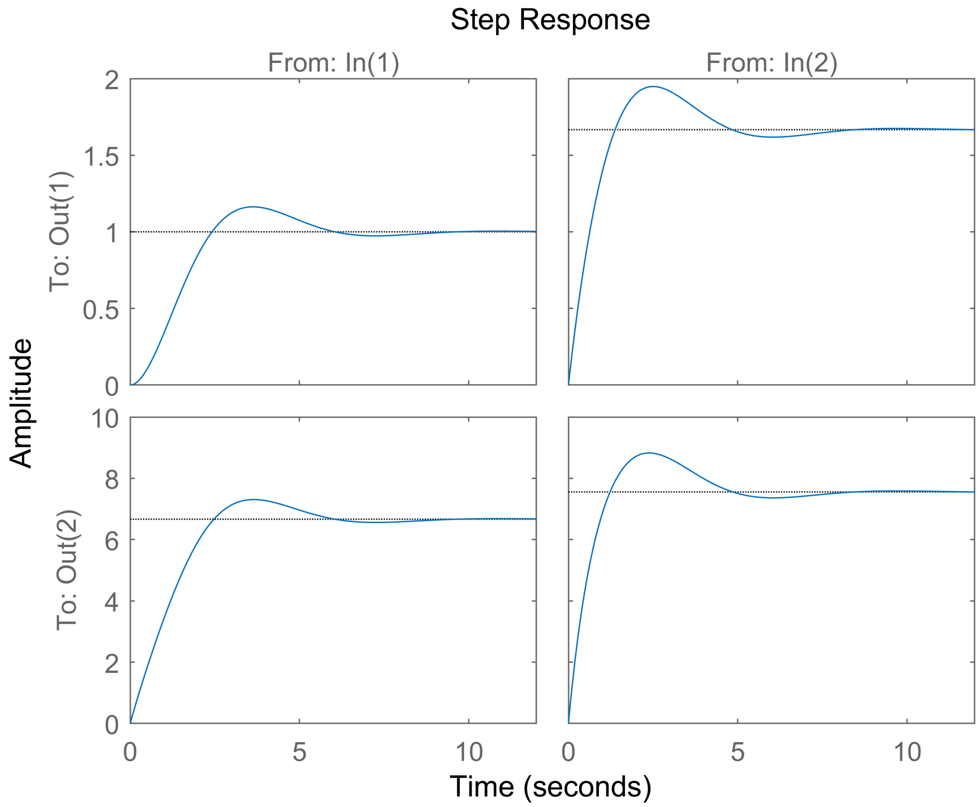
```
clear
clc
clf

a0=[-1.6,-0.9,0,0;0.9,0,0,0; 0.4,0.5,-5,-2.45;0,0,2.45,0];
b0=[1;0;1;0];
c0=[1,1,1,1];
d0=[0];
t=0.5;
[a,b,c,d]=c2dm(a0,b0,c0,d0,t,'tustin');
figure(3);
subplot(2,2,1);
dstep(a,b,c,d);
title('Descrete Step Responce');
subplot(2,2,2);
dimpulse(a,b,c,d);
title('Descrete Impluse Responce');
subplot(2,2,3);
x0=[1;1;1;-1];
```

```
dinitial(a,b,c,d,x0);
axis([0 6 -0.5 2.5]);
title('Descrete Initial Responce');
subplot(2,2,4);
[z,p,k]=ss2zp(a,b,c,d,1);
zplane(z,p);
title('Descrete Ploe-Zero Map');
```

