Scilab Textbook Companion for Numerical Methods: Principles, Analysis, And Algorithms by S. Pal[1]

Created by
Saurav Suman
B.Tech
Others
NIT Jamshedpur
College Teacher
NA
Cross-Checked by

August 15, 2013

[1]Funded by a grant from the National Mission on Education through ICT, http://spoken-tutorial.org/NMEICT-Intro. This Textbook Companion and Scilab codes written in it can be downloaded from the "Textbook Companion Project" section at the website http://scilab.in

Book Description

Title: Numerical Methods: Principles, Analysis, And Algorithms

Author: S. Pal

Publisher: Oxford University Press

Edition: 1

Year: 2009

ISBN: 9780195693751

Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

Contents

List of Scilab Codes

Chapter 1

Background to Numerical Methods

Scilab code Exa 1.1 Conversion to Decimal System

```
1  //Example 1.1
2  //Conversion to Decimal System
3  //Page no. 4
4  clc;close;clear;
5  function [s]=bas2dec(x,b)
6      xi=int(x)
7      xd=x-int(x)
8      s=0
9      for i=1:10
10         xi=xi/10
11         s=s+(10*(xi-fix(xi))*b^(i-1))
12         xi=int(xi)
13         if(xi==0)
14             break
15         end
16     end
17     for i=1:1
```

```
18          xd=xd*10;
19          s=s+(ceil(xd)/b^(i))
20          xd=xd-fix(xd)
21          if(xd==0)
22              break
23          end
24      end
25  endfunction
26
27  //conversion from hexadecimal to decimal system
28  disp(hex2dec('1A2C'),'1A2C=');      //inbuit function
29
30  //conversion from hexadecimal to decimal system
31  disp(bas2dec(428.5,8),'428.5=')    //inline function
32
33  //conversion from hexadecimal to decimal system
34  disp(bas2dec(120.1,3),'120.1=')      //inline
    function
```

Scilab code Exa 1.2 Conversion Using Shortcut Method

```
1  //Example 1.2
2  //Conversion Using Shortcut Method
3  //Page no. 4
4  clc;close;clear;
5  A=10;C=12;
6  d=(((1)*16+A)*16+2)*16+C;
7  disp(d,'Decimal form of 1A2C is =');
```

Scilab code Exa 1.3 Conversion to Base B from Decimal System

```
1 //Example 1.3
2 //Conversion to Base B from Decimal System
3 //Page no. 5
4 clc;close;clear;
5 //conversion from binary to octal
6 disp(dec2oct(bin2dec('10101101110')),'Octal form of
    10101101110 is =');    //inbuilt function
7
8 //conversion from binary to hexadecimal
9 disp(dec2hex(bin2dec('10101101110')),'Hexadecimal
    form of 10101101110 is =');    //inbuilt function
10
11 //conversion from binary to octal
12 s=dec2oct(bin2dec('1011'));
13 s1=dec2oct(bin2dec('110011010100'));    //inbuilt
    function
14 printf('\n Octal form of 1011.1100110101 is = \n\n
    %s.%s',s,s1)
15
16 //conversion from binary to hexadecimal
17 s=dec2hex(bin2dec('1011'));
18 s1=dec2hex(bin2dec('110011010100'));    //inbuilt
    function
19 printf('\n\n Hexadecimal form of 1011.1100110101 is
    = \n\n %s.%s',s,s1)
```

Scilab code Exa 1.4 Conversion to Binary System

```
1 //Example 1.4
2 //Conversion to Binary System
3 //Page no. 6
```

```
clc;close;clear;
//conversion from octal to binary
disp(dec2bin(oct2dec('1753')),'Binary form of 1753
   is =');    //inbuilt function

//conversion from octal to binary
disp(dec2bin(hex2dec('A478')),'Binary form of A478
   is =');    //inbuilt function

//conversion from octal to binary
s=dec2bin(oct2dec('3'));
s1=dec2bin(oct2dec('154'));    //inbuilt function
printf('\n Octal form of 3.154 is = \n\n %s.00%s',s,
   s1)
```

Scilab code Exa 1.5 Conversion to Binary System

```
//Example 1.5
//Conversion to Binary System
//Page no. 6
clc;close;clear;
//conversion from octal to binary
b=dec2bin(oct2dec('1753'))
disp(b,'Binary form of 1753 is =');    //inbuilt
   function
b=dec2hex(oct2dec('1753'))
disp(b,'Hexadecimal form of 1753 is =');    //
   inbuilt function
//conversion from octal to binary
b=dec2bin(hex2dec('A478'))
disp(b,'Binary form of A478 is =');    //inbuilt
   function
b=dec2oct(hex2dec('A478'))
```

```
14 disp(b,'Octal form of A478 is =');     //inbuilt
     function
15 //conversion from octal to binary
16 s=dec2bin(oct2dec('3'));
17 s1=dec2bin(oct2dec('154'));     //inbuilt function
18 printf('\n Octal form of 3.154 is = \n\n %s.00%s',s,
     s1)
19 s=dec2hex(oct2dec('3'));
20 s1=dec2hex(oct2dec('154'));     //inbuilt function
21 printf('\n\n Hexadecimal form of 3.154 is = \n\n %s.
     %s',s,s1)
```

Scilab code Exa 1.6 Conversion to Decimal Number

```
1 //Example 1.6
2 //Conversion to Decimal Number
3 //Page no. 7
4 clc;close;clear;
5
6 disp(dec2bin(182),'Binary of 182=')    //inbuilt
     function
```

Scilab code Exa 1.7 Conversion to Decimal Number

```
1 //Example 1.7
2 //Conversion to Decimal Number
3 //Page no. 7
4 clc;close;clear;
5
```

```
6 disp(dec2oct(467),'Octal of 467=')            //
    inbuilt function
```

Scilab code Exa 1.8 Conversion to Base B from Binary System

```
1 //Example 1.8
2 //Conversion to Base B from Binary System
3 //Page no. 8
4 clc;close;clear;
5 //conversion from binary to octal
6 disp(dec2oct(bin2dec('10101101110')),'Octal form of
    10101101110 is =');    //inbuilt function
7
8 //conversion from binary to hexadecimal
9 disp(dec2hex(bin2dec('10101101110')),'Hexadecimal
    form of 10101101110 is =');    //inbuilt function
10
11 //conversion from binary to octal
12 s=dec2oct(bin2dec('1011'));
13 s1=dec2oct(bin2dec('110011010100'));    //inbuilt
    function
14 printf('\n Octal form of 1011.1100110101 is = \n\n
    %s.%s',s,s1)
15
16 //conversion from binary to hexadecimal
17 s=dec2hex(bin2dec('1011'));
18 s1=dec2hex(bin2dec('110011010100'));    //inbuilt
    function
19 printf('\n\n Hexadecimal form of 1011.1100110101 is
    = \n\n %s.%s',s,s1)
```

Scilab code Exa 1.9 Conversion to Binary System

```
1 //Example 1.9
2 //Conversion to Binary System
3 //Page no. 8
4 clc;close;clear;
5 //conversion from octal to binary
6 disp(dec2bin(oct2dec('1753')),'Binary form of 1753
     is =');     //inbuilt function
7
8 //conversion from octal to binary
9 disp(dec2bin(hex2dec('A478')),'Binary form of A478
     is =');     //inbuilt function
10
11 //conversion from octal to binary
12 s=dec2bin(oct2dec('3'));
13 s1=dec2bin(oct2dec('154'));     //inbuilt function
14 printf('\n Octal form of 3.154 is = \n\n %s.00%s',s,
     s1)
```

Scilab code Exa 1.10 Conversion to Binary System and to Base N

```
1 //Example 1.10
2 //Conversion to Binary System and to Base N
3 //Page no. 9
4 clc;close;clear;
5
6 b=dec2bin(oct2dec('1753'))
```

```
7 disp(b,'Binary form of 1753 is =');     //inbuilt
    function
8 b=dec2hex(oct2dec('1753'))
9 disp(b,'Hexadecimal form of 1753 is =');     //
    inbuilt function
10 //conversion from octal to binary
11 b=dec2bin(hex2dec('A478'))
12 disp(b,'Binary form of A478 is =');     //inbuilt
    function
13 b=dec2oct(hex2dec('A478'))
14 disp(b,'Octal form of A478 is =');     //inbuilt
    function
15 //conversion from octal to binary
16 s=dec2bin(oct2dec('3'));
17 s1=dec2bin(oct2dec('154'));     //inbuilt function
18 printf('\n Octal form of 3.154 is = \n\n %s.00%s',s,
    s1)
19 s=dec2hex(oct2dec('3'));
20 s1=dec2hex(oct2dec('154'));     //inbuilt function
21 printf('\n\n Hexadecimal form of 3.154 is = \n\n %s.
    %s',s,s1)
```

Scilab code Exa 1.13 1s compliment and 2s compliment

```
1 //Example 1.13
2 //1s compliment and 2s compliment
3 //Page no. 11
4 clc;close;clear;
5
6 function [x1]=com1(x)       //function for 1s
    compliment
7     for i=8:-1:1
8         x=x/10;
```

```
 9          xd=x-fix(x)
10          if(floor((xd*10)+0.1)==1)
11              x1(1,i)=0;
12          else
13              x1(1,i)=1;
14          end
15          x=x-xd;
16      end
17  endfunction
18  function [x1]=com2(x)          //function for 2s
       compliment()
19      for i=8:-1:1
20          x=x/10;
21          xd=x-fix(x)
22          if(int((xd*10)+0.1)==1)
23              x1(1,i)=0;
24          else
25              x1(1,i)=1;
26          end
27      end
28      for i=8:-1:1
29          if (x1(1,i)==0) then
30             x1(1,i)=1;
31             break;
32          else
33             x1(1,i)=0;
34          end
35
36      end
37  endfunction
38  a
       =[00010011,01110110,11101101,10000001,10000000,00000000];

39  for i=1:6
40      printf('1s Compliment of %.8i=',a(i));
41      disp(com1(a(i)))
42      printf('2s Compliment of %.8i=',a(i));
43      disp(com2(a(i)))
```

```
44      printf('\n\n')
45  end
```

Scilab code Exa 1.14 1s compliment

```
1  //Example 1.14
2  //1s compliment
3  //Page no. 12
4  clc;close;clear;
5
6  function [x1]=com1(x)        //function for 1s
       compliment
7      for i=8:-1:1
8          x=x/10;
9          xd=x-fix(x)
10         if(floor((xd*10)+0.1)==1)
11             x1(1,i)=0;
12         else
13             x1(1,i)=1;
14         end
15         x=x-xd;
16     end
17 endfunction
18 a
       =[00010011,01110110,11101101,10000001,10000000,00000000];

19 for i=1:6
20     printf('1s Compliment of %.8i=',a(i));
21     disp(com1(a(i)))
22     printf('\n\n')
23 end
```

Scilab code Exa 1.15 Addition and Subtraction

```
1  //Example 1.15
2  //Addition and Subtraction
3  //Page no. 13
4  clc;clear;close;
5  function [x1]=add(x,y)                    //function
       for addition of binaries
6      c=0;
7      for i=1:10
8          x1(1,i)=0
9      end
10     for i=10:-1:1
11         x=x/10;
12         xd=x-fix(x)
13         x=x-xd;
14         y=y/10;
15         yd=y-fix(y)
16         y=y-yd;
17         if c==1 then
18             if floor((xd*10)+0.1)==1 & floor((yd*10)
                   +0.1)==1 then
19                 x1(1,i)=1;c=1;
20             elseif floor((xd*10)+0.1)==0 & floor((yd
                   *10)+0.1)==0
21                 x1(1,i)=1;c=0;
22             else
23                 x1(1,i)=0;c=0;
24             end
25         else
26             if floor((xd*10)+0.1)==1 & floor((yd*10)
                   +0.1)==1 then
```

```
27                  x1(1,i)=0;c=1;
28              elseif floor((xd*10)+0.1)==0 & floor((yd
                   *10)+0.1)==0
29                  x1(1,i)=0;c=0;
30              else
31                  x1(1,i)=1;c=0;
32              end
33          end
34      end
35      disp(x1,'Addition of 173 and 141= ')
36  endfunction
37  function [x1]=sub(x,y)              //function for
       subtraction of binaries
38          c=0;
39          for i=1:10
40              x1(1,i)=0
41          end
42          for i=10:-1:1
43              x=x/10;
44              xd=x-fix(x)
45              x=x-xd;
46              y=y/10;
47              yd=y-fix(y)
48              y=y-yd;
49              if c==1 then
50                  if floor((xd*10)+0.1)==0 & floor((yd
                       *10)+0.1)==1 then
51                      x1(1,i)=0;c=1;
52                  elseif floor((xd*10)+0.1)==0 & floor
                       ((yd*10)+0.1)==0
53                      x1(1,i)=1;c=0;
54                  elseif floor((xd*10)+0.1)==1 & floor
                       ((yd*10)+0.1)==1
55                      x1(1,i)=1;c=1;
56                  elseif floor((xd*10)+0.1)==1 & floor
                       ((yd*10)+0.1)==0
57                      x1(1,i)=0;c=0;
58                  end
```

```
59              else
60                  if floor((xd*10)+0.1)==1 & floor((yd
                       *10)+0.1)==1 then
61                      x1(1,i)=1;c=1;
62                  elseif floor((xd*10)+0.1)==0 & floor
                       ((yd*10)+0.1)==0
63                      x1(1,i)=0;c=0;
64                  elseif floor((xd*10)+0.1)==1 & floor
                       ((yd*10)+0.1)==0
65                      x1(1,i)=1;c=0;
66                  elseif floor((xd*10)+0.1)==0 & floor
                       ((yd*10)+0.1)==1
67                      x1(1,i)=1;c=1;
68                  end
69              end
70          end
71      disp(x1,'Subtraction of 45 from 228= ')
72  endfunction
73  add(10101101,10001101)
74  sub(11100100,00101101)
```

Scilab code Exa 1.16 Addition

```
1  //Example 1.16
2  //Addition
3  //Page no. 14
4  clc;close;clear;
5
6  function [x1]=add(x,y)                    //function
       for addition of binaries
7      c=0;
8      printf('Addition of %.4i and %.4i= ',x,y)
9      for i=1:4
```

```
10          x1(1,i)=0
11      end
12      for i=4:-1:1
13          x=x/10;
14          xd=x-fix(x)
15          x=x-xd;
16          y=y/10;
17          yd=y-fix(y)
18          y=y-yd;
19          if c==1 then
20              if floor((xd*10)+0.1)==1 & floor((yd*10)
                   +0.1)==1 then
21                  x1(1,i)=1;c=1;
22              elseif floor((xd*10)+0.1)==0 & floor((yd
                   *10)+0.1)==0
23                  x1(1,i)=1;c=0;
24              else
25                  x1(1,i)=0;c=1;
26              end
27          else
28              if floor((xd*10)+0.1)==1 & floor((yd*10)
                   +0.1)==1 then
29                  x1(1,i)=0;c=1;
30              elseif floor((xd*10)+0.1)==0 & floor((yd
                   *10)+0.1)==0
31                  x1(1,i)=0;c=0;
32              else
33                  x1(1,i)=1;c=0;
34              end
35          end
36      end
37
38      disp(x1)
39  endfunction
40  add(0010,0101);
41  add(1110,1011);
42  add(1110,0101);
43  add(0010,1011);
```

```
44 add(1110,0010);
45 add(0000,0000);
```

Scilab code Exa 1.17 Addition

```
1  //Example 1.17
2  //Addition
3  //Page no. 14
4  clc;close;clear;
5
6  function [x1]=add(x,y)                    //function
       for addition of binaries
7      c=0;
8      printf('Addition of %.4i and %.4i= ',x,y)
9      for i=1:5
10         x1(1,i)=0
11     end
12     for i=5:-1:1
13         x=x/10;
14         xd=x-fix(x)
15         x=x-xd;
16         y=y/10;
17         yd=y-fix(y)
18         y=y-yd;
19         if c==1 then
20             if floor((xd*10)+0.1)==1 & floor((yd*10)
                   +0.1)==1 then
21                 x1(1,i)=1;c=1;
22             elseif floor((xd*10)+0.1)==0 & floor((yd
                   *10)+0.1)==0
23                 x1(1,i)=1;c=0;
24             else
25                 x1(1,i)=0;c=1;
```

```
26              end
27          else
28              if floor((xd*10)+0.1)==1 & floor((yd*10)
                   +0.1)==1 then
29                  x1(1,i)=0;c=1;
30              elseif floor((xd*10)+0.1)==0 & floor((yd
                   *10)+0.1)==0
31                  x1(1,i)=0;c=0;
32              else
33                  x1(1,i)=1;c=0;
34              end
35          end
36      end
37
38      disp(x1)
39  endfunction
40
41  add(0010,0101);
42  add(1101,1010);
43  add(1101,0101);
44  add(0010,1010);
45  add(1101,0010);
46  add(1111,0000);
```

Scilab code Exa 1.18 Addition

```
1  //Example 1.18
2  //Addition
3  //Page no. 15
4  clc;close;clear;
5
6  function [x1]=add(x,y)                    //function
       for addition of binaries
```

```
7       c=0;
8       printf('Addition of %.4i and %.4i= ',x,y)
9       for i=1:5
10          x1(1,i)=0
11      end
12      for i=5:-1:1
13          x=x/10;
14          xd=x-fix(x)
15          x=x-xd;
16          y=y/10;
17          yd=y-fix(y)
18          y=y-yd;
19          if c==1 then
20              if floor((xd*10)+0.1)==1 & floor((yd*10)
                    +0.1)==1 then
21                  x1(1,i)=1;c=1;
22              elseif floor((xd*10)+0.1)==0 & floor((yd
                    *10)+0.1)==0
23                  x1(1,i)=1;c=0;
24              else
25                  x1(1,i)=0;c=1;
26              end
27          else
28              if floor((xd*10)+0.1)==1 & floor((yd*10)
                    +0.1)==1 then
29                  x1(1,i)=0;c=1;
30              elseif floor((xd*10)+0.1)==0 & floor((yd
                    *10)+0.1)==0
31                  x1(1,i)=0;c=0;
32              else
33                  x1(1,i)=1;c=0;
34              end
35          end
36      end
37
38      disp(x1)
39  endfunction
40
```

```
41 add(0100,0101);
42 add(1100,1011);
43 add(1000,1000);
```

Scilab code Exa 1.19 Addition

```
1  //Example 1.19
2  //Addition
3  //Page no. 15
4  clc;close;clear;
5
6  function [x1]=add(x,y)                    //function
       for addition of binaries
7      c=0;
8      printf('Addition of %.4i and %.4i= ',x,y)
9      for i=1:5
10         x1(1,i)=0
11     end
12     for i=5:-1:1
13         x=x/10;
14         xd=x-fix(x)
15         x=x-xd;
16         y=y/10;
17         yd=y-fix(y)
18         y=y-yd;
19         if c==1 then
20             if floor((xd*10)+0.1)==1 & floor((yd*10)
                   +0.1)==1 then
21                 x1(1,i)=1;c=1;
22             elseif floor((xd*10)+0.1)==0 & floor((yd
                   *10)+0.1)==0
23                 x1(1,i)=1;c=0;
24             else
```

```
25                  x1(1,i)=0;c=1;
26              end
27          else
28              if floor((xd*10)+0.1)==1 & floor((yd*10)
                   +0.1)==1 then
29                  x1(1,i)=0;c=1;
30              elseif floor((xd*10)+0.1)==0 & floor((yd
                   *10)+0.1)==0
31                  x1(1,i)=0;c=0;
32              else
33                  x1(1,i)=1;c=0;
34              end
35          end
36      end
37
38      disp(x1)
39  endfunction
40
41  add(0010,0101);
42  add(11110,11011);
43  add(1000,0101);
44  add(00010,11011);
45  add(11110,00010);
46  add(11111,0000);
```

Scilab code Exa 1.20 Subtraction

```
1  //Example 1.20
2  //Subtraction
3  //Page no. 16
4  clc;close;clear;
5  function [x1]=add(x,y)                    //function
       for addition of binaries
```

```
6       c=0;
7       for i=1:5
8           x1(1,i)=0
9       end
10      for i=5:-1:1
11          x=x/10;
12          xd=x-fix(x)
13          x=x-xd;
14          y=y/10;
15          yd=y-fix(y)
16          y=y-yd;
17          if c==1 then
18              if floor((xd*10)+0.1)==1 & floor((yd*10)
                    +0.1)==1 then
19                  x1(1,i)=1;c=1;
20              elseif floor((xd*10)+0.1)==0 & floor((yd
                    *10)+0.1)==0
21                  x1(1,i)=1;c=0;
22              else
23                  x1(1,i)=0;c=0;
24              end
25          else
26              if floor((xd*10)+0.1)==1 & floor((yd*10)
                    +0.1)==1 then
27                  x1(1,i)=0;c=1;
28              elseif floor((xd*10)+0.1)==0 & floor((yd
                    *10)+0.1)==0
29                  x1(1,i)=0;c=0;
30              else
31                  x1(1,i)=1;c=0;
32              end
33          end
34      end
35      disp(x1,'Addition of 173 and 141= ')
36  endfunction
37
38  add(0100,1011);
39  add(1100,0101);
```

```
40 add(1000,1000);
```

Scilab code Exa 1.23 Multiplication

```
1  //Example 1.23
2  //Multiplication
3  //Page no. 18
4  clc;clear;close;
5
6  function [x1]=mul(x,y)
7      for i=1:8
8          x1(1,i)=0
9      end
10     printf('Multiplication of %.4i and %.4i = ',x,y)
11     x=x*y;
12     c=0;
13     for i=8:-1:1
14         x=x/10;
15         xd=floor((x-fix(x))*10+0.1)
16         if c==1 then
17             if xd==0 then
18                 x1(1,i)=1;c=0
19             elseif xd==1
20                 x1(1,i)=0;
21                 c=1;
22             elseif xd==2
23                 x1(1,i)=1;c=1;
24             end
25         else
26             if xd==0 | xd==1 then
27                 x1(1,i)=xd;c=0
28             elseif xd==2
29                 x1(1,i)=0;
```

```
30                  i=i-1;c=1;
31              end
32          end
33      end
34      disp(x1)
35  endfunction
36  mul(1110,1011);
```

Scilab code Exa 1.24 Multiplication

```
1  //Example 1.24
2  //Multiplication
3  //Page no. 18
4  clc;clear;close;
5
6  function [x1]=mul(x,y)
7      for i=1:8
8          x1(1,i)=0
9      end
10     printf('Multiplication of %.4i and %.4i = ',x,y)
11     x=x*y;
12     c=0;
13     for i=8:-1:1
14         x=x/10;
15         xd=floor((x-fix(x))*10+0.1)
16         if c==1 then
17             if xd==0 then
18                 x1(1,i)=1;c=0
19             elseif xd==1
20                 x1(1,i)=0;
21                 c=1;
22             elseif xd==2
23                 x1(1,i)=1;c=1;
```

```
24              end
25          else
26              if xd==0 | xd==1 then
27                  x1(1,i)=xd;c=0
28              elseif xd==2
29                  x1(1,i)=0;
30                  i=i-1;c=1;
31              end
32          end
33      end
34      disp(x1)
35  endfunction
36  mul(1110,1011);
```

Scilab code Exa 1.25 Division

```
1  //Example 1.25
2  //Division
3  //Page no. 19
4  clc;close;clear;
5  function [co]=com(x,y)
6      co=1;
7      for i=1:length(x)
8          if x(i)>y(i) then
9              break
10         elseif x(i)==y(i)
11             continue
12         else
13             co=0;break
14         end
15     end
16 endfunction
17 function [x1]=sub(x,y)            //function for
```

```
    subtraction of binaries
18          c=0;m=0;
19          for i=1:5
20              x1(1,i)=0
21          end
22          for i=5:-1:1
23              if c==1 then
24                  if x(i)==0 & y(i)==1 then
25                      x1(1,i)=0;c=1;
26                  elseif x(i)==0 & y(i)==0
27                      x1(1,i)=1;c=0;
28                  elseif x(i)==1 & y(i)==1
29                      x1(1,i)=1;c=1;
30                  elseif x(i)==1 & y(i)==0
31                      x1(1,i)=0;c=0;
32                  end
33              else
34                  if x(i)==1 & y(i)==1 then
35                      x1(1,i)=0;c=0;
36                  elseif x(i)==0 & y(i)==0
37                      x1(1,i)=0;c=0;
38                  elseif x(i)==1 & y(i)==0
39                      x1(1,i)=1;c=0;
40                  elseif x(i)==0 & y(i)==1
41                      x1(1,i)=1;c=1;
42                  end
43              end
44          end
45      disp(x1,'Remainder = ')
46  endfunction
47  d1=11011001;d2=01011;d22=[0,0,0,0,0]
48  for i=8:-1:1
49      d3=d1/10;
50      div(1,i)=int(10*(d3-int(d3)))
51      d1=d1/10
52  end
53  for i=5:-1:1
54      d3=d2/10;
```

```
55      d21(1,i)=int(10*(d3-int(d3))+0.5)
56      d2=d2/10
57  end
58  div1(1,1)=0
59  for j=1:4
60      div1(1,j+1)=div(1,j)
61  end
62  for i1=1:5
63      printf('After Step %i : \n',i1)
64      if com(div1,d21)==1 then
65          dis(1,i1)=1
66          n=sub(div1,d21)
67      else
68          dis(1,i1)=0
69          n=sub(div1,d22)
70  end
71  disp(dis,'Divisor = ')
72  if i1==5 then
73      break
74  end
75          for j=1:5
76                      if j<5 then
77                          div1(1,j)=n(j+1)
78                      else
79                          div1(1,j)=div(1,i1+4)
80                      end
81           end
82
83  printf('\n\n\n\n')
84  end
```

Scilab code Exa 1.26 Multiplication

```
1  //Example 1.26
2  //Multiplication
3  //Page no. 19
4  clc;clear;close;
5
6
7  function [x1]=mul(x,y)
8      for i=1:8
9          x1(1,i)=0
10     end
11     printf('Multiplication of %.4i and %.4i = ',x,y)
12     x=x*y;
13     c=0;
14     for i=10:-1:1
15         x=x/10;
16         xd=floor((x-fix(x))*10+0.1)
17         if c==1 then
18             if xd==0 then
19                 x1(1,i)=1;c=0
20             elseif xd==1
21                 x1(1,i)=0;
22                 c=1;
23             elseif xd==2
24                 x1(1,i)=1;c=1;
25             end
26         else
27             if xd==0 | xd==1 then
28                 x1(1,i)=xd;c=0
29             elseif xd==2
30                 x1(1,i)=0;
31                 i=i-1;c=1;
32             end
33         end
34     end
35     for i=1:10
36         if x1(1,i)==1 then
37             x1(1,i-1)=1;
38             break
```

```
39          end
40      end
41      disp(x1)
42  endfunction
43  mul(1110,1011);
```

Scilab code Exa 1.29 Normalized Floating Point Representation

```
1  //Example 1.29
2  //Normalized Floating Point Representation
3  //Page no. 23
4  clc;clear;close;
5
6  function []=fp(x)
7      x1=x;
8      if x>0 then
9          for i=1:10
10             x=x/10
11              if int(x)==0 then
12                 break
13              end
14         end
15          printf('\n

                %i\nNormalized Floating Point
                Representation of %g = %.4f x 10',i,x1,x
                )
16      else
17          for i=1:10
18             x=x*10
19              if ceil(x)~=0 then
20                 break
21              end
```

```
22            end
23            x=x/10;i=i-1;
24            printf('\n

                 -%i\nNormalized Floating Point
                 Representation of %g = %.4f x 10',i,x1,x
                 )
25        end
26
27  endfunction
28
29  x=[25.12,-0.00287,87000];
30  for i=1:3
31        fp(x(i))
32  end
```

Scilab code Exa 1.30 Add

```
1  //Example 1.30
2  //Add
3  //Page no. 26
4  clc;clear;close;
5  a=0.4532e7;b=0.5427e7;
6  c=a+b
7  printf('Addition of %.6g and %.6g = %.6g',a,b,c)
```

Scilab code Exa 1.31 Add

```
1  //Example 1.31
```

```
2 //Add
3 //Page no. 26
4 clc;clear;close;
5 a=0.4532e5;b=0.5427e7;
6 c=a+b
7 printf('Addition of %.4g and %.6g = %.6g',a,b,c)
```

Scilab code Exa 1.32 Add

```
1 //Example 1.32
2 //Add
3 //Page no. 26
4 clc;clear;close;
5 a=0.4532e3;b=0.5427e7;
6 c=a+b
7 printf('Addition of %.2g and %.6g = %.4g',a,b,c)
```

Scilab code Exa 1.33 Add

```
1 //Example 1.33
2 //Add
3 //Page no. 27
4 clc;clear;close;
5 a=[0.4632e3,0.4632e99];b=[0.5427e3,0.5427e99];
6
7 for i=1:2
8     c(i)=a(i)+b(i)
9     printf('\nAddition of %.2g and %.2g = %.5g\n',a(
        i),b(i),c(i))
```

```
10 end
```

Scilab code Exa 1.34 Subtraction

```
1 //Example 1.34
2 //Subtraction
3 //Page no. 27
4 clc;clear;close;
5 a=[0.5427e-3,0.9627e4,0.9627e-99];b=[0.9632e
    -4,0.9622e4,0.9622e-99];
6 for i=1:3
7     c(i)=a(i)-b(i)
8     printf('\nSubtraction of %.2g from %.3g = %.6g\n
        ',a(i),b(i),c(i))
9 end
```

Scilab code Exa 1.35 Multiplication

```
1 //Example 1.35
2 //Multiplication
3 //Page no. 28
4 clc;clear;close;
5 a=[0.9632e12,0.1132e12,0.1132e52,0.1132e-52];b
    =[0.5427e-15,0.1027e15,0.1027e50,0.1027e-50];
6 for i=1:4
7     c(i)=a(i)*b(i)
8     printf('\nMultiplication of %.3g and %.2g = %.6g
        \n',a(i),b(i),c(i))
9 end
```

Scilab code Exa 1.36 Division

```
1 //Example 1.36
2 //Division
3 //Page no. 28
4 clc;clear;close;
5 a=[0.1132e1,0.1132e-6,0.1132e6];b=[0.1000e-99,0.1000
     e99,0.1000e3];
6 for i=1:3
7     c(i)=a(i)/b(i)
8     printf('\nDivision of %.2g by %.3g= %.3g\n',a(i)
         ,b(i),c(i))
9 end
```

Chapter 2

Scope of Numerical and Mathematical Methods

Scilab code Exa 2.4 Solving Simultaneous Linear Equation

```
1  //Example 2.4
2  //Solving Simultaneous Linear Equation
3  //Page 36
4  clc;close;clear;
5  //eq1= 5x-331y=3.5
6  //eq2= 6x-397y=5.2
7
8  A=[5,-331;6,-397];
9  B=[3.5;5.2];
10 C=inv(A)*B;       //finding value by multiplying
       inverse with values
11 disp(C(1,1),'Value of x=');
12 disp(C(2,1),'Value of y=');
```

Scilab code Exa 2.6 Integration

```
1 //Example 2.6
2 //Integration
3 //Page no. 36
4 clc;clear;close;
5 disp(integrate('1/x','x',exp(-4),1),'Integration
    Value=');    //performing integration with
    respect to dx
```

Chapter 3

Errors and Their Propagation

Scilab code Exa 3.1 Limiting Error

```
1 //Example 3.1
2 //Limiting Error
3 //Page no. 45
4 clc;clear;close;
5 R=1000;
6 e=0.1*1000;          //limiting error calculation
7 printf('Magnitude of the Resistor resistence (R) =\
    n%i <= R <= %i',R-e,R+e)
```

Scilab code Exa 3.2 Known Error

```
1 //Example 3.2
2 //Known Error
3 //Page no. 46
4 clc;clear;close;
```

```
5 l=28;d=5;
6 v=%pi*l*(d/2)^2;
7 printf('\nVolume of Cylinder= %f cu. cm',v);
8 re_d=0.1;re_l=-0.5;
9 re_v=2*re_d+re_l;                    //relative error
     computation
10 printf('\n\nRelative error in volume= %f %%',re_v);
```

Scilab code Exa 3.3 Absolute Relative and Percentage Errors

```
1 //Example 3.3
2 //Absolute, Relative and Percetage Errors
3 //Page no. 48
4 clc;clear;close;
5 x=0.00006;x1=0.00005;
6 ex=x-x1;                  //absolute error
7 Ex=ex/x1;          //relative error
8 px=100*Ex;        //percentage error
9 printf('\nAbsolute Error= %f\nRelative Error= %f\
     nPercentage Error= %f %%',ex,Ex,px);
```

Scilab code Exa 3.4 Absolute Relative and Percentage Errors

```
1 //Example 3.4
2 //Absolute, Relative and Percetage Errors
3 //Page no. 48
4 clc;clear;close;
5 x=100500;x1=100000;
6 ex=x-x1;                  //absolute error
```

```
7 Ex=ex/x1;          //relative error
8 px=100*Ex;        //percentage error
9 printf('\nAbsolute Error= %f\nRelative Error= %f\
    nPercentage Error= %f %%',ex,Ex,px);
```

Scilab code Exa 3.5 Absolute Relative and Percentage Errors

```
1 //Example 3.5
2 //Absolute, Relative and Percentage Errors
3 //Page no. 52
4 clc;clear;close;
5 x=9.12345;y=7.654321;
6 x1=9.1234;y1=7.6543;        //on a 5 decimal computer
7 ex=x-x1;                  //absolute error of x
8 ey=y-y1;                  //absolute error of y
9 z1=x1+y1;
10 printf('\nAbsolute Error in x= %f',ex);
11 printf('\nAbsolute Error in y= %f',ey);
12 printf('\nAddition on a 5 decimal computer yields= %
    .5g',z1);
13 z2=16.777;
14 printf('\nAbsolute Total Error= %f',x+y-z2);
15 printf('\nAbsolute Propagated Error= %f',x+y-z1);
16 printf('\nAbsolute Round-off Error= %.4g',z1-z2);
17 printf('\nRealtive Total Error= %.4g',(x+y-z2)/(x+y)
    );
18 printf('\nRelative Propagated Error= %.2g',(x+y-z1)
    /(x+y));
19 printf('\nRelative Round-off Error= %.3g',(z1-z2)/(x
    +y));
20 printf('\nBound on the propagated relative error= %f
    ',2*10^-4);
21 printf('\nBound on the total relative error= %f'
```

```
    ,3*10^-4);
22 printf('\nAs we can see that both the propagated and
    total relative error are less than their bound
    values')
```

