Scilab Textbook Companion for Basics Of Electrical Engineering by S. Sharma[1]

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July 31, 2019

[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: Basics Of Electrical Engineering

Author: S. Sharma

Publisher: I. K. International Publishing House, New Delhi

Edition: 2

Year: 2008

ISBN: 978-81-906942-5-4

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

DC Circuit Analysis and Network Theorems

Scilab code Exa 1.1 `Independent loop equations`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 1

clc;
disp("CHAPTER 1");
disp("EXAMPLE 1");

//VARIABLE INITIALIZATION
b=14;                              //number of branches
n=8;                               //number of nodes

//SOLUTION
m=b-n+1;                          //number of loop equations
disp(sprintf("The total number of independent loop equations are %d",m));

//END
```

Scilab code Exa 1.2 Resistance between A and B

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 2

clc;
disp("CHAPTER 1");
disp("EXAMPLE 2");

//VARIABLE INITIALIZATION
//star values ra, rc and rd
ra=2;                              //in Ohms
rc=4;                              //in Ohms
rd=3;                              //in Ohms
r1=5;                              //in Ohms
r2=4;                              //in Ohms
r3=6;                              //in Ohms

//SOLUTION
//converting star with points A, C and D into delta ACD
r=(ra*rc)+(rc*rd)+(rd*ra);         //'r' is the resistance that appears in the numerator of the equation of star-delta conversion

//delta values rac, rcd and rad
rac=r/rd;
rcd=r/ra;
rad=r/rc;
req1=(r1*rad)/(r1+rad);            //equivalent resistance between A and D
req2=(r2*rcd)/(r2+rcd);            //equivalent resistance between C and D
```

```
req3=req1+req2;                      //series combination
   of resistors
req4=(req3*rac)/(req3+rac);          //parallel
   combination of resistors
req5=req4+r3;
req6=(req5*7)/(req5+7);
disp(sprintf("The eqivalent resistance between
   points A and B is %f   ",req6));

//END
```

Scilab code Exa 1.3 Resistance between A and B

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 3

clc;
disp("CHAPTER 1");
disp("EXAMPLE 3");

//VARIABLE INITIALIZATION
r1=4.6;                              //in Ohms
r2=7.6;                              //in Ohms


//star values
rc=3;
rd=7;
re=5;

//SOLUTION
//converting star with points C, D and E to delta
   CDE
r=(rc*rd)+(rd*re)+(re*rc);           //'r' is the
```

```
   resistance that appears in the numerator of the
   equation of star-delta conversion

//delta values rcd, rde and rec
rcd=r/re;
rde=r/rc;
rec=r/rd;
req1=(8*rec)/(8+rec);            //equivalent
   resistance between C and E
req2=(6*rde)/(6+rde);            //equivalent
   resistance between D and E
req3=(4*rcd)/(4+rcd);            //equivalent
   resistance between C and D
req4=req2+req3;
req5=(req1*req4)/(req1+req4);   //parallel
   combination of resistors
req6=req5+r1;                    //series combination
   of resistors
req7=(req6*r2)/(req6+r2);
disp(sprintf("The equivalent resistance between
   points A and B is %f   ",req7));

//END
```

Scilab code Exa 1.4 Values of Rab Rcd and Rde

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 4

clc;
disp("CHAPTER 1");
disp("EXAMPLE 4");

//VARIABLE INITIALIZATION
```

```
r1=1;                          //LHS resistance in
   Ohms
r2=2;                          //in Ohms
r3=3;                          //in Ohms
r4=4;                          //in Ohms
r5=5;                          //in Ohms
r6=6;                          //in Ohms
r7=7;                          //in Ohms
r8=8;                          //RHS resistance in
   Ohms

//SOLUTION

//To find resistance between a and b
req1=r1+r2;                    //series combination
   of resistors
req2=(req1*r3)/(req1+r3);      //parallel combination
    of resistors
req3=req2+(r4+r5);
req4=(req3*r6)/(req3+r6);
req5=req4+r7;
req6=(req5*r8)/(req5+r8);
disp(sprintf("The equivalent resistance between
   points a and b is %f  ",req6));

//To find resistance between c and d
req7=r7+r8;
req8=(req7*r6)/(req7+r6);
req9=req2+r5+req8;
req10=(req9*r4)/(req9+r4);
disp(sprintf("The equivalent resistance between
   points c and d is %f  ",req10));

//To find resistance between d and e
req11=req2+r4+r5;
req12=(req11*r6)/(req11+r6);
req13=(req12*req7)/(req12+req7);
disp(sprintf("The equivalent resistance between
```

```
    points d and e is %f    ",req13));

//END
```

Scilab code Exa 1.5 `Rac and Rbd`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 5

clc;
disp("CHAPTER 1");
disp("EXAMPLE 5");

//VARIABLE INITIALIZATION
r1=2;                              //in Ohms
r2=4;                              //in Ohms
r3=8;                              //in Ohms
r4=8;                              //in Ohms
r5=2;                              //middle resistance in
   Ohms

//SOLUTION

//To find resistance between a and c
req1=r1+r2;
req2=r1+r4;
req3=(req1*r1)/(req1+r1);
rac=(req3*req2)/(req3+req2);
disp(sprintf("The eqiuvalent resistance between
    points a and c is %f    ",rac));

//To find resistance between b and d
//converting delta abc into star with points a, b
   and c
```

```
//delta values
rab=r1;
rbc=r2;
rac=6;
//star values
r=rab+rbc+rac;                    //'r' is the resistance
    that appears in the denominator of the equation
   of delta-star conversion
ra=(rab*rbc)/r;
rb=(rab*rac)/r;
rc=(rbc*rac)/r;
req5=rb+rac;
req6=rc+8;
rbd=ra+((req5*req6)/(req5+req6));
disp(sprintf("The eqiuvalent resistance between
   points b and d is %f   ",rbd));

//END
```

Scilab code Exa 1.6 Finding value of current by mesh analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 6

clc;
disp("CHAPTER 1");
disp("EXAMPLE 6");

//VARIABLE INITIALIZATION
n=4;                                    //number of
   nodes
b=6;                                    //number of
   branches

```

```
//SOLUTION
m=b-n+1;                                        //number of
    mesh equations
disp(sprintf("Number of mesh equations are %d",m));
nd=n-1;                                         //number of
    node equations
disp(sprintf("Number of node equations are %d",nd));

//(5/2)I1+(-2)I2+(-1/2)I3=4.....eq (1)
//(0)I1+(0)I2+(1)I3= -2.........eq (2)
//(-2)I1+(10/3)I2+(-1/3)I3=0....eq (3)
//using matrix method to solve the set of equations
A=[5/2 -2 -1/2;-2 10/3 -1/3;0 0 1];
b=[4;0;-2];
x=inv(A)*b;
I=x(1,:);                                        //to access
    the 1st element of 3X1 matrix
disp(sprintf("The current from the source Vs is %d A
    ",I));

//END
```

Scilab code Exa 1.7 Source transformation

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 7

clc;
disp("CHAPTER 1");
disp("EXAMPLE 7");

//VARIABLE INITIALIZATION
I1=1;                                   //current source in
    Amperes
```

```
v1=4;                                      //voltage source in Volts
v2=3;                                      //voltage source in Volts
v3=6;                                      //voltage source in Volts
r1=2;                                      //resistance in Ohms
r2=2;                                      //resistance in Ohms
r3=1;                                      //resistance in Ohms
r4=3;                                      //resistance in Ohms

//SOLUTION
//converting all the voltage sources into current sources
I2=v1/r1;
I3=v2/r3;
I4=v3/r4;
disp(sprintf("The four current sources are %d A, %d A, %d A and %d A",I1,I2,I3,I4));

req1=(r1*r2)/(r1+r2);                      //parallel combination of resistors
req2=(r3*r4)/(r3+r4);
v2=(I1+I4)*req1;
v3=(I3-I2)*req2;
req=req1+req2;
v=v2+v3;
I=v/req;
disp("VOLTAGE EQUIVALENT CIRCUIT:");
disp(sprintf("    Voltage source= %f V",v));
disp(sprintf("    Equivalent resistance(in series)= %f    ",req));
disp("CURRENT EQUIVALENT CIRCUIT:");
disp(sprintf("    Current source= %f A",I));
disp(sprintf("    Equivalent resistance(in parallel)= %f    ",req));

//END
```

Scilab code Exa 1.8 Source transformation and mesh analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 8

clc;
disp("CHAPTER 1");
disp("EXAMPLE 8");

//VARIABLE INITIALIZATION
I=2;                                //current source in Amperes
r1=1/2;                             //in Ohms
r2=1/2;                             //in Ohms

//SOLUTION
//the current source of 2A is converted into two 1V sources
v1=I*r1;
v2=I*r2;
disp(sprintf("The voltage sources after conversion are %d V and %d V",v1,v2));
//(5/2)I1+(-1)I2 =0........eq (1)   //applying KVL in mesh 1
//(-1)I1+(7/2)I2 =2........eq (2)   //applying KVL in mesh 2
//using matrix method to solve the set of equations
A=[5/2 -1;-1 7/2];
b=[2;2];
x=inv(A)*b;
x=x(2,:);
disp(sprintf("The current in 2  resistor is %f A",x));
```

```
//END
```

Scilab code Exa 1.9 Equivalent resistance

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 9

clc;
disp("CHAPTER 1");
disp("EXAMPLE 9");

//VARIABLE INITIALIZATION
r1=1;                              //in Ohms
r2=2;                              //in Ohms
r3=3;                              //in Ohms
r4=1;                              //in Ohms

//SOLUTION

//delta values
rab=r1;                            //between points a
   and b
rac=r2;                            //between points a
   and c
rbc=r3;                            //between points b
   and c
//coverting delta abc into star with points a, b and
    c
//star values ra, rb and rc
r=rab+rbc+rac;                     //'r' is the
   resistance that appears in the denominator of the
    equation of delta-star conversion
ra=(rab*rac)/r;
```

```
rb=(rab*rbc)/r;
rc=(rbc*rac)/r;
req1=r1+r4;
req2=rb+r2;
req3=(req1*req2)/(req1+req2);
req4=ra+req3;
disp(sprintf("The equivalent input resistance is %f ",req4));

//END
```

Scilab code Exa 1.10 Current through R3 using nodal analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 10

clc;
disp("CHAPTER 1");
disp("EXAMPLE 10");

//VARIABLE INITIALIZATION
v=10;                          //voltage source in Volts
I=5;                           //current source in Amperes
r1=2;                          //in Ohms
r2=2;                          //in Ohms
r3=4;                          //in Ohms

//SOLUTION
res=I+(v/r1);
v1=res/((1/r1)+(1/r2)+(1/r3));
I1=v1/r3;
disp(sprintf("By Nodal analysis, the current through
```

```
    resistor R3 is %d A",I1));

//END
```

Scilab code Exa 1.11 `Current through R3 using mesh analysis`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 11

clc;
disp("CHAPTER 1");
disp("EXAMPLE 11");

//VARIABLE INITIALIZATION
I3=-5;                                  //direction of
   I3 is opposite to the current which flows from
   the current source

//SOLUTION

//using mesh analysis, the following equations are
   obtained
//(4)I1+(-2)I2 =10...........eq (1)
//(-2)I1+(6)I2 = -20.........eq (2)
//solving the two equations using matrix method
A=[4 -2; -2 6];
b=[10;-20];
x=inv(A)*b;
I1=x(1,:);                              //to access 1st
   element of 2X1 matrix
I2=x(2,:);                              //to access 2nd
   element of 2X1 matrix
I=I2-I3;
disp(sprintf("By mesh analysis, the current through
```

```
resistor R3 is %d A",I));

//END
```

Scilab code Exa 1.12 Current through R3 using superposition theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 12

clc;
disp("CHAPTER 1");
disp("EXAMPLE 12");

//VARIABLE INITIALIZATION
v=10;                              //voltage source in Volts
I=5;                               //current source in Amperes
r1=2;                              //in Ohms
r2=2;                              //in Ohms
r3=4;                              //in Ohms

//SOLUTION

//deactivating current source
v1=(v/r1)/((1/r1)+(1/r2)+(1/r3));  //using nodal analysis
I1=v1/r3;

//deactivating voltage source
v2=I/((1/r1)+(1/r2)+(1/r3));       //using nodal analysis
I2=v2/r3;
I_tot=I1+I2;                       //applying
```

```
Superposition Theorem (I1 and I2 are in same direction)

disp(sprintf("By Superposition Theorem, the current through resistor R3 is %d A",I_tot));

//END
```

Scilab code Exa 1.13 `Current through R3 using Thevenin theorem`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 13

clc;
disp("CHAPTER 1");
disp("EXAMPLE 13");

//VARIABLE INITIALIZATION
v=10;                           //voltage source in Volts
I=5;                            //current source in Amperes
r1=2;                           //in Ohms
r2=2;                           //in Ohms
r3=4;                           //in Ohms

//SOLUTION
//solving by nodal analysis
res=I+(v/r1);                   //'res' is used to make the calculation easy
vth=res/((1/r1)+(1/r2));        //Thevenin voltage
rth=(r1*r2)/(r1+r2);            //Thevenin resistance
Ith=vth/(rth+r3);           //Thevenin current
disp(sprintf("By Thevenin Theorem, the current
```

```
through resistor R3 is %d A",Ith));

//END
```

Scilab code Exa 1.14 Current through R3 using Norton theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 14

clc;
disp("CHAPTER 1");
disp("EXAMPLE 14");

//VARIABLE INITIALIZATION
v=10;                           //voltage source in
   Volts
I3=-5;                          //current source in
   Amperes
r1=2;                           //in Ohms
r2=2;                           //in Ohms
r3=4;                           //in Ohms

//SOLUTION
//by loop analysis
//(1)I1+(-1)I2=0.........eq (1)
//(4)I1+(-2)I2=10........eq (2)
//solving the equations by matrix method
A=[1 -1;4 -2];
b=[0;10];
x=inv(A)*b;
I1=x(1,:);                      //to access 1st
   element of 2X1 matrix
I2=x(2,:);                      //to access 2nd
   element of 2X1 matrix
```

```
In=I2-I3;
rn=(r1*r2)/(r1+r2);
I=(rn*In)/(rn+r3);
disp(sprintf("By Norton Theorem, the current through
    resistor R3 is %d A",I));

//END
```

Scilab code Exa 1.15 To find Vx by mesh analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 15

clc;
disp("CHAPTER 1");
disp("EXAMPLE 15");

//VARIABLE INITIALIZATION
v=7;                                //voltage source in
    Volts
I=7;                                //current source in
    Amperes
r3=1;                               //in Ohms

//SOLUTION
//(1)I1+(-4)I2+(4)I3 = 7............eq (1)
//(-1)I1+(6)I2+(-3)I3 = 0..........eq (2)
//(1)I1+(0)I2+(-1)I3 = 7............eq (3)
//solving the equations by matrix method
A=[1 -4 4;-1 6 -3;1 0 -1];
b=[7;0;7];
x=inv(A)*b;
I1=x(1,:);                          //to access the 1st
    element of 3X1 matrix
```

```
I2=x(2,:);                          //to access the 2nd element of 3X1 matrix
I3=x(3,:);                          //to access the 3rd element of 3X1 matrix
vx=-(I3*r3);
disp(sprintf("By Mesh analysis , the value of Vx is %d V",vx));

//END
```

Scilab code Exa 1.16 To find Vx by nodal analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 16

clc;
disp("CHAPTER 1");
disp("EXAMPLE 16");

//VARIABLE INITIALIZATION
v=7;                                //voltage source in Volts
I=7;                                //current source in Amperes
r1=1;                               //in Ohms
r2=2;                               //in Ohms
r3=1;                               //in Ohms
r4=2;                               //in Ohms
r5=3;                               //in Ohms

//SOLUTION
//(4)vb+(-1)vc=0........eq (1)
//(-2)vb+(11)vc=21......eq (2)
//solving the equations by matrix method
```

```
A=[4 -1;-2 11];
b=[0;21];
x=inv(A)*b;
vb=x(1,:);                              //to access the 1st element of 2X1 matrix
vc=x(2,:);                              //to access the 2nd element of 2X1 matrix
vx=-vc;
disp(sprintf("By Nodal analysis, the value of Vx is %d V",vx));

//END
```

Scilab code Exa 1.17 `To find Vx by Superposition theorem`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 17

clc;
disp("CHAPTER 1");
disp("EXAMPLE 17");

//VARIABLE INITIALIZATION
v=7;                                    //voltage source in Volts
I=7;                                    //current source in Amperes
r1=1;                                   //in Ohms
r2=2;                                   //in Ohms
r3=1;                                   //in Ohms
r4=2;                                   //in Ohms
r5=3;                                   //in Ohms

//SOLUTION
```

```
//deactivating the current source
res=(v/4)+(v/2);
vc=res/((1/4)+(1/r1)+(1/r2));
vx1=-vc;

//deactivating voltage source
//(4)va+(-1)vb=-21........eq (1)
//(2)va+(-11)vb=0.........eq (2)
//solving the equations by matrix method
A=[4 -1;2 -11];
b=[-21;0];
x=inv(A)*b;
va=x(1,:);                        //to access 1st
    element of 2X1 matrix
vb=x(2,:);                        //to access 2nd
    element of 2X1 matrix
vx2=-vb;
vx=vx1+vx2;
disp(sprintf("By Superposition Theorem, the value of
     Vx is %d V",vx));

//END
```

Scilab code Exa 1.18 To find Vx by Thevenin theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 18

clc;
disp("CHAPTER 1");
disp("EXAMPLE 18");

//VARIABLE INITIALIZATION
```

```
v=7;                              //voltage source in
   Volts
I=7;                              //current source in
   Amperes
r1=1;                             //in Ohms
r2=2;                             //in Ohms
r3=1;                             //in Ohms
r4=2;                             //in Ohms
r5=3;                             //in Ohms

//SOLUTION
//solving by mesh analysis
I2=0;                             //since mesh 2 is
   open
I1=I-I2;
I3=I1/6;                          //from the equation
   of mesh 3
vth=-(r2*I3)+v;                   //Thevenin voltage
r=r1+r5;                          //series combination
    of resistors
rth=(r*r4)/(r+r4);                //parallel
   combination of resistors (Thevenin resistance)
I=vth/(rth+r3);                   //Thevenin current
vx=-I*r3;
disp(sprintf("By Thevenin Theorem, the value of Vx
   is %d V",vx));

//END
```

Scilab code Exa 1.19 To find Vx by Norton theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 19

```

```
clc;
disp("CHAPTER 1");
disp("EXAMPLE 19");

//VARIABLE INITIALIZATION
v=7;                                //voltage source in Volts
I=7;                                //current source in Amperes
r1=1;                               //in Ohms
r2=2;                               //in Ohms
r3=1;                               //in Ohms
r4=2;                               //in Ohms
r5=3;                               //in Ohms

//SOLUTION
//by using mesh analysis, the following equations are obtained
//(1)I1+(-4)I2+(3)In=7.......eq (1)
//(-1)I1+(6)I1+(-3)In=0......eq (2)
//(0)I1+(1)I2+(-1)In=0.......eq (3)
//solving the equations by matrix method
A=[1 -4 3;-1 6 -3;0 1 -1];
b=[7;0;0];
x=inv(A)*b;
I1=x(1,:);                          //to access the 1st element of 3X1 matrix
I2=x(2,:);                          //to access the 2nd element of 3X1 matrix
IN=x(3,:);                          //to access the 3rd element of 3X1 matrix; IN is Norton current
r=r1+r5;                            //series combination of resistors
rN=(r*r4)/(r+r4);                   //parallel combination of resistors (Norton resistance)
I=(rN*IN)/(rN+r3);
vx=-I*r3;
disp(sprintf("By Norton Theorem, the value of Vx is
```

```
%d V",vx));

//END
```

Scilab code Exa 1.20 To find I using Norton theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 20

clc;
disp("CHAPTER 1");
disp("EXAMPLE 20");

//VARIABLE INITIALIZATION
I=20;                                //current source
   in Amperes
v1=10;                               //voltage source
   in Volts
v2=40;                               //voltage source
   in Volts
r1=8;                                //in Ohms
r2=5;                                //in Ohms
r3=4;                                //in Ohms
r4=12;                               //in Ohms

//SOLUTION
req=r1+r2;
rn=(req*r3)/(req+r3);
//finding In by mesh analysis
//(17)I2+(-4)I3 =110.......eq (1)
//(1)I2+(-1)I3 = -10........eq (2)
//solving the equations by matrix mehod
A=[17 -4;1 -1];
b=[110;-10];
```

```
x=inv(A)*b;
I2=x(1,:);                          //to access the 1st element of 2X1 matrix
I3=x(2,:);                          //to access the 2nd element of 2X1 matrix
In=I3;
I=(rn*In)/(rn+r4);
disp(sprintf("By Norton Theorem, the value of I is %f A",I));

//END
```

Scilab code Exa 1.21 `To find I using Thevenin theorem`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 21

clc;
disp("CHAPTER 1");
disp("EXAMPLE 21");

//VARIABLE INITIALIZATION
I=20;                              //current source in Amperes
v1=10;                             //voltage source in Volts
v2=40;                             //voltage source in Volts
r1=8;                              //in Ohms
r2=5;                              //in Ohms
r3=4;                              //in Ohms
r4=12;                             //in Ohms

//SOLUTION
```

```

req=r1+r2;                              //series
    combination of resistors
rth=(req*r3)/(req+r3);                  //parallel
    connection of resistors (Thevenin resistance)

//by using nodal analysis, the following equations
    are obtained
//(13)v1+(-8)v2=750.......eq (1)
//(-4)v1+(9)v2=200........eq (2)
//solving the equations by matrix mehod

A=[13 -8;-4 9];
b=[750;200];
x=inv(A)*b;
v1=x(1,:);                              //to access the 1
    st element of 2X1 matrix
v2=x(2,:);                              //to access the 2
    nd element of 2X1 matrix
vth=v2;                                 //Thevenin voltage
I=vth/(rth+r4);                         //Thevenin current
disp(sprintf("By Thevenin Theorem, the value of I is
     %f A",I));

//END
```

Scilab code Exa 1.22 To find I using mesh analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 22

clc;
disp("CHAPTER 1");
disp("EXAMPLE 22");
```

```

//VARIABLE INITIALIZATION
I1=20;                                  //current source in Amperes
v1=10;                                  //voltage source in Volts
v2=40;                                  //voltage source in Volts
r1=8;                                   //in Ohms
r2=5;                                   //in Ohms
r3=4;                                   //in Ohms
r4=12;                                  //in Ohms

//SOLUTION

//by using mesh analysis the following equations are obtained
//(17)I2+(-4)I3 =110.......eq (1)
//(-1)I2+(4)I3 =10.........eq (2)
//solving the equations by matrix method
A=[17 -4;-1 4];
b=[110;10];
x=inv(A)*b;
I2=x(1,:);                               //to access the 1 st element of 2X1 matrix
I3=x(2,:);                               //to access the 2 nd element of 2X1 matrix
I=I3;
disp(sprintf("By mesh analysis, the value of I is %f A",I));

//END
```

Scilab code Exa 1.23 To find I using nodal analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 23

clc;
disp("CHAPTER 1");
disp("EXAMPLE 23");

//VARIABLE INITIALIZATION
I1=20;                                  //current source
   in Amperes
v1=10;                                  //voltage source
   in Volts
v2=40;                                  //voltage source
   in Volts
r1=8;                                   //in Ohms
r2=5;                                   //in Ohms
r3=4;                                   //in Ohms
r4=12;                                  //in Ohms

//SOLUTION
//(17)I2+(-4)I3=110.......eq (1)
//(-4)v1+(16)I3=40........eq (2)
//solving the equations by matrix mehod
A=[17 -4;-4 16];
b=[110;40];
x=inv(A)*b;
I2=x(1,:);                               //to access the 1
   st element of 2X1 matrix
I3=x(2,:);                               //to access the 2
   nd element of 2X1 matrix
disp(sprintf("By Nodal analysis, the value of I is
   %f A",I3));

//END
```

Scilab code Exa 1.24 To find I using Superposition theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 24

clc;
disp("CHAPTER 1");
disp("EXAMPLE 24");

//VARIABLE INITIALIZATION
I=20;                                  //current source
   in Amperes
v1=10;                                 //voltage source
   in Volt
v2=40;                                 //voltage source
   in Volts
r1=8;                                  //in Ohms
r2=5;                                  //in Ohms
r3=4;                                  //in Ohms
r4=12;                                 //in Ohms

//SOLUTION

//activating 20A current source
r=r2+((r3*r4)/(r3+r4));
I1=(r*I)/(r+r1);
I_20=(r3*I1)/(r3+r4);

//activating 10V battery source
req=r1+r2;
v_10=(-v1/req)/((1/req)+(1/r3)+(1/r4));
I_10=v_10/r4;

```

```
//activating 40V battery source
v_40=(v2/r3)/((1/req)+(1/r3)+(1/r4));
I_40=v_40/r4;
I_tot=I_20+I_10+I_40;
disp(sprintf("By Superposition Theorem, the value of
    I is %f A",I_tot));

//END
```

Scilab code Exa 1.25 To find I using mesh analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 25

clc;
disp("CHAPTER 1");
disp("EXAMPLE 25");

//SOLUTION
//(1)I1+(0)I2+(0)I3=5.............eq (1)
//(-20)I1+(50)I2+(-20)I3=0........eq (2)
//(0)I1+(1)I2+(-1)I3=5............eq (3)
//solving the equations by matrix mehod
A=[1 0 0;-20 50 -20;0 1 -1];
b=[5;0;5];
x=inv(A)*b;
I1=x(1,:);                          //to access the 1
   st element of 3X1 matrix
I2=x(2,:);                          //to access the 2
   nd element of 3X1 matrix
I3=x(3,:);                          //to access the 3
   rd element of 3X1 matrix
I=I2;
disp(sprintf("By Mesh analysis, the value of I is %d
```

```
A",I));

//END
```

Scilab code Exa 1.26 `To find I using nodal analysis`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 26

clc;
disp("CHAPTER 1");
disp("EXAMPLE 26");

//VARIABLE INITIALIZATION
I1=5;                              //current source in
    Amperes
v2=100;                            //voltage source in
    Volts
r1=20;                             //in Ohms
r2=10;                             //in Ohms
r3=20;                             //in Ohms

//SOLUTION
v1=(I1+(v2/r2))/((1/r1)+(1/r2));
I=(v1-v2)/r2;
disp(sprintf("By Nodal analysis, the value of I is
    %d A",I));

//END
```

Scilab code Exa 1.27 `To find I using Thevenin theorem`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 27

clc;
disp("CHAPTER 1");
disp("EXAMPLE 27");

//VARIABLE INITIALIZATION
I1=5;                              //current source in
   Amperes
vb=100;                            //voltage source in
   Volts
r1=20;                             //in Ohms
r2=10;                             //in Ohms
r3=20;                             //in Ohms

//SOLUTION
va=I1*r1;                          //by applying node
   analysis at point 'a'
vth=va-vb;                         //Thevenin voltage
   vth=vab
rth=r1+((r3*0)/(r3+0));            //Thevenin resistance
I=vth/(rth+r2);
disp(sprintf("By Thevenin Theorem, the value of I is
    %d A",I));

//END
```

Scilab code Exa 1.28 To find I using Norton theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 28

```

```
clc;
disp("CHAPTER 1");
disp("EXAMPLE 28");

//VARIABLE INITIALIZATION
I1=5;                         //current source in Amperes
va=100;                       //voltage source in Volts
r1=20;                        //in Ohms
r2=10;                        //in Ohms
r3=20;                        //in Ohms

//SOLUTION
IN=I1-(va/r1);                //using nodal analysis at point 'a'
rN=r1+((r3*0)/(r3+0));
I=(rN*IN)/(rN+r2);
disp(sprintf("By Norton Theorem, the value of I is %d A",I));

//END
```

Scilab code Exa 1.29 To find I using Superposition theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 29

clc;
disp("CHAPTER 1");
disp("EXAMPLE 29");

//VARIABLE INITIALIZATION
I=5;                          //current source in
```

```
Amperes
v=100;                              //voltage source in Volts
r1=20;                              //in Ohms
r2=10;                              //in Ohms
r3=20;                              //in Ohms

//SOLUTION

//activating current source
I1=(I*r1)/(r1+r2);                  //by current divider law

//activating voltage source
I2=-(v/(r1+r2));

I_tot=I1+I2;
disp(sprintf("By Superposition Theorem, the value of I is %d A",I_tot));

//END
```

Scilab code Exa 1.30 `Source transformation and mesh and nodal methods`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 30

clc;
disp("CHAPTER 1");
disp("EXAMPLE 30");

//VARIABLE INITIALIZATION
I1=25;                                 //current source in Amperes
```

```
I2=20;                                  //current source in Amperes
v=20;                                   //voltage source in Volts
r1=4;                                   //LHS resistance in Ohms
r2=10;                                  //in Ohms
r3=2;                                   //in Ohms
r4=1;                                   //in Ohms
r5=10;                                  //RHS resistance in Ohms

//SOLUTION

//source transformation
v1=I1*r1;                               //current source I1 is converted to voltage source v1
v2=I2*r3;                               //current source I2 is converted to voltage source v2

//using mesh analysis
//(8)IA+(-1)IB=30........eq (1)
//(-2)IA+(3)IB=20........eq (2)
//solving the equations by matrix method
A=[8 -1;-2 3];
b=[30;20];
x=inv(A)*b;
IA=x(1,:);                              //to access the 1 st element of 2X1 matrix
IB=x(2,:);                              //to access the 2 nd element of 2X1 matrix
disp(sprintf("By Mesh analysis I_A= %d A and I_B= %d A",IA,IB));

//using nodal analysis
req=r1+r2;
res=(v1/req)+(v2/r3)+(v/r4);
v3=res/((1/req)+(1/r3)+(1/r4));
```

```
I3=(v1-v3)/req;
I4=(v2-v)/r3;                        //since here ((v2−
    v)/r3)=((v3−v)/r4) (this is only done for
    convinient calculation)
disp(sprintf("By Nodal analysis I_1= %d A and I_2=
    %d A",I3,I4));

//END
```

Scilab code Exa 1.31 Delta to star transformation

```
//CHAPTER 1− D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 31

clc;
disp("CHAPTER 1");
disp("EXAMPLE 31");

//VARIABLE INITIALIZATION
r1=6;                              //in Ohms
r2=4;                              //in Ohms
r3=4;                              //in Ohms
r4=4;                              //in Ohms
r5=6;                              //in Ohms
r6=6;                              //in Ohms
r7=6;                              //in Ohms
r8=8;                              //in Ohms
r9=4;                              //in Ohms
r10=10;                            //in Ohms
r11=10;                            //middle resistance
    in Ohms

//SOLUTION
//converting delta cde in a star
```

```
req1=r5+r6+r7;
req2=(r6*r7)/req1;
req3=(r5*r6)/req1;
req4=(r5*r7)/req1;

req5=r1+r2+r3;                    //on LHS of middle resistance
req6=r4+req2;                     //top LHS
req7=req4+r11;                    //equivalent middle resistance
req8=req3+r8+r9+r10;              //top RHS

req9=(req7*req8)/(req7+req8);     //parallel combination of resistors
req10=req9+req6;                  //series combination of resistors
req11=(req5*req10)/(req5+req10);

disp(sprintf("The equivalent resistance between A and B is %d   ",req11));

//END
```

Scilab code Exa 1.32 To find I through 1 ohm by mesh analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 32

clc;
disp("CHAPTER 1");
disp("EXAMPLE 32");

//VARIABLE INITIALIZATION
I=10;                             //current source in
```

```
    Amperes
v=10;                                  //voltage source in
    Volts
r1=4;                                  //top resistance in
    Ohms
r1=4;                                  //right resistance
    in Ohms
r3=4;                                  //bottom resistance
    in Ohms
r4=6;                                  //left resistance in
     Ohms
r5=1;                                  //in Ohms

//SOLUTION
//without converting the current source into voltage
     source
//(10)I1+(-4)I2+(0)I3 =50........eq (1)
//(-4)I1+(9)I2+(-4)I3 =0.........eq (2)
//(0)I1+(-4)I2+(8)I3 =10.........eq (3)
//solving the equations by matrix method
A=[10 -4 0;-4 9 -4;0 -4 8];
b=[50;0;10];
x=inv(A)*b;
I2=x(2,:);                              //to access the 2nd
     element of 3X1 matrix
disp(sprintf("By Mesh analysis , the current through
    1   resistor is %f A",I2));

//END
```

Scilab code Exa 1.33 `To find I through 1 ohm R by nodal analysis`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 33
```

```
clc;
disp("CHAPTER 1");
disp("EXAMPLE 33");

//VARIABLE INITIALIZATION
I=10;                                   //current source in
    Amperes
v=10;                                   //voltage source in
    Volts
r1=4;                                   //top resistance in
    Ohms
r1=4;                                   //right resistance
    in Ohms
r3=4;                                   //bottom resistance
    in Ohms
r4=6;                                   //left resistance in
     Ohms
r5=1;                                   //in Ohms

//SOLUTION

//by applying nodal analysis at node 1, the
    following equations are obtained:
//(17)v1+(−12)v2 =150.......eq (1)
//(−4)v1+(6)v2 =10..........eq (2)
//solving the equations by matrix method

A=[17 -12;-4 6];
b=[150;10];
x=inv(A)*b;
v1=x(1,:);                               //to access the 1st
     element of 2X1 matrix
v2=x(2,:);                               //to access the 1st
     element of 2X1 matrix
if(v1>v2) then
I=(v1-v2)/r5;
disp(sprintf("By nodal analysis, the current through
```

```
1   resistor is %f A",I));
else
I=(v2-v1)/r5;
disp(sprintf("By nodal analysis , the current through 1   resistor is %f A",I));
end;

//END
```

Scilab code Exa 1.34 `To find I through 1 ohm R by Superposition theorem`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 34

clc;
disp("CHAPTER 1");
disp("EXAMPLE 34");

//VARIABLE INITIALIZATION
I=10;                                //current source in Amperes
v=10;                                //voltage source in Volts
r1=4;                                //top resistance in Ohms
r1=4;                                //right resistance in Ohms
r3=4;                                //bottom resistance in Ohms
r4=6;                                //left resistance in Ohms
r5=1;                                //in Ohms

//SOLUTION
```

```

//activating the current source
//(17)v1+(−12)v2=120.......eq (1)
//(−4)v1+(6)v2=0...........eq (2)
//solving the equations by matrix method
A=[17 -12;-4 6];
b=[120;0];
x=inv(A)*b;
v1=x(1,:);                              //to access the 1st
    element of 2X1 matrix
v2=x(2,:);                              //to access the 1st
    element of 2X1 matrix
if(v1>v2) then
I1=(v1-v2)/r5;
else
I1=(v2-v1)/r5;
end;

//activating the voltage source
//(17)v1+(−12)v2=30.......eq (1)
//(−4)v1+(6)v2=10...........eq (2)
//solving the equations by matrix method
A=[17 -12;-4 6];
b=[30;10];
x=inv(A)*b;
v3=x(1,:);                              //to access the 1st
    element of 2X1 matrix
v4=x(2,:);                              //to access the 1st
    element of 2X1 matrix
if(v3>v4) then
I2=(v3-v4)/r5;
else
I2=(v4-v3)/r5;
end;

I_tot=I1+I2;
disp(sprintf("By Superposition Theorem, the current
   through 1   resistor is %f A",I_tot));
```

```

//END
```

Scilab code Exa 1.35 `To find I through 1 ohm by Thevenin theorem`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 35

clc;
disp("CHAPTER 1");
disp("EXAMPLE 35");

//VARIABLE INITIALIZATION
I=10;                              //current source in Amperes
v=10;                              //voltage source in Volts
r1=4;                              //top resistance in Ohms
r2=4;                              //right resistance in Ohms
r3=4;                              //bottom resistance in Ohms
r4=6;                              //left resistance in Ohms
r5=1;                              //in Ohms

//SOLUTION
res=I+(v/r1);                      //'res' is used to make calucations easy
va=res/((1/r4)+(1/r1));            //applying nodal analysis at node 1
vb=(v/r2)/((1/r2)+(1/r3));         //applying nodal analysis at node 2
```

```
vth=va-vb;
req1=(r1*r4)/(r1+r4);
req2=(r2*r3)/(r2+r3);
rth=req1+req2;
Ith=vth/(rth+r5);
disp(sprintf("By Thevenins Theorem, the current
    through the 1  resistor is %f A",Ith));

//END
```

Scilab code Exa 1.36 To find I through 1 ohm R by Norton theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 36

clc;
disp("CHAPTER 1");
disp("EXAMPLE 36");

//VARIABLE INITIALIZATION
I=10;                                   //current source
    in Amperes
v=10;                                   //voltage source
    in Volts
r1=4;                                   //top resistance
    in Ohms
r2=4;                                   //right
    resistance in Ohms
r3=4;                                   //bottom
    resistance in Ohms
r4=6;                                   //left resistance
     in Ohms
r5=1;                                   //in Ohms

```

```
//SOLUTION
//(1)v1+(12/5)In=30........eq (1)
//(2)v1+(-4)In=10..........eq (2)
A=[1 12/5;2 -4];
b=[30;10];
x=inv(A)*b;
v1=x(1,:);                          //to access the 1st element of 2X1 matrix
In=x(2,:);                          //to access the 2nd element of 2X1 matrix
req1=(r1*r4)/(r1+r4);
req2=(r2*r3)/(r2+r3);
rn=req1+req2;
I1=(rn*In)/(rn+r5);
disp(sprintf("By Norton Theorem, the current through 1  resistor is %f A",I1));