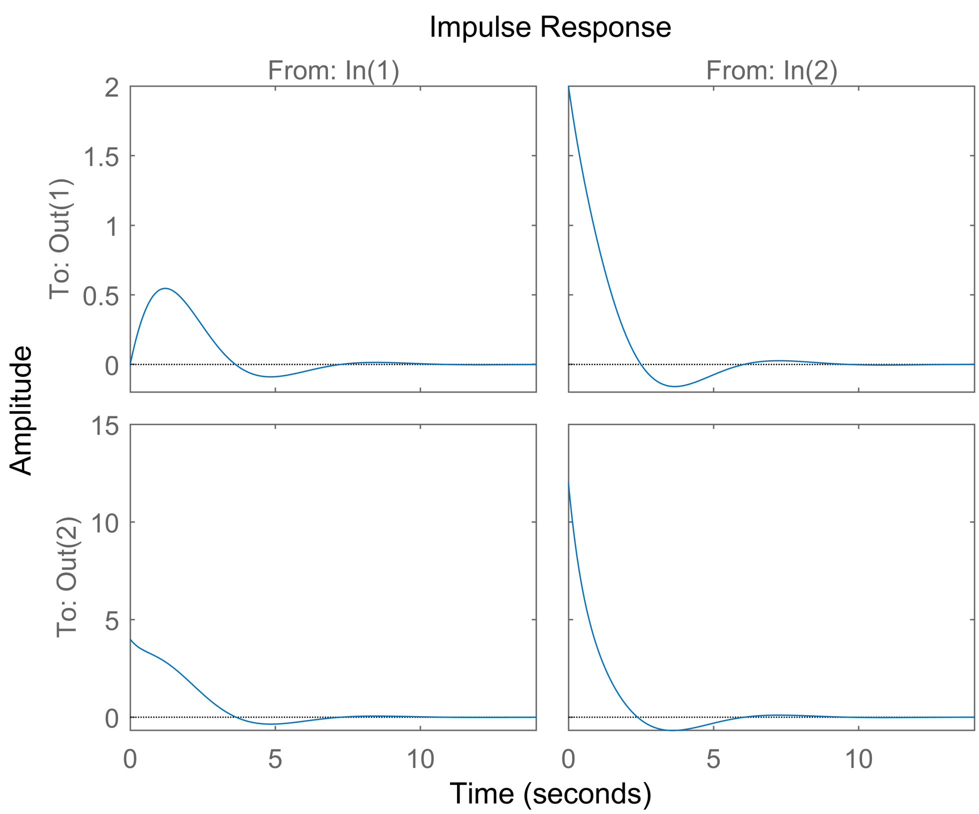


例2.6：求多输入多输出系统的单位阶跃响应和单位冲激响应

```
clf
a=[2.25 -5 -1.25 -0.5;2.25 -4.25 -1.25 -0.25;0.25 -0.5 -1.25 -1;1.25 -1.75 -0.25 -0.75];
b=[4 6;2 4;2 2;0 2];
c=[0 0 0 1;0 2 0 2];
d=zeros(2,2);
step(a,b,c,d);
```




```
impulse(a,b,c,d);
```



例2.7：将例**2.5** 中的连续系统，以**t=0.5** 取样周期，采用双线性变换算法转换成离散系统，然后求出离散系统的单位阶跃响应、单位冲激响应及零输入响应（设初始状态**x0=[1 1 1** -1]T）

```
clf

a=[-1.6 -0.9 0 0;0.9 0 0 0;0.4 0.5 -5 -2.45;0 0 2.45 0];
b=[1;0;1;0];
c=[1 1 1 1 ];
d=[0];
t=0.5;
sys = ss(a,b,c,d)
```

```
sys =

  A =
           x1     x2     x3     x4
   x1    -1.6   -0.9      0      0
   x2     0.9      0      0      0
   x3     0.4    0.5     -5  -2.45
   x4       0      0   2.45      0

  B =
       u1
   x1   1
   x2   0
   x3   1
   x4   0

  C =
       x1  x2  x3  x4
   y1   1   1   1   1

  D =
       u1
   y1   0

Continuous-time state-space model.
```

```
sysd=c2d(sys,t,'tustin')
```

```
sysd =

  A =
             x1        x2        x3        x4
   x1    0.3787   -0.3102         0         0
   x2    0.3102    0.9302         0         0
   x3   0.06729   0.08009   -0.2381   -0.4666
   x4   0.04122   0.04906    0.4666    0.7142

  B =
             u1
   x1    0.3447
   x2   0.07755
   x3    0.2073
   x4     0.127

  C =
```

```
          x1      x2      x3      x4
   y1  0.8987  0.8746  0.6142  0.6238

  D =
          u1
   y1  0.3782

Sample time: 0.5 seconds
Discrete-time state-space model.
```

```
a = sysd.A
```

```
a = 4×4
    0.3787   -0.3102         0         0
    0.3102    0.9302         0         0
    0.0673    0.0801   -0.2381   -0.4666
    0.0412    0.0491    0.4666    0.7142
```

```
b = sysd.B
```

```
b = 4×1
    0.3447
    0.0776
    0.2073
    0.1270
```