Chapter 4

Programming Tools and Techniques

Scilab code Exa 4.1 Quadratic Equation

```
1 //Example 4.1
2 //Quadratic Equation
3 //Page no. 96
4 clc;clear;close;
5 a=input("Enter value of a= ");
6 b=input("Enter vlaue of b= ");
7 c=input("Enter value of c= ");
8 x1=(-1*b+sqrt((b^2)-4*a*c))/(2*a);     //1st root
9 x2=(-1*b-sqrt((b^2)-4*a*c))/(2*a);     //2nd root
10 printf('\n1st Root= %f', x1);
11 printf('\n2nd Root= %f', x2);
```

Scilab code Exa 4.2 Database Management

```
1  //Example 4.2
2  //Database Management
3  //Page no. 112
4  clc;clear;close;
5  M
      =[12,25,21,35;25,7,23,29;10,27,7,36;26,26,26,35;29,0,23,30];
         //marks
6
7  //calculation of composite score
8  for i=1:5,
9      j=1;k=0;
10     max1=M(i,j);
11     if(max1<M(i,j+1))
12         max1=M(i,j+1)
13     else
14         k=1;
15     end,
16
17         if(M(i,j+2)>M(i,j+k))
18         max2=M(i,j+2);
19     else
20         max2=M(i,j);
21     end,
22        CS(i,1)=max1+max2+M(i,4);
23 end
24
25 I=['Reg. No.','Name of Students','Test 1','Test 2','
      Test 3','Final';
26 'CS/01','C.V.Rajan','12','25','21','35';
27 'CS/02','B.X.Roy','25','07','23','29';
28 'CS/03','P.C.Sasikumar','10','27','07','36';
29 'CS/04','B.D.Box','26','26','26','35';
30 'CS/05','K.K.Mukherjee','29','0','23','30';]
31 printf('\n')
32 for i=1:6
33     for j=1:6
34         if(j>2)
35                 printf('\t')
```

```
36              end
37
38          printf('%s   ',I(i,j));
39          if(i~=1)
40              if(j>2)
41                  printf('\t')
42              end
43              printf('     ')
44
45          end
46          if(i==1 & j==6)
47              printf('Composite Score\n')
48          end
49
50      end
51
52      if(i~=1)
53      printf('%i\n',CS(i-1,1));
54  end
55
56  end
57  //disp(CS,'Composite Score',I);
58  max1=CS(1,1);j=1;
59  for i=2:5
60      if(max1<CS(i,1))
61          max1=CS(i,1);j=i;
62      end,
63  end
64  printf('\n\nTopper is:\n%s\t%s\t%s',I(1,1),I(1,2),'
       Composite Score')
65  printf('\nCS/0%i\t\t%s\t\t\t%i',j,I(j+1,2),CS(j,1))
```

Chapter 5

Solutions of Algebraic and Transcendental Equations

Scilab code Exa 5.1 Bisection Method

```
1  //Example 5.1
2  //Bisection Method
3  //Page no. 145
4  clc;clear;close;
5  deff('y=f(x)','y=2^x-3*x')
6  x1=0;x2=2;e=0.001;i=0;
7  printf('Iteration\tx1\t\tx2\t\tz\t\tf(z)\n')
8  printf('
     ------------------------------------------------------------------------
     n')
9  while abs(x1-x2)>e
10     z=(x1+x2)/2
11     printf('      %i\t\t%f\t%f\t%f\t%f\n',i,x1,x2,z,f
          (z))
12     if f(z)*f(x1)>0
13         x1=z
14     else
```

```
15          x2=z
16      end
17      i=i+1
18  end
19  printf('\n\nThe solution of this equation is %g
       after %i Iterations',z,i-1)
```

Scilab code Exa 5.2 Bisection Method

```
1  //Example 5.2
2  //Bisection Method
3  //Page no. 147
4  clc;clear;close;
5  deff('y=f(x)','y=x^x-2*x+2')
6  x1=0;x2=2;e=0.001;i=0;
7  printf('Iteration\tx1\t\tx2\t\tz\t\tf(z)\n')
8  printf('
       ------------------------------------------------------------------------
       n')
9  while abs(x1-x2)>e
10      z=(x1+x2)/2
11      printf('      %i\t\t%f\t%f\t%f\t%f\n',i,x1,x2,z,f
           (z))
12      if f(z)*f(x1)>0
13          x1=z
14      else
15          x2=z
16      end
17      i=i+1
18  end
19  printf('\n\nThe solution of this equation is %g
       after %i Iterations',z,i-1)
20
```

```
21 printf('\n\n\nNote : There are computational errors
      in the answer given by the book for this example'
      )
```

Scilab code Exa 5.3 Regula Falsi Method

```
1  //Example 5.3
2  //Regula Falsi Method
3  //Page no. 149
4  clc;clear;close;
5  deff('y=f(x)','y=x^3-3*x-5')
6  x1=2;x2=3;e=0.00001
7  printf('n\tx1\t\tf(x1)\t\tx2\t\tf(x2)\t\tx3\t\tf(x3)
      ')
8  printf('\n
      ------------------------------------------------------------------------------
      n')
9  for i=0:19
10     x3=x2*f(x1)/(f(x1)-f(x2))+x1*f(x2)/(f(x2)-f(x1))
11     printf(' %i\t%f\t%f\t%f\t%f\t%f\t%f\n',i,x1,f(x1
          ),x2,f(x2),x3,f(x3))
12     if f(x1)*f(x3)>0 then
13         x1=x3
14     else
15         x2=x3
16     end
17     if abs(f(x3))<e then
18         break
19     end
20 end
21 printf('\n\nTherefore the solution is %.10g',x3)
```

Scilab code Exa 5.4 Ridders Method

```
1  //Example 5.4
2  //Ridders Method
3  //Page no. 153
4  clc;clear;close;
5  deff('y=f(x)','y=x^3-3*x-5')
6  x1=2;x2=3;e=0.00001
7  printf('n\tx1\t\tf(x1)\t\tx2\t\tf(x2)\t\tx3\t\tf(x3)
       \t    sign\t  x4')
8  printf('\n
       ----------------------------------------------------------------------
       n')
9  for i=0:8
10     x3=(x1+x2)/2
11     a=f(x1)-f(x2);
12     s=a*abs(1/a)
13     x4=x3+(x3-x2)*(s*f(x3))/sqrt(f(x3)-f(x1)*f(x2))
14     printf(' %i\t%f\t%f\t%f\t%f\t%f\t%f     %i\t%f\n'
           ,i,x1,f(x1),x2,f(x2),x3,f(x3),s,x4)
15     if f(x1)*f(x4)>0 then
16         x1=x4
17     else
18         x2=x4
19     end
20     if abs(f(x4))<e then
21         break
22     end
23 end
24 printf('\n\nThe solution of this equation is %g
       after %i Iterations',x4,i)
25 printf('\n\n\nThere are computation error in the
```

```
    answers given by the book in this example\n\n(
    value of x1 is used instead of x2)')
```

Scilab code Exa 5.5 General Iterative Method

```
1  //Example 5.5
2  //General Iterative Method
3  //Page no. 154
4  clc;clear;close;
5  deff('x=f(x)','x=sqrt(3+5/x)')
6  printf('n\tx\t\tf(x)\n')
7  printf('-----------------------------------------\n')
8  x=2;
9  for i=1:8
10     printf(' %i\t%.10f\t%.10f\n',i,x,f(x))
11     x=f(x);
12 end
13 printf('\n\nThe solution of this equation after %i
       Iterations is %.10f',i,x)
```

Scilab code Exa 5.6 Linear Iterative Method

```
1  //Example 5.6
2  //Linear Iterative Method
3  //Page no. 159
4  clc;clear;close;
5  deff('x=f(x)','x=1+sin(x)/10')
6  printf('n\tx\t\tf(x)\n')
7  printf('-----------------------------------------\n')
```

```
x=0;
for i=1:7
    printf(' %i\t%.10f\t%.10f\n',i,x,f(x))
    x=f(x);
end
printf('\n\nThe solution of this equation after %i
   Iterations is %.10f',i,x)
```

Scilab code Exa 5.7 Aitkens Method

```
//Example 5.7
//Aitkens Method
//Page no. 161
clc;clear;close;
deff('x=f(x)','x=exp(-x)')
printf('n\tx0\t\tx1\t\tx2\t\tx3\t\ty\t\tdx0\n')
printf('
   ------------------------------------------------------------------------------
   n')
x0=0.5;e=0.0001
for i=1:3
    x1=f(x0);x2=f(x1);x3=f(x2);
    y=x3-((x3-x2)^2)/(x3-2*x2+x1)
    dx0=y-x0;

    printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\
       t%.10f\n',i,x0,x1,x2,x3,y,dx0)
    x0=y;
    if abs(x0)<e then
        break;
    end
end
printf('\n\nThe solution of this equation after %i
```

```
    Iterations is %.10f',i,y)
```

Scilab code Exa 5.8 Newton Raphson Method

```
1  //Example 5.8
2  //Newton Raphson Method
3  //Page no. 163
4  clc;clear;close;
5  deff('x=f(x)','x=x-exp(-x)')
6  deff('x=f1(x)','x=1+exp(-x)')
7  printf('n\txn\t\tf(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
       ')
8  printf('
       ---------------------------------------------------------------------------
       n')
9  x0=0.5;e=0.00001
10 for i=1:4
11     x1=x0-f(x0)/f1(x0)
12     e1=abs(x0-x1)
13     printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
           ',i-1,x0,f(x0),f1(x0),x1,e1)
14     x0=x1;
15     if abs(x0)<e then
16         break;
17     end
18 end
19 printf('\n\nThe solution of this equation after %i
       Iterations is %.10f',i,x1)
```

Scilab code Exa 5.9 Modified Newton Raphson Method

```
1 //Example 5.9
2 //Modified Newton Raphson Method
3 //Page no. 165
4 clc;clear;close;
5 deff('x=f(x)','x=exp(x)-3*x-sin(x)')
6 deff('x=f1(x)','x=exp(x)-3-cos(x)')
7 printf('n\txn\t\t\f(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
    ')
8 printf('
    ------------------------------------------------------------------------------
    n')
9 x0=0;e=0.00001
10 for i=1:4
11     x1=x0-f(x0)/f1(x0)
12     e1=abs(x0-x1)
13     printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
         ',i-1,x0,f(x0),f1(x0),x1,e1)
14     x0=x1;
15     if abs(x0)<e then
16         break;
17     end
18 end
19 printf('\n\nTherefore, the root is %.10f',x1)
```

Scilab code Exa 5.10 Newton Raphson Method

```
1 //Example 5.10
2 //Newton Raphson Method
3 //Page no. 167
4 clc;clear;close;
5 deff('x=f(x)','x=x*exp(-x)')
```

```
deff('x=f1(x)','x=exp(-x)-x*exp(-x)')
printf('n\txn\t\t\f(xn)\t\tf1(xn)\t\tXn+1\t\tError\n')
printf('
    ------------------------------------------------------------------------------
    n')
x0=2;e=0.00001
for i=1:11
    x1=x0-f(x0)/f1(x0)
    e1=abs(x0-x1)
    printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n',i-1,x0,f(x0),f1(x0),x1,e1)
    x0=x1;
    if abs(x0)<e then
        break;
    end
end
printf('\n\nTherefore, this is not convergent (i.e.) divergent')
```

Scilab code Exa 5.11 Newton Raphson Method

```
//Example 5.11
//Newton Raphson Method
//Page no. 167
clc;clear;close;
deff('x=f(x)','x=x^3-x-3')
deff('x=f1(x)','x=3*x^2-1')
printf('n\txn\t\t\f(xn)\t\tf1(xn)\t\tXn+1\t\tError\n')
printf('
    ------------------------------------------------------------------------------
    n')
```

```
x0=0;e=0.00001
for i=1:11
    x1=x0-f(x0)/f1(x0)
    e1=abs(x0-x1)
    printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
       ',i-1,x0,f(x0),f1(x0),x1,e1)
    x0=x1;
    if abs(x0)<e then
        break;
    end
end
printf('\n\nTherefore, it is cyclic in nature')
```

Scilab code Exa 5.12 Newton Raphson Method

```
//Example 5.12
//Newton Raphson Method
//Page no. 168
clc;clear;close;
deff('x=f(x)','x=atan(x)')
deff('x=f1(x)','x=1/(1+x^2)')
printf('n\txn\t\tf(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
   ')
printf('
   ------------------------------------------------------------------------------
   n')
x0=1.45;e=0.00001
for i=1:12
    x1=x0-f(x0)/f1(x0)
    e1=abs(x0-x1)
    printf(' %i\t%.5g    \t\t%.5g\t\t%.5g \t\t%.5g \t
       \t%.5g\n',i-1,x0,f(x0),f1(x0),x1,e1)
    x0=x1;
```

```
15      if abs(x0)<e then
16          break;
17      end
18  end
19  printf('\n\nTherefore, it is divergent')
```

Scilab code Exa 5.13 Secant Method

```
1  //Example 5.13
2  //Secant Method
3  //Page no. 170
4  clc;clear;close;
5  deff('x=f(x)','x=exp(x)-3*x-sin(x)')
6  deff('x=f1(x)','x=exp(x)-3-cos(x)')
7  printf('n\txn\t\tf(xn)\t\tXn+1\t\tf(Xn+1)\t\tXn+2\t\
       tError\n')
8  printf('
       ------------------------------------------------------------------------------
       n')
9  x0=0.567123008;x1=1;e=0.00001
10 for i=1:9
11      x2=x1-f(x1)*(x1-x0)/(f(x1)-f(x0))
12      e1=abs(x0-x2)
13      printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\
           t%.10f\n',i-1,x0,f(x0),x1,f(x1),x2,e1)
14      x0=x1;
15      x1=x2
16      if abs(x0)<e then
17          break;
18      end
19  end
20  printf('\n\nTherefore, the root is %.10f',x2)
```

Scilab code Exa 5.14 Kizner Method

```
1  //Example 5.14
2  //Kizner Method
3  //Page no. 172
4  clc;clear;close;
5  h2=0.00001
6  deff('x=f(x)','x=2*x-3-cos(x)')
7  deff('y=f1(x,y)','y=h2/(-x+y)')        //function for
       differentiation
8  printf('n\th\tc\txn\t\tf(xn)\t\tF(xn)\t\tk1\t\t v\t\
       tXn+1\n')
9  printf('
       ------------------------------------------------------------------------------
       n')
10 x0=2;e=0.00001;h=0.5;c=0.5;
11 for i=1:11
12     h1=-f(x0);
13     F=f1(f(x0),f(x0+h2))
14     k1=h1*F/2;
15     v=h*f(x0)/(c*(f(x0+c+h)-f(x0+c)))-k1/c;
16     a=0;
17     for j=0:3
18         a=a+(v^j)/factorial(j+1)
19     end
20     x1=x0+k1*a
21     printf(' %i\t%g\t%g\t%.6f\t%.6f\t%.6f\t%.8f\t %
           .5f\t%.6f\n',i-1,h,c,x0,f(x0),F,k1,v,x1)
22     x0=x1;
23     if abs(x0)<e then
24         break;
25     end
```

```
26 end
27 printf('\n\nTherefore, the solution is %.10f',x1)
```

Scilab code Exa 5.15 Brent Method

```
1 //Example 5.15
2 //Brent Method
3 //Page no. 173
4 clc;clear;close;
5 deff('y=f(x)','y=x^2+x-2')
6 x1=0;x2=0.5;x3=2;
7 r=f(x2)/f(x3);s=f(x2)/f(x1);t=f(x1)/f(x3);
8 q=(t-1)*(r-1)*(s-1);
9 p=r*t*(s-1)*(x2-x3)-s*(1-r)*(x2-x1)+(t*s-r)*x2
10 printf('Root is : %.10g',x2+(p/q))
```

Scilab code Exa 5.19 Horner Method

```
1 //Example 5.19
2 //Horner Method
3 //Page no. 177
4 clc;clear;close;
5 deff('y=f(x,a1,a2,a3,a4)','y=a1*x^3+a2*x^2+a3*x+a4')
6
7 k=1;m=2;
8 a=[4;-13;-31;-275];
9 for i=1:10
10     s=1;
```

```
11      si=f(s,a(1),a(2),a(3),a(4))*abs(1/f(s,a(1),a(2),
           a(3),a(4)))
12      while 1
13          a1=f(s,a(1),a(2),a(3),a(4))*abs(1/f(s,a(1),a
               (2),a(3),a(4)))
14          if si~=a1 then
15              d(i)=s-1
16              break
17          end
18          si=a1;
19          s=s+1;
20      end
21      b(1)=a(1)
22      for j=1:3
23          for k=1:4-j
24              b(k+1)=a(k+1)+b(k)*d(i)
25              a(k+1)=b(k+1)
26          end
27      end
28      for j=1:3
29          a(j+1)=10^j*a(j+1)
30      end
31  end
32  printf('The positive root is %i.',d(1))
33  for i=2:10
34      printf('%i',d(i))
35  end
```

Scilab code Exa 5.20 Laguerre Method

```
1  //Example 5.20
2  //Laguerre Method
3  //Page no. 180
```

```
clc;clear;close;
deff('y=f(x)','y=x^3+x^2+10*x-20')
deff('y=f1(x)','y=3*x^2+2*x+10')
deff('y=f2(x)','y=6*x+2')
n=3;
printf('i\tn\txi\t\tP(x)\t\tP1(x)\t\tP2(x)\t\tProot\
   t\tNroot\n')
printf('
   ------------------------------------------------------------------------------
   n')
xi=1
for i=0:9
    Proot=xi-(n*f(xi))/(f1(xi)+sqrt((n-1)*f1(xi)^2-n
       *f(xi)*f2(xi)))
    Nroot=xi-(n*f(xi))/(f1(xi)-sqrt((n-1)*f1(xi)^2-n
       *f(xi)*f2(xi)))
    printf(' %i\t%i\t%f\t%f\t%f\t%f\t%f\t%f\n',i,n,
       xi,f(xi),f1(xi),f2(xi),Proot,Nroot)
    xi=Proot
end
printf('\n\nProot = %f\n\nNroot = %f',Proot,Nroot)
```

Scilab code Exa 5.21 Mullers Method

```
//Example 5.21
//Mullers Method
//Page no. 182
clc;clear;close;

deff('y=f(x)','y=x^3-x-4')
zi=[1;2;3];
s=["i","z2","z0","z1","f2","f0","f1","a0","a1","a2",
   "zr+","zr-"]
```

```
li(1)=(zi(3,1)-zi(2,1))/(zi(2,1)-zi(1,1))
hi(1)=zi(3,1)-zi(2,1);
for i=2:6
    for j=1:3
       fz(j,i-1)=f(zi(j,i-1))
    end
    di(i-1)=1+li(i-1)
    gi(i-1)=fz(1,i-1)*li(i-1)^2-fz(2,i-1)*di(i-1)^2+
       fz(3,i-1)*(li(i-1)+di(i-1))
    D1(i-1)=gi(i-1)+sqrt(gi(i-1)^2-4*fz(3,i-1)*di(i
       -1)*li(i-1)*(fz(1,i-1)*li(i-1)-fz(2,i-1)*di(i
       -1)+fz(3,i-1)))
    D2(i-1)=gi(i-1)-sqrt(gi(i-1)^2-4*fz(3,i-1)*di(i
       -1)*li(i-1)*(fz(1,i-1)*li(i-1)-fz(2,i-1)*di(i
       -1)+fz(3,i-1)))
    if abs(D1(i-1))>abs(D2(i-1)) then
        li(i)=-2*fz(3,i-1)*di(i-1)/D1(i-1)
    else
        li(i)=-2*fz(3,i-1)*di(i-1)/D2(i-1)
    end
    hi(i)=li(i)*hi(i-1);
    z(i-1)=zi(3,i-1)+hi(i)
    for j=1:2
        zi(j,i)=zi(j+1,i-1)
    end
    zi(3,i)=z(i-1)
end
for i=1:12
    if i==1 then
        printf(s(i))
        for j=1:5
            printf('\t\t\t%i',j-1)
        end
    elseif i<=4
        printf('\n %s',s(i))
        for j=1:5
            printf('\t\t%.10f',zi(i-1,j))
        end
```

```
42      elseif i<=7
43          printf('\n %s',s(i))
44          for j=1:5
45              printf('\t\t%.10f',fz(i-4,j))
46          end
47      elseif i<=8
48          printf('\n %s',s(i))
49          for j=1:5
50              printf('\t\t%.10f',li(j))
51          end
52      elseif i<=9
53          printf('\n %s',s(i))
54          for j=1:5
55              printf('\t\t%.10f',di(j))
56          end
57      elseif i<=10
58          printf('\n %s',s(i))
59          for j=1:5
60              printf('\t\t%.10f',gi(j))
61          end
62      elseif i<=11
63          printf('\n %s',s(i))
64          for j=1:5
65              printf('\t\t%.10f',z(j))
66          end
67      elseif i<=12
68          printf('\n %s',s(i))
69          for j=1:5
70              printf('\t\t%.10f',zi(j))
71          end
72      end
73  end
74  printf('\n\nAt the end of the %i iteration, the root
        of the equation is %.10f',j-2,z(j))
```

Scilab code Exa 5.22 Mullers Method

```
1  //Example 5.22
2  //Mullers Method
3  //Page no. 183
4  clc;clear;close;
5
6  deff('y=f(x)','y=x^3-x-4')
7  zi=[1;2;3];
8  s=["i","z0","z1","z2","f0","f1","f2","li","di","gi",
       "li+1","hi","hi+1","zi+1","D+","D-"]
9  li(1)=(zi(3,1)-zi(2,1))/(zi(2,1)-zi(1,1))
10 hi(1)=zi(3,1)-zi(2,1);
11 for i=2:6
12     for j=1:3
13        fz(j,i-1)=f(zi(j,i-1))
14     end
15     di(i-1)=1+li(i-1)
16     gi(i-1)=fz(1,i-1)*li(i-1)^2-fz(2,i-1)*di(i-1)^2+
          fz(3,i-1)*(li(i-1)+di(i-1))
17     D1(i-1)=gi(i-1)+sqrt(gi(i-1)^2-4*fz(3,i-1)*di(i
          -1)*li(i-1)*(fz(1,i-1)*li(i-1)-fz(2,i-1)*di(i
          -1)+fz(3,i-1)))
18     D2(i-1)=gi(i-1)-sqrt(gi(i-1)^2-4*fz(3,i-1)*di(i
          -1)*li(i-1)*(fz(1,i-1)*li(i-1)-fz(2,i-1)*di(i
          -1)+fz(3,i-1)))
19     if abs(D1(i-1))>abs(D2(i-1)) then
20         li(i)=-2*fz(3,i-1)*di(i-1)/D1(i-1)
21     else
22         li(i)=-2*fz(3,i-1)*di(i-1)/D2(i-1)
23     end
24     hi(i)=li(i)*hi(i-1);
```

```
25      z(i-1)=zi(3,i-1)+hi(i)
26      for j=1:2
27          zi(j,i)=zi(j+1,i-1)
28      end
29      zi(3,i)=z(i-1)
30  end
31  for i=1:16
32      if i==1 then
33          printf(s(i))
34          for j=1:5
35              printf('\t\t%i',j-1)
36          end
37      elseif i<=4
38          printf('\n %s',s(i))
39          for j=1:5
40              printf('\t\t%.10f',zi(i-1,j))
41          end
42      elseif i<=7
43          printf('\n %s',s(i))
44          for j=1:5
45              printf('\t\t%.10f',fz(i-4,j))
46          end
47      elseif i<=8
48          printf('\n %s',s(i))
49          for j=1:5
50              printf('\t\t%.10f',li(j))
51          end
52      elseif i<=9
53          printf('\n %s',s(i))
54          for j=1:5
55              printf('\t\t%.10f',di(j))
56          end
57      elseif i<=10
58          printf('\n %s',s(i))
59          for j=1:5
60              printf('\t\t%.10f',gi(j))
61          end
62      elseif i<=11
```

```
63          printf('\n %s',s(i))
64          for j=1:5
65              printf('\t\t%.10f',li(j+1))
66          end
67      elseif i<=12
68          printf('\n %s',s(i))
69          for j=1:5
70              printf('\t\t%.10f',hi(j))
71          end
72          elseif i<=13
73          printf('\n %s',s(i))
74          for j=1:5
75              printf('\t\t%.10f',hi(j+1))
76          end
77          elseif i<=14
78          printf('\n %s',s(i))
79          for j=1:5
80              printf('\t\t%.10f',z(j))
81          end
82          elseif i<=15
83          printf('\n %s',s(i))
84          for j=1:5
85              printf('\t\t%.10f',D1(j))
86          end
87          elseif i<=16
88          printf('\n %s',s(i))
89          for j=1:5
90              printf('\t\t%.10f',D2(j))
91          end
92      end
93  end
94  printf('\n\nAt the end of the %ith iteration, the
       root of the equation is %.10f',j-1,z(j))
```

Scilab code Exa 5.23 Bairstow Hitchcock Method

```
1  //Example 5.23
2  //Bairstow Hitchcock Method
3  //Page no. 187
4  clc;clear;close;
5  deff('y=f(x,p,q)','y=x^2+p*z+q')
6  a=[1,-1,1,-1,1]
7  a=a';a=[a,a,a,a,a]
8  printf('Iteration -->')
9  for i=1:5
10     printf('\t%i\t',i)
11 end
12 printf('\n
   ----------------------------------------------------------------------
   ')
13 p(1,1)=-1.2;q(1,1)=0.95;
14 s=["b1","b2","b3","b4","c1","c2","c3","c4","c","dp",
   "dq","p","q"]
15 //s1=[b1;b2;b3;b4;c1;c2;c3;c4;c;dp;dq;p;q]
16 for i=1:5
17     b(1,i)=0;b(2,i)=a(1,i);c(1,i)=0;c(2,i)=a(1,i);
18        for k=1:4
19            b(k+2,i)=a(k+1,i)-p(1,i)*b(k+1,i)-q(1,i)*
                 b(k,i)
20            c(k+2,i)=b(k+2,i)-p(1,i)*c(k+1,i)-q(1,i)*
                 c(k,i)
21        end
22       cb(1,i)=c(6,i)-b(6,i);
23       dq(1,i)=(b(6,i)*c(4,i)-b(5,i)*cb(1,i))/(c(4,i)
            ^2-cb(1,i)*c(3,i))
24        dp(1,i)=(b(5,i)*c(4,i)-b(6,i)*c(3,i))/(c(4,i)
            ^2-cb(1,i)*c(3,i))
25     p(1,i+1)=p(1,i)+dp(1,i);q(1,i+1)=q(1,i)+dq(1,i)
          ;
26 end
27 for j=1:13
28   printf('\n      %s\t\t',s(j))
```

```
29    if j<5 then
30        for i=1:5
31            printf('%.9f\t',b(j+2,i))
32        end
33    elseif j<9 then
34        for i=1:5
35            printf('%.9f\t',c(j-2,i))
36        end
37    elseif j<10
38        for i=1:5
39            printf('%.9f\t',cb(1,i))
40        end
41        elseif j<11
42        for i=1:5
43            printf('%.9f\t',dp(1,i))
44        end
45        elseif j<12
46        for i=1:5
47            printf('%.9f\t',dq(1,i))
48        end
49        elseif j<13
50        for i=1:5
51            printf('%.9f\t',p(1,i+1))
52        end
53        else
54        for i=1:5
55            printf('%.9f\t',q(1,i+1))
56        end
57    end
58 end
59 z=poly(0,'z');
60 a=f(z,p(1,i+1),q(1,i+1));
61 printf('\n\nRoots for Quadratic Equation Q = ')
62 disp(a)
63 a=roots(a)
64 printf('\n\tare\n')
65 disp(a(1))
66 disp(a(2))
```

Scilab code Exa 5.24 Bernoulli Method

```
1 //Example 5.24
2 //Bernoulli Method
3 //Page no. 189
4 clc;clear;close;
5
6 a=[1,-8,-15,10];
7 for i=1:2
8     c(i)=0;
9 end
10 c(3)=1;
11 for k=4:13
12    c(k)=-(a(2)*c(k-1)+a(3)*c(k-2)+a(4)*c(k-3))
13    r(k-3)=c(k)/c(k-1)
14 end
15 disp(c,'Ck Values')
16 disp(r,'Rk Values')
17 disp(r(k-3),'Therefore the exact root is = ')
```

Scilab code Exa 5.25 Graeffe Method

```
1 //Example 5.25
2 //Graeffe Method
3 //Page no. 191
4 clc;clear;close;
5
```

```
a=[1,-6,11,-6]
k=0;
for k=2:6
    for i=1:4
        a(k,i)=(-1)^(i-1)*(a(k-1,i))^2
        j=1;
        while i+j<5 & i+j>2
            a(k,i)=a(k,i)+(-1)^(i-j-1)*2*(a(k-1,i-j)
               )*a(k-1,i+j)
            break
            j=j+1;
        end
    end
end
printf('\t\t\t\ta1\t\t\t\ta2\t\t\t\ta3\n k\ta0\ta1\t
   \t--\t\ta2\t\t--\t\ta3\t\t--\t\n\t\t\t\ta0\t\t\t\
   a1\t\t\t\a2')
printf('\n
   ----------------------------------------------------------------------------
   n')
for i=1:4
    printf(' %i\t%g\t%.4g\t\t%.5g\t\t%.9g\t\t%.8g\
       t%g\t\t%.10g\n',i-1,a(i,1),a(i,2),abs(a(i,2)/
       a(i,1))^(1/(2^(i-1))),a(i,3),abs(a(i,3)/a(i
       ,2))^(1/(2^(i-1))),a(i,4),abs(a(i,4)/a(i,3))
       ^(1/(2^(i-1))))
end
for i=5:6
    printf(' %i\t%g\t%.4g\t%.5g\t\t%.9g\t%.8g\t%.7g\
       t%.10g\n',i-1,a(i,1),a(i,2),abs(a(i,2)/a(i,1)
       )^(1/(2^(i-1))),a(i,3),abs(a(i,3)/a(i,2))
       ^(1/(2^(i-1))),a(i,4),abs(a(i,4)/a(i,3))
       ^(1/(2^(i-1))))
end
printf('\n\nThe Absolute Values of the roots are %g,
    %.8g and %g',abs(a(i,2)/a(i,1))^(1/(2^(i-1))),
   abs(a(i,3)/a(i,2))^(1/(2^(i-1))),abs(a(i,4)/a(i
   ,3))^(1/(2^(i-1))))
```

Scilab code Exa 5.26 QD Method

```
1  //Example 5.26
2  //QD Method
3  //Page no. 194
4  clc;clear;close;
5
6  a=[32,-48,18,-1]
7  for i=1:5
8      e(i,1)=0;
9      e(i,4)=0;
10 end
11 q(1,1)=-a(2)/a(1);
12 q(1,2)=0;q(1,3)=0;
13 e(1,2)=a(3)/a(2);
14 e(1,3)=a(4)/a(3);
15 for i=2:16
16     for j=1:3
17         q(i,j)=e(i-1,j+1)+q(i-1,j)-e(i-1,j)
18     end
19     for j=1:2
20         e(i,j+1)=e(i-1,j+1)*q(i,j+1)/q(i,j)
21     end
22 end
23 printf('e0\t\tq1\t\te1\t\tq2\t\te2\t\tq3\t\te3\n')
24 printf('
   ------------------------------------------------------------------------------
   n')
25 for i=1:14
26     for j=1:3
27         printf('\t\t%.10f\t',q(i,j))
28     end
```

```
29      printf('\n')
30      for j=1:4
31          printf('%.10f\t\t\t',e(i,j))
32      end
33      printf('\n')
34  end
35  printf('\t\t%.10f\t\t\t%.10f\t\t\t%.10f\n',q(15,1),q
    (15,2),q(15,3))
36  printf('\nThe exact roots are \t%.10f    and    %.10
    f',q(15,1),q(15,3))
```

Scilab code Exa 5.27 Linear Iteration Method

```
1  //Example 5.27
2  //Linear Iteration Method
3  //Page no. 198
4  clc;clear;close;
5
6  deff('x=f(x)','x=20/(x^2+2*x+10)')
7  printf('n\tx\t\tf(x)\n')
8  printf('-----------------------------------------\n')
9  x=1;
10 for i=1:19
11      printf(' %i\t%.10f\t%.10f\n',i,x,f(x))
12      x1=x;
13      x=f(x);
14 end
15 printf('\n\nx = %.10f',x1)
```

Scilab code Exa 5.28 Aitkens Method

```
1 //Example 5.28
2 //Aitkens Method
3 //Page no. 199
4 clc;clear;close;
5
6 deff('x=f(x)','x=20/(x^2+2*x+10)')
7 printf('n\tx0\t\tx1\t\tx2\t\tx3\t\ty\t\tdx0\n')
8 printf('
    ------------------------------------------------------------------------
    n')
9 x0=1;e=0.0001
10 for i=1:3
11     x1=f(x0);x2=f(x1);x3=f(x2);
12     y=x3-((x3-x2)^2)/(x3-2*x2+x1)
13     dx0=y-x0;
14
15     printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\
         t%.10f\n',i,x0,x1,x2,x3,y,dx0)
16     x0=y;
17     if abs(x0)<e then
18         break;
19     end
20 end
21 printf('\n\nThe solution of this equation after %i
    Iterations is %.10f',i,y)
```

Scilab code Exa 5.29 Newton Raphson Method

```
1 //Example 5.29
2 //Newton Raphson Method
3 //Page no. 199
```

```
clc;clear;close;
deff('x=f(x)','x=x^3+2*x^2+10*x-20')
deff('x=f1(x)','x=3*x^2+4*x+10')
printf('n\txn\t\t\f(xn)\t\tf1(xn)\t\tXn+1\t\tError\n')
printf('
   ------------------------------------------------------------------------------
   n')
x0=01;e=0.00001
for i=1:4
    x1=x0-f(x0)/f1(x0)
    e1=abs(x0-x1)
    printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
       ',i-1,x0,f(x0),f1(x0),x1,e1)
    x0=x1;
    if abs(x0)<e then
        break;
    end
end
printf('\n\nThe solution of this equation after %i
   Iterations is %.10f',i,x1)
```

Scilab code Exa 5.31 Secant Method

```
//Example 5.31
//Secant Method
//Page no. 200
clc;clear;close;
deff('x=f(x)','x=(x-0.6)*(x-1.3)^2*(x-2)^3+0.01234*
   log(x)')
printf('n\txn\t\tf(xn)\t\tXn+1\t\tf(Xn+1)\t\tXn+2\t\
   tError\n')
printf('
```

```
    n')
x0=0.1;x1=1.2;e=0.00001
for i=1:7
    x2=x1-f(x1)*(x1-x0)/(f(x1)-f(x0))
    e1=abs(x0-x2)
    printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\
       t%.10f\n',i-1,x0,f(x0),x1,f(x1),x2,e1)
    x0=x1;
    x1=x2
    if abs(x0)<e then
        break;
    end
end
printf('\n\nTherefore, the root is %.10f',x2)
```