//END
```

Scilab code Exa 1.37 `To calculate Vab by Thevenin and Norton theorm`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 37

clc;
disp("CHAPTER 1");
disp("EXAMPLE 37");

//VARIABLE INITIALIZATION
v1=90;                              //voltage source in Volts
r1=8;                               //in Ohms
r2=6;                               //in Ohms
r3=5;                               //in Ohms
```

```
r4=4;                                         //in Ohms
r5=8;                                         //diagonal resistance in Ohms
r6=8;                                         //in Ohms

//SOLUTION

//solution (i): using Thevenin's Theorem
//(3)v1+(−2)v2=90...........eq (1)  //applying nodal analysis at node 1
//(−2)v1+(4)v2=−90..........eq (2)  //applying nodal analysis at node 2
A=[3 -2;-2 4];
b=[90;-90];
x=inv(A)*b;
v1=x(1,:);
v2=x(2,:);
vth=v1;
req1=(r1*r5)/(r1+r5);
req2=req1+r4;
req3=(req2*r6)/(req2+r6);
rth=req3+r2;
vab1=(vth*r3)/(rth+r3);
disp(sprintf("By Thevenins Theorem, the value of Vab is %f V",vab1));

//solution (ii): using Norton's Theorem
//(13)v1+(−7)v2=270.........eq (1)  //applying nodal analysis at node 1
//(7)v1+(−13)v2=0...........eq (2)  //applying nodal analysis at node 2
A=[13 -7;7 -13];
b=[270;0];
x=inv(A)*b;
v1=x(1,:);
v2=x(2,:);
req1=(r1*r5)/(r1+r5);
req2=req1+r4;
```

```
req3=(req2*r6)/(req2+r6);
rN=req3+r2;
if(v1>v2) then
IN=(v1-v2)/r2;
else
IN=(v2-v1)/r2;
end;
vab2=(r3*IN)*(rN/(rth+r3));
disp(sprintf("By Nortons Theorem, the value of Vab is %f V",vab2));

//END
```

Scilab code Exa 1.38 Thevenin and Norton equivalent

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 38

clc;
disp("CHAPTER 1");
disp("EXAMPLE 38");

//VARIABLE INITIALIZATION
I=2;                              //current source in Amperes
r1=2;                             //in Ohms
r2=1;                             //in Ohms
r3=1;                             //in Ohms
r4=2;                             //in Ohms

//SOLUTION

//Thevenin Equivalent circuit
I1=1;                             //since there is
```

```
equal resistance of 3 , hence, current=1A
vth=(I1*r2)+(-I1*r4);
req1=r1+r2;
req2=r3+r4;
rth=(req1*req2)/(req1+req2);
disp("THEVENIN EQUIVALENT CIRCUIT IS-");
disp(sprintf("      Thevenin voltage= %d V",vth));
disp(sprintf("      Thevenin resistance= %f   ",rth));

//Norton Equivalent circuit
v1=I/((1/r2)+(1/r4));
v2=-I/((1/r3)+(1/r1));
req1=r1+r2;
req2=r3+r4;
rn=(req1*req2)/(req1+req2);
Isc=(v1/r4)+v2;
disp("NORTON EQUIVALENT CIRCUIT IS-");
disp(sprintf("      Norton current= %f A",Isc));
disp(sprintf("      Norton resistance= %f   ",rn));

//END
```

Scilab code Exa 1.39 `Delta to star transformation to find I`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 39

clc;
disp("CHAPTER 1");
disp("EXAMPLE 39");

//VARIABLE INITIALIZATION
v=2;                                //in Volts
```

```
r=2;                              //in Ohms

//SOLUTION
z_star=r/3;
req1=(r/3)+r;
req2=(r/3)+r;
req3=(req1*req2)/(req1+req2);
req4=(r/3)+req3;
req5=(req4*r)/(req4+r);
I=v/req5;
disp(sprintf("The value of I is %d A",I));

//END
```

Scilab code Exa 1.40 Currents in different branches

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 40

clc;
disp("CHAPTER 1");
disp("EXAMPLE 40");

//VARIABLE INITIALIZATION
v1=20;                            //in Volts
v2=10;                            //in Volts
r1=5;                             //top resistance in Ohms
r2=10;                            //bottom resistance in Ohms
r3=5;                             //in Ohms
r4=5;                             //in Ohms
r5=10;                            //in Ohms

```

```
//SOLUTION
//(5)I1+(10)I3+(-10)I4 =20............eq (1)
//(0)I1+(10)I3+(10)I4 = -50...........eq (2)
//(5)I1+(20)I3+(0)I4 = -30............eq (3) (eq(1) + eq(2))
//Since the determinant of matrix A is 0, hence, the set of these equations cannot be solved by matrix method
//So, solving them directly,

I3=-15/25;
I1=-3-(3/5);
I4=-5-(-3/5);
I=I1+3+5;
disp("The currents (in Amperes) flowing in different branches are:");
disp(I1);
disp(I3);
disp(I4);
disp(sprintf("The total current is %f A",I));

//END
```

Scilab code Exa 1.41 `Current when resistance is connected across AB`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 41

clc;
disp("CHAPTER 1");
disp("EXAMPLE 41");

//VARIABLE INITIALIZATION
vs=6;                               //in Volts
```

```
Is=4;                              //in Amperes
r1=5;                              //in Ohms
r2=2;                              //in Ohms
r3=2;                              //in Ohms
r=2/3;                             //in Ohms
r4=3;                              //in Ohms
r5=1;                              //in Ohms
r6=2;                              //in Ohms

//SOLUTION
req1=(r2*r3)/(r2+r3);
req2=req1+r1;                      //resistance across vs
va=vs/req2;                        //voltage divider law
rth1=(req1*r1)/(req1+r1);
I1=Is*(r2/req2);                   //current divider law
vb=I1*r4;
rth2=(r4*r4)/(r4+r4);
I=(vb-va)/(rth1+r+rth2);
disp(sprintf("The value of the current is %d A",I));

//END
```

Scilab code Exa 1.42 Thevenin and Nodal analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 42

clc;
disp("CHAPTER 1");
disp("EXAMPLE 42");

//VARIABLE INITIALIZATION
v=10;                                   //in Volts
```

```
I=0.5;                                  //in Amperes
r1=4;                                   //top LHS resistance in Ohms
r2=2;                                   //top RHS resistance in Ohms
r3=2;                                   //first resistance in Ohms
r4=2;                                   //second resistance in Ohms

//SOLUTION

//using Thevenin's theorem
rth=(r1*r3)/(r1+r3);
vth=v*(r3/(r1+r3));                     //Thevenin voltage
R=(40-(56*I))/(24*I);                   //solving for R directly
disp(sprintf("(i) By Thevenins Theorem, the value of R is %d   ",R));

//v1=(10R+4)/(3R+4)........eq(1)        //using nodal analysis at node 1
//v1=1+R...................eq(2)        //using nodal analysis at node 2
//the following the quadratic equation is formed when both the equations are compared
//(3)R^2+(-3)R+(0)=0
//solving the quadratic equation
a=3;
b=-3;
c=0;
D=(b^2)-(4*a*c);                        //discriminant
R1=(-b+sqrt(D))/(2*a);
R2=(-b-sqrt(D))/(2*a);
if(R1==1) then
disp(sprintf("(ii) By Nodal analysis, the value of R is %d   ",R1));
```

```
else
disp(sprintf("(ii) By Nodal analysis, the value of R
    is %d   ",R1));
end;

//END
```

Scilab code Exa 1.43 `Superposition theorem`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 43

clc;
disp("CHAPTER 1");
disp("EXAMPLE 43");

//VARIABLE INITIALIZATION
Is1=2;                              //first current
   source in Amperes
Is2=4;                              //second current
   source in Amperes
v=2;                                //in Volts
r1=200;                             //in Ohms
r2=100;                             //in Ohms
r3=4;                               //in Ohms

//SOLUTION
req1=34;
Ia=Is2*(r3/req1);
req2=24;
Iab=Is1*(req2/req1);
I=Ia+Iab;
vab=I*10;
disp(sprintf("By Superposition Theorem the voltage
```

```
   Vab is %f V",vab));

//END
```

Scilab code Exa 1.44 Determination of voltage

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 44

clc;
disp("CHAPTER 1");
disp("EXAMPLE 44");

//VARIABLE INITIALIZATION
I=40;                                //in Amperes
r=5;                                 //in Ohms

//SOLUTION
v=I*r;                               //Ohm's Law
disp(sprintf("The voltage required is %d V",v));

//END
```

Scilab code Exa 1.45 value of resistance

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 45

clc;
disp("CHAPTER 1");
disp("EXAMPLE 45");
```

```

//VARIABLE INITIALIZATION
w=5*1000;                           //power consumed by coil in Watts
v=200;                              //applied voltage in Volts

//SOLUTION
r=(v^2)/w;                          //since w=(v^2)/r
disp(sprintf("Value of resistance is %d   ",r));

//END
```

Scilab code Exa 1.46 `Resistance of metal filament lamp`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 46

clc;
disp("CHAPTER 1");
disp("EXAMPLE 46");

//VARIABLE INITIALIZATION
v=240;                               //in Volts

//SOLUTION
//case1: p=60W
p1=60;                               //in Watts
r1=(v^2)/p1;
disp(sprintf("Resistance of the metal filament lamp is %d   ",r1));

//case2: p=100W
p2=100;                              //in Watts
```

```
r2=(v^2)/p2;

if(r1>r2) then
disp(sprintf("Resistance of %d W lamp will be
   greater",p1));
else
disp(sprintf("Resistance of %d W lamp will be
   greater",p2));
end;

//END
```

Scilab code Exa 1.47 `Copper wire and platinum silver wire`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 47

clc;
disp("CHAPTER 1");
disp("EXAMPLE 47");

//VARIABLE INITIALIZATION
lc=20;                          //length of copper
   wire in m
dc=0.015/100;                   //diameter of copper
   wire in m
rhoc=1.7;                       //specific resistance
    for copper
lp=15;                          //length of platinum
   silver wire in m
dp=0.015/100;                   //diameter of
   platinum silver wire in m
rhop=2.43;                      //specific resistance
    for platinum silver
```

```
//SOLUTION

//for copper wire
sc=(%pi/4)*(dc^2);                    //area
rc=rhoc*(lc/sc);

//for platinum silver
sp=(%pi/4)*(dp^2);                    //area
rp=rhop*(lp/sp);


if(rc>rp) then
disp("Copper wire has greater resistance");
else
disp("Platinum silver wire has greater resistance");
end;

//END
```

Scilab code Exa 1.48 `Cells B1 and b2`

```
//CHAPTER 1− D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 48

clc;
disp("CHAPTER 1");
disp("EXAMPLE 48");

//VARIABLE INITIALIZATION
v1=2.05;                              //1st cell in Volts
v2=2.15;                              //2nd cell in Volts
```

```
r1=0.05;                                    //in Ohms
r2=0.04;                                    //in Ohms
r3=1;                                       //in Ohms

//SOLUTION
//(r3+r1)I1+(r3)I2=v1......eq (1)
//(r3)I1+(r3+r2)I2=v2......eq (2)
req1=r3+r1;
req2=r3+r2;
A=[req1 r3;r3 req2];
b=[v1;v2];
x=inv(A)*b;
I1=x(1,:);                                  //to access the
    1st element of 2X1 matrix
I2=x(2,:);                                  //to access the
    2nd element of 2X1 matrix
I=I1+I2;
pd=I*r3;
disp(sprintf("Current through B1 is %f A",I1));
disp(sprintf("Current through B2 is %f A",I2));
disp(sprintf("Potential difference across AC is %f V
   ",pd));

//END
```

Scilab code Exa 1.49 `Values of R1 and R2`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 49

clc;
disp("CHAPTER 1");
disp("EXAMPLE 49");

```

```
//VARIABLE INITIALIZATION
v1=110;                              //voltage source in Volts
v2=80;                               //voltage source in Volts
v3=50;                               //voltage source in Volts
r=2;                                 //in Ohms

//SOLUTION

//solution (a)
I1=4;                                //charging
I2=6;                                //charging
r1=((v1-v2)-((I1+I2)*r))/I1;
r2=((v1-v3)-((I1+I2)*r))/I2;
disp(sprintf("(a) R1= %f    ",r1));
disp(sprintf("    R2= %f    ",r2));

//solution (b)
I1=2;                                 //discharging
I2=20;                                //charging
r1=((v1-v2)-((I2-I1)*r))/(-I1);
r2=((v1-v3)-((I2-I1)*r))/I2;
disp(sprintf("(b) R1= %f    ",r1));
disp(sprintf("    R2= %f    ",r2));

//solution (c)
I1=0;
I2=(v1-v2)/r;
r2=((v1-v3)-(I2*r))/I2;
disp(sprintf("(c) I1=0 when R2= %d    ",r2));

//END
```

Scilab code Exa 1.50 Currents i1 and i2

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 50

clc;
disp("CHAPTER 1");
disp("EXAMPLE 50");

//SOLUTION
//(5)I1+(-3)I2 =10..........eq (1)
//(-3)I1+(34)I2 =40.........eq (2)
A=[5 -3;-3 34];
b=[10;40];
x=inv(A)*b;
I1=x(1,:);                    //to access the 1st
    element of 2X1 matrix
I2=x(2,:);                    //to access the 2nd
    element of 2X1 matrix
I=I2-I1;
disp(sprintf("Current i1 is %f A (loop EFAB)",I1));
disp(sprintf("Current i2 is %f A (loop BCDE)",abs(I)
    ));

//END
```

Scilab code Exa 1.51 Currents in all branches

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 51

clc;
disp("CHAPTER 1");
```

```
disp("EXAMPLE 51");

//SOLUTION
//(9)I1+(-5)I2+(-3)I3 = 5..........eq (1)
//(-5)I1+(8)I2+(-1)I3 = 5..........eq (2)
//(-3)I1+(-1)I2+(6)I3 = 3..........eq (3)
A=[9 -5 -3;-5 8 -1;-3 -1 6];
b=[5;5;3];
x=inv(A)*b;
I1=x(1,:);                          //to access the 1st element of 3X1 matrix
I2=x(2,:);                          //to access the 2nd element of 3X1 matrix
I3=x(3,:);                          //to access the 3rd element of 3X1 matrix
disp(sprintf("Current i1 is %f A (loop ABGH)",I1));
disp(sprintf("Current i2 is %f A (loop BCDH)",I2));
disp(sprintf("Current i3 is %f A (loop GDEF)",I3));

//END
```

Scilab code Exa 1.52 Thevenin theorem and Norton theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 52

clc;
disp("CHAPTER 1");
disp("EXAMPLE 52");

//VARIABLE INITIALIZATION
v1=20;                              //LHS voltage source in Volts
v2=12;                              //RHS voltage source
```

```
in Volts
r1=5;                              //LHS resistance in Ohms
r2=2;                              //in Ohms
r3=8;                              //in Ohms
r4=10;                             //RHS resistance in Ohms

//SOLUTION

//by Thevenin's Theorem
rth=r3+((r1*r2)/(r1+r2));          //Thevenin resistance
v=v1*(r2/(r1+r2));                 //voltage divider law
vab=-v2+(r3*0)+(rth*0)+v;
It=vab/(rth+r4);                   //current obtained by applying Thevenin's Theorem
Isc=vab/rth;
disp(sprintf("By Thevenins Theorem, current in the 10  resistor is %f A",It));

//verification by Norton's Theorem
//(7)I1+(2)I2 = 20.................eq (1)
//(2)I1+(10)I2 = 12................eq (2)
//solving the equations using matrix method
A=[7 2;2 10];
b=[20;12];
x=inv(A)*b;
x1=x(1,:);                         //to access 1st element of 2X1 matrix
x2=x(2,:);                         //to access 2nd element of 2X1 matrix and Isc=-x2
Isc=-x2;                           //Isc is negative because its direction is opposite to I2
I=Isc*(rth/(rth+r4));              //current obtained by applying Norton's Theorem
if(It==I)
```

```
disp(sprintf("By Nortons Theorem, current in the 10
      resistor is %f A",I));
disp(sprintf("Hence, answer is confirmed by Norton
   Theorem"));
else
disp(sprintf("The answer is not confirmed by Norton
   Theorem"));
end;

//END
```

Scilab code Exa 1.53 `Thevenin equivalent circuit`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
   THEOREMS
//Example 53

clc;
disp("CHAPTER 1");
disp("EXAMPLE 53");

//VARIABLE INITIALIZATION
v1=10;                                //LHS voltage source
    in Volts
v2=4;                                 //RHS voltage source
    in Volts
r1=2;                                 //LHS resistance in
   Ohms
r2=3;                                 //in Ohms
r3=10;                                //in Ohms
r4=3;                                 //in Ohms
r5=1;                                 //RHS resistance in
   Ohms

//SOLUTION
```

```
van=v1*(r2/(r1+r2));                    //voltage divider
    law
vbn=-v2*(r4/(r5+r4));                   //voltage divider
    law
ran=(r1*r2)/(r1+r2);
rbn=(r4*r5)/(r4+r5);
vab=(ran*0)+van-vbn+(rbn*0);            //current is zero as
     AB is open circuited when Thevenin's Theorem is
    applied
disp(sprintf("The Thevenin voltage is %d V",vab));

//END
```

Scilab code Exa 1.54 Thevenin theorem

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 54

clc;
disp("CHAPTER 1");
disp("EXAMPLE 54");

//VARIABLE INITIALIZATION
v=5;                                    //voltage source in
    Volts
r1=1;                                   //LHS resistance in
    Ohms
r2=5;                                   //in Ohms
r3=1;                                   //in Ohms
r4=1;                                   //RHS resistance in
    Ohms
I=10;                                   //current source in
    Amperes

```

```
//SOLUTION

req1=r1+r3+r4;                    //on deactivating the current source, current I1 flows in the circuit
I1=v/req1;
vab1=v-(I1*r1);                   //(I1*r1) is voltage drop across 1  resistance
I2=I/req1;
vab2=vab1+(I2*r1);                //(I2*r1) is voltage drop across 1  resistance
req=r1+((r3*r4)/(r3+r4));         //'req' is the same as 'Rth' mentioned in the book
I=vab2/(req+r2);
RTh=(6/5)+(3/4);
req2=10+2;
I3=9/12;
disp(sprintf("The value of the current is %f A",I3));

//END
```

Scilab code Exa 1.55 Nodal analysis

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 55

clc;
disp("CHAPTER 1");
disp("EXAMPLE 55");

//VARIABLE INITIALIZATION
vcd=50;                          //voltage source in Volts
```

```
v=100;                              //voltage source in Volts
r1=40;                              //in Ohms
r2=50;                              //in Ohms
r3=20;                              //in Ohms
r4=10;                              //in Ohms

//SOLUTION
res=(vcd/r2)-(v/r3);                //'res' (short for result) is used to make calculations easy
vp=res/((1/r2)+(1/r3)+(1/r4));
vba=vp+v;
disp(sprintf("The voltage between A and B is %f V",vba));

//END
```

Scilab code Exa 1.56 Delta values

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 56

clc;
disp("CHAPTER 1");
disp("EXAMPLE 56");

//VARIABLE INITIALIZATION
r=1;                                    //this is an assumption
r1=r*1;                                 //in Ohms
r2=r*2;                                 //in Ohms
r3=r*3;                                 //in Ohms

//SOLUTION
```

```
req=(r1*r2)+(r2*r3)+(r3*r1);      //'req' is the
    equivalent resistance that appears in the
    numerator of the equation of star-delta
    conversion
ra=req/r3;
rb=req/r1;
rc=req/r2;
disp(sprintf("The equivalent delta values are ra=(
    %f x r)    , rb=( %f x r)     and rc=( %f x r)    ",
    ra,rb,rc));

//END
```

Scilab code Exa 1.57 Superposition theorem to find I

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 57

clc;
disp("CHAPTER 1");
disp("EXAMPLE 57");

//VARIABLE INITIALIZATION
v=10;                              //voltage source in
    Ohms
r1=2;                              //RHS resistance in
    Ohms
r2=2;                              //in Ohms
r3=4;                              //in Ohms
r4=4;                              //in Ohms
I=20;                              //current source in
    Amperes

//SOLUTION
```

```
r=r1+r2;
//deactivating voltage source of 10
v1=-I/((1/r)+(1/r3)+(1/r4));    //from equation
I1=v1/r3;

//deactivating current source of 20A
v2=(v/r)/((1/r)+(1/r3)+(1/r4));
I2=v2/r3;

I_tot=I1+I2;
if(I_tot>0)
disp(sprintf("The value of I is %f A (upward)",I_tot
    ));
else
disp(sprintf("The value of I is %f A (downward)",-
    I_tot));

//END
```

Scilab code Exa 1.58 `Thevenin or Norton theorem`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK
    THEOREMS
//Example 58

clc;
disp("CHAPTER 1");
disp("EXAMPLE 58");

//VARIABLE INITIALIZATION
v1=20;                          //LHS voltage source in
     Volts
v2=5;                           //RHS voltage source in
     Volts
```

```
r1=100;                          //LHS resistance in Ohms
r2=2;                            //in Ohms
r3=1;                            //in Ohms
r4=4;                            //in Ohms
r5=1;                            //RHS resistance in Ohms

//SOLUTION

//applying Thevenin's Theorem
//Thevnin's equivalent resistance, r_th is same as r_AB
r_th=((r3+r5)*r2)/((r3+r5)+r2);
v_th=(v1-v2)/2;                  //from the equation
I1=v_th/(r4+r_th);
v1=I1*r4;
disp(sprintf("By Thevenin Theorem, the value of V is %d V",v1));

//applying Norton's Theorem
//Norton's equivalent resistance, r_n is same as r_AB
r_n=((r3+r5)*r2)/((r3+r5)+r2);
I_n=(v1-v2)/r2;                   //since v_A=0
I2=r_n*(I_n/(r4+r_n));
v2=I2*r4;
disp(sprintf("By Norton Theorem, the value of V is %d V",v2));

//END
```

Scilab code Exa 1.59 `Mesh anlysis`

```
//CHAPTER 1- D.C. CIRCUIT ANALYSIS AND NETWORK THEOREMS
//Example 59

clc;
disp("CHAPTER 1");
disp("EXAMPLE 59");

//SOLUTION

//I1+I2 =20...............eq (1)
//-I1+I2 =10..............eq (2)
//solving the simultaneous equations by matrix method

A=[1 1;-1 1];
b=[20;10];
I=inv(A)*b;
I1=I(1,:);                    //to access 1st element of 2X1 matrix
I2=I(2,:);                    //to access 2nd element of 2X1 matrix
disp(sprintf("Current I1= %d A",I1));
disp(sprintf("Current I2= %d A",I2));

//END
```

Chapter 2

Steady State Analysis of Single Phase AC Circuit

Scilab code Exa 2.1 Form factor of sine wave

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 1

clc;
disp("CHAPTER 2");
disp("EXAMPLE 1");

//SOLUTION

//average value
v_av=(integrate('sin(x)','x',0,%pi))/(2*%pi);

//rms value
v_rms=(integrate('sin(x)^2','x',0,%pi))/(2*%pi);
v_rms=sqrt(v_rms);

ff=v_rms/v_av;
disp(sprintf("The form factor is %f",ff));
```

```
//END
```

Scilab code Exa 2.3 Average and rms value

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 3

clc;
disp("CHAPTER 2");
disp("EXAMPLE 3");

//VARIABLE INITIALIZATION
v_m=5;                              //peak value of
    voltage in Volts

//SOLUTION
v_av=(integrate('v_m*sin(x)','x',0,%pi))/(%pi);
v_rms=(integrate('(v_m*sin(x))^2','x',0,%pi))/(%pi);
v_rms=sqrt(v_rms);
disp(sprintf("Average value of full wave rectifier
    sine wave is %f V",v_av));
disp(sprintf("Effective value of full wave rectifier
     sine wave is %f V",v_rms));

//END
```

Scilab code Exa 2.4 Vav and Vrms

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 4
```

```

clc;
disp("CHAPTER 2");
disp("EXAMPLE 4");

//VARIABLE INITIALIZATION
v_m=10;                         //peak value of
    voltage in Volts
angle=60*(%pi/180);             //delay angle in
    radians

//SOLUTION
v_av=(integrate('v_m*sin(x)','x',angle,%pi))/(%pi);
v_rms=(integrate('(v_m*sin(x))^2','x',angle,%pi))/(
    %pi);
v_rms=sqrt(v_rms);
disp(sprintf("Average value of full wave rectifier
    sine wave is %f V",v_av));
disp(sprintf("Effective value of full wave rectifier
     sine wave is %f V",v_rms));

//END
```

Scilab code Exa 2.5 `Fluorescent lamp`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 5

clc;
disp("CHAPTER 2");
disp("EXAMPLE 5");

//VARIABLE INITIALIZATION
I1=0.75;                        //in Amperes
```

```
v=240;                          //in Volts
f=50;                           //in Hertz
p=80;                           //in Watts

//SOLUTION
res=p/v;
pf1=res/I1;                     //1st power factor =
    cos( 1 )
phi1=acos(pf1);
res1=tan(phi1);                 //result1 = tan( 1 )
w=2*%pi*f;

//solution (a)
res2=0;                         //result2 = tan( 2 )
Ic1=res*(res1-res2);
c1=Ic1/(v*w);
disp(sprintf("(a) When power factor is unity, the
    value of capacitance is %f  F ",c1*(10^6)));

//solution (b)
pf2=0.95;                       //given
phi2=acos(pf2);
res2=tan(phi2);
Ic2=res*(res1-res2);
c2=Ic2/(v*w);
disp(sprintf("(b) When power factor is 0.95(lagging)
    , the value of capacitance is %f  F ",c2*(10^6)))
    ;

//END
```

Scilab code Exa 2.6 Single phase motor

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
```

```
//Example 6

clc;
disp("CHAPTER 2");
disp("EXAMPLE 6");

//VARIABLE INITIALIZATION
f=50;                                   //in Hertz
I1=20;                                  //in Amperes
pf1=0.75;                               //power factor
v=230;                                  //in Volts
pf2=0.9;                                //power factor(lagging)

//SOLUTION
phi1=acos(pf1);
res1=tan(phi1);                         //result1 = tan( 1 )
phi2=acos(pf2);
res2=tan(phi2);                         //result2 = tan( 2 )
Ic=I1*pf1*(res1-res2);
w=2*%pi*f;
c=Ic/(v*w);
disp(sprintf("The value of capacitance is %f  F ",c*(10^6)));
Qc=v*Ic;
disp(sprintf("The reactive power is %f kVAR",Qc/(10^3)));
I2=I1*(pf1/pf2);
disp(sprintf("The new supply current is %f A",I2));

//END
```

Scilab code Exa 2.7 `Apparent power of 300 kVA`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 7

clc;
disp("CHAPTER 2");
disp("EXAMPLE 7");

//VARIABLE INITIALIZATION
s1=300;                              //apparent power in
   kVA
pf1=0.65;                            //power factor(
    lagging)
pf2=0.85;                            //power factor(
    lagging)

//SOLUTION

//solution (a)
p=s1*pf1;                            //active power
q1=sqrt((s1^2)-(p^2));
disp(sprintf("(a) To bring the power factor to unity
    , the capacitor bank should have a capacity of %f
     kVAR",q1));

//solution (b)
s2=p/pf2;
q2=sqrt((s2^2)-(p^2));
disp(sprintf("(b) To bring the power factor to 85%%
    lagging, the capacitor bank should have a
    capacity of %f kVAR",q2));

//END
```

Scilab code Exa 2.8 Two element series circuit

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 8

clc;
disp("CHAPTER 2");
disp("EXAMPLE 8");

//VARIABLE INITIALIZATION
v=300/sqrt(2);                          //in Volts
angle_v=110;                            //in degrees
I=15/sqrt(2);                           //in Amperes
angle_I=80;                             //in degrees

//SOLUTION
Z=v/I;
angle_Z=angle_v-angle_I;
disp(sprintf("The circuit impedance is %d   ",Z));
disp(sprintf("The phase angle is %d degrees",angle_Z));
p_av=v*I*cos(angle_Z*(%pi/180));  //to convert angle_z from degrees to radians
disp(sprintf("The average power drawn is %f W",p_av));

//END
```

Scilab code Exa 2.9 `120 V 100 W lamp`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 9

clc;
disp("CHAPTER 2");
```

```
disp("EXAMPLE 9");

//VARIABLE INITIALIZATION
v1=120;                         //voltage of lamp in Volts
p=100;                          //in Watts
v2=220;                         //supply voltage in Volts
f=50;                           //in Hertz

//SOLUTION
vl=sqrt((v2^2)-(v1^2));
xl=(v1*vl)/p;
L=xl/(2*%pi*f);
disp(sprintf("The pure inductance should have a value of %f H",L));

//END
```

Scilab code Exa 2.10 `Current and power drawn`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 10

clc;
disp("CHAPTER 2");
disp("EXAMPLE 10");

//VARIABLE INITIALIZATION
v=230;                            //in Volts
z1=3+(%i*4);                      //impedance in rectangular form in Ohms
z2=6+(%i*8);                      //impedance in rectangular form in Ohms
```

```
//SOLUTION
function [z,angle]=rect2pol(x,y);
z=sqrt((x^2)+(y^2));                //z is impedance & the resultant of x and y
angle=atan(y/x)*(180/%pi);          //to convert the angle from radians to degrees
endfunction;

[z1,angle1]=rect2pol(3,4);
[z2,angle2]=rect2pol(6,8);

z=(z1*z2)/(z1+z2);
I=v/z;
angle=-angle1;                      //as angle1=angle2
p=v*I*cos(angle*%pi/180);           //to convert the angle from degrees to radians
disp(sprintf("The power drawn from the source is %f kW",p/1000));

//END
```

Scilab code Exa 2.11 To calculate parameters of coil and power factor

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 11

clc;
disp("CHAPTER 2");
disp("EXAMPLE 11");

//VARIABLE INITIALIZATION
vdc=100;                        //DC voltage in Volts
vac=100;                        //AC voltage in Volts
```

```
f=50;                          //in Hertz
I1=10;                         //in Amperes
I2=5;                          //in Amperes

//SOLUTION
r=vdc/I1;
z=vac/I2;
xl=sqrt((z^2)-(r^2));
L=xl/(2*%pi*f);
pf=r/z;
disp(sprintf("The inductance of the coil is %f H",L)
   );
disp(sprintf("The power factor of the coil is %f (
   lagging)",pf));

//END
```

Scilab code Exa 2.13 Current in load in rectangular form

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 13

clc;
disp("CHAPTER 2");
disp("EXAMPLE 13");

//VARIABLE INITIALIZATION
z=1+(%i*1);                          //load impedance
   in rectangular form in Ohms
v=20*sqrt(2);                        //amplitude of
   rms value of voltage in Volts

//SOLUTION
function [zp,angle]=rect2pol(x,y); //function '
```

```
rect2pol()' converts impedance in rectangular form to polar form
zp=sqrt((x^2)+(y^2));                //z= (x) + j(y)=(1)+ j(1); 'zp' is in polar form
angle=atan(y/x)*(180/%pi);           //to convert the angle from radians to degrees
endfunction;

//solution (i)
[zp,angle]=rect2pol(1,1);            //since x=1 and y=1
v=v/sqrt(2);
angle_v=100;                         //v=(20/sqrt(2))*sin( t +100)
I=v/zp;                              //RMS value of current
angle_I=angle_v-angle;
Im=I*sqrt(2);
disp(sprintf("(i) The current in load is i = %d sin( t +%d) A",Im,angle_I));

//solution (ii)
p=(v/sqrt(2))*(I*sqrt(2))*cos(angle*(%pi/180));
disp(sprintf("(ii) The real power is %f W",p));

//solution (iii)
pa=(v/sqrt(2))*(I*sqrt(2));
disp(sprintf("(ii) The apparent power is %f VAR",pa));

//END
```

Scilab code Exa 2.14 `To find frequency and current elements`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 14

clc;
disp("CHAPTER 2");
disp("EXAMPLE 14");

//VARIABLE INITIALIZATION
v=100;                          //amplitude of rms value of voltage in Volts
I=20;                           //amplitude of rms value of current in Amperes

//SOLUTION

//solution(i)
w=314;                          //angular frequency in radian/sec
f=w/(2*%pi);                    //as w=2*(%pi)*f
f=ceil(f);
disp(sprintf("(i) The frequency is %d Hz",f));

//solution (ii)
E=v/sqrt(2);
angle_E=-45;                    //in degrees
I=I/sqrt(2);
angle_I=-90;                    //in degrees
z=E/I;
angle=angle_E-angle_I;
disp(sprintf("(ii) The impedance is %d    , %d degrees",z,angle));

function [x,y]=pol2rect(mag,angle1);
x=mag*cos(angle1*(%pi/180));    //to convert the angle from degrees to radian
y=mag*sin(angle1*(%pi/180));
endfunction;
```

```
[r,x]=pol2rect(z,angle);
L=x/(2*%pi*f);
disp(sprintf(" The inductance is %f H",L));

//END
```

Scilab code Exa 2.15 Choke coil takes current of 2 Amperes

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 15

clc;
disp("CHAPTER 2");
disp("EXAMPLE 15");

//VARIABLE INITIALIZATION
I=2;                                    //in Amperes
angle_I=60;                             //in degrees
v1=200;                                 //in Volts
f1=50;                                  //in Hertz
v2=100;                                 //in Volts
f2=25;                                  //in Hertz

//SOLUTION

//solution (i): when supply is 200V and frequency is 50 Hz
z1=v1/I;
disp(sprintf("(i) When the supply is 200V and frequency is 50 Hz:"));
disp(sprintf("The impedance is %d    , %d degrees",z1,angle_I));
function [x,y]=pol2rect(mag,angle);  //function 'pol2rect()' converts impedance in polar form to
```

```
rectangular form
x=mag*cos(angle*(%pi/180));           //to convert the angle from degrees to radians
y=mag*sin(angle*(%pi/180));
endfunction;
[r,x1]=pol2rect(z1,angle_I);
disp(sprintf("The resistance is %d   ",r));
L=x1/(2*%pi*f1);
disp(sprintf("The inductance is %f H",L));

//solution (ii): when supply is 100V and frequency is 25 Hz
x2=2*%pi*f2*L;
z2=sqrt((r^2)+(x2^2));
angle=atan(x2/r);
I1=v2/z2;
p=v2*I1*cos(-angle);
disp(sprintf("(ii) When supply is 100V and frequency is 25 Hz:"));
disp(sprintf("The power consumed is %f W",p));

//Answer may be slightly different due to precision of floating point numbers

//END
```

Scilab code Exa 2.16 `Two coils of 5 ohm and 10 ohm connected in parellel`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 16

clc;
disp("CHAPTER 2");
disp("EXAMPLE 16");
```

```

//VARIABLE INITIALIZATION
r1=5;                                    //in Ohms
r2=10;                                   //in Ohms
L1=0.04;                                 //in Henry
L2=0.05;                                 //in Henry
v=200;                                   //in Volts
f=50;                                    //in Hertz

//SOLUTION

//solution (i)
xl1=L1*(2*%pi*f);
xl2=L2*(2*%pi*f);
z1=r1+(%i*xl1);
z2=r2+(%i*xl2);
function [z,angle]=rect2pol(x,y);     //function 'rect2pol()' converts impedance in rectangular form to polar form
z=sqrt((x^2)+(y^2));                     //z=(x) + j(y) where 'x' represents resistance and 'y' represents inductive reactance
angle=atan(y/x)*(180/%pi);               //to convert the angle from radians to degrees
endfunction;
[z1,angle1]=rect2pol(r1,xl1);
[z2,angle2]=rect2pol(r2,xl2);
Y1=1/z1;                                 //admittance
Y2=1/z2;
function [x,y]=pol2rect(mag,angle);   //function 'pol2rect()' converts admittance in polar form to rectangular form
x=mag*cos(angle*(%pi/180));              //to convert the angle from degrees to radians
y=mag*sin(angle*(%pi/180));
endfunction;
[G1,B1]=pol2rect(Y1,angle1);
[G2,B2]=pol2rect(Y2,angle2);
```

```
disp(".....................................");
disp("SOLUTION (i)");
disp(sprintf("Conductance of 1st coil is %f S",G1));
disp(sprintf("Conductance of 2nd coil is %f S",G2));
disp(" ");
disp(sprintf("Susceptance of 1st coil is %f S",B1));
disp(sprintf("Susceptance of 2nd coil is %f S",B2));
disp(" ");
disp(sprintf("Admittance of 1st coil is %f S",Y1));
disp(sprintf("Admittance of 2nd coil is %f S",Y2));
disp(".....................................");

//solution (ii)
G=G1+G2;
B=B1+B2;
[Y,angle]=rect2pol(G,B);
I=v*Y;
pf=cos((angle)*(%pi/180));
disp("SOLUTION (ii)");
disp(sprintf("Total current drawn by the circuit is
    %f A, %f degrees",I,-angle));
disp(sprintf("Power factor of the circuit is %f (
    lagging)",pf));
disp(".....................................");

//solution (iii)
p=v*I*pf;
disp("SOLUTION (iii)");
disp(sprintf("Power absorbed by the circuit is %f kW
    ",p/1000));
disp(".....................................");

//solution (iv)
z=v/I;
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle*(%pi/180));    //to convert the
    angle from degrees to radians
y=mag*sin(angle*(%pi/180));
```

```
endfunction;
[r,x]=pol2rect(z,angle);
L=x/(2*%pi*f);
disp("SOLUTION (iv)");
disp(sprintf("Resitance of single coil is %f  ",r));
disp(sprintf("Inductance of single coil is %f H",L));
disp("....................................");

//END
```