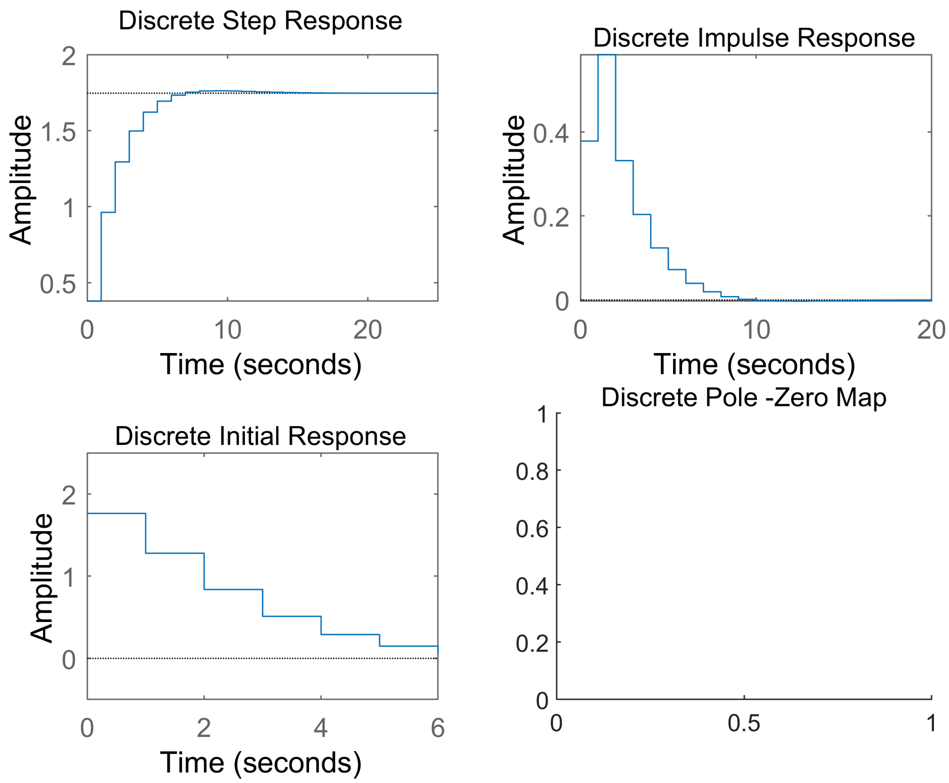
```
c = sysd.C
```

```
c = 1×4
    0.8987    0.8746    0.6142    0.6238
```

```
d = sysd.D
```

```
d = 0.3782
```

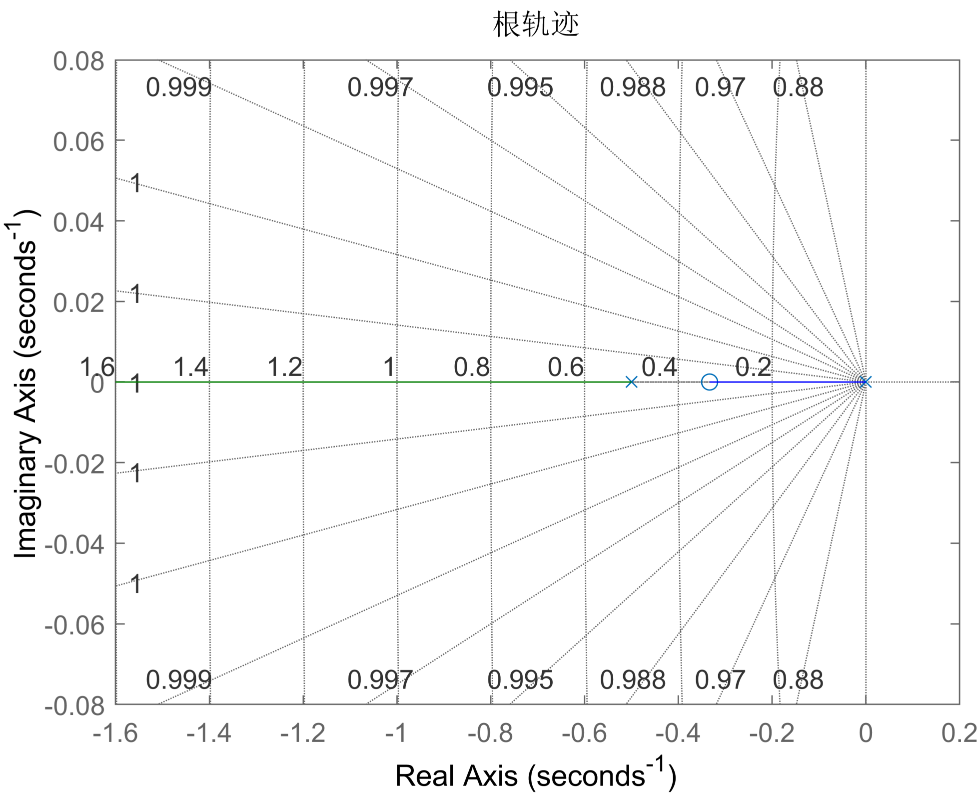
```
figure(1)
subplot(2,2,1);
dstep(a,b,c,d);
title('Discrete Step Response');
subplot(2,2,2);
dimpulse(a,b,c,d);
title('Discrete Impulse Response');
subplot(2,2,3);
x0=[1;1;1;-1];
dinitial(a,b,c,d,x0);
axis([0 6 -0.5 2.5]);
title('Discrete Initial Response');
subplot(2,2,4);
[z,p,k]=ss2zp(a,b,c,d,1);
title('Discrete Pole -Zero Map');
```