Scilab code Exa 5.32 Regula Falsi Newton Raphson and Mullers Method

```
//Example 5.32
//Regula Falsi, Newton Raphson and Mullers Method
//Page no. 201
clc;clear;close;
deff('x=f(x)','x=x^5-3.7*x^4+7.4*x^3-10.8*x^2+10.8*x
   -6.8')
deff('x=f1(x)','x=5*x^4-4*3.7*x^3+3*7.4*x^2-21.6*x
   +10.8')
//newton raphson
printf('n\txn\t\t\tf(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
   ')
printf('
   n')
x0=1.5;e=0.00001
```

```
11 for i=1:4
12     x1=x0-f(x0)/f1(x0)
13     e1=abs(x0-x1)
14     printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
          ',i-1,x0,f(x0),f1(x0),x1,e1)
15     x0=x1;
16     if abs(x0)<e then
17         break;
18     end
19 end
20 printf('\n\nThe solution of this equation by newton
     raphshon after %i Iterations is %.10f\n\n\n',i,x1
     )
21
22 //regula falsi
23 x1=1;x2=2;e=0.00001
24 printf('n\tx1\t\tf(x1)\t\tx2\t\tf(x2)\t\tx3\t\tf(x3)
     ')
25 printf('\n
     ----------------------------------------------------------------------------------
     n')
26 for i=0:7
27     x3=x2*f(x1)/(f(x1)-f(x2))+x1*f(x2)/(f(x2)-f(x1))
28     printf(' %i\t%f\t%f\t%f\t%f\t%f\t%f\n',i,x1,f(x1
          ),x2,f(x2),x3,f(x3))
29     if f(x1)*f(x3)>0 then
30         x1=x3
31     else
32         x2=x3
33     end
34     if abs(f(x3))<e then
35         break
36     end
37 end
38 printf('\n\nTherefore the solution by regula falsi
     method after %i iterations is %.10g',i,x3)
39
40 //mullers method
```

```
41 zi=[1;2;3];
42 s=["i","z0","z1","z2","f0","f1","f2","li","di","gi",
     "li+1","hi","hi+1","zi+1","D+","D-"]
43 li(1)=(zi(3,1)-zi(2,1))/(zi(2,1)-zi(1,1))
44 hi(1)=zi(3,1)-zi(2,1);
45 for i=2:6
46     for j=1:3
47        fz(j,i-1)=f(zi(j,i-1))
48     end
49     di(i-1)=1+li(i-1)
50     gi(i-1)=fz(1,i-1)*li(i-1)^2-fz(2,i-1)*di(i-1)^2+
          fz(3,i-1)*(li(i-1)+di(i-1))
51     D1(i-1)=gi(i-1)+sqrt(gi(i-1)^2-4*fz(3,i-1)*di(i
          -1)*li(i-1)*(fz(1,i-1)*li(i-1)-fz(2,i-1)*di(i
          -1)+fz(3,i-1)))
52     D2(i-1)=gi(i-1)-sqrt(gi(i-1)^2-4*fz(3,i-1)*di(i
          -1)*li(i-1)*(fz(1,i-1)*li(i-1)-fz(2,i-1)*di(i
          -1)+fz(3,i-1)))
53     if abs(D1(i-1))>abs(D2(i-1)) then
54         li(i)=-2*fz(3,i-1)*di(i-1)/D1(i-1)
55     else
56         li(i)=-2*fz(3,i-1)*di(i-1)/D2(i-1)
57     end
58     hi(i)=li(i)*hi(i-1);
59     z(i-1)=zi(3,i-1)+hi(i)
60     for j=1:2
61         zi(j,i)=zi(j+1,i-1)
62     end
63     zi(3,i)=z(i-1)
64 end
65 printf('\n\n ')
66 for i=1:16
67     if i==1 then
68         printf(s(i))
69         for j=1:5
70             printf('\t\t\t %i',j-1)
71         end
72         printf('\n
```

```
            ')
    elseif i<=4
        printf('\n %s',s(i))
        for j=1:5
            printf('\t\t%.10f',zi(i-1,j))
        end
    elseif i<=7
        printf('\n %s',s(i))
        for j=1:5
            printf('\t\t%.10f',fz(i-4,j))
        end
    elseif i<=8
        printf('\n %s',s(i))
        for j=1:5
            printf('\t\t%.10f',li(j))
        end
    elseif i<=9
        printf('\n %s',s(i))
        for j=1:5
            printf('\t\t%.10f',di(j))
        end
    elseif i<=10
        printf('\n %s',s(i))
        for j=1:5
            printf('\t\t%.10f',gi(j))
        end
    elseif i<=11
        printf('\n %s',s(i))
        for j=1:5
            printf('\t\t%.10f',li(j+1))
        end
    elseif i<=12
        printf('\n %s',s(i))
        for j=1:5
            printf('\t\t%.10f',hi(j))
        end
        elseif i<=13
```

```
109           printf('\n %s',s(i))
110           for j=1:5
111               printf('\t\t%.10f',hi(j+1))
112           end
113           elseif i<=14
114           printf('\n %s',s(i))
115           for j=1:5
116               printf('\t\t%.10f',z(j))
117           end
118           elseif i<=15
119           printf('\n %s',s(i))
120           for j=1:5
121               printf('\t\t%.10f',D1(j))
122           end
123           elseif i<=16
124           printf('\n %s',s(i))
125           for j=1:5
126               printf('\t\t%.10f',D2(j))
127           end
128       end
129   end
130   printf('\n\nAt the end of the %ith iteration by
      mullers method, the root of the equation is %.10f
      ',j-1,z(j))
```

Scilab code Exa 5.33 Newton Raphson and Mullers Method

```
1  //Example 5.33
2  //Newton Raphson and Mullers Method
3  //Page no. 202
4  clc;clear;close;
5  deff('x=f(x)','x=x^4-8*x^3+18*x^2+0.12*x-24.24')
6  deff('x=f1(x)','x=4*x^3-24*x^2+36*x+0.12')
```

```
7
8  //newton raphson
9  x9=[1.5,2.5,2.7,3.1;4,5,14,10]
10 for h=1:4
11     x0=x9(1,h);e=0.00001
12 for i=1:x9(2,h)
13     x1=x0-f(x0)/f1(x0)
14     e1=abs(x0-x1)
15     x0=x1;
16     if abs(x0)<e then
17         break;
18     end
19 end
20 printf('\nThe solution of this equation by newton
      raphshon after %i Iterations is %.5f\n',i,x1)
21 end
22
23 //mullers method
24 zx=[1,2,2.7,3.1;2,3,3.7,4.1;3,4,4.7,5.1]
25 zi=[1;2;3];
26 s=["i","z0","z1","z2","f0","f1","f2","li","di","gi",
      "li+1","hi","hi+1","zi+1","D+","D-"]
27 li(1)=(zi(3,1)-zi(2,1))/(zi(2,1)-zi(1,1))
28 hi(1)=zi(3,1)-zi(2,1);
29 for i=2:4
30     for j=1:3
31        fz(j,i-1)=f(zi(j,i-1))
32     end
33     di(i-1)=1+li(i-1)
34     gi(i-1)=fz(1,i-1)*li(i-1)^2-fz(2,i-1)*di(i-1)^2+
          fz(3,i-1)*(li(i-1)+di(i-1))
35     D1(i-1)=gi(i-1)+sqrt(gi(i-1)^2-4*fz(3,i-1)*di(i
          -1)*li(i-1)*(fz(1,i-1)*li(i-1)-fz(2,i-1)*di(i
          -1)+fz(3,i-1)))
36     D2(i-1)=gi(i-1)-sqrt(gi(i-1)^2-4*fz(3,i-1)*di(i
          -1)*li(i-1)*(fz(1,i-1)*li(i-1)-fz(2,i-1)*di(i
          -1)+fz(3,i-1)))
37     if abs(D1(i-1))>abs(D2(i-1)) then
```

```
38          li(i)=-2*fz(3,i-1)*di(i-1)/D1(i-1)
39      else
40          li(i)=-2*fz(3,i-1)*di(i-1)/D2(i-1)
41      end
42      hi(i)=li(i)*hi(i-1);
43      z(i-1)=zi(3,i-1)+hi(i)
44      for j=1:2
45          zi(j,i)=zi(j+1,i-1)
46      end
47      zi(3,i)=z(i-1)
48  end
49  printf('\n\nAt the end of the %ith iteration by
       mullers method, the root of the equation is %.10f
       ',j+2,z(j))
```

Scilab code Exa 5.34 QD Method

```
1  //Example 5.34
2  //QD Method
3  //Page no. 202
4  clc;clear;close;
5  a=[1,2,10,-20]
6  for i=1:5
7      e(i,1)=0;
8      e(i,4)=0;
9  end
10 q(1,1)=-a(2)/a(1);
11 q(1,2)=0;q(1,3)=0;
12 e(1,2)=a(3)/a(2);
13 e(1,3)=a(4)/a(3);
14 for i=2:7
15     for j=1:3
16         q(i,j)=e(i-1,j+1)+q(i-1,j)-e(i-1,j)
```

```
17      end
18      for j=1:2
19          e(i,j+1)=e(i-1,j+1)*q(i,j+1)/q(i,j)
20      end
21  end
22  printf('e0\t\tq1\t\te1\t\tq2\t\te2\t\tq3\t\te3\n')
23  printf('
    ------------------------------------------------------------------------------
    n')
24  for i=1:7
25      for j=1:3
26          printf('\t\t%.10f\t',q(i,j))
27      end
28      printf('\n')
29      for j=1:4
30          printf('%.10f\t\t\t',e(i,j))
31      end
32      printf('\n')
33  end
34  printf('\t\t%.10f\t\t\t%.10f\t\t\t%.10f\n',q(7,1),q
    (7,2),q(7,3))
35  printf('\nThe exact roots are \t%.10f    and    %.10
    f',q(7,1),q(7,3))
```

Scilab code Exa 5.35 Newton Raphson Method

```
1  //Example 5.35
2  //Newton Raphson Method
3  //Page no. 203
4  clc;clear;close;
5  deff('x=f(x)','x=x^3-30*x^2+2552')
6  deff('x=f1(x)','x=3*x^2-60*x')
7  //newton raphson
```

```
8  printf('n\txn\t\t\f(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
   ')
9  printf('
   ------------------------------------------------------------------------------
   n')
10 x0=10;e=0.00001
11 for i=1:4
12     x1=x0-f(x0)/f1(x0)
13     e1=abs(x0-x1)
14     printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
          ',i-1,x0,f(x0),f1(x0),x1,e1)
15     x0=x1;
16     if abs(x0)<e then
17         break;
18     end
19 end
20 printf('\n\nThus the ball is submerged upto height
   of %.10f cm\n\n\n',x1)
```

Scilab code Exa 5.36 Secant Method

```
1  //Example 5.36
2  //Secant Method
3  //Page no. 204
4  clc;clear;close;
5  a=8670;c=10^-8;t2=1.4*10^-4;
6  deff('x=f(x)','x=-t2+log((1-2*x/a)/(2-x/a))*(a*x*c)
   /(a+x)')
7
8  printf('n\txn\t\tf(xn)\t\tXn+1\t\tf(Xn+1)\t\tXn+2\t\
   tError\n')
9  printf('
   ------------------------------------------------------------------------------
```

```
    n')
10 x0=20000;x1=25000;e=0.00001
11 for i=1:8
12     x2=x1-f(x1)*(x1-x0)/(f(x1)-f(x0))
13     e1=abs(x0-x2)
14     printf(' %i\t%f\t%.10f\t%f\t%.10f\t%f\t%.10f\n',
           i-1,x0,f(x0),x1,f(x1),x2,e1)
15     x0=x1;
16     x1=x2
17     if abs(x0)<e then
18         break;
19     end
20 end
21 printf('\n\nTherefore, Rb = %.10f ohm',x2)
```

Scilab code Exa 5.37 Newton Raphson Method

```
1  //Example 5.37
2  //Newton Raphson Method
3  //Page no. 204
4  clc;clear;close;
5  p=1.1;T=250;R=0.082;a=3.6;b=0.043;
6  deff('y=f(v)','y=p*v^3-(b*p+R*T)*v^2+a*v-a*b')
7  deff('y=f1(v)','y=3*p*v^2-2*(b*p+R*T)*v')
8  printf('n\txn\t\tf(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
       ')
9  printf('
       ------------------------------------------------------------------------------
       n')
10 x0=0.1;e=0.00001
11 for i=1:10
12     x1=x0-f(x0)/f1(x0)
13     e1=abs(x0-x1)
```

```
14      printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
            ',i-1,x0,f(x0),f1(x0),x1,e1)
15      x0=x1;
16      if abs(x0)<e then
17          break;
18      end
19  end
20  printf('\n\nTherefore, Volume v = %.10f ltr',x1)
```

Scilab code Exa 5.38 Newton Raphson Method

```
1  //Example 5.38
2  //Newton Raphson Method
3  //Page no. 205
4  clc;clear;close;
5  deff('y=f(p)','y=p^3-9*p^2+33*p-65')
6  deff('y=f1(p)','y=3*p^2-18*p+33')
7  printf('n\txn\t\t\tf(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
       ')
8  printf('
       ------------------------------------------------------------------------------------------
       n')
9  x0=6;e=0.00001
10 for i=1:10
11      x1=x0-f(x0)/f1(x0)
12      e1=abs(x0-x1)
13      printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
            ',i-1,x0,f(x0),f1(x0),x1,e1)
14      x0=x1;
15      if abs(x0)<e then
16          break;
17      end
18  end
```

```
19 printf('\n\nTherefore, Market Price at equilibrium =
       Rs. %.f',x1)
```

Scilab code Exa 5.39 Newton Raphson Method

```
1  //Example 5.39
2  //Newton Raphson Method
3  //Page no. 205
4  clc;clear;close;
5  deff('y=f(v)','y=v^3-20*v+30')
6  deff('y=f1(v)','y=3*v^2-20')
7  printf('n\txn\t\t\f(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
       ')
8  printf('
       ---------------------------------------------------------------------------
       n')
9  x0=10;e=0.00001
10 for i=1:10
11     x1=x0-f(x0)/f1(x0)
12     e1=abs(x0-x1)
13     printf(' %i\t%.10f\t%.10f\t%.10f\t%.10f\t%.10f\n
           ',i-1,x0,f(x0),f1(x0),x1,e1)
14     x0=x1;
15     if abs(x0)<e then
16         break;
17     end
18 end
19 printf('\n\nTherefore, sides are  = %.5f m x %.5f m
       x %.5f m',x1,x1,20/x1^2)
```

Scilab code Exa 5.40 Newton Raphson Method

```
1  //Example 5.40
2  //Newton Raphson Method
3  //Page no. 206
4  clc;clear;close;
5  deff('y=f(F)','y=-10*F^3-21*F+10')
6  deff('y=f1(F)','y=-21-30*F^2')
7  printf('n\txn\t\t\f(xn)\t\tf1(xn)\t\tXn+1\t\tError\n
       ')
8  printf('
       ----------------------------------------------------------------------------
       n')
9  x0=1;e=0.00001
10 for i=1:10
11     x1=x0-f(x0)/f1(x0)
12     e1=abs(x0-x1)
13     printf(' %i\t%.10f\t%.6f\t%.5f\t%.10f\t%.10f\n',
           i-1,x0,f(x0),f1(x0),x1,e1)
14     x0=x1;
15     if abs(x0)<e then
16         break;
17     end
18 end
19 printf('\n\t\t\t\t\t2\n Therefore, Magnetic Flux = %
       .5f Wb m',x1)
```

Chapter 6

Numerical Methods of Linear Equations Direct Methods

Scilab code Exa 6.1 Gaussian Elimination Method

```
1  //Example 6.1
2  //Gaussian Elimination Method
3  //Page no. 220
4  clc;clear;close;
5
6  A=[5,10,1,28;1,1,1,6;4,8,3,29];            //
       augmented matrix
7
8  //triangularization
9  for i=1:4
10     B(1,i)=A(1,i)
11     B(2,i)=A(2,i)-(A(2,1)/A(1,1))*A(1,i)
12     B(3,i)=A(3,i)-(A(3,1)/A(1,1))*A(1,i)
13 end
14 disp(A,'Augmented Matrix=')
15 disp(B,'Triangulated Matrix=')
16 //back substitution
```

```
x(3)=B(3,4)/B(3,3);
printf('\nx(3)=%f\n',x(3))
for i=2:-1:1
    k=0
    for j=i+1:3
       k=k+B(i,j)*x(j)
    end
    x(i)=(1/B(i,i))*(B(i,4)-k)
     printf('\nx(%i)=%f\n',i,x(i))
end
```

Scilab code Exa 6.2 Gaussian Elimination Method for TriDiagonal System

```
//Example 6.2
//Gaussian Elimination Method for Tri-Diagonal
   System
//Page no. 222
clc;clear;close;

//equation matrix
A=[1,2,0,0;2,3,-1,0;0,4,2,3;0,0,2,-1];
K=[5;5;11;10];i=1;

//initialization
w(1)=A(1,2)/A(1,1);
g(1)=K(1)/A(1,1);
printf('\nw(%i)=%f',i,w(i));printf('\ng(%i)=%f',i,g(
   i))

//computation
for i=2:3
    w(i)=(A(i,i+1))/(A(i,i)-A(i,i-1)*w(i-1))
```

```
18      g(i)=(K(i)-A(i,i-1)*g(i-1))/(A(i,i)-A(i,i-1)*w(i
           -1))
19      printf('\nw(%i)=%f',i,w(i))
20      printf('\ng(%i)=%f',i,g(i))
21  end
22  i=4
23  m=-2
24  g(i)=m*(K(i)-A(i,i-1)*g(i-1))/(A(i,i)-A(i,i-1)*w(i
       -1))
25  x(i)=g(i)
26  printf('\ng(%i)=%f',i,g(i))
27  printf('\n\nx(%i)=%f',i,x(i))
28
29  //solution
30  for i=3:-1:1
31      x(i)=g(i)-w(i)*x(i+1)
32      printf('\n\nx(%i)=%f',i,x(i))
33  end
```

Scilab code Exa 6.3 Gauss Jordan Method

```
1  //Example 6.3
2  //Gauss-Jordan Method
3  //Page no. 224
4
5  clc;clear;close;
6
7  A=[5,10,1,28;4,8,3,29;1,1,1,6];      //augmented
       matrix
8
9  for i=1:3
10     j=i
11     while (A(i,i)==0 & j<=3)
```

```
12          for k=1:4
13              B(1,k)=A(j+1,k)
14              A(j+1,k)=A(i,k)
15              A(i,k)=B(1,k)
16          end
17          disp(A)
18          j=j+1
19      end
20      disp(A)
21      for k=4:-1:i
22          A(i,k)=A(i,k)/A(i,i)
23      end
24      disp(A)
25      for k=1:3
26          if(k~=i) then
27              l=A(k,i)/A(i,i)
28              for m=i:4
29                  A(k,m)=A(k,m)-l*A(i,m)
30              end
31          end
32
33      end
34      disp(A)
35  end
36
37  for i=1:3
38      printf('\nx(%i) = %g\n',i,A(i,4))
39  end
```

Scilab code Exa 6.4 Gaussian Elimination Method without Pivoting

```
1  //Example 6.4
2  //Gaussian Elimination Method without Pivoting
```

```
3  //Page no. 227
4  clc;clear;close;
5
6  A=[0.3*10^-11,1,0.7;1,1,0.9];              //augmented
       matrix
7
8  //triangularization
9  for i=1:3
10     B(1,i)=A(1,i)
11     B(2,i)=A(2,i)-(A(2,1)/A(1,1))*A(1,i)
12 end
13 disp(A,'Augmented Matrix=')
14 disp(B,'Triangulated Matrix=')
15
16 //back substitution
17 x(2)=B(2,3)/B(2,2);
18 printf('\nx(2)=%f\n',x(2))
19 for i=1:-1:1
20     k=0
21     for j=i+1:2
22        k=k+B(i,j)*x(j)
23     end
24     x(i)=(1/B(i,i))*(B(i,3)-k)
25      printf('\nx(%i)=%f\n',i,x(i))
26 end
```

Scilab code Exa 6.5 Dolittle Factorization Method

```
1  //Example 6.5
2  //Dolittle Factorization Method
3  //Page no. 233
4  clc;clear;close;
5
```

```
A=[2,1,1;1,3,1;1,1,4];
printf('\tL\t\t  *\t\tU\t\t  =\t\tA')
U(2,1)=0;U(3,1)=0;U(3,2)=0;
L(1,2)=0;L(1,3)=0;L(2,3)=0;
for i=1:3
    L(i,i)=1
end
for i=1:3
    U(1,i)=A(1,i)
end
L(2,1)=1/U(1,1);
for i=2:3
    U(2,i)=A(2,i)-U(1,i)*L(2,1);
end
L(3,1)=1/U(1,1);
L(3,2)=(A(3,2)-U(1,2)*L(3,1))/U(2,2);
U(3,3)=A(3,3)-U(1,3)*L(3,1)-U(2,3)*L(3,2);
printf('\n')
for i=1:3
    for j=1:3
        printf('%.2f\t',L(i,j))
    end

    if(i==2)
        printf('  *      ')
    else
        printf('\t')
    end

    for j=1:3
        printf('%.2f\t',U(i,j))
    end
    if(i==2)
        printf('  =      ')
    else
        printf('\t')
    end
    for j=1:3
```

```
44          printf('%.2f\t',A(i,j))
45      end
46      printf('\n')
47  end
```

Scilab code Exa 6.6 Trangularization Method

```
1  //Example 6.6
2  //Trangularization Method
3  //Page no. 236
4  clc;clear;close;
5
6  A=[2,1,1;1,3,1;1,1,4];
7  B=[7;10;15];
8  printf('A can be factorizaed as follows:\n')
9  printf('\tL\t\t *\t\tU\t\t =\t\tA')
10 U(2,1)=0;U(3,1)=0;U(3,2)=0;
11 L(1,2)=0;L(1,3)=0;L(2,3)=0;
12 for i=1:3
13     L(i,i)=1
14 end
15 for i=1:3
16     U(1,i)=A(1,i)
17 end
18 L(2,1)=1/U(1,1);
19 for i=2:3
20     U(2,i)=A(2,i)-U(1,i)*L(2,1);
21 end
22 L(3,1)=1/U(1,1);
23 L(3,2)=(A(3,2)-U(1,2)*L(3,1))/U(2,2);
24 U(3,3)=A(3,3)-U(1,3)*L(3,1)-U(2,3)*L(3,2);
25 printf('\n')
26 for i=1:3
```

```
27      for j=1:3
28          printf('%.2f\t',L(i,j))
29      end
30
31      if(i==2)
32          printf('  *      ')
33      else
34          printf('\t')
35      end
36
37      for j=1:3
38          printf('%.2f\t',U(i,j))
39      end
40      if(i==2)
41          printf('  =      ')
42      else
43          printf('\t')
44      end
45      for j=1:3
46          printf('%.2f\t',A(i,j))
47      end
48      printf('\n')
49  end
50  printf('\nY=U*X')
51      Y=inv(L)*B
52      X=inv(U)*Y
53  printf('\n\nX=')
54  for i=1:3
55      printf('\n    %i',X(i,1))
56  end
```

Scilab code Exa 6.7 Wilkinson Method

```
1 //Example 6.7
2 //Wilkinson Method
3 //Page no. 240
4 clc;clear;close;
5
6 A
     =[0.3*10^5,0.212,0.332;0.216,0.376,0.477;0.173,0.663,0.626];

7 B=[0.235;0.128;0.285];
8 X=inv(A)
9 disp(X*B,'Final Solution = ')
```

Scilab code Exa 6.8 Choleskys Factorization

```
1 //Example 6.8
2 //Cholesky's Factorization
3 //Page no. 243
4 clc;clear;close;
5
6 A=[1,2,3;2,5,8;3,8,22];
7 U(2,1)=0;U(3,1)=0;U(3,2)=0;
8 for i=1:3
9     for j=1:3
10        if(i==j)
11            k=0;
12            for m=1:i-1
13               k=k+U(m,i)^2;
14            end
15            U(i,j)=sqrt(A(i,j)-k)
16        end
17        if(j>i)
18            k=0;
19            for m=1:i-1
```

```
20                  k=k+U(m,j)*U(m,i);
21              end
22              U(i,j)=(A(i,j)-k)/U(i,i)
23          end
24      end
25  end
26  disp(U,'Required Matrix (U)=')
```

Scilab code Exa 6.9 Complex System of Linear Equation

```
1  //Example 6.9
2  //Complex System of Linear Equation
3  //Page no. 244
4  clc;clear;close;
5
6  for i=1:7
7      s=0;
8      for j=1:7
9          A(i,j)=j^i
10         s=s+(-1)^(j+1)*A(i,j)
11     end
12     B(i,1)=s;
13 end
14 X=inv(A)*B
15 disp(X,'The Solution = ')
```

Scilab code Exa 6.10 Solving Matrices

```
1  //Example 6.10
```

```
2  //Solving Matrices
3  //Page no. 244
4  clc;close;clear;
5  warning('off')
6  for i=1:7
7      s=0;
8      for j=1:7
9          A(i,j)=360360/(i+j)
10     end
11     B(i,1)=1;
12 end
13 X=inv(A)*B
14 disp(360360*X,'The Solution by 360360*X= ')
15 disp(X,'Final Solution = ')
```

Chapter 7

Numerical Solutions for Matrix Inversion

Scilab code Exa 7.1 Gauss Jordan Two Array Method

```
1  //Example 7.1
2  //Gauss-Jordan Two Array Method
3  //Page no. 254
4  clc;clear;close;
5
6  A=[2,6,1;3,9,2;0,-1,3];    //matrix
7  C=eye(3,3);                //Unit Matrix
8  for i=1:3                   //interchange of row 1
       and 2
9      B(1,i)=A(1,i);
10     A(1,i)=A(2,i);
11     A(2,i)=B(1,i);
12     B(2,i)=C(1,i);
13     C(1,i)=C(2,i);
14     C(2,i)=B(2,i);
15 end
16 printf('\n')
```

```
17
18 //printing of matrices A and C
19 for i=1:3
20     for j=1:3
21         printf('%f\t',A(i,j))
22     end
23     printf('|\t');
24     for j=1:3
25         printf('%f\t',C(i,j))
26     end
27     printf('\n')
28 end
29 printf('\n\n');
30
31
32 for i=1:3
33     A(1,i)=A(1,i)/3;
34     C(1,i)=C(1,i)/3;
35 end
36
37 //printing of matrices A and C
38 for i=1:3
39     for j=1:3
40         printf('%f\t',A(i,j))
41     end
42     printf('|\t');
43     for j=1:3
44         printf('%f\t',C(i,j))
45     end
46     printf('\n')
47 end
48 printf('\n\n');
49
50 for i=1:3
51     A(2,i)=A(2,i)-2*A(1,i);
52     C(2,i)=C(2,i)-2*C(1,i);
53 end
54
```

```
55 //printing of matrices A and C
56 for i=1:3
57     for j=1:3
58         printf('%f\t',A(i,j))
59     end
60     printf('|\t');
61     for j=1:3
62         printf('%f\t',C(i,j))
63     end
64     printf('\n')
65 end
66 printf('\n\n');
67
68 for i=1:3          //interchange of row 2 and 3
69     B(1,i)=A(2,i);
70     A(2,i)=A(3,i);
71     A(3,i)=B(1,i);
72     B(2,i)=C(2,i);
73     C(2,i)=C(3,i);
74     C(3,i)=B(2,i);
75 end
76
77 //printing of matrices A and C
78 for i=1:3
79     for j=1:3
80         printf('%f\t',A(i,j))
81     end
82     printf('|\t');
83     for j=1:3
84         printf('%f\t',C(i,j))
85     end
86     printf('\n')
87 end
88 printf('\n\n');
89
90 for i=1:3
91     A(2,i)=-1*A(2,i);
92     C(2,i)=-1*C(2,i);
```

```
93  end
94  for i=1:3
95      A(1,i)=A(1,i)-3*A(2,i);
96      C(1,i)=C(1,i)-3*C(2,i);
97  end
98
99  //printing of matrices A and C
100 for i=1:3
101     for j=1:3
102         printf('%f\t',A(i,j))
103     end
104     printf('|\t');
105     for j=1:3
106         printf('%f\t',C(i,j))
107     end
108     printf('\n')
109 end
110 printf('\n\n');
111
112 for i=1:3
113     A(3,i)=-3*A(3,i);
114     C(3,i)=-3*C(3,i);
115 end
116
117 //printing of matrices A and C
118 for i=1:3
119     for j=1:3
120         printf('%f\t',A(i,j))
121     end
122     printf('|\t');
123     for j=1:3
124         printf('%f\t',C(i,j))
125     end
126     printf('\n')
127 end
128 printf('\n\n');
129
130 for i=1:3
```

```
131     A(1,i)=A(1,i)-A(3,i)*(29/3);
132     C(1,i)=C(1,i)-29*C(3,i)/3;
133 end
134 for i=1:3
135     A(2,i)=A(2,i)+A(3,i)*3;
136     C(2,i)=C(2,i)+C(3,i)*3;
137 end
138
139 //printing of matrices A and C
140 for i=1:3
141     for j=1:3
142         printf('%f\t',A(i,j))
143     end
144     printf('|\t');
145     for j=1:3
146         printf('%f\t',C(i,j))
147     end
148     printf('\n')
149 end
150 printf('\n\n');
151
152 disp(C,'Inverse Matrix of A')
```

Scilab code Exa 7.2 Inverse in Place without Pivoting

```
1 //Example 7.2
2 //Inverse in Place without Pivoting
3 //Page no. 256
4 clc;clear;close;
5
6 A=[3,-6,7;9,0,-5;5,-8,6];    //matrix
7 B=[3,-6,7;9,0,-5;5,-8,6];    //copied matrix
8 for i=1:3
```

```
9       printf('\n\nStage %i',i);
10      for j=1:3
11          if(i==j)
12              B(i,j)=1/B(i,j);
13          else
14              B(i,j)=A(i,j)/A(i,i);
15          end,
16      end
17      disp(B)
18          for j=1:3
19              for k=1:3
20                  if(i~=j)
21                      B(j,k)=A(j,k)-A(j,i)*B(i,k);
22                  end,
23              end
24          end
25          disp(B)
26      for j=1:3
27          if(i~=j)
28              B(j,i)=-1*A(j,i)*B(i,i);
29          end,
30
31      end
32      disp(B)
33      A=B;
34  end
35  disp(B,'Inverse of Matrix A=')
```

Scilab code Exa 7.3 Inverse in Place with Pivoting

```
1  //Example 7.3
2  //Inverse in Place with Pivoting
3  //Page no. 258
```

```
clc;clear;close;

A=[3,-6,7;9,0,-5;5,-8,6];       //matrix
B=[3,-6,7;9,0,-5;5,-8,6];        //copied matrix

for i=1:3
    printf('\n\nStage %i',i)
    if(i<3)
        for j=1:3           //interchange of rows
            C(i,j)=A(i,j);
            A(i,j)=A(i+1,j);
            A(i+1,j)=C(i,j);
            C(i,j)=B(i,j);
            B(i,j)=B(i+1,j);
            B(i+1,j)=C(i,j);
        end
    end
    disp(B)
    for j=1:3
        if(i==j)
            B(i,j)=1/B(i,j);
        else
            B(i,j)=A(i,j)/A(i,i);
        end,
    end
        for j=1:3
            for k=1:3
                if(i~=j)
                    B(j,k)=A(j,k)-A(j,i)*B(i,k);
                end,
            end
        end
    for j=1:3
        if(i~=j)
            B(j,i)=-1*A(j,i)*B(i,i);
        end,

    end
```

```
42      disp(B)
43      A=B;
44  end
45  for j=1:3       //interchange of column 2 and 3
46      C(j,1)=A(j,2);
47      A(j,2)=A(j,3);
48      A(j,3)=C(j,1);
49  end
50  for j=1:3       //interchange of column 2 and 1
51      C(j,1)=A(j,2);
52      A(j,2)=A(j,1);
53      A(j,1)=C(j,1);
54  end
55  disp(A,'Inverse of Matrix A=')
```

Scilab code Exa 7.4 Inverse of Triangular Matrices

```
1  //Example 7.4
2  //Inverse of Triangular Matrices
3  //Page no. 260
4  clc;clear;close;
5
6  R=[2,4,-4,0;0,3,-3,-3;0,0,4,2;0,0,0,3];     //matrix
       R
7  for i=4:-1:1
8      for j=4:-1:1
9          if(i>j)
10             Y(i,j)=0;
11         end
12         if(i==j)
13             Y(i,j)=1/R(i,j);
14         end
15         if(i<j)
```

```
16              l=0;
17              for k=i+1:j
18                  l=l-R(i,k)*Y(k,j);
19              end
20              Y(i,j)=l/R(i,i);
21          end
22      end
23  end
24  disp(Y,'Inverse of Matrix R=')
```

Scilab code Exa 7.5 Inverse of Complex Matrices

```
1  //Example 7.5
2  //Inverse of Complex Matrices
3  //Page no. 262
4  clc;clear;close;
5
6  A=[1,-1,0;2,3,4;0,1,2];
7  B=[1,1,3;1,3,-3;-2,-4,-4];
8  P=A+%i*B;
9  disp(P,'Matrix P=')
10 disp(A,'Matrix A=');disp(B,'Matrix B=');
11 A1=inv(A);B1=inv(B);
12 disp(A1,'Inverse of Matrix A=');
13 disp(B1,'Inverse of Matrix B=');
14 B1A=B1*A;disp(B1A,'Inverse(B)*A=');
15 AB1A_B=A*B1A+B;disp(AB1A_B,'A*Inverse(B)*A+B=');
16 AB1A_B1=inv(AB1A_B);disp(AB1A_B1,'Inverse(A*Inverse(
     B)*A+B)=');
17 X=B1A*AB1A_B1;disp(X,'X=');
18 Y=-1*AB1A_B1;disp(Y,'Y=');
19 Q=X+%i*Y;disp(Q,'Inverse of Matrix P=')
```

Scilab code Exa 7.6 Iterative Procedure

```
1  //Example 7.6
2  //Iterative Procedure
3  //Page no. 265
4  clc;clear;close;
5
6      A=[3,1,3/2;-5/4,-1/4,-3/4;-1/4,-1/4,-1/4];
7  disp(A,'Matrix A=');
8  B=[1,1,3.5;1,3,-3;-2,-3,-4];
9  disp(B,'Assumed Matrix B=');
10 e=0.1;
11
12 //iterations
13 E1=e;k=1;
14 while(E1>=e)
15     printf('\n\n\nIteration %i\n',k)
16 C=B*(2*eye(3,3)-A*B);disp(C,'Matrix C=');
17 E=A*C-eye(3,3);disp(E,'Matrix E=');
18 B=C;printf('\nInverse of Matrix A after %i
      iterations=',k);disp(B);
19 E1=0;
20 for i=1:3
21     for j=1:3
22         E1=E1+E(i,j)^2;
23     end
24 end
25 E1=sqrt(E1);
26 k=k+1;
27 end
```