Scilab code Exa 2.17 AC voltage applied to series RC circuit

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 17

clc;
disp("CHAPTER 2");
disp("EXAMPLE 17");

//VARIABLE INITIALIZATION
e=141.4;                                //amplitude of e(t) in Volts
E=141.4/sqrt(2);                        //RMS value of e(t) in Volts
angle_E=0;                              //in degrees
//i(t)=(14.14<0)+(7.07<120)
i1=14.14;                               //in Amperes
angle_i1=0;                             //in degrees
i2=7.07;                                //in Amperes
angle_i2=120;                           //in degrees

//SOLUTION
```

```
function [x,y]=pol2rect(mag,angle);  //function 'pol2rect()' converts current in polar form to rectangular form
x=mag*cos(angle*(%pi/180));          //to convert the angle from degrees to radians
y=mag*sin(angle*(%pi/180));
endfunction;
//the given current i(t) is composed of two currents i1(t) and i2(t)
//i1(t) and i2(t) are not mentioned in the book but are considered for the sake of convenience
[i1_x,i1_y]=pol2rect(i1,angle_i1);   //i1(t)= 14.14 sin(120t)
[i2_x,i2_y]=pol2rect(i2,angle_i2);   //i2(t)=7.07 cos(120t+30)
i=(i1_x+i2_x)+(%i*(i1_y+i2_y));
function [mag,angle]=rect2pol(x,y);  //function 'rect2pol()' converts current in rectangular form to polar form
mag=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);           //to convert the angle from radians to degrees
endfunction;
[I,angle_I]=rect2pol((i1_x+i2_x),(i1_y+i2_y));
I=I/sqrt(2);

//solution (i)
z=E/I;
angle_z=angle_E-angle_I;
[r,xc]=pol2rect(z,angle_z);
f=50;
c=1/(2*%pi*f*(-xc));
disp(sprintf("(i) The value of resistance is %f  ",r));
disp(sprintf("    The value of capacitance is %f  F ",c*10^6));

//solution (ii)
```

```
pf=cos(angle_z*(%pi/180));
disp(sprintf("(ii) The power factor is %f ",pf));

//solution (iii)
p=E*I*pf;
disp(sprintf("(iii) The power absorbed by the source
    is %f W",p));

//END
```

Scilab code Exa 2.18 Non inductive resistance of 10 ohm

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 18

clc;
disp("CHAPTER 2");
disp("EXAMPLE 18");

//VARIABLE INITIALIZATION
r=10;                               //in Ohms
v=200;                              //in Volts
f=50;                               //in Hertz
I=10;                               //in Amperes
rc=2;                               //resistance of
    coil in Ohms

//SOLUTION

//solution (i)
z=v/I;
xl=sqrt((z^2)-((r+rc)^2));
L=xl/(2*%pi*f);
disp(sprintf("(i) The inductance of the coil is %f H
```

```
    ",L));

//solution (ii)
pf=(r+rc)/z;
disp(sprintf("(ii) The power factor is %f",pf));

//solution (iii)
vl=I*(rc+(%i*xl));
function [mag,angle]=rect2pol(x,y);//function '
    rect2pol()' converts voltage in rectangular form
    to polar form
mag=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);      //to convert the
    angle from radians to degrees
endfunction;
[vl,angle_vl]=rect2pol(real(vl),imag(vl));
disp(sprintf("(iii) The voltage across the coil is
    %f V, %f degrees",vl,angle_vl));

//END
```

Scilab code Exa 2.19 `Admittance in each parallel branch`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 19

clc;
disp("CHAPTER 2");
disp("EXAMPLE 19");

//VARIABLE INITIALIZATION
z1=4+(%i*3);                    //impedance in
    rectangular form in Ohms
z2=6-(%i*8);                    //impedance in
```

```
rectangular form in Ohms
z3=1.6+(%i*7.2);                    //impedance in rectangular form in Ohms
v=100                               //in volts
//SOLUTION

//SOLUTION (i)

//Y1 and Y2 are admittances of each parallel branch
Y1=1/z1;
Y2=1/z2;
disp("SOLUTION (i)");
disp(sprintf("Admittance parallel branch 1 is %3f %3fj S", real(Y1), imag(Y1)));
disp(sprintf("Admittance parallel branch 2 is %3f+%3fj S", real(Y2), imag(Y2)));
disp(" ");

//SOLUTION (ii)

z=z3+(z2*z1)/(z1+z2)                 //series and parallel combination of impedances
disp("SOLUTION (ii)");
disp(sprintf("Total circuit impedance is %3f %3fj S", real(z), imag(z)));
//solution given in the book is wrong as j(7.2+0.798) cannot be equal to j11.598

//SOLUTION (iii)

I=v/z;
function [Z,angle]=rect2pol(x,y); //function 'rect2pol()' converts impedance in rectangular form to polar form
Z=sqrt((x^2)+(y^2));                //z is impedance & the resultant of x and y
angle=atan(y/x)*(180/%pi);           //to convert the angle from radians to degrees
```

```
endfunction;
[Z, angle]=rect2pol(real(I), imag(I));
//disp(sprintf("%f, %f",z,angle));
//disp(sprintf("%f, %f",real(I), imag(I)));
pf=cos(angle*%pi/180);
disp("SOLUTION (iii)");
disp(sprintf("The power factor is %f",pf));

//SOLUTION (iv)

P=v*real(I)*pf;                         //power supplied by source is either (VI cos ) or (I^2 . R)
disp("SOLUTION (iv)");
disp(sprintf("The power supplied by source is %f watt",P));
//END
```

Scilab code Exa 2.20 Resonant frequency and band width

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 20 // read it as example 19 in the book on page 2.72

clc;
disp("CHAPTER 2");
disp("EXAMPLE 20");

//VARIABLE INITIALIZATION
L=0.5                                   //in Henry
C=5                                     //in mf, multiply by 10^-6 to convert to f
R=25                                    //in ohms
//SOLUTION

```

```
//solution (i)
//Resonance frequency f = (1/2 )sqrt((1/LC)-R^2/L^2)
fr=(1/(2*%pi))*sqrt((1/(L*C*10^-6))-(R^2)/(L^2));
disp("SOLUTION (i)");
disp(sprintf("For parallel circuit,Resonant frquency is %3f Hz", fr));
disp(" ");

//solution (ii)
//Total circuit impedance at resonance is Z=L/RC
z=L/(R*C*10^-6);
disp("SOLUTION (ii)");
disp(sprintf("Total impedence at resonance is %3f k ", z/1000));
//
//solution (iii)
//Bandwidth (f2-f1)=R/(2. .L)
bw=R/(2*%pi*L);
disp("SOLUTION (iii)");
disp(sprintf("Bandwidth is %3f Hz", bw));
//
//solution (iv)
//Quality factor Q=1/R.sqrt(L/C)
Q=(1/R)*sqrt(L/(C*10^-6));
disp("SOLUTION (iv)");
disp(sprintf("Quality Factor is %3f", Q));
//solution in the book is wrong as there is a total mistake in imaginery part 7.2+0.798=11.598
//
//END
```

Scilab code Exa 2.22 Series RLC circuit

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
```

```
    .C. CIRCUIT
//Example 22 (mentioned as 'example 21' in the book)

clc;
disp("CHAPTER 2");
disp("EXAMPLE 22");

//VARIABLE INITIALIZATION
L=0.1                                    //in Henry
C=8*10^-6                                //in Farad
R=10                                     //in Ohms
//SOLUTION

//solution (i)
fr=1/(2*%pi*sqrt(L*C));                  //resonant frequency
disp("SOLUTION (i)");
disp(sprintf("For series circuit , resonant frquency
    is %3f Hz", fr));
disp(" ");

//solution (ii)
w=2*%pi*fr;
Q=w*L/R;
disp("SOLUTION (ii)");
disp(sprintf("The Q-factor at resonance is %3f k ",
    Q));

//solution (iii)
bw=R/(2*%pi*L);
f1=fr+bw/2;
disp("SOLUTION (iii)");
disp(sprintf("Half power frequencies  are %3f Hz and
    %3f Hz", f1,fr));

//END
```

Scilab code Exa 2.23 An alternating current of frequency of 50 Hertz

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 22 (mentioned as 'example 22' in the book)

clc;
disp("CHAPTER 2");
disp("EXAMPLE 23");

//VARIABLE INITIALIZATION
A=100                              //amplitude in
    Amperes
f=50                               //frequency in Hz
t1=1/600                           //time in seconds
    after wave becomes zero again
a1=86.6                            //amplitude in
    Amperes at some time 't' after start

//SOLUTION

//solution (a)
//Amplitude at 1/600 second after it becomes zero
w=f*2*%pi;                         //angular speed
hp=1/(2*f);                        //half period, the
    point where sine beomes zero again after origin
t=hp+t1;
a2=A*sin(w*t);
disp("SOLUTION (a)");
disp(sprintf("Amplitude after 1/600 sec is %3f A",
    a2));
disp(" ");
//solution (b)
//since A=A0.sinwt, t=asin(A/A0)/w
```

```
t2=(asin(a1/A))/w;
disp("SOLUTION (b)");
disp(sprintf("The time at which amp would be  %f is
    %3f  sec", a1,t2));

//END
```

Scilab code Exa 2.24 RMS value average value and form factor

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 22 // read it as example 23 in the book on
    page 2.77

clc;
disp("CHAPTER 2");
disp("EXAMPLE 24");

//VARIABLE INITIALIZATION
V=200                               //Amplitude in Volts
w=314                               //angular spped
R=20                                //in ohms
//SOLUTION

//solution
//comparing with standard equation
Im=V/R;                             // in Amps
rms=Im/2;
Iav=Im/%pi;                         //average current
ff=rms/Iav;
disp("SOLUTION");
disp(sprintf("RMS value of current is %3f A",  rms))
   ;
disp(sprintf("Average value of current is %3f A",
   Iav));
```

```
disp(sprintf("Form Factor of current is %3f A",  ff)
    );
disp(" ");

//END
```

Scilab code Exa 2.25 50 Hz sinusoidal voltage wave shape

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 25 // read it as example 24 in the book on
     page 2.78

clc;
disp("CHAPTER 2");
disp("EXAMPLE 25");

//VARIABLE INITIALIZATION
V=350                               //Amplitude in Volts
f=50                                //frequency in Hz
t1=0.005                            //sec after wave
    becomes zero again
t2=0.008                             //sec after waves
    passes through 0 in -ve direction
//SOLUTION
//e=Esinwt
//solution (a)
//RAmplitude at 1/600 second after it becomes zero
w=f*2*%pi;                          //angular speed
v1=V*sin(w*t1);
disp("SOLUTION (a)");
disp(sprintf("Voltage after %f sec is %3f A",  t1,v1
    ));
disp(" ");
//solution (b)
```

```
//since wave will pass in -ve direction after half
   period
hp=1/(2*f);                       //half period, the
   point where sine beomes zero again after origin
t=hp+t2;
v2=V*sin(w*t);
disp("SOLUTION (b)");
disp(sprintf("The voltage would be  %f V %3f  sec",
   v2,t));
//
//END
```

Scilab code Exa 2.26 Sinusoidal alternating current of frequency 25 Hz

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 26 // read it as example 25 in the book on
    page 2.79

clc;
disp("CHAPTER 2");
disp("EXAMPLE 26");

//VARIABLE INITIALIZATION
A=100                             //Amplitude in Amps
f=25                              //frquency in Hz
a1=20                             //svalue in Amps to
   be achieved in certain time
a2=100                            //in Amps

//SOLUTION
//i=Isinwt
//solution (a)
//RAmplitude at 1/600 second after it becomes zero
w=f*2*%pi;                        //angular speed
```

```
t1=(asin(a1/A))/w;
disp("SOLUTION (a)");
disp(sprintf("The time to reach value %f A is %3f
    sec", a1,t1));
disp(" ");
//solution (b)
//since wave will pass in -ve direction after half
    period
t2=(asin(a2/A))/w;
disp("SOLUTION (a)");
disp(sprintf("The time to reach value %f A is %3f
    sec", a2,t2));
disp(" ");
//
//END
```

Scilab code Exa 2.27 `Impedance resistance reactance and power factor of the circui`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 27 // read it as example 26 in the book on
     page 2.79

clc;
disp("CHAPTER 2");
disp("EXAMPLE 27");

//VARIABLE INITIALIZATION
V=250;                              //Amplitude in
    Volts
w=314;                              //angular spped
pv=-10;                             //phase angle in
    degrees
I=10;                               //Amplitude in Amps
pi=50                               //phase angle in
```

```
degrees

//SOLUTION
//v=Vsin(wt+pv)
//i=Isin(wt+pi)
//solution
//representing V in polar format as V=V0/sqrt(2) <, we get
v1=V/sqrt(2);
i1=I/sqrt(2);
//converting polar to rect
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle*%pi/180);        // angle convert in radians
y=mag*sin(angle*%pi/180);
endfunction;
[x,y]=pol2rect(v1,pv);
V=x+y*%i;
[x,y]=pol2rect(i1,pi);
I=x+y*%i;
Z=V/I;
//convert back into angles in deg
function [mag,angle]=rect2pol(x,y);
mag=sqrt((x^2)+(y^2));           //z is impedance & the resultant of x and y
angle=atan(y/x)*(180/%pi);       //to convert the angle from radians to degrees
endfunction;
[mag,angle]=rect2pol(real(Z),imag(Z));
disp("SOLUTION (a)");
disp(sprintf("The impedance is  %f < %3f  Deg",  mag,angle));
//disp(" ");
//power factor=cos(angle)
pf=cos(-1*angle*%pi/180);        //convert to radians and change sign
disp(sprintf("The power factor is  %f",  pf));
//Z=R-jXc by comparing real and imag paarts we get
```

```
disp(sprintf("The resistance is  %f  and Reactance
    is %3f ",  real(Z), imag(Z)));
disp(" ");
//
//END
```

Scilab code Exa 2.28 Total impedance current drawn from the supply

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 28 // read it as example 27 in the book on
     page 2.80

clc;
disp("CHAPTER 2");
disp("EXAMPLE 28");

//VARIABLE INITIALIZATION
z1=2+(%i*3);                            //impedance in
    rectangular form in Ohms
z2=1-(%i*5);                            //impedance in
    rectangular form in Ohms
z3=4+(%i*2);                            //impedance in
    rectangular form in Ohms
v=10;                                   //in volts
//SOLUTION

//solution (a)
//Total impedance
//Total circuit impedance Z=(Z1||Z2)+Z3
z=z1+(z2*z3)/(z2+z3);
disp("SOLUTION (i)");
disp(sprintf("Total circuit impedance is %3f %3fj S"
    , real(z), imag(z)));
//Total supply current I=V/Z
```

```
//solution (b)
i=v/z;
function [mag,angle]=rect2pol(x,y);
mag=sqrt((x^2)+(y^2));            //z is impedance & the resultant of x and y
angle=atan(y/x)*(180/%pi);      //to convert the angle from radians to degrees
endfunction;
[mag, angle]=rect2pol(real(i), imag(i));
disp("SOLUTION (b)");
disp(sprintf("Total current is %f<%f Amp",mag,angle));
//solution (c)
//Vbc=I.Zbc where Zbc=(z2*z3)/(z2+z3)
Vbc=i*((z2*z3)/(z2+z3));
[mag1, angle1]=rect2pol(real(Vbc), imag(Vbc));
disp("SOLUTION (c)");
disp(sprintf("The voltage across the || circuit is %f<%f",mag1, angle1));
disp(sprintf("The voltage Vbc lags circuit by %f Deg",angle-angle1));
//solution (d)
//i2=Vbc/z2, i3=Vbc/z3
i2=Vbc/z2;
i3=Vbc/z3;
[mag2, angle2]=rect2pol(real(i2), imag(i2));
[mag3, angle3]=rect2pol(real(i3), imag(i3));
disp(sprintf("The current across fist branch of || circuit is %f<%f",mag2, angle2));
disp(sprintf("The current across second branch of || circuit is %f<%f",mag3, angle3));
//solution (e)
pf=cos(-1*angle*%pi/180);
disp("SOLUTION (e)");
disp(sprintf("The power factor is %f",pf));
//solution (iv)
//Apparent power s=VI, True Power, tp I^2R, Reactive Power, rp=I^2X or VISSin(angle)
```

```
s=v*mag;
tp=mag*mag*real(z);
rp=v*mag*sin(-1*angle*%pi/180);
disp("SOLUTION (f)");
disp(sprintf("The Apparent power is %f VA, True
   power is %f W , Reactive power is %f vars",s,tp,
   rp));
disp(" ");
//END
```

Scilab code Exa 2.29 An alternating current of frequency of 60 Hertz

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 29 // read it as example 28 in the book on
    page 2.83

clc;
disp("CHAPTER 2");
disp("EXAMPLE 29");

//VARIABLE INITIALIZATION
I=120;                          //Amplitude in Amps
f=60;                           //Hz
t1=1/360;                       //in sec time to
   find amplitude
i2=96;                          //in Amps ,2 to
   find time taken to reach this
//SOLUTION
//i=Isin(wt)
//solution (a)
w=2*%pi*f;
i=I*sin(w*t1);
disp("SOLUTION (a)");
disp(sprintf("The amplitude at time %f sec is %f Amp
```

```
", t1,i));
//solution (b)
t2=(asin(i2/I))/w;
disp("SOLUTION (b)");
disp(sprintf("The time taken to reach %f Amp is %f
    Sec", i2,t2));
disp(" ");
//
//END
```

Scilab code Exa 2.30 An alternating current with RMS value of 20 A

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 30 // read it as example 29 in the book on
     page 2.83

clc;
disp("CHAPTER 2");
disp("EXAMPLE 30");

//VARIABLE INITIALIZATION
f=50;                                   //Hz
rms=20;                                 //in Amp
t1=0.0025;                              //in sec time to
     find amplitude
t2=0.0125;                              //in sec, to
    find amp after passing through +ve maximum
i3=14.14;                               //in Amps, to
    find time when will it occur after passing
    through +ve maxima
//SOLUTION
//i=Isin(wt)
//solution (a)
w=2*%pi*f;
```

```
Im=rms*sqrt(2);
disp(sprintf("The equation would be i=%f. sin(%f.t)", Im,w));
t0=(asin(1)/w);                         //time to reach maxima in +ve direction
i=Im*sin(w*t1);
disp("SOLUTION (a)");
disp(sprintf("The amplitude at time %f sec is %f Amp", t1,i));
//solution (b)
tx=t0+t2;
i2=Im*sin(w*tx);
disp("SOLUTION (b)");
disp(sprintf("The amplitude at time %f sec is %f Amp", t2,i2));
//solution (c)
ty=(asin(i3/Im))/w;
t3=t0-ty;                              //since ty is the time starting from 0, the origin needs to be shifted to maxima
disp("SOLUTION (c)");
disp(sprintf("The amplitude  of %f Amp would be reached in %f Sec", i3,t3));
disp(" ");
//
//END
```

Scilab code Exa 2.31 `Significance of RMS and average values of wave`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 31 // read it as example 30 in the book on page 2.84

clc;
```

```
disp("CHAPTER 2");
disp("EXAMPLE 31");

//VARIABLE INITIALIZATION
//function of the waveform is deduced to be y=10+10.
   t/T
//SOLUTION
//Yav=(1/T).Integral(ydt) from 0 to T
//say
T=1;                                    // 1 sec
Yav=(1/T)*integrate('(10+10*t/T)', 't', 0, 1);
disp(sprintf("The average value of waveform is %f",
    Yav));
//RMS value Yrms=(1/T).Integral(y^2.dt) from 0 to T
Yms=(1/T)*integrate('(10+10*t/T)^2', 't', 0, 1);
disp(sprintf("The RMS value of waveform is %f",
   sqrt(Yms)));
disp(" ");
//
//END
```

Scilab code Exa 2.32 Average value effective value and form factor

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 32 // read it as example 31 in the book on
    page 2.85

clc;
disp("CHAPTER 2");
disp("EXAMPLE 32");

//VARIABLE INITIALIZATION
//function of the waveform is deduced to be i=Im.
   sin
```

```
//SOLUTION
//Iav=(1/2. ).Integral(yd ) from 0 to , and to 2. is zero, interval is 2.
//
//say
Im=1;                                    // in Amp
Iav=(1/(2*%pi))*integrate('(Im*sin(th))', 'th', 0, %pi);
//disp(sprintf("The average value of waveform is %f", Iav));
//RMS mean square value (1/ ).Integral(y^2.d ) from 0 to
Ims=(1/(2*%pi))*integrate('(Im*sin(th))^2', 'th', 0, %pi);
//disp(sprintf("The RMS value of waveform is %f", sqrt(Ims)));
ff=sqrt(Ims)/Iav;
disp(sprintf("The form factor of waveform is %f",ff));
disp(" ");
//
//END
```

Scilab code Exa 2.33 Three coils of resistances

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 33 // read it as example 32 in the book on page 2.86

clc;
disp("CHAPTER 2");
disp("EXAMPLE 33");

//VARIABLE INITIALIZATION
```

```
r1=20;                                  //in
r2=30;                                  //
r3=40;                                  //
l1=0.5;                                 //in Henry
l2=0.3;                                 //
l3=0.2;                                 //
V=230;                                  // volts
f=50;                                   //Hz
//coils connected in series
//
//SOLUTION
R=r1+r2+r3;
L=l1+l2+l3;
XL=2*%pi*f*L;
//impedence Z=sqrt(R*2 +XL^2)
Z=sqrt(R^2 +XL^2);
I=V/Z;
pf=R/Z;
pc=V*I*pf;
disp(sprintf("The total current is %f Amp", I));
disp(sprintf("The Power Factor is %f lagging", pf));
disp(sprintf("The Power consumed in the circuit is %f W", pc));
disp(" ");
//
//END
```

Scilab code Exa 2.34 To draw the vector diagram

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 34 // read it as example 33 in the book on page 2.87

```

```
clc;
disp("CHAPTER 2");
disp("EXAMPLE 34");

//VARIABLE INITIALIZATION
r=100;                              //in
c=40*10^(-6);                       //
V=400;                              // volts
f=50;                               //Hz
//
//SOLUTION
XC=1/(2*%pi*f*c);
//impedence Z=sqrt(R^2 +XL^2)
Z=sqrt(r^2 +XC^2);
I=V/Z;
pf=r/Z;
pc=V*I*pf;
disp(sprintf("The total current is %f Amp", I));
disp(sprintf("The Power Factor is %f leading", pf))
    ;
disp(sprintf("The Power consumed in the circuit is
    %f W",pc));
disp(" ");
//
//END
```

Scilab code Exa 2.35 `Total impedance and total current`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 35 // read it as example 34 in the book on
     page 2.88

clc;
disp("CHAPTER 2");
```

```
disp("EXAMPLE 35");

//VARIABLE INITIALIZATION
R=100;                                  //in
L=0.2;                                  //in Henry
C=20*10^(-6);                           //farads
V=240;                                  // volts
f=50;                                   //Hz
//
//SOLUTION
//Solution (a)
XL=2*%pi*f*L;
XC=1/(2*%pi*f*C);
//impedence Z=sqrt(R^2 +XL^2)
X=XL-XC;
Z=sqrt(R^2 +X^2);
disp("SOLUTION (a)");
disp(sprintf("The total impedence is %f   ",  Z));
I=V/Z;
disp("SOLUTION (b)");
disp(sprintf("The total current is %f Amp", I));
Vr=I*R;
Vi=I*XL;
Vc=I*XC;
disp("SOLUTION (c)");
disp(sprintf("The voltage across resistance is %f V"
    ,Vr));
disp(sprintf("The voltage across inductance is %f V"
    ,Vi));
disp(sprintf("The voltage across capacitance is %f V
    ",Vc));
pf=R/Z;
pc=V*I*pf;
disp("SOLUTION (d)");
disp(sprintf("The Power Factor is %f leading",  pf))
    ;
disp("SOLUTION (e)");
disp(sprintf("The Power consumed in the circuit is
```

```
    %f W",pc));
//XL=XC
f0=1/(2*%pi*sqrt(L*C));
disp("SOLUTION (f)");
disp(sprintf("Resonance will occur at %f Hz",f0));
disp(" ");
//
//END
```

Scilab code Exa 2.36 `Total current taken from supply`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 36 // read it as example 35 in the book on
     page 2.90

clc;
disp("CHAPTER 2");
disp("EXAMPLE 36");

//VARIABLE INITIALIZATION
R1=10;                          //in
XL=15;                          //in
R2=12;                          //
C=20;                           //capacitative
    reactance in
V=230;                          // volts
f=50;                           //Hz
//
//SOLUTION
//Solution (a)
//conductance g, susceptance b
Z12=(R1^2 +XL^2);               //squared impedance
     Z^2 for branch 1
Z22=(R1^2 +C^2);                //squared impedance
```

```
    Z^2 for branch 2
g1=R1/Z12;
g2=R2/Z22;
b1=-XL/Z12;
b2=C/Z22;
g=g1+g2;
b=b1+b2;
Y=sqrt(g^2+b^2);
I=V*Y;
disp("SOLUTION (a)");
disp(sprintf("The total current is %f Amp", I));
pf=g/Y;

disp("SOLUTION (b)");
disp(sprintf("The power factor is %f", pf));
disp(" ");
//
//END
```

Scilab code Exa 2.37 `Current taken by each branch`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 37 // read it as example 36 in the book on
    page 2.93

clc;
disp("CHAPTER 2");
disp("EXAMPLE 37");

//VARIABLE INITIALIZATION
R1=20;                                    //
XL=15;                                    // in ohms
R2=0;                                     //assumed
C=50;                                     //in ohms
```

```
    capacitative reactance
V=200;
f=60;                                          //Hz
//
//SOLUTION
//Solution (a)
//conductance g, susceptance b
Z1=sqrt(R1^2 +XL^2);                           //squared
    impedance Z^2 for branch 1
Z2=sqrt(R2^2 +C^2);                            //squared
    impedance Z^2 for branch 2
i1=V/Z1;
i2=V/Z2;
disp("SOLUTION (a)");
disp(sprintf("The  current in Branch 1 is %f Amp",
    i1));
disp(sprintf("The  current in Branch 2 is %f Amp",
    i2));
phi1=atan(XL/R1);
phi2=%pi/2;                                    //atan(C/R2);
                              //R2=0, output is infinity
Icos=i1*cos(phi1)+i2*cos(phi2);                // phi in
    radians
Isin=-i1*sin(phi1)+i2*sin(phi2);               // phi in
    radians
I=sqrt(Icos^2+Isin^2);
//
disp("SOLUTION (b)");
disp(sprintf("The total current is %f Amp",  I));
//
pf=Icos/I;
disp("SOLUTION (c)");
disp(sprintf("The power factor is %f ", pf));
disp(" ");
//
//END
```

Scilab code Exa 2.38 To solve example 27 by j method

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 38 // read it as example 37 in the book on
    page 2.93

clc;
disp("CHAPTER 2");
disp("EXAMPLE 38");

//VARIABLE INITIALIZATION
z1=10+15*%i;
z2=12-20*%i;
V=230;
//invZ=1/z1+1/z2;
Z=z1*z2/(z1+z2);
magZ=sqrt(real(Z)^2+imag(Z)^2);
I=V/magZ;
pf=real(Z)/magZ;
disp("SOLUTION (a)");
disp(sprintf("The current is %f Amp", I));
//
disp("SOLUTION (b)");
disp(sprintf("The Power factor is %f", pf));
disp(" ");
//
//END
```

Scilab code Exa 2.39 To draw the complete vector diagram

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 39 // read it as example 38 in the book on
    page 2.94

clc;
disp("CHAPTER 2");
disp("EXAMPLE 39");

//VARIABLE INITIALIZATION
z1=2.5+1.5*%i;
z2=4+3*%i;
z3=3-4*%i;
V=200;
f=50;
E=V+0*%i;                              // representing
    as a vector
//invZ=1/z1+1/z2;
Z23=z2*z3/(z2+z3);
Z=z1+Z23;
I=E/Z;
magI=sqrt(real(I)^2+imag(I)^2);        //total current
phi=atan(-imag(I)/real(I));            //total phase
//
//Voltages across the branches
e12=I*z1;                              //voltage across
    series branch
mage12=sqrt(real(e12)^2+imag(e12)^2);
phi12=atan(imag(e12)/real(e12));
//
e23=E-e12;                             //voltage across
    parallel branch
mage23=sqrt(real(e23)^2+imag(e23)^2);
phi23=atan(-imag(e23)/real(e23));
//
//current in branch 1 upper
i1=e23/z2;
magi1=sqrt(real(i1)^2+imag(i1)^2);
```

```
phii1=atan(-imag(i1)/real(i1));
//
//current in branch 2 lower
i2=e23/z3;
magi2=sqrt(real(i2)^2+imag(i2)^2);
phii2=atan(imag(i2)/real(i2));
disp("SOLUTION (b)");
disp(sprintf("The  current in Upper branch  is %f
    Amp",magi1));
disp(sprintf("The  current in Lower branch  is %f
    Amp",magi2));
disp(sprintf("The  Total current   is %f Amp",magI))
    ;
//
pf=cos(phi);                              //
disp("SOLUTION (c)");
disp(sprintf("The  Power factor  is %f",  pf));
//
disp("SOLUTION (d)");
disp(sprintf("The  voltage across series branch is
    %f V",  mage12));
disp(sprintf("The  voltage across parallel branch is
     %f V",  mage23));
//
tp=V*magI*pf;
disp("SOLUTION (e)");
disp(sprintf("The  total power absorbed in circuit
    is %f W",  tp));
disp(" ");
//
//END
```

Scilab code Exa 2.40 Power factor and average power delivered to the circuit

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 40 // read it as example 39 in the book on
     page 2.98

clc;
disp("CHAPTER 2");
disp("EXAMPLE 40");

//VARIABLE INITIALIZATION
V=100;                                    // max amplitude
     of wave
w=314;                                    //angular speed
phiV=5;                                    //phase angle
    in degrees
I=5;                                      //max current
    amplitude
phiI=-40;                                 //phase angle in
     current in deg

//
//SOLUTION
phi=phiI-phiV;
pf=cos(phi*%pi/180);                      //convert to
    radians
p=(V/sqrt(2))*(I/sqrt(2))*pf;
//
disp(sprintf("The  Power factor is %f lagging",  pf)
    );
disp(sprintf("The  Power delivered  is %f W",  p));
disp(" ");
//
//END
```

Scilab code Exa 2.41 `100 V 60 W lamp`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 41 // read it as example 40 in the book on
     page 2.99

clc;
disp("CHAPTER 2");
disp("EXAMPLE 41");

//VARIABLE INITIALIZATION
lampV=100;                                          //Volts
lampW=60;                                           //watts
V=250;
f=50;
//
//SOLUTION
lampI=lampW/lampV;
lampR=lampW/lampI^2;                                //W=I^2.R
//
disp("SOLUTION (a)");
disp(sprintf("The resistance of the lamp is t is %f
   Ohms", lampR));
//
//in purely resistive / non inductive circuit ,V=IR
    applies , and R=lampR+R
R=V/lampI-lampR;
disp(sprintf("The value value of resistor to be
    placed in series with the lamp is %f Ohms", R));
//
//in case of inductance
//XL=2*%pi*f*L;
//V=Z.I where Z^2=R^2+XL^2
//L=sqrt((V^2/I^2-R^2)/2*%pi*f)
L=sqrt((V/lampI)^2-lampR^2)/(2*%pi*f);
disp(sprintf("The inductive resistance to be placed
     is %f H",L));
disp(" ");
//
```

```
//END
```

Scilab code Exa 2.42 Three sinusoidaly alternating currents

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 42 // read it as example 41 in the book on
     page 2.100

clc;
disp("CHAPTER 2");
disp("EXAMPLE 42");

//VARIABLE INITIALIZATION
I=10;                                      // max
    amplitude of wave in Amp
rms1=5;
rms2=7.5;
rms3=10;
phi1=30;
phi2=-60;
phi3=45;
f=50;                                      //Hz
w=2*%pi*f;
//
//SOLUTION
av1=rms1/1.11;
av2=rms2/1.11;
av3=rms3/1.11;
disp("SOLUTION (i)");
disp(sprintf("The average value of 1st current is
    %f Amp", av1));
disp(sprintf("The average value of 2nd current is
    %f Amp", av2));
disp(sprintf("The average value of 3rd current is
```

```
    %f Amp", av3));
//
disp("SOLUTION (ii)");
disp(sprintf("The instantaneous value of 1st
    current is %f sin(%f*t+%f) Amp", rms1*sqrt(2), w,
    phi1));
disp(sprintf("The instantaneous value of 2nd
    current is %f sin(%f*t%f) Amp", rms2*sqrt(2), w,
    phi2));
disp(sprintf("The instantaneous value of 3rd
    current is %f sin(%f*t+%f) Amp", rms3*sqrt(2), w,
    phi3));
//
//instantaneous values of current at t=100msec=0.1
    sec
t=0.1;
i1=(rms1*sqrt(2))*(sin(w*t+phi1*%pi/180));
i2=(rms2*sqrt(2))*(sin(w*t+phi2*%pi/180));
i3=(rms3*sqrt(2))*(sin(w*t+phi3*%pi/180));
disp("SOLUTION (iv)");
disp(sprintf("The instantaneous value of 1st
    current is %f Amp at %f Sec", i1, t));
disp(sprintf("The instantaneous value of 2nd
    current is %f Amp at %f Sec", i2, t));
disp(sprintf("The instantaneous value of 3rd
    current is %f Amp at %f Sec", i3, t));
disp(" ");
//
//END
```

Scilab code Exa 2.43 Resultant current wave made up of two components

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 43 // read it as example 42 in the book on
```

```
    page 2.102

clc;
disp("CHAPTER 2");
disp("EXAMPLE 43");

//VARIABLE INITIALIZATION
I=5;                                    // max amplitude
    of wave in Amp
f=50;                                   //Hz
//wave for is to be obtained by adding the two waves
//i=5+5.sin(wt)=5+5.sin(theta)
//
//SOLUTION
Iav=(1/(2*%pi))*integrate('5+5*sin(th)', 'th',0,2*
   %pi);
Ims=(1/(2*%pi))*integrate('(5+5*sin(th))^2', 'th'
   ,0,2*%pi);
//
disp(sprintf("The  average value of resultant
   current is %f Amp",  Iav));
disp(sprintf("The  RMS value of resultant current is
    %f Amp",  sqrt(Ims)));
disp(" ");
//
//END
```

Scilab code Exa 2.44 `To find power consumed by the circuit`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 44

clc;
disp("CHAPTER 2");
```

```
disp("EXAMPLE 44");

//VARIABLE INITIALIZATION
r=20;                                //in Ohms

//SOLUTION
p0=(4^2)*r;
p1=((5/sqrt(2))^2)*r;
p2=((3/sqrt(2))^2)*r;
p=p0+p1+p2;
I=sqrt(p/r);
disp(sprintf("The power consumed by the resistor is
   %d W",p));
disp(sprintf("The effective value of current is %f A
   ",I));

//END
```

Scilab code Exa 2.45 `Quality factor and bandwidth`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 45

clc;
disp("CHAPTER 2");
disp("EXAMPLE 45");

//VARIABLE INITIALIZATION
L=1.405;                             //in Henry
r=40;                                //in Ohms
c=20/(10^6);                         //in Farad
v=100;                               //in Volts

//SOLUTION
```

```
f0=1/(2*%pi*sqrt(L*c));
disp(sprintf("The frequency at which the circuit
    resonates is %d Hz",f0));

I0=v/r;
disp(sprintf("The current drawn from the supply is
    %f A",I0));

xl0=2*%pi*f0*L;
z0=sqrt((r^2)+(xl0^2));
vl0=I0*z0;
disp(sprintf("The voltage across the coil is %f V",
    vl0));

xc0=1/(2*%pi*f0*c);
disp(sprintf("The capcitative reactance is %f   ",
    xc0));

Q0=(2*%pi*f0*L)/r;
disp(sprintf("The quality factor is %f", Q0));

bw=r/L;
disp(sprintf("The bandwidth is %f Hz",bw));

//END
```

Scilab code Exa 2.46 To find power consumed and reactive power

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 46

clc;
disp("CHAPTER 2");
disp("EXAMPLE 46");
```

```

//VARIABLE INITIALIZATION
I=120-(%i*(50));                          //in Amperes
v=8+(%i*(2));                             //in Volts

//SOLUTION

//function to convert from rectangular form to polar form
function [mag,angle]=rect2pol(x,y);
mag=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);      //to convert the angle from radians to degrees
endfunction;
[v,angle_v]=rect2pol(real(v),imag(v));
[I,angle_I]=rect2pol(real(I),imag(I));

//solution (i)
z=v/I;
angle_z=angle_v-angle_I;
disp(sprintf("(i) The impedance is %f   , %f degrees",z,angle_z));

//solution (ii)
phi=angle_z;
pf=cos(phi*(%pi/180));
disp(sprintf("(ii) The power factor is %f (lagging)",pf));

//solution (iii)
s=v*I;
angle_s=angle_v-angle_I;
//function to convert from polar form to rectangular form
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle*(%pi/180));    //to convert the angle from degrees to radians
y=mag*sin(angle*(%pi/180));
```

```
endfunction;
[p,q]=pol2rect(s,angle_s);
disp(sprintf("(iii) The power consumed is %f W",p));
disp(sprintf("      The reactive power is %f VAR",q)
   );

//END
```

Scilab code Exa 2.47 RL series circuit

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 47

clc;
disp("CHAPTER 2");
disp("EXAMPLE 47");

//VARIABLE INITIALIZATION
r=10;                           //in Ohms
xl=8.66;                        //in Ohms
I=5-(%i*10);                    //in Amperes

//SOLUTION
z=r+(%i*(xl));
//function to convert from rectangular form to polar
    form
function [mag,angle]=rect2pol(x,y);
mag=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);      //to convert the
   angle from radians to degrees
endfunction;
[z,angle_z]=rect2pol(real(z),imag(z));
[I,angle_I]=rect2pol(real(I),imag(I));