实验三．控制系统的根轨迹法

例3.1：绘制出通过单位负反馈构成的闭环系统的根轨迹

```
clear
clc
clf

num = [3 1];
den = [2 1 0];
rlocus(num,den)
sgrid
title('根轨迹')
```



例3.2：绘制出闭环系统的根轨迹，并确定交点处的增益 **k**

```
num=[1,5]
```

```
num = 1×2
     1     5
```

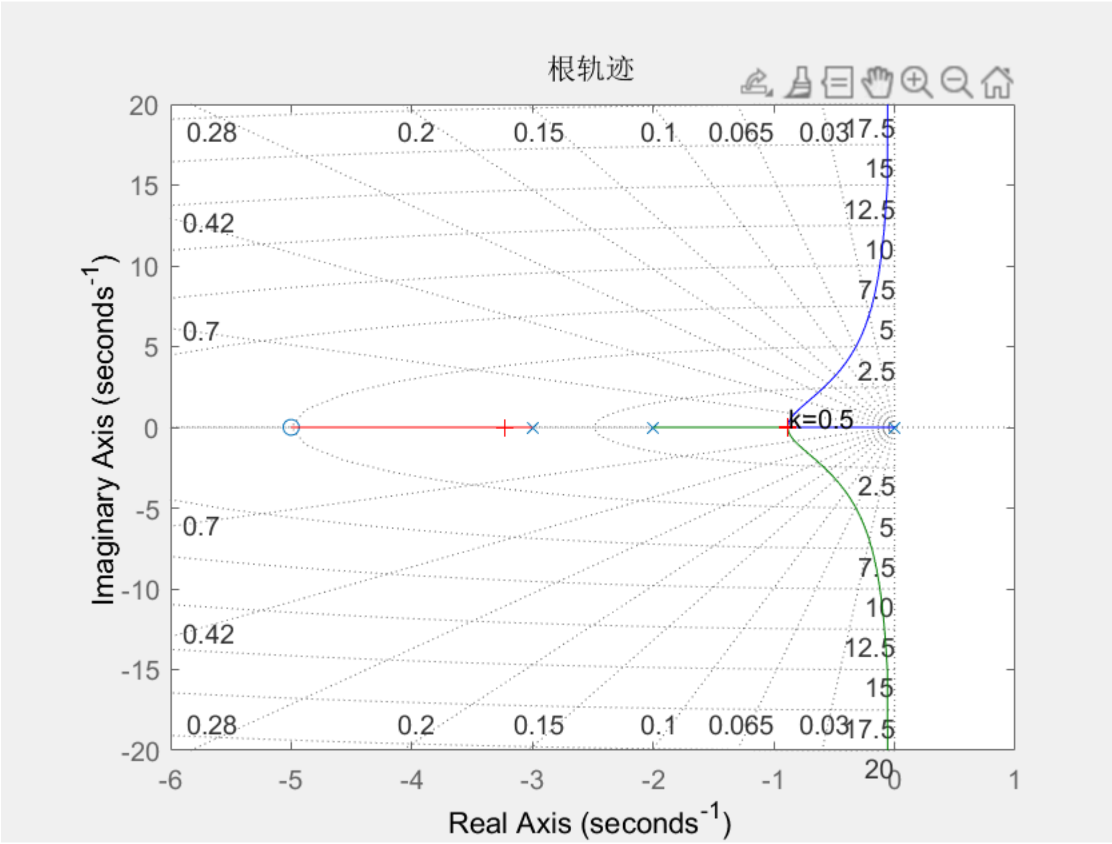
```
den=[1,5,6,0]
```

```
den = 1×4
     1     5     6     0
```

```
rlocus(num,den)
sgrid
title('根轨迹')
[k,p]=rlocfind(num,den)
```