Chapter 8

Numerical Solutions of Linear Systems of Equations Iterative Methods

Scilab code Exa 8.1 Jacobi Method

```
1  //Example 8.1
2  //Jacobi Method
3  //Page no. 273
4  clc;clear;close;
5
6  A=[8,-3,2;4,11,-1;6,3,12];          //equation matrix
7  B=[20;33;36]                        //solution matrix
8  for i=0:19
9      X(i+1,1)=i;
10 end
11 for i=2:4
12     X(1,i)=0;
13 end
14 for r=1:19
15     for i=1:3
```

```
16          k=0;
17          for j=1:3
18              if(i~=j)
19                  k=k-A(i,j)*X(r,j+1);
20              end
21          end
22          X(r+1,i+1)=(k+B(i,1))/A(i,i);
23      end
24  end
25  printf('    r\t    x(r)\t\ty(r)\t      z(r)');
26  printf('\n    ----------------------------------------');
27  disp(X)
28  printf('\n\nAfter 18 iterations exact solution is:\
    nx=%i\ty=%i\tz=%i',X(19,2),X(19,3),X(19,4))
```

Scilab code Exa 8.2 Gauss Seidel Method

```
1  //Example 8.2
2  //Gauss-Seidel Method
3  //Page no. 274
4  clc;clear;close;
5
6  A=[8,-3,2;4,11,-1;6,3,12];          //equation matrix
7  B=[20;33;36]                        //solution matrix
8  for i=0:10
9      X(i+1,1)=i;
10 end
11 for i=2:4
12     X(1,i)=0;
13 end
14 for r=1:10
15     for i=1:3
16         k1=0;
```

```
17          for j=1:i-1
18
19                  k1=k1-A(i,j)*X(r+1,j+1);
20
21          end
22          k2=0;
23          for j=i+1:3
24
25                  k2=k2-A(i,j)*X(r,j+1);
26
27          end
28          X(r+1,i+1)=(k1+k2+B(i,1))/A(i,i);
29      end
30  end
31  printf('    r\t    x(r)\t\ty(r)\t      z(r)');
32  printf('\n    ------------------------------------------');
33  disp(X)
34  printf('\n\nAfter 9 iterations exact solution is:\nx
    =%i\ty=%i\tz=%i',X(10,2),X(10,3),X(10,4))
```

Scilab code Exa 8.3 SOR Method

```
1  //Example 8.3
2  //SOR Method
3  //Page no. 275
4  clc;clear;close;
5
6  A=[5,2,1;-1,4,2;2,-3,10];
7  B=[-12;20;3];
8  w=0.9;
9  for i=0:13
10     X(i+1,1)=i;
11 end
```

```
X(1,2)=-2.4;
X(1,3)=5;
X(1,4)=0.3;
for r=1:13
    for i=1:3
        k1=0;
        for j=1:i-1

                k1=k1-A(i,j)*X(r+1,j+1);

        end
        k2=0;
        for j=i+1:3

                k2=k2-A(i,j)*X(r,j+1);

        end
        X(r+1,i+1)=(1-w)*X(r,i+1)+(w*k1+w*k2+w*B(i
           ,1))/A(i,i);
    end
end
printf('    r\t    x(r)\t\ty(r)\t      z(r)');
printf('\n    ----------------------------------------')
   ;
disp(X);
printf('\n\nAfter 12 iterations exact solution is:\
   nx=%i\ty=%i\tz=%i',X(13,2),X(13,3),X(13,4));
```

Scilab code Exa 8.4 Gauss Seidel Point Iterative Method

```
//Example 8.4
//Gauss-Seidel Point Iterative Method
//Page no. 278
```

```
4  clc;clear;close;
5
6
7  A
      =[10,1,0,0,0,-1;1,10,1,0,0,0;2,0,20,1,0,0;0,0,1,10,-1,0;0,3,0,0,3
                //equation matrix
8  B=[5;10;10;0;0;5]                          //solution
      matrix
9  for i=1:6
10     for j=1:6
11         if(A(j,j)==0)
12             for k=1:6
13                 C(j,k)=A(j,k);
14                 A(j,k)=A(j+1,k);
15                 A(j+1,k)=C(j,k);
16             end
17         end
18     end
19 end
20 for i=0:7
21     X(i+1,1)=i;
22 end
23 for i=2:7
24     X(1,i)=0;
25 end
26 for r=1:7
27     for i=1:6
28         k1=0;
29         for j=1:i-1
30
31                 k1=k1-A(i,j)*X(r+1,j+1);
32
33         end
34         k2=0;
35         for j=i+1:6
36
37                 k2=k2-A(i,j)*X(r,j+1);
38
```

```
39          end
40          X(r+1,i+1)=(k1+k2+B(i,1))/A(i,i);
41      end
42  end
43  printf('    r       ');
44  for i=1:6
45      printf('x%i             ',i);
46  end
47  printf('\n
    ------------------------------------------------------------------------------
    ')
48  disp(X)
49  printf('\n\nAfter 6 iterations exact solution is:\n'
    );
50  for i=1:6
51      printf('x%i=%f      ',i,X(7,i+1));
52  end
```

Scilab code Exa 8.5 Gauss Seidel Point Iterative Method

```
1  //Example 8.5
2  //Gauss-Seidel Point Iterative Method
3  //Page no. 279
4  clc;clear;close;
5
6  A=[2,3,-4,1;1,-2,-5,1;5,-3,1,-4;10,2,-1,2];        //
       equation matrix
7  B=[3;2;1;-4];           //solution matrix
8
9  //transformation of the equations
10 for i=1:4
11     A1(1,i)=A(4,i);
12     B1(1,1)=B(4,1);
```

```
13 end
14 for i=1:4
15     A1(3,i)=A(2,i);
16     B1(3,1)=B(2,1);
17 end
18 for i=1:4
19     A1(2,i)=A(1,i)-A(2,i);
20     B1(2,1)=B(1,1)-B(2,1);
21 end
22 for i=1:4
23     A1(4,i)=2*A(1,i)-A(2,i)+2*A(3,i)-A(4,i);
24     B1(4,1)=2*B(1,1)-B(2,1)+2*B(3,1)-B(4,1);
25 end
26
27 //printing of transformed equations
28 printf('\nTransformed Equations are=\n\n')
29 for i=1:4
30     for j=1:4
31         printf('(%ix(%i))',A1(i,j),j);
32         if(j<4)
33             printf(' + ')
34         end
35     end
36     printf('= %i\n',B1(i,1));
37 end
38
39 for i=1:4
40     for j=1:4
41         if(A(j,j)==0)
42             for k=1:4
43                 C(j,k)=A(j,k);
44                 A(j,k)=A(j+1,k);
45                 A(j+1,k)=C(j,k);
46             end
47         end
48     end
49 end
50 for i=0:12
```

```
51      X(i+1,1)=i;
52  end
53  for i=2:5
54      X(1,i)=0;
55  end
56  for r=1:12
57      for i=1:4
58          k1=0;
59          for j=1:i-1
60
61                  k1=k1-A1(i,j)*X(r+1,j+1);
62
63          end
64          k2=0;
65          for j=i+1:4
66
67                  k2=k2-A1(i,j)*X(r,j+1);
68
69          end
70          X(r+1,i+1)=(k1+k2+B1(i,1))/A1(i,i);
71      end
72  end
73  printf('\n\n     r      ');
74  for i=1:4
75      printf('x%i            ',i);
76  end
77  printf('\n
    ------------------------------------------------------------
    ')
78  disp(X)
79  printf('\n\nAfter 11 iterations exact solution is:\n
    ');
80  for i=1:4
81      printf('x%i=%f      ',i,X(12,i+1));
82  end
```

Scilab code Exa 8.6 Block Jacobi Method

```
1  //Example 8.6
2  //Block Jacobi Method
3  //Page no. 281
4  clc;clear;close;
5
6  A
      =[10,1,0,0,0,-1;1,10,1,0,0,0;2,0,20,1,0,0;0,0,1,10,-1,0;0,3,0,0,3
             //equation matrix
7  B=[5;10;10;0;0;5]                          //solution
      matrix
8  disp(B,'B=',A,'A=')
9  for i=1:3
10     for j=1:3
11         A11(i,j)=A(i,j);
12     end
13     B1(i,1)=B(i,1);
14 end
15 for i=1:3
16     for j=1:3
17         A12(i,j)=A(i,j+3);
18     end
19 end
20 for i=1:3
21     for j=1:3
22         A21(i,j)=A(i+3,j);
23     end
24 end
25 for i=1:3
26     for j=1:3
27         A22(i,j)=A(i+3,j+3);
```

```
28      end
29      B2(i,1)=B(i+3,1);
30  end
31  disp(B2,'B2=',B1,'B1=',A22,'A22=',A21,'A21=',A12,'
       A12=',A11,'A11=');
32  A11_1=inv(A11);A22_1=inv(A22);
33  disp(A22_1,'Inverse of A22=',A11_1,'Inverse of A11='
       )
34  for i=1:3
35      X1(i,1)=0;
36      X2(i,1)=0;
37  end
38  for r=1:2
39      X11=A11_1*(-1*A12*X2+B1);
40      X22=A22_1*(-1*A21*X1+B2);
41      X1=X11;
42      X2=X22;
43      disp(X1,'X1=')
44      disp(X2,'X2=')
45  end
46  for i=1:6
47      if(i<4)
48          X(i,1)=X1(i,1);
49      else
50          X(i,1)=X2(i-3,1);
51      end
52  end
53  disp(X,'X=')
54  printf('\n\n\nNote : There is a computation error in
       calculation of X1(2)')
```

Scilab code Exa 8.7 Block Gauss Seidel Method

```
1  //Example 8.7
2  //Block Gauss-Seidel Method
3  //Page no. 283
4  clc;clear;close;
5
6  A
      =[10,1,0,0,0,-1;1,10,1,0,0,0;2,0,20,1,0,0;0,0,1,10,-1,0;0,3,0,0,3
              //equation matrix
7  B=[5;10;10;0;0;5]                          //solution
      matrix
8  disp(B,'B=',A,'A=')
9
10 for i=1:2
11     for j=1:2
12         A11(i,j)=A(i,j);
13     end
14     B1(i,1)=B(i,1);
15 end
16 for i=1:2
17     for j=1:2
18         A12(i,j)=A(i,j+2);
19     end
20     B2(i,1)=B(i+2,1);
21 end
22 for i=1:2
23     for j=1:2
24         A13(i,j)=A(i,j+4);
25     end
26     B3(i,1)=B(i+4,1);
27 end
28 for i=1:2
29     for j=1:2
30         A21(i,j)=A(i+2,j);
31     end
32 end
33 for i=1:2
34     for j=1:2
35         A22(i,j)=A(i+2,j+2);
```

```
    end
end
for i=1:2
    for j=1:2
        A23(i,j)=A(i+2,j+4);
    end
end
for i=1:2
    for j=1:2
        A31(i,j)=A(i+4,j);
    end
end
for i=1:2
    for j=1:2
        A32(i,j)=A(i+4,j+2);
    end
end
for i=1:2
    for j=1:2
        A33(i,j)=A(i+4,j+4);
    end
end
disp(B3,'B3=',B2,'B2=',B1,'B1=',A33,'A33=',A32,'A32=
    ',A31,'A31=',A23,'A23=',A22,'A22=',A21,'A21=',A13
    ,'A13=',A12,'A12=',A11,'A11=');
A11_1=inv(A11);A22_1=inv(A22);A33_1=inv(A33);
disp(A33_1,'Inverse of Matrix A33=',A22_1,'Inverse
   of Matrix A22=',A11_1,'Inverse of Matrix A11=');
for i=1:2
    X1(i,1)=0;
    X2(i,1)=0;
    X3(i,1)=0;
end
for i=1:6
    X(i,1)=i-1;
end
for i=2:7
    X(1,i)=0;
```

```
end
for r=1:5
    X11=A11_1*(-1*A12*X2+(-1)*A13*X3+B1);
    X22=A22_1*(-1*A21*X11+(-1)*A23*X3+B2);
    X33=A33_1*(-1*A31*X11+(-1)*A32*X22+B3);
    X1=X11;
    X2=X22;
    X3=X33;
    disp(X3,'X3=',X2,'X2=',X1,'X1=')
    for i=2:7
        if(i<4)
            X(r+1,i)=X1(i-1,1);
        end
        if(i<6 & i>3)
            X(r+1,i)=X2(i-3,1);
        end
        if(i<8 & i>5)
            X(r+1,i)=X3(i-5,1);
        end
    end
end
printf('\n\nIteration');
for i=1:6
    printf('    x%i       ',i);
end
printf('\n
   ------------------------------------------------------------------------
   ')
disp(X)
printf('\n\nAfter 4 iterations exact solution is:\n'
   );
for i=1:6
    printf('x%i=%f     ',i,X(5,i+1));
end
```

Scilab code Exa 8.8 Block SOR Method

```
1  //Example 8.8
2  //Block SOR Method
3  //Page no. 284
4  clc;clear;close;
5
6
7  A
      =[10,1,0,0,0,-1;1,10,1,0,0,0;2,0,20,1,0,0;0,0,1,10,-1,0;0,3,0,0,3
               //equation matrix
8  B=[5;10;10;0;0;5]                          //solution
      matrix
9  disp(B,'B=',A,'A=')
10 w=0.8
11 for i=1:2
12      for j=1:2
13          A11(i,j)=A(i,j);
14      end
15      B1(i,1)=B(i,1);
16 end
17 for i=1:2
18      for j=1:2
19          A12(i,j)=A(i,j+2);
20      end
21      B2(i,1)=B(i+2,1);
22 end
23 for i=1:2
24      for j=1:2
25          A13(i,j)=A(i,j+4);
26      end
27      B3(i,1)=B(i+4,1);
```

```
28 end
29 for i=1:2
30     for j=1:2
31         A21(i,j)=A(i+2,j);
32     end
33 end
34 for i=1:2
35     for j=1:2
36         A22(i,j)=A(i+2,j+2);
37     end
38 end
39 for i=1:2
40     for j=1:2
41         A23(i,j)=A(i+2,j+4);
42     end
43 end
44 for i=1:2
45     for j=1:2
46         A31(i,j)=A(i+4,j);
47     end
48 end
49 for i=1:2
50     for j=1:2
51         A32(i,j)=A(i+4,j+2);
52     end
53 end
54 for i=1:2
55     for j=1:2
56         A33(i,j)=A(i+4,j+4);
57     end
58 end
59 disp(B3,'B3=',B2,'B2=',B1,'B1=',A33,'A33=',A32,'A32=
       ',A31,'A31=',A23,'A23=',A22,'A22=',A21,'A21=',A13
       ,'A13=',A12,'A12=',A11,'A11=');
60 A11_1=inv(A11);A22_1=inv(A22);A33_1=inv(A33);
61 disp(A33_1,'Inverse of Matrix A33=',A22_1,'Inverse
       of Matrix A22=',A11_1,'Inverse of Matrix A11=');
62 for i=1:2
```

```
63      X1(i,1)=0;
64      X2(i,1)=0;
65      X3(i,1)=0;
66  end
67  for i=1:7
68      X(i,1)=i-1;
69  end
70  for i=2:7
71      X(1,i)=0;
72  end
73  for r=1:6
74      X11=A11_1*((1-w)*X1+(-1)*w*A12*X2+(-1)*w*A13*X3+
           w*B1);
75      X22=A22_1*((1-w)*X2+(-1)*w*A21*X11+(-1)*w*A23*X3
           +w*B2);
76      X33=A33_1*((1-w)*X3+(-1)*w*A31*X11+(-1)*w*A32*
           X22+w*B3);
77      X1=X11;
78      X2=X22;
79      X3=X33;
80      disp(X3,'X3=',X2,'X2=',X1,'X1=')
81      for i=2:7
82          if(i<4)
83              X(r+1,i)=X1(i-1,1);
84          end
85          if(i<6 & i>3)
86              X(r+1,i)=X2(i-3,1);
87          end
88          if(i<8 & i>5)
89              X(r+1,i)=X3(i-5,1);
90          end
91      end
92  end
93  printf('\n\nIteration');
94  for i=1:6
95      printf('     x%i        ',i);
96  end
97  printf('\n
```

```
    ')
disp(X)
printf('\n\nAfter 5 iterations exact solution is:\n')
for i=1:6
    printf('x%i=%f      ',i,X(6,i+1));
end
```

Chapter 9

Linear Least Squares Problem

Scilab code Exa 9.1 Moore Penrose Generalized Inverse

```
1  //Example 9.1
2  //Moore-Penrose Generalized Inverse
3  //Page no. 292
4  clc;clear;close;
5
6  AT=[3,0,3;0,3,3];
7  A=AT';              //transpose
8  I=inv(AT*A);          //inverse
9  disp(I,'Inverse of AT*A=',AT*A,'AT*A=',A,'A=',AT,'AT
       =');
10 A#=I*AT;
11 disp(A#,'Moore-Penrose Generalized Inverse of A=')
```

Scilab code Exa 9.2 Curve Fitting

```
1  //Example 9.2
2  //Curve Fitting
3  //Page no. 293
4  clc;clear;close;
5  x(1)=0.25;
6  for i=2:6
7      x(1,i)=x(1,i-1)+0.25;
8  end                  //x values
9  y(1,1)=3.1;y(1,2)=1.7;y(1,3)=1;y(1,4)=0.68;y(1,5)
       =0.42;y(1,6)=0.26; //y values
10
11 //construction of normal equations
12 for i=1:6
13     Y(1,i)=log10(y(1,i));
14 end
15 Ex=0;
16 for i=1:6
17     Ex=Ex+x(1,i);
18 end
19 EY=0;
20 for i=1:6
21     EY=EY+Y(1,i);
22 end
23 Ex2=0;
24 for i=1:6
25     Ex2=Ex2+x(1,i)^2;
26 end
27 ExY=0;
28 for i=1:6
29     ExY=ExY+x(1,i)*Y(1,i);
30 end
31 printf('E x(k)\t\t y(k)\t\tE Y(k)\t\tE x2(k)\t\tE x(
       k)*Y(k)')
32 printf('\n
       ----------------------------------------------------------------------
       ')
33 for i=1:6
34     printf('\n%f\t%f\t%f\t%f\t%f',x(1,i),y(1,i),Y(1,
```

```
        i),x(1,i)^2,x(1,i)*Y(1,i))
end
printf('\n
    ----------------------------------------------------------------------
    ')
printf('\n%f\t%f\t%f\t%f\t%f',Ex,0,EY,Ex2,ExY)
printf('\n
    ----------------------------------------------------------------------
    n\n')
A=[6,Ex;Ex,Ex2];        //system of normal equations
B=[EY;ExY];
X=inv(A)*B;
a=exp(X(1,1));
b=-1*X(2,1);
for i=1:2
    for j=1:2
        printf('%f    ',A(i,j))
    end
    if(i==1)
        printf('  *')
    end

    printf('\ta%i',i);
    if(i==1)
        printf('  =')
    end

    printf('\t%f\n',B(i,1))
end
printf('\n\na1=%f\na2=%f\n\na=%f\nb=%f\n\n',X(1,1),X
    (2,1),a,b)
printf('The fitted curve is:\n                %fx\ny=%f
    e',b,a)
```

Scilab code Exa 9.3 Gram Schmidt Orthogonalization or Orthonormalization Process

```
1  //Example 9.3
2  //Gram-Schmidt Orthogonalization/Orthonormalization
       Process
3  //Page no. 294
4  clc;clear;close;
5  deff('y=f(x,a)','y=sqrt(x(1,a)^2+x(2,a)^2+x(3,a)^2+x
       (4,a)^2)');
6  deff('y=f1(g,a,h,b)','y=g(1,a)*h(1,b)+g(2,a)*h(2,b)+
       g(3,a)*h(3,b)+g(4,a)*h(4,b)');
7
8  U=[1/sqrt(3),-2/sqrt(7),1,0,0,0;0,1/sqrt(7)
       ,0,1,0,0;1/sqrt(3),1/sqrt(7),0,0,1,0;-1/sqrt(3)
       ,-1/sqrt(7),0,0,0,1];
9  for i=1:4
10         V(i,1)=U(i,1);
11 end
12 for i=1:4
13     if(f(V,1)~=0)
14         W(i,1)=V(i,1)/f(V,1);
15     else
16         W(i,1)=0;
17     end
18 end
19 for j=2:6
20     for i=1:4
21         for l=1:4
22             k(l,1)=0;
23         end
24         for l=1:j-1
25             for m=1:4
26                 w(m,1)=W(m,l);
27             end
28             k=k-(f1(U,j,W,l))*w;
29         end
30         V(i,j)=U(i,j)+k(i,1);
```

```
31      end
32      for i=1:4
33          if(j~=4)
34              if(f(V,j)~=0)
35                  W(i,j)=V(i,j)/f(V,j);
36              else
37                  W(i,j)=0;
38              end
39          else
40              W(i,j)=0;
41          end
42      end
43
44  end
45  disp(U,'U=')
46  disp('W=')
47  printf('\n')
48  for i=1:4
49      for j=1:6
50          printf('%.4f\t\t',W(i,j))
51      end
52      printf('\n')
53  end
54  disp('V=')
55  printf('\n')
56  for i=1:4
57      for j=1:6
58          printf('%.4f\t\t',V(i,j))
59      end
60      printf('\n')
61  end
```

Scilab code Exa 9.4 QR Decomposition

```
//Example 9.4
//QR Decomposition
//Page no. 296
clc;clear;close;

A=[2,1,1;1,3,1;1,1,4];
B=A*A';
disp(B,'AT*A=')
//cholesky factorization to find R
R(2,1)=0;R(3,1)=0;R(3,2)=0;
for i=1:3
    for j=1:3
        if(i==j)
            k=0;
            for m=1:i-1
               k=k+R(m,i)^2;
            end
            R(i,j)=sqrt(B(i,j)-k)
        end
        if(j>i)
            k=0;
            for m=1:i-1
                k=k+R(m,j)*R(m,i);
            end
            R(i,j)=(B(i,j)-k)/R(i,i)
        end
    end
end
//cholesky factorization end
disp(R,'Upper Triangular Matrix (R)=')
R_1=inv(R);
disp(R_1,'Inverse of R')
Q=A*R_1;
disp(Q,'Orthogonal Matrix Q=')
```

Scilab code Exa 9.5 Vector Computation

```
1  //Example 9.5
2  //Vector Computation
3  //Page no. 299
4  clc;clear;close;
5
6  X=[2,3,0,1];
7  n=X(1);
8  for i=2:4
9      if(n<X(i))
10         n=X(i);
11     end
12 end
13 printf('\nMaximum Value (n)=%i\n',n)
14 for i=1:4
15     X(i)=X(i)/n;
16 end
17 disp(X,'Normalized X=')
18 k=0;
19 for i=1:4
20     k=k+X(i)^2;
21 end
22 sigma=X(1)*abs(1/X(1))*sqrt(k);
23 printf('\nsigma=%f\n',sigma);
24 X(1)=X(1)+sigma;
25 printf('\nModified x1 = %g\n',X(1))
26 for i=1:4
27     U(1,i)=X(i);
28 end
29 disp(U,'U=')
30 p=sigma*X(1);sigma=n*sigma;
```

```
31 printf('\n p = %f\n\n sigma = %f',p,sigma);
32 printf('\n\n\nNote : There is a computation error in
       calculation of U1')
```

Scilab code Exa 9.6 House Holder Transformation

```
1  //Example 9.6
2  //House Holder Transformation
3  //Page no. 300
4  clc;clear;close;
5
6  A=[4,2,1;2,5,-2;1,-2,7]
7  disp(A,'A=')
8  k=0;
9  for j=2:3
10     k=k+A(j,1)^2;
11 end
12 a=A(2,1)*abs(1/A(2,1))*sqrt(k);
13 disp(a,'alpha=')
14 U=[0;a+A(2,1);A(3,1)];
15 disp(U,'U=')
16 U1=U'*U;
17 disp(U1,'UT*U=')
18 U2=U*U';
19 disp(U2,'U*UT=')
20 P=eye(3,3)-(2*U2)/U1;
21 disp(P,'P=');
22 B=P*A*P;
23 disp(B,'B=');
24 printf('\n\n\nThere are computation error in the
     answers given by the book in this example\n\n(a22
      value error in U*UT)')
```

Scilab code Exa 9.7 Givens QR Method

```
1  //Example 9.7
2  //Givens QR Method
3  //Page no. 303
4  clc;clear;close;
5
6  A=[4,2,1;2,5,-2;1,-2,7]
7  deff('y=c(i,j)','y=A(j,j)/sqrt((A(i,j)^2+A(j,j)^2))'
       )
8  deff('y=s(i,j)','y=A(i,j)/sqrt((A(i,j)^2+A(j,j)^2))'
       )
9  disp(A,'A=')
10 R=A;Q=eye(3,3);
11 m=1;
12 for j=1:2
13     for i=j+1:3
14         for k=1:3                    //C matrix evaluation
15             for l=1:3
16                 if(k==l)
17                     if(k==i | k==j)
18                         C(k,l)=c(i,j)
19                     else
20                         C(k,l)=1
21                     end
22                 end
23                 if(k>l)
24                     if(k==i & l==j)
25                         C(k,l)=-1*s(i,j)
26                     else
27                         C(k,l)=0
28                     end
```

```
                    end
                    if(k<l)
                        if(k==j & l==i)
                            C(k,l)=s(i,j)
                        else
                            C(k,l)=0
                        end
                    end
                end
            end
            printf('\n\n Iteration %i',m)
            m=m+1
            disp(C,'C=');
            R=C*R;
            Q=Q*C';
            disp(Q,'Q=',R,'R=')
        end
end
disp(Q*R,'Q*R=A=')                    //verification
```

Scilab code Exa 9.8 Recursive Least Square Method

```
//Example 9.8
//Recursive Least-Square Method
//Page no. 308
clc;clear;close;

A0=[3,0;0,3;3,3];
B0=[2;2;2];
A1=[6,3];B1=[6];
A0T=A0';
G0=A0T*A0;
disp(G0,'G0=')
```

```
G0_1=inv(G0);
disp(G0_1,'Inverse of G0=')
X0=G0_1*A0T*B0;
disp(X0,'X0=')

//by recursive least square algorithm
G1=G0+A1'*A1;
disp(G1,'G1=');
G1_1=inv(G1);
disp(G1_1,'Inverse of G1')
X1=X0+G1_1*A1'*(B1-A1*X0);
disp(X1,'X1=')

//verification
A=[3,0;0,3;3,3;6,3];
B=[2;2;2;6];
AT=A';
G=AT*A;
disp(G,'G=')
G_1=inv(G);
disp(G_1,'Inverse of G=')
X=G_1*AT*B;
disp(X,'X=')
disp('Thus X and X1 are Same')
```

Chapter 10

Numerical Solutions of System of Non Linear Equations

Scilab code Exa 10.1 System of Non Linear Equations

```
1  //Example 10.1
2  //System of Non Linear Equations
3  //Page no. 311
4  clc;clear;close;
5
6  deff('y=f(x)','y=x^2-exp(2*x)-4')
7  deff('y=f1(x)','y=2*x-2*exp(2*x)')
8  x0=0;e=0.00001
9  for i=1:10
10     x1=x0-f(x0)/f1(x0)
11     e1=abs(x0-x1)
12     x0=x1;
13     if abs(x0)<e then
14         break;
15     end
16 end
17 printf('\n\nThe solution of this equation after %i
```

```
Iterations by newton raphshon method is %.10f',i,
x1)
```

Scilab code Exa 10.2 Contraction Method and Seidel Method

```
1  //Example 10.2
2  //Contraction Method and Seidel Method
3  //Page no. 315
4  clc;clear;close;
5  x(1)=0;y(1)=0
6  printf('(a) Contraction Mapping\n\nn\txn\t\tyn\n
   ------------------------------------\n 0\t%f\t%f\n',x
   (1),y(1))
7  for i=2:9
8      x(i)=sin(x(i-1)+y(i-1))
9      y(i)=cos(x(i-1)-y(i-1))
10     printf(' %i\t%f\t%f\n',i-1,x(i),y(i))
11 end
12 printf('\n\n\n(b) Seidel Method\n\nn\txn\t\tyn\n
   ------------------------------------\n 0\t%f\t%f\n',x
   (1),y(1))
13 for i=2:9
14     x(i)=sin(x(i-1)+y(i-1))
15     y(i)=cos(x(i)-y(i-1))
16     printf(' %i\t%f\t%f\n',i-1,x(i),y(i))
17 end
```

Scilab code Exa 10.3 Non Linear System of Equation

```
1  //Example 10.3
2  //Non Linear System of Equation
3  //Page no. 315
4  clc;clear;close;
5  x(1,1)=1;x(1,2)=0;x(1,3)=0;
6  y(1,1)=0;y(1,2)=2;y(1,3)=2;
7  printf('Case -->\t\tI\t\t\t\t\II\t\t\t\tIII\n
   ------------------------------------------------------------------------
   nIteration\tx\t\ty\t\tx\t\ty\t\tx\t\ty\n\n    0\t
   \t%f\t%f\t%f\t%f\t%f\t%f\n',x(1,1),y(1,1),x(1,2),
   y(1,2),x(1,3),y(1,3))
8  for i=2:9
9      printf('    %i\t',i-1)
10     for j=1:3
11         if j==1 | j==2 then
12             x(i,j)=(-y(i-1,j)^2-4*x(i-1,j)^2+8*x(i
                  -1,j)+4)/8
13         y(i,j)=(2*y(i-1,j)^2-2*x(i-1,j)+1)/4
14         printf('\t%f\t%f',x(i,j),y(i,j))
15         end
16         if j==3 then
17             x(i,j)=(-y(i-1,j)^2-4*x(i-1,j)^2+11*x(i
                  -1,j)+4)/11
18         y(i,j)=(-2*y(i-1,j)^2+8*y(i-1,j)-2*x(i-1,j)
              -1)/4
19         printf('\t%f\t%f',x(i,j),y(i,j))
20         end
21     end
22     printf('\n')
23 end
24 printf('\n\n\nNote : There are computational
   errors in this example given by the book')
```

Scilab code Exa 10.4 Newton Method

```
1  //Example 10.4
2  //Newton Method
3  //Page no. 317
4  clc;clear;close;
5
6  deff('y=f1(x1,x2)','y=x1+3*log10(x1)-x2^2')
7  deff('y=f2(x1,x2)','y=2*x1^2-x1*x2-5*x1+1')
8  deff('y=f11(x1,x2)','y=1+3/(log(10)*x1)')
9  deff('y=f12(x1,x2)','y=-2*x2')
10 deff('y=f21(x1,x2)','y=4*x1-x2-5')
11 deff('y=f22(x1,x2)','y=-x1')
12 x=[3.4;2.2];
13 disp(x,'x(0) = ')
14 for i=1:3
15     fx=[f1(x(1),x(2));f2(x(1),x(2))]
16     printf('\n fx(%i) = \n',i)
17     disp(fx)
18     A=[f11(x(1),x(2)),f12(x(1),x(2));f21(x(1),x(2)),
          f22(x(1),x(2)),]
19     disp(A,'A = ')
20     A_1=inv(A)
21     disp(A_1,'Inverse of A = ')
22     x=x-A_1*fx
23     printf('\n x(%i) = \n',i)
24     disp(x)
25 end
```

Scilab code Exa 10.5 Newton Raphshon Method

```
1  //Example 10.5
2  //Newton Raphshon Method
```

```
3  //Page no. 320
4  clc;clear;close;
5
6  deff('y=f1(x,y)','y=x^3-3*x*y^2+1')
7  deff('y=f2(x,y)','y=3*x^2*y-y^3')
8  deff('y=f11(x,y)','y=3*x^2-6*y^2')
9  deff('y=f12(x,y)','y=-6*x*y')
10 deff('y=f21(x,y)','y=6*x*y')
11 deff('y=f22(x,y)','y=3*x^2-3*y^2')
12 x=[0;1];
13 printf('\nx(0) = %g\ny(0) = %g\n',x(1),x(2))
14 for i=1:3
15     fx=[f1(x(1),x(2));f2(x(1),x(2))]
16     printf('\n fx(%i) = \n',i)
17     disp(fx)
18     J=[f11(x(1),x(2)),f12(x(1),x(2));f21(x(1),x(2)),
          f22(x(1),x(2)),]
19     disp(J,'J = ')
20     d=det(J);
21     if d==0 then
22         dx1=0;dx2=0;
23     else
24         dx1=(fx(1)*J(2,2)-fx(2)*J(1,2))/d;
25         dx2=(fx(2)*J(1,1)-fx(1)*J(2,1))/d;
26     end
27     x(1)=x(1)+dx1;
28     x(2)=x(2)+dx2;
29     printf('\nx(%i) = %g\ny(%i) = %g\n',i,x(1),i,x
          (2))
30 end
```

Scilab code Exa 10.6 Newton Method

```
1  //Example 10.6
2  //Newton Method
3  //Page no. 322
4  clc;clear;close;
5
6  deff('y=f1(x,y,z)','y=x-0.1*y^2+0.05*z^2-0.7')
7  deff('y=f2(x,y,z)','y=y+0.3*x^2-0.1*x*z-0.5')
8  deff('y=f3(x,y,z)','y=z+0.4*y^2+0.1*x*y-1.2')
9  deff('y=f11(x,y,z)','y=1')
10 deff('y=f12(x,y,z)','y=-0.2*y')
11 deff('y=f13(x,y,z)','y=0.1*z')
12 deff('y=f21(x,y,z)','y=0.6*x-0.1*z')
13 deff('y=f22(x,y,z)','y=1')
14 deff('y=f23(x,y,z)','y=-0.1*x')
15 deff('y=f31(x,y,z)','y=0.1*y')
16 deff('y=f32(x,y,z)','y=0.8*y+0.1*x')
17 deff('y=f33(x,y,z)','y=1')
18 x=[0;0;0];
19 printf('n\txn\t\tyn\t\tzn\n
   ------------------------------------------------------------\
   n')
20 for i=1:6
21     fx=[f1(x(1),x(2),x(3));f2(x(1),x(2),x(3));f3(x
          (1),x(2),x(3))]
22     J=[f11(x(1),x(2),x(3)),f12(x(1),x(2),x(3)),f13(x
          (1),x(2),x(3));f21(x(1),x(2),x(3)),f22(x(1),x
          (2),x(3)),f23(x(1),x(2),x(3));f31(x(1),x(2),x
          (3)),f32(x(1),x(2),x(3)),f33(x(1),x(2),x(3))]
23     J_1=inv(J)
24     printf(' %i\t%f\t%f\t%f\n',i-1,x(1),x(2),x(3))
25     x=x-J_1*fx
26 end
27 printf('\n\nThe solution is x = %f, y = %f and z =
   %f',x(1),x(2),x(3))
28
29 printf('\n\n\nNote : There are computation errors in
    calculation given by the book')
```