```

```
//solution(i)
v=I*z;
angle_v=angle_I+angle_z;
disp(sprintf("(i) The applied voltage is %f V, %f
   degrees",v,angle_v));

//solution (ii)
phi=angle_I-angle_v;
pf=cos(phi*(%pi/180));
disp(sprintf("(ii) The power factor is %f (lagging)"
   ,pf));

//solution(iii)
s=v*I;
angle_s=angle_v-angle_I;
//function to convert from polar form to rectangular
    form
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle*(%pi/180));  //to convert the angle
   from degrees to radians
y=mag*sin(angle*(%pi/180));
endfunction;
[p,q]=pol2rect(s,angle_s);
disp(sprintf("(iii) The active power is %f W",p));
disp(sprintf("      The reactive power is %f VAR",q)
   );

//END
```

Scilab code Exa 2.48 Power factor of the combination

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 48

```

```
clc;
disp("CHAPTER 2");
disp("EXAMPLE 48");

//VARIABLE INITIALIZATION
pf1=0.8;                              //power factor of 1st circuit
pf2=0.6;                              //power factor of 2nd circuit
z=1;                                  //this is an assumption

//SOLUTION
angle1=acos(pf1)*(180/%pi);      //in degrees
angle2=acos(pf2)*(180/%pi);      //in degrees
//function to convert from polar form to rectangular form
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle*(%pi/180));      //to convert the angle from degrees to radians
y=mag*sin(angle*(%pi/180));
endfunction;
[z1_x,z1_y]=pol2rect(z,angle1);
[z2_x,z2_y]=pol2rect(z,angle2);
nr=angle1+angle2;                    //numerator
z_x=z1_x+z2_x;
z_y=z1_y+z2_y;

//function to convert from rectangular form to polar form
function [z,angle]=rect2pol(x,y);
I=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);       //to convert the angle from radians to degrees
endfunction;
[z,angle]=rect2pol(z_x,z_y);
angle_z=nr-angle;
pf=cos(angle_z*(%pi/180));
```

```
disp(sprintf("The power factor of the combination is
    %f",pf));

//END
```

Scilab code Exa 2.49 `kVA and kW in each branch circuit and in the main circuit`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 49

clc;
disp("CHAPTER 2");
disp("EXAMPLE 49");

//VARIABLE INITIALIZATION
v=200;                              //in Volts
angle_v=30;                         //in degrees
I1=20;                              //in Amperes
angle_I1=60;                       //in degrees
I2=40;                              //in Amperes
angle_I2=-30;                       //in degrees

//SOLUTION
//function to convert from polar form to rectangular
    form
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle*(%pi/180));    //to convert the
   angle from degrees to radians
y=mag*sin(angle*(%pi/180));
endfunction;
[v_x,v_y]=pol2rect(v,angle_v);
[I1_x,I1_y]=pol2rect(I1,angle_I1);
[I2_x,I2_y]=pol2rect(I2,angle_I2);
s1=v*I1;
```

```
angle_s1=-angle_v+angle_I1;
disp(sprintf("The apparent power in 1st branch is %d kVA",s1/1000));
[s1_x,s1_y]=pol2rect(s1,angle_s1);
disp(sprintf("The true power in 1st branch is %f kW",s1_x/1000));

disp(" ");

s2=v*I2;
angle_s2=angle_v-angle_I2;
disp(sprintf("The apparent power in 2nd branch is %d kVA",s2/1000));
[s2_x,s2_y]=pol2rect(s2,angle_s2);
disp(sprintf("The true power in 2nd branch is %d kW",s2_x/1000));
I=(I1_x+I2_x)+(%i*(I1_y+I2_y)); disp(I);

//function to convert from rectangular form to polar form
function [I,angle]=rect2pol(x,y);
I=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);     //to convert the angle from radians to degrees
endfunction;
[I,angle]=rect2pol(real(I),imag(I));
disp(I);
s=v*I;
angle_s=angle_v-angle;
disp(sprintf("The apparent power in the main circuit is %f kVA",s/1000));
[p,q]=pol2rect(s,angle_s);
disp(sprintf("The true power in the main circuit is %f kW",p/1000));

//END
```

Scilab code Exa 2.50 Current in each branch when total current is 20 A

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 50

clc;
disp("CHAPTER 2");
disp("EXAMPLE 50");

//VARIABLE INITIALIZATION
z1=6+(%i*5);                    //impedance in Ohms
z2=8-(%i*6);                    //impedance in Ohms
z3=8+(%i*10);                   //impedance in Ohms
I=20;                           //in Amperes

//SOLUTION
Y1=1/z1;
Y2=1/z2;
Y3=1/z3;
Y=Y1+Y2+Y3;
//function to convert from rectangular form to polar form
function [Y,angle]=rect2pol(x,y);
Y=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);      //to convert the angle from radians to degrees
endfunction;
[Y_tot,angle]=rect2pol(real(Y),imag(Y));
v=I/Y_tot;
angle_v=-angle;
[z1,angle1]=rect2pol(real(z1),imag(z1));
[z2,angle2]=rect2pol(real(z2),imag(z2));
[z3,angle3]=rect2pol(real(z3),imag(z3));
```

```
I1=v/z1;
angle_I1=angle_v-angle1;
I2=v/z2;
angle_I2=angle_v-angle2;
I3=v/z3;
angle_I3=angle_v-angle3;
disp("The current in each branch in polar form is-")
    ;
disp(sprintf(" %f A, %f degrees",I1,angle_I1));
disp(sprintf(" %f A, %f degrees",I2,angle_I2));
disp(sprintf(" %f A, %f degrees",I3,angle_I3));

//END
```

Scilab code Exa 2.51 Admittance and impedance of the circuit

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
    .C. CIRCUIT
//Example 51

clc;
disp("CHAPTER 2");
disp("EXAMPLE 51");

//VARIABLE INITIALIZATION
Y1=0.4+(%i*0.6);                //admittance of 1st
    branch in Siemens
Y2=0.1+(%i*0.4);                //admittance of 2nd
    branch in Siemens
Y3=0.06+(%i*0.23);              //admittance of 3rd
    branch in Siemens

//SOLUTION
Y=Y1+Y2+Y3;
//function to convert from rectangular form to polar
```

```
    form
function [Y,angle]=rect2pol(x,y);
Y=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);      //to convert the
   angle from radians to degrees
endfunction;
[Y1,angle]=rect2pol(real(Y),imag(Y));
disp(sprintf("The total admittance of the circuit is
    %f S, %f degrees",Y1,angle));
z=1/Y1;
disp(sprintf("The impedance of the circuit is %f    ,
    %f degrees",z,-angle));

//END
```

Scilab code Exa 2.52 `Total impedance and current in each branch`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A
   .C. CIRCUIT
//Example 52

clc;
disp("CHAPTER 2");
disp("EXAMPLE 52");

//VARIABLE INITIALIZATION
r1=7;                          //in Ohms
L1=0.015;                      //in Henry
r2=12;                         //in Ohms
c2=180*(10^(-6));              //in Farad
r3=5;                          //in Ohms
L3=0.01;                       //in Henry
v=230;                         //in Volts
f=50;                          //in Hertz

```

```
//SOLUTION

//solition (a)
xl1=2*%pi*f*L1;
xc2=1/(2*%pi*f*c2);
xl3=2*%pi*f*L3;
Z1=r1+xl1*%i;                    //complex
   representations
Z2=r2-xc2*%i;
Z3=r3+xl3*%i;
//function to convert from rectangular form to polar
    form
function [z,angle]=rect2pol(r,x);
z=sqrt((r^2)+(x^2));
angle=atan(x/r)*(180/%pi);   //to convert the angle
   from radians to degrees
endfunction;
[z1,angle1]=rect2pol(r1,xl1);
[z2,angle2]=rect2pol(r2,xc2);
[z3,angle3]=rect2pol(r3,xl3);
//to obtain rectangular form of (Z1+Z2)
req1=r1+r2;
xeq1=xl1-xc2;
//to obtain polar form of (Z1+Z2)
[zeq1,angle_eq1]=rect2pol(req1,-xeq1);
zp=(z1*z2)/(zeq1);
angle_p=(angle1-angle2)+angle_eq1;
//function to convert from polar form to rectangular
    form
function [r,x]=pol2rect(z,angle);
r=z*cos(angle*(%pi/180));    //to convert the angle
   from degrees to radians
x=z*sin(angle*(%pi/180));
endfunction;
[rp,xp]=pol2rect(zp,angle_p);
[req,xeq]=pol2rect(z3,angle3);
r_tot=req+rp;
x_tot=xeq+xp;
```

```
[z_tot,angle_tot]=rect2pol(r_tot,x_tot);
Z=r_tot+x_tot*%i;                    //complex representation
disp(sprintf("(a) The total impedance is %f    , %f degrees",z_tot,angle_tot));

//solution (b)
I=v/Z;                               //complex division
angle_I=-angle_tot;
[I_x,I_y]=pol2rect(I,angle_I);
disp(sprintf("(b) The total currrent is (%f-j%f) A",real(I),imag(I)));

//solution (c)
//Voltage drop across Z3
Vab=I*Z3;
disp(sprintf("    The Voltage between AB is (%f-j%f) A",real(Vab),imag(Vab)));
//since we know that V=Vab+Vbc
Vbc=v-Vab;
disp(sprintf("    The Voltage between BC is (%f-j%f) A",real(Vbc),imag(Vbc)));
I1=Vbc/Z1;                           //Branch 1 current
I2=Vbc/Z2;                           //branch 2 current
//I3=I, main branch current
[mag1,angle1]=rect2pol(real(I1),imag(I1));
[mag2,angle2]=rect2pol(real(I2),imag(I2));
disp(sprintf("(c) Current in branch 1 is %f A, %f degrees",mag1,angle1));
disp(sprintf("    The currrent in branch 1 is (%f-j%f) A",real(I1),imag(I1)));
disp(sprintf("    The current in branch 2 is %f A, %f degrees",mag2,angle2));
disp(sprintf("    The currrent in branch 2 is (%f-j%f) A",real(I2),imag(I2)));
//END
```

Scilab code Exa 2.53 Total impedance and power taken

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 53 Read Example 52 of the Text Book

clc;
disp("CHAPTER 2");
disp("EXAMPLE 53");

//VARIABLE INITIALIZATION
v=230;                              //in Volts
angle_v=30;                         //in degrees
I1=20;                              //in Amperes
angle_I1=60;                        //in degrees
I2=40;                              //in Amperes
angle_I2=-30;                       //in degrees

//SOLUTION
//function to convert from polar form to rectangular form
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle*(%pi/180));     //to convert the angle from degrees to radians
y=mag*sin(angle*(%pi/180));
endfunction;
[x1,y1]=pol2rect(I1,angle_I1);
[x2,y2]=pol2rect(I2,angle_I2);
X=x1+x2;
Y=y1+y2;

//function to convert from rectangular form to polar form
function [I,angle]=rect2pol(x,y);
```

```
I=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);      //to convert the angle from radians to degrees
endfunction;
[I,angle]=rect2pol(X,Y);

//solution (i)
z=v/I;
angle_z=angle_v-angle;
disp(sprintf("(i) The total impedance of the circuit is %f   , %f degrees",z,angle_z));

//solution (ii)
//disp(sprintf("The value of I is %f and angle is %f ",I, angle_z));
pf=cos(angle_z*(%pi/180));
p=v*I*pf;
disp(sprintf("(ii) The power taken is %f W",p));
//END
```

Scilab code Exa 2.54 `Q factor at resonance`

```
//CHAPTER 2- STEADY-STATE ANALYSIS OF SINGLE-PHASE A.C. CIRCUIT
//Example 54 Read example 53 of the Book

clc;
disp("CHAPTER 2");
disp("EXAMPLE 54");

//VARIABLE INITIALIZATION
C=2.5/(10^6);                   //capcaitance in Farads
R=15;                           //in Ohms
L=260/1000;                     //in Henry
```

```
//SOLUTION

//solution (i)
f_r=(1/(2*%pi))*sqrt((1/(L*C)-(R^2/L^2)));
f_r=round(f_r);                    //to round off the
    value
disp(sprintf("(i) The resonant frequency is %d Hz",
    f_r));

//solution (ii)
q_factor=(2*%pi*f_r*L)/R;
disp(sprintf("(ii) The Q-factor of the circuit is %f
    ",q_factor));

//solution (iii)
Z_r=L/(C*R);
disp(sprintf("(iii) The dynamic impedance of the
    circuit is %f   ",Z_r));

//END
```

Chapter 3

Three Phase AC Circuits

Scilab code Exa 3.1 Identical impedances each consisting of 15 ohm in series

```
//CHAPTER 3- THREE-PHASE A.C. CIRCUITS
//Example 1

clc;
disp("CHAPTER 3");
disp("EXAMPLE 1");

//VARIABLE INITIALIZATION
v_l=400;                          //line voltage in
    Volts
r=15;                             //resistance in
    Ohms
xc=10;                            //capacitive
    reactance in Ohms

//SOLUTION

//solution (i)
v_ph=v_l/sqrt(3);                 //phase voltage=(
    line voltage)/sqrt(3) for star connection
disp(sprintf("(i) The phase voltage is %f V",v_ph));
```

```

//solution (ii)
z_ph=sqrt((r^2)+(xc^2));
I_l=v_ph/z_ph;                          //phase current = line current for star connection
disp(sprintf("(ii) The line current is %f A",I_l));

//solution (iii)
disp(sprintf("(iii) The phase current is %f A",I_l));

//solution (iv)
pow_fact=r/z_ph;
disp(sprintf("(iv) The power factor of the circuit is %f (leading)",pow_fact));

//solution (v)
p=sqrt(3)*v_l*I_l*pow_fact;
disp(sprintf("(v) The total power absorbed is %f W",p));

//solution (vi)
va=sqrt(3)*v_l*I_l;
disp(sprintf("(vi) The apparent power is %f VA",va));
var=sqrt((va^2)-(p^2));
disp(sprintf("The reactive power is %f VAR",var));

//Answers (v) and (vi) are different due to precision of floating point numbers

//END
```

Scilab code Exa 3.2 `Resistance and reactance values of each impedance`

```
//CHAPTER 3- THREE-PHASE A.C. CIRCUITS
//Example 2

clc;
disp("CHAPTER 3");
disp("EXAMPLE 2");

//VARIABLE INITIALIZATION
v_l=400;                              //line voltage in Volts
I_l=30;                               //line current in Amperes
p=12*1000;                            //power absorbed in Watts

//SOLUTION
v_ph=v_l/sqrt(3);                     //phase voltage = (line voltage)/sqrt(3)
z_ph=v_ph/I_l;                        //phase current = line current for star connection
pow_fact=p/(sqrt(3)*v_l*I_l);         //three-phase power = sqrt(3)*v_l*I_l*pow_fact
r_ph=z_ph*pow_fact;                   //from impedance tringle
disp(sprintf("The resisatnce of each impedance is %f",r_ph));
x_ph=sqrt((z_ph^2)-(r_ph^2));
disp(sprintf("The ractance of each impedance is %f",x_ph));

//END
```

Scilab code Exa 3.3 `Three similar coils each of 30 ohms`

```
//CHAPTER 3- THREE-PHASE A.C. CIRCUITS
```

```
//Example 3

clc;
disp("CHAPTER 3");
disp("EXAMPLE 3");

//VARIABLE INITIALIZATION
r_ph=30;                        //resistance of coils
    in Ohms
l=0.07;                         //inductance of coils
    in Henry
v_l=400;                        //line voltage in Volts
f=50;                           //frequency in Hertz

//SOLUTION

//solution (a)
x_ph=2*(%pi)*f*l;               //inductive reactance
z_ph=sqrt((r_ph^2)+(x_ph^2));
I_ph=v_l/z_ph;                  //phase voltage = line
    voltage for delta connection
disp(sprintf("(a) The phase current is %f A",I_ph));

//solution (b)
I_l=sqrt(3)*I_ph;               //phase current = (line
     current)/sqrt(3) for delta connection
disp(sprintf("(b) The line current is %f A",I_l));

//solution (c)
pow_fact=r_ph/z_ph;
disp(sprintf("(c) The power factor is %f (lagging)",
    pow_fact));

//solution (d)
p=sqrt(3)*v_l*I_l*pow_fact;
disp(sprintf("(d) The power absorbed is %f W",p));

//Answer is different due to precision of floating
```

```
point numbers

//END
```

Scilab code Exa 3.4 Line and phase current when phase sequence is positive

```
//CHAPTER 3— THREE—PHASE A.C. CIRCUITS
//Example 4

clc;
disp("CHAPTER 3");
disp("EXAMPLE 4");

//VARIABLE INITIALIZATION
v_l=866;                                    //line voltage in Volts
z_delta=177-(%i*246);                       //impedance of delta connected load in Ohms
z_wire=1+(%i*2);                            //impedance of each wire of the line in Ohms

//SOLUTION
v_ph=v_l/sqrt(3);                           //phase current = (line current)/sqrt(3) for star connection
z_star=z_delta/3;
z=z_wire + z_star;
I=v_ph/z;                                   //I_na in rectangular form
//I_na, I_nb and I_nc are same in magnitude and are the line currents for delta connection or vice—versa
//function is not used to covert quantities in rectangular form to polar form
//I_na
```

```
I_na=sqrt((real(I))^2+(imag(I))^2);    //I_na from rectangular to polar form
a=atan(imag(I)/real(I));                //angle in radians
a=a*(180/%pi);                          //radians to degrees
//I_nb
I_na=sqrt((real(I))^2+(imag(I))^2);
b=a-120;                                //lags by 120 degrees
//I_nc
I_na=sqrt((real(I))^2+(imag(I))^2);
c=a-240;                                // lags by another 120 degrees ie.,240 degrees
disp(sprintf("The line currents are %f A (%f degrees), %f A (%f degrees) and %f A (%f degrees)",I_na,a,I_na,b,I_na,c));


//line current lags phase current by 30 degrees, hence (-30)
//I_AB
I_AB=I_na/sqrt(3);
a1=a-(-30);
//I_BC
I_BC=I_na/sqrt(3);
b1=b-(-30);
//I_AC
I_AC=I_na/sqrt(3);
c1=c-(-30);
disp(sprintf("The phase currents are %f A (%f degrees), %f A (%f degrees) and %f A (%f degrees)",I_AB,a1,I_BC,b1,I_AC,c1));

//converting z_delta from polar form to rectangular form
z=sqrt((real(z_delta))^2+(imag(z_delta))^2);
angle=atan(imag(z_delta)/real(z_delta));
```

```
angle=angle*(180/%pi);

//line voltages for load or phase voltages for the delta load-
//v_AB
v_AB=I_AB*z;
a2=a1+angle;
//v_B
v_BC=I_BC*z;
b2=b1+angle;
//v_AC
v_AC=I_AC*z;
c2=c1+angle;
disp(sprintf("The phase voltages for the delta load are %f A (%f degrees), %f A (%f degrees) and %f A (%f degrees)",v_AB,a2,v_BC,b2,v_AC,c2));

p_AB=(I_AB^2)*real(z_delta);
p_load=3*p_AB;
disp(sprintf("The power absorbed by the load is %f W",p_load));
p_l=3*(I_na^2)*real(z_wire);
disp(sprintf("The power dissipated by the line is %f W",p_l));
p=p_load+p_l;
disp(sprintf("The total power supplied by 3-source is %f W",p));

//Answers may be slightly different due to precision of floating point numbers

//END
```

Scilab code Exa 3.5 `Power measurement by 2 wattmeter method`

```
//CHAPTER 3− THREE−PHASE A.C. CIRCUITS
//Example 5

clc;
disp("CHAPTER 3");
disp("EXAMPLE 5");

//VARIABLE INITIALIZATION
w1=5000;                          //reading of 1st
    wattmeter in Watts
w2=-1000;                         //reading of 2nd
    wattmeter in Watts

//SOLUTION

//solution (a)
p1=w1+w2;
disp(sprintf("(a) The total power is %d W",p1));

//solution (b)
p2=w1-w2;
phi=atan((sqrt(3)*p2)/p1);        //this equation comes
     from two−wattmeter method
pow_fact=cos(phi);
disp(sprintf("(b) The power factor of the load is %f
    ", pow_fact));

//END
```

Scilab code Exa 3.6 `3300 V synchronous alternator`

```
//CHAPTER 3− THREE−PHASE A.C. CIRCUITS
//Example 6

clc;
```

```
disp("CHAPTER 3");
disp("EXAMPLE 6");

//VARIABLE INITIALIZATION
v_l=3300;                         //line voltage in Volts
p_out=1500*735.5;                 //output power in Watts (1 metric horsepower= 735.498W)
eff=0.85;
pow_fact=0.81;

//SOLUTION

//solution (a)
p_in=p_out/eff;
disp(sprintf("(a) The motor input is %f kW",p_in/1000));

//solution (b)
I=p_in/(sqrt(3)*v_l*pow_fact);//phase current = line current for star connection
disp(sprintf("(b) The line and phase current of the alternator is %f A",I));

//solution (c)
I_l=I;
I_ph=I_l/sqrt(3);                 //phase current = (line current)/sqrt(3) for delta connection
disp(sprintf("(c) The line current of the motor is %f A",I_l));
disp(sprintf("The phase current of the motor is %f A",I_ph));

//Answers may be different due to precision of floating point numbers

//END
```

Scilab code Exa 3.7 Three phase star connected system

```
//CHAPTER 3- THREE-PHASE A.C. CIRCUITS
//Example 7

clc;
disp("CHAPTER 3");
disp("EXAMPLE 7");

//VARIABLE INITIALIZATION
v_ph=200;                               //phase voltage in Volts
r1=5;                                   //in Ohms
r2=8;                                   //in Ohms
r3=10;                                  //in Ohms

//SOLUTION
I1=v_ph/r1;
I2=v_ph/r2;
I3=v_ph/r3;
disp(sprintf("The current in the three phases are %d A, %d A and %d A",I1,I2,I3));

I_x=0+I2*(sqrt(3)/2)-I3*(sqrt(3)/2); //x-component of the three currents =>I_x = I1*cos(90) + I2*cos(30) + I3*cos(30)
I_y=I1-(I2*0.5)-(I3*0.5);               //y-component of the three currents =>I_y = I1*sin(90) + I2*sin(30) + I3*sin(30)
I=sqrt((I_x^2)+(I_y^2));
disp(sprintf("The neutral current is %f A",I));

p1=v_ph*I1;                             //power consumed in 1st phase
```

```
p2=v_ph*I2;                                  //power
   consumed in 2nd phase
p3=v_ph*I3;                                  //power
   consumed in 3rd phase
disp(sprintf("The power consumed in the three phases
    are %d W, %d W and %d W",p1,p2,p3));

p=p1+p2+p3;
disp(sprintf("The total power is %d W",p));

//END
```

Scilab code Exa 3.8 Balanced delta connection

```
//CHAPTER 3- THREE-PHASE A.C. CIRCUITS
//Example 8

clc;
disp("CHAPTER 3");
disp("EXAMPLE 8");

//VARIABLE INITIALIZATION
v_ph=230;                                       //in Volts
   and in polar form
z=8+(%i*6);                                     //in Ohms
   and in rectanglar form

//SOLUTION
//converting z from rectangular form to polar form
z_mag=sqrt(real(z)^2+imag(z)^2);
phi=atan(imag(z)/real(z));                      //atan()
   gives output in radians

I_ph=v_ph/z_mag;
I_l=sqrt(3)*I_ph;
```

```
disp(sprintf("The line current is %f A",I_l));

pow_fact=cos(phi);
disp(sprintf("The power factor is %f",pow_fact));

p=sqrt(3)*v_ph*I_l*pow_fact;           //phase volt=
    line volt in delta connection(v_l=v_ph)
disp(sprintf("The power is %f W",p));

var=sqrt(3)*v_ph*I_l*sin(phi);
var=var/1000;                          //from VAR to
     kVAR
disp(sprintf("The reactive power is %f kVAR",var));

va=sqrt(3)*v_ph*I_l;
va=va/1000;                            //from VA to
    kVA
disp(sprintf("The total volt amperes is %f kVA",va))
    ;

//END
```

Scilab code Exa 3.9 400 V 50 Hz three phase supply

```
//CHAPTER 3- THREE-PHASE A.C. CIRCUITS
//Example 9

clc;
disp("CHAPTER 3");
disp("EXAMPLE 9");

//VARIABLE INITIALIZATION
v_ab=400;                    //in Volts
v_bc=400;                    //in Volts
v_ac=400;                    //in Volts
```

```
z_ab=100;                         //in Ohms
z_bc=100;                         //in Ohms
z_ac=100;                         //in Ohms

//solution (a)

//function to convert from polar to rectangular form
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle);
y=mag*sin(angle);
endfunction;

I_AB=v_ab/z_ab;
mag1=abs(real(I_AB));
ang1=0;                    //I_AB is represented as mag 1 ang1
I_BC=v_bc/z_bc;
ang2=-210*(%pi/180);            //I_BC is represented as mag 1 ang2
I_AC=v_ac/z_ac;
ang3=210*(%pi/180);             //I_AB is represented as mag 1 ang3
[x1,y1]=pol2rect(I_AB,ang1);
[x2,y2]=pol2rect(I_BC,ang2);
[x3,y3]=pol2rect(I_AC,ang3);
//let us consider values X1, Y1, X2, Y2, X3 and Y3 for the ease of calculation (these are not mentioned in the book)
X1=x1-x3;
Y1=y1-y3;
X2=x2-x1;
Y2=y2-y1;
X3=x3-x2;
Y3=y3-y2;
I_A=X1+(%i*Y1);
I_B=X2+(%i*Y2);
I_C=X3+(%i*Y3);

```

```
//function to convert from rectangular to polar form
function [z,angle]=rect2pol(x,y);
z=sqrt((x^2)+(y^2));                //z is impedance & the resultant of x and y
if(x==0 & y>0) then angle=90;       //in case atan=
elseif(x==0 & y<0) then angle=-90 //in case atan=-
else
angle=atan(y/x)*(180/%pi);          //to convert the angle from radians to degrees
end;
endfunction;

[mag4,ang4]=rect2pol(X1,Y1);
[mag5,ang5]=rect2pol(X2,Y2);
[mag6,ang6]=rect2pol(X3,Y3);
disp(sprintf("(a) The line current I_A is  %f %f  A",mag4,ang4));
disp(sprintf("The line current I_B is  %f %f  A",mag5,(180+ang5)));
disp(sprintf("The line current I_C is  %f %f  A",mag6,ang6));

//solution (b)
//since power is consumed only by 100   resistance in the arm AB
r1=100;
p1=(I_AB^2)*r1;
p2=160000;
r2=p2/p1;
disp(sprintf("(b) The star connected balanced resistance is %d   ",r2));

//END
```

Scilab code Exa 3.11 Balanced load of 20kVA

```
//CHAPTER 3- THREE-PHASE A.C. CIRCUITS
//Example 11

clc;
disp("CHAPTER 3");
disp("EXAMPLE 11");

//SOLUTION
function power_sum=p1(phi);
power_sum=20*cos(phi);                  //power_sum=p1+p2=20*cos(phi) and in KiloWatts
endfunction;
function power_diff=p2(phi);
power_diff=(20*sin(phi))/sqrt(3);       //power_diff=p1-p2=(20*sin(phi))/sqrt(3) and in KiloWatts
endfunction;

//solution (a): when phi=0
power_sum=20*cos(0);                    //eq(i)
power_diff=(20*sin(0))/sqrt(3);         //eq(ii)
//solving eq(i) and eq(ii) to get values of p1 and p2
A=[1 1;1 -1];
b=[power_sum;power_diff];
x=inv(A)*b;
x1=x(1,:);                              //to access the 1st row of 2X1 matrix
x2=x(2,:);                              //to access the 2nd row of 2X1 matrix
disp("Solution (a)");
disp(sprintf("P1 + P2 = %d kW",power_sum));
disp(sprintf("P1 - P2 = %d kW",power_diff));
disp(sprintf("The two wattmeter readings are %d kW and %d kW",x1,x2));

//solution (b): when phi=30 or %pi/6 (lagging)
```

```
power_sum=20*cos(%pi/6);
power_diff=(20*sin(%pi/6))/sqrt(3);
A=[1 1;1 -1];
b=[power_sum;power_diff];
x=inv(A)*b;
x1=x(1,:);
x2=x(2,:);
disp("Solution (b)");
disp(sprintf("P1 + P2 = %f kW",power_sum));
disp(sprintf("P1 - P2 = %f kW",power_diff));
disp(sprintf("The two wattmeter readings are %f kW
    and %f kW",x1,x2));

//solution (c): when phi=60 or %pi/3
power_sum=20*cos(%pi/3);
power_diff=(20*sin(-(%pi/3)))/sqrt(3); //leading
A=[1 1;1 -1];
b=[power_sum;power_diff];
x=inv(A)*b;
x1=x(1,:);
x2=x(2,:);
disp("Solution (c)");
disp(sprintf("P1 + P2 = %f kW",power_sum));
disp(sprintf("P1 - P2 = %f kW",power_diff));
disp(sprintf("The two wattmeter readings are %f kW
    and %f kW",x1,x2));

//solution (d): when phi=90 or %pi/2
power_sum=20*cos(%pi/2);
power_diff=(20*sin(%pi/2))/sqrt(3);   //leading
A=[1 1;1 -1];
b=[power_sum;power_diff];
x=inv(A)*b;
x1=x(1,:);
x2=x(2,:);
disp("Solution (d)");
disp(sprintf("P1 + P2 = %f kW",power_sum));
disp(sprintf("P1 - P2 = %f kW",power_diff));
```

```
disp(sprintf("The two wattmeter readings are %f kW
   and %f kW",x1,x2));

//END
```

Scilab code Exa 3.12 Three identical impedances each having a resistance R

```
//CHAPTER 3- THREE-PHASE A.C. CIRCUITS
//Example 12

clc;
disp("CHAPTER 3");
disp("EXAMPLE 12");

//VARIABLE INITIALIZATION
v_l=400;                        //in Volts
f=50;                           //in Hertz
w1=2000;                        //in Watts
w2=800;                         //in Watts

//SOLUTION
//solution (a)
p1=w1+w2;
p2=w1-w2;
phi=atan((sqrt(3)*p2)/p1);    //this equation comes
   from two-wattmeter method
pow_fact=cos(phi);
disp(sprintf("(a) The power factor of the circuit is
    %f (leading)",pow_fact));

//solution (b)
I_l=p1/(sqrt(3)*v_l*pow_fact);
disp(sprintf("(b) The line current is %f A",I_l));

//solution (c)
```

```
v_ph=v_l/sqrt(3);
z_ph=v_ph/I_l;                //phase current = line current for delta connection
r_ph=z_ph*pow_fact;
disp(sprintf("(c) The resistance of each phase is %f ",r_ph));
xc=sqrt((z_ph^2)-(r_ph^2));
c=1/(2*%pi*f*xc);
disp(sprintf("The capacitance of each phase is %E F",c));

//END
```

Chapter 4

Measuring Instruments

Scilab code Exa 4.1 Deflecting torque exerted on a coil

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 1

clc;
disp("CHAPTER 4");
disp("EXAMPLE 1");

//VARIABLE INITIALIZATION
N=10;            //number of turns
I=5;             //in amperes
B=500;           //flux density in Wb/m^2
ar=15/10000;     //area in m^2

//SOLUTION
T_d=N*B*I*ar;
disp(sprintf("The deflecting torque exerted on the
    coil is %f N-m",T_d));

//END
```

Scilab code Exa 4.2 Current through galvanometer

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 2

clc;
disp("CHAPTER 4");
disp("EXAMPLE 2");

//VARIABLE INITIALIZATION
G=10;           //galvanometer resistance in Ohms
S=1;            //shunt resistance in Ohms
r=12;           //total resistance in Ohms
emf=2;          //emf of cell in Volts

//SOLUTION
I=emf/r;        //current in the circuit
I_g=(S*I)/(S+G);
disp(sprintf("The current through the galvanometer
   is %f A",I_g));

//END
```

Scilab code Exa 4.3 Resistance of wire

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 3

clc;
disp("CHAPTER 4");
disp("EXAMPLE 3");

```

```
//VARIABLE INITIALIZATION
I=1;                    //in Amperes (I=1 is an
   assumption)
I_g=I/100;              //in Amperes
G=2970;                 //in Ohms

//SOLUTION
S=(G*I_g)/(I-I_g); //since I_g=(S*I)/(S+G);

disp(sprintf("The wire should have a resistance of
   %f  ",S));

//END
```

Scilab code Exa 4.4 Resistance required to read current and voltage

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 4

clc;
disp("CHAPTER 4");
disp("EXAMPLE 4");

//VARIABLE INITIALIZATION
r_A=10;                          //in Ohms
I_A=15/1000;                     //from mA to A
I=100;                           //in A
V=500;                           //in Volts

//SOLUTION

//solution (a)
R_sh=r_A/((I/I_A)-1);            //(I/I_A) is the
   multiplying factor of the shunt

```

```
disp(sprintf("The required shunt resistance is %f ",R_sh));

//solutuion (b)
r=V/I_A;                          //total resistance required
R_se=r-r_A;
disp(sprintf("The required resistance to be added in series is %f  ",R_se));

//END
```

Scilab code Exa 4.5 Number of revolutions made by energy meter and percentage erro

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 5

clc;
disp("CHAPTER 4");
disp("EXAMPLE 5");

//VARIABLE INITIALIZATION
m_c=100;                    //meter constant in rev/kWh
I=20;                       //load current in Amperes
v=230;                      //supply voltage in Volts
pow_fact=0.8;
rev_act=360;                //actual number of revolutions

//SOLUTION
E=(v*I*pow_fact)/1000;      //'E' is energy consumed in one hour in kWh
rev=m_c*E;                  //number of revolutions for true energy
```

```
disp(sprintf("The number of revolutions made by the meter is %f",rev));
err=(rev_act-rev)/rev;      //error
err=err*100;                //percentage error
disp(sprintf("The percentage error is %f %%",err));
if(err<0) then
disp("The negative sign indicates that the meter will run slow");
end

//END
```

Scilab code Exa 4.6 Series resistance to measure 500 V on full scale

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 6

clc;
disp("CHAPTER 4");
disp("EXAMPLE 6");

//VARIABLE INITIALIZATION
I_m=20/1000;          //full scale deflection in Amperes
v_m=50/1000;          //applied potential difference in Volts
v=500;                //in Volts

//SOLUTION
r_m=v_m/I_m;          //resistance of moving-coil instrument
r_s=(v/I_m)-r_m;
disp(sprintf("The series resistance to measure 500 V on full scale is %f   ",r_s));

```

```
//END
```

Scilab code Exa 4.7 Percentage error of energy meter

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 7

clc;
disp("CHAPTER 4");
disp("EXAMPLE 7");

//VARIABLE INITIALIZATION
m_c=100;                    //meter constant in rev/kwh
I=20;                       //in Amperes
v=210;                      //in Volts
pow_fact=0.8;               //leading
rev_act=350;                //actual revolution

//SOLUTION
E=(v*I*pow_fact)/1000;      //from Wh to kWh
rev_true=m_c*E;
disp(sprintf("The number of revolutions made by the
    meter is %f",rev_true));
err=(rev_act-rev_true)/rev_true;
err=err*100;                 //percentage error
disp(sprintf("The percentage error is %f %%",err));
if(err<0) then
disp("The negative sign indicates that the meter
    will run slow");
end

//END
```

Scilab code Exa 4.8 Resistance required to read current and voltage

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 8

clc;
disp("CHAPTER 4");
disp("EXAMPLE 8");

//VARIABLE INITIALIZATION
I_m=15/1000;          //from mA to A
r_m=5;                //in Ohms
I=2;                  //in Amperes
v=30;                 //in Volts

//SOLUTION
R_sh=(I_m*r_m)/I;     //I_m=I*(R_sh/(R_sh+r_m)) if
    R_sh<<5  , then I_m=I*(R_sh/r_m) neglecting R_sh
    in the denominator
disp(sprintf("In order to read upto 2A, a shunt of
    %f   has to be connected in parallel",R_sh));

R_se=(v-(I_m*r_m))/I_m;
disp(sprintf("In order to read upto 30V, a
    resistance of %f   has to be connected in series
    ",R_se));

//END
```

Scilab code Exa 4.9 Percentage error of meter

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 9

clc;
```

```
disp("CHAPTER 4");
disp("EXAMPLE 9");

//VARIABLE INITIALIZATION
I=50;                       //in Amperes
v=230;                      //in Volts
rev=61;                     //revolutions
t=37/3600;                  //from seconds to hours
m_c=500;                    //meter constant in rev/
    kwh
pow_fact=1;                 //since load is purely
    resistive

//SOLUTION
E1=(v*I*t*pow_fact)/1000; //energy consumed in 37
    seconds in kWh
E2=rev/m_c;                 //energy consumption
    registered by meter
err=(E2-E1)/E1;
err=err*100;                //percentage error
disp(sprintf("The percentage error is %f %%",err));
if(err<0) then
disp("The negative sign indicates that the meter
    will run slow");
end

//END
```

Scilab code Exa 4.10 Readings of two voltmeters

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 10

clc;
disp("CHAPTER 4");
```

```
disp("EXAMPLE 10");

//VARIABLE INITIALIZATION
r1=2;                      //in Ohms (r1=2 is an assumption)
r2=2;                      //in Ohms (since r1=r2)
v=100;                     //in Volts

//SOLUTION
v1=(v*r1)/(r1+r2);         //voltage divider law
v2=(v*r2)/(r1+r2);         //voltage divider law
disp(sprintf("Reading of the 1st voltmeter is %d V",v1));
disp(sprintf("Reading of the 2nd voltmeter is %d V",v2));

//END
```