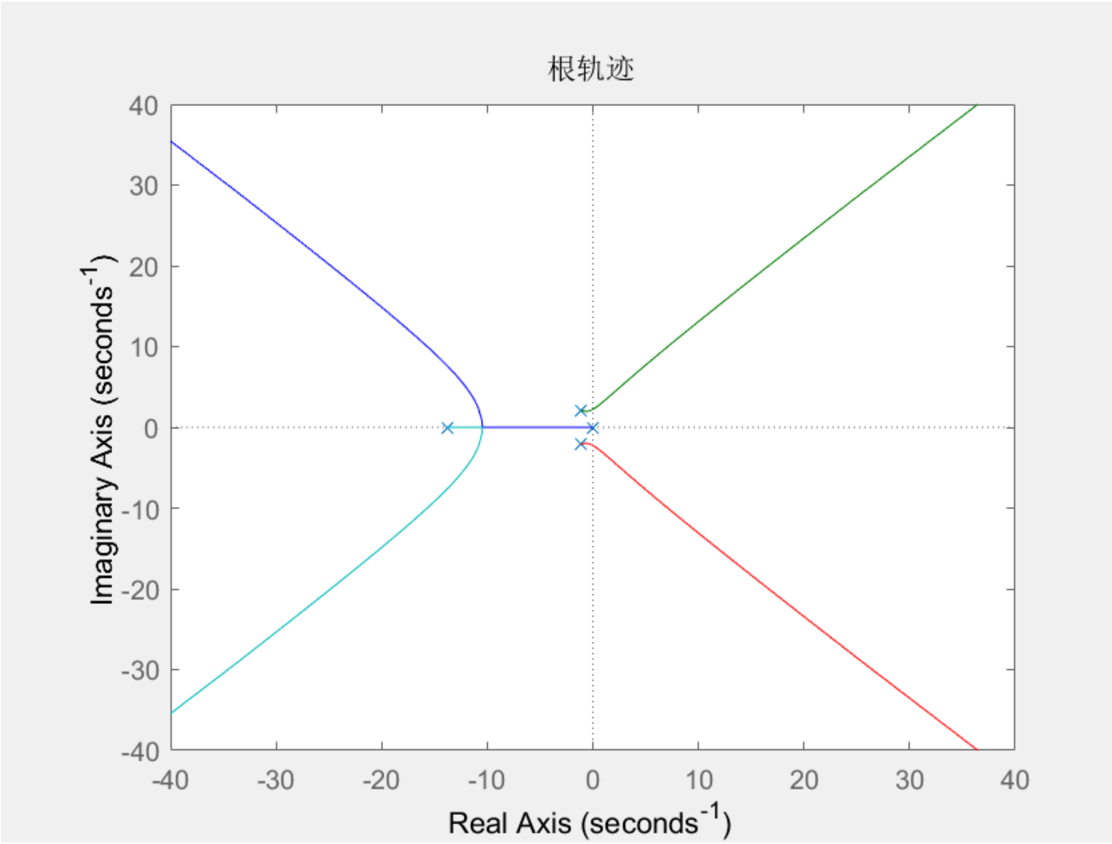
```
Select a point in the graphics window
selected_point = -0.8744 - 0.0413i
k = 0.5081
p = 3×1
  -3.2274
  -0.8863
  -0.8863
```

```
gtext('k=0.5')
```