Scilab code Exa 10.7 Iterative Method

```
1 //Example 10.7
2 //Iterative Method
3 //Page no. 326
4 clc;clear;close;
5
6 x=[0;0;0];
7 printf('n\txn\t\tyn\t\tzn\n
    ------------------------------------------------------------\
    n')
8 for i=1:7
9     printf(' %i\t%.10f\t%.10f\t%.10f\n',i-1,x(1),x
        (2),x(3))
10    x(1)=0.7+0.1*x(2)^2-0.05*x(3)^2
11    x(2)=0.5-0.3*x(1)^2+0.1*x(1)*x(3)
12    x(3)=1.2-0.4*x(2)^2-0.1*x(1)*x(2)
13 end
14 printf('\n\nThe solution is x = %.10f, y = %.10f and
    z = %.10f',x(1),x(2),x(3))
```

Scilab code Exa 10.8 Steepest Descent

```
1 //Example 10.8
2 //Steepest Descent
3 //Page no. 328
4 clc;clear;close;
5
```

```
6  deff('y=f(x1,x2)','y=(x1-2)^4+3*(x2+3)^2')
7  x=[1;-2];
8  printf('n\t      x1\t\t      x2\t\t   F(x1,x2)\n
      ------------------------------------------------------------\
      n')
9  for i=1:11
10     Fx=[f(x(1),x(2))];
11     J=[4*(x(1)-2)^3,6*(x(2)+3)];
12     u=(Fx*J*J'*Fx)/(J*J'*Fx*J*J'*Fx)
13     printf(' %i\t%.10f\t%.10f\t%.10f\n',i-1,x(1),x
          (2),Fx)
14     x=x-u*J'*Fx
15 end
16 printf('\n\nThis shows that the solution tends to x1
      = %i    and    x2 = %i',ceil(x(1)),floor(x(2)))
```

Chapter 11

Eigenvalues and Eigenvectors

Scilab code Exa 11.1 Eigenvalues and Eigenvectors

```
1  //Example 11.1
2  //Eigenvalues and Eigenvectors
3  //Page no. 333
4  clc;clear;close;
5
6  A1=[0.6;0.2];A2=[-0.2;0.6];A3=[-0.6;-0.2];A4
       =[0.2;-0.6];
7  T=[1.1,-0.3;-0.3,1.9];
8  B1=T*A1;B2=T*A2;B3=T*A3;B4=T*A4;
9  disp(B4,B3,B2,B1,'The transformed vectors are :')
10 disp('These points lie on the ellipse:')
11 printf('      2       2\n(x-3y)+(3x+y)\n------ ------\
       n   16      4\n\n')
12 A5=[0;2/sqrt(10)];
13 disp('The vector (0,2/10^(1/2)) lies on the circle:'
       )
14 printf(' 2    2\nx + y = 4\n         -\n         10\n\n
       ')
15 B5=T*A5;
```

```
16 disp('Also lies on the same ellipse',B5)
17 printf('\n\nWe can see that there is a linear
     relationship between the first 4 vectors and
     their respective transformend vectors through the
      scalars known as eigenvectors and eigenvalues
     respectively')
```

Scilab code Exa 11.2 Leverriers Method

```
1  //Example 11.2
2  //Leverrier's Method
3  //Page no. 337
4  clc;close;clear;
5
6  A=[2,2,2;2,5,5;2,5,1];
7  A1=A;
8  C(1)=0;
9      for j=1:3
10         for k=1:3
11             if(j==k)
12                 C(1)=C(1)+A1(j,k)
13             end
14         end
15     end
16     disp(A,'A=')
17         disp(A1,'A1=')
18     printf('\nC1=')
19     disp(C(1));
20 for i=2:3
21     A2=A*(A1-C(i-1)*eye(3,3));
22     printf('\n\n\nA%i=',i)
23     disp(A2);
24     C(i)=0;
```

```
25      for j=1:3
26          for k=1:3
27              if(j==k)
28                  C(i)=C(i)+A2(j,k)/i
29              end
30          end
31      end
32      printf('\nC%i=',i)
33      disp(C(i))
34      A1=A2;
35  end
36  printf('\n\n\nTherefore the characteristic
       polynomial is:\n 3    2\nx - %ix - %ix %i = 0',C
       (1),C(2),C(3))
37
38  //verification
39  printf('\n\nVerification:')
40  s=poly(0,"s");
41  p=poly(A,'x');
42  A=A-eye(3,3)*%s;
43  disp(p,'=',A)
```

Scilab code Exa 11.3 Danilevsky Method

```
1  //Example 11.3
2  //Danilevsky Method
3  //Page no. 341
4  clc;close;clear;
5
6  A=[-1,0,0;1,-2,3;0,2,-3];
7  G=[A;eye(3,3)];
8  disp(G);
9  //transformation to frobenius matrix
```

```
for k=3:-1:2
    g(k)=0;
    for j=1:k-1
        if(g(k)<G(k,j))
            g(k)=G(k,j)
            p=j;
        end
    end
    if(g(k)~=0)
        for j=1:3
            r(1,j)=G(k,j)
        end
        for i=1:6
            G(i,k-1)=G(i,k-1)/g(k)
        end
        disp(G)
        for j=1:3
            if(j~=k-1)
                l=G(k,j)
                for i=1:6
                    G(i,j)=G(i,j)-l*G(i,k-1)
                end
            end
        end
        disp(G)
    end
    for j=1:3
        for i=1:3
            c(i,1)=G(i,j)
        end
        G(k-1,j)=0
        for i=1:3
            G(k-1,j)=G(k-1,j)+r(1,i)*c(i,1)
        end
    end
    disp(G)
end

```

```
48 //partition g
49 for i=4:6
50     for j=1:3
51         T(i-3,j)=G(i,j)
52     end
53 end
54 disp(T,'T=')
55
56 //eigenvalues computation
57 printf('\n\n\nCharateristic polynomial:')
58 p=poly(A,'x')
59 disp(p)
60 printf('\n\n\nEigenvalues:')
61 a=roots(p)
62 disp(a')
63 //eigenvectors computation
64 for k=1:3
65     m=2
66     for l=1:3
67         y(l,k)=a(k,1)^(m)
68         m=m-1;
69     end
70 end
71 printf('\n\n')
72 disp(y,'y=')
73
74 //eigenvector computation
75
76 for k=1:3
77     for l=1:3
78         y1(l,1)=y(l,1)
79         y2(l,1)=y(l,2)
80         y3(l,1)=y(l,3)
81     end
82     x1=T*y3;
83     x2=T*y2;
84     x3=T*y1;
85 end
```

```
86 printf('\n\nEigenvectors :\n')
87 for i=1:3
88     printf('|%.1f|\t\t|%.1f|\t\t|%.1f| ',x1(i,1),x2(i
       ,1),x3(i,1))
89     printf('\n')
90 end
```

Scilab code Exa 11.4 Power Method

```
1  //Example 11.4
2  //Power Method
3  //Page no. 345
4  clc;close;clear;
5
6  A=[1,2;3,4];
7  e=0.001;
8  q0=[1;1];
9  for i=1:5
10     q1=A*q0;
11     a=max(q1)
12     for j=1:2
13         q2(j)=q1(j)/a;
14     end
15     printf('\nq(%i) = %.4f      a = %.4f      Scaled
       q(%i) = %.4f\n        %.4f
                                                %i\n\n',
       i,q1(1),a,i,q2(1),q1(2),q2(2))
16     q1=q2;
17     q0=q1;
18 end
19 printf('Hence the largest eigenvalue is %.4f with
    the corresponding eigenvector as %.4f\n
```

```
%i',a,q0(1),q0(2))
```

Scilab code Exa 11.5 Inverse Power Method

```
1  //Example 11.5
2  //Inverse Power Method
3  //Page no. 347
4  clc;close;clear;
5
6  A=[7,6,-3;-12,-20,24;-6,-12,16];
7  e=10^-6;
8  X=[1;1;1];
9  B=0;
10 Y=[0;0;0]
11 a=0;l=0;
12 for i=1:2
13     printf('When a=%i\n',a);
14     C=A-a*eye();
15     disp(C,"C=")
16     C_1=inv(C);
17     disp(C_1,"Inverse of C=");
18     printf('\n\nItr          lambda
                                    X')
19     printf('\n
          ------------------------------------------------------------------
          n')
20     for j=1:10
21         printf('\n%i          %f              %f       %f
                  %f',j-1,l,X(1),X(2),X(3));
22         Y=C_1*X;
23         B=max(Y);
24         e1=abs(l-B);
25         X=Y/B;
```

```
26          m=0;
27          for k=1:3
28              m=m+(Y(k)-X(k))^2;
29          end
30          e2=sqrt(m);
31          er=max(e1,e2);
32          if(er<e)
33              break
34          end
35          l=B;
36
37      end
38      a=-3;
39      printf('\n\n\n\n')
40  end
41  printf('\n\n\nNote : Computation of Y is wrong given
        in the book')
```

Scilab code Exa 11.6 Rayleigh Quotient

```
1  //Example 11.6
2  //Rayleigh Quotient
3  //Page no. 348
4  clc;close;clear;
5
6  A=[10,7,8,7;7,5,6,5;8,6,10,9;7,5,9,10];
7  q0=[1;1;1;1];
8  for i=0:4
9      X=(A^i)*q0;
10     l=(X'*A*X)/(X'*X)
11     printf('\nLambda(%i) = %f\n',i+1,l)
12 end
13 printf('\n\nDominant Eigenvalue = %f\n\n\n',l)
```

```
14
15 e=0.001;
16 for i=1:5
17     q1=A*q0;
18     a=max(q1)
19     for j=1:4
20         q2(j)=q1(j)/a;
21     end
22
23     q1=q2;
24     q0=q1;
25 end
26 disp(q2,'Corresponding Eigenvector = ')
```

Scilab code Exa 11.7 Jacobi Method

```
1 //Example 11.7
2 //Jacobi's Method
3 //Page no. 355
4 clc;close;clear;
5
6 A=[1,1,1/2;1,1,1/4;1/2,1/4,2];
7 C=A;
8 V=[sqrt(2),0,1/2;sqrt(2),0,1/4;3/(4*sqrt(2)),-1/(4*
    sqrt(2)),2]
9 S=eye(3,3)
10 disp(A,"A =")
11 VI=0;
12 for i=1:3
13     for j=1:3
14         if(i~=j)
15             VI=VI+A(i,j)^2
                //initial off diag norm
```

```
16          end
17      end
18  end
19  VI=sqrt(VI);
20  VF=VI*10^-7;        //final threshold
21  V1=VI/3;
22  o=poly(0,"o");
23  for i=1:3
24  for q=2:3
25      for p=q-1:-1:1
26          if(A(p,q)>V1)
27              a=-A(p,q);
28              b=(A(p,p)-A(q,q))/2
29              if(b~=0)
30                  w=b*abs(1/b)*(a/sqrt(a^2+b^2));
31              else
32                  w=(a/sqrt(a^2+b^2));
33              end
34              sin0=w/sqrt(2*(1+sqrt(1-w^2)));
35              cos0=sqrt(1-sin0^2)
36          end
37          B(p,p)=A(p,p)*cos0^2+A(q,q)*sin0^2-2*A(p,q)*
               sin0*cos0
38              B(q,q)=A(p,p)*sin0^2+A(q,q)*cos0^2+2*A(p
                   ,q)*sin0*cos0
39              B(p,q)=(A(p,p)-A(q,q))*sin0*cos0+A(p,q)
                   *(cos0^2-sin0^2)
40              S(i,i)=S(i,i)
41              S(i,p)=S(i,p)*cos0-S(i,q)*sin0
42              S(i,q)=S(i,p)*sin0+S(i,q)*cos0
43
44      end
45  end
46  end
47  disp(B,"B =")
48  disp(S,"S =")
49  printf('\n\n\nComputation error in the solution
       provided by book')
```

Scilab code Exa 11.8 Recursive Formula

```
1 //Example 11.8
2 //Recursive Formula
3 //Page no. 357
4 clc;close;clear;
5
6 A=[2,-1,0,0;-1,2,-1,0;0,-1,2,-1;0,0,-1,2];
7 l=poly(0,"l");
8 p0=1;
9 p1=A(1,1)-l;
10 for i=2:4
11     p2=(A(i,i)-l)*p1-A(i,i-1)^2*p0;
12     p0=p1;
13     p1=p2;
14     printf('\n\np%i(l) = ',i);
15     disp(p2)
16 end
```

Scilab code Exa 11.9 QR Method

```
1 //Example 11.9
2 //QR Method
3 //Page no. 360
4 clc;close;clear;
5
6 A=[2,-1,0;-1,2,-1;0,-1,2];
```

```
7  deff('y=c(i,j)','y=A(j,j)/sqrt((A(i,j)^2+A(j,j)^2))'
   )
8  deff('y=s2(i,j)','y=A(i,j)/sqrt((A(i,j)^2+A(j,j)^2))
   ')
9  disp(A,'A=')
10 l0=0;f=1;m=0;s=0;w=0;
11 for n=1:5
12     for j=1:2
13         for k=1:2
14             V(j,k)=A(j,k)
15         end
16     end
17     disp(V,'V=')
18     p=poly(V,'x');
19     disp('=0',p);
20     a=roots(p);
21     for j=1:2
22         printf('\na(%i) = %f',j,a(j))
23     end
24         if(abs(a(1)-V(1,1))<=abs(a(2)-V(1,1)))
25             a=a(1)
26         else
27             a=a(2)
28         end
29     printf('\na = %f\n',a)
30     s=s+a;
31     A=A-a*eye()
32     R=A;Q=eye(3,3);
33
34    for j=1:2
35        for i=j+1:3
36            for k=1:3              //C matrix
                 evaluation
37                for l=1:3
38                    if(k==l)
39                        if(k==i | k==j)
40                            C(k,l)=c(i,j)
41                        else
```

```
42                                  C(k,l)=1
43                              end
44                          end
45                          if(k>l)
46                              if(k==i & l==j)
47                                  C(k,l)=-1*s2(i,j)
48                             else
49                                  C(k,l)=0
50                              end
51                          end
52                          if(k<l)
53                              if(k==j & l==i)
54                                  C(k,l)=s2(i,j)
55                              else
56                                  C(k,l)=0
57                              end
58                          end
59                      end
60                end
61
62                 R=C*R;
63                 Q=Q*C';
64
65             end
66         end
67     disp(Q,'Q=',R,'R=')
68     disp(Q*R,'Q*R=')
69     A=R*Q;
70     disp(A,'A=')
71     end
72     l1=l0+s;
73     for i=2:3
74         for j=2:3
75             V(i-1,j-1)=A(i,j)
76         end
77     end
78     disp(V,'V=')
79         p=poly(V,'x');
```

```
80      disp('=0',p);
81      a=roots(p);
82      for j=1:2
83          printf('\na(%i) = %f',j,a(j))
84      end
85      l2=l1+a(1)
86      l3=l1+a(2)
87      disp(l3,'l3=',l2,'l2=',l1,'l1=')
88  printf('\n\n\nNote : Values of V varies in each step
        resulting in different results due to error in
    book calculation')
```

Scilab code Exa 11.10 LU Method

```
1  //Example 11.10
2  //LU Method
3  //Page no. 363
4  clc;close;clear;
5
6  A
       =[120,80,40,-16;80,120,16,-40;40,16,120,-80;-16,-40,-80,120];

7  disp(A,"A =")
8  L=eye(4,4);
9  for l=1:20
10 for j=1:4
11      for i=1:j
12          k=0
13          for p=1:i-1
14              k=k-A(i,p)*A(p,j)
15          end
16          A(i,j)=A(i,j)+k
17      end
```

```
18      for i=j+1:4
19          k=0;
20          for p=1:j-1
21              k=k-A(i,p)*A(p,j)
22          end
23          A(i,j)=(A(i,j)+k)/A(j,j)
24      end
25  end
26  disp(A,"Modified A = ")
27      for i=1:4
28      for j=1:4
29          if i>j then
30              L(i,j)=A(i,j)
31          else
32              U(i,j)=A(i,j)
33          end
34      end
35  end
36  disp(U,"U =",L,"L =")
37  A=U*L;
38  printf('\n\nAfter %i iterations, matrix A =\n\n',1)
39  for i=1:4
40      for j=1:4
41          printf('    %.2f\t',A(i,j))
42      end
43      printf('\n')
44  end
45  end
46  printf('\n\nTherefore the eigenvalues are the
       diagonal elements f the transformed triangular
       matrix are:\n\n')
47  for i=1:4
48      printf(' %.2f,',A(i,i))
49  end
```

Scilab code Exa 11.11 Generalized Eigenvalue Problem

```
1  //Example 11.11
2  //Generalized Eigenvalue Problem
3  //Page no. 365
4  clc;close;clear;
5
6  A=[1,1,0.5;1,1,0.25;0.5,0.25,2]
7  B=[2,2,2;2,5,5;2,5,11]
8  disp(B,"B =",A,"A =")
9  for i=1:3
10     G(i,i)=sqrt(B(i,i))
11 end
12 G=[B;eye(3,3)];
13
14 //transformation to frobenius matrix
15 for k=3:-1:2
16     g(k)=0;
17     for j=1:k-1
18         if(g(k)<G(k,j))
19             g(k)=G(k,j)
20             p=j;
21         end
22     end
23     if(g(k)~=0)
24         for j=1:3
25             r(1,j)=G(k,j)
26         end
27         for i=1:6
28             G(i,k-1)=G(i,k-1)/g(k)
29         end
30         for j=1:3
```

```
31              if(j~=k-1)
32                  l=G(k,j)
33                  for i=1:6
34                      G(i,j)=G(i,j)-l*G(i,k-1)
35                  end
36              end
37          end
38      end
39      for j=1:3
40          for i=1:3
41              c(i,1)=G(i,j)
42          end
43          G(k-1,j)=0
44          for i=1:3
45              G(k-1,j)=G(k-1,j)+r(1,i)*c(i,1)
46          end
47      end
48  end
49
50  //partition g
51  for i=4:6
52      for j=1:3
53          T(i-3,j)=G(i,j)
54      end
55  end
56
57  //eigenvalues computation
58  p=poly(B,'x')
59  a=roots(p)
60  printf('\n\nDiagonalized Matrix B = \n\n')
61  for i=1:3
62      for j=1:3
63          if i~=j then
64              B(i,j)=0
65          else
66              B(i,j)=a(i)
67          end
68      end
```

```
69  end
70  disp(B)
71  //eigenvectors computation
72  for k=1:3
73      m=2
74      for l=1:3
75          y(l,k)=a(k)^(m)
76          m=m-1;
77      end
78  end
79  printf('\n\n')
80
81
82  for k=1:3
83      for l=1:3
84          y1(l,1)=y(l,1)
85          y2(l,1)=y(l,2)
86          y3(l,1)=y(l,3)
87      end
88      x1=T*y3;
89      x2=T*y2;
90      x3=T*y1;
91  end
92  printf('\n\nEigenvectors of B are :\n\n')
93  for i=1:3
94      printf('|%.5f|\t\t|%.5f|\t\t|%.5f|',x3(i,1),x2(i
           ,1),x1(i,1))
95      printf('\n')
96  end
97  x=[x3,x2,x1]
98
99
100
101
102
103 B=[2,2,2;2,5,5;2,5,11]
104 G=0
105 for i=1:3
```

```
106     for j=1:3
107         if i==j then
108             G(i,j)=sqrt(B(i,j))
109         else
110             G(i,j)=0;
111         end
112     end
113 end
114 
115 B=inv(G)*x'*A*x*inv(G)
116 disp(B,"Eigenvectors of A =")
117 
118 printf('\n\n\nNote : Computation Error in book in
    caculation of eigenvector of B thus for A')
```

Chapter 12

Interpolation and Extrapolation

Scilab code Exa 12.1 Linear Interpolation Technique

```
1  //Example 12.1
2  //Linear Interpolation Technique
3  //Page no. 372
4  clc;close;clear;
5
6  printf('x:     ')
7  f=[1,4,9,16,25];
8  for i=1:5
9      printf('%i\t',i)
10 end
11 printf('\nf(x):   ')
12 for i=1:5
13     printf('%i\t',f(i))
14 end
15 x=2.5;
16 x1=2;x2=3;printf('\n\nfor (2,4) and (3,9)')
17 f(2.5)=f(x1)+(f(x2)-f(x1))*(x-x1)/(x2-x1)
```

```
18 printf('\nf(2.5) = %.1f',f(2.5))
19
20 x=2.5;
21 x1=2;x2=4;printf('\n\nfor (2,4) and (4,16)')
22 f(2.5)=f(x1)+(f(x2)-f(x1))*(x-x1)/(x2-x1)
23 printf('\nf(2.5) = %.1f',f(2.5))
24
25 x=2.5;
26 x1=1;x2=3;printf('\n\nfor (1,1) and (3,9)')
27 f(2.5)=f(x1)+(f(x2)-f(x1))*(x-x1)/(x2-x1)
28 printf('\nf(2.5) = %.1f',f(2.5))
29
30 printf('\n\nExact value = %.2f',2.5^2)
```

Scilab code Exa 12.2 Lagarangian Method

```
1  //Example 12.2
2  //Lagarangian Method
3  //Page no. 373
4  clc;close;clear;
5
6  xk=[-1,0,2,5];
7  yk=[10,7,7,22];
8
9  P=0;
10 x=poly(0,"x");
11 for k=0:3
12     p=yk(k+1)
13     for j=0:3
14         if(j~=k)
15             p=p*((x-xk(j+1))/(xk(k+1)-xk(j+1)))
16         end
17     end
```

```
18      P=P+p;
19  end
20  disp(P,'P=')
```

Scilab code Exa 12.3 Aitken Nevilles Method

```
1  //Example 12.3
2  //Aitken-Neville's Method
3  //Page no. 378
4  clc;close;clear;
5
6  function [x,y,z]=tran(a,b)          // function for
       exchanging values
7      z=a;y=b;x=z;
8  endfunction
9  deff('y=P(a,b,c,d,e)','y=(c(d)*b(d+1)-c(d+e)*b(d))/(
       a(d+e)-a(d))')  //function for finding
       polynomials
10 xi=[0.8,1,1.2,1.4,1.6];
11 yi=[2.2255,2.7183,3.3201,4.0552,4.9530];
12 x=1.23
13 [xi(5),xi(1),a]=tran(xi(1),xi(5))
14 [xi(4),xi(1),a]=tran(xi(1),xi(4))
15 [xi(3),xi(2),a]=tran(xi(2),xi(3))
16 [xi(2),xi(1),a]=tran(xi(1),xi(2))
17 [yi(5),yi(1),a]=tran(yi(1),yi(5))
18 [yi(4),yi(1),a]=tran(yi(1),yi(4))
19 [yi(3),yi(2),a]=tran(yi(2),yi(3))
20 [yi(2),yi(1),a]=tran(yi(1),yi(2))
21 for i=1:5
22     x_xi(i)=x-xi(i);
23 end
24 printf('xi      x-xi        yi\n')
```

```
25 printf('-------------------------\n')
26 for i=1:5
27     printf('%.1f      %.2f\t%f\n',xi(i),x_xi(i),yi(i)
       )
28 end
29 printf('\n\nPolynomials\n')
30 printf('-----------\n')
31 for i=1:4
32     for j=1:5-i
33          printf('%f\n',P(xi,yi,x_xi,j,i))
34          yi(j)=P(xi,yi,x_xi,j,i)
35     end
36     printf('\n\n\n')
37 end
```

Scilab code Exa 12.4 Newtons Divided Difference Interpolation

```
1  //Example 12.4
2  //Newton's Divided Difference Interpolation
3  //Page no. 381
4  clc;close;clear;
5
6  x=[0,1,2,3,4,5]
7  y=[1,2,5,10,17,26];
8  y1=y;
9  deff('yi=P(a,b,d,e)','yi=(b(d+1)-b(d))/(a(d+e)-a(d))
       ') //function for finding polynomials
10 for i=1:3
11     for j=1:6-i
12         z(j,i)=P(x,y,j,i)
13          y(j)=z(j,i)
14     end
15 end
```

```
z(6,1)=0;
printf('x      y          f(x0,x1)              f(x0,x1,x3)       f
    (x0,x1,x2,x3)\n')
printf('
    ------------------------------------------------------------\
    n')
      for j=1:6
          printf(' %i     %i \t%i\t\t%i\t\t%i\n',x(1,j)
              ,y1(1,j),z(j,1),z(j,2),z(j,3))
      end
x1=2.6;
f=y1(4)+(x1-x(4))*(z(4,1))+(x1-x(4))*(x1-x(5))*z
    (4,2)
printf('\n\nf(2.6)=%.2f',f)
```

Scilab code Exa 12.5 Interpolation Methods

```
//Example 12.5
//Interpolation Methods
//Page no. 403
clc;close;clear;

x=[0,1,2,3,4];
y=[0,1,8,27,64];

//Inverse lagrange Method
P=0;
y1=20;
for k=0:4
    p=x(k+1)
    for j=0:4
        if(j~=k)
            p=p*((y1-y(j+1))/(y(k+1)-y(j+1)))
```

```
17          end
18      end
19      P=P+p;
20  end
21  disp(P,'Inverse Lagrange interpolation x=')
22
23
24  //Newton's divide difference interpolation
25  x1=x;
26  deff('xi=P(a,b,d,y)','xi=(b(d+1)-b(d))/(a(d+y)-a(d))
    ')  //function for finding polynomials
27  for i=1:2
28      for j=1:5-i
29          z(j,i)=P(y,x,j,i)
30           x(j)=z(j,i)
31      end
32  end
33  z(5,1)=0;
34  printf('\n\n y\tx       f(y0,y1)          f(y0,y1,y3)\n
    ')
35  printf('-------------------------------------------------\n
    ')
36      for j=1:5
37          printf(' %i\t%i \t%i\t\t%i\t\n',y(1,j),x1(1,
              j),z(j,1),z(j,2))
38      end
39  y1=20;
40  f=x1(4)+(y1-y(4))*(z(4,1))+(y1-y(4))*(y1-y(5))*z
    (4,2)
41  printf('\n\nNewton Divide Difference x(20)=%.2f',f)
42
43  x=x1;
44  //Iterated Linear Interpolation
45  function [x,y,z]=tran(a,b)          // function for
    exchanging values
46      z=a;y=b;x=z;
47  endfunction
48  deff('y=P(a,b,c,d,e)','y=(c(d)*b(d+1)-c(d+e)*b(d))/(
```

```
    a(d+e)-a(d))')  //function for finding
    polynomials
y1=20

[y(4),y(1),a]=tran(y(1),y(4))
[y(3),y(2),a]=tran(y(2),y(3))
[x(4),x(1),a]=tran(x(1),x(4))
[x(3),x(2),a]=tran(x(2),x(3))
for i=1:5
    y1_y(i)=y1-y(i);
end
printf('y\ty1-y\tx\n')
printf('--------------------\n')
for i=1:5
    printf('%.1f\t%i\t%i\n',y(i),y1_y(i),x(i))
end
printf('\n\nPolynomials\n')
printf('------------\n')
for i=1:4
    for j=1:5-i
        printf('%f\n',P(y,x,y1_y,j,i))
        x(j)=P(y,x,y1_y,j,i)
    end
    printf('\n\n')
end
printf('Iterated Linear Interpolation x(20) = %f',x(
    j))

x=[0,1,2,3,4];
y=[0,1,8,27,64];
y1=y;
//Suggested Interpolation

for i=1:4
    for j=1:5-i
        z(j,i)=y(j+1)-y(j);
        y(j)=z(j,i)
    end
```

```
84 end
85 printf('\n\n\n x\ty\tdy\td2y\td3y\td4y\n')
86 printf('
   ------------------------------------------------------\n')
87 for i=1:5
88     printf(' %i\t%i\t%i\t%i\t%i\t%i\n',x(i),y1(i),z(
       i,1),z(i,2),z(i,3),z(i,4))
89 end
90 s=poly(0,'s')
91 p=y1(4);k=3;
92 for i=1:3
93     r=1;
94     for j=1:i
95         r=r*(s+(j-1))
96     end
97     r=r*z(k,i)/factorial(j);
98     k=k-1;
99     p=p+r;
100    printf('\n\nStage %i :',i)
101    disp(p)
102 end
103 s0=-7/19;
104 disp(s0,'s0=');
105 s1=(-7-s0*(s0+1)*6)/19
106 disp(s1,'s1=')
107 disp(3+s1,'x1=')
108 s2=(-7-s1*(s1+1)*6-s1*(s1+1)*(s1+2))/19
109 disp(s2,'s2=')
110 x2=3+s2;
111 disp(x2,'Suggested Interpolation x(20)=');
```

Scilab code Exa 12.6 Chebyshev Interpolating Polynomial

```
1  //Example 12.6
2  //Chebyshev Interpolating Polynomial
3  //Page no. 407
4  clc;close;clear;
5
6  deff('y=f(x)','y=1/(1+exp(-x))');
7  a=-2;b=2;n=3;
8  D=%pi/(2*n+2)
9  for k=0:n
10     t(k+1)=-cos(D*(2*k+1))
11     x(k+1)=((a+b)/2)+(b-a)*t(k+1)/2
12     y(k+1)=f(x(k+1))
13     C(k+1)=0
14 end
15 for j=0:n
16     for k=0:n
17         L=(2*k+1)*D
18         C(j+1)=C(j+1)+y(k+1)*cos(j*L)
19     end
20 end
21 C(1)=C(1)/(n+1);
22 for j=1:n
23     C(j+1)=2*C(j+1)/(n+1)
24 end
25
26 x=poly(0,"x")
27 T(1)=1;T(2)=x;
28 for j=1:n-1
29     T(j+2)=2*x*T(j+1)-T(j)
30 end
31 P=C(1)*T(1)
32 for j=1:n
33     P=P+C(j+1)*T(j+1)
34 end
35 disp(P,'P3(x)=')
36 printf('\n\n\nNote : Book has Calculation errors in
      calculation of coefficients')
```

Scilab code Exa 12.7 Double Interpolation

```
1 //Example 12.7
2 //Double Interpolation
3 //Page no. 409
4 clc;close;clear;
5
6 x=[0,1,2,3,4];
7 y=[0,1,2,3,4];
8 z
     =[0,1,8,27,64;1,3,11,31,69;4,7,16,37,76;9,13,23,45,85;16,21,32,55

9 printf('y / x')
10 for i=1:5
11     printf('\t%i',x(i))
12 end
13 for i=1:5
14     printf('\n %i',y(i))
15     for j=1:5
16         printf('\t%i',z(j,i))
17     end
18 end
19 printf('\n\n\n')
20 for i=1:5
21     x=2.5;
22     x1=2;x2=3;
23     z1(1,i)=z(i,x1+1)+(z(i,x2+1)-z(i,x1+1))*(x-x1)/(
         x2-x1)
24 end
25 printf('Values of z at x=2.5:\n\n  y')
26 for i=1:5
27     printf('\t%i',y(i))
```

```
28 end
29 printf('\n  z')
30 for i=1:5
31     printf('\t%g',z1(i))
32 end
33 y=1.5;
34 y1=1;y2=2;
35 z2=z1(y1+1)+(z1(y2+1)-z1(y1+1))*(y-y1)/(y2-y1)
36 printf('\n\nValue of z at x=2.5 and y=1.5 :  %g',z2)
```

Scilab code Exa 12.8 Spline Interpolation

```
1  //Example 12.8
2  //Spline Interpolation
3  //Page no. 414
4  clc;close;clear;
5
6  xi=[0.10,0.11,0.12,0.13,0.14,0.15,0.16,0.17];
7  yi
      =[0.1110,0.1234,0.1361,0.1491,0.1623,0.1759,0.1897,0.2038];

8  h=0.01;
9
10 pi(1)=0;qi(1)=0;pi(8)=0;qi(8)=0;
11 for i=2:7
12     pi(i)=-1/(4+pi(i-1))
13     qi(i)=((6/h^2)*(yi(i+1)-2*yi(i)+yi(i-1))-qi(i-1)
          )/(4+pi(i-1))
14 end
15 si2(8)=0;
16 si2(1)=0;si1(8)=0;
17 si1(1)=0;
18 for i=7:-1:2
```

```
19      si2(i)=pi(i)*si2(i+1)+qi(i)
20  end
21  for i=2:8
22      si1(i)=si1(i-1)+h*(si2(i)+si2(i-1))/2
23  end
24  printf('\n i\t xi\t fi\t   pi\t\t   qi\t\t  si2\t\t
        si1')
25  printf('\n
    ------------------------------------------------------------------------
    ')
26  for i=1:8
27      printf('\n %i\t%g\t%g\t%f\t%f\t%f\t%f',i,xi(i),
           yi(i),pi(i),qi(i),si2(i),si1(i))
28  end
29  x=0.1325;
30  i=4;
31  s=yi(i)+(x-xi(i))*si1(i)+(si2(i)*(x-xi(i))^2)/2+((
       si2(i+1)-si2(i))/(xi(i+1)-xi(i)))*((x-xi(i))^3)/6
32  printf('\n\nSpline Interpolated Value of s(0.1325)
       is : %f',s)
```

Chapter 13

Numerical Differentiation

Scilab code Exa 13.1 Differentiation

```
1  //Example 13.1
2  //Differentiation
3  //Page no. 420
4  clc;close;clear;
5
6  deff('y=f(x)','y=x^2+5')
7  deff('y=f1(x,h)','y=(f(x+h)-f(x))/h')
8  h=0.01;x=2.4
9  d=f1(x,h)
10 d1=(f1(x+h,h)-f1(x))/h
11 printf('dy\n -- = %g\n dx',d)
12 printf('\n\n\n d2y\n --- = %g\n dx2',d1)
```

Scilab code Exa 13.2 Calculation of x coordinate of Minimum Point

```
//Example 13.2
//Calculation of x-coordinate of Minimum Point
//Page no. 422
clc;close;clear;

for i=1:7
    for j=1:6
        z(i,j)=0
    end
end
h=0.2
printf('    x        y             d            d2
          d3          d4\n')
printf('
    ------------------------------------------------------------------------
    ')
for i=1:7
    z(i,1)=i/5;
end
z(1,2)=2.10022
z(2,2)=1.98730
z(3,2)=1.90940
z(4,2)=1.86672
z(5,2)=1.85937
z(6,2)=1.88755
z(7,2)=1.95147
for i=3:6
    for j=1:9-i
        z(j,i)=z(j+1,i-1)-z(j,i-1)
    end
end
disp(z)

s=poly(0,'s')
p=z(5,2);k=4;
for i=3:5
    r=1;
    for j=1:i-2
```

```
36          r=r*(s+(j-1))
37      end
38      r=r*z(k,i)/factorial(j);
39      k=k-1;
40      p=p+r;
41
42  end
43  disp(p)
44  s=(-z(4,3)+z(3,4)/2)/z(3,4)
45  disp(s,'s=')
46  x=z(5,1)+s*h
47  disp(x,'x=')
```