Scilab code Exa 4.11 Readings of two voltmeters with different internal resistance

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 11

clc;
disp("CHAPTER 4");
disp("EXAMPLE 11");

//VARIABLE INITIALIZATION
r1=30000;                   //in Ohms
r2=20000;                   //in Ohms
v=600;                      //in Volts

//SOLUTION
v1=(r1*v)/(r1+r2);          //voltage divider law
v2=(r2*v)/(r1+r2);          //voltage divider law
```

```
disp(sprintf("Reading of the 1st voltmeter is %d V",
    v1));
disp(sprintf("Reading of the 2nd voltmeter is %d V",
    v2));

//END
```

Scilab code Exa 4.12 `Total current carried by two ammeters`

```
//CHAPTER 4- MEASURING INSTRUMENTS
//Example 12

clc;
disp("CHAPTER 4");
disp("EXAMPLE 12");

//VARIABLE INITIALIZATION
I1=1;                  //full scale current in 1st
    ammeter in mA
I2=10;                 //full scale current in 2nd
    ammeter in mA
r1=100;                //internal resistance of 1st
    ammeter in Ohms
r2=25;                 //internal resistance of 2nd
    ammeter in Ohms

//SOLUTION
R1=r2/(r1+r2);         //resistance for 1st ammeter
R2=r1/(r1+r2);         //resistance for 2nd ammeter
I=I1/R1;               //by current divider law I1=(I*
    r2)/(r1+r2) =>I1=I*R1 =>I=I1/R1
A2=I*R2;               //A2=reading of second ammeter
disp(sprintf("The total current that the two
    ammeters can carry is %d mA",I));

```

```
//END
```

Chapter 6

Magnetic Circuits

Scilab code Exa 6.1 Magnetic circuit having two air gaps

```
//CHAPTER 6- MAGNETIC CIRCUITS
//Example 1

clc;
disp("CHAPTER 6");
disp("EXAMPLE 1");

//VARIABLE INITIALIZATION
lA=17/100;          //length of A in meters (lA is
    calculated in the solution in the book; here it
    is initialised directly for the sake of
    convinience)
l=3/100;            //in meters
lg=2/1000;          //width of air-gap in meters
N=1000;             //number of turns
AB=10/100;          //in meters
BC=20/100;          //in meters
CD=10/100;          //in meters
I=1;                //exciting current in Amperes
murA=1000;          //relative permeability of part A
murB=1200;          //relative permeability of part B
```

```
mu0=4*%pi*10^(-7);//absolute permeability in Henry/meters

//SOLUTION

//solution (i)
ar=l*l;           //area of cross-section
rA=lA/(mu0*murA*ar);
disp(sprintf("(i) Reluctance of part A is %E AT/Wb",rA));
lB=(AB-(l/2))+(BC-l)+(CD-(l/2));
rB=lB/(mu0*murB*ar);
disp(sprintf("Reluctance of part B is %E AT/Wb",rB));

//solution (ii)
lg=2*lg;
murg=1;
rg=lg/(mu0*murg*ar);
disp(sprintf("(ii) Reluctance of the two air gaps is %E AT/Wb",rg));

//solution (iii)
rT=rA+rB+rg;
disp(sprintf("(iii) Total reluctance is %E AT/Wb",rT));

//solution (iv)
mmf=N*I;
disp(sprintf("(iv) MMF is %d AT",mmf));

//solution (v)
totFlux=mmf/rT;
disp(sprintf("(v) Total flux is %E Wb",totFlux));


//solution (vi)
b=totFlux/ar;
```

```
disp(sprintf("(vi) Flux density is %f Wb/m^2",b));

//Answers of (v) and (vi) do not match due to calculation mistake in the book

//END
```

Scilab code Exa 6.2 `Steel ring of 25 cm mean diameter`

```
//CHAPTER 6- MAGNETIC CIRCUITS
//Example 2

clc;
disp("CHAPTER 6");
disp("EXAMPLE 2");

//VARIABLE INITIALIZATION
dr=25/100;                              //diameter of steel ring in m
ds=3/100;                               //diameter of circular section in m
lg=1.5/1000;                            //length of air-gap in m
N=700;                                  //number of turns
mu0=4*%pi*10^(-7);                      //absolute permeability in Henry/m
I=2;                                    //in Amperes

//SOLUTION

//solution (i)
mmf=N*I;
disp(sprintf("(i) MMF is %d AT", mmf));

//solution (ii)
```

```
netMMF=(mmf-(0.35*mmf));                //mmf taken by iron path is 35% of total mmf
b=(mu0*netMMF)/lg;                      //phi=b*area, r=lg/(mu0*area) & mmf=phi*r => mmf=(b*lg)/mu0 => b=(mmf*mu0)/lg
disp(sprintf("(ii) The flux density of the air gap is %E Wb/m^2", b));

//solution (iii)
ar=%pi*((ds/2)^2);                      //area of cross-section of circular section
phi=ar*b;
disp(sprintf("(iii) The magnetic flux is %E Wb",phi));

//solution (iv)
rt=mmf/phi;
disp(sprintf("(iv) The total reluctance is %E AT/wb",rt));

//solution (v)
rg=lg/(mu0*ar);                         //reluctance of air gap
rs=rt-rg;                               //reluctance of steel
lr=%pi*dr;                              //circumference of ring
mur=lr/(mu0*rs*ar);
disp(sprintf("(v) The relative permeability of the steel ring is %E",mur));

//solution (vi)
disp(sprintf("(vi) Reluctance of steel is %E AT/Wb",rs));

//END
```

Scilab code Exa 6.3 Magnetic circuit with cast steel core

```
//CHAPTER 6- MAGNETIC CIRCUITS
//Example 3

clc;
disp("CHAPTER 6");
disp("EXAMPLE 3");

//VARIABLE INITIALIZATION
lg1=0.025/100;                  //length of 1st air-gap in m
a1=(1*1)/10000;                 //in m^2
lg2=0.02/100;                   //length of 2nd air-gap in m
a2=(1*1)/10000;                 //in m^2
lg3=0.02/100;                   //length of 3rd air-gap in m
a3=(2*1)/10000;                 //in m^2
phi=0.75/1000;                  //flux in Wb
lc1=0.5;                        //length through outer limb in m
lc2=0.5;                        //length through outer limb in m
lc3=0.2;                        //length through central limb in m
mu0=4*%pi*10^(-7);              //absolute permeability in Henry/m

//SOLUTUION

//solution (a): when mur=infinity i.e., no mmf drops in any member of the core
rg1=lg1/(mu0*a1);               //reluctance of 1st
```

```
air-gap
rg2=lg2/(mu0*a2);                  //reluctance of 2nd air-gap
rg3=lg3/(mu0*a3);                  //reluctance of 3rd air-gap
rgeq=(rg1*rg2)/(rg1+rg2);          //parallel combination of resistors
mmf1=phi*(rgeq+rg3);
mmf1=round(mmf1);                  //to round off the value
disp(sprintf("(a) MMF of the exciting coil when permeability is infinity is %d AT",mmf1));

//solution (b): when mur=5000 i.e., reluctance of magnetic core must be considered
mur=5000;
rc1=lc1/(mu0*mur*a1);              //reluctance of first path in the core
rc2=lc2/(mu0*mur*a2);              //reluctance of second path in the core
rc3=lc3/(mu0*mur*a3);              //reluctance of third path in the core
r1=rg1+rc1;
r2=rg2+rc2;
r3=rg3+rc3;
req=(r1*r2)/(r1+r2);
totr=req+r3;                       //total resistance
mmf2=phi*totr;
mmf2=round(mmf2);
disp(sprintf("(b) MMF of the exciting coil when permeability is 5000 is %d AT",mmf2));

//END
```

Scilab code Exa 6.4 `Iron ring made of round iron rod`

```
//CHAPTER 6- MAGNETIC CIRCUITS
//Example 4

clc;
disp("CHAPTER 6");
disp("EXAMPLE 4");

//VARIABLE INITIALIZATION
di=10;                              //diameter of iron
    ring in cm
dr=1.5;                             //diameter of iron
    rod in cm
mui=900;                            //relative
    permeability of rod
mu0=4*%pi*10^(-7);                  //absolute
    permeability in Henry/m
lg=5/10;                            //length of air-gap
    in cm
N=400;                              //number of turns
I=3.4;                              //current through
    the winding in Amperes

//SOLUTION
li=(di*%pi)-lg;                     //length of iron
    path
area=((dr^2)*%pi)/4;                //area of iron cross
    -section

//solution (a)
mmf=(4*%pi*N*I)/10;                 //in gilberts, since
     1 AT=(4*pi)/10
mmf=round(mmf);                     //to round off the
    value
disp(sprintf("(a) MMF is %d Gilberts",mmf));

//solution (b)
//tot reluctance = iron reluctance + air gap
    reluctance(mur=1 for air)
```

```
totR=(li/(area*mu0*mui))+(lg/(area*mu0*1));
disp(sprintf("(b) The total reluctance is %E Gilberts/Maxwell",totR));

//solution (c)
phi=mmf/totR;
disp(sprintf("(c) The flux in the circuit is %f Maxwell",phi));

//solution (d)
b=phi/area;
disp(sprintf("(d) The flux density in the circuit is %f Gauss",b));

//Answers of (b), (c) & (d) are different because absolute permeability is not included in (b)

//END
```

Scilab code Exa 6.5 Ring made of composite material

```
//CHAPTER 6- MAGNETIC CIRCUITS
//Example 5

clc;
disp("CHAPTER 6");
disp("EXAMPLE 5");

//VARIABLE INITIALIZATION
li=100/100;                    //length of iron part in m
ls=200/100;                    //length of steel part in m
lg=1/100;                      //length of air gap in m
```

```
ai=20/10000;                  //cross-sectional area of iron in m^2
as=10/10000;                  //cross-sectional area of steel in m^2
ag=20/10000;                  //cross-sectional area of air-gap in m^2
muRi=300;                     //relative permeability of iron
muRs=900;                     //relative permeability of steel
muRg=1;                       //relative permeability of air
N=170;                        //number of turns
phi=9000*10^(-8);             //flux in Wb (1 line = 10^(-8) Wb)
lkg=1.2;                      //leakage coefficient
mu0=4*%pi*10^(-7);            //absolute permeability in Henry/m

//SOLUTION
rg=lg/(mu0*muRg*ag);
mg=rg*phi;
mg=round(mg);                 //to round off the value
disp(sprintf("MMF of the air gap is %d AT",mg));

ri=li/(mu0*muRi*ai);          //reluctance of iron paths
mi=lkg*ri*phi;                //MMF for iron path
mi=round(mi);
disp(sprintf("MMF of iron is %d AT",mi));

rs=ls/(mu0*muRs*as);          //reluctance of steel paths
ms=lkg*rs*phi;                //MMF for steel path
ms=round(ms);
disp(sprintf("MMF of cast steel is %d AT",ms));

```

```
totMMF=mg+mi+ms;
I=totMMF/N;
disp(sprintf("Current through the coil is %f A",I));

//END
```

Chapter 7

Single Phase Transformer

Scilab code Exa 7.1 To calculate magnetizing component of no load current

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 1

clc;
disp("CHAPTER 7");
disp("EXAMPLE 1");

//VARIABLE INITIALIZATION
I_0=10;                              //no load current in Amperes
pf=0.25;                             //power factor
v1=400;                              //in Volts
f=50;                                //in Hertz

//SOLUTION

//solution (a)
//magnetizing component
//Iphi=I0.sin theta
theta=acos(pf);                       //taking value of theta from the given power factor
```

```
I_phi=I_0*sin(theta);
disp(sprintf("(a) The magnetizing component of no
   load current is %.2f A",I_phi));

//solution (b)
//iron loss
//Pc=V1.Ic
//Ic=I0.cos theta & also Ic=I0.pf as pf=cos theta
p_c=v1*I_0*pf;
disp(sprintf("(b) The iron loss is %d W",p_c));

//solution (c)
N1=500;                       // number of turns in
   primary given
phi_m=v1/(sqrt(2)*%pi*f*N1);
disp(sprintf("(c) The maximum value of flux in the
   core is %.2f mWb",phi_m*1000));

//END
```

Scilab code Exa 7.2 To calculate the primary current

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 2

clc;
disp("CHAPTER 7");
disp("EXAMPLE 2");
//
//400/200V transformer
//VARIABLE INITIALIZATION
v1=400;                          //primary voltage in
    Volts
v2=200;                          //secondary voltage
   in Volts
```

```
I0=1;                              //in Amperes
pf1=0.4;                           //power factor in degrees on no load
I2=50;                             //secondary current in Amperes
pf2=0.8;                           //secondary supplies lagging power factor in degrees

//SOLUTION
//primary current is given by
//I1=I0+I2
//function to convert from polar to rectangular form
function [x,y]=pol2rect(mag,angle1);
x=mag*cos(angle1);
y=mag*sin(angle1);
endfunction;
//
phi_0=acos(pf1);                   // cosine inverse of the power factor which is given
phi=acos(pf2);                     // cosine inverse of the power factor which is given
I2_dash=(v2*I2)/v1;                //v1.i1=v2.i2
//I0=1 < phi_0 in polar format
[x0,y0]=pol2rect(I0,-phi_0);
[x2_dash,y2_dash]=pol2rect(I2_dash,-phi);
I1_x=x0+x2_dash;                   //x-component of I1
I1_y=y0+y2_dash;                   //y-component of I1
disp(sprintf("The primary current in reactangular form is (%.3f-j%.2f) A",I1_x,-I1_y));
//
//function to convert from rectangular form to polar form
function [I,angle]=rect2pol(x,y);
I=sqrt((x^2)+(y^2));
angle=atan(y/x)*(180/%pi);      //to convert the angle from radians to degrees
endfunction;
[I,angle]=rect2pol(I1_x,I1_y);          // converting
```

```
current from rectangular to polar form
disp(sprintf("The primary current in polar form is (%.3f <%.2f) A",I,angle));
//END
```

Scilab code Exa 7.3 To find the voltage regulation

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 3

clc;
disp("CHAPTER 7");
disp("EXAMPLE 3");
//
//2300/230 V 50 Hz transformer
//VARIABLE INITIALIZATION
v1=2300;                                    //primary voltage in Volts
v2=230;                                     //secondary voltage in Volts
f=50;
R1=0.286;
X1=0.73;
R_dash_2=0.319;
X_dash_2=0.73;
Rc=250;
Xphi=1250;
Zl=0.387+0.29*%i;
//
//SOLUTION
Z_e1=(R1+R_dash_2)+(X1+X_dash_2)*%i;
Z_dash_l=(v1/v2)^2*Zl;
//
I_dash_1=v1/(Z_dash_l+Z_e1);
//[mag,angle]=rect2pol(real(I_dash_1),imag(I_dash_1)
```

```
);
//disp(sprintf("The  current is %f <%f  A",mag,angle));
//impedance of shunt branch
Zm=Rc*(Xphi*%i)/(Rc+Xphi*%i);
//[mag,angle]=rect2pol(real(Zm),imag(Zm));
//disp(sprintf("The  Zm is %f <%f  A",mag,angle));
I0=v1/Zm;
//[mag,angle]=rect2pol(real(I0),imag(I0));
//disp(sprintf("The  I0 is %f <%f  A",mag,angle));
//
//primary current
I1=I0+I_dash_1;
function [mag,angle]=rect2pol(x,y);
mag=sqrt((x^2)+(y^2));             //z is impedance & the resultant of x and y
angle=atan(y/x)*(180/%pi);       //to convert the angle from radians to degrees
endfunction;
[mag,angle]=rect2pol(real(I1),imag(I1));
theta1=angle;
disp("SOLUTION (i)");
disp(sprintf("The primay current in rectangulr form is %.3f -j%.2f  A",real(I1),-imag(I1)));
disp(sprintf("The primay current in polar form is %.3f <%.2f  A",mag,angle));
//
//input power
Pin=v1*I1; ;                             //=I1.cos(theta1)
//disp(sprintf("The  input power is %.3f kW",Pin/1000));
//output power
V_dash_2=I_dash_1*Z_dash_l;
[mag,angle]=rect2pol(real(V_dash_2),imag(V_dash_2));
theta2=angle;
//disp(sprintf("The  V_dash_2 is %.2f <%.2f  A",mag,angle));
```

```
//
Pout= V_dash_2*I_dash_1;                    //I_dash_1.
    cos(theta1)
//disp(sprintf("The  output power is %.3f kW",real(
    Pout)/1000));
//Efficiency
disp("SOLUTION (ii)");
disp(sprintf("The  Efficiency is %.2f kW",Pout*100/
    Pin));// text Book answer is 78.75%
//Losses
Pc=v1*I0;                                   //core loss
loss=Pin-Pout;
Pcu=loss-Pc;                                //copper
    loss
disp(sprintf("The  core loss is %.2f kW",Pc/1000));
    //text book answer is 0.8 kW
disp(sprintf("The  copper loss is %.2f kW",Pcu/1000)
    );//text book answer is 1..38 kW
//efficiency
//eff=Pout*100/Pin;
//disp(sprintf("The  percent efficiency is %f W",eff
    ));
disp(" ");
// The answers from V_dash_2 calculation onward do
    not match with the book on page 7.21 and 7.22
//END
```

Scilab code Exa 7.4 `10 kVA transformer`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 4

clc;
disp("CHAPTER 7");
disp("EXAMPLE 4");
```

```

//10kVA Transformer with 50 turns on primary and 10 turns on secondary
//connected to 440 V 50Haz supply
//VARIABLE INITIALIZATION
va=10*1000;                          //apparent power, converting kVA to VA
N1=50;                               //number of turns on primary side
N2=10;                               //number of turns on secondary side
v1=440;                              //primary voltage in Volts
f=50;                                //in Hertz

//SOLUTION

//solution (a)
//K=N2/N1=V2/V1
v2=v1*(N2/N1);
disp(sprintf("(a) The secondary voltage on no load is %d V",v2));

//solution (b)
//Current on Full load
//primary side I1=VA/V1
//secondary side I2=VA/V2
I1=va/v1;
disp(sprintf("(b) The full load primary current is %.4f A",I1));
I2=va/v2;
disp(sprintf("The full load secondary current is %.4f A",I2));

//solution (c)
//As per EMF equation
//E2=sqrt(2).pi.f.phimax.N2
phi_m=v2/(sqrt(2)*%pi*f*N2);
```

```
disp(sprintf("(c) The maximum value of the flux is %
    .3f mWb",phi_m*1000));

//END
```

Scilab code Exa 7.5 Transformer with 350 primary and 1050 secondary turns

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 5

clc;
disp("CHAPTER 7");
disp("EXAMPLE 5");

//single phase transformer
//350 primary and 1050 secondary turns
//VARIABLE INITIALIZATION
N1=350;                       //number of turns on
    primary side
N2=1050;                      //number of turns on
    secondary side
v1=400;                       //primary voltage in
    Volts
f=50;                         //in Hertz
ar=50/10000;                  //cross-sectional area
     of core in m^2

//SOLUTION

//solution (i)
//emf1=sqrt(2).pi.f.Phimax.N1
//Phimax=Bm.Area, Bm=flux density
//Bm=e1/sqrt(2).pi.A.f.N1
Bm=v1/(sqrt(2)*%pi*ar*f*N1);
disp(sprintf("(i) The maximum flux density is %.4f
```

```
Wb/m^2",Bm));

//solution (ii)
//e2/e1=n2/n1=K
K=N2/N1;
e2=K*v1;
disp(sprintf("(ii) The induced emf in the secondary
    winding is %d V",e2));

//END
```

Scilab code Exa 7.6 Primary current and power factor

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 6

clc;
disp("CHAPTER 7");
disp("EXAMPLE 6");

//2200/20V 50Hz single phase transformer
//VARIABLE INITIALIZATION
v1=2200;                              //primary voltage
     in Volts
v2=220;                               //secondary
    voltage in Volts
I=0.6;                                //exciting
    current in Amperes
p_c=361;                              //core loss in
    Watts
I2=60;                                //load current in
     Amperes
pf=0.8;                               //power factor

//SOLUTION
```

```

//solution (a)
//core loss components
I1=p_c/v1;                        //vertical component of I0
I_phi=sqrt((I^2)-(I1^2));         //horizontal component of I0
disp(sprintf("(a) The core loss component is %.3f A",I1));
disp(sprintf("And the magnetising component is %.3f A",I_phi));

//solution (b)
//I1.N1=I2.N2
I1_dash=(v2/v1)*I2;
theta=acos(pf);
I1_x=I1_dash*sin(theta)+I_phi;    //horizontal component of I0
I1_y=I1_dash*pf+I1;               //vertical component of I0
I1_res=sqrt((I1_x^2)+(I1_y^2));   //primary current
pf_p=I1_y/I1_res;                 //primary power factor
disp(sprintf("(b) The primary current is %.3f A",I1_res));
disp(sprintf("And the power factor is %.3f A",pf_p));

//END
```

Scilab code Exa 7.8 `Efficiency of transformer`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 8

```

```
clc;
disp("CHAPTER 7");
disp("EXAMPLE 8");

//23 kVA 2300/230 V 60 Hz step down transformer

//VARIABLE INITIALIZATION
va=23000;                          //apparent power
v1=2300;                           //primary voltage in Volts
v2=230;                            //secondary voltage in Volts
r1=4;                              //primary resistance in Ohms
r2=0.04;                           //secondary resistance in Ohms
X1=12;                             //leakage reactance primary in Ohms
X2=0.12;                           //leake reactance in secondary in Ohms
pf=0.866;                          //power factor(leading)

//SOLUTION
//assume voltage across load be 230 V
//V'1=I2.(Re2+jXe2)+V2
//Re2=R'1+R2
//R'1=R1.(N2/N1)^2
//Xe2=X'1+X2
//X'1=X1.(N2/N1)^2
//Ze2=Re2+j.Xe2
r1_dash=r1*((v2/v1)^2);
r_e2=r1_dash+r2;
X1_dash=X1*((v2/v1)^2);
X_e2=X1_dash+X2;
//
//disp(sprintf("The value of Re2 %f and Xe2 %f",r_e2,X_e2));
```

```
I2=0.75*(va/v2);                    //since transformer
   operates at 75% of its rated load
//
function [x,y]=pol2rect(mag,angle);
x=mag*cos(angle*(%pi/180));         //to convert the
    angle from degrees to radians
y=mag*sin(angle*(%pi/180));
endfunction;
[x,y]=pol2rect(I2,-30);
I_dash_2=x+y*%i;
//disp(sprintf("The value %f %f",real(I_dash_2),imag
   (I_dash_2)));
//
Z_e2=r_e2+X_e2*%i;                  //in rect
   coordinates
//disp(sprintf("The value %f %f",real(Z_e2),imag(
   Z_e2)));
//
V_dash_1=v2+I_dash_2*Z_e2;
//disp(sprintf("The value %f %f",real(V_dash_1),imag
   (V_dash_1)));
//
function [mag,angle]=rect2pol(x,y);
mag=sqrt((x^2)+(y^2));              //z is impedance &
    the resultant of x and y
angle=atan(y/x)*(180/%pi);          //to convert the
   angle from radians to degrees
endfunction;
//
[magV1,angleV1]=rect2pol(real(V_dash_1),imag(
   V_dash_1));
//disp(sprintf("The value %f <%f",magV1,angleV1));
//
//Pin=V'1.I2.cos theta1
//Pout=V2.I2.cos theta2
Pin=magV1*I2*cos((30+angleV1)*%pi/180);
Pout=v2*I2*cos(30*%pi/180);
eff=Pout*100/Pin;
```

```
//
disp(sprintf("The efficiency of the transformer is %
   .2f",eff));
disp(" ");
//
//END
```

Scilab code Exa 7.9 `Core loss current of distribution transformer`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 9

clc;
disp("CHAPTER 7");
disp("EXAMPLE 9");

//11000/400 V distribution transformer
//VARIABLE INITIALIZATION
v1=11000;                          //primary voltage in
    Volts
v2=400;                            //secondary voltage
   in Volts
Io=1;                              //primary current in
    Amp
pf=0.24                            //power factor
   lagging

//SOLUTION
//core loss current
//Ic=Io.cos phi
//Ic=Io.pf
Ic=Io*pf;
disp("SOLUTION (a)");
disp(sprintf("The value of core loss current is %.2f
    Amp",Ic));
```

```
//
//magnetizing current
//Iphi=sqrt(Io^2-Ic^2)
Iphi=sqrt(Io^2-Ic^2);
disp("SOLUTION (b)");
disp(sprintf("The value ofmagnetizing current is %.3
   f Amp",Iphi));
//
//Iron Loss
//Iron loss=primary voltage X core loss current
IronLoss=v1*Ic;
disp("SOLUTION (c)");
disp(sprintf("The iron loss  is %.0f W",IronLoss));
disp(" ");
//
//END
```

Scilab code Exa 7.10 `Number of turns on HT and LT sides`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 10

clc;
disp("CHAPTER 7");
disp("EXAMPLE 10");

//6600/220 V single phase transformer
//VARIABLE INITIALIZATION
v1=6600;                          //primary voltage in
    Volts
v2=220;                           //secondary voltage
   in Volts
coreA=0.05;                       //core section m^2
fluxD=1.2;                        //flux density in wm
   /m^2
```

```
f=50;                              //Hz

//SOLUTION
//E1=sqrt(2).pi.f.N1. m
//flux density = Phimax/core area
phiM=coreA*fluxD;
N1=v1/(4.44*f*phiM);      //4.44=sqrt(2).pi
N1=round(N1);
//
//N2=N1.E2/E1
N2=N1*(v2/v1);
N2=round(N2);
disp(sprintf("The no. of turns on HT side is %d",N1)
   );
disp(sprintf("The no. of turns on LT side is %d",N2)
   );
disp(" ");
//
//END
```

Scilab code Exa 7.11 To calculate primary and full load currents

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 11

clc;
disp("CHAPTER 7");
disp("EXAMPLE 11");

//2200/220 V 44 kVA transformer with 50 turns in the
    secondary
//VARIABLE INITIALIZATION
va=44000;                          //
v1=2200;                           //primary voltage in
    Volts
```

```
v2=220;                          //secondary voltage
   in Volts
N2=50;                           //turns in secondary
    coil

//SOLUTION
// N1/N2=V1/V2
N1=N2*(v1/v2);
disp("SOLUTION (a)");
disp(sprintf("The no. of turns on HT side is %f",N1)
   );
//
//since losses are negligible, input=output, V1.I1=
   V2.I2
I1=va/v1;
I2=va/v2;
disp("SOLUTION (b)");
disp(sprintf("The primary full load current is %.0f
   Amp",I1));
disp(sprintf("The secondary full load current is %.0
   f Amp",I2));
disp(" ");
//
//END
```

Scilab code Exa 7.12 Magnetising component of no load current

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 12

clc;
disp("CHAPTER 7");
disp("EXAMPLE 12");

//no load cuurent of transformer ia 10A at pf of
```

```
   0.25 lagging when connected to 400V, 50 Hz supply
//VARIABLE INITIALIZATION
v1=400;                        //primary voltage in
    Volts
f=50;                          //Hz
Io=10;                         //in Amp no load
   current
pf =0.25;                      //lagging
N1=500;                        //given

//SOLUTION
//magnetizing component of no load current
// N1/N2=V1/V2
//Iphi=Io.sin phi0
//pf=cos phi0
phi0=acos(pf);
Iphi=Io*sin(phi0);
disp("SOLUTION (a)");
disp(sprintf("The magnetic component of no load
   current is %f Amp",Iphi));
//
//iron loss
//Pi=ironloss=power input on no load
//Pi=Wo=V1.Io.cos phi0
ironLoss=v1*Io*pf;
disp("SOLUTION (b)");
disp(sprintf("The iron loss on no load is %.0f W",
   ironLoss));
//
//maximum flux in the core
//E1=sqrt(2).pi.f.N1. m
//E1=V1
phiM=v1/(4.44*f*N1);
disp("SOLUTION (c)");
disp(sprintf("The value of flux in the core is %5.4f
    mWb",phiM*1000));
disp(" ");
//
```

```
//END
```

Scilab code Exa 7.13 Current taken by primary

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 13

clc;
disp("CHAPTER 7");
disp("EXAMPLE 13");
//230/115 V single phase transformer
//VARIABLE INITIALIZATION
v1=230;                                //primary voltage
   in Volts
v2=115;
f=50;                                  //Hz
Io=2;                                 //in Amp no load
   current
pf0 =0.28;                            //lagging
I2=20;                                //
pf2=0.8;                              //lagging

//SOLUTION
//
//given power factors in primary and secondary
// I1.N1=I2.N2
phi0=acos(pf0);
phi2=acos(pf2);
//let Ix and Iy be the components of I0 and I'1
   along X and Y axes
//then
//Ix=Io.sin phi0 + I'2.sin phi2
//
//Ix=Io.cos phi0 + I'2.cos phi2
I_dash_2=I2*v2/v1;
```

```
Ix=Io*sin(phi0)+I_dash_2*sin(phi2);
Iy=Io*cos(phi0)+I_dash_2*cos(phi2);
I1=sqrt(Ix^2+Iy^2);
disp(sprintf("The current taken by primary is %.1f Amp",I1));
disp(" ");
//
//END
```

Scilab code Exa 7.14 To calculate total resistance and reactance referred to prima

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 14

clc;
disp("CHAPTER 7");
disp("EXAMPLE 14");

//1100/110 V 22 kVA single phase transformer
//VARIABLE INITIALIZATION
va=22000;                          //apparent power
v1=1100;                           //primary voltage in Volts
v2=110;                            //secondary voltage in Volts
R1=2;                              //in Ohms
R2=0.02;                           //in Ohms
X1=5;                              //in Ohms
X2=0.045;                          //in Ohms

//SOLUTION
//N1/N2=v1/v2;

R_dash_2=R2*((v1/v2)^2);
X_dash_2=X2*((v1/v2)^2);
```

```
disp("SOLUTION (a)");
disp(sprintf("The equivalent resistance of secondary referred to primary is %.1f  ",R_dash_2));
disp(sprintf("The equivalent reactance of secondary referred to primary is %.1f   ",X_dash_2));
//
R_e1=R_dash_2+R1;
X_e1=X_dash_2+X1;
disp("SOLUTION (b)");
disp(sprintf("The total resistance referred to primary is %.1f   ",R_e1));
disp(sprintf("The total reactance referred to primary is %.1f   ",X_e1));
//
R_dash_1=R1*((v2/v1)^2);
X_dash_1=X1*((v2/v1)^2);
disp("SOLUTION (c)");
disp(sprintf("The equivalent resistance of secondary referred to secondary is %.2f   ",R_dash_1));
disp(sprintf("The equivalent reactance of secondary referred to secondary is %.2f   ",X_dash_1));
//
R_e2=R_dash_1+R2;
X_e2=X_dash_1+X2;
disp("SOLUTION (d)");
disp(sprintf("The total resistance referred to secondary is %.3f   ",R_e2));
disp(sprintf("The total reactance referred to secondary is %.3f   ",X_e2));
//
I1=va/v1;
I2=va/v2;
copperLoss=R1*I1^2+R2*I2^2;
disp("SOLUTION (e)");
disp(sprintf("The total copper loss is %4.0f W",copperLoss));
disp(" ");
//
```

```
//END
```

Scilab code Exa 7.15 To calculate percent regulation at full load

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 15

clc;
disp("CHAPTER 7");
disp("EXAMPLE 15");
//20kVA single phase transformer
//VARIABLE INITIALIZATION
va=20000;                              //apparent power
v1=2000;                               //primary voltage in Volts
v2=200;                                //secondary voltage in Volts
R1=2.5;                                //in Ohms
R2=0.04;                               //in Ohms
X1=8;                                  //in Ohms
X2=0.07;                               //in Ohms
pf2=0.8;

//SOLUTION
//N1b/N2=v1/v2;
I2=va/v2;
phi2=acos(pf2);
//
R_dash_1=R1*((v2/v1)^2);
X_dash_1=X1*((v2/v1)^2);
//
R_e2=R_dash_1+R2;
X_e2=X_dash_1+X2;
//disp(sprintf("The total resistance referred to secondary is %f   ",R_e2));
```

```
//disp(sprintf("The total reactance referred to
   secondary is %f   ",X_e2));
//
//R=ercosphi2+vx.sinphi2
//E2=V2+I2.R
V2=v2-(I2*R_e2*pf2+I2*X_e2*sin(phi2));
%reg=(v2-V2)*100/v2;
disp(sprintf("The secondary terminal voltage is %.2f
    V",V2));
disp(sprintf("The percent regulation at full load is
    %.2f",%reg));
disp(" ");
//
//END
```

Scilab code Exa 7.16 Maximum value of percent regulation

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 16

clc;
disp("CHAPTER 7");
disp("EXAMPLE 16");

//Values from the previous example.
//VARIABLE INITIALIZATION
va=20000;                          //apparent power
v1=2000;                           //primary voltage
   in Volts
v2=200;                            //secondary voltage
    in Volts
R1=2.5;                            //in Ohms
R2=0.04;                           //in Ohms
X1=8;                              //in Ohms
X2=0.07;                           //in Ohms
```

```
pf2=0.8;

//SOLUTION
//N1/N2=v1/v2;
I2=va/v2;
phi2=acos(pf2);

//
R_dash_1=R1*((v2/v1)^2);
X_dash_1=X1*((v2/v1)^2);
//
R_e2=R_dash_1+R2;
X_e2=X_dash_1+X2;
//disp(sprintf("The total resistance referred to
    secondary is %f   ",R_e2));
//disp(sprintf("The total reactance referred to
    secondary is %f   ",X_e2));
//
//power factor angle at which regulation is zero is
    given by tan.phi2=-Re2/Xe2
phi2=atan(-R_e2/X_e2);
disp(sprintf("The PF at which the regulation is zero
     is %.3f",cos(phi2)));
//
//power factor angle at which regulation is maximum
    is given by tan.phi2=Xe2/Re2
phi2=atan(X_e2/R_e2);
disp(sprintf("The PF at which the regulation is
    maximum is %.3f",cos(phi2)));
//R=ercosphi2+vx.sinphi2
//E2=V2+I2.R

V2=v2-(I2*R_e2*cos(phi2)+I2*X_e2*sin(phi2));
%reg=(v2-V2)*100/v2;
disp(sprintf("The maximum value of percent
    regulation is %.2f ",%reg));
disp(" ");
//
```

```
//END
```

Scilab code Exa 7.17 `200 kVA transformer with 1000 W iron loss and 2000 W copper l`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 17

clc;
disp("CHAPTER 7");
disp("EXAMPLE 17");

//200kVA single phase transformer
//VARIABLE INITIALIZATION
va=200000;                          //
ironLoss=1000;                      // Watts
cuLoss=2000;                        //Watts
pf=0.8;
//
//SOLUTION
//
Pout=va*pf;                         //Full load output
loss=ironLoss+cuLoss;
Pin=Pout+loss;                      //INPUT=OUTPUT+LOSS
eff=Pout*100/Pin;
disp("SOLUTION (a)");
disp(sprintf("The percent efficiency at full load is %.2f",eff));
//
//at half load
Pout=va*pf/2;
loss=ironLoss+cuLoss*(1/2)^2;          // ironloss is independent of output
Pin=Pout+loss;
eff=Pout*100/Pin;
disp("SOLUTION (b)");
```

```
disp(sprintf("The percent efficiency at full load is %.2f",eff));
//
//fraction x of copperloss=ironloss for maximum efficiency
//x^2.cuLoss=ironLoss
x=sqrt(ironLoss/cuLoss);
Pout=x*va*pf;
loss=ironLoss+cuLoss*x^2;
Pin=Pout+loss;
eff=Pout*100/Pin;
disp("SOLUTION (c)");
disp(sprintf("The percent efficiency at %f load is %.2f ",x,eff));

disp(" ");
//
//END
```

Scilab code Exa 7.18 To calculate all day efficiency

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 18

clc;
disp("CHAPTER 7");
disp("EXAMPLE 18");

//400kVA distribution transformer variously loaded during day
//VARIABLE INITIALIZATION
va=400000;                    //
ironLoss=1500;                // Watts
cuLoss=4000;                  //Watts
//during the day frommidnight to midnight is as
```

```
below:
h1=6;                              //first 6 hours from midnight to 6 hrs
load1=0;
pf1=0;
h2=6;                              //next 6 hours from 6 am to noon
load2=100000;                      //kVA converted to VA
pf2=0.8;
h3=5;                              //next from noon to 5 pm
load3=400000;
pf3=0.8;
h4=3;                              //next from  5 pm to 8 pm
load4=300000;
pf4=0.7;
h5=4;                              //next from  8 pm to midnight
load5=200000;
pf5=0.85;
//
//SOLUTION
//
//energy loss at any load=(VA output/VA rated)^2 . Full load cuLoss
loss1=h1*load1;
loss2=h2*(load2/va)^2*cuLoss;
loss3=h3*(load3/va)^2*cuLoss;
loss4=h4*(load4/va)^2*cuLoss;
loss5=h5*(load5/va)^2*cuLoss;
//loss in 24 hours
loss24=loss1+loss2+loss3+loss4+loss5;
//disp(sprintf("The all day loss is %f ",loss24));
Pout=h1*load1*pf1+h2*load2*pf2+h3*load3*pf3+h4*load4*pf4+h5*load5*pf5;
//disp(sprintf("The all day energy output is %f ",
```

```
    Pout));
Pin=Pout+ironLoss*24+loss24;
eff=Pout*100/Pin;
disp(sprintf("The all day percent efficiency is %.2f
    ",eff));
disp(" ");
//
//END
```