例3.3：绘制出闭环系统的根轨迹

```
clear
clc
clf

num=[1];
den=[1,16,36,80,0];
rlocus(num,den)
title('根轨迹')
```



例3.4：绘制出闭环系统的根轨迹

```
num=[1,2]
```

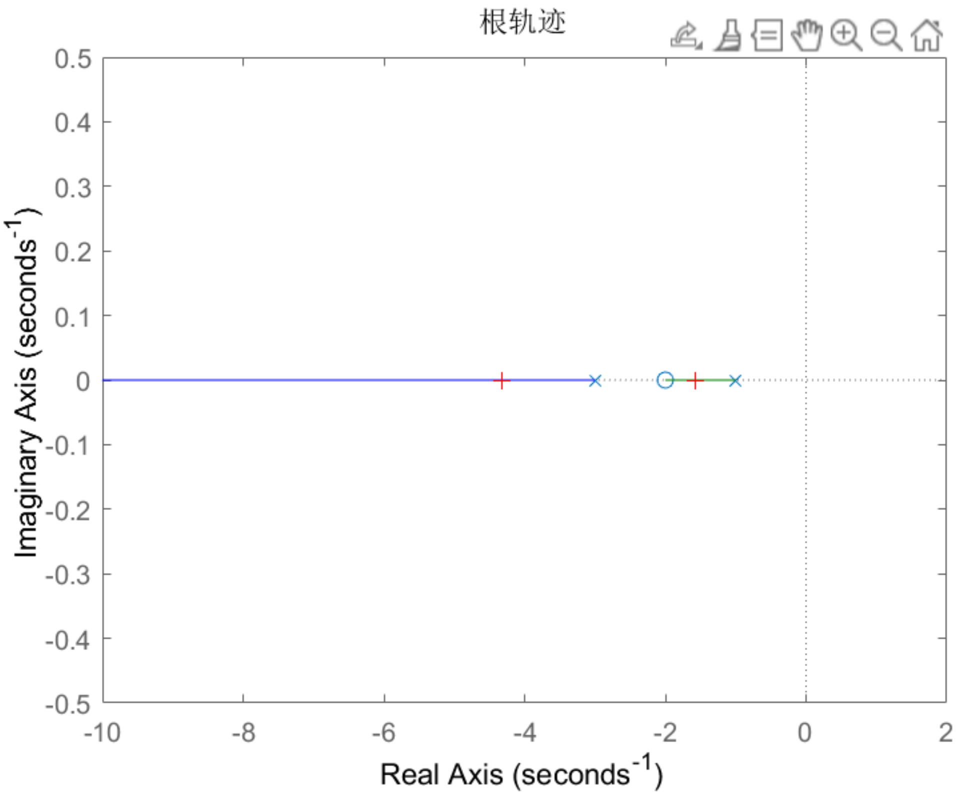
```
num = 1×2
     1     2
```

```
den=[1,4,3]
```

```
den = 1×3
     1     4     3
```

```
figure(1);
rlocus(num,den)
title('根轨迹')
[k,p]=rlocfind(num,den)
```

```
Select a point in the graphics window
```




```
selected_point = -4.3223 + 0.0010i
k = 1.8917
p = 2×1
   -4.3223
   -1.5694
```