Scilab code Exa 13.3 Newton Forward Difference Formula

```
1  //Example 13.3
2  //Newton's Forward Difference Formula
3  //Page no. 423
4  clc;close;clear;
5  printf('   x\t\t    y\t\t    d\t\t    d2\t\t    d3\t
       \t    d4\n')
6  printf('
       ----------------------------------------------------------------------------
       ')
7  h=0.05;
8  z
       =[1.00,1.00000;1.05,1.02470;1.10,1.04881;1.15,1.07238;1.20,1.0954

9  deff('y=f1(x,s)','y=(z(x,3)+(s-1/2)*z(x,4)+z(x,5)
       *(3*s^2-6*s+2)/6)/h')
10 deff('y=f2(x,s)','y=(z(x,4)+z(x,5)*(s-1))/h^2')
11 deff('y=f3(x,s)','y=z(x,5)/h^3')
12 for i=3:6
```

```
13      for j=1:9-i
14          z(j,i)=z(j+1,i-1)-z(j,i-1)
15      end
16  end
17  printf('\n')
18  for i=1:7
19      for j=1:6
20          if z(i,j)==0 then
21              printf(' \t')
22          else
23              printf('%.7f\t',z(i,j))
24          end
25      end
26      printf('\n')
27  end
28  s=poly(0,'s')
29  p=z(5,2);k=4;
30  for i=3:5
31      r=1;
32      for j=1:i-2
33          r=r*(s+(j-1))
34      end
35      r=r*z(k,i)/factorial(j);
36      k=k-1;
37      p=p+r;
38
39  end
40  disp(p,'y(s) = ')
41  printf('\n\ny1(1) = %g',f1(1,0))
42  printf('\n\ny2(1) = %g',f2(1,0))
43  printf('\n\ny3(1) = %g',f3(1,0))
44  printf('\n\ny1(1.025) = %g',f1(1,0.5))
```

Scilab code Exa 13.4 Newton Backward Difference Formula

```
1 //Example 13.4
2 //Newton's Backward Difference Formula
3 //Page no. 425
4 clc;close;clear;
5 printf('   x\t\t    y\t\t    d\t\t    d2\t\t    d3\t
    \t    d4\n')
6 printf('
    ------------------------------------------------------------------------------
    ')
7 h=0.02;
8 z
    =[0.96,1.8025;0.98,1.7939;1.00,1.7851;1.02,1.7763;1.04,1.7673];

9 deff('y=f1(x,s)','y=(z(x,3)+(s+1/2)*z(x,4))/h')
10 for i=3:6
11     for j=1:7-i
12         z(j,i)=z(j+1,i-1)-z(j,i-1)
13     end
14 end
15 printf('\n')
16 for i=1:5
17     for j=1:6
18         if z(i,j)==0 then
19             printf(' \t')
20         else
21             printf('%.7f\t',z(i,j))
22         end
23     end
24     printf('\n')
25 end
26 printf('\n\ny1(1) = %g',f1(2,0))
27 printf('\n\ny1(1.03) = %g',f1(4,0.5))
```

Scilab code Exa 13.5 Stirlings Central Difference Derivatives

```
1 //Example 13.5
2 //Stirlings Central Difference Derivatives
3 //Page no. 426
4 clc;close;clear;
5 printf('    x\t\t    y\t\t    d\t\t    d2\t\t    d3\n
    ')
6 printf('
    ------------------------------------------------------------------------------
    ')
7 h=0.01;s=0.5;
8 deff('y=f1(x,s)','y=((z(x,3)+z(x-1,3))/2+s*z(x-1,4)
    +(z(x-1,5)+z(x-2,5))*(3*s^2-1)/12)/h')
9 deff('y=f2(x,s)','y=(z(x-1,4))/h^2')
10 deff('y=f3(x,s)','y=(z(x-1,5)+z(x-2,5))/(2*h^3)')
11 z
    =[1.00,1.00000;1.01,1.00499;1.02,1.00995;1.03,1.01489;1.04,1.0198

12 for i=3:5
13     for j=1:19-i
14         z(j,i)=z(j+1,i-1)-z(j,i-1)
15     end
16 end
17 printf('\n')
18 for i=1:17
19     for j=1:5
20         if z(i,j)==0 then
21             printf(' \t')
22         else
23             printf('%.7f\t',z(i,j))
24         end
```

```
25      end
26      printf('\n')
27  end
28  printf('\n\ny1(1.125) = %g    (exact value =
       0.4771404)',f1(13,0.5))
29  printf('\n\ny2(1.125) = %g    (exact value =
       -0.20951)',f2(13,0.5))
30  printf('\n\ny3(1.125) = %g    (exact value = 0.27935)
       ',f3(13,0.5))
```

Scilab code Exa 13.6 Extrapolation

```
1  //Example 13.6
2  //Extrapolation
3  //Page no. 430
4  clc;close;clear;
5  x=[-0.8,-0.6,-0.4,-0.2,0,0.2,0.4,0.6,0.8];
6  y
      =[0.2019,0.30119,0.44933,0.67032,1,1.49182,2.22554,3.32012,4.9530
7  for i=1:4
8      printf('\nh = %g\n',x(10-i))
9      y1=(y(10-i)-y(i))/(2*x(10-i))
10     printf('f1(0) = %g\n\n',y1)
11 end
```

Scilab code Exa 13.7 Richardson Extrapolation

```
1  //Example 13.7
```

```
2  //Richardson Extrapolation
3  //Page no. 431
4  clc;close;clear;
5
6  deff('y=f(x)','y=exp(2*x)')
7  e=10^-4;h=0.8;
8  D1=0;
9  for i=1:4
10     printf('\n')
11     for j=1:i
12         if j==1 then
13             D(i,j)=(f(h)-f(-h))/(2*h)
14         else
15             D(i,j)=D(i,j-1)+(D(i,j-1)-D(i-1,j-1))
                  /(2^(2*(j-1))-1)
16         end
17         printf('%g\t\t',D(i,j))
18     end
19     h=h/2
20 end
21 printf('\n\n\t\t\t\t\t\t  2x\nHence, the derivative
   of the function y = f(x) = e    at x=0 is D(3,3) =
    %g',D(i,j))
```

Scilab code Exa 13.8 Application

```
1  //Example 13.8
2  //Application
3  //Page no. 433
4  clc;close;clear;
5
6  deff('y=f(x)','y=2/x^2')
7  a=1;b=2;a1=1;b1=0;
```

```
N=4;
h=(b-a)/(N+1);
for j=1:N
    s(j)=f(a+j*h)
end
for i=1:N
    for j=1:N
        if abs(i-j)==1 then
            A(i,j)=-1
        end
        if i==j then
            A(i,j)=2+s(i)*h^2
        end
    end
    if i==1 then
        k(i,1)=s(i)+a1/h^2
    elseif i==N
        k(i,1)=s(i)+b1/h^2
    else
        k(i,1)=s(i)
    end
end
disp(A,'A = ')
disp(k,'k = ')
```

Chapter 14

Numerical Integration

Scilab code Exa 14.2 Simpsons 1 3rd Rule

```
1  //Example 14.2
2  //Simpsons 1/3rd Rule
3  //Page no 442
4  clc;clear;close;
5  x(1,1)=0
6  for i=2:9
7
8      x(1,i)=x(1,1)+(i-1)*10
9  end
10 y
      =[30,31.63,33.44,35.47,37.75,40.33,43.29,46.69,50.67]

11
12 //trapezoidal rule
13 S=0;
14 h=(x(9)-x(1))/8
15 for j=1:9
16     S=0;
17     for i=1:j
```

```
18          if(i==1 | i==j)
19              S=S+y(i)
20          else
21              S=S+2*y(i)
22          end
23      end
24      S=S*h/2
25      printf('\n Velocity at t (%i) = %.2f',x(j),S)
26      y1(j)=S
27  end
28
29  y1(1)=0;
30  //Simpsons 1/3rd Rule
31  S=0;
32  h=(x(9)-x(1))/8
33  for i=1:9
34      if(i==1 | i==9)
35          S=S+y1(i)
36      elseif(((i)/2)-fix((i)/2)==0)
37          S=S+4*y1(i)
38      else
39          S=S+2*y1(i)
40      end
41  end
42  S=S*h/3;
43  S=S/1000
44  printf('\n\nSimpsons 1/3rd Rule Sum = %g km',S)
```

Scilab code Exa 14.3 Trapezoidal Rule and Simpsons Rule

```
1  //Example 14.3
2  //Trapezoidal Rule and Simpsons Rule
3  //Page no. 442
```

```
clc;close;clear;
n=2;a=0;b=1;
h=(b-a)/n
deff('y=f(x)','y=1/(1+x)')
for i=0:2
    x(i+1)=i/2;
    y(i+1)=f(x(i+1))
end
printf('xi\t ')
for i=1:3
    printf('%g\t ',x(i))
end
printf('\n yi\t')
for i=1:3
    printf('1/%g\t',1+(i-1)/2)
end

//trapezoidal rule
S=0;
for i=1:3
    if(i==1 | i==3)
        S=S+y(i)
    else
        S=S+2*y(i)
    end
end
S=S*h/2
printf('\n\nTrapezoidal Rule Sum = %g',S)

//Simpsons 1/3rd Rule
S=0;
for i=1:3
    if(i==1 | i==3)
        S=S+y(i)
    elseif(((i)/2)-fix((i)/2)==0)
        S=S+4*y(i)
    else
        S=S+2*y(i)
```

```
42      end
43  end
44  S=S*h/3
45  printf('\n\nSimpsons 1/3rd Rule Sum = %g',S)
```

Scilab code Exa 14.5 Romberg Method

```
1  //Example 14.5
2  //Romberg Method
3  //Page no. 457
4  clc;close;clear;
5
6  deff('y=f(x)','y=1/(1+x)')
7
8  h=[0.5,0.25,0.125]
9  for k=1:3
10     for i=0:h(k):1
11         x(i/h(k)+1)=i;
12         y(i/h(k)+1)=f(x(i/h(k)+1))
13     end
14     n=1+(1/h(k))
15     //trapezoidal rule
16     S=0;
17      for i=1:n
18         if(i==1 | i==n)
19             S=S+y(i)
20         else
21             S=S+2*y(i)
22         end
23     end
24     S=S*h(k)/2
25     printf('\n\nI(%g) = %g',h(k),S)
26     z(2*k-1,1)=S
```

```
27 end
28 for i=2:3
29     for k=1:4-i
30     z(k*2+i-2,i)=z(2*k-1+i,i-1)+(z(2*k-1+i,i-1)-z(2*
          k-3+i,i-1))/3
31 end
32 end
33
34 printf('\n\n')
35 disp(z,'The Table of values:')
```

Scilab code Exa 14.7 Gaussian Quadrature Formula

```
1 //Example 14.7
2 //Gaussian Quadrature Formula
3 //Page no. 463
4 clc;close;clear;
5
6 deff('y=f(x)','y=cos(x)*log(x)')
7 s=0;
8 for i=0:2:2000
9     s=s+integrate('((-1)^(i/2))*(x^i)/factorial(i)*
          log(x)','x',0,1)
10 end
11 disp(s,'Till 1000 terms .... I =')
```

Scilab code Exa 14.8 Gauss Legendre Two Point Rule

```
1 //Example 14.8
```

```
2 //Gauss Legendre Two Point Rule
3 //Page no. 472
4 clc;close;clear;
5
6 deff('y=f(x)','y=1/(x+3)')
7 s=integrate('f(x)','x',-1,1)
8 printf('By Direct Method, I = %g',s)
9 s=f(-1/sqrt(3))+f(1/sqrt(3))
10 printf('\n\n By Gauss-Legendre 2 point rule, I = %g'
   ,s)
```

Scilab code Exa 14.9 Gauss Legendre Three Point Rule

```
1 //Example 14.9
2 //Gauss Legendre Three Point Rule
3 //Page no. 473
4 clc;close;clear;
5
6 deff('y=f(x)','y=1/(x+3)')
7 s=integrate('f(x)','x',-1,1)
8 printf('By Direct Method, I = %g',s)
9 s=5/9*f(-sqrt(3/5))+8/9*f(0)+5/9*f(sqrt(3/5))
10 printf('\n\n By Gauss-Legendre 3 point rule, I = %g'
   ,s)
```

Scilab code Exa 14.10 Spline Integration Method

```
1 //Example 14.10
2 //Spline Integration Method
```

```
3 //Page no. 478
4 clc;close;clear;
5
6 deff('y=f(x)','y=sind(%pi*x)')
7 deff('y=f1(x,h)','y=(f(x+h)-f(x))/h')
8 h=0.01;
9 n=2;h=0.5;a=0;b=1;
10 disp(integrate('f(x)','x',0,1),'I = ')
```

Scilab code Exa 14.11 Trapezoidal Rule

```
1 //Example 14.1
2 //Trapezoidal Rule
3 //Page no 440
4 clc;clear;close;
5 x1=1.46
6 for i=1:6
7     x(1,i)=x1+i/100
8 end
9 y=[3.86,3.90,3.96,4.02,4.06,4.12]
10
11 //trapezoidal rule
12 S=0;
13 h=(x(6)-x1)/6
14 for i=1:6
15     if(i==1 | i==6)
16         S=S+y(i)
17     else
18         S=S+2*y(i)
19     end
20 end
21 S=S*h/2
22 printf('\n I = %g',S)
```

Scilab code Exa 14.14 Trapezoidal and Simpsons Rule

```
1  //Example 14.14
2  //Trapezoidal and Simpsons Rule
3  //Page no. 486
4  clc;close;clear;
5
6  x(1)=0.5;y(1)=0.5;h=0.25
7  for i=2:3
8      x(i)=x(i-1)+h
9      y(i)=y(i-1)+h
10 end
11 printf(' y/x\t|\t%g\t%g\t%g',x(1),x(2),x(3))
12 printf('\n---------|------------------------------')
13 for i=1:3
14      printf('\n%g\t|\t',y(i))
15     for j=1:3
16         z(i,j)=x(j)*y(i)
17         printf('%g\t',z(i,j))
18     end
19 end
20
21 //trapezoidal rule
22 s=0;
23 for i=1:3
24     for j=1:3
25         if i==1 & j==1 then
26             s=s+z(i,j)
27         elseif i==3 & j==3
28             s=s+z(i,j)
29         else
30             s=s+2*z(i,j)
```

```
31          end
32      end
33  end
34  s=(s*(h^2))/4
35  printf('\n\n')
36  disp(s,'Trapezoidal Rule Sum = ')
37  printf('\n\n')
38  //simpsons rule
39  s=0;
40  for i=1:3
41      for j=1:3
42          if i/2-int(i/2)==0 & j/2-int(j/2)==0 then
43              s=s+16*z(i,j)
44          elseif i/2-int(i/2)~=0 & j/2-int(j/2)~=0
45              s=s+z(i,j)
46          else
47              s=s+4*z(i,j)
48          end
49      end
50  end
51  s=(s*(h^2))/9
52  disp(s,'Simpsons Rule Sum = ')
```

Scilab code Exa 14.15 Trapezoidal and Simpsons Rule

```
1  //Example 14.15
2  //Trapezoidal and Simpsons Rule
3  //Page no. 487
4  clc;close;clear;
5
6  x(1)=0;y(1)=0;h=0.25
7  for i=2:5
8      x(i)=x(i-1)+h
```

```
9       y(i)=y(i-1)+h
10  end
11  printf(' y/x\t|\t%g\t%g\t%g\t%g\t%g',x(1),x(2),x(3),
       x(4),x(5))
12  printf('\n
       ---------|-------------------------------------------------
       ')
13  for i=1:5
14       printf('\n%g\t|\t',y(i))
15      for j=1:5
16          z(i,j)=x(j)*y(i)
17          printf('%g\t',z(i,j))
18      end
19  end
20
21  //trapezoidal rule
22  s=0;
23  for i=1:5
24      for j=1:5
25          if i==1 & j==1 then
26              s=s+z(i,j)
27          elseif i==5 & j==5
28              s=s+z(i,j)
29          else
30              s=s+2*z(i,j)
31          end
32      end
33  end
34  s=(s*(h^2))/4
35  printf('\n\n')
36  disp(s,'Trapezoidal Rule Sum = ')
37  printf('\n\n')
38
39  //simpsons rule
40  s=0;
41  for i=1:5
42      for j=1:5
43          if i/2-int(i/2)==0 & j/2-int(j/2)==0 then
```

```
44              if i==j then
45                  s=s+16*z(i,j)
46              else
47                  s=s+4*z(i,j)
48              end
49
50          elseif i/2-int(i/2)~=0 & j/2-int(j/2)~=0
51              s=s+z(i,j)
52          else
53              s=s+4*z(i,j)
54          end
55      end
56  end
57  s=(s*(h^2))/9
58  disp(s,'Simpsons Rule Sum = ')
```

Scilab code Exa 14.16 Multiple Integration with Variable Limits

```
1  //Example 14.16
2  //Multiple Integration with Variable Limits
3  //Page no. 491
4  clc;close;clear;
5
6  deff('z=f(x)','z=x+1')
7  deff('z=f1(y)','z=(y+1)^3*(y+3)^2')
8  s=5/9*f(-sqrt(3/5))+8/9*f(0)+5/9*f(sqrt(3/5))
9  s=s*5/9*f1(-sqrt(3/5))+8/9*f1(0)+5/9*f1(sqrt(3/5))
10 s=s/256;
11 disp(s,'I = ')
```

Scilab code Exa 14.18 Integration

```
1 //Example 14.18
2 //Integration
3 //Page no. 494
4 clc;close;clear;
5
6 s=integrate('x^2*sin(x^2)','x',0,1)
7 disp(s,'I = ')
```

Scilab code Exa 14.19 Integration

```
1 //Example 14.19
2 //Integration
3 //Page no. 494
4 clc;close;clear;
5
6 s=integrate('sin(t)/t','t',1,999)
7 disp(s,'I = ')
```

Chapter 15

Numerical Solutions of Ordinary Differential Equations Initial Value Problem

Scilab code Exa 15.1 Ordinary Differential Equation

```
1 //Example 15.1
2 //Ordinary Differential Equation
3 //Page no. 503
4 clc;clear;close;
5 s=log(2)/log(1.02)
6 disp(s,'Time Taken = ')
```

Scilab code Exa 15.6 Taylor Method

```
1 //Example 15.6
```

```
2  //Taylor Method
3  //Page no. 510
4  clc;clear;close;
5
6  deff('y=f1(x,y)','y=x^2+y^2')
7  deff('y=f2(x,y)','y=2*x+2*y*f1(x,y)')
8  deff('y=f3(x,y)','y=2+2*f1(x,y)^2+2*y*f2(x,y)')
9  deff('y=f4(x,y)','y=6*f1(x,y)*f2(x,y)+2*y*f3(x,y)')
10 h=0.2;
11 for l=1:2
12     a=0;y=0;x=0;
13     printf('\n----------------\nh = %g\n
           ----------------\n',h)
14     for i=1:4
15     x=a+(i-1)*h
16     k=0;
17     for j=1:4
18     if j==1 then
19         k=k+(h^j)*f1(x,y)/factorial(j)
20     elseif j==2
21         k=k+(h^j)*f2(x,y)/factorial(j)
22     elseif j==3
23         k=k+(h^j)*f3(x,y)/factorial(j)
24     else
25         k=k+(h^j)*f4(x,y)/factorial(j)
26     end
27 end
28 y=y+k;
29 printf('\nx = %g\n\ny(%g) = %g\n\n',x,x+0.2,y)
30 end
31 h=h+0.2;
32 end
```

Scilab code Exa 15.7 Picard Method

```
1  //Example 15.7
2  //Picard Method
3  //Page no. 511
4  clc;clear;close;
5  deff('y=f(x,y)','y=x^2+y^2')
6  y(1)=0;
7  for i=1:2
8      y(i+1)=y(1)+integrate('f(x,y(i))','x',0,i/10)
9      printf('\n y(%g) = %g\n',i/10,y(i+1))
10 end
```

Scilab code Exa 15.8 Euler Method

```
1  //Example 15.8
2  //Euler Method
3  //Page no. 513
4  clc;clear;close;
5  deff('y=f(x,y)','y=x+y')
6  y(1)=1;
7  h=0.1;
8  for i=1:6
9      printf('\ny(%g) = %g\n',(i-1)/10,y(i))
10     y(i+1)=y(i)+h*f((i-1)/10,y(i))
11
12 end
```

Scilab code Exa 15.9 Trapezium Method

```
1  //Example 15.9
2  //Trapezium Method
3  //Page no. 516
4  clc;clear;close;
5  deff('y=f(x,y)','y=x*y^2')
6  y=1;
7  h=0.2;
8  y2=poly(0,'y2')
9  for i=1:2
10     x=(i-1)*h;
11     x1=x+h
12     y1=roots(-y2+y+h*(f(x,y)+f(x1,y2))/2)
13     printf('\n  Y(%i) = %g  or  %g\n',i,y1(1),y1(2))
14 end
```

Scilab code Exa 15.10 Heun Method

```
1  //Example 15.10
2  //Heun Method
3  //Page no. 517
4  clc;clear;close;
5  deff('y=f(x,y)','y=y*2/x')
6  y=2;
7  h=0.25;
8  for i=1:4
9      x=1+(i-1)*h
10     x1=x+h
11     ye=y+h*f(x,y)
12     y=y+h*(f(x,y)+f(x1,ye))/2
13     printf('\n  y(%g) = %g\n',x1,y)
14 end
```

Scilab code Exa 15.11 Midpoint Method

```
1 //Example 15.11
2 //Midpoint Method
3 //Page no. 518
4 clc;clear;close;
5 deff('y=f(x,y)','y=y+x')
6 y=1;
7 h=0.2;
8 printf('i\txi\tyi\tslope1\tslope2\ty(i+1)\n
    ----------------------------------------------------\n
    ')
9 for i=1:3
10     x=(i-1)*h
11     s1=f(x,y);
12     s2=f(x+h/2,y+s1*h/2);
13     printf(' %i\t%g\t%g\t%g\t%g',i-1,x,y,s1,s2)
14     y=y+s2*h;
15     printf('\t%g\n',y)
16 end
```

Scilab code Exa 15.12 Modified Midpoint Method

```
1 //Example 15.12
2 //Modified Midpoint Method
3 //Page no. 519
4 clc;clear;close;
5 deff('y=f(x,y)','y=y+x')
```

```
y=1;
h=0.2;
Z(1)=y;
Z(2)=Z(1)+h*f(0,Z(1))
printf('Z(%i) = %g',1,Z(2))
for i=2:5
    x=(i-1)*h;
    Y(i-1)=(Z(i)+Z(i-1)+h*f(x,Z(i)))/2
    Z(i+1)=Z(i-1)+2*h*f(x,Z(i))
    printf('\n Y(%i) = %g\n\n\n Z(%i) = %g',i-1,Y(i
       -1),i,Z(i+1))
end
printf('\n\n\n y4 = %g',(4*Y(4)-Y(2))/3)
```

Scilab code Exa 15.13 Single Step Method

```
//Example 15.13
//Single Step Method
//Page no. 521
clc;clear;close;

deff('y=f(x)','y=x^2')
deff('y=f1(x)','y=1/(1-x)')
y=1;h=0.2;
printf('n\tXn\tYn (by single-step method)\tYn (
   computed)\n
   ------------------------------------------------------------------------
   n')
for i=1:6
    x=(i-1)*h
    if i<6 then
        printf(' %i\t%.2f\t%.5f\t\t\t%.5f\n',i-1,x
           ,y,f1(x))
```

```
14      else
15          printf(' %i\t%.2f\t%.5f\t\t\t\t \n',i-1,x,y)
16      end
17      y=y+h*f(y);
18  end
```

Scilab code Exa 15.14 Second Order Runge Kutta Method

```
1  //Example 15.14
2  //Second Order Runge Kutta Method
3  //Page no. 525
4  clc;clear;close;
5
6  deff('y=f(x,y)','y=x-y')
7  y=1;x=1;h=0.1;
8  //simple runge kutta method
9  K1=h*f(x,y);
10 K2=h*f(x+h,y+K1);
11 y1=y+(K1+K2)/2
12 printf('\ny(1.1) by simple runge kutta method = %g\n
       \n',y1)
13
14 //euler cauchy method
15 K1=h*f(x,y);
16 K2=h*f(x+h/2,y+K1/2);
17 y1=y+(K1+K2)
18 printf('y(1.1) by euler cauchy method = %g\n\n',y1)
19
20 //optimal method
21 K1=h*f(x,y);
22 K2=h*f(x+2*h/3,y+2*K1/3);
23 y1=y+(K1+3*K2)/4
24 printf('y(1.1) by optimal method = %g',y1)
```

Scilab code Exa 15.15 Third Order Runge Kutta Method

```
1 //Example 15.15
2 //Third Order Runge Kutta Method
3 //Page no. 526
4 clc;clear;close;
5 deff('y=f(x,y)','y=x-y')
6 y=1;x=1;h=0.1;
7 //scheme 1
8 K1=h*f(x,y);
9 K2=h*f(x+h/2,y+K1/2);
10 K3=h*f(x+h/2,y-K1+2*K2);
11 y1=y+(K1+4*K2+K3)/6
12 printf('\ny(1.1) by scheme 1 = %g\n\n',y1)
13
14 //scheme 2
15 K1=h*f(x,y);
16 K2=h*f(x+h/3,y+K1/3);
17 K3=h*f(x+2*h/3,y+2*K2/3);
18 y1=y+(K1+3*K3)/4
19 printf('\ny(1.1) by scheme 2 = %.7f\n\n',y1)
```

Scilab code Exa 15.16 Fourth Order Runge Kutta Method

```
1 //Example 15.16
2 //Fourth Order Runge Kutta Method
3 //Page no. 528
```

```
clc;clear;close;
deff('y=f(x,y)','y=x-y')
y=1;x=1;h=0.1;
K1=h*f(x,y);
K2=h*f(x+h/2,y+K1/2);
K3=h*f(x+h/2,y+K2/2);
K4=h*f(x+h,y+K3);
disp(K4,'K4 =',K3,'K3 =',K2,'K2 =',K1,'K1 =')
y1=y+(K1+2*K2+2*K3+K4)/6
printf('\ny(1.1) = %.8f\n\n',y1)
```

Scilab code Exa 15.17 New Variant of Runge Kutta Method

```
//Example 15.17
//New Variant of Runge Kutta Method
//Page no. 530
clc;clear;close;
deff('y=f(x,y)','y=x-y')
y=1;x=1;h=0.1;
K1=h*f(x,y);
K2=h*f(x+h/2,y+K1/2);
K3=h*f(x+h/2,y+K2/2);
K4=h*f(x+h,y+K3);
K5=h*f(x+3*h/4,y+(5*K1+7*K2+13*K3-K4)/32)
disp(K5,'K5 =',K4,'K4 =',K3,'K3 =',K2,'K2 =',K1,'K1
   =')
y1=y+(K1+2*K2+2*K3+K5)/6
printf('\ny(1.1) = %.8f\n\n',y1)
```

Scilab code Exa 15.18 Runge Kutta Merson Method

```
1  //Example 15.18
2  //Runge Kutta Merson Method
3  //Page no. 532
4  clc;clear;close;
5  deff('y=f(x,y)','y=x+y')
6  y=1;x=0;h=0.1;
7  printf('n\t Xn\t Yn\t K1\t K2\t K3\t K4\t K5\tY(n+1)
       \n
       ----------------------------------------------------------------------------
       ')
8  for i=0:14
9      K1=h*f(x,y);
10 K2=h*f(x+h/3,y+K1/3);
11 K3=h*f(x+h/3,y+(K1+K2)/6);
12 K4=h*f(x+h/2,y+(K1+3*K3)/8);
13 K5=h*f(x+h,y+(K1-3*K3+4*K4)/2)
14 y1=y+(K1+4*K4+K5)/6
15 printf('\n %i\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%
       .3f\t%.3f',i,x,y,K1,K2,K3,K4,K5,y1)
16 y=y1;
17 x=x+h;
18 end
```

Scilab code Exa 15.19 Runge Kutta Fehlberg Method

```
1  //Example 15.19
2  //Runge Kutta Fehlberg Method
3  //Page no. 535
4  clc;clear;close;
5  deff('y=f(x,y)','y=x-y')
6  y=1;x=1;h=0.1;
```

```
K1=h*f(x,y);
K2=h*f(x+h/4,y+K1/4);
K3=h*f(x+3*h/8,y+3*(K1+3*K2)/32);
K4=h*f(x+12*h/13,y+1932*K1/2197-7200*K2/2197+7296*K3
   /2197);
K5=h*f(x+h,y+439*K1/216-8*K2+3680*K3/513-845*K4
   /4104)
K6=h*f(x+h/2,y-8*K1/27+2*K2-3544*K3/2565+1859*K4
   /4104-11*K5/40)
disp(K6,'K6 =',K5,'K5 =',K4,'K4 =',K3,'K3 =',K2,'K2
   =',K1,'K1 =')
y1=y+(25*K1/216+1408*K3/2565+2197*K4/4104-K5/5)
y11=y+(16*K1/135+6656*K3/12825+28561*K4/56430-9*K5
   /50+2*K6/55)
printf('\ny(1.1) = %.9f\n\n',y1)
printf('\ny~(1.1) = %.9f\n\n',y11)
```

Scilab code Exa 15.20 Carp Karp Runge Kutta Method

```
//Example 15.20
//Carp Karp Runge Kutta Method
//Page no. 537
clc;clear;close;
deff('y=f(x,y)','y=x-y')
y=1;x=1;h=0.1;printf('\n')
U=[0,1/5,3/10,3/5,1,7/8];
v
   =[0,0,0,0,0;1/5,0,0,0,0;3/40,9/40,0,0,0;3/10,-9/10,6/5,0,0;-11/54

a=[37/378,0,250/621,125/594,0,512/1771];
a1
   =[2825/27648,0,18575/48384,13525/55296,277/14336,1/4];
```

```
for l=1:5
    K(1)=h*f(x,y);
for i=2:6
    k=0;
    for j=1:i-1
        k=k+v(i,j)*K(j)
    end
    K(i)=h*f(x+U(i)*h,y+k)
end
k=0;
for i=1:6
    k=k+a(i)*K(i)
end
y1=y+k;
k=0;
for i=1:6
    k=k+a1(i)*K(i)
end
y11=y+k;
for i=1:6
    printf('K%i = %.9f\n',i,K(i))
end
printf('\ny(1.1) = Y%i = %.9f\n',l,y1)
printf('y~(1.1) = Y%i~ = %.9f\n',l,y11)
y=y1;
printf('\n\n\n')
end
```

Scilab code Exa 15.21 Implicit Runge Kutta Method

```
//Example 15.21
//Implicit Runge Kutta Method
//Page no. 539
```

```
clc;clear;close;
deff('y=f(x,y)','y=x-y')
y=1;x=1;h=0.1;printf('\n')
U=[0,1/5];
v=[0,0;1/2,1/2];
a2=1;
K(1)=h*f(x,y);
K(2)=(x+h/2-y-K(1)/2)/(1/h-1/2)
y1=y+(K(1)+a2*K(2))
printf('\ny(1.1) = %.9f\n\n',y1)
```

Scilab code Exa 15.22 Linear Multi Step Method

```
//Example 15.22
//Linear Multi Step Method
//Page no. 540
clc;clear;close;
deff('y=f(x,y)','y=x+y')
y(1)=1;y(2)=1;x(1)=0;h=0.1;
printf('n\tXn\t\tYn\t\tfn\n
   ------------------------------------------------------\n
    0\t%g\t\t%.3f\t\t%.3f\n',x(1),y(1),f(x(1),y(1)))
   ;
for i=2:11
    x(i)=(i-1)*h;
    y(i+1)=(-y(i)-y(i-1)+h*(f(x(i),y(i))+f(x(i-1),y(
       i-1))))/2;
    printf(' %i\t%.3f\t\t%.3f\t\t%.3f\n',i-1,x(i),y(
       i),f(x(i),y(i)))
end
```

Scilab code Exa 15.23 Milne Simpson Predictor Corrector Method

```
1 //Example 15.23
2 //Milne Simpson Predictor Corrector Method
3 //Page no. 544
4 clc;clear;close;
5 deff('y=f(x,y)','y=y+exp(x)')
6 h=0.5;
7 y=[1,1.824,3.718,7.722]
8 for i=1:4
9     x=(i-1)*h;
10    f1(i)=f(x,y(i));
11    printf('\nf%i = %g',i-1,f1(i))
12 end
13 y41=y(1)+4*h*(2*f1(4)-f1(3)+2*f1(2))/3
14 f4=f(x+h,y41);
15 y4=y(3)+h*(f4+4*f1(4)+f1(3))/3
16 printf('\n\n\nPredictor = %.9f\n\n',y41)
17 printf('Evaluator = %.9f\n\n',f4)
18 printf('Corrector = %.9f',y4)
```

Scilab code Exa 15.24 Improved Milne Simpson Predictor Corrector Method

```
1 //Example 15.24
2 //Improved Milne Simpson Predictor Corrector Method
3 //Page no. 546
4 clc;clear;close;
5
```

```
deff('y=f(x,y)','y=y-x^2')
y(1)=1;h=0.25;x=0;
printf('n\tXn\tYn\tfn\tY`n\tYn\tY`n+1\tm(n+1)\tv(n+1)\n
   ------------------------------------------------------------------------------
   n')
f1(1)=f(x,y(1));
for i=1:3
    K1=h*f(x,y(i));
    K2=h*f(x+2*h/3,y(i)+2*K1/3);
    y(i+1)=y(i)+(K1+3*K2)/4
    printf(' %i\t%.3f\t%.3f\t%.3f\n',i-1,x,y(i),f1(i))
    x=x+h
    f1(i+1)=f(x,y(i+1))
end
Y31=0
for i=3:10
    Y41=y(i-2)+4*h*(2*f1(4)-f1(3)+2*f1(2))/3        //predictor
    m4=Y41+28*(y(i+1)-Y31)/29    //modifier
    v4=f(x+h,m4)      //evaluator
    Y4=y(i)+h*(v4+4*f1(4)+f1(3))/3        //corrector
    printf(' %i\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\n',i,x,y(i+1),f1(4),Y31,y(i+1),Y41,m4,v4)
    y(i+2)=Y4
    Y31=Y41;
    f1(2)=f1(3);
    f1(3)=f1(4);
    f1(4)=f(x+h,y(i+2))
    x=x+h
end
```