Scilab code Exa 7.19 `Open circuit and short circuit test`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 19

clc;
disp("CHAPTER 7");
disp("EXAMPLE 19");

//Open circuit and short circuit test on 10 kVA
    transformer 500/250 V 50 Hz single phase
    transformer
//VARIABLE INITIALIZATION
va=10000;                          //apparent power
v1=500;                            //primary
    voltage in Volts
v2=250;                            //secondary
    voltage in Volts
f=50;
//open circuit parameters
Voc=500;
Io=2;
Wi=100;                           // watts HT side
Woc=Wi;                            //just another
    nomenclature
//short circuit test
```

```
Vsc=25;
Isc=20;
Wc=90;                                  // watts HT side
//
pf=0.8;
//SOLUTION
//open circuit
phi0=acos(Woc/(v1*Io));
Ic=Io*cos(phi0);
Iphi=Io*sin(phi0);
Rc=v1/Ic;
X=v1/Iphi;
disp("SOLUTION (a)");
disp(sprintf("The value of Ic is %.2f Amp",Ic));
disp(sprintf("The value of I   is %.2f Amp",Iphi));
disp(sprintf("The value of Rc is %.0f Ohm",Rc));
disp(sprintf("The value of X is %.0f  ",X));
//
//short circuit
phisc=acos(Wc/(Vsc*Isc));
pf1=cos(phisc);
R_e1=Vsc*pf1/Isc;
Z_e1=Vsc/Isc;
X_e1=sqrt(Z_e1^2-R_e1^2);
disp(sprintf("The value of Power factor is %.3f",pf1
    ));
disp(sprintf("The value of Re1 is %.3f Ohm",R_e1));
disp(sprintf("The value of Ze1 is %.3f Ohm",Z_e1));
disp(sprintf("The value of Xe1 is %.3f  ",X_e1));
//
//Regulation and efficiency
//% Regulation
I1=va/v1;
phi=acos(pf);
//R=ercosphi2+vx.sinphi2
//E2=V2+I2.R
%reg=(Isc*R_e1*pf+Isc*X_e1*sin(phi))*100/v1;
disp("SOLUTION (c(i))");
```

```
disp(sprintf("The percent regulation at full load is
    %.2f",%reg));
//
//Efficiency
//full load output at pf=0.8
Pout=va*pf;
ironLoss=Wi;
cuLoss=Wc;
loss=ironLoss+cuLoss;
Pin=Pout+loss;
eff=Pout*100/Pin;
disp("SOLUTION (c(ii))");
disp(sprintf("The percent efficiency at full load is
    %.2f",eff));
disp(" ");
//
//END
```

Scilab code Exa 7.20 4kVA 200 400 V transformer

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 20

clc;
disp("CHAPTER 7");
disp("EXAMPLE 20");

//4 kVA 200/400 V 50 hz single phase transformer
//VARIABLE INITIALIZATION
va=4000;                              //apparent power
v1=200;                               //primary
   voltage in Volts
v2=400;                               //secondary
   voltage in Volts
f=50;
```

```
R_e1=0.15;
Pi=60;                                    //core losses iron core
pf1=0.9;                                  //power factor of primary
pf2=0.8;                                  //power factor of secondary

//SOLUTION
//Copper loss on full load
R_e2=(v2/v1)^2*R_e1;
I1=va/v1;
I2=va/v2;
Pcu=I2^2*R_e2;                            //cu losses
disp("SOLUTION (i)");
disp(sprintf("The value of Copper Losses at full load is %.0f W",Pcu));
//
//efficiency
Pout=va*pf1;
Pin=Pout+Pi+Pcu;
eff=Pout*100/Pin;
disp("SOLUTION (ii)");
disp(sprintf("The percent efficiency at full load %f PF is %.2f",pf1,eff));
//
//
//efficiency at half load
Pout=va*pf2/2;
Pin=Pout+Pi+Pcu*(1/2)^2;
eff=Pout*100/Pin;
disp("SOLUTION (ii)");
disp(sprintf("The percent efficiency at half load %f PF is %.2f",pf2,eff));

disp(" ");
//
//END
```

Scilab code Exa 7.21 To determine the regulation while supplying full load

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 21

clc;
disp("CHAPTER 7");
disp("EXAMPLE 21");

//250/125 V 5kVA single phase transformer
//VARIABLE INITIALIZATION
va=5000;                    //apparent power
v1=250;                     //primary voltage in Volts
v2=125;                     //secondary voltage in Volts
R1=0.2;                     //resistance of primary
X1=0.75;                    //leakage reactance of primary
R2=0.05;                    //resistance of secondary
X2=0.2;                     //leakage reactance of secondary
pf=0.8;                     //power factor (leading)

//SOLUTION
R_e2=(v2/v1)^2*R1+R2;
X_e2=(v2/v1)^2*X1+X2;
I1=va/v1;
I2=va/v2;
//
//at full load leading
```

```
phi=acos(pf);
%reg=(I2*R_e2*pf-I2*X_e2*sin(phi))*100/v2;
disp("SOLUTION (i)");
disp(sprintf("The percent regulation at full load is %.2f",%reg));
//
//%R=(E2-V2).100/E2
V2=v2-%reg*v2/100;
disp("SOLUTION (ii)");
disp(sprintf("The secondary terminal voltage at full load is %.2f V",V2));
disp(" ");
//
//END
```

Scilab code Exa 7.22 `Total equivalent resistance referred to primary and secondary`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 22

clc;
disp("CHAPTER 7");
disp("EXAMPLE 22");

//6600/400 V single phase transformer
//VARIABLE INITIALIZATION
v1=6600;                                //primary voltage in Volts
v2=400;                                 //secondary voltage in Volts
R1=2.5;                                 //primary resistance
R2=0.01;                                //secondary resistance

```

```
//SOLUTION
//while finding equivalent resistance referrd to primary
//transfer R2 resistance to R'2
R_dash_2=R2*(v1/v2)^2;
R_e1=R1+R_dash_2;
//
//to find total equivalent resistance referred to secondary
//first calculate R'1
R_dash_1=R1*(v2/v1)^2;
R_e2=R2+R_dash_1;
//
disp(sprintf("The total equivalent resistance referred to primary is %.6f   ",R_e1));
disp(sprintf("The total equivalent resistance referred to secondary is %.6f   ",R_e2));
disp(" ");
//
//END
```

Scilab code Exa 7.23 33 kVA 2200 220 V 50 Hz transformer

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 23

clc;
disp("CHAPTER 7");
disp("EXAMPLE 23");

//33kVA 2200/220 V 50Hz single phase transformer
//VARIABLE INITIALIZATION
va=33000;
v1=2200;                              //primary voltage in Volts
```

```
v2=220;                                   //secondary voltage in Volts
f=50;                                     // frequency in Hz
R1=2.4;                                   //primary winding (High Voltage side) resistance
X1=6;                                     //primary winding (High Voltage side)leakage reactance
R2=0.03;                                  //secondary winding (Low Voltage side) resistance
X2=0.07;                                  //secondary winding (Low Voltage side)leakage reactance

//SOLUTION
//
//Primary resistance and leakage reactance referred to secondary
//R'1 & X'1
//Secondary resistance and leakage reactance referred to primary
//R'2 & X'2
//Equivalent resistance & leakage reactance referred to primary
//Re1 & Xe1
//Equivalent resistance & leakage reactance referred to secondary
//Re2 & Xe2
//
R_dash_2=R2*(v1/v2)^2;
R_e1=R1+R_dash_2;
X_dash_2=X2*(v1/v2)^2;
X_e1=X1+X_dash_2;
//
R_dash_1=R1*(v2/v1)^2;
R_e2=R2+R_dash_1;
X_dash_1=X1*(v2/v1)^2;
X_e2=X2+X_dash_1;

```

```
disp("SOLUTION (a)");
disp(sprintf("The primary resistance referred to secondary %.2f  ",R_dash_1));
disp(sprintf("The primary leakage reactance referred to secondary %.2f  ",X_dash_1));
//
disp("SOLUTION (b)");
disp(sprintf("The secondary resistance referred to secondary %.2f  ",R_dash_2));
disp(sprintf("The secondary leakage reactance referred to secondary %.2f  ",X_dash_2));
//
disp("SOLUTION (C(i))");
disp(sprintf("The equivalent resistance referred to primary %.2f  ",R_e1));
disp(sprintf("The equivalent leakage reactance referred to primary %.2f  ",X_e1));
//
disp("SOLUTION (C(ii))");
disp(sprintf("The equivalent resistance referred to secondaryy %.2f  ",R_e2));
disp(sprintf("The equivalent leakage reactance referred to secondary %.2f  ",X_e2));
//
//Ohmic load
I1=va/v1;                    // primary full load current
I2=va/v2;                    // secondary full load current
oLoss=I2^2*R_e2;             //ohmic loss
disp("SOLUTION (d)");
disp(sprintf("The ohmic loss at full load %.0f W",oLoss));
//
//Voltage to be applied on the HV side
//to obtain short circuit currnet of 160 A in L.V side winding
Z_e1=sqrt(R_e1^2+X_e1^2);                    //
```

```
    equivalent leakage impedance
//voltage to be applied on HV side is equivalent
    leakage reactance x primary current
//relationship between current and voltage in
    transformer
//I1/I2=V2/V1
//Given V2=220 V, V1=2200 V, I2=160 Amp
//Therefore, I1=I2.(V2/V1)
I1=160*(v2/v1);
V=I1*Z_e1;                          //160*(v2/v1)*Z_e1;
//Power Input
P=(I1)^2*R_e1                       //P=I^2.R
disp("SOLUTION (e)");
disp(sprintf("The voltage to be applied on HV side
    is %.2f V",V));
disp(sprintf("The power input is %.1f W",P));
disp(" ");
//
//END
```

Scilab code Exa 7.24 `To calculate secondary terminal voltage`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 24

clc;
disp("CHAPTER 7");
disp("EXAMPLE 24");

//10kVA 2500/250 V single phase transformer
//VARIABLE INITIALIZATION
va=10000;
v1=2500;                                //primary
    voltage in Volts
v2=250;                                 //secondary
```

```
voltage in Volts
R1=4.8;                                      //primary HV side winding resistance
X1=11.2;                                     //primary HV side winding leakage reactance
R2=0.048;                                    //secondary LV side winding resistance
X2=0.112;                                    //secondary LV side winding leakage reactaance

//SOLUTION
//
//Primary resistance and leakage reactance referred to secondary
//R'1 & X'1
//Secondary resistance and leakage reactance referred to primary
//R'2 & X'2
//Equivalent resistance & leakage reactance referred to primary
//Re1 & Xe1
//Equivalent resistance & leakage reactance referred to secondary
//Re2 & Xe2
//
R_dash_2=R2*(v1/v2)^2;
R_e1=R1+R_dash_2;
X_dash_2=X2*(v1/v2)^2;
X_e1=X1+X_dash_2;
//
R_dash_1=R1*(v2/v1)^2;
R_e2=R2+R_dash_1;
X_dash_1=X1*(v2/v1)^2;
X_e2=X2+X_dash_1;
//leakage impedence
//The transformer leakage impedance=z0=Re2+j.Xe2
//Therefore:
z0=R_e2+X_e2*%i;
```

```
//Further Given
//the LV winding side is connected to load impedance of 5+j.3.5 Ohm
//The power factor 0.8 lagging on LV side
//applied load is
Zl=5+3.5*%i;
//total impedence in series
//The leakage impedance and load impedance are in series, therefore, total impedance is sum of the two
//
Z=z0+Zl;
magZ=sqrt(real(Z)^2+imag(Z)^2);
magZl=sqrt(real(Zl)^2+imag(Zl)^2);
//V2=I2.Zl
I2=v2/magZ;
V2=I2*magZl
disp("SOLUTION (a)");
disp(sprintf("The secondary terminal voltage is %.0f V",V2));
//
//part (b) and (c) of the problem cannot be solved mathematically alone.
disp(" ");
//
//END
```

Scilab code Exa 7.25 `15 kVA 2200 110 V transformer`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 25

clc;
disp("CHAPTER 7");
disp("EXAMPLE 25");
```

```
//15kVA 2200/110 V transformer
//VARIABLE INITIALIZATION
va=25000;                                   //power rating
v1=2200;                                    //primary
   voltage in Volts
v2=110;                                     //secondary
   voltage in Volts
f=50;
R1=1.75;
X1=2.6;
R2=0.0045;
X2=0.0075;

//SOLUTION
//
//Primary resistance and leakage reactance referred
   to secondary
//R'1 & X'1
//Secondary resistance and leakage reactance
   referred to primary
//R'2 & X'2
//Equivalent resistance & leakage reactance referred
    to primary
//Re1 & Xe1
//Equivalent resistance & leakage reactance referred
    to secondary
//Re2 & Xe2
//
R_dash_2=R2*(v1/v2)^2;
R_e1=R1+R_dash_2;
X_dash_2=X2*(v1/v2)^2;
X_e1=X1+X_dash_2;
//
R_dash_1=R1*(v2/v1)^2;
R_e2=R2+R_dash_1;
X_dash_1=X1*(v2/v1)^2;
X_e2=X2+X_dash_1;
```

```
//
Z_e1=R_e1+X_e1*%i;
Z_e2=R_e2+X_e2*%i;
magZ_e1=sqrt(real(Z_e1)^2+imag(Z_e1)^2);
magZ_e2=sqrt(real(Z_e2)^2+imag(Z_e2)^2);
//
//
disp("SOLUTION (a)");
disp(sprintf("The equivalent resistance referred to primary %.2f  ",R_e1));
disp("SOLUTION (b)");
disp(sprintf("The equivalent resistance referred to secondaryy %.5f  ",R_e2));
disp("SOLUTION (c)");
disp(sprintf("The equivalent leakage reactance referred to primary %.1f  ",X_e1));
disp("SOLUTION (d)");
disp(sprintf("The equivalent leakage reactance referred to secondary %.3f  ",X_e2));
disp("SOLUTION (e)");
disp(sprintf("The equivalent impedance referred to primary %.5f  ",magZ_e1));
disp("SOLUTION (f)");
disp(sprintf("The equivalent impedance referred to secondary %.5f  ",magZ_e2));
//
//primary and secondary full load current and voltage relationship with power rating
I1=va/v1;           //primary current
I2=va/v2;           //secondary current
cuLoss=I2^2*R_e2;   //copper loss    or also as I1^2.R1 + I2^2.R2
disp("SOLUTION (d)");
disp(sprintf("The copper loss at full load %f W",cuLoss));
disp(" ");
//
//END
```

Scilab code Exa 7.26 `Open circuit and short circuit test`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 26

clc;
disp("CHAPTER 7");
disp("EXAMPLE 26");

//open circuit & short circuit test
//10 kVA 500/250 V 50 Hz single phase
//VARIABLE INITIALIZATION
va=10000;                           //apparent power
v1=500;                             //primary voltage in Volts
v2=250;                             //secondary voltage in Volts
f=50;                               // frequency
//open circuit parameters
Voc=500;
Io=2;
Wi=100;                            // watts HT side
Woc=Wi;                             //just to keep symbology
//short circuit test
Vsc=25;
Isc=20;
Wc=90;                             // watts HT side
//
pf=0.8;
//SOLUTION
//open circuit
phi0=acos(Woc/(v1*Io));
Ic=Io*cos(phi0);
```

```
Iphi=Io*sin(phi0);
Rc=v1/Ic;
X=v1/Iphi;
disp("SOLUTION (a)");
disp(sprintf("The value of Ic is %.2f Amp",Ic));
disp(sprintf("The value of I  is %.2f Amp",Iphi));
disp(sprintf("The value of Rc is %.2f Ohm",Rc));
disp(sprintf("The value of X is %.2f  ",X));
//
//short circuit
phisc=acos(Wc/(Vsc*Isc));
pf1=cos(phisc);
R_e1=Vsc*pf1/Isc;
Z_e1=Vsc/Isc;
X_e1=sqrt(Z_e1^2-R_e1^2);
disp(sprintf("The value of Power factor is %f",pf1));
disp(sprintf("The value of Re1 is %f Ohm",R_e1));
disp(sprintf("The value of Ze1 is %f Ohm",Z_e1));
disp(sprintf("The value of Xe1 is %f ",X_e1));
//
I1=va/v1;
phi=acos(pf);
//R=er.cos phi2+vx.sin phi2
//E2=V2+I2.R
%reg=(Isc*R_e1*pf+Isc*X_e1*sin(phi))*100/v1;
disp("SOLUTION (c(i))");
disp(sprintf("The percent regulation at full load is %.2f",%reg));
//
//full load output at pf=0.8
Pout=va*pf;                    // Output Power
ironLoss=Wi;
cuLoss=Wc;
loss=ironLoss+cuLoss;
Pin=Pout+loss;                 //Input Power
eff=Pout*100/Pin;              //efficiency
disp("SOLUTION (c(ii))");
```

```
disp(sprintf("The percent efficiency at full load is
    %.2f",eff));
disp(" ");
//
//END
```

Scilab code Exa 7.27 Open and short circuit test

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 27

clc;
disp("CHAPTER 7");
disp("EXAMPLE 27");

//200kVA 1100/400 V delta star distribution
    transformer
//three phase
//VARIABLE INITIALIZATION
va=200000;                                  //apparent
    power
v1=11000;                                    //primary
    voltage in Volts
v2=400;                                    //secondary
    voltage in Volts
f=50;                                      // frequency
//open circuit test parameters
V3=400;
I3=9;
W3=1500;                                   //load in watts
   HT side
//short circuit test parameters
Vsc=350;
Isc=20;
Wc=2100;                                    //load in watts
```

```
    HT side
//
pf=0.8;
//SOLUTION
Voc=V3/sqrt(3);                    //per phase applied voltage in open circiut
Io=9;                              //per phase exciting current.= I3
Wi=W3/3;                           // per phase core loss in watts HT side
Pc=Wi;                             //core losses
//power factor Pc=V1.Io.cos phi0  //v1=Voc
//open circuit test performed on LV side
phi0=acos(Wi/(Voc*Io));
Ic=Io*cos(phi0);                   //core loss current
Iphi=Io*sin(phi0);                 //magnetising current
Rc=Voc/Ic;                         //Core loss resistance
X=Voc/Iphi;                        //
disp("SOLUTION (a)");
disp(sprintf("The value of Ic is %.0f Amp",Ic));
disp(sprintf("The value of I  is %.2f Amp",Iphi));
disp(sprintf("The value of Rc is %.2f Ohm",Rc));
disp(sprintf("The value of X is %.2f  ",X));
//
//core loss resistance referred to hv side
Rch=Rc*(v1/Voc)^2;
XphiH=X*(v1/Voc)^2;
disp(sprintf("The value of Rch is %.2f k  ",Rch/1000));
disp(sprintf("The value of X h is %.2f K  ",XphiH/1000));
//short circuit
//This test performed on HV side
//first find rated current
Isc=va/(3*v1);
```

```
Psc=Wc/3;                              //ohmic loss per
    phase
phisc=acos(Wc/(Vsc*Isc));
pf1=cos(phisc);
R_e1=Psc/Isc^2;
Z_e1=Vsc/Isc;
X_e1=sqrt(Z_e1^2-R_e1^2);
disp(sprintf("The value of ohmic loss per phase is %
   .0f W",Psc));
disp(sprintf("The value of Re1 is %.2f Ohm",R_e1));
disp(sprintf("The value of Ze1 is %.2f Ohm",Z_e1));
disp(sprintf("The value of Xe1 is %.2f  ",X_e1));
//
//efficiency at half load
pf=1;                                      //unity
   power factor
Pout=(va/3)*(1/2)*pf;
//core losses=Pc
//cuLosses ohmic loss =Psc
Pin=Pout+Pc+(1/2)^2*Psc;
eff=Pout*100/Pin;
disp(sprintf("The efficiency at half load is %.2f",
   eff));

disp(" ");
//
//END
```

Scilab code Exa 7.28 Open and short circuit test

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 28

clc;
disp("CHAPTER 7");
```

```
disp("EXAMPLE 28");

//10 kVA 2500/250 V single phase transformer
//open circuit and short circuit tests
//VARIABLE INITIALIZATION
va=10000;                                   //apparent power
v1=2500;                                    //primary voltage in Volts
v2=250;                                     //secondary voltage in Volts
f=50;
//open circuit parameters
Voc=250;
Io=0.8;
Wi=50;                                      // watts HT side
//short circuit test
Vsc=60;
Isc=3;
Wc=45;                                      // watts HT side
//
//loads
pf=0.8;
//SOLUTION
//Open circuit test conducted on lv because 250 V during this test  is equal to rated voltage on lv side.
I1=va/v1;                                   //full rated current on hv side
Psc0=Wc*(I1/Isc)^2;                         //ohmic loss/cu loss at full load rated current
Pc=Wi;                                      // core losses
// 1/4 load
Psc=(1/4)^2*Psc0;
Pout=va*pf*(1/4);
Pin=Pout+Pc+Psc;
eff=Pout*100/Pin;
```

```
disp("SOLUTION (a)");
disp(sprintf("The efficiency at 1/4 load is %.2f",eff));
//
// 1/2 load
Psc=(1/2)^2*Psc0;
Pout=va*pf*(1/2);
Pin=Pout+Pc+Psc;
eff=Pout*100/Pin;
disp(sprintf("The efficiency at 1/2 load is %.2f",eff));
//
// full load
Psc=(1/1)^2*Psc0;
Pout=va*pf*(1/1);
Pin=Pout+Pc+Psc;
eff=Pout*100/Pin;
disp(sprintf("The efficiency at full load is %.2f",eff));
//
// 1 1/4 = 5/4 load
Psc=(5/4)^2*Psc0;
Pout=va*pf*(5/4);
Pin=Pout+Pc+Psc;
eff=Pout*100/Pin;
disp(sprintf("The efficiency at 1 1/4 or 5/4 load is %.2f",eff));
//
//maximum efficiency at x, but then ohmic loss=core loss
x=sqrt(Pc/Psc0);
Pout=va*x*pf;
Pin=Pout+Pc+Pc;                                   //Ohmic losses = core losses at max efficiency
eff=Pout*100/Pin;
disp("SOLUTION (b)");
disp(sprintf("The maximum efficiency  is %.2f",eff));
```

```
//
//short circuit test performed on lv side
phisc=acos(Wc/(Vsc*Isc));
pf1=cos(phisc);
R_e1=Vsc*pf1/Isc;
Z_e1=Vsc/Isc;
X_e1=sqrt(Z_e1^2-R_e1^2);
disp("SOLUTION (c)");
disp(sprintf("The value of Re1 is %.2f Ohm",R_e1));
disp(sprintf("The value of Ze1 is %.2f Ohm",Z_e1));
disp(sprintf("The value of Xe1 is %.2f ",X_e1));
//
//ee, ex;
er=I1*R_e1/v1;
ex=I1*X_e1/v1;
disp(sprintf("The value of Er is %.3f pu",er));
disp(sprintf("The value of Ex is %.3f",ex));
//
phi=acos(pf);
//R=ercosphi2+vx.sinphi2
//E2=V2+I2.R
%reg=(I1*R_e1*pf+I1*X_e1*sin(phi))*100/v1; //same as using er and ex
disp(sprintf("The percent regulation at full load lagging is %.2f",%reg));
%reg1=(I1*R_e1*pf-I1*X_e1*sin(phi))*100/v1; //same as using er and ex
disp(sprintf("The percent regulation at full load leading is %.2f",%reg1));
V21=(1-%reg/100)*v2;
V22=(1-%reg1/100)*v2;
disp(sprintf("The secondary terminal voltage at full load lagging is %.2f",V21));
disp(sprintf("The secondary terminal voltage at full load leading is %.2f",V22));
disp(" ");
//
//END
```

Scilab code Exa 7.29 `200 kVA 4000 1000 V transformer`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 29

clc;
disp("CHAPTER 7");
disp("EXAMPLE 29");

//20kVA 4000/1000 V single phase transformer
//VARIABLE INITIALIZATION
va=200000;                                  //apparent power
v1=4000;                                   //primary voltage in Volts
v2=1000;                                    //secondary voltage in Volts
f=50;                                        // frequency in Hz
//loads
pf=1;                                        //power factor is unity
eff=0.97;                                    // at full load and at 60% of full load
nlpf=0.5;                                    //no load pf
lpf=0.8                                      //lagging pf
reg=0.05;                                    //%regulation at 0.8 pf
//
//SOLUTION
loss=(1-eff)*va/eff;                         //=Pc+Pcu losses
//simultaneous equation to be solved
//eq 1: Pc+Pcu=loss;
```

```
//fractipon of copper/ ohmic losses
f=(0.6)^2;                                    // 60% of
    full load
//the 2nd equation is Pc+f*Pcu=loss
//now the matrix
M=[1,1;1,f];
A=[loss,loss*0.6];
Mi=inv(M);
Ans=A*inv(M);
Pc=Ans(1,1);
Pcu=Ans(1,2);
//disp(sprintf("The Pc is %f",Pc));
//disp(sprintf("The Pcu is %f",Pcu));
//LV side
R_e2=Pcu/va;
//from %reg find X_e2
phi=acos(lpf);
X_e2=(reg-R_e2*cos(phi))/sin(phi);
//in oms units
R_e2=R_e2*v2^2/va;                              // in ohms
X_e2=X_e2*v2^2/va;                              // in ohms
disp(sprintf("The Re2 is %.3f   ",R_e2));
disp(sprintf("The Xe2 is %.3f   ",X_e2));
//
Rc=v2^2/Pc;
Ie2=Pc/(v2*0.25);
Ic=Pc/v2;
Iphi=sqrt(Ie2^2-Ic^2);
Xphi=v2/Iphi;
disp(sprintf("The Rc is %.2f   ",Rc));
disp(sprintf("The Ie2 is %.3f A",Ie2));
disp(sprintf("The Ic is %.3f A",Ic));
disp(sprintf("The Iphi is %.4f A",Iphi));
disp(sprintf("The Xphi is %.2f   ",Xphi));
disp(" ");
//
//END
```

Scilab code Exa 7.30 Secondary terminal voltage at full load

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 30

clc;
disp("CHAPTER 7");
disp("EXAMPLE 30");

//6600/440 V single phase transformer
//VARIABLE INITIALIZATION
v1=6600;                                     //primary
   voltage in Volts
v2=440;                                      //secondary
   voltage in Volts
e_r=0.02;                                    //equivalent
    resistance
e_x=0.05;                                    //equivalent
    reactance
pf=0.8;                                      //power
   factor
//
//SOLUTION
//worked out differently a bit from the text book in
    terms of the steps
phi=acos(pf);                                //phase
   angle
reg=e_r*cos(phi)+e_x*sin(phi);               //voltage
   regulation
V2=v2*(1-reg);                               //secondary
   terminal voltage
disp(sprintf("The secondary terminal voltage is %.2f
    V",V2));
disp(" ");
```

```
//
//END
```

Scilab code Exa 7.31 `To calculate the value of maximum flux density in the core an`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 31

clc;
disp("CHAPTER 7");
disp("EXAMPLE 31");

//single phase transformer having 400 primary and
   1000 secondary turns
//VARIABLE INITIALIZATION
N1=400;
N2=1000;
coreA=60;                                   //net core
   area in cm^2
v1=500;                                     //primary
   voltage in Volts
f=50;                                       //frequency

//
//SOLUTION
//v1=E1=4.44. m .N1.f Volts
phiM=v1/(4.44*N1*f);
//flux density Bm= m /area
Bm=phiM/coreA;                              //lines per
   cm
//voltage per turn
vpt=v1/N1;
v2=N2*vpt;
//
disp(sprintf("The maximum flux density is %.3fx10^-5
```

```
Wb per cm^2",Bm*10^5));//text book anser is 9383 lines per cm^2
disp(sprintf("The secondary voltage is %.0f V",v2));
disp(" ");
//
//END
```

Scilab code Exa 7.32 To calculate total copper loss

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 32

clc;
disp("CHAPTER 7");
disp("EXAMPLE 32");

//50 kVA 4400/220 V single phase transformer
//VARIABLE INITIALIZATION
va=50000;
v1=4400;                                   //primary voltage in Volts
v2=220;                                    //secondary voltage in Volts
f=50;
R1=3.45;
X1=5.2;
R2=0.0009;
X2=0.015;

//SOLUTION
//
//Primary resistance and leakage reactance referred to secondary
//R'1 & X'1
//Secondary resistance and leakage reactance
```

```
referred to primary
//R'2 & X'2
//Equivalent resistance & leakage reactance referred to primary
//Re1 & Xe1
//Equivalent resistance & leakage reactance referred to secondary
//Re2 & Xe2
//
R_dash_2=R2*(v1/v2)^2;
R_e1=R1+R_dash_2;
X_dash_2=X2*(v1/v2)^2;
X_e1=X1+X_dash_2;
//
R_dash_1=R1*(v2/v1)^2;
R_e2=R2+R_dash_1;
X_dash_1=X1*(v2/v1)^2;
X_e2=X2+X_dash_1;
//
Z_e1=R_e1+X_e1*%i;
Z_e2=R_e2+X_e2*%i;
magZ_e1=sqrt(real(Z_e1)^2+imag(Z_e1)^2);
magZ_e2=sqrt(real(Z_e2)^2+imag(Z_e2)^2);
//
disp("SOLUTION (i)");
disp(sprintf("The equivalent resistance referred to primary %.4f   ",R_e1));//text book answer is 7.05 ohm
disp("SOLUTION (ii)");
disp(sprintf("The equivalent resistance referred to secondaryy %.4f   ",R_e2));
disp("SOLUTION (iii)");
disp(sprintf("The equivalent leakage reactance referred to primary %.4f   ",X_e1));
disp(sprintf("The equivalent leakage reactance referred to secondary %.4f   ",X_e2));
disp("SOLUTION (iv)");
disp(sprintf("The equivalent impedance referred to
```

```
    primary %.4f    ",magZ_e1)); // text book answer
    is 13.23 ohm
disp(sprintf("The equivalent impedance referred to
    secondary %.4f    ",magZ_e2));//text book answer
    is 0.0331 ohm
//
I1=va/v1;
I2=va/v2;
Pcu=I2^2*R_e2;
disp("SOLUTION (d)");
disp(sprintf("The copper loss at full load %.0f W",
    Pcu));
disp(" ");
//The answers in the book on page 7.77 are wrong for
     all but Xe1 and Xe2 values.
//END
```

Scilab code Exa 7.33 No load and short circuit results of transformer

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 33

clc;
disp("CHAPTER 7");
disp("EXAMPLE 33");

// 5kVA 400/200 V 50 Hz single phase transformer
//open ciruit and short circuit tests
//VARIABLE INITIALIZATION
va=5000;                                //apparent
    power
v1=400;                                //primary
    voltage in Volts
v2=200;                                //secondary
    voltage in Volts
```

```
f=50;
//no load parameters
Voc=400;
Io=1;
Woc=50;                                    // watts HT side
//short circuit test
Vsc=12;
Isc=10;
Wc=40;                                     // watts HT side
//
pf=0.8;
//SOLUTION
//no load condition
phi0=acos(Woc/(v1*Io));
Ic=Io*cos(phi0);
Iphi=Io*sin(phi0);
Rc=v1/Ic;
X=v1/Iphi;
disp("SOLUTION (i)");
disp(sprintf("The value of Ic is %f Amp",Ic));
disp(sprintf("The value of I   is %f Amp",Iphi));
//disp(sprintf("The value of Rc is %f Ohm",Rc));
//disp(sprintf("The value of X is %f ",X));
//
//short circuit
phisc=acos(Wc/(Vsc*Isc));
pf1=cos(phisc);
R_e1=Vsc*pf1/Isc;
Z_e1=Vsc/Isc;
X_e1=sqrt(Z_e1^2-R_e1^2);
disp(sprintf("The value of Re1 is %.2f Ohm",R_e1));
disp(sprintf("The value of Ze1 is %.2f Ohm",Z_e1));
disp(sprintf("The value of Xe1 is %.2f ",X_e1));
//
I1=va/v1;
phi=acos(pf);
//R=ercosphi2+vx.sinphi2
//E2=V2+I2.R
```

```
%reg=(I1*R_e1*pf+I1*X_e1*sin(phi))*100/v1;
disp("SOLUTION (c(i))");
disp(sprintf("The percent regulation at full load is
    %.3f",%reg));
//
//full load output at pf=0.8
Pout=va*pf;                    //output power
ironLoss=Woc;
cuLoss=Wc;
loss=ironLoss+cuLoss;
Pin=Pout+loss;                 // input power
eff=Pout*100/Pin;
disp("SOLUTION (c(ii))");
disp(sprintf("The percent efficiency at full load is
    %.2f",eff)); // not calculated in the text book
disp(" ");
//
//END
```

Scilab code Exa 7.34 50 kVA transformer of 5 is to 1 ratio of turns

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 35

clc;
disp("CHAPTER 7");
disp("EXAMPLE 35");

//single phase 50 hz, 200kVA, 11kVA/230 V
//open circuit and short circuit tests
//VARIABLE INITIALIZATION
va=200000;                                 //apparent
   power
v1=11000;                                  //primary
   voltage in Volts
```

```
v2=230;                                        //secondary
   voltage in Volts
Woc=1600;                                      //watts also
    equals core losses
Wc=2600;                                       //watts, also
    equals cu losses
f=50;
//no load parameters
//day cycle given
h1=8;                                          // hours
load1=160000;                                  //load in
   watts
pf1=0.8;                                       //power
   factor
h2=6;
load2=100000;
pf2=1;
h3=10;
load3=0;
pf3=0;
//SOLUTION
//24 hr energy output
Pout=load1*h1*pf1+load2*h2*pf2+load3*h3*pf3;
Pc24=Woc*24;                                   // 24 hours
   Pc loss
//cu loss= hours.(kva output/kva rated)^2.Full load
   Cu loss
Pcu24=h1*(load1/va)^2*Wc+h2*(load2/va)^2*Wc+h3*(
   load3/va)^2*Wc;
Pin=Pout+Pc24+Pcu24;
eff=Pout*100/Pin;
//disp(sprintf("The value Pout is %f",Pout));
//disp(sprintf("The value Pc is %f",Pc24));
//disp(sprintf("The value Pcu is %f",Pcu24));
disp(sprintf("The percent efficiency at full load is
    %.2f",eff));
disp(" ");
//
```

```
//END
```

Scilab code Exa 7.35 No load and short circuit results of transformer

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 36

clc;
disp("CHAPTER 7");
disp("EXAMPLE 36");

// 100kVA 50 Hz 440/11000 V single phase transformer
//VARIABLE INITIALIZATION
va=100000;                                 //apparent
    power
v1=440;                                    //primary
    voltage in Volts
v2=11000;                                  //secondary
     voltage in Volts
f=50;                                      //
    efficiency
//loads
pf=1;                                      //power
    factor at half load current
eff1=0.985;                                // at full
    load at 0.8pf
eff2=0.99;                                 //at half
    full load at unity pf
pf1=0.8;                                   // power
    factor at full load current
pf2=1;                                     //
//
//SOLUTION
loss1=(1-eff1)*va*pf1/eff1;                      //=Pc
    +Pcu losses
```

```
loss2=(1-eff2)*va*(1/2)*pf2/eff2;
                              //=Pc+Pcu losses
//simultaneous equation to be solved
//eq 1: Pc+Pcu=loss;
//fractipon of copper/ ohmic losses
f=(1/2)^2;                                   // 60% of
   full load
//the 2nd equation is Pc+f*Pcu=loss
//now the matrix
M=[1,1;1,f];                                 //Pc+Pcu=
   loss1; Pc+(1/2)^2*Pcu=loss2: 1,1,; 1,f
A=[loss1,loss2];
Mi=inv(M);
Ans=A*inv(M);
Pc=Ans(1,1);
Pcu=Ans(1,2);
disp(sprintf("The Pc is %.1f W",Pc));
disp(sprintf("The Pcu is %.1f W",Pcu));
//
//maximumefficiency at farction x times the full
   load;and then f.Pcu=Pc
x=sqrt(Pc/Pcu);
disp(sprintf("The maximum efficiency would occur at
   a load of %.0f kVA",x*va/1000));
I1=va/v1;
I1maxEff=I1*x;
disp(sprintf("The current at maximum efficeincy is %
   .0f A",I1maxEff));
disp(" ");
//
//END
```

Scilab code Exa 7.36 Value of load for maximum efficiency

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
```

```
//Example 36

clc;
disp("CHAPTER 7");
disp("EXAMPLE 36");

//100kVA 50 Hz 440/1100 V single phase transformer
//VARIABLE INITIALIZATION
va=100000;                                          //apparent power
v1=440;                                             //primary voltage in Volts
v2=11000;                                           //secondary voltage in Volts
f=50;                                               // frequency
//loads
pf=1;                                               //power factor unity
eff1=0.985;                                         // at full load at 0.8pf
eff2=0.99;                                          //at half full load at unity pf
pf1=0.8;                                            // power factor
pf2=1;                                              //power factor
//
//SOLUTION
loss1=(1-eff1)*va*pf1/eff1;                                //=Pc+Pcu losses
loss2=(1-eff2)*va*(1/2)*pf2/eff2;                        //=Pc+Pcu losses
//simultaneous equation to be solved
//eq 1: Pc+Pcu=loss;
//fractipon of copper/ ohmic losses
f=(1/2)^2;                                          // 60% of full load
//the 2nd equation is Pc+f*Pcu=loss
```

```
//now the matrix
M=[1,1;1,f];                              //Pc+Pcu=loss1; Pc+(1/2)^2*Pcu=loss2: 1,1,; 1,f
A=[loss1,loss2];
Mi=inv(M);
Ans=A*inv(M);
Pc=Ans(1,1);
Pcu=Ans(1,2);
disp(sprintf("The Pc is %.1f W",Pc));
disp(sprintf("The Pcu is %.1f W",Pcu));
//
//maximumefficiency at farction x times the full load;and then f.Pcu=Pc
x=sqrt(Pc/Pcu);
disp(sprintf("The maximum efficiency would occur at a load of %.0f kVA",x*va/1000));
I1=va/v1;
I1maxEff=I1*x;
disp(sprintf("The current at maximum efficeincy is %.0f A",I1maxEff));
disp(" ");
//
//END
```