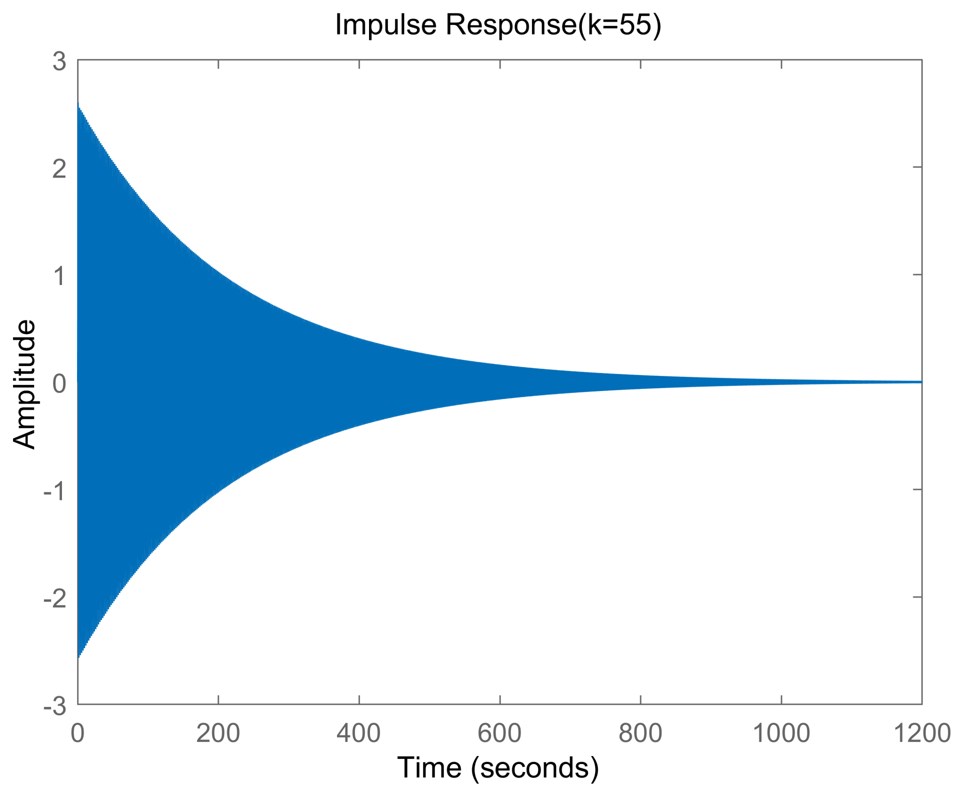
```
figure(2);
k=55;
num1=k*[1 2]
```

```
num1 = 1×2
    55   110
```

```
den=[1 4 3]
```

```
den = 1×3
     1     4     3
```

```
den1=conv(den,den);
[num,den]=cloop(num1,den1,-1);
impulse(num,den);
title('Impulse Response(k=55)')
```



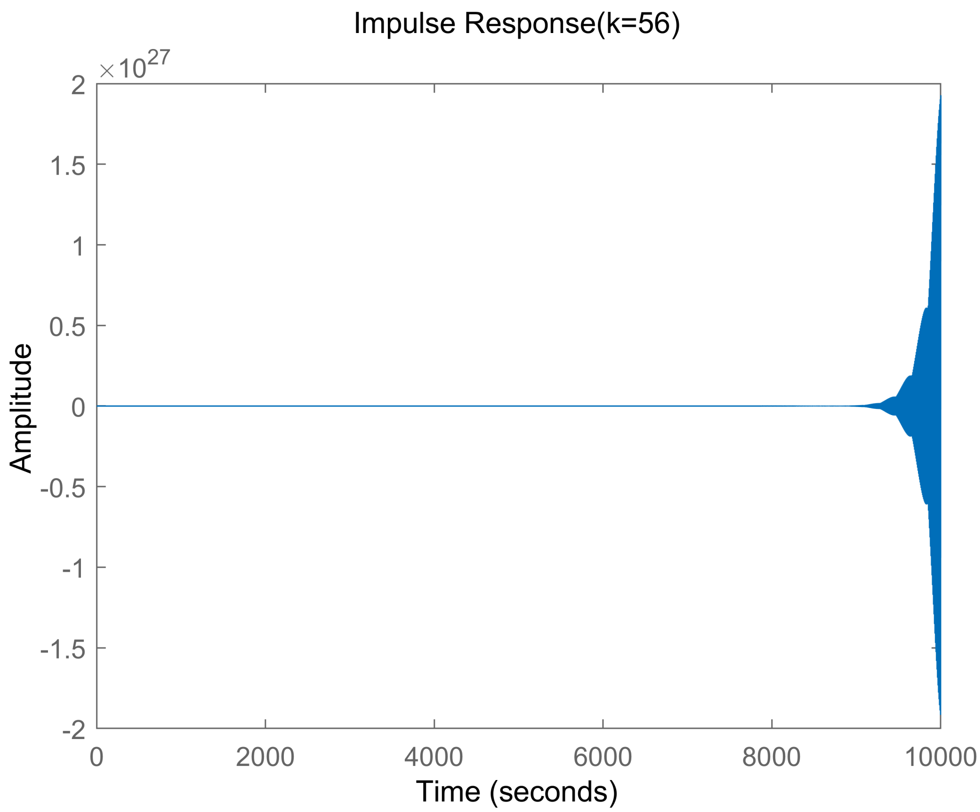

```
figure(3);
k=56;
num1=k*[1 2]
```

```
num1 = 1×2
    56   112
```

```
den=[1 4 3]
```

```
den = 1×3
     1     4     3
```

```
den1=conv(den,den);
[num,den]=cloop(num1,den1,-1);
impulse(num,den);
title('Impulse Response(k=56)')
```