Scilab code Exa 15.25 Hamming Predictor Corrector Method

```
1  //Example 15.25
2  //Hamming Predictor Corrector Method
3  //Page no. 548
4  clc;clear;close;
5
6  deff('y=f(x,y)','y=y-x^2')
7  y(1)=1;h=0.25;x=0;
8  printf('n\tXn\tYn\tfn\tY'n\tYc(n)\tY'n+1\tm(n+1)\tv(
       n+1)\tYc(n+1)\n
       ------------------------------------------------------------------------
       n')
9  f1(1)=f(x,y(1));
10 for i=1:3
11     K1=h*f(x,y(i));
12     K2=h*f(x+2*h/3,y(i)+2*K1/3);
13     y(i+1)=y(i)+(K1+3*K2)/4
14     printf(' %i\t%.3f\t%.3f\t%.3f\n',i-1,x,y(i),f1(i
           ))
15     x=x+h
16     f1(i+1)=f(x,y(i+1))
17 end
18 Y31=y(4);Yc=0
19 for i=3:10
20     Y41=y(i-2)+4*h*(2*f1(4)-f1(3)+2*f1(2))/3   //
           predictor
21     m4=Y41+112*(Y31-Yc)/121      //modifier
22     v4=f(x+h,m4)                 //evaluator
23     Y4c=(9*y(i+1)-y(i-1))/8+3*h*(v4+2*f1(4)-f1(3))/8
           //corrector
24     Y4=Y4c+9*(Y41-Y4c)/121          //final value
25     printf(' %i\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\
           t%.3f\t%.3f\t%.3f\n',i,x,y(i+1),f1(4),Y31,Yc,
           Y41,m4,v4,Y4c)
26     y(i+2)=Y4
27     Y31=Y41;
28     f1(2)=f1(3);
```

```
29      f1(3)=f1(4);
30      f1(4)=f(x+h,y(i+2))
31      Yc=Y4c
32      x=x+h
33  end
```

Scilab code Exa 15.26 Multi Valued Method

```
1  //Example 15.26
2  //Multi Valued Method
3  //Page no. 553
4  clc;clear;close;
5
6  deff('y=f1(x,y)','y=2*x^2-y')
7  h=0.1;x=0;y=-1;
8  deff('y=f2(x,y)','y=4*x-f1(x,y)')
9  deff('y=f3(x,y)','y=4-f2(x,y)')
10 B=[1,1,1,1;0,1,2,3;0,0,1,3;0,0,0,1];
11 y0=[y;h*f1(x,y);h^2*f2(x,y)/2;h^3*f3(x,y)/6]
12 y01=y0;
13 r=[0;1;3/4;1/6]
14
15 disp(r,'If r = ')
16 printf('\n\n
     ------------------------------------------------------------------------
     nx = 0\t\t\tx = 0.1\t\t\t\tx = 0.2\n\t')
17 for i=1:2
18      y11=B*y01
19      s(i)=h*(f1(x+h,y11(1)))-y11(2)
20      y1=y11+s(i)*r
21      if i==2 then
22          break
23      end
```

```
24      y2=y1;
25      y22=y11;
26      y01=y1
27  end
28  printf('\t    (s = %.5g)\t\t    (s = %.9f)\n
      ------------------------------------------------------------------------
      n    Y0\t\t    Y'i\t\t    Y1\t\t    Y'2\t\t    Y2\n
      ------------------------------------------------------------------------
      n',s(1),s(2))
29  for i=1:4
30      printf('%.5f \t%.5f \t%.5f \t%.5f \t%.5f\n',y0(i
          ),y22(i),y2(i),y11(i),y1(i))
31  end
32  y0=[y;h*f1(x,y);h^2*f2(x,y)/2;h^3*f3(x,y)/6]
33  y01=y0;
34  r=[5/12;1;3/4;1/6]
35  disp(r,'If r = ')
36  printf('\n\n
      ------------------------------------------------------------------------
      nx = 0\t\t\tx = 0.1\t\t\t\tx = 0.2\n\t')
37  for i=1:2
38      y11=B*y01
39      s(i)=h*(f1(x+h,y11(1)))-y11(2)
40      y1=y11+s(i)*r
41      if i==2 then
42          break
43      end
44      y2=y1;
45      y22=y11;
46      y01=y1
47  end
48  printf('\t    (s = %.5g)\t\t    (s = %.9f)\n
      ------------------------------------------------------------------------
      n    Y0\t\t    Y'i\t\t    Y1\t\t    Y'2\t\t    Y2\n
      ------------------------------------------------------------------------
      n',s(1),s(2))
49  for i=1:4
50      printf('%.5f \t%.5f \t%.5f \t%.5f \t%.5f\n',y0(i
```

```
        ),y22(i),y2(i),y11(i),y1(i))
51 end
```

Scilab code Exa 15.27 First order ODE

```
1  //Example 15.27
2  //First order ODE
3  //Page no. 558
4  clc;clear;close;
5
6  deff('y=f1(x,y1,y2)','y=y1*y2+x')
7  deff('y=f2(x,y1,y2)','y=y1-x')
8  h=0.2;x=0;y1=0;y2=1;
9  //heun method
10 printf('Heun Method:\n\n x\ty1\ty2\n
     ----------------------------\n')
11 Y=[y1;y2]
12 for i=1:8
13
14     F=[f1(x,Y(1),Y(2));f2(x,Y(1),Y(2))]
15     Y1=Y+h*F
16     x=x+h;
17     F1=[f1(x,Y1(1),Y1(2));f2(x,Y1(1),Y1(2))]
18     Y=Y+(h/2)*(F+F1)
19     printf(' %g\t%.3f\t%.3f\n',x-h,Y(1),Y(2))
20
21 end
22
23 //classical runge kutta method
24 printf('\n\n\nClassical Runge Kutta Method:\n\n n\tx
     \tYn\tK1\tK2\tK3\tK4\tY(n+1)\n
     ------------------------------------------------------------------
     n')
```

```
Y=[y1;y2];x=0;
for i=1:6
    K1=h*[f1(x,Y(1),Y(2));f2(x,Y(1),Y(2))]
    K2=h*[f1(x+h/2,Y(1)+K1(1)/2,Y(2)+K1(2)/2);f2(x+h
       /2,Y(1)+K1(1)/2,Y(2)+K1(2)/2)]
    K3=h*[f1(x+h/2,Y(1)+K2(1)/2,Y(2)+K2(2)/2);f2(x+h
       /2,Y(1)+K2(1)/2,Y(2)+K2(2)/2)]
    K4=h*[f1(x+h,Y(1)+K3(1),Y(2)+K3(2));f2(x+h,Y(1)+
       K3(1),Y(2)+K3(2))]
    Y1=Y+(K1+2*K2+2*K3+K4)/6
    printf(' %i\t%.2f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\
       t%.3f\n\t\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f
       \n
       ------------------------------------------------------------------------------------------
       n',i-1,x,Y(1),K1(1),K2(1),K3(1),K4(1),Y1(1),Y
       (2),K1(2),K2(2),K3(2),K4(2),Y1(2))
    Y=Y1;
    x=x+h
end
```

Scilab code Exa 15.28 Differential Equation

```
//Example 15.28
//Differential Equation
//Page no. 562
clc;clear;close;

deff('y=f(x,y)','y=2*y^2/(1+x)')
h=0.1;z(1)=-1;
for i=1:11
    printf('\nZ(%g) = %g\n',(i-1)/10,z(i))
    z(i+1)=z(i)+h*f((i-1)/10,z(i))
end
```

Chapter 16

Numerical Solutions of Ordinary Differential Equations Boundary Value Problems

Scilab code Exa 16.1 Outline of Linear Shooting Method

```
1  //Example 16.1
2  //Outline of Linear Shooting Method
3  //Page no. 572
4  clc;close;clear;
5
6  deff('y=f(x)','y=x^2');
7  h=0.5;X0=0;Y0=1;Z1=[-1,-1.5,-1.1771];i=1;Y1=Y0;
8  for j=1:3
9      Z0=Z1(i);
10     i=i+1
11     Y0=1;
12     for n=1:2
13         printf('\nFor n = %i\n
               ----------\n',n-1)
14         K1(1)=h*Z0;
```

```
15          printf('\n K11 = %g',K1(1));
16          K1(2)=h*f(Y0);
17          printf('\n K12 = %g',K1(2));
18          K2=h*f(Y0+K1(2))
19          printf('\n K22 = %g',K2);
20          Z0=Z0+(K1(2)+K2)/2
21          printf('\n Z%i = %g',n,Z0);
22          K2=h*Z0;
23          printf('\n K21 = %g',K2);
24          Y0=Y0+(K1(1)+K2)/2
25          printf('\n Y%i = %g',n,Y0);
26          printf('\n\n\n')
27          if n==1 then
28              Y2=Y0
29          end
30      end
31      printf('\n\n\n')
32  end
33  printf('Hence the solution is y(%g) = %i, y(%g) = %
    .4f   and   y(%g) = %.1f',X0,Y1,X0+h,Y2,X0+2*h,Y0)
```

Scilab code Exa 16.2 Linear Shooting Method

```
1  //Example 16.2
2  //Linear Shooting Method
3  //Page no. 576
4  clc;close;clear;
5
6  deff('y=f1(x,y,y1)','y=-x*y1+x^2*y+2*x^3')
7  deff('y=F1(x,y,y1)','y=-x*y1+x^2*y+2*x^3')
8  deff('y=F2(x,y,y1)','y=-x*y1+x^2*y')
9  a=0;b=1;
10 y0=1;y1=-1;n=5;
```

```
h=(b-a)/n
y=y0;y01=0;x=a;
for i=0:5
    yi1(1,i+1)=y
    K1=h*y01;
    R1=h*F1(x,y,y01);
    K2=h*(y+R1/2);
    R2=h*F1(x+h/2,y+K1/2,y01+R1/2)
    K3=h*(y01+R2/2)
    R3=h*F1(x+h/2,y+K2/2,y01+R2/2)
    K4=h*(y+R3)
    R4=h*F1(x+h,y+K3,y01+R3)
    y=y+(K1+2*K2+2*K3+K4)/6
    y01=y01+(R1+2*R2+2*R3+R4)/6
    x=x+h
end
y=0;y01=1;x=a;
for i=0:5
    yi2(1,i+1)=y
    K1=h*y01;
    R1=h*F2(x,y,y01);
    K2=h*(y+R1/2);
    R2=h*F2(x+h/2,y+K1/2,y01+R1/2)
    K3=h*(y01+R2/2)
    R3=h*F2(x+h/2,y+K2/2,y01+R2/2)
    K4=h*(y+R3)
    R4=h*F2(x+h,y+K3,y01+R3)
    y=y+(K1+2*K2+2*K3+K4)/6
    y01=y01+(R1+2*R2+2*R3+R4)/6
    x=x+h
end
for i=1:6
    yi(i)=yi1(1,i)+((y1-yi1(6))/yi2(6))*yi2(i)
end
y=1;x=a;y01=y1
for i=0:5
    yir(1,i+1)=y;
    K1=h*y01;
```

```
49      R1=h*f1(x,y,y01);
50      K2=h*(y+R1/2);
51      R2=h*f1(x+h/2,y+K1/2,y01+R1/2)
52      K3=h*(y01+R2/2)
53      R3=h*f1(x+h/2,y+K2/2,y01+R2/2)
54      K4=h*(y+R3)
55      R4=h*f1(x+h,y+K3,y01+R3)
56      y=y+(K1+2*K2+2*K3+K4)/6
57      y01=y01+(R1+2*R2+2*R3+R4)/6
58      x=x+h
59  end
60  x=a;
61  printf('\n
    ------------------------------------------------------------------------
    n\tx')
62  for i=1:6
63      printf('\t%.1f\t',x)
64      x=x+h
65  end
66  printf('\n\ty')
67  for i=1:6
68      printf('\t%.4f\t',yi(i))
69  end
70  printf('\n     by RK')
71  for i=1:6
72      printf('\t%.4f\t',yir(i))
73  end
74  printf('\n
    ------------------------------------------------------------------------
    ')
75  printf('\n\n\nNote: Computation error in calculation
    of values by RK method performed in book')
```

Scilab code Exa 16.3 Multiple Shooting Method

```
1  //Example 16.3
2  //Multiple Shooting Method
3  //Page no. 577
4  clc;close;clear;
5
6  h=0.25;x=0;y1=0;
7  deff('y=f(x)','y=-(4*h^2)/(1+x)^2')
8  deff('y=f1(x)','y=-2*(1+(h^2)/(1+x)^2)')
9
10 for i=1:4
11     x=x+h
12     B(i)=f(x);
13     for j=1:4
14         if i==4 & i==j
15             A(i,j)=f1(x)+1/4
16             A(i,j-1)=2
17         elseif j==i then
18             A(i,j)=f1(x)
19             A(i,j+1)=1
20             if j-1~=0 then
21                 A(i,j-1)=1
22             end
23         end
24     end
25 end
26 y=inv(A)*B
27 disp(B,"B =",A,'A = ')
28 printf('\n\n\n x :')
29 for i=1:5
30     printf('\t%.2f',x)
31     x=x+h
32 end
33 x=0;printf('\n y :\t%.2f',y1);
34 for i=1:4
35     printf('\t%.4f',y(i))
36 end
```

Scilab code Exa 16.4 Finite Difference Method

```
1  //Example 16.4
2  //Finite Difference Method
3  //Page no. 582
4  clc;close;clear;
5
6  x=0;h=0.25;q=-1;Y(1)=-2;Y(5)=1;
7  printf('\n i\txi\tYi\tpi\tqi\tri\n
       ----------------------------------------------------\n
       ')
8  for i=1:5
9      r(i)=-x^2
10     if i>1 & i<5 then
11         printf(' %i\t%g\t%s\t%g\t%i\t%g\n',i-1,x,"?"
               ,x,q,r(i))
12     else
13         printf(' %i\t%g\t%g\t%g\t%i\t%g\n',i-1,x,Y(i
               ),x,q,r(i))
14     end
15     x=x+h
16 end
17 x=0;
18 printf('
       ----------------------------------------------------\n
       ')
19 for i=1:3
20     x=x+h
21     for j=1:3
22         if i==j then
23             A(i,j)=2+h^2*q
24         elseif i<j & abs(i-j)~=2
```

```
25              A(i,j)=-1+h*x/2
26          elseif i>j & abs(i-j)~=2
27              A(i,j)=-1-h*x/2
28          end
29      end
30      if i==3 then
31          B(i)=-h^2*r(i+1)+(-h*x/2+1)*Y(1+2*(i-1))
32      else
33          B(i)=-h^2*r(i+1)+(h*x/2+1)*Y(1+2*(i-1))
34      end
35      B(i)=(-1)^(i+1)*B(i)
36  end
37  disp(B,"B =",A,'A = ')
38  y=inv(A)*B
39  for i=1:3
40      Y(i+1)=y(i)
41  end
42  x=0;
43  disp("The Solution is :",B,"B =",A,'A = ')
44  printf(' x :')
45  for i=1:5
46      printf('\t %.2f',x)
47      x=x+h
48  end
49  x=0;printf('\n y :');
50  for i=1:5
51      printf('\t%.3f',Y(i))
52  end
```

Scilab code Exa 16.5 Non Linear Problem

```
1  //Example 16.5
2  //Non Linear Problem
```

```
3  //Page no. 584
4  clc;close;clear;
5
6  deff('y=f(x)','y=2/(1+x)')
7  Y=[1,0.75,0.75,0.75,0.5];h=0.25
8  A=[-2,1,0;1,-2,1;0,1,-2];A_1=inv(A)
9  disp(A_1,"Inverse of A =",A,"A =")
10 printf('\nThe Solution of the system is: \n\n
      Iteration\t  Y0\t\t  Y1\t\t  Y2\t\t  Y3\t\t  Y4\n
      ------------------------------------------------------------------------------
      ')
11 for i=0:6
12     printf('\n      %i',i)
13     for j=1:5
14         if j<4 & i~=0 then
15             Y(j+1)=y(j)
16         end
17         printf('\t\t%.4f',Y(j))
18     end
19     x=0;
20     for j=1:3
21         x=x+h
22         if j~=2 then
23             B(j)=h^2*f(x)*Y(j+1)^2-Y(1+2*(j-1))
24         else
25             B(j)=h^2*f(x)*Y(j+1)^2
26         end
27     end
28     y=A_1*B
29 end
```

Scilab code Exa 16.6 Collocation Method

```
1  //Example 16.6
2  //Collocation Method
3  //Page no. 589
4  clc;close;clear;
5
6  h1=0.000001;h=0.25;x=0;
7  Y(1)=0;Y(5)=0;
8  deff('y=p(x)','y=1')
9  deff('y=q(x)','y=-2/(1+x)^2')
10 deff('y=f(x)','y=(2*x-4)/(1+x)^4')
11 deff('y=fi(x,j)','y=(1-x)*x^j')
12 deff('y=f1(x,y)','y=(-x+y)/h1')    //function for
      differentiation
13 for i=1:4
14     x=x+h
15     for j=1:4
16         A(i,j)=p(x)*f1(f1(fi(x,j),fi(x+h1,j)),f1(fi(
               x+h1,j),fi(x+2*h1,j)))+f1(p(x),p(x+h1))*
               f1(fi(x,j),fi(x+h1,j))+q(x)*fi(x,j)
17     end
18 end
19 x=0;
20 for i=1:4
21     x=x+h
22     B(i)=f(x)
23 end
24 disp(B,'B =',A,"A =")
25 C=inv(A)*B
26 x=0;
27 for i=2:4
28     x=x+h;
29     for j=1:4
30         Y(i)=Y(i)+C(j)*fi(x,j)
31     end
32 end
33 disp(Y,"Solution Matrix Y = ")
```

Chapter 18

Numerical Solutions of Parabolic Partial Differential Equations

Scilab code Exa 18.4 Forward Difference Method

```
1  //Example 18.4
2  //Forward Difference Method
3  //Page no. 624
4  clc;clear;close;
5
6  h=0.2;k=0.02;
7  r=k/h^2;
8  printf('\n j\tt\t|\ti -->\t')
9  for i=0:5
10     printf('  %i\t',i)
11 end
12 printf('\n |\t|\t|\tx -->\t')
13 for i=0:5
14     printf('%.3f\t',(i)/5)
15 end
```

```
16 printf('\n
   ------------------------------------------------------------------------
   ')
17 for j=1:6
18     printf('\n %i\t%.3f\t|\t\t',j-1,(j-1)/50)
19     for i=1:6
20         if i==1 | i==6 then
21             u(j,i)=0;
22         elseif j==1 then
23             u(j,i)=sin(%pi*(i-1)/5)
24         else
25             u(j,i)=(u(j-1,i-1)+u(j-1,i+1))/2
26         end
27         printf('%.3f\t',u(j,i))
28     end
29 end
```

Scilab code Exa 18.5 Bender Schmidt Method

```
1  //Example 18.5
2  //Bender Schmidt Method
3  //Page no. 625
4  clc;clear;close;
5
6  h=0.1;k=0.005;
7  r=k/h^2;
8  printf('\n j   |\ti -->\t')
9  for i=0:10
10     printf('  %i\t',i)
11 end
12 printf('\n |   |\tx -->\t')
13 for i=0:10
14     printf('%.3f\t',(i)/10)
```

```
15 end
16 printf('\n
   ------------------------------------------------------------------------
   ')
17 for j=1:9
18     printf('\n %i  |\t\t',j-1)
19     for i=1:11
20         if i==1 | i==11 then
21             u(j,i)=0;
22         elseif j==1 then
23             u(j,i)=sin(%pi*(i-1)/10)
24         else
25             u(j,i)=u(j-1,i)/2+(u(j-1,i-1)+u(j-1,i+1)
                  )/4
26         end
27         printf('%.3f\t',u(j,i))
28     end
29 end
```

Scilab code Exa 18.6 Crank Nicolson Method

```
1 //Example 18.6
2 //Crank Nicolson Method
3 //Page no. 631
4 clc;clear;close;
5 h=1/2;k=1/8;
6 r=k/h^2;
7 for i=1:2:3
8     for j=1:9
9         if i==1 | j==1 then
10            u(i,j)=0;
11        end
12        if i==3 then
```

```
13              u(i,j)=(j-1)/8
14          end
15      end
16  end
17  a=[3,-1,0;-1,3,-1;0,-1,3];
18  a=inv(a);
19  for j=2:9
20          u(2,j)=(u(1,j-1)+2*u(2,j-1)+u(3,j-1)+u(1,j)+
                u(3,j))/6
21  end
22  u=u'
23  printf('\nfor h = 1/2\n\n')
24  printf('i\\j --> ')
25  for i=1:3
26      printf('\t%i\t',i)
27  end
28  printf('\n
    ------------------------------------------------------------------------
    n')
29  for i=1:9
30      printf('\n %i',i)
31      for j=1:3
32          printf('\t   %.9f',u(i,j))
33      end
34  end
35
36
37
38
39  h=1/4;k=1/8;
40  r=k/h^2;
41  for i=1:4:5
42      for j=1:9
43          if i==1 | j==1 then
44              u(i,j)=0;
45          end
46          if i==5 then
47              u(i,j)=(j-1)/8
```

```
48          end
49      end
50  end
51  a=[3,-1,0;-1,3,-1;0,-1,3];
52  a=inv(a);
53  for j=2:9
54          b=[u(1,j-1)-u(2,j-1)+u(3,j-1)+u(1,j);u(2,j
                -1)-u(3,j-1)+u(4,j-1);u(3,j-1)-u(4,j-1)+u
                (5,j-1)+u(5,j)]
55      x=a*b
56      u(2,j)=x(1);u(3,j)=x(2);u(4,j)=x(3);
57  end
58  u=u'
59  printf('\n\n\n\nfor h = 1/4\n\n')
60  printf('i\\j --> ')
61  for i=1:5
62      printf('\t%i\t',i)
63  end
64  printf('\n
    ------------------------------------------------------------------------------
    n')
65  for i=1:9
66      printf('\n %i',i)
67      for j=1:5
68          printf('\t   %.9f',u(i,j))
69      end
70  end
```

Scilab code Exa 18.7 Gauss Seidel Method

```
1  //Example 18.7
2  //Gauss Seidel Method
3  //Page no. 637
```

```
clc;clear;close;
deff('y=f(x)','y=4*x-4*x^2')
h=0.2;k=0.04;
r=k/h^2;
printf('\n k\t|\ti -->\t')
for i=0:5
    printf('  %i\t',i)
end
printf('\n |\t|\tx -->\t')
for i=0:5
    printf('%.2f\t',(i)/5)
end
printf('\n
    ------------------------------------------------------------------------------
    ')
for k=1:7
    printf('\n %i\t|\t\t',k-1)
    for i=1:6
        if i==1 | i==6 then
            u(k,i)=0;
        elseif k==1 then
            u(k,i)=f((i-1)/5)
        else
            u(k,i)=(u(k-1,i-1)+u(k-1,i+1))/2
        end
        printf('%.2f\t',u(k,i))
    end
end
```

Scilab code Exa 18.8 ADI Method

```
//Example 18.8
//ADI Method
```

```
3  //Page no. 642
4  clc;clear;close;
5
6  for i=1:4
7      for j=1:5
8          P(i,j)=20
9      end
10 end
11 r=1;k=0;
12 for i=1:6
13     v1(i)=20
14     u1(i)=20
15 end
16 P1
      =[25,30,35,50,60;35,0,0,0,70;45,0,0,0,80;60,70,80,100,90]

17 for i=1:4
18     printf('\n')
19     for j=1:5
20         printf('%i\t',P(i,j))
21     end
22     if i==2 then
23         printf('-->')
24     end
25     printf('\t')
26     for j=1:5
27         printf('%i\t',P1(i,j))
28         if i>1 & i<4 & j>1 & j<5 then
29             P1(i,j)=P(i,j)
30         end
31     end
32 end
33 P1v=P1;P1h=P1;
34 for i=1:6
35     for j=1:6
36         if i==j then
37             Av(i,j)=1+2*r
38         elseif abs(i-j)==1 & i+j~=5 & i+j~=9
```

```
39              Av(i,j)=-r
40          end
41      end
42  end
43  for i=1:6
44      for j=1:6
45          if i==j then
46              Ah(i,j)=1+2*r
47          elseif abs(i-j)==1 & i+j~=7
48              Ah(i,j)=-r
49          end
50      end
51  end
52  n=8
53  for l=1:n
54      k=0;
55  for j=0:2
56      for i=1:2
57          if i==1 then
58              Bv(i+j+k)=r*P1h(i+1,j+1)+(1-2*r)*P1h(i
                   +1,j+2)+r*P1h(i+1,j+3)+r*P1h(i,j+1)
59          else
60              Bv(i+j+k)=r*P1h(i+1,j+1)+(1-2*r)*P1h(i
                   +1,j+2)+r*P1h(i+1,j+3)+r*P1h(i+2,j+1)
61          end
62      end
63      k=k+1;
64  end
65  k=0;
66  Bh=[r*30+(1-2*r)*v1(1)+r*v1(4)+r*35;r*35+(1-2*r)*v1
       (3)+r*v1(5);r*v1(1)+(1-2*r)*v1(2)+r*v1(3)+r*(70);
       r*v1(1)+(1-2*r)*v1(2)+r*(70+45);r*v1(3)+(1-2*r)*
       v1(4)+r*80;r*v1(5)+(1-2*r)*v1(6)+r*(100+80)]
67        for i=1:6
68            v(i,l)=v1(i)
69        end
70        for i=1:6
71            u(i,l)=u1(i)
```

```
72        end
73        v1=inv(Av)*Bv
74        u1=inv(Ah)*Bh
75        k=1;
76        for i=2:3
77            for j=2:4
78                P1h(i,j)=u1(i+j+k-4)
79            end
80            k=k+2
81        end
82        k=0;
83        for j=2:4
84            for i=2:3
85                P1v(i,j)=v1(i+j+k-3)
86            end
87            k=k+1
88        end
89    end
90    printf('\n\n\n\nResults for Vertical Transverse in
         Celsius :\n')
91    for i=1:7
92        printf('\n')
93        if i==1 then
94            printf('Itr -->')
95            for j=1:n
96            printf('\t  %i',j-1)
97        end
98        printf('\n
            ----------------------------------------------------------------------
            ')
99        else
100           printf(' v%i',i-1)
101           for j=1:n
102           printf('\t%.2f',v(i-1,j))
103           end
104       end
105   end
106   printf('\n\n\n\nResults for Horizontal Transverse in
```

```
      Celsius :\n')
for i=1:7
      printf('\n')
      if i==1 then
          printf('Itr -->')
          for j=1:n
          printf('\t  %i',j-1)
      end
      printf('\n
         ---------------------------------------------------------------------------
         ')
      else
          printf(' u%i',i-1)
          for j=1:n
          printf('\t%.2f',u(i-1,j))
          end
      end
end
```

Chapter 19

Numerical Solutions of Hyperbolic Partial Differential Equations

Scilab code Exa 19.3 Simple Explicit Method

```
1  //Example 19.3
2  //Simple Explicit Method
3  //Page no. 658
4  clc;clear;close;
5
6  c=-2;dt=0.07;dx=0.2;
7  r=abs(c)*dt/dx;
8  printf('\n  x\ti\t|\tj -->\t')
9  for i=0:6
10     printf('  %i\t',i)
11 end
12 printf('\n  |\t|\t|\tt -->\t')
13 for i=0:6
14     printf('%.3f\t',i*dt)
15 end
```

```
16 printf('\n
   ------------------------------------------------------------------------------
   ')
17 for j=1:6
18     printf('\n %.1f\t%i\t|\t\t',(j-1)*dx,j-1)
19     for i=1:7
20         if i==1 then
21             u(j,i)=0;
22         elseif j==1 then
23             u(j,i)=1
24         else
25             u(j,i)=(1-r)*u(j,i-1)+r*u(j-1,i-1)
26         end
27         printf('%.3f\t',u(j,i))
28     end
29 end
```

Scilab code Exa 19.4 Simple Implicit Method

```
1  //Example 19.4
2  //Simple Implicit Method
3  //Page no. 659
4  clc;clear;close;
5
6  c=-2;dt=0.07;dx=0.2;
7  r=abs(c)*dt/dx;
8  printf('\n  x\ti\t|\tj -->\t')
9  for i=0:6
10     printf('  %i\t',i)
11 end
12 printf('\n  |\t|\t|\tt -->\t')
13 for i=0:6
14     printf('%.3f\t',i*dt)
```

```
15 end
16 printf('\n
    ------------------------------------------------------------------------
   ')
17 for j=1:6
18     printf('\n %.1f\t%i\t|\t\t',(j-1)*dx,j-1)
19     for i=1:7
20         if i==1 then
21             u(j,i)=0;
22         elseif j==1 then
23             u(j,i)=1
24         else
25             u(j,i)=(1/(1+r))*u(j,i-1)+r*u(j-1,i)/(1+
                  r)
26         end
27         printf('%.3f\t',u(j,i))
28     end
29 end
```

Scilab code Exa 19.5 Lax Wendroff Method

```
1 //Example 19.5
2 //Lax Wendroff Method
3 //Page no. 660
4 clc;clear;close;
5
6 c=-2;dt=0.07;dx=0.2;
7 r=abs(c)*dt/dx;
8 printf('\n  x\ti\t|\tj -->\t')
9 for i=0:6
10     printf('  %i\t',i)
11 end
12 printf('\n  |\t|\t|\tt -->\t')
```

```
for i=0:6
    printf('%.3f\t',i*dt)
end
i=1;
printf('\n
    ----------------------------------------------------------------------------------------------------
    ')
for j=1:7
    for i=1:6
        if j==1 then
            u(i,j)=0;
            u(i+1,j)=0;
        elseif i==1 then
            u(i,j)=1
        else
            u(i,j)=r*(r-1)*u(i+1,j-1)/2+(1-r^2)*u(i,
               j-1)+r*(1+r)*u(i-1,j-1)/2
        end
    end
end
for i=1:6
    printf('\n %.1f\t%i\t|\t\t',(i-1)*dx,i-1)
    for j=1:7
        printf('%.3f\t',u(i,j))
    end
end
```

Scilab code Exa 19.6 Wendroff Method

```
//Example 19.6
//Wendroff Method
//Page no. 661
clc;clear;close;
```

```
5
6  c=2;k=0.07;h=0.2;
7  a=(h+k*c)/(h-k*c)
8  printf('\n  x\ti\t|\tj -->\t')
9  for i=0:6
10     printf('  %i\t',i)
11 end
12 printf('\n  |\t|\t|\tt -->\t')
13 for i=0:6
14     printf('%.3f\t',i*k)
15 end
16 printf('\n
       ------------------------------------------------------------------------
   ')
17 for i=1:6
18     printf('\n %.1f\t%i\t|\t\t',(i-1)*h,i-1)
19     for j=1:7
20         if j==1 then
21             u(i,j)=0;
22         elseif i==1 then
23             u(i,j)=1
24         else
25             u(i,j)=u(i-1,j-1)+(u(i,j-1)-u(i-1,j))/a
26         end
27         printf('%.3f\t',u(i,j))
28     end
29 end
```

Scilab code Exa 19.7 Leapfrog Method

```
1  //Example 19.7
2  //Leapfrog Method
3  //Page no. 662
```

```
clc;clear;close;

c=2;k=0.07;h=0.2;
r=c*k/h
printf('\n  x\ti\t|\tj -->\t')
for i=0:6
    printf('  %i\t',i)
end
printf('\n  |\t|\t|\tt -->\t')
for i=0:6
    printf('%.3f\t',i*k)
end
printf('\n ---------------------------------------------------------------------------------------------------------------
    ')

for j=1:7
    for i=1:6
        if j==1 | j==2 & i~=1 then
            u(i,j)=0;
            u(i+1,j)=0;
        elseif i==1 then
            u(i,j)=1
        else
            u(i,j)=u(i,j-2)-r*(u(i+1,j-1)-u(i-1,j-1)
               )
        end
    end
end
for i=1:6
    printf('\n %.1f\t%i\t|\t\t',(i-1)*h,i-1)
    for j=1:7
        printf('%.3f\t',u(i,j))
    end
end
```

Scilab code Exa 19.8 Variable Coefficients

```
1  //Example 19.8
2  //Variable Coefficients
3  //Page no. 663
4  clc;clear;close;
5
6  //simple explicit method
7  printf('\n\nBy Simple Explicit Method:\n\n')
8  dt=0.05;dx=0.2;
9  x=0;
10 printf('\n i\t  x\t  r\t|\tj -->\t')
11 for i=0:6
12     printf('  %i\t',i)
13 end
14 printf('\n  \t\t\t|\tt -->\t')
15 for i=0:6
16     printf('%.3f\t',i*dt)
17 end
18 printf('\n
    ------------------------------------------------------------------------
   ')
19 for j=1:6
20     r=sqrt(1+2*x)*dt/dx;
21     printf('\n %i\t%.3f\t%.3f\t|\t\t',(j-1),x,r)
22     for i=1:7
23         if i==1 then
24             u(j,i)=0;
25         elseif j==1 then
26             u(j,i)=1
27         else
28             u(j,i)=(1-r)*u(j,i-1)+r*u(j-1,i-1)
```

```
29          end
30          printf('%.3f\t',u(j,i))
31
32      end
33      x=x+dx
34  end
35
36
37  //simple implicit method
38  printf('\n\n\nBy Simple Implicit Method:\n')
39  c=-2;dt=0.05;dx=0.2;x=0
40  printf('\n i\t  x\t  r\t|\tj -->\t')
41  for i=0:6
42      printf('  %i\t',i)
43  end
44  printf('\n  \t\t\t|\tt -->\t')
45  for i=0:6
46      printf('%.3f\t',i*dt)
47  end
48  printf('\n
      ------------------------------------------------------------------------
      ')
49  for j=1:6
50      r=sqrt(1+2*x)*dt/dx;
51      printf('\n %i\t%.3f\t%.3f\t|\t\t',(j-1),x,r)
52      for i=1:7
53          if i==1 then
54              u(j,i)=0;
55          elseif j==1 then
56              u(j,i)=1
57          else
58              u(j,i)=(1/(1+r))*u(j,i-1)+r*u(j-1,i)/(1+
                    r)
59          end
60          printf('%.3f\t',u(j,i))
61      end
62      x=x+dx
63  end
```

```
64
65
66  //wendroff method
67  printf('\n\n\nBy Wendroff Method:\n')
68  k=0.05;h=0.2;
69  x=0.1;
70  printf('\n i\t  x\t  c\t  a\t|\tj -->\t')
71  for i=0:6
72      printf('  %i\t',i)
73  end
74  printf('\n  \t\t\t\t|\tt -->\t')
75  for i=0:6
76      printf('%.3f\t',i*k)
77  end
78  printf('\n
      ------------------------------------------------------------------------
      ')
79  for i=1:6
80      c=sqrt(1+2*x);
81      a=(h+k*c)/(h-k*c)
82      printf('\n %i\t%.3f\t%.3f\t%.3f\t|\t\t',(i-1),x-
          h/2,c,a)
83      for j=1:7
84          if j==1 then
85              u(i,j)=0;
86              u(i+1,j)=0;
87          elseif i==1 then
88              u(i,j)=1
89          else
90              u(i,j)=u(i-1,j-1)+(u(i,j-1)-u(i-1,j))/a
91          end
92          printf('%.3f\t',u(i,j))
93      end
94      x=x+h
95  end
```