Scilab code Exa 7.37 To calculate regulation at full load

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 37

clc;
disp("CHAPTER 7");
disp("EXAMPLE 37");

//500 kVA 3300/500 V 50 hz single phase transformer
//VARIABLE INITIALIZATION
```

```
va=500000;                                           //apparent power
v1=3300;                                             //primary voltage in Volts
v2=500;                                              //secondary voltage in Volts
f=50;
//loads
pf=1;                                                //power factor unity
eff=0.97;                                            // at 3/4 full load at unity pf
pf2=0.8;                                             //power factor
//
//SOLUTION
I1=va/v1;
loss=(1-eff)*va*(3/4)*pf/eff;                        //=Pc+Pcu losses at 3/4 load
//since the eff value is maximum, Pcu=Pc; therefore, 2*Pc=loss
Pc=loss/2;
//(3/4)^2*Pcu=Pc;
f=(3/4)^2;                                           //3/4 load
//Pcu=Pc/f
Pcu=Pc/f;
//disp(sprintf("The Pc is %f W",Pc));
//disp(sprintf("The Pcu is %f W",Pcu));
//
R_e1=Pcu/I1^2;
disp(sprintf("The value of Re1 is %.3f W",R_e1));
//10% impedance
Z_e1=v1*0.1/I1;
X_e1=sqrt(Z_e1^2-R_e1^2);
phi=acos(0.8);
%reg=(I1*R_e1*cos(phi)+I1*X_e1*sin(phi))*100/v1;
disp(sprintf("The percent regulation at full load
```

```
    0.8 pf is %.2f W',%reg));
disp(" ");
//
//END
```

Scilab code Exa 7.38 `Total no load loss`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 38

clc;
disp("CHAPTER 7");
disp("EXAMPLE 38");

//220/115 V 25 Hz single phase transformer
//VARIABLE INITIALIZATION
v1=220;                                     //primary voltage in Volts
v2=115;                                     //secondary voltage in Volts
f1=25;                                      //frequency rating of the transformer in Hz
f2=50;                                      //frequency of the connected load
//loads
V=440                                       // i Volts
We1=100;                                    //in Watts at 220 V, eddy losses
Pc1=2*We1;                                  //Total iron losses which equals We+Wh due to eddy and hysteresis
Wh1=Pc1-We1;
//
//SOLUTION
```

```
//since we know that We=kh.f.B^1.6 and Wh=Ke.Kf^2.f^2.B^2
//since all being constant exept frequency, we may take We2/We1=f2^2/f1^2
//and Wh2/Wh1=f2/f1
//flux density in both cases is same as in second case voltage and frquency both are doubled
//find values for We2 and Wh2, whence Pc2=We2+Wh2
We2=f2^2*We1/f1^2;
Wh2=f2*Wh1/f1;
Pc2=We2+Wh2;
disp(sprintf("The total no load losses at 400 V is %.0f W",Pc2));
disp(" ");
//
//END
```

Scilab code Exa 7.39 Percentage of hysteresis and copperloss

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 39

clc;
disp("CHAPTER 7");
disp("EXAMPLE 39");

//220/440 v 50 Hz transformer
//VARIABLE INITIALIZATION
v1=220;                  //primary voltage in Volts
v2=440;                  //secondary voltage in Volts
f1=50;                   //rated frequency in Hz

```

```
//loads
V=110;
f2=25;                                              //frquency of the applied load
//say, else computation may not be possible using computer
Pout1=100;                                          //in watt, just assumed for computational purposes for the 220V supply
We1=0.01*Pout1;                                     //in Watts at 220 V, eddy losses which are 1% of the output at 220V
Wh1=0.01*Pout1;                                     //in Watts at 220 V, hysteresis losses which are 1% of the output at 220V
//Pc1=We1+Wh1;                                      //Total iron losses which equals We+Wh due to eddy and hysteresis
Pcu1=0.01*Pout1;                                    //copper losses
//
//SOLUTION
//since on connecting to half the power ie 110V, the output would get halved
Pout2=Pout1/2;
xPcu=Pcu1/Pout2;
disp(sprintf("The copper losses at 110 V would be %.0f percent of the output",xPcu*100));
//now coming to frequency dependant losses ie eddy and hysteresis
//since we know that We=kh.f.B^1.6 and Wh=Ke.Kf^2.f^2.B^2
//since all being constant exept frequency, we may
```

```
   take We2/We1=f2^2/f1^2
//and Wh2/Wh1=f2/f1
//find values for We2 and Wh2, whence Pc2=We2+Wh2
We2=f2^2*We1/f1^2;
Wh2=f2*Wh1/f1;
xWe=We2/Pout2;
xWh=Wh2/Pout2;
disp(sprintf("The eddy losses at 110 V would be %.2f
    percent of the output",xWe*100));
disp(sprintf("The hysteresis losses at 110 V would
   be %.2f percent of the output",xWh*100));
disp(" ");
//
//END
```

Scilab code Exa 7.40 To draw the phasor diagram

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 40

clc;
disp("CHAPTER 7");
disp("EXAMPLE 40");

//Given
//transformer on no load has a core loss 50W, draws
   a current of 2 A (RMS) and induced emf 220 V(RMS)
//VARIABLE INITIALIZATION
loss=50;                        //core loss in Watts
I0=2;                           //no load current in
   Amperes
v0=220;                         //induced emf in
   Volts

//SOLUTION
```

```
pf=loss/(v0*I0);
I_c=I0*pf;                              //core loss component
I_phi=I0*sin(acos(pf));                 //magnetizing component
disp(sprintf("The magnetizing component, I_c= %.4f A,",I_phi));
disp(sprintf("The core loss component, I_ = %.4f A,",I_c));

//END
```

Scilab code Exa 7.41 `Star connected auto transformer`

```
//CHAPTER 7- SINGLE PHASE TRANSFORMER
//Example 41

clc;
disp("CHAPTER 7");
disp("EXAMPLE 41");

//3-phase 550/440 V star connected transformer supplies a load of 400kW
//VARIABLE INITIALIZATION
v1=550;                                 //primary voltage in Volts
v2=440;                                 //secondary voltage in Volts
p=400*1000;                             //load in Watts
pf=0.8;                                 //power factor(lagging)

//SOLUTION

//solution (a)
I2=p/(sqrt(3)*v2*pf);                   //current on
```

```
    secondary side
I1=I2*(v2/v1);                          //since I1:I2=N2:N1
I=I2-I1;                                //in sections Oa, Ob and Oc
disp(sprintf("(a) The current flowing in sections Oa, Ob and Oc is %.0f A",I));
disp(sprintf("The current flowing in sections aA, bB and cC is %.0f A",I1));

//solution (b)
//power transferred by transformer action = Pin.(1-k)
p_o=p*(1-(v2/v1));                      //k=v2/v1
disp(sprintf("(b) The power transferred by transformer action %.0f kW",p_o/1000));

//solution (c)
p_d=p-p_o;
disp(sprintf("(c) The power conducted directly %d kW",p_d/1000));

//END
```

Chapter 8

Direct Current Machines

Scilab code Exa 8.1 Generated emf

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 1

clc;
disp("CHAPTER 8");
disp("EXAMPLE 1");

//VARIABLE INITIALIZATION
v_t=250;            //terminal voltage in Volts
I_l=500;            //load current in Amperes
r_a=0.04;           //armature resistance in Ohms
r_f=50;             //shunt field resistance in Ohms

//SOLUTION
I_f=v_t/r_f;
I_a=I_l+I_f;
E_a=v_t+(I_a*r_a); //E_a=emf of generator
disp(sprintf("The generated emf is %f V",E_a));

//END
```

Scilab code Exa 8.2 `Ratio of speed`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 2

clc;
disp("CHAPTER 8");
disp("EXAMPLE 2");

//VARIABLE INITIALZATION
v_t=230;              //terminal voltage in Volts
r_a=0.5;              //armature resistance in Ohms
r_f=115;              //shunt field resistance in Ohms
I_l=40;               //line current in Amperes

//SOLUTION

//for generator
I_f=v_t/r_f;
I_a=I_l+I_f;
E_a=v_t+(I_a*r_a);  //here E_a=emf of generator

//for motor
I_f=v_t/r_f;
I_a=I_l-I_f;
E_b=v_t-(I_a*r_a);  //here E_b=emf of motor

ratio=E_a/E_b;       //E_a:E_b=(k_a*flux*N_g):(k_a*
    flux*N_m) =>E_a:E_b=N_g:N_m (as flux is constant)
disp(sprintf("The ratio of speed as a generator to
    the speed as a motor i.e. N_g:N_m is %f",ratio));

//END
```

Scilab code Exa 8.3 Armature induced emf and developed torque and efficiency

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 3

clc;
disp("CHAPTER 8");
disp("EXAMPLE 3");

//VARIABLE INITIALIZATION
p_o=10*1000;                    //output of generator in
    Watts
v_t=250;                        //terminal voltage in
    Volts
N=1000;                         //speed in rpm
r_a=0.15;                       //armature resistance in
    Ohms
I_f=1.64;                       //field current in
    Amperes
rot_loss=540;                   //rotational loss in
    Watts

//SOLUTION

//solution (i)
I_l=p_o/v_t;
I_a=I_l+I_f;
E_a=v_t+(I_a*r_a);
disp(sprintf("(i) The armature induced emf is %f V",
    E_a));

//solution (ii)
w=(2*%pi*N)/60;                  //in radian/sec
T_e=(E_a*I_a)/w;
```

```
disp(sprintf("(ii) The torque developed is %f N-m",T_e));

//solution (iii)
arm_loss=(I_a^2)*r_a;          //armature loss
fld_loss=v_t*I_f;              //field loss
tot_loss=rot_loss+arm_loss+fld_loss;
p_i=p_o+tot_loss;
eff=(p_o/p_i)*100;
disp(sprintf("(iii) The efficiency is %f %%",eff));

//END
```

Scilab code Exa 8.4 Armature resistance and load current at maximum efficiency

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 4

clc;
disp("CHAPTER 8");
disp("EXAMPLE 4");

//VARIABLE INITIALIZATION
v_t=240;                    //in Volts
I_l=200;                    //full load current in Amperes
r_f=60;                     //shunt field resisatnce in Ohms
eff=90;                     //percentage full load efficiency
s_loss=800;                 //stray(iron + friction) loss in Watts

//SOLUTION

```

```
//solution (a)
p_o=v_t*I_l;                   //output
eff=eff/100;
p_i=p_o/eff;
tot_loss=p_i-p_o;              //since input=output+loss
I_f=v_t/r_f;
I_a=I_l+I_f;
cu_loss=(I_f^2)*r_f;           //copper loss
c_loss=cu_loss+s_loss;         //constant loss
arm_loss=tot_loss-c_loss;      //armature loss ((I_a^2)*
    r_a)
r_a=arm_loss/(I_a^2);
disp(sprintf("(a) The armature resisatnce is %f   ",
    r_a));

//solution (b)
//for maximum efficiency , armature loss = constant
    loss =>(I_a^2)*r_a=c_loss
I_a=sqrt(c_loss/r_a);
disp(sprintf("(b) The load current corresponding to
    maximum efficiency is %f A",I_a));

//END
```

Scilab code Exa 8.5 `BHP of prime mover`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 5

clc;
disp("CHAPTER 8");
disp("EXAMPLE 5");

//VARIABLE INITIALIZATION
v_t=200;                      //in Volts
```

```
I_l=50;                          //in Amperes
r_a=0.1;                         //armature resistance in Ohms
r_f=100;                         //field resistance in Ohms
s_loss=500;                      //core and iron loss in Watts

//SOLUTION

//solution (a)
I_f=v_t/r_f;                    //I_sh is same as I_f and r_sh is same as r_f
I_a=I_f+I_l;
E_a=v_t+(I_a*r_a);
disp(sprintf("(a) The induced emf is %f V",E_a));

//solution (b)
arm_loss=(I_a^2)*r_a;            //armature copper loss
sh_loss=(I_f^2)*r_f;            //shunt field copper loss
tot_loss=arm_loss+sh_loss+s_loss;
p_o=v_t*I_l;                     //output power
p_i=p_o+tot_loss;                //input power
bhp=p_i/735.5;                   //1 metric horsepower= 735.498W
disp(sprintf("(b) The Break Horse Power(B.H.P.) of the prime mover is %f H.P.(metric)",bhp));

//solution (c)
c_eff=(p_o/p_i)*100;
p_EE=E_a*I_a;                    //electrical power
m_eff=(p_EE/p_i)*100;
e_eff=(p_o/p_EE)*100;
disp(sprintf("(c) The commercial efficiency is %f %%, the mechanical efficiency is %f %% and the electrical efficiency is %f %%",c_eff,m_eff,e_eff));

//END
```

Scilab code Exa 8.6 `20 HP 230 V 1150 rpm shunt motor`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 6

clc;
disp("CHAPTER 8");
disp("EXAMPLE 6");

//VARIABLE INITIALIZATION
p_o=20*746;          //output power from H.P. to Watts (1 H.P.=745.699 or 746 W)
v_t=230;             //in Volts
N=1150;              //speed in rpm
P=4;                 //number of poles
Z=882;               //number of armature conductors
r_a=0.188;           //armature resistance in Ohms
I_a=73;              //armature current in Amperes
I_f=1.6;             //field current in Amperes

//SOLUTION

//solution (i)
E_b=v_t-(I_a*r_a);
w=(2*%pi*N)/60;      //in radian/sec
T_e=(E_b*I_a)/w;
disp(sprintf("(i) The electromagnetic torque is %f N-m",T_e));

//solution (ii)
A=P;                 //since it is lap winding, so A=P and A=number of parallel paths
phi=(E_b*60*A)/(P*N*Z);
disp(sprintf("(ii) The flux per pole is %f Wb",phi))
```

```
;

//solution (iii)
p_rotor=E_b*I_a;    //power developed on rotor
p_rot=p_rotor-p_o; //p_shaft=p_out
disp(sprintf("(iii) The rotational power is %f W",p_rot));

//solution (iv)
tot_loss=p_rot+((I_a^2)*r_a)+(v_t*I_f);
p_i=p_o+tot_loss;
eff=(p_o/p_i)*100;
disp(sprintf("(iv) The efficiency is %f %%",eff));

//solution (v)
T=p_o/w;
disp(sprintf("(v) The shaft torque is %f N-m",T));

//The answers are slightly different due to the precision of floating point numbers

//END
```

Scilab code Exa 8.7 `New operating speed`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 7

clc;
disp("CHAPTER 8");
disp("EXAMPLE 7");

//VARIABLE INITIALIZATION
p_o=20*746;                    //output power from H.P. to Watts (1 H.P.=745.699 or 746 W)
```

```
v_t=230;                      //in Volts
N1=1150;                      //speed in rpm
P=4;                          //number of poles
Z=882;                        //number of armature
    conductors
r_a=0.188;                    //armature resistance
    in Ohms
I_a1=73;                      //armature current in
    Amperes
I_f=1.6;                      //field current in
    Amperes
ratio=0.8;                    //phi2:phi1=0.8  (here
    phi=flux)

//SOLUTION

E_b1=v_t-(I_a1*r_a);
I_a2=I_a1/ratio;              //(phi2*I_a2)=(phi1*
    I_a1)
E_b2=v_t-(I_a2*r_a);
N2=(E_b2/E_b1)*(1/ratio)*N1; //N2:N1=(E_b2/E_b1)*(
    phi1/phi2)
N2=round(N2);                 //to round off the
    value of N2 (before rounding off N2=1414.695516
    rpm)
disp(sprintf("The new operating speed is %d rpm",N2)
    );

//The answer is slightly different due to the
    precision of floating point numbers

//END
```

Scilab code Exa 8.8 250 V DC shunt machine

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 8

clc;
disp("CHAPTER 8");
disp("EXAMPLE 8");

//VARIABLE INITIALIZATION
v_t=250;                        //in Volts
r_a=0.1;                        //armature resistance in Ohms
r_f=125;                        //field resistance in Ohms
p_o=20*1000;                    //output power in Watts
N_g=1000;                       //speed as generator in rpm

//SOLUTION

//machine as a generator
I_l=p_o/v_t;
I_f=v_t/r_f;                    //I_f is same as I_sh
I_ag=I_l+I_f;
E_a=v_t+(I_ag*r_a);             //induced emf = E_a = E_g

//machine as a motor
I_l=p_o/v_t;
I_f=v_t/r_f;
I_am=I_l-I_f;
E_b=v_t-(I_am*r_a);            //back emf = E_b = E_m

//solution (a)
N_m=(N_g*E_b)/E_a;
N_m=round(N_m);                //to round off the value of N_m
disp(sprintf("(a) The speed of the same machine as a motor is %d rpm",N_m));
```

```

//solution (b)

//(i)
p1=(E_a*I_ag)/1000;             //to express the answer in kW
disp(sprintf("(b) (i) The internal power developed as generator is %f kW",p1));

//(ii)
p2=(E_b*I_am)/1000;
disp(sprintf("(b) (ii) The internal power developed as motor is %f kW",p2));

//END
```

Scilab code Exa 8.9 `Torque developed in the motor`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 9

clc;
disp("CHAPTER 8");
disp("EXAMPLE 9");

//VARIABLE INITIALIZATION
P=4;                        //number of poles
v_t=230;                    //in Volts
I_l=52;                     //in Amperes
Z=600;                      //tottal number of conductors
r_f=115;                    //in Ohms
d=30/100;                   //airgap diameter from cm to m
l=20/100;                   //effective length of pole
```

```
B=4100/10000;                  //flux density from Gauss
   to Wb/m^2

//SOLUTION
I_f=v_t/r_f;                   //I_f is same as I_sh
I_a=I_l-I_f;
ar=(%pi*d*l)/P;                //area of pole
phi=ar*B;                      //phi = flux
A=P;
T=(phi*Z*I_a)/(2*%pi*A);
disp(sprintf("The torque developed in the motor is
   %f N-m",T));

//The answer is different as 'A' has not been
   included in the denominator(in the book)

//END
```

Scilab code Exa 8.10 6 pole DC machine with 400 conductors

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 10

clc;
disp("CHAPTER 8");
disp("EXAMPLE 10");

//VARIABLE INITIALIZATION
P=6;                           //number of poles
I=80;                          //current per conductor in
    Amperes
Z=400;                         //tottal number of
   conductors
phi=0.020;                     //flux per pole in Wb
N=1800;                        //in rpm
```

```

//SOLUTION

//soluion (a): for wave connected
disp("(a) For Wave connected");

//(i)
A=2;                    //A=number of parallel paths
I_a=I*A;
disp(sprintf("(i) The total current is %f A",I_a));

//(ii)
E_a=(phi*Z*N*P)/(60*A);
disp(sprintf("(ii) The emf is %f V",E_a));

//(iii)
p=E_a*I_a;
disp(sprintf("(iii) The power developed in armature is %f kW",p/1000));
w=(2*%pi*N)/60;
T_e=p/w;
disp(sprintf("The electromagnetic torque is %f N-m",T_e));


//soluion (b): for lap connected
disp("(b) For Lap connected");

//(i)
A=P;
I_a=I*A;
disp(sprintf("(i) The total current is %f A",I_a));

//(ii)
E_a=(phi*Z*N*P)/(60*A);
disp(sprintf("(ii) The emf is %f V",E_a));

```

```
//(iii)
p=E_a*I_a;
disp(sprintf("(iii) The power developed in armature
    is %f kW",p/1000));
w=(2*%pi*N)/60;
T_e=p/w;
disp(sprintf("The electromagnetic torque is %f N-m",
    T_e));

//END
```

Scilab code Exa 8.11 Total emf generated in the armature

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 11

clc;
disp("CHAPTER 8");
disp("EXAMPLE 11");

//VARIABLE INITIALIZATION
p_o=20*1000;                //output in W
v_t=250;                    //in Volts
r_a=0.05;                   //aramture resistance in
    Ohms
r_se=0.025;                 //series resistance in
    Ohms
r_sh=100;                   //shunt resistance in Ohms

//SOLUTION
I_t=p_o/v_t;
v_se=I_t*r_se;              //for series winding
v_sh=v_t+v_se;              //for shunt winding
I_sh=v_sh/r_sh;
I_a=I_sh+I_t;
```

```
E_a=v_t+(I_a*r_a)+v_se;
disp(sprintf("The total emf generated is %f V",E_a))
    ;

//END
```

Scilab code Exa 8.12 `Terminal voltage of the machine`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 12

clc;
disp("CHAPTER 8");
disp("EXAMPLE 12");

//VARIABLE INITIALIZATION
P=4;                             //number of poles
N=750;                           //in rpm
r_a=0.4;                         //in Ohms
r_f=200;                         //in Ohms
Z=720;
phi=2.895*(10^6)*(10^(-8));      //in Wb (1 line=10^(-8)
     Wb)
r_l=10;                          //load resistance in
    Ohms
A=2;                             //for wave winding

//SOLUTION
E_a=(phi*Z*N*P)/(60*A);
disp(sprintf("The induced emf is %f V",E_a));
// E_a=v+(I_a*r_a) but I_a=I_l+I_f and I_l=v/r_l,
    I_f=v/r_f =>I_a=(v/r_l) + (v/r_f)
// =>E_a=v+(((v/r_l) + (v/r_f))*r_a)
// taking v common, the following equation is
    obtained
```

```
v=E_a/(1+(r_a/r_f)+(r_a/r_l));
disp(sprintf("The terminal voltage of the machine is
    %f V",v));

//The answer is slightly different due to the
    precision of floating point numbers

//END
```

Scilab code Exa 8.13 `Current in each conductor and emf generated`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 13

clc;
disp("CHAPTER 8");
disp("EXAMPLE 13");

//VARIABLE INITIALIZATION
P=4;                            //number of poles
v_t=220;                        //in Volts
I_l=42;                         //load current in
    Amperes
r_a=0.1;                        //in Ohms
r_f=110;                        //in Ohms
drop=1;                         //contact drop per brush
//SOLUTION

//solution (i)
A=P;                            //for lap winding
I_f=v_t/r_f;                    //I_f is same as I_sh
I_a=I_l+I_f;
I_c=I_a/A;                      //conductor current
disp(sprintf("The current in each conductor of the
    armature is %d A",I_c));
```

```

//solution (ii)
v_a=I_a*r_a;                    //armature voltage drop
v_b=2*drop;                     //brush drop
emf=v_t+v_a+v_b;
disp(sprintf("The total emf generated is %f V",emf));

//END
```

Scilab code Exa 8.14 `Armature resistance and load current at maximum efficiency`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 14

clc;
disp("CHAPTER 8");
disp("EXAMPLE 14");

//VARIABLE INITIALIZATION
v_t=220;                        //in Volts
I_l=196;                        //in Amperes
s_loss=720;                     //stray loss in Watts
r_f=55;                         //shunt field ressitance in Ohms
eff=88/100;                     //efficiency

//SOLUTION
p_o=v_t*I_l;
p_i=p_o/eff;                    //electrical input
tot_loss=p_i-p_o;
I_f=v_t/r_f;
I_a=I_l+I_f;
cu_loss=v_t*I_f;                //shunt field copper loss
```

```
c_loss=cu_loss+s_loss;        //constant loss
arm_loss=tot_loss-c_loss;     //armature copper loss
r_a=arm_loss/(I_a^2);
disp(sprintf("The armature resistance is %f   ",r_a)
  );

//for maximum efficiency , armature loss = constant
  loss =>(I_a^2)*r_a=c_loss
I_a=sqrt(c_loss/r_a);
disp(sprintf("The load current corresponding to
  maximum efficiency is %f A",I_a));

//END
```

Scilab code Exa 8.15 `Full load speed`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 15

clc;
disp("CHAPTER 8");
disp("EXAMPLE 15");

//VARIABLE INITIALIZATION
v_t=230;                       //in Volts
I_a1=3.33;                     //in Amperes
N1=1000;                       //in rpm
r_a=0.3;                       //armature resistance in
   Ohms
r_f=160;                       //field resistance in
  Ohms
I_l=40;                        //in Amperes
phi1=1;                        //in Wb (phi=1 is an
  assumption)
phi2=(1-(4/100));              //in Wb (phi2=0.96 of
```

```
    phi1)

//SOLUTION

//At no load
E_a1=v_t-(I_a1*r_a);
I_f=v_t/r_f;

//At full load
I_a2=I_l-I_f;
E_a2=v_t-(I_a2*r_a);
N2=(E_a2/E_a1)*(phi1/phi2)*N1;
N2=round(N2);                    //to round off the value
disp(sprintf("The full load speed is %d rpm",N2));

//END
```

Scilab code Exa 8.16 `250 V 4 pole shunt motor`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 16

clc;
disp("CHAPTER 8");
disp("EXAMPLE 16");

//VARIABLE INITIALIZATION
v_t=250;                        //in Volts
P=4;                            //number of poles
Z=500;                          //number of conductors
r_a=0.25;                       //in Ohms
r_f=125;                        //in Ohms
phi=0.02;                       //in Wb
I_l=14;                         //in Amperes
A=2;
```

```
rot_loss=300;                    //rotational loss in Watts

//SOLUTION

//solution (i)
I_f=v_t/r_f;
I_a=I_l-I_f;
E_a=v_t-(I_a*r_a);
N=(E_a*A*60)/(phi*Z*P);
N=round(N);                      //to round off the value of N
disp(sprintf("(i) The speed is %d rpm",N));
p_e=E_a*I_a;
w=(2*%pi*N)/60;
T1=p_e/w;
disp(sprintf("The internal torque developed is %f N-m",T1));

//solution (ii)
p_o=p_e-rot_loss;
disp(sprintf("(ii)The shaft power is %f W",p_o));
T2=p_o/w;
disp(sprintf("The shaft torque is %f N-m",T2));
p_i=v_t*I_l;
eff=(p_o/p_i)*100;
disp(sprintf("The efficiency is %f %%",eff));

//END
```

Scilab code Exa 8.17 200 V DC shunt motor

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 17

```

```
clc;
disp("CHAPTER 8");
disp("EXAMPLE 17");

//VARIABLE INITIALIZATION
v_t=200;                        //in Volts
I_l=22;                         //in Amperes
N1=1000;                        //in rpm
r_a=0.1;                        //in Ohms
r_f=100;                        //in Ohms
N2=800;                         //in rpm

//SOLUTION

//solution (i)
I_f=v_t/r_f;
I_a1=I_l-I_f;
E_a1=v_t-(I_a1*r_a);
//on rearranging the equation E_a2:E_a1=N2:N1, where
    E_a2=v_t-I_a1*(r_a+r_s) and E_a1=v_t-(I_a1*r_a),
    we get,
r_s1=((v_t - ((N2*E_a1)/N1))/I_a1)-r_a;
disp(sprintf("(i) When the load torque is
   independent of speed, the additional resistance
   is %f   ",r_s1));

//solution (ii)
I_a2=(N2/N1)*I_a1;
//on rearranging the equation E_a2:E_a1=N2:N1, where
    E_a2=v_t-I_a2*(r_a+r_s) and E_a1=v_t-(I_a1*r_a),
    we get,
r_s2=((v_t - ((N2*E_a1)/N1))/I_a2)-r_a;
disp(sprintf("(ii)When the load torque is
   proportional to speed, the additional resistance
   is %f   ",r_s2));

//solution (iii)
I_a2=(N2^2/N1^2)*I_a1;
```

```
//on rearranging the equation E_a2:E_a1=N2:N1, where
    E_a2=v_t-I_a2*(r_a+r_s) and E_a1=v_t-(I_a1*r_a),
    we get,
r_s3=((v_t - ((N2*E_a1)/N1))/I_a2)-r_a;
disp(sprintf("(iii)When the load torque varies as
   the square of speed, the additional resistance is
    %f   ",r_s3));

//solution (iv)
I_a2=(N2^3/N1^3)*I_a1;
//on rearranging the equation E_a2:E_a1=N2:N1, where
    E_a2=v_t-I_a2*(r_a+r_s) and E_a1=v_t-(I_a1*r_a),
    we get,
r_s4=((v_t - ((N2*E_a1)/N1))/I_a2)-r_a;
disp(sprintf("(iv)When the load torque varies as the
    cube of speed, the additional resistance is %f
     ",r_s4));

//END
```

Scilab code Exa 8.18 Value of inserted resistance

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 18

clc;
disp("CHAPTER 8");
disp("EXAMPLE 18");

//VARIABLE INITIALIZATION
v_t=460;                    //in Volts
p_o=10*736;                 //in Watts (1 metric H.
   P=735.5 W)
ratio=85/100;               //as given in the
   question
```

```
eff=84/100;
I_f=1.1;                          //in Amperes
r_a=0.2;                          //in Ohms

//SOLUTION
p_i=p_o/eff;
I_l=p_i/v_t;
I_a=I_l-I_f;
E1=v_t-(I_a*r_a);
E2=E1*ratio;                      //E2:E1=N2:N1=ratio
v=v_t-E2;                         //voltage drop across r_a and r_s (r_s is the series resistance to be inserted)
r_s=(v/I_a)-r_a;
disp(sprintf("The resistance required is %f  ",r_s));

//The answer is different because ratio equals 85/100 and not 75/100

//END
```

Scilab code Exa 8.19 New speed of motor on inserting a 250 ohm resistance

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 19

clc;
disp("CHAPTER 8");
disp("EXAMPLE 19");

//VARIABLE INITIALIZATION
v_t=250;                         //in Volts
r_a=0.5;                         //in Ohms
r_f=250;                         //in Ohms
```

```
N1=600;                              //in rpm
I=21;                                //in Amperes
r_s=250;                             //in Ohms

//SOLUTION
I_f1=v_t/r_f;
I_f2=v_t/(r_f+r_s);
I_a1=I-I_f1;
// T is directly proportional to (  *I_a)
// I_f is directly proportional to
// => I_f1*I_a1=I_f2*I_a2, therefore,
I_a2=(I_f1*I_a1)/I_f2;
E_b1=v_t-(I_a1*r_a);
E_b2=v_t-(I_a2*r_a);
// E_b is directly proportional to (  *N)
// (  *N) is directly proportional to (I_f*N)
// =>E_b1:E_b2=(I_f1:I_f2)*(N1:N2)
N2=(I_f1/I_f2)*(E_b2/E_b1)*N1;
N2=round(N2);                       //to round off the value
disp(sprintf("The new speed of the motor is %d rpm",
   N2));

//END
```

Scilab code Exa 8.20 Reduction of main flux to raise the speed by 50 percent

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 20

clc;
disp("CHAPTER 8");
disp("EXAMPLE 20");

//VARIABLE INITIALIZATION
v_t=250;                             //in Volts
```

```
I_a1=20;                        //in Amperes
N1=1000;                        //in rpm
r_a=0.5;                        //in Ohms
drop=1;                         //brush contact drop in
   Volts
ratio=1.5;                      //N2:N1=1.5
phi1=1;                         //it is an assumption

//SOLUTION
E_1=v_t-(I_a1*r_a)-(2*drop);
//solving the quadratic equation directly,
a=1;
b=-496;
c=14280;
D=b^2-(4*a*c);
x1=(-b+sqrt(D))/(2*a);
x2=(-b-sqrt(D))/(2*a);
if(x1<40)
I_a2=x1;
else if(x2<40)
I_a2=x2;
end;
phi2=(I_a1/I_a2)*phi1;
phi=(1-phi2)*100;
disp(sprintf("The flux to be reduced is %f %% of the
    main flux",phi));

//END
```

Scilab code Exa 8.21 10 kW 6 pole DC generator

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 21

clc;
```

```
disp("CHAPTER 8");
disp("EXAMPLE 21");

//VARIABLE INITIALIZATION
p_o=10*1000;                    //in Watts
P=6;                            //number of poles
E_g=200;                        //in Volts
N=1500;                         //in rpm
A=P;                            //since the armature
    is lap connected
B=0.9;                          //flux density in
    Tesla
l=0.25;                         //length of armature
    in m
dia=0.2;                        //diameter of armature
     in m

//SOLUTION

//solution (a)
area=2*%pi*(dia/2)*l;
phi=B*area;
disp(sprintf("(a) The flux per pole is %f Wb",phi));

//solution (b)
Z=(60*E_g)/(phi*N);
disp(sprintf("(b) The total number of active
    conductors is %d",Z));

//solution (c)
I_a=50;
p=E_g*I_a;
w=(2*%pi*N)/60;
T=p/w;
disp(sprintf("(c) The torque developed when armature
     current is 50 A is %f N-m",T));

//END
```

Scilab code Exa 8.22 Shunt wound motor running at 600 rpm from a 230 V supply

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 22

clc;
disp("CHAPTER 8");
disp("EXAMPLE 22");

//VARIABLE INITIALIZATION
N1=600;                          //in rpm
v=230;                           //in Volts
I_l1=50;                         //line current in
    Amperes
r_a=0.4;                         //armature resistance
    in Ohms
r_f=104.5;                       //field resistance in
    Ohms
drop=2;                          //brush drop in Volts

//SOLUTION

//solution (i)
I_l2=5;
I_a1=I_l1-(v/r_f);
E_b1=v-(I_a1*r_a)-drop;
I_a2=I_l2-(v/r_f);
E_b2=v-(I_a2*r_a)-drop;
N2=(E_b2/E_b1)*N1;
N2=round(N2);
disp(sprintf("(i) The speed at no load is %d rpm",N2
    ));

//solution (ii)
```

```
I_l2=50;
N2=500;
E_b2=(N2/N1)*E_b1;
dif=v-drop;                       //difference
I_a2=I_l2-(v/r_f);
r_se=((dif-E_b2)/I_a2)-r_a;
disp(sprintf("(ii) The additional resistance is %f
     ",r_se));

//solution (iii)
phi1=1;                           //it is an assumption
I_a3=30;
N2=750;
E_b3=v-(I_a3*r_a)-drop;
phi2=(E_b3/E_b1)*(N1/N2)*phi1;
red=((1-phi2)*100*phi1)/phi1;
disp(sprintf("(iii) The percentage reduction of flux
    per pole is %f %%",red));

//END
```

Scilab code Exa 8.23 Value of inserted resistance in field circuit for increasing

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 23

clc;
disp("CHAPTER 8");
disp("EXAMPLE 23");

//VARIABLE INITIALIZATION
v=230;                             //in Volts
r_a=0.4;                           //in Ohms
r_f1=115;                          //in Ohms
I_a=20;                            //in Amperes
```

```
N1=800;                                //in rpm
N2=1000;                               //in rpm

//SOLUTION
I_f1=v/r_f1;
E_b1=v-(I_a*r_a);
//rearranging the equation, we get,
r_f2=((E_b1*N2)/((v*N1)-(N1*I_a*r_a)))*r_f1;
r_f2_dash=r_f2-r_f1;
disp(sprintf("The external resistance is %f    ",
   r_f2_dash));

//The answer is slightly different due to the
   precision of floating point numbers

//END
```

Scilab code Exa 8.24 New speed of motor on inserting a 250 ohm resistance in the f

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 24

clc;
disp("CHAPTER 8");
disp("EXAMPLE 24");

//This example is same as example 19

//VARIABLE INITIALIZATION
v=250;                                   //in Volts
r_a=0.5;                                 //in Ohms
r_f=250;                                 //in Ohms
N1=600;                                  //in rpm
I_l=21;                                  //in Amperes
r=250;                                   //in Ohms
```

```
//SOLUTION
I_f1=v/r_f;
I_a1=I_l-I_f1;
I_a2=2*I_a1;
E_b1=v-(I_a1*r_a);
E_b2=v-(I_a2*r_a);
ratio=(r+r_f)/r_f;
N2=(ratio*N1*E_b2)/E_b1;
N2=round(N2);
disp(sprintf("The new speed is %d rpm",N2));

//END
```

Scilab code Exa 8.25 `24 slot 2 pole DC machine`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 25

clc;
disp("CHAPTER 8");
disp("EXAMPLE 25");


//VARIABLE INITIALIZATION
slot=24;                    //number of slots
P=2;                        //number of poles
N=18;                       //number of turns per
    coil
B=1;                        //in Webers
l=20/100;                   //effective length in
    meters
rad=10/100;                 //radius in meters
w=183.2;                    //angular velocity in
    rad/s
```

```
//SOLUTION
A=2;
Z=slot*P*N;                        //total number of
    conductors
ar1=(2*%pi*rad*l)/P;
ar2=ar1*0.8;                       //since the magnetic
    poles 80% of the armature periphery
phi=B*ar2;                         //effective flux per
    pole

//solution (a)
E_a=(P*Z*phi*w)/(2*%pi*A);
disp(sprintf("(a) The induced emf is %f V",E_a));

//solution (b)
coil=slot/P;                        //number of coils in
    each path
E_coil=E_a/coil;
disp(sprintf("(b) The induced emf per coil is %f V",
    E_coil));

//solution (c)
E_turn=E_coil/N;
disp(sprintf("(c) The induced emf per turn is %f V",
    E_turn));

//solution (d)
E_cond=E_turn/A;
disp(sprintf("(d) The induced emf per conductor is
    %f V",E_cond));

//The answers are slightly different due to the
    precision of floating point numbers