实验四．控制系统反馈校正设计

例4.1：设计反馈控制器

```
clear
clc
clf

disp('Pole Placement …… using transformation matrix')
```

```
Pole Placement …… using transformation matrix
```

```
a=[0 1 0;0 0 1;-6 -11 -6];
b=[0;0;10]
```

```
b = 3×1
     0
     0
    10
```

```
cam=ctrb(a,b);
disp('Tha rank of controllability matrix');
```

```
Tha rank of controllability matrix
```

```
rc=rank(cam)
```

```
rc = 3
```

```
beta=poly(a)
```

```
beta = 1×4
    1.0000    6.0000   11.0000    6.0000
```

```
a1=beta(2);a2=beta(3);a3=beta(4);
w=[a2 a1 1;a1 1 0;1 0 0];
t=cam*w;
j=[-2+2*sqrt(3)*i 0 0;0 -2-2*sqrt(3)*i 0;0 0 -10];
alph=poly(j);
aa1=alph(2);aa2=alph(3);aa3=alph(4);
k=[aa3-a3 aa2-a2 aa1-a1]*(inv(t))
```

```
k = 1×3
   15.4000    4.5000    0.8000
```

```
disp('Pole Placement …… using Ackermann''s formula');
```

```
Pole Placement …… using Ackermann's formula
```

```
a=[0 1 0;0 0 1;-6 -11 -6];
b=[0;0;10];
cam=ctrb(a,b);
disp('The rank of controllability matrix');
```

```
The rank of controllability matrix
```

```
rc=rank(cam)
```

```
rc = 3
```

```
j=[-2+2*sqrt(3)*i 0 0;0 2-2*sqrt(3)*i 0;0 0 -10];
alph=poly(j);
phi=polyvalm(alph,a);
k=[0 0 1]*(inv(cam))*phi
```

```
k = 1×3 complex
   7.4000 +13.8564i  -0.3000 + 1.3856i   0.4000 + 0.0000i
```

```
p=[-2+2*sqrt(3)*i -2-2*sqrt(3)*i -10];
k=place(a,b,p)
```

```
k = 1×3
   15.4000    4.5000    0.8000
```

例4.2：设计全阶状态观测器

```
a=[0 1 0;0 0 1;-6 -1 -6];
b=[0;0;1]
```

```
b = 3×1
     0
     0
     1
```

```
c=[1 0 0]
```

```
c = 1×3
     1     0     0
```

```
disp('The rank of obserbability matrix')
```

```
The rank of obserbability matrix
```

```
ro=rank(obsv(a,c))
```

```
ro = 3
```

```
a1=a';
b1=c';
c1=b';
p=[-2+2*sqrt(3)*i -2-2*sqrt(3)*i -5];
k=acker(a1,b1,p)
```

```
k = 1×3
    3.0000   17.0000  -31.0000
```

```
ke=k'
```

```
ke = 3×1
    3.0000
   17.0000
  -31.0000
```

例4.3：设计最小阶状态观测器

```
a=[0 1 0;0 0 1;-6 -11 -6];
b=[0;0;1];c=[1 0 0]
```

```
c = 1×3
     1     0     0
```

```
aaa=[a(1,1)];aab=[a(1,2:3)];
aba=[a(2:3,1)];abb=[a(2:3,2:3)];
ba=b(1,1);bb=b(2:3,1);
a1=abb;c1=aab;
disp('Design of a minimum-order observer');
```

```
Design of a minimum-order observer
```

```
ro=rank(obsv(a1,c1))
```

```
ro = 2
```

```
ax=a1';
bx=c1';
p=[-2+2*sqrt(3)*i -2-2*sqrt(3)*i];
```

```
k=acker(ax,bx,p);
ke=k'
```

```
ke = 2×1
    -2
    17
```