Scilab code Exa 19.9 Inhomogeneous 1st Order Hyperboolic Differential Equation

```
1  //Example 19.9
2  //Inhomogeneous 1st Order Hyperboolic Differential
       Equation
3  //Page no. 665
4  clc;clear;close;
5
6  //simple explicit method
7  printf('\n\nBy Simple Explicit Method:\n')
8  c=-2;dt=0.07;dx=0.2;
9  r=abs(c)*dt/dx;
10 printf('\n  i\tx\t|\tj -->\t')
11 for i=0:6
12     printf('  %i\t',i)
13 end
14 printf('\n  |\t|\t|\tt -->\t')
15 for i=0:6
16     printf('%.3f\t',i*dt)
17 end
18 printf('\n
       ------------------------------------------------------------------------
       ')
19 x=0;
20 for j=1:6
21     printf('\n %i\t%.1f\t|\t\t',j-1,x)
22     for i=1:7
23         if i==1 then
24             u(j,i)=exp(-x);
25         elseif j==1 then
26             u(j,i)=1
```

```
27          else
28              u(j,i)=(1-r)*u(j,i-1)+r*u(j-1,i-1)+dt*2*
                    x
29          end
30          printf('%.3f\t',u(j,i))
31      end
32      x=x+dx
33  end
34
35
36  //simple implicit method
37  printf('\n\n\nBy Simple Implicit Method:\n')
38  c=-2;dt=0.07;dx=0.2;
39  r=abs(c)*dt/dx;
40  printf('\n  i\tx\t|\tj -->\t')
41  for i=0:6
42      printf('  %i\t',i)
43  end
44  printf('\n  |\t|\t|\tt -->\t')
45  for i=0:6
46      printf('%.3f\t',i*dt)
47  end
48  printf('\n
      ------------------------------------------------------------------------------
      ')
49  x=0;
50  for j=1:6
51      printf('\n %i\t%.1f\t|\t\t',j-1,x)
52      for i=1:7
53          if i==1 then
54              u(j,i)=exp(-x);
55          elseif j==1 then
56              u(j,i)=1
57          else
58              u(j,i)=(1/(1+r))*u(j,i-1)+r*u(j-1,i)/(1+
                    r)+dt*2*x
59          end
60          printf('%.3f\t',u(j,i))
```

```
61      end
62      x=x+dx
63  end
64
65
66  //wendroff method
67  printf('\n\n\nBy Wendroff Method:\n')
68  c=2;k=0.07;h=0.2;
69  a=(h+k*c)/(h-k*c)
70  printf('\n  x\ti\t|\tj -->\t')
71  for i=0:6
72      printf('  %i\t',i)
73  end
74  printf('\n  |\t|\t|\tt -->\t')
75  for i=0:6
76      printf('%.3f\t',i*k)
77  end
78  printf('\n
    ------------------------------------------------------------------------
    ')
79  x=0;
80  for i=1:6
81      printf('\n %.1f\t%i\t|\t\t',x,i-1)
82      for j=1:7
83          if j==1 then
84              u(i,j)=exp(-x);
85          elseif i==1 then
86              u(i,j)=1
87          else
88              u(i,j)=u(i-1,j-1)+(u(i,j-1)-u(i-1,j))/a
                    +(2*h*k)*(x+h/2)/(a*(h+c*k))
89          end
90          printf('%.3f\t',u(i,j))
91      end
92      x=x+h
93  end
```

Scilab code Exa 19.10 Non Linear 1st Order Hyperboolic Differential Equation

```
1  //Example 19.10
2  //Non Linear 1st Order Hyperboolic Differential
       Equation
3  //Page no. 667
4  clc;clear;close;
5
6  c=-2;k=0.05;h=0.2;
7  r=abs(c)*k/h;
8  printf('\n i\t x\t|\tj -->\t')
9  for i=0:6
10     printf('  %i\t',i)
11 end
12 printf('\n |\t |\t|\tt -->\t')
13 for i=0:6
14     printf('%.3f\t',i*k)
15 end
16 i=1;
17 x=0;
18 printf('\n
       ----------------------------------------------------------------------------
       ')
19 for j=1:7
20     for i=1:6
21         if j==1 then
22             u(i,j)=exp(-x);
23             u(i+1,j)=exp(-(x+h));
24         elseif i==1 then
25             u(i,j)=1
26         else
```

```
27              u(i,j)=u(i,j-1)-k*(u(i+1,j-1)^2-u(i-1,j
                   -1)^2)/(4*h)+k^2*((u(i+1,j-1)+u(i,j
                   -1))*(u(i+1,j-1)^2-u(i,j-1)^2)-(u(i,j
                   -1)+u(i-1,j-1))*(u(i,j-1)^2-u(i-1,j
                   -1)^2))/(8*h^2)
28      end
29      x=x+h
30      end
31  end
32  x=0;
33  for i=1:6
34      printf('\n %i\t%.1f\t|\t\t',i-1,x)
35      for j=1:7
36          printf('%.3f\t',u(i,j))
37      end
38      x=x+h
39  end
```

Scilab code Exa 19.11 Finite Difference Method

```
1  //Example 19.11
2  //Finite Difference Method
3  //Page no. 670
4  clc;clear;close;
5  deff('y=f(x)','y=sin(%pi*x)')
6  deff('y=g(x)','y=0')
7  a=1;b=1;c=1;n=5;m=10;
8  h=a/n;k=b/m;r=c*k/h;
9  r1=r^2;r2=r1/2;s1=1-r1;s2=2*(1-r2)
10 printf('\n i ')
11 for i=1:n
12     printf('\t  %i',i)
13 end
```

```
14 printf('\n
   ------------------------------------------------------------\
   nfi')
15 for i=1:n
16     f1(i)=f(h*(i-1))
17     printf('\t%.3f',f1(i))
18 end
19 printf('\ngi')
20 for i=1:n
21     g1(i)=g(h*(i-1))
22     printf('\t  %g',g1(i))
23 end
24 printf('\n\n\n i / j --> ')
25 for i=1:m
26     printf('\t  %i',i)
27 end
28 printf('\n
   ------------------------------------------------------------------------------------------
   ')
29 for j=1:m
30     for i=1:n
31         if i==1 | i==n then
32             u(i,j)=0;
33         elseif j==1
34             u(i,j)=f1(i)
35         elseif j==2
36             u(i,j)=s1*f1(i)+k*g1(i)+r2*(f1(i+1)+f1(i
                  -1))
37         else
38             u(i,j)=s2*u(i,j-1)+r1*u(i-1,j-1)+u(i+1,j
                  -1)-u(i,j-2)
39         end
40
41     end
42 end
43 for i=1:n
44     printf('\n %i\t',i)
45     for j=1:m
```

```
46          printf('\t%.3f',u(i,j))
47      end
48  end
```

Scilab code Exa 19.12 Hyperbolic Partial Differential Equations

```
1  //Example 19.12
2  //Hyperbolic Partial Differential Equations
3  //Page no. 673
4  clc;clear;close;
5  deff('y=f(x)','y=12*x')
6  Ua(1)=0.25;
7  Ua(2)=0.75
8  A=[1,-2;1,2];
9  x1=inv(A)*Ua;
10 printf('Xb = %g    and    Tb = %g',x1(1),x1(2))
11 A=[2,-1;2,1];
12 B=[-7.5;-8.5];
13 x2=inv(A)*B;
14 printf('\n\n Pb = %g    and    Qb = %g',x2(1),x2(2))
15 x1(1)=x1(1)-Ua(1)
16 du=x1'*x2
17 printf('\n\n dU = %g',du)
18 Ub=f(Ua(1))+du;
19 printf('\n\n Modified Ub = %g',Ub)
```

Scilab code Exa 19.13 Hyperbolic Differential Equations in 2D or 3D

```
1  //Example 19.13
```

```
2  //Hyperbolic Differential Equations in 2D or 3D
3  //Page no. 675
4  clc;clear;close;
5
6  deff('y=f(x,y)','y=x*(2-x)*y*(2-y)')
7  c2=3;k=0.4;h=0.4;c2=3;s2=0.5
8  for l=0:11
9      if l==0 then
10         printf('\n t = %i\n\n i\t  x\t|\tj -->\t',l)
11     for i=0:5
12         printf('  %i\t',i)
13     end
14     printf('\n |\t  |\t|\ty -->\t')
15     for i=0:5
16          printf('%.3f\t',i*k)
17     end
18     x=0;
19      printf('\n
           ----------------------------------------------------------------------
           ')
20      for i=1:6
21          y=0;
22         printf('\n %i\t%.3f\t|\t\t',i-1,x)
23         for j=1:6
24              if i==1 | i==6 then
25                  u(i,j)=0;
26              elseif j==1 | j==6 then
27                  u(i,j)=0
28              else
29                  u(i,j)=f(x,y)
30         end
31             printf('%.3f\t',u(i,j))
32        y=y+k;
33         end
34     x=x+h
35 end
36 u2=u;
37 else
```

```
38      printf('\n\n\n t = %i\n\n i\t   x\t|\tj -->\t',l)
39      for i=0:5
40          printf('   %i\t',i)
41      end
42      printf('\n |\t   |\t|\ty -->\t')
43      for i=0:5
44           printf('%.3f\t',i*k)
45      end
46      x=0;
47       printf('\n
            ----------------------------------------------------------------------
            ')
48       for i=1:6
49           y=0;
50          printf('\n %i\t%.3f\t|\t\t',i-1,x)
51          for j=1:6
52               if i==1 | i==6 then
53                   u(i,j)=0;
54               elseif j==1 | j==6 then
55                   u(i,j)=0
56               elseif l==1
57                   u(i,j)=s2*(u1(i+1,j)+u1(i-1,j)+u1(i,
                        j+1)+u1(i,j-1)-4*u1(i,j))+2*u1(i,
                        j)
58               else
59                   u(i,j)=s2*(u1(i+1,j)+u1(i-1,j)+u1(i,
                        j+1)+u1(i,j-1)-4*u1(i,j))+2*u1(i,
                        j)-u2(i,j)
60          end
61               printf('%.4f\t',u(i,j))
62         y=y+k;
63           end
64      x=x+h
65      end
66  end
67  if l>1 then
68      u2=u1
69  end
```

```
70  u1=u;
71  end
```

Chapter 20

Numerical Solutions of Elliptical Partial Differential Equations

Scilab code Exa 20.1 Direct Method

```
1  //Example 20.1
2  //Direct Method
3  //Page no. 682
4  clc;clear;close;
5  h=1/3;
6  A=[-4,1,1,0;1,-4,0,1;1,0,-4,1;0,1,1,-4]
7  x=0;
8  for i=1:4
9      x=x+h
10     if i==4 then
11         B(i,1)=0
12     else
13         B(i,1)=-1*sin(x*%pi)^2
14     end
15 end
```

```
16 disp(A,'A =')
17 disp(B,'B =')
18 U=inv(A)*B
19 disp(U,'U =')
```

Scilab code Exa 20.2 Five Point Formula

```
1  //Example 20.2
2  //Five Point Formula
3  //Page no. 683
4  clc;clear;close;
5
6  A=[-4,1,1,0;1,0,-4,1;1,-4,0,1;0,1,1,-4];
7  B=[-25;-150;-25;-150];
8  u1=inv(A)*B;
9  j=0;k=1
10 for i=1:4
11     j=j+1;
12     printf('\nu%i%i = %g\n',k,j,u1(i))
13     if i==2 then
14         j=0;k=2
15     end
16 end
17 printf('\n\n  U = \n')
18 for i=1:4
19     printf('\n')
20     for j=1:4
21         if j==1 then
22             u(i,j)=0
23         elseif j==4
24             u(i,j)=100
25         elseif (i==1 | i==4) & j==2
26             u(i,j)=25
```

```
27          elseif i==1 | i==4
28              u(i,j)=u(i,j-1)*2
29          else
30              u(i,j)=u1((j-1)*2-i+2)
31          end
32          printf('\t%g\t',u(i,j))
33      end
34  end
```

Scilab code Exa 20.3 Finite Difference Method

```
1  //Example 20.3
2  //Finite Difference Method
3  //Page no. 685
4  clc;clear;close;
5
6  printf('Itr\t\t U11\t\t U21\t\t U12\t\t U22\n
       ----------------------------------------------------------------------
       n')
7  for i=1:4
8      for j=1:4
9          if j==1 then
10             u(i,j)=0
11         elseif j==4
12             u(i,j)=100
13         elseif (i==1 | i==4) & j==2
14             u(i,j)=25
15         elseif i==1 | i==4
16             u(i,j)=u(i,j-1)*2
17         else
18             u(i,j)=0
19         end
20     end
```

```
21 end
22 for k=0:17
23     printf('   %i\t\t%.3f\t\t%.3f\t\t%.3f\t\t%.3f\n',
          k,u(3,2),u(3,3),u(2,2),u(2,3))
24     for i=3:-1:2
25         for j=2:3
26             u1(i,j)=(u(i,j+1)+u(i,j-1)+u(i-1,j)+u(i
                  +1,j))/4
27         end
28     end
29     for i=3:-1:2
30         for j=2:3
31             u(i,j)=u1(i,j)
32         end
33     end
34 end
35 disp(u,'U = ')
```

Scilab code Exa 20.4 Seven Point Formula

```
1 //Example 20.4
2 //Seven Point Formula
3 //Page no. 686
4 clc;clear;close;
5 printf('Itr\t\t U111\t\t U211\t\t U121\t\t U221\n
    ------------------------------------------------------------------
    n')
6 for i=1:4
7     for j=1:4
8         for k=3:-1:1
9             if k==3 then
10                u(i,j,k)=100
11            elseif (i==1 | i==4 | j==1 | j==4) & k
```

```
                ==2
12                  u(i,j,k)=300
13              elseif k==2
14                  u(i,j,k)=0
15              elseif (i==1 | i==4 | j==1 | j==4) & k
                    ==1
16                  u(i,j,k)=500
17              else
18                  u(i,j,k)=700
19              end
20          end
21      end
22  end
23  k=2
24  for l=0:14
25      printf('  %i\t\t%.3f\t\t%.3f\t\t%.3f\t\t%.3f\n',
            l,u(3,2,2),u(3,3,2),u(2,2,2),u(2,3,2))
26      for i=3:-1:2
27          for j=2:3
28              u1(i,j)=(u(i,j+1,k)+u(i,j-1,k)+u(i-1,j,k
                    )+u(i+1,j,k)+u(i,j,k+1)+u(i,j,k-1))/6
29          end
30      end
31      for i=3:-1:2
32          for j=2:3
33              u(i,j,2)=u1(i,j)
34          end
35      end
36  end
```

Scilab code Exa 20.5 Nine Point Formula

```
1  //Example 20.5
```

```
2  //Nine Point Formula
3  //Page no. 688
4  clc;clear;close;
5
6  printf('Itr\t\t U11\t\t U12\t\t U21\t\t U22\n
       ------------------------------------------------------------------------
       n')
7  for i=1:4
8      for j=1:4
9          if j==1 then
10             u(i,j)=0
11         elseif j==4
12             u(i,j)=100
13         elseif (i==1 | i==4) & j==2
14             u(i,j)=25
15         elseif i==1 | i==4
16             u(i,j)=u(i,j-1)*2
17         else
18             u(i,j)=0
19         end
20     end
21 end
22 for k=0:17
23     printf('  %i\t\t%.3f\t\t%.3f\t\t%.3f\t\t%.3f\n',
           k,u(3,2),u(2,2),u(3,3),u(2,3))
24     for i=3:-1:2
25         for j=2:3
26             u1(i,j)=(u(i+1,j-1)+u(i-1,j-1)+u(i+1,j
                   +1)+u(i-1,j+1)+4*(u(i,j+1)+u(i,j-1)+u
                   (i-1,j)+u(i+1,j)))/20
27         end
28     end
29     for i=3:-1:2
30         for j=2:3
31             u(i,j)=u1(i,j)
32         end
33     end
34 end
```

```
35 disp(u,'The Solution of the System is = ')
```

Scilab code Exa 20.6 Five Point Formula

```
1  //Example 20.6
2  //Five Point Formula
3  //Page no. 689
4  clc;clear;close;
5
6  h=0.25;k=0.25;y=1;x=0;
7  deff('x=f(y)','x=y^3')
8
9  for i=1:5
10     x=0;
11     printf('\n%g\t|',y)
12     for j=1:5
13         if (i==1 | i==5)
14             u(i,j)=f(x)
15         elseif j==5
16             u(i,j)=f(x)
17         else
18             u(i,j)=0
19         end
20         x=x+k;
21         printf('%f\t',u(i,j))
22     end
23     y=y-h
24 end
25 printf('\n\t
   ------------------------------------------------------------------------------
   n')
26 x=0;
27     for j=1:5
```

```
28          printf('\t    %g\t',x)
29          x=x+k
30      end
31  printf('\n\n\n Itr\t U11\t U12\t U13\t U21\t U22\t
    U23\t U31\t U32\t U33\n
    ------------------------------------------------------------------------
    n')
32
33  for l=0:20
34      y=0;
35      printf('  %i\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f
            \t%.3f\t%.3f\t%.3f\n',l,u(4,2),u(4,3),u(4,4),
            u(3,2),u(3,3),u(3,4),u(2,2),u(2,3),u(2,4))
36      for i=4:-1:2
37          y=y+k
38          for j=2:4
39              u1(i,j)=(u(i,j+1)+u(i,j-1)+u(i-1,j)+u(i
                    +1,j)-h^2*y)/4
40          end
41      end
42      for i=4:-1:2
43          for j=2:4
44              u(i,j)=u1(i,j)
45          end
46      end
47  end
```

Scilab code Exa 20.7 Laplace Distribution

```
1  //Example 20.7
2  //Laplace Distribution
3  //Page no. 694
4  clc;clear;close;
```

```
5
6  dr=3;r0=4;dth=%pi/4;
7  deff('y=f(u1,u2,u3,u4)','y=(u1+u3+(dr*(u3-u1))/(2*r0
       )+(u2+u4)*(dr/(r0*dth))^2)/(2*(1+(dr/(r0*dth))^2)
       )')          //laplace distribution
8  for i=1:8
9      U(i)=0;
10 end
11 printf('Itr\t  U1\t  U2\t  U3\t  U4\t  U5\t  U6\t
       U7\t  U8\n
       ------------------------------------------------------------------------
       ')
12 for l=0:15
13     printf('\n  %i',l)
14     for i=1:8
15         if i==1 then
16             u1(i)=f(100,U(8),40,U(i+1))
17         elseif i==8
18             u1(i)=f(100,U(i-1),40,U(1))
19         else
20             u1(i)=f(100,U(i-1),40,U(i+1))
21         end
22
23     end
24     for i=1:8
25         U(i)=u1(i)
26         printf('\t%.3f',U(i))
27     end
28 end
```

Scilab code Exa 20.8 Spherical Coordinate System

```
1  //Example 20.8
```

```
2  //Spherical Coordinate System
3  //Page no. 697
4  clc;clear;close;
5  deff('y=cot(x)','y=1/tan(x)')
6  dr=5;r0=50;dth=%pi/4;dfi=%pi/4;N=-10;Z=60;Nb=0;Zt
       =70;
7  deff('y=f(u1,u2,u3,u4,u5,u6,th0)','y=((u1+u3)/dr^2+(
       u3-u1)/(r0*dr)+(u2+u4)/(r0*dth)^2+(u2*cot(th0)/(
       r0^2*dth)+(u5+u6)/(r0*sin(th0)*dfi)^2))/(2/dr
       ^2+2/(r0*dth)^2+cot(th0)/(r0^2*dth)+2/(r0*sin(th0
       )*dfi)^2)')          //laplace distribution in
       spherical coordinate
8  T1=40;T2=20;H1=35;H2=10;B1=5;B2=0;t1=240;t2=180;b1
       =100;b2=80;h1=210;h2=150
9  printf('\n
       ----------------------------------------------------------------------------------------------------
       n')
10 s=["T","H","B","t","h","b"];
11 for i=1:8
12     if i<4 | i>6 then
13         T(1,i)=T1;
14         H(1,i)=H1;
15         B(1,i)=B1;
16         b(1,i)=b1;
17         t(1,i)=t1;
18         h(1,i)=h1;
19     else
20         T(1,i)=T2;
21         H(1,i)=H2;
22         b(1,i)=b2;
23         B(1,i)=B2;
24         t(1,i)=t2;
25         h(1,i)=h2;
26     end
27 end
28 h(1)=0;h(2)=0;
29 Al=[T;H;B;t;h;b]
30 for i=1:6
```

```
31      if i==1 then
32          printf('Temperature Distribution in Outer
               Sphere\n')
33          printf('
               ------------------------------------------------------------
               n')
34      end
35      if i==4 then
36          printf('\nTemperature Distribution in Inner
               Sphere\n')
37          printf('
               ------------------------------------------------------------
               n')
38      end
39      printf('\nPoint : ')
40      for j=1:8
41              printf('\t%s%i',s(i),j)
42      end
43      printf('\nTemperature : ')
44      for j=1:8
45          if (j==1 | j==2) & i==5 then
46              printf('\t%s',"?")
47          else
48              printf('\t%i',Al(i,j))
49          end
50      end
51      printf('\n
           ------------------------------------------------------------
           ')
52  end
53  th0=10^-30
54  Uh1=f(1000,Al(5,8),Al(2,1),Al(5,2),Al(6,1),Al(4,1),
       th0)
55  disp(Uh1,'Uh1 = ')
56  th0=%pi/4;
57  Uh2=f(1000,Uh1,Al(2,2),Al(5,3),Al(6,2),Al(4,2),th0)
58  disp(Uh2,'Uh2 = ')
```

Chapter 21

Advances in Numerical Methods Using Parallel Computing Paradigm

Scilab code Exa 21.1 Parallel Bisection Method

```
1  //Example 21.1
2  //Parallel Bisection Method
3  //Page no. 721
4  clc;close;clear;
5
6  deff('y=f(x)','y=x^2-cos(x)')
7  a=0;b=1;e=0.0001;i=1;
8  printf('Itr\ta\tb\th\t\tx0\t\tx1\t\tx2\t\tx3\t\tx4\t
       \tx5\n\t\t\t\ty0\t\ty1\t\ty2\t\ty3\t\ty4\t\ty5'
       )
9  printf('\n
       ------------------------------------------------------------------------
       n')
10 while (abs(a-b)>=e)
11
```

```
12
13      h=(b-a)/5;
14      y(1)=f(a);
15      x(1)=a;
16      printf(' %i\t%g\t%g\t%f\t%f',i,a,b,h,x(1))
17      for j=2:6
18          x(j)=x(j-1)+h;
19          y(j)=f(x(j));
20          if (y(j-1)*y(j)<0)
21                  a=x(j-1);
22                  b=x(j);
23          end
24          printf('\t%f',x(j))
25      end
26      printf('\n\t\t\t\t\t')
27      for j=1:6
28          printf('%f\t',y(j))
29      end
30
31      printf('\n')
32      i=i+1;
33  end
```

Scilab code Exa 21.2 Lagrange Interpolation in Parallel Computing

```
1  //Example 21.2
2  //Lagrange Interpolation in Parallel Computing
3  //Page no. 723
4  clc;close;clear;
5
6  xi=[-1,0,2,5];
7  yi=[9,5,3,15];
8  s=["x=1","n=4","Data:","(-1,9)","(0,5)","(2,3)","
```

```
    (5,15)"]
for i=1:4
    printf('\tProcessor\t')
end
printf('\n')
for i=1:4
    printf('\t    N%i\t\t',i)
end
printf('\n')
for i=1:7
    for j=1:4
        printf('          %s\t\t',s(i))
    end
    printf('\n')
end

x=1;T=0;
for k=0:3
    p=yi(k+1)
    for j=0:3
        if(j~=k)
            p=p*((x-xi(j+1))/(xi(k+1)-xi(j+1)))
        end
    end
    T=T+p;
    printf('\nT(%i) = %g',k+1,p)
end
printf('\n\nT = %g',T)
```

Scilab code Exa 21.3 Trapezoidal Rule and Simpsons Rule in Parallel Computing

```
//Example 21.3
```

```
2  //Trapezoidal Rule and Simpsons Rule in Parallel
       Computing
3  //Page no. 726
4  clc;close;clear;
5  n=8;a=0;b=8;
6  h=(b-a)/n
7  deff('y=f(x)','y=1/(1+x)')
8  for i=0:8
9      x(i+1)=i;
10     y(i+1)=f(x(i+1))
11 end
12 printf('xi\t ')
13 for i=1:9
14     printf('%i\t ',x(i))
15 end
16 printf('\n yi\t')
17 for i=1:9
18     printf('1/%i\t',i)
19 end
20
21 //trapezoidal rule
22 S=0;
23 for i=1:9
24     if(i==1 | i==9)
25         S=S+y(i)
26     else
27         S=S+2*y(i)
28     end
29 end
30 S=S*h/2
31 printf('\n\nTrapezoidal Rule Sum = %g',S)
32
33 //Simpsons 1/3rd Rule
34 S=0;
35 for i=1:9
36     if(i==1 | i==9)
37         S=S+y(i)
38     elseif(((i)/2)-fix((i)/2)==0)
```

```
39          S=S+4*y(i)
40      else
41          S=S+2*y(i)
42      end
43  end
44  S=S*h/3
45  printf('\n\nSimpsons 1/3rd Rule Sum = %g',S)
```

Scilab code Exa 21.4 Parallel Gauss Seidel Method

```
1  //Example 21.4
2  //Parallel Gauss-Seidel Method
3  //Page no. 730
4  clc;close;clear;
5
6  A=[3,2;6,2];
7  B=[2;3];
8  x(1)=1/4;
9  x(2)=1/5;
10 e=0.002;
11 old(1)=x(1);
12 old(2)=x(2);
13 new(1)=old(1);
14 new(2)=old(2);
15 printf('\t\tProcess 1\t\tProcess 2\n Itr\t\told\
   tnew1\t\told2\tnew2\n\n')
16 printf('  %i\t\t%g\t%g\t\t%g\t%g\n',0,old(1),new(1),
   old(2),new(2))
17 for i=1:4
18     printf('  %i',i)
19     for j=1:2
20         k=0;
21         for l=1:j-1
```

```
22              k=k-(A(j,l)*old(l));
23          end
24          m=0;
25          for l=j+1:2
26              m=m-(A(j,l)*old(l));
27          end
28          new(j)=(B(j)+k+m)/A(j,j)
29          printf('\t\t%.5g\t%.5g',old(j),new(j))
30      end
31      printf('\n')
32      old(1)=new(1)
33      old(2)=new(2)
34  end
```

Scilab code Exa 21.5 Poissons Partial Differential Equation

```
1  //Example 21.5
2  //Poissons Partial Differential Equation
3  //Page no. 733
4  clc;clear;close;
5
6  s=["st","nd","rd"]
7  for i=4:20
8      s(i)="th"
9  end
10 h=0.25;deff('y=f(x)','y=x^3');y=1;x=0;
11 for i=1:6
12
13
14     if i~=6 then
15         printf('%g\t|',y)
16         y=y-h;
17         x=0;
```

```
18          for j=1:5
19              if i==1 | i==5 | j==5 then
20                  P(i,j)=f(x)
21              else
22                  P(i,j)=0
23              end
24          printf('%f\t',P(i,j))
25          x=x+h;
26          end
27      else
28          printf('
                ------------------------------------------------------------------------------
                n\t')
29          x=0;
30          for j=1:5
31              printf('    %g\t\t',x)
32              x=x+h
33          end
34      end
35      printf('\n')
36  end
37
38  printf('\n\n\n')
39
40  for l=0:17
41      y=1;
42      if l~=0 then
43          printf('After the %i%s Iteration : \n
                ------------------------------------------------------------------------\
                n  %i',l,s(l),l)
44      for i=1:6
45          if i~=6 then
46              printf('\t%g',y)
47          y=y-h
48              for j=1:5
49              printf('\t%.3f',P(i,j))
50             end
51          else
```

```
52              x=0;
53              printf('\t')
54              for j=1:5
55                  printf('\t%g',x)
56                  x=x+h
57              end
58          end
59          printf('\n')
60      end
61      printf('
          ------------------------------------------------------------\
          n')
62  end
63  y=0;
64      for i=4:-1:2
65          y=y+h
66          for j=2:4
67              P1(i,j)=(P(i,j+1)+P(i,j-1)+P(i-1,j)+P(i
                    +1,j)-h^2*y)/4
68          end
69      end
70      for i=4:-1:2
71          for j=2:4
72              P(i,j)=P1(i,j)
73          end
74      end
75  end
```

Chapter 22

Numerical Methods Using Neural Networks

Scilab code Exa 22.1 MLP Algorithm

```
1  //Example 22.1
2  //MLP Algorithm
3  //Page no. 748
4  clc;clear;close;
5  deff('y=f(x)','y=1/(1+exp(-x))')
6  Wih=[0.1,-0.3;0.3,0.4];
7  Who=[0.4;0.5]
8  i=[0.2,0.6];
9  t=0.7;
10 a=10;
11 for k=1:3
12     printf('\n\n\nAfter Iteration %i :\n\n',k)
13     disp(Wih,'Wih = ')
14     disp(Who,'Who = ')
15 a1=i*Wih;
16 disp(a1,'a = ')
17 h=[f(a1(1)),f(a1(2))]
```

```
18 disp(h,'h = ')
19 b1=h*Who
20 disp(b1,'b1 =')
21 o=f(b1)
22 disp(o,'o = ')
23 d=o*(1-o)*(t-o)
24 disp(d,'d =')
25 for j=1:2
26     e(1,j)=h(j)*(1-h(j))*d*Who(j)
27 end
28 disp(e,'e =')
29 dWho=a*h'*d;
30 disp(dWho,'dWho =')
31 Who=Who+dWho;
32 dWih=a*i'*e;
33 disp(dWih,'dWih =')
34 Wih=Wih+dWih;
35 end
```

Scilab code Exa 22.2 MLP

```
1 //Example 22.2
2 //MLP
3 //Page no. 758
4 clc;clear;close;
5
6 deff('y=f(x)','y=x^3-x^2+x-1')
7 printf('Input\t\tDesired\t\tNetwork\t\tError\n\t\t
    Output\t\t Output\n
    ------------------------------------------------------------\
    n')
8 in
    =[0.7572,0.7601,0.7620,1.4831,1.4874,1.4900,2.0913,2.0934,2.1006,
```

```
9  n
      =[-0.3941,-0.3896,-0.3867,1.6054,1.6259,1.6391,5.8762,5.8969,5.96

10 for i=1:18
11     printf(' %.4f\t\t%.4f\t\t%.4f\t\t%.4f\n',in(i),f
          (in(i)),n(i),n(i)-f(in(i)))
12 end
```

Scilab code Exa 22.3 Bisection Method

```
1  //Example 22.3
2  //Bisection Method
3  //Page no. 764
4  clc;clear;close;
5
6  deff('y=f(x)','y=x^3-x^2+x-1')
7  printf('N01\tN02\tN11\tN12\tN21\tNet31\tO31\tN41\
      tN42\n
      ------------------------------------------------------------------
      n')
8  N01
      =[0,1,0.5,0.75,0.875,0.938,0.969,0.984,0.992,0.996,0.998,0.999,1,

9  N02(1)=2
10 for i=2:13
11     N02(i)=1;
12 end
13 for i=1:13
14     net31(i)=f(N01(i+1))*f(N01(i))
15     if net31(i)>0 then
16         O31(i)=1;
17     else
```

```
18          O31(i)=0;
19      end
20      N41(i)=(1-O31(i))*(NO1(i))+O31(i)*NO1(i+1)
21      N42(i)=(1-O31(i))*NO1(i+1)+O31(i)*NO2(i)
22      if i==2 then
23          printf('%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\
               t%.3f\t%.3f\t%.3f\n',0,NO2(i),f(NO1(i)),
               NO1(i+1),f(NO1(i+1)),net31(i),O31(i),N41(
               i),N42(i))
24      else
25      printf('%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f\t%.3f
           \t%.3f\t%.3f\n',NO1(i),NO2(i),f(NO1(i)),NO1(i
           +1),f(NO1(i+1)),net31(i),O31(i),N41(i),N42(i)
           )
26  end
27
28  end
29  printf('\n\nTherefore the solution is %.3f',N42(13))
```

Scilab code Exa 22.4 Hopfield Neural Network

```
1  //Example 22.4
2  //Hopfield Neural Network
3  //Page no. 766
4  clc;clear;close;
5
6  A=[1,2,1;-1,1,1;1,0,-1];
7  disp(inv(A),'Inverse of A =',A,'A =')
8  for i=1:3
9      for j=1:3
10         k=0;
11         for l=1:3
12             k=k+A(i,l)*A(j,l)
```

```
13          end
14          T(i,j)=k;
15      end
16  end
17  disp(T,'T =')
```

Scilab code Exa 22.5 RBF Network

```
1  //Example 22.5
2  //RBF Network
3  //Page no. 773
4  clc;clear;close;
5
6  deff('y=f(x)','y=10*sin(x)')
7  printf('Input\t\tDesired\t\tNetwork\t\tError\n\t\t
      Output\t\t Output\n
      ------------------------------------------------------------\
      n')
8  in
      =[0.7053,0.7060,0.7097,1.5056,1.5103,1.5377,2.2481,2.2514,2.2599,

9  n
      =[6.4828,6.4883,6.5164,9.9786,9.9816,9.9944,7.7926,7.7718,7.7180,-

10 for i=1:18
11     printf(' %.4f\t\t%.4f\t\t%.4f\t\t%.4f\n',in(i),f
          (in(i)),n(i),f(in(i))-n(i))
12 end
```

Scilab code Exa 22.7 First Order ODE

```
1 //Example 22.7
2 //First Order ODE
3 //Page no. 783
4 clc;clear;close;
5
6 deff('y=f(x)','y=(exp(-x^2/2))/(1+x+x^3)')
7 printf('Test Points\tActual Solution \tEstimated
    Solution\tError\n   x\t\twa(x)\t\t\twt(x)\t\t\tdw
    (x)\n
    ------------------------------------------------------------------------
    n')
8 x
    =[0.1054,0.1091,0.2693,0.2703,0.3067,0.3088,0.4268,0.4284,0.5098,

9 e
    =[0.1027,0.1063,0.2513,0.2522,0.2832,0.2849,0.3792,0.3805,0.4398,

10 for i=1:10
11     printf(' %.4f \t%.4f  \t\t%.4f\t\t\t%.4f\t\n',x(
         i),(1-f(x(i))),e(i),-e(i)+(1-f(x(i))))
12 end
13 printf('\n\n\nExperimental result varying from
    calculated result')
```