//END
```

Scilab code Exa 8.27 Counter emf of motor and power developed in armature

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 27

clc;
disp("CHAPTER 8");
disp("EXAMPLE 27");


//VARIABLE INITIALIZATION
v_t=200;                        //in volts
r_a=0.06;                       //in Ohms
r_se=0.04;                      //in Ohms
p_i=20*1000;                    //in Watts

//SOLUTION

//solution (a)
I_a=p_i/v_t;
E_b=v_t-I_a*(r_a+r_se);
disp(sprintf("(a) The counter emf of the motor is %d
    V",E_b));

//solution (b)
p_a=E_b*I_a;
p_a=p_a/1000;                    //from W to kW
disp(sprintf("(b) The power developed in the
   armature is %d kW",p_a));

//END
```

Scilab code Exa 8.28 `Voltage between far end of feeder and bus bar`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 28

clc;
disp("CHAPTER 8");
disp("EXAMPLE 28");

//VARIABLE INITIALIZATION
E_a=120;                              //in Volts
r_se=0.03;                            //in Ohms
r_a=0.02;                             //in Ohms
v1=240;                               //in Volts
r=0.25;                               //in Ohms
I=300;                                //in Amperes

//SOLUTION
v=I*(r_se+r_a+r);
disp(sprintf("The voltage drop across the three
   resistances is %d V",v));
v_t=v1+E_a-v;
disp(sprintf("The voltage between far end and the
   bus bar is %d V",v_t));
disp(sprintf("The net increase of %d V may be beyond
    the desired limit",v_t-v1));
disp("Hence, a field diverter resistance may be
   necessary to regulate the far-end terminal
   voltage");

//END
```

Scilab code Exa 8.29 `Speed of motor when connected in series with 5 ohm resistance`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
```

```
//Example 29

clc;
disp("CHAPTER 8");
disp("EXAMPLE 29");

//VARIABLE INITIALIZATION
r_a=1;                             //in Ohms
N1=800;                            //in rpm
v_t=200;                           //in Volts
I_a=15;                            //in Amperes
r_s=5;                             //series resistance in
    Ohms

//SOLUTION
E_b1=v_t-(I_a*r_a);
E_b2=v_t-I_a*(r_a+r_s);
N2=(E_b2/E_b1)*N1;
N2=round(N2);                      //to round off the value
disp(sprintf("The speed attained after connecting
    the series resistance is %d rpm",N2));

//END
```

Scilab code Exa 8.30 `Value of starting torque`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 30

clc;
disp("CHAPTER 8");
disp("EXAMPLE 30");

//VARIABLE INITIALIZATION
p=5*735.5;                        //in Watts (1 metric H.P
```

```
.=735.5 W)
N=1000;                          //in rpm
I=30;                            //in Amperes
I_s=45;                          //starting current in Amperes

//SOLUTION
T=(p*60)/(2*%pi*1000);
T_s=(T*(I_s^2))/(I^2);
disp(sprintf("The starting torque is %f N-m",T_s));

//The answer is slightly different due to precision of floating point numbers

//END
```

Scilab code Exa 8.31 `Value of speed when flux is increased by 20 percent`

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 31

clc;
disp("CHAPTER 8");
disp("EXAMPLE 31");

//VARIABLE INITIALIZATION
r_a=0.1;                         //combined resistance of armature & field resistance in Ohms
v_t=230;                         //in Volts
I_a1=100;                        //in Amperes
N1=1000;                         //in rpm
I_a2=200;                        //in Amperes
ratio=1.2;                       //ratio of 2 : 1 =1.2

//SOLUTION
```

```
E_b1=v_t-(I_a1*r_a);          //numerator of LHS
    according to the book
E_b2=v_t-(I_a2*r_a);          //denominator of LHS
    according to the book
N2=(E_b2/E_b1)*(1/ratio)*N1;
N2=round(N2);                 //to round off the value
disp(sprintf("The new speed of the armature is %d
    rpm",N2));

//END
```

Scilab code Exa 8.32 250 V series motor with 20 A current and 1000 rpm

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 32

clc;
disp("CHAPTER 8");
disp("EXAMPLE 32");

//VARIABLE INITIALIZATION
v_t=250;                       //in Volts
I=20;                          //in Amperes
N1=1000;                       //in rpm
P=4;                           //number of poles
r_p=0.05;                      //resistance of field
    coil on each pole in Ohms
r_a=0.2;                       //in Ohms

//SOLUTION

r_se=P*r_p;
r_m=r_a+r_se;                  //resistance of motor
E_b1=v_t-(I*r_m);
T1=I^2;
```

```
//solution (a)
//solving the quadratic equation directly,
r=10;                              //in Ohms
a=1.02;
b=-25;
c=-400;
D=b^2-(4*a*c);
x1=(-b+sqrt(D))/(2*a);
x2=(-b-sqrt(D))/(2*a);
//to extract the positive root out of the two
if (x1>0 & x2<0)
I1=x1;
else (x1<0 & x2>0)
I1=x2;
end;
I_a=((10.2*I1)-v_t)/r;
E_b2=v_t-(I_a*r_a);
N2=((E_b2/E_b1)*I*N1)/I1;
N2=round(N2);                     //to round off the value
disp(sprintf("(a) The speed with 10    resistance in
    parallel with the armature is %d rpm",N2));

//solution (b)
//solving the quadratic equation directly,
a=5/7;
b=0;
c=-400;
D=b^2-(4*a*c);
y1=(-b+sqrt(D))/(2*a);
y2=(-b-sqrt(D))/(2*a);
//to extract the positive root out of the two
if (y1>0 & y2<0)
I2=y1;
else (y1<0 & y2>0)
I2=y2;
end;
E_b3=v_t-(I2*r_a);
```

```
N3=((E_b3/E_b1)*I*N1)/(I2*a);
N3=round(N3);                    //to round off the value
disp(sprintf("(b) The speed with 0.5    resistance
    in parallel with series field is %d rpm",N3));

//The answers are slightly different due to the
    precision of floating point numbers

//END
```

Scilab code Exa 8.33 Resistance to be added to obtain rated torque at starting and

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 33

clc;
disp("CHAPTER 8");
disp("EXAMPLE 33");

//VARIABLE INITIALIZATION
v_t=230;                        //in Volts
N1=1500;                        //in rpm
I_a1=20;                        //in Amperes
r_a=0.3;                        //armature resistance
     in Ohms
r_se=0.2;                       //series field
    resistance in Ohms

//SOLUTION

//solution (a)
E_b=0;                          //at starting
nr1=v_t-I_a1*(r_a+r_se);        //value of numerator
r_ext=nr1/I_a1;
disp(sprintf("(a) At starting, the resistance that
```

```
   must be added is %f   ",r_ext));

//solution (b)
I_a2=I_a1;
N2=1000;
ratio=N2/N1;
nr2=v_t-I_a2*(r_a+r_se);
r_ext=((ratio*nr1)-nr2)/(-I_a2);
disp(sprintf("(b) At 1000 rpm, the resistance that
   must be added is %f   ",r_ext));

//END
```

Scilab code Exa 8.34 Total emf and armature current

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 34

clc;
disp("CHAPTER 8");
disp("EXAMPLE 34");

//VARIABLE INITIALIZATION
r_a=0.06;                      //armature resistance
   in Ohms
r_se=0.04;                     //series resistance in
    Ohms
r_sh=25;                       //shunt resistance in
   Ohms
v_t=110;                       //in Volts
I_l=100;                       //in Amperes

//SOLUTION

//solution (a)
```

```
I_sh=v_t/r_sh;
I_a=I_sh+I_l;
E_g=v_t+I_a*(r_a+r_se);
disp("(a) When the machine is connected as long
    shunt compound generator-");
disp(sprintf("The armature current is %f A and the
    total emf is %f V",I_a,E_g));

//solution (b)
I_sh=(v_t/r_sh)+(I_l*r_se/r_sh);
I_a=I_sh+I_l;
E_g=v_t+(I_a*r_a)+(I_l*r_se);
disp("(b) When the machine is connected as short
    shunt compound generator-");
disp(sprintf("The armature current is %f A and the
    total emf is %f V",I_a,E_g));

//END
```

Scilab code Exa 8.35 Armature current and induced emf

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 35

clc;
disp("CHAPTER 8");
disp("EXAMPLE 35");

//VARIABLE INITIALIZATION
r_a=0.06;                    //armature resistance
    in Ohms
r_se=0.04;                   //series resistance in
     Ohms
r_sh=25;                     //shunt resistance in
    Ohms
```

```
v_t=110;                          //in Volts
I_l=100;                          //in Amperes

//SOLUTION

//solution (a)
I_sh=v_t/r_sh;
I_a=I_l-I_sh;
E_g=v_t-I_a*(r_a+r_se);
disp("(a) When the machine is connected as long
    shunt compound generator-");
disp(sprintf("The armature current is %f A and the
    total emf is %f V",I_a,E_g));

//solution (b)
I_sh=(v_t/r_sh)-(I_l*r_se/r_sh);
I_a=I_l-I_sh;
E_g=v_t-(I_a*r_a)-(I_l*r_se);
disp("(b) When the machine is connected as short
    shunt compound generator-");
disp(sprintf("The armature current is %f A and the
    total emf is %f V",I_a,E_g));

//END
```

Scilab code Exa 8.36 Constant losses and full load efficiency

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 36

clc;
disp("CHAPTER 8");
disp("EXAMPLE 36");

//VARIABLE INITIALIZATION
```

```
v_t=250;                       //in Volts
I_l=150;                       //in Amperes
loss1=1200;                    //core loss at full load
    in Watts
loss2=800;                     //mechanical loss in
   Watts
r_b=0.08;                      //brush resistance in
   Ohms
r_sh=62.5;                     //shunt field resistance
    in Ohms
r_se=0.03;                     //series field
   resistance in Ohms
r_ip=0.02;                     //interpole resistance
   in Ohms

//SOLUTION

//solution (a)
p_o=v_t*I_l;
I_sh=v_t/r_sh;
I_a=I_l+I_sh;
r_tot=r_b+r_se+r_ip;
arm_loss=(I_a^2)*r_tot;         //armature circuit
   copper loss
cu_loss=v_t*I_sh;               //shunt field copper
   loss
c_loss=cu_loss+loss1+loss2;     //constant loss
disp(sprintf("(a) The constant loss is %f W",c_loss)
   );

//solution (b)
tot_loss=arm_loss+c_loss;       //total loss
p_i=p_o+tot_loss;
eff=(p_o/p_i)*100;
disp(sprintf("(b) The full load efficiency is %f %%"
   ,eff));

//END
```

Scilab code Exa 8.37 Hysteresis and eddy current losses

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 37

clc;
disp("CHAPTER 8");
disp("EXAMPLE 37");

//VARIABLE INITIALIZATION
p_o=50*1000;                //in Watts
v_t=250;                    //in Volts
loss1=5000;                 //total core loss in
    Watts
loss2=2000;                 //total core loss in
    Watts (when speed is reduced to half)
speed=125/100;

//SOLUTION

//solution (a)

//W_h=A*N, where W_h=hysteresis loss, A=constant and
     N=speed
//W_e=B*(N^2), where W_e=eddy current loss, B=
    constant and N=speed
//W_h+(W_e^2)=loss1 =>W_h+W_e=5000
//(W_h/2)+(W_e/4)=loss2 =>(0.5*W_h)+(0.25*W_e)=2000
    (when speed reduces to half)
//So, we get two equations
//W_h+W_e=5000.......................eq(i)
//(0.5*W_h)+(0.25*W_e)=2000.........eq(ii)
//solving the equations by matrix method
A=[1 1;0.5 0.25];
```

```
b=[5000;2000];
x=inv(A)*b;
W_h1=x(1,:);                  //to access the 1st row
    of 2X1 matrix
W_e1=x(2,:);                  //to access the 2nd row
    of 2X1 matrix
disp("Solution (a)");
disp(sprintf("The hysteresis loss at full speed is
   %d W",W_h1));
disp(sprintf("The eddy current loss at full speed is
    %d W",W_e1));

//solution (b)
W_h2=speed*W_h1;
W_e2=(speed^2)*W_e1;
disp("Solution (b)");
disp(sprintf("The hysteresis loss at 125%% of the
    full speed is %d W",W_h2));
disp(sprintf("The eddy current loss at 125%% of the
    full speed is %d W",W_e2));

//END
```

Scilab code Exa 8.38 Speed of motor when flux per pole is increased by 10 percent

```
//CHAPTER 8- DIRECT CURRENT MACHINES
//Example 38

clc;
disp("CHAPTER 8");
disp("EXAMPLE 38");

//VARIABLE INITIALIZATION
v_t=215;                      //in Volts
r_a=0.4;                      //in Ohms
```

```
p=5*1000;                    //in Watts
N_g=1000;                    //speed as generator in rpm
ratio=1.1;                   //according to the solution , _b : _a =1.1

//SOLUTION

//As generator
I_ag=p/v_t;
E_a=v_t+(I_ag*r_a);

//As motor
I_am=p/v_t;
E_b=v_t-(I_am*r_a);
N_m=(1/ratio)*N_g*(E_b/E_a);
N_m=round(N_m);                   //to round off the value
disp(sprintf("The speed of the machine as motor is %d rpm",N_m));

//END
```

Chapter 10

Three Phase Induction Machines

Scilab code Exa 10.2 `6 pole wound rotor induction motor`

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 2

clc;
disp("CHAPTER 10");
disp("EXAMPLE 2");

//VARIABLE INITIALIZATION
P=6;                        //number of poles
f1=60;                      //stator frequency in
    Hertz
N_r1=1140;                  //in rpm

//SOLUTION
N_s=(120*f1)/P;             //synchronous speed
s1=(N_s-N_r1)/N_s;          //slip at full load

//solution (a)
N_r2=0;                     //rotor speed at
```

```
standstill is zero
s2=(N_s-N_r2)/N_s;
disp(sprintf("(a) At standstill , the slip is %f %%", s2*100));
if(s2>1)
disp("Since the slip is greater than 100%, the motor operates as brake");
end;
if(s2<0)
disp("Since the slip is negative , the motor operates as generator");
end;
f2=s2*f1;
disp(sprintf("And the frequency of rotor current is %d Hz",f2));
if(f2<0)
disp("Since frequency is negative , phase sequence of voltage induced in rotor winding is reversed");
end;

//solution (b)
N_r3=500;
s3=(N_s-N_r3)/N_s;
disp(sprintf("(b) At %d rpm, the slip is %f %%",N_r3,s3*100));
if(s3>1)
disp("Since the slip is greater than 100%, the motor operates as brake");
end;
if(s3<0)
disp("Since the slip is negative , the motor operates as generator");
end;
f3=s3*f1;
disp(sprintf("And the frequency is %d Hz",f3));
if(f3<0)
disp("Since frequency is negative , phase sequence of voltage induced in rotor winding is reversed");
```

```
end;

//solution (c)
N_r4=500;
s4=(N_s+N_r4)/N_s;                //as motor runs in
    opposite direction
disp(sprintf("(c) At %d rpm, the slip is %f %%",N_r4
    ,s4*100));
if(s4>1)
disp("Since the slip is greater than 100%, the motor
     operates as brake");
end;
if(s4<0)
disp("Since the slip is negative, the motor operates
     as generator");
end;
f4=s4*f1;
disp(sprintf("And the frequency is %d Hz",f4));
if(f4<0)
disp("Since frequency is negative, phase sequence of
     voltage induced in rotor winding is reversed");
end;

//solution (d)
N_r5=2000;
s5=(N_s-N_r5)/N_s;
disp(sprintf("(d) At %d rpm, the slip is %f %%",N_r5
    ,s5*100));
if(s5>1)
disp("Since the slip is greater than 100%, the motor
     operates as brake");
end;
if(s5<0)
disp("Since the slip is negative, the motor operates
     as generator");
end;
f5=s5*f1;
disp(sprintf("And the frequency is %d Hz",f5));
```

```
if(f5<0)
disp("Since frequency is negative, phase sequence of voltage induced in rotor winding is reversed");
end;

//END
```

Scilab code Exa 10.3 3 phase induction motor running at 1140 rpm

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 3

clc;
disp("CHAPTER 10");
disp("EXAMPLE 3");

//VARIABLE INITIALIZATION
N_r=1140;                          //full load speed in rpm
f=60;                              //frequency in Hz

//SOLUTION

//solution (i)
P=(120*f)/N_r;
P=round(P);                        //since the number of poles cannot be a fraction
disp(sprintf("(i) The number of poles is %d",P));

//solution (ii)
N_s=(120*f)/P;
s=(N_s-N_r)/N_s;
disp(sprintf("(ii) The slip at full load is %d %%",s*100));

```

```
//solution (iii)
f_r=s*f;
disp(sprintf("(iii) The frequency of the rotor
    voltge is %d Hz",f_r));

//solution (iv)
N1=(120*f_r)/P;                    //speed of rotor
    field w.r.t stator
N1=round(N1);
disp(sprintf("(iv) The speed of rotor field w.r.t
    rotor is %d rpm",N1));

//solution (v)
N2=N_r+N1;                         //speed of stator
    field w.r.t stator field
N3=N_s-N2;                         //speed of rotor
    field w.r.t stator field
disp(sprintf("(v) The speed of rotor field w.r.t
    stator field is %d rpm",N3));
disp("Hence, the rotor field is stationary w.r.t
    stator field");

//solution (vi)
ratio=10/100;                       //since it is
    specified that slip is 10%
N_r=N_s*(1-ratio);
N_r=round(N_r);
disp(sprintf("(vi) The speed of rotor at 10%% slip
    is %d rpm",N_r));
s1=(N_s-N_r)/N_s;
fr=s1*f;
disp(sprintf(" The rotor frequency at this speed is
    %f Hz",fr));

//solution (vii)
v=230;
ratio1=1/0.5;                      //stator to rotor
    turns ratio
```

```
E_rotor=v*(1/ratio1);
E_rotor_dash=ratio*E_rotor;
disp(sprintf("(vii) The rotor induced emf is %f V",
   E_rotor_dash));

//END
```

Scilab code Exa 10.4 3 phase squirrel cage motor

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 4

clc;
disp("CHAPTER 10");
disp("EXAMPLE 4");

//VARIABLE INITIALIZATION
r2=0.2;                          //in Ohms
X2=2;                            //in Ohms

//SOLUTION
s_m=r2/X2;

//solution (a)
s=1;
ratio1=2/((s/s_m)+(s_m/s));     //ratio of T_starting
    and T_max
ratio2=2*ratio1;                 //ratio of T_starting
    and T_full-load (T_max=2*T_full-load)
disp(sprintf("(a) If the motor is started by direct-
   on-line starter, the ratio of starting torque to
   full load torque is %f",ratio2));

//solution (b)
ratio3=(1/3)*ratio2;             //In star-delta
```

```
   starter , T_starting=(1/3)*T_starting_of_DOL
disp(sprintf("(b) If the motor is started by star-
   delta starter , the ratio of starting torque to
   full load torque is %f",ratio3));

//solution (c)
ratio4=0.7*2*ratio2;            //due to 70% tapping
disp(sprintf("(c) If the motor is started by auto-
   transformer , the ratio of starting torque to full
    load torque is %f",ratio4));

//END
```

Scilab code Exa 10.5 `Speed of motor`

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 5

clc;
disp("CHAPTER 10");
disp("EXAMPLE 5");

//VARIABLE INITIALIZATION
P1=12;                              //number of poles
   of alternator
N_s1=500;                           //synchronous speed
    of 12-pole alternator in rpm
P2=8;                               //number of poles
   of motor
s=0.03;                             //slip of the motor
    in p.u.

//SOLUTION
f=(N_s1*P1)/120;
N_s2=(120*f)/P2;                    //synchronous speed
```

```
of 8-pole alternator in rpm
N_r=N_s2*(1-s);
N_r=round(N_r);                    //to round off the value
disp(sprintf("The speed of the motor is %d rpm",N_r));

//END
```

Scilab code Exa 10.6 Speed of 4 pole induction motor

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 6

clc;
disp("CHAPTER 10");
disp("EXAMPLE 6");

//VARIABLE INITIALIZATION
P=4;                          //number of poles
f_r=2;                        //rotor frequency in Hertz
f_s=50;                       //stator frequency in Hertz
E=400;                        //line voltage in Volts
ratio=1/0.5;                  //stator to rotor turn ratio

//SOLUTION
s=f_r/f_s;
N_s=(120*f_s)/P;              //synchronous speed
N_r=N_s*(1-s);                //rotor speed
N_r=round(N_r);
disp(sprintf("The speed of the motor is %d rpm",N_r));
```

```
E_s=E/sqrt(3);                    //phase voltage=(line voltage)/sqrt(3) for star connection
E_r=E_s*(1/ratio);
E_r_dash=s*E_r;
disp(sprintf("The rotor induced emf above 2 Hz is %f V per phase",E_r_dash)); //Answer given in the book is wrong

//END
```

Scilab code Exa 10.7 `4 pole 3 phase induction motor`

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 7

clc;
disp("CHAPTER 10");
disp("EXAMPLE 7");

//VARIABLE INITIALIZATION
P=4;                               //number of poles
f=50;                              //frequency in Hz
r2=0.1;                            //rotor resistance in Ohms
X2=2;                              //standstill reactance in Ohms
E1=100;                            //induced emf between slip ring in Volts
N_r=1460;                          //full load speed in rpm

//SOLUTION

//solution (i)
N_s=(120*f)/P;
```

```
s_fl=(N_s-N_r)/N_s;
disp(sprintf("(i) The slip at full load is %f %%",s_fl*100));
s_m=r2/X2;
disp(sprintf("The slip at which maximum torque occurs is %f %%",s_m*100));

//solution (ii)
E2=E1/sqrt(3);                    //phase voltage=(line voltage)/sqrt(3) for star connection
disp(sprintf("(ii) The emf induced in rotor is %f V per phase",E2));

//solution (iii)
X2_dash=s_fl*X2;
disp(sprintf("(iii) The rotor reactance per phase is %f  ",X2_dash));

//solution (iv)
z=sqrt((r2^2)+(X2_dash)^2);
I2=(s_fl*E2)/z;
disp(sprintf("(iv) The rotor current is %f A",I2));

//solution (v)
pow_fact_r=r2/z;
disp(sprintf("(v) The rotor power factor is %f (lagging)",pow_fact_r));

//END
```

Scilab code Exa 10.8 3 phase induction motor with synchronous speed 1200 rpm

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 8

```

```
clc;
disp("CHAPTER 10");
disp("EXAMPLE 8");

//VARIABLE INITIALIZATION
N_s=1200;                          //synchronous speed in rpm
p_in=80;                           //input power in kW
loss=5;                            //copper and iron losses in kW
f_loss=2;                          //friction and windage loss in kW
N=1152;                            //rotor speed in rpm

//SOLUTION

//solution (a)
p_rotor=p_in-loss;
disp(sprintf("(a) The active power transmitted to rotor is %d kW",p_rotor));

//solution (b)
s=(N_s-N)/N_s;
cu_loss=s*p_rotor;
disp(sprintf("(b) The rotor copper loss is %d kW",cu_loss));

//solution (c)
p_m=(1-s)*p_rotor;                 //since P2:Pcu:Pm=1:s:(1-s)
disp(sprintf("(c) The mechanical power developed is %d kW",p_m));

//solution (d)
p_shaft=p_m-f_loss;                //output power
disp(sprintf("(d) The mechanical power developed to load is %d kW",p_shaft));

```

```
//solution (e)
eff=p_shaft/p_in;
disp(sprintf("(e) The efficiency of the motor is %f
    %%",eff*100));

//END
```

Scilab code Exa 10.9 `150 kW 6 pole star connected induction motor`

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 9

clc;
disp("CHAPTER 10");
disp("EXAMPLE 9");

//VARIABLE INITIALIZATION
p=150*1000;                        //in Watts
v=3000;                            //in Volts
f=50;                              //in Hertz
P=6;                               //number of poles
ratio=3.6;                         //ratio of stator
    turn to rotor turn
r2=0.1;                            //rotor resistance
    in Ohms
L=3.61/1000;                       //leakage
    inductance per phase in Henry

//SOLUTION

//solution (a)
X2=2*%pi*f*L;
E1=v/sqrt(3);
E2=E1*(1/ratio);
z1=sqrt((r2^2)+(X2^2));
```

```
I2=E2/z1;                                    //rotor current
I_s=I2/ratio;                                //stator current
N_s=(120*f)/P;
w=(2*%pi*N_s)/60;
T_s1=(3*E2^2*r2)/(w*z1^2);
disp(sprintf("(a) The starting current is %f A and torque is %f N-m",I_s,T_s1));

//solution (b)
I_s1=30;
I_r=ratio*I_s1;
r=sqrt(((E2/I_r)^2)-(X2^2));
r_ext=r-r2;
z2=sqrt((r_ext^2)+(X2^2));
T_s2=(3*E2^2*r)/(w*z2^2);
disp(sprintf("(b) The external resistance is %f and torque is %f N-m",r_ext,T_s2));

//There answers are different due to precision of floating point numbers

//END
```

Scilab code Exa 10.10 `6 pole 60 Hz induction motor`

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 10

clc;
disp("CHAPTER 10");
disp("EXAMPLE 10");

//VARIABLE INITIALIZATION
P=6;                                         //number of poles
f=60;                                        //in Hertz
```

```
p=48;                              //stator input in
   Watts
N_r=1140;                          //in rpm
cu_loss=1.4;                       //stator copper loss
    in Watts
cr_loss=1.6;                       //stator core loss
   in Watts
me_loss=1;                         //rotor mechanical
   loss in Watts

//SOLUTION
N_s=(120*f)/P;
s=(N_s-N_r)/N_s;
p_g=p-(cu_loss+cr_loss);           //rotor input
p_m=p_g*(1-s);                     //output mechanical
   power
p_sh=p_m-me_loss;                  //shaft power
eff=p_sh/p;
disp(sprintf("The motor efficiency is %f %%",eff
   *100));

//END
```

Scilab code Exa 10.11 4 pole induction motor

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 11

clc;
disp("CHAPTER 10");
disp("EXAMPLE 11");

//VARIABLE INITIALIZATION
P1=4;                            //number of poles
s=5/100;                         //slip
```

```
f=60;                          //frequency of
   synchronous generator in Hertz

//SOLUTION

//solution (a)
N_s=(120*f)/P1;                //synchronous speed of
    generator in rpm with four poles
N_r=N_s*(1-s);                 //rotor or motor speed
    in rpm
N_r=round(N_r);                //to round off the
   value
disp(sprintf("(a) The speed of the motor is %d rpm",
   N_r));

//solution (b)
P2=6;
N_s=(120*f)/P2;                //synchronous speed of
    generator in rpm with six poles
disp(sprintf("(b) The speed of the generator is %d
   rpm",N_s));

//END
```

Scilab code Exa 10.12 `3 phase 440 V distribution`

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 12

clc;
disp("CHAPTER 10");
disp("EXAMPLE 12");

//VARIABLE INITIALIZATION
v=440;                            //line voltage in
```

```
Volts
I=1200;                              //line current in Amperes
eff=0.85;                            //full load efficiency
pow_fact=0.8;                        //full load power factor

//SOLUTION

//solution (a)
I_fl1=I/5;                           //starting current at rated voltage is 5 times the rated full-load current
p1=sqrt(3)*v*I_fl1*pow_fact*eff;
disp(sprintf("(a) The maximum permissible kW rating when the motor when it starts at full voltage is %f kW",p1/1000));

//solution (b)
x=0.8;                                //voltage is stepped down to 80%
I_fl2=I/((x^2)*5);
p2=sqrt(3)*v*I_fl2*pow_fact*eff;
disp(sprintf("(b) The maximum permissible kW rating when the motor is used with an auto-transformer is %f kW",p2/1000));

//solution (c)
I_fl3=I/((0.578^2)*5);                //since a star-delta is equivalent to an auto-transformer starter with 57.8% tapping
p3=sqrt(3)*v*I_fl3*pow_fact*eff;
disp(sprintf("(c) The maximum permissible kW rating when the motor is used with star-delta starter is %f kW",p3/1000));

//The answers are slightly different due to
```

```
precision of floating point numbers

//END
```

Scilab code Exa 10.13 `3 phase 50 Hz induction motor`

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 13

clc;
disp("CHAPTER 10");
disp("EXAMPLE 13");

//VARIABLE INITIALIZATION
f=50;                          //frequency in Hertz
N_r=1440;                      //full-load rotor speed in rpm

//SOLUTION

//solution (a)
function N=speed(pole);        //function 'speed()' calculates the synchronous speed in rpm
N=(120*f)/pole;
endfunction;

pole=2;
N=speed(pole);
if(N>N_r & N<2000)
P=pole;
N_s1=N;
disp(sprintf("(a) The number of poles is %d",P));
end;
pole=4;
N=speed(pole);
```

```
if(N>N_r & N<2000)
P=pole;
N_s1=N;
disp(sprintf("(a) The number of poles is %d",P));
end;
pole=6;
N=speed(pole);
if(N>N_r & N<2000)
P=pole;
N_s1=N;
disp(sprintf("(a) The number of poles is %d",P));
end;

//solution (b)
s=(N_s1-N_r)/N_s1;
f_r=s*f;
disp(sprintf("(b) The slip is %f %% and rotor frequency is %d Hz",s*100,f_r));

//solution (c)
w1=(2*%pi*N_s1)/60;
disp(sprintf("(c(i)) The speed of stator field w.r.t. stator structure is %f rad/s",w1));  //Answer given in the book is wrong
N_s2=N_s1-N_r;
w2=(2*%pi*N_s2)/60;
disp(sprintf("(c(ii)) The speed of stator field w.r.t. rotor structure is %f rad/s",w2));

//solution (d)
factor=(2*%pi)/60;              //converting rpm to radian/second
N_r1=(120*f_r)/P;
disp(sprintf("(d(i)) The speed of rotor field w.r.t. rotor structure is %f rad/s",N_r1*factor));
N_r2=N_r+N_r1;
disp(sprintf("(d(ii)) The speed of rotor field w.r.t. stator structure is %f rad/s",N_r2*factor));
```

```
N_r3=N_s1-N_r2;
disp(sprintf("(d(iii)) The speed of rotor field w.r.
    t. stator structure is %d rad/s",N_r3));

//END
```

Scilab code Exa 10.14 10 kW 400 V delta connected induction motor

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 14

clc;
clear
disp("CHAPTER 10");
disp("EXAMPLE 14");

//VARIABLE INITIALIZATION
p=10*1000;                          //in Watts
I_nl=8;                             //no load line
    current in Amperes
p_ni=660;                           //input power at no
    load in Watts
I_fl=18;                            //full load current
    in Amperes
p_fi=11.20*1000;                    //input power at
    full load in Watts
r=1.2;                              //stator resistance
    per phase in Ohms
loss=420;                           //friction and
    winding loss in Watts

//SOLUTION

//solution (a)
I1=I_nl/sqrt(3);                    //phase current=(
```

```
line current)/sqrt(3) for delta connection
i_sq_r1=(I1^2)*r*3;                //stator ((I^2)*R) loss at no load; since resistance is given in per phase, 3 needs to be multiplied for 3-phase
s_loss=(p_ni-loss)-(i_sq_r1);
disp(sprintf("(a) The stator core loss is %f W",s_loss));

//solution (b)
I2=I_fl/sqrt(3);
i_sq_r2=(I2^2)*r*3;
p_g=p_fi-s_loss-i_sq_r2;           //air-gap power at full load
r_loss=p_g-p;
disp(sprintf("(b) The total rotor loss at full load is %f W",r_loss));

//solution (c)
o_loss=r_loss-loss;
disp(sprintf("(c) The total rotor ohmic loss at full load is %f W",o_loss));

//solution (d)
s_fl=o_loss/p_g;                   //full load slip
N_s=1500;
N_r=N_s*(1-s_fl);
disp(sprintf("(d) The full load speed is %f rpm",N_r));

//solution (e)
w=(2*%pi*N_s)/60;
T_e=p_g/w;
disp(sprintf("(e) The internal torque is %f N-m",T_e));
T_sh=p/(w*(1-s_fl));
disp(sprintf("    The shaft torque is %f N-m",T_sh));
eff=p/p_fi;
```

```
disp(sprintf("    The motor efficiency is %f %%",eff
    *100));

//The answers may be slightly different due to
    precision of floating point numbers

//END
```

Scilab code Exa 10.15 4 pole 3 phase SRIM

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 15

clc;
disp("CHAPTER 10");
disp("EXAMPLE 15");

//VARIABLE INITIALIZATION
P=4;                              //number of poles
f_s=50;                           //in Hertz
f_l=20;                           //in Hertz

//SOLUTION

//solution (a)
N1=(120*f_s)/P;                   //speed of rotor
    field w.r.t. stator structure
N2=(120*f_l)/P;                   //speed of rotor
    field w.r.t. rotor structure
N_r1=N1-N2;
N_r2=N1+N2;
disp("(a) The prime mover should should drive the
    rotor at two speeds-");
disp(sprintf("At %d rpm in the direction of stator
    field",N_r1));
```

```
disp(sprintf("At %d rpm against the direction of stator field",N_r2));

//solution (b)
s1=(N1-N_r1)/N1;
s2=(N1-N_r2)/N1;
ratio=s1/s2;                              //all other parameters in the expressions of the two voltages are equal
disp(sprintf("(b) The ratio of the two voltages at the two speeds is %d",ratio));

//solution (c)
disp("(c) The poles sequence of -3  rotor voltage do not remain the same");

//END
```

Scilab code Exa 10.16 3 phase induction motor

```
//CHAPTER 10- THREE-PHASE INDUCTION MACHINES
//Example 16

clc;
disp("CHAPTER 10");
disp("EXAMPLE 16");

//VARIABLE INITIALIZATION
ratio1=1.5;                          //ratio of starting torque (T_est) and full load torque (T_efl)
ratio2=2.5;                          //ratio of maximum torque (T_em) and T_efl

//SOLUTION

```

```
//solution (a) (taking the ratio of T_est and T_em)
s=1;                              //at starting slip is
    equal to 1

//directly solving the quadratic equation (a,b and c
    are the coefficients of the quadratic equation)
a=1;
b=-3.333;
c=1;
D=(b)^2-(4*a*c);                  //discriminant
sm1=(-b+sqrt(D))/(2*a);
sm2=(-b-sqrt(D))/(2*a);
if(sm1<=0 & sm2<=0) then
disp("The value of the slip at maximum torque (
   maximum slip) is not valid");
else if(sm1>0 & sm1<1)
disp(sprintf("The slip at maximum torque (maximum
   slip) is %f",sm1));   //slip is a unitless
   quantity
else if(sm2>0 & sm2<1)
disp(sprintf("The slip at maximum torque (maximum
   slip) is %f",sm2));
end;

//solution (b) (taking the ratio of T_efl and T_em)
//directly solving the quadratic equation
a=1;
b=-1.665;
c=0.111;
D=(b)^2-(4*a*c);
ans1=(-b+sqrt(D))/(2*a);
ans2=(-b-sqrt(D))/(2*a);
if(ans1>0 & ans1<1)
disp(sprintf("The full load slip is %f",ans1));
sfl=ans1;
else if(ans2>0 & ans2<1)
disp(sprintf("The full load slip is %f",ans2));
sfl=ans2;
```

```
end;

//solution (c)
I=sqrt(ratio1/sfl);
disp(sprintf("The rotor current at the starting in
   terms of full load current is %f A",I));

//END
```

Chapter 11

Single Phase Induction Motor

Scilab code Exa 11.1 Shaft torque

```
//CHAPTER 11- SINGLE PHASE INDUCTION MOTOR
//Examle 1

clc;
disp("CHAPTER 11");
disp("EXAMPLE 1");

//VARIABLE INITIALIZATION
P=6;                        //number of poles
f=50;                       //frequency in Hz
p_fd=160;                   //gross power absorbed by
   forward field in Watts
p_bd=20;                    //gross power absorbed by
   backward field in Watts
N_r=950;                    //rotor speed in rpm
loss=75;                    //no load frictional loss
   in Watts

//SOLUTION
P_g=p_fd-p_bd;              //air-gap power in Watts
N_s=(120*f)/P;              //synchronous speed in rpm
```

```
S=(N_s-N_r)/N_s;            //slip
P_m=P_g*(1-S);              //mechanical power developed in Watts
P_o=P_m-loss;               //output or shaft power in Watts
w=(2*%pi*N_r)/60;
T=P_o/w;                    //shaft torque in Newton-meters
disp(sprintf("The shaft torque is %f N-m",T));

//END
```

Scilab code Exa 11.2 `Slip and resistance in forward and backward direction`

```
//CHAPTER 11- SINGLE PHASE INDUCTION MOTOR
//Example 2

clc;
disp("CHAPTER 11");
disp("EXAMPLE 2");

//VARIABLE INITIALIZATION
P=4;                    //number of poles
f=60;                   //frequency in Hz
N_r=1710;               //rotor speed in rpm
r2=12.5;                //rotor resistance at standstill in Ohms

//SOLUTION

N_s=(120*f)/P;      //synchronous speed in rpm

//solution (a)
disp("Solution (a)");
S_f=(N_s-N_r)/N_s;
```

```
disp(sprintf("The per unit slip in the direction of rotation is %f pu",S_f));
r_f=0.5*(r2/S_f);
disp(sprintf("The effective forward rotor resistance is %f   ",r_f));

//solution (b)
disp("Solution (b)");
S_b=(N_s+N_r)/N_s;
disp(sprintf("The per unit slip in the opposite direction is %f pu",S_b));
r_b=0.5*(r2/S_b);
disp(sprintf("The effective backward rotor resistance is %f   ",r_b));

//END